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BNMC Community Microgrid

Stage 1 - Feasibility Study Report

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NY Prize Community Microgrid Competition

Prepared by

Buffalo Niagara Medical Campus
Knowledge works.

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Abbreviations

ADMS	Advanced Distribution Management System
AMI	Advanced Metering Infrastructure
BCA	Benefit Cost Analysis
BEMS	Building Energy Management System
BNMC	Buffalo Niagara Medical Campus
BTU	British Thermal Unit
CAIDI	Customer Average Interruption Duration Index
CB	Cleveland Biolabs
CHP	Combined Heat and Power
CO2	Carbon Dioxide
CT	Combustion Turbine (Natural Gas)
DER	Distributed Energy Resources
DERMS	Distributed Energy Resource Management System
DG	Diesel Generator
DMS	Distribution Management System
DNP3	Distributed Network Protocol 3
DoD	U.S. Department of Defense
DOE	U.S. Department of Energy
DPS	New York State Department of Public Service
DR	Demand Response
D-SCADA	Distribution - Supervisory Control and Data Acquisition
DSP	Distribution System Platform
EMS	Emergency Medical Services
EPC	Engineering, Procurement, and Construction
EPRI	Electric Power Research Institute
ES	Energy Storage
ESCO	Energy Supply Company
EV	Electric Vehicle
FAN	Field Area Network
FB	Fruit Belt Residential Neighborhood
FEMA	Federal Emergency Management Agency
FERC	Federal Energy Regulatory Commission
FOA	Funding Opportunity Announcement
GHG	Greenhouse Gases
HRSG	Heat Recovery Steam Generator
ICE	Internal Combustion Engine (Natural Gas)
ICE	Interruption Cost Estimate Calculator
IEEE	Institute of Electrical and Electronics Engineers
IT	Information Technology
KH	Kaleida Health

KVA	Kilovolt-Amperes
kW	Kilowatt
kWh	Kilowatt hour
LLC	Limited Liability Corporation
M&V	Measurement and Verification
MG	Microgrid
MIT	Massachusetts Institute of Technology
MOU	Memorandum of Understanding
MPLS	Multiprotocol Label Switching
MV	Medium Voltage
MW	Megawatt
MWh	Megawatt hour
NDA	Non-Disclosure Agreement
NFGDC	National Fuel Gas Distribution Corporation
NOC	Network Operation Center
NOx	Mono-Nitrogen Oxides
NYISO	New York Independent System Operator
NYSDEC	New York State Department of Environmental Conservation
O&M	Operations and Maintenance
PCC	Point of Common Coupling (Interconnection/Islanding)
PPA	Power Purchase Agreement
PV	Photovoltaics
REV	New York State Reforming the Energy Vision proceeding
RMF	Risk Management Framework
RPCI	Roswell Park Cancer Institute
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
SCADA	Supervisory Control and Data Acquisition
SO2	Sulfur Dioxide
SPE	Special Purpose Entity
SSID	Service Set Identifier
SWOT	Strengths, Weaknesses, Opportunities, and Threats
UB	The State University of New York at Buffalo
UPS	Uninterruptible Power Supply
VLAN	Virtual Local Area Network
VPLS	Virtual Private LAN Service
VPN	Virtual Private Network
WHO	World Health Organization

1 DESCRIPTION OF MICROGRID CAPABILITIES

Introduction

This feasibility analysis evaluates a broad, comprehensive strategic plan that seeks to meet the resiliency needs of individual Buffalo Niagara Medical Campus (“BNMC” or “Campus”) member institutions, the BNMC as a whole, and the Greater Buffalo Region. A tiered approach is proposed that builds upon the resiliency of its existing underground network, backup generation assets, distributed energy resources (DER), and energy-efficient facilities. As illustrated in the figure below, this microgrid strategy consists of three layers that would ultimately lead to a regional community microgrid enabling the service footprint of National Grid’s Elm Street Substation, which includes the Campus, its surrounding neighborhoods, and greater Buffalo, to withstand a catastrophic weather event or system failure while also positioning itself to leverage ‘blue-sky’ monetization opportunities.

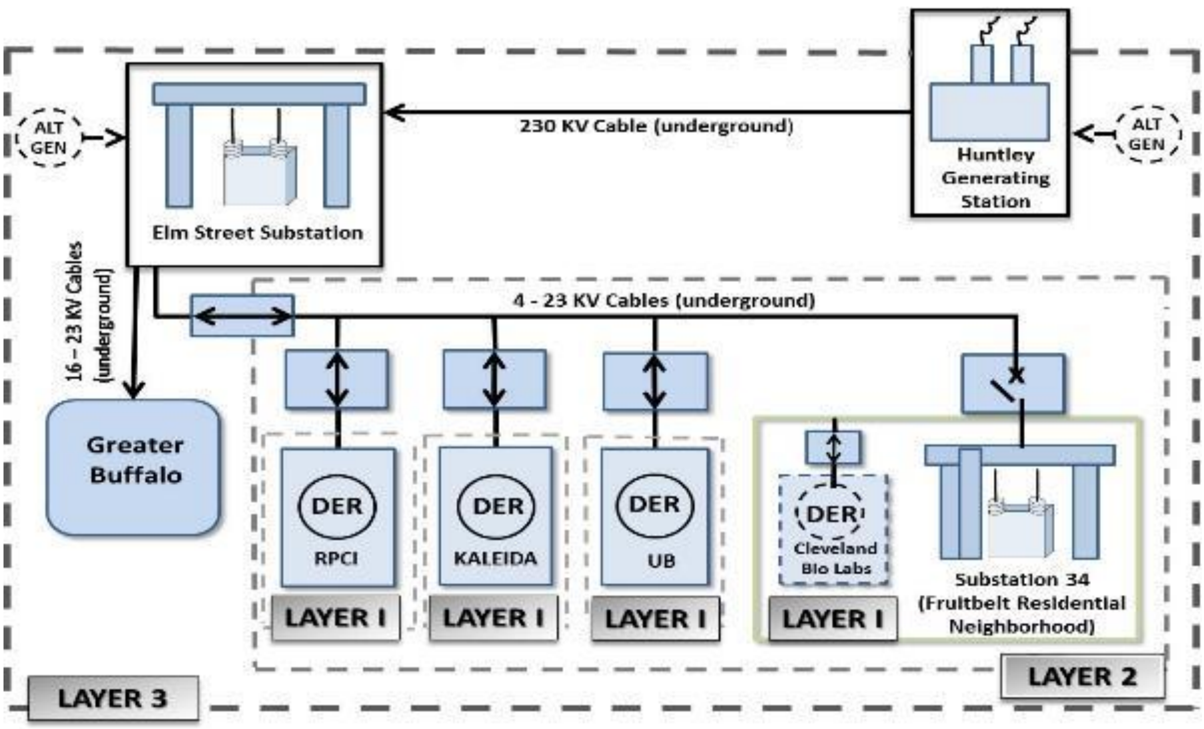

Figure 1.1. Proposed BNMC Community Grid Strategy for Greater Buffalo

The (3) layers of the proposed microgrid strategy consist of:

- ***Layer 1:*** As a precursor to a Campus-centric, dynamic portfolio, enabling each of the member institutions who employ emergency, back-up generation to disconnect, island, and optimize their facilities during weather or system-related events in order to maximize the capability of their back-up generating systems and other DER assets. This layer is characterized by maximizing the use of existing back-up generation assets (that electrically cannot be paralleled with the grid), existing/planned DER's and optimizing the loading and control of individual member institution facilities. Existing and/or future generation assets could potentially serve facilities that are currently without back-up generation.

- ***Layer 2:*** Enabling the aggregate Campus to draw from on-site generation resources/DER at the individual member institution level or from common locations to disconnect during weather while also positioned to leverage 'blue-sky' monetization opportunities.

  - Layer 2 is characterized by installing individual interface equipment to connect the member institutions' back-up generation to the grid, making it available to others on the Campus, and potentially to the close to 2,000 residential and 500 commercial customers residing in Buffalo's Fruit Belt neighborhood who are served by National Grid's Substation 34, during grid outages. This layer also allows member institutions to self-generate and participate in energy markets (e.g. ISO markets, potential distribution level and future opportunities under the Distributed System Platform (DSP) model) under normal, grid-connected mode.

- ***Layer 3:*** Creating a regional community microgrid through installation of combined-cycle gas turbines either at the Huntley Generating Station or within National Grid's right-of-way at the Elm Street Substation. This would work in tandem with campus back-up generation and National Grid's existing 230kV underground transmission infrastructure to ensure regional load served by the Elm Street Substation remains on-line during weather or system-related events.

While the plan outlines three (3) layers of increasing complexity, the work described here, as part of the NY Prize Stage 1 Feasibility Assessment, seeks to evaluate the feasibility of Layer 2. Layer 1 feasibility is currently being evaluated in a parallel effort funded by NYSERDA and National Grid[1] . Once complete, it will be possible to have portions of Layers 1 and 2 operating concurrently as well as redundantly. In addition to enabling both the Campus and portions of the adjacent Fruit Belt residential neighborhood[2] that share common infrastructure to endure weather-related or other adverse grid events, the proposed approach would also enable member institutions to capitalize on available revenue and market opportunities for grid-paralleled generation during the vast majority of time.

Task 1.1 Identify the minimum required capabilities of the proposed microgrid community

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

[1]"Assessment of an Urban Micro-grid", NYSERDA Project #: 36660.
[2] This neighborhood is also the location of a PSC-approved, National Grid REV Demonstration Project.

Layer 2 of the BNMC microgrid strategy will include the following member institution-owned buildings within the Campus proper and its surrounding area:

- Kaleida Health: Buffalo General Hospital, Gates Vascular Institute, High Pointe on Michigan, Women and Children's Hospital (currently under construction)
- Roswell Park Cancer Institute: Main hospital complex, Gratwick Basic Science Building, Administrative Services Building, Cell and Virus Building, and Grace Cancer Drug Center
- State University of New York at Buffalo ("UB"): Clinical and Translational Research Center ("CTRC") and the School of Medicine (currently under construction)
- Cleveland Biolabs
- Portions of the adjacent Fruit Belt residential neighborhood that share common electric infrastructure with the Campus

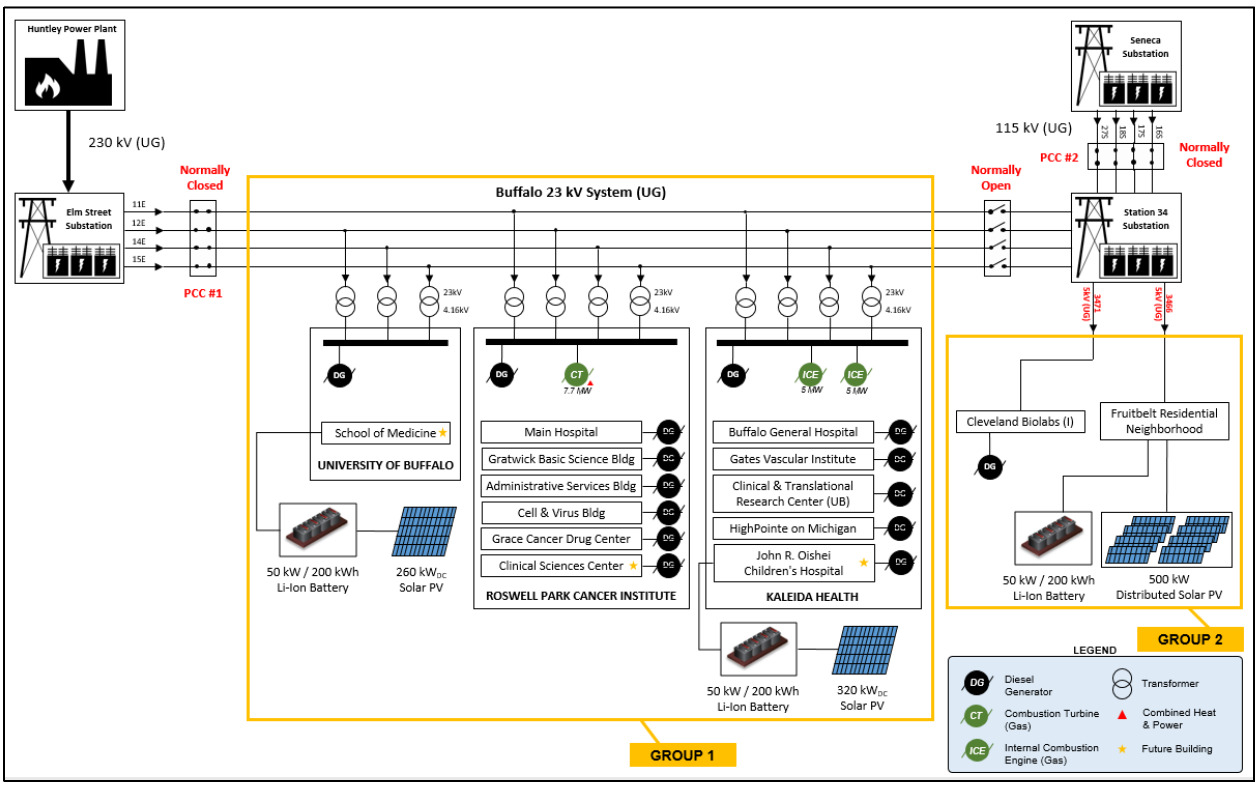

Figure 1.2. One-Line Diagram of the "Proposed State" for the BNMC Community Microgrid within Layer 2

- ***The primary generation source capacity cannot be totally diesel-fueled generators***. Layer 2 of the BNMC microgrid strategy will consider, but is not limited to, the following distributed energy resource technologies:
  - Dual-fuel natural gas/diesel generators
  - Combined heat and power generators (e.g. micro-turbines, internal combustion engines, fuel cells)

- Solar photovoltaics
- Battery energy storage
- Electric chillers
- Absorption chillers
- Boilers
- Thermal storage (e.g. hot water, cold water, ice)

The DER-CAM and HOMER modeling tools will inform the exact technology type, mix, and respective capacities that should be considered. The Distributed Energy Resources Customer Adoption Model (DER-CAM) is an economic and environmental model of customer DER adoption. This model has been in development at Berkeley Lab since 2000. The objective of the model is to minimize the cost of operating on-site generation and combined heat and power (CHP) systems, either for individual customer sites or for a microgrid. The HOMER Pro® microgrid software by HOMER Energy is a tool for evaluating microgrid design in all sectors, from village power and island utilities to grid-connected campuses and military bases. Originally developed at the National Renewable Energy Laboratory, and enhanced and distributed by HOMER Energy, HOMER (Hybrid Optimization Model for Multiple Energy Resources) nests three powerful tools in one software product, so that engineering and economics work side by side: simulation, optimization, and sensitivity analysis.

- ***A combination of generation resources must provide on-site power in both grid-connected and islanded mode***.
  The modeling objective of the DER-CAM and HOMER tools will be to fully serve the identified loads in both grid-connected and grid-islanded modes of operation while minimizing overall project costs and risk. Both the electrical and thermal needs of the BNMC community will be analyzed using these tools. Considerations for the BNMC community with respect to grid-connected and islanded operations are: (1) generating capacity requirements, (2) DER optimization, (3) generation and load serving plan, and (4) performance targets and community objectives as well as business drivers.

- ***Must be able to form an intentional island***.
  Within the Layer 2 microgrid concept, the local distribution network and power system assets will be modified, if needed, to allow all identified buildings to form a single, electrical island from the utility grid. This will be achieved primarily by isolating 23 kV feeders 11E, 12E, 14E, and 15E fed from the Elm Street substation, which powers the majority of the buildings. Both the Cleveland Biolabs facility and portions of the Fruit Belt residential neighborhood will also be part of the overall microgrid boundary by nature of its shared infrastructure. They would be manually energized only after adequate generation and load capacity is reached and maintained at the facilities of the three primary BNMC entities (Kaleida Health, Roswell Park Cancer Institute, and the University at Buffalo). As part of the design stage of NY Prize, the

following scenarios will be evaluated in detail:

- Planned intentional islanding
  - *Command planned islanding* - Utility or operating entity requests the microgrid transition to an islanded mode at a specific time in the future with sufficient time for planning.
  - *Scheduled planned islanding* - A scheduled tariff transition or operating agreement dictates that the microgrid transition to an islanded mode at a specific time.
- Unplanned/unscheduled intentional islanding - Supported by the microgrid controller, this function could consist of two scenarios:
  - *Outage-Driven unplanned islanding* - A confirmed grid outage is detected by the recloser or switch at the Point of Common Coupling ("PCC") which would open and start the unplanned/unscheduled islanded mode transition.
  - *Command-Driven unplanned islanding* - A triggering event is detected by the monitoring platform that initiates the island recloser or switch at the PCC to open and start the unscheduled islanding transition. Alternatively, the utility operation center receives notification of the triggering event(s) and works with the Grid Operator to use DMS/SCADA in order to open the recloser.

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

The microgrid controller will perform these functions (i.e. transition from grid-connected to islanded mode and resynchronization with the grid) under intentional as well as unintentional islanding scenarios. Within the design stage of NY Prize, the microgrid controller will be tested to ensure the following necessary functions are available: voltage regulation, frequency regulation, protection coordination, and black-start. Mirroring DOE FOA 997[3] functionality requirements the microgrid controller will include:

- Requirement C1: Island Operation – Disconnection: Electric Power System (EPS) Point of Common Coupling (PCC) voltage/frequency controlled according to modified version of procedure in IEEE Std. 1547.1
- Requirement C2: Resynchronization and Reconnection
- Requirement C3: Steady-State Frequency Range, Voltage Range, and Power Quality
- Requirement C4: Protection
- Requirement C5: Dispatch, and
- Requirement C6: Enhanced Resiliency

[3] EPRI, in partnership with National Grid, was awarded a $1.2 million grant to develop a commercially-viable standardized microgrid controller to complement, and enhance, the feasibility of an urban, community microgrid at the BNMC.

- ***Must comply with manufacturer's requirements for scheduled maintenance intervals for all generation; plan on intermittent renewable resources that will be utilized toward overall generation capacity only if paired with proper generation and/or energy storage that will allow 24 hrs. per day and 7 days per week utilization of the power produced by these resources***.
    - DER-CAM and HOMER modeling results will inform the best operating strategy for each distributed energy resource asset in order to: (1) ensure load and generation is in balance at all times, taking into account output variability and generator/storage ramp/discharge rates, (2) maximize economic return, and (3) minimize overall project costs and risk.
    - The DER-CAM and HOMER models will take into account required maintenance schedules and costs as specified by manufacturers.
    - Comply with IEEE 2030.7 requirement and standards described in Table 1 below.

Table 1-1 Standard Microgrid Functions for Integration within BNMC Community

<table>
<tr><th>Grid-Tied Functions</th><th>Islanded Functions</th></tr>
<tr><td>Grid Services
Connect/Disconnect (non-islanding)
Utility SCADA and DMS coordination
Connectivity and interface with power flow models, utility DMS and DERMS
Market interface for capacity, energy, and ancillary services
kW availability at any given moment in time</td><td>Microgrid Services
Disconnection
Intentional, planned (scheduled, command)
Intentional, unplanned (unscheduled)
Unintentional, unplanned
Resynchronization
Voltage and frequency control
Grid Configurations/Operations
Isochronous/Droop Operations
Protection
Black start
DER anti-islanding (within the microgrid)
Market interface for capacity, energy, and ancillary services</td></tr>
<tr><td>Local Services (Optimization)
Load, weather and price forecasting
Energy management and dispatch
Max generation level control
Power quality (PQ), outage, fault detection
Voltage regulation
Volt-VAR management and PF control
Power (Volt/Watt or Freq/Watt) curtailment/control
Power smoothing
DG, storage, load management
Voltage and frequency ride-through</td><td>Local Services (Optimization)
Load, weather and price forecasting
Energy management and dispatch
Max generation level control
Load and generation following
PQ and reliability
Voltage regulation
Volt-VAR management and PF control
Power (Volt/Watt or Freq/Watt) curtailment/control
Power smoothing
DG, storage, load management</td></tr>
<tr><td>Operator Services
State/Status monitoring
Communication with DSO/ISO/RTO
User interface and data management
Billing
Event logging</td><td>Operator Services
State/Status monitoring
Communication with DSO/ISO/RTO
User interface and data management
Billing
Event logging</td></tr>
</table>

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

  Preliminary analysis of the current and future DER portfolio will consider which DER assets will need to and/or are able to be paralleled with the grid or if subsequent retrofits are required in order to achieve such functionality. As part of NYSERDA #36660 project (and prior to NY Prize Stage 2) an initial design analysis will be conducted to confirm that the DER portfolio selected as part of the feasibility study conforms to the requirements tables for islanded steady state operation:
  - Maintain frequency in the range 59.3 Hz < f < 60.5 Hz — a range consistent with the frequency range for an area EPS and suitable for most loads
  - Maintain voltage according to ANSI 84.1-2006 standards, specifically the required voltage range for microgrid islanded steady-state operation of 0.95 pu<V< 1.05 pu at the PCC.
  - Maintain power quality at the PCC in compliance with customer-specific requirements.

- ***Include a means for two-way communication and control between the Community Grid owner/operator and the local distribution utility through automated, seamless integration. Include processes to secure control/communication systems from cyber-intrusions/disruptions and protect the privacy of sensitive data.***
  - The microgrid controller selected as part of this project will perform and guarantee these functions. Industry standards for communications will be implemented.
  - The following EPRI report will be used as a reference: "*Grid Interactive Micro-grid Controllers and the Management of Aggregated Distributed Energy Resources (DER): Relationship of Micro-grid Controller with Distributed Energy Resource Management System (DERMS) and Utility Distributed Management System (DMS),"* Grid Interactive Micro-Grid Controllers

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

  The footprint of the BNMC Layer 2 microgrid serves a cross section of Large Commercial and Industrial (in-patient and out-patient medical facilities, research, higher education, and office administration), Small Commercial, and Residential (the Fruit Belt neighborhood) customers. Refer to Task 3, Question 1 for more details.

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

  Large natural-gas fueled generators, in concert with combined heat and power capabilities, will likely be the primary sources of generation for the Layer 2 community microgrid. In an event of an outage, natural gas delivery pipelines are unlikely to be interrupted. Solar photovoltaics, coupled with storage, will be considered as secondary sources of generation during islanded modes of operation. The natural gas delivery system in the Western New York region has demonstrated very high reliability historically, and is not susceptible to the types of severe weather phenomena typically seen in this region, namely snow, ice, and wind storms. In the event of a grid outage, it is extremely unlikely that natural gas delivery would be interrupted simultaneously.

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

  The entire 23KV electrical distribution infrastructure serving the BNMC is already underground. Many of the existing Campus DER assets are sheltered either within "utility plants" or individually within a building. All the thermal loops and piping are also underground.

  The objective of the Layer 2 microgrid is to sustain, at a minimum, an outage duration of 7 days. Once more, given the robustness of the existing underground electrical and natural gas infrastructure, Layer 2 seeks to leverage this inherent resiliency in any future build out(s).

- ***Provide black-start capability***.

  Black-start capability (an individual generator's capability) and load re-energizing sequence will be evaluated in the NYSERDA #36660 project as well as through NY Prize Stage 2 – Detailed Design process.

  As one of the Campus' key goals is resiliency, the BNMC community microgrid will likely need to have black-start capability. This feature will be accessed based on existing back-up generation as well as the DER portfolio. For 'black-start' capability, motor starting is also important. Additional controls may be required for larger motors to prevent an in-rush current during microgrid re-energization. Cold-load pickup and in-rush will be key considerations. Some of these features are also being monitored and evaluated as part of NYSERDA #36660 study.

Task 1.2 What are the preferable microgrid capabilities

- ***Integrate and demonstrate operation of advanced, innovative technologies in electric system design and operations, including, but not limited to, technologies that enable customer interaction with the grid such as, Microgrid Logic Controllers, Smart Grid Technologies, Smart Meters, Distribution Automation, and Energy Storage.***
  - Include an active network control system that optimizes demand, supply and other network operation functions within the microgrid.

- The microgrid controller deployed within the Layer 2 microgrid will enable supervisory control in order to optimize the demand and supply of power within the BNMC corridor. The microgrid controller will automatically dispatch assets to meet the current operational criterion including: maintaining local survival, supporting economic operations, minimizing environmental impacts, and all combinations thereof. When grid-connected, the controller will manage the local resources to ensure high power quality and readiness to island in case of emergency. In addition, economic and environmental objectives issued by internal or external parties will also be evaluated and supported by dispatching additional assets (or modifying current asset set points) if capacity is available. While islanded, the controller's primary objective will be to maintain critical loads and will automatically dispatch or shed generation and load assets as necessary. During extended islanded operation, the objectives may be modified to maximize survivability or to provide black-start support. The allocation of assets will be determined by taking an account of each asset's availability, capabilities (e.g., capacity and dynamic responsiveness), and operational constraints against the current list of objectives. Some common objectives may include active and reactive power capacity, response time, minimum and maximum operating times, calendar constraints, etc. The controller environment will have the capability to manage a database of the asset parameters that can be easily updated via a user-interface to accommodate schedule changes or operational changes. The dispatch of assets may be configured to be automatic or to require operator acknowledgment.

- Include energy efficiency options to minimize new microgrid generation requirements.
  - The proposed controller will enhance energy production efficiency as well reduce emissions within the community microgrid by using efficient generation sources coupled with combined heat and power techniques that integrate renewables, if applicable. The controller will enable this by intelligently dispatching resources to maximize electrical generation efficiency while also meeting thermal loads. Further, the microgrid controller can include and overcome the challenges of intermittent generation by providing intelligent dispatch of microgrid generation and storage to optimize renewable resources while still maintaining microgrid stability. With proper design and an intelligent controller, potentially large amounts of PV (relative to the total load) can be integrated into the microgrid and CHP applications are made more feasible.

    As part of the NYSERDA Project described prior, EPRI is also performing a Power Quality Audit through the monitoring of end-use equipment across the Campus to identify additional energy efficiency opportunities for lighting, compressors, chillers, waste heat recovery, etc.

- Address installation, operations and maintenance, and communications for the electric system to which interconnection is planned (e.g., underground networks, overhead loops, radial overhead systems).
  - The controller shall be capable of receiving and interpreting status information from DER assets in the field.
  - The proposed controller will be designed with open communications standards such as Enterprise Service Bus, DNP3, SEP2.0, SunSpec Alliance, IEC61850, ModBus, among others**.** In addition to these protocols, the proposed controller platform will be capable of interfacing with any SCADA, DMS, NOC (Network Operation Center) or DER assets that use open protocols. Within Stage 2 of the proposal, the project team will design and develop the monitoring system requirements and protocols for DER assets. Microgrid operations, namely those that coordinate with building management systems, breakers/switches, and protection devices will be designed. Transition capability will be evaluated as part of the Stage 2 design analysis. As some individual Campus buildings or loads might require seamless transition capability or where it is prudent uninterruptible power supply (UPS) systems will be employed.
- Coordinate with and support the objectives of the New York State Reforming the Energy Vision (REV) work to provide a platform for the delivery of innovative services to the end use customers.
  - The New York State Department of Public Service REV proceeding seeks to improve the resiliency, reliability, quality, efficiency, and performance of the grid while advancing the adoption of clean energy. The BNMC community microgrid proposal supports these objectives through its integrated grid concept that seeks to ensure resiliency during weather-related events – but also to leverage and expand market opportunities that enable Campus member institutions to both generate revenue and achieve energy cost savings. In the future, through its use of a local controller or NOC (Network Operations Center), the BNMC Community Microgrid will serve to optimize and aggregate Campus-based DER assets by connecting energy supply and demand while providing visibility into each customer-level DER to the benefit of the future DSP (Distributed System Platform). Through this process, customers can become more engaged, supporting the effective management of their total energy bill. The project showcases fuel and resource diversity, protecting New York’s natural resources. All of these efforts align well with New York State’s goals of reducing GHG emissions from 1990 levels, decreasing overall energy consumption in buildings from 2012 levels and a saturation of 50% renewable energy resources.
- Take account of a comprehensive cost/benefit analysis that includes, but is not limited to, the community, utility and developer’s perspective
  - The cost-benefit analysis will look at the microgrid concept holistically,

including the value of uninterrupted electric service to its end-use customers, energy and demand cost savings, fuel savings, sales to the grid, energy efficiency, power quality, black-start support, etc.

Benefits to National Grid will be also evaluated, in terms of peak load management, demand response, increased generation efficiency, improved reliability benefits (e.g. decreasing SAIDI, SAIFI), emissions reductions, improved distribution system visibility, etc. This will be captured as part of the societal benefits

- Leverage private capital to the maximum extent possible as measured by total private investment in the project and the ratio of public to private dollars invested in the project.
  - Public-Private ownership, special purpose vehicle/entity, utility ownership will be evaluated. Cost recovery business models will also be evaluated as part of the CBA analysis.
  - With more than two million additional square feet under construction scheduled to come on-line in 2017, the proposed BNMC community microgrid will have leveraged a total of $1.4 billion in private/public investment since 2006.
- Involve clean power supply sources that minimize environmental impacts, including local renewable resources, as measured by total percentage of community load covered by carbon-free energy generation.
  - The combination of solar PV (based on preliminary rooftop space analysis, up to 4.3 MW_{DC} may be installed), energy storage (electrical, thermal, fuel cell), natural gas generation, and combined-heat-and-power will help to substantially reduce environmental impacts.
  - It also demonstrates tangible community benefits, including but not limited to, (e.g. jobs created, number of customers served, number of buildings affected, scale of energy efficiency retrofits, etc.).
  - The project will develop methods for monetizing various DER portfolios and penetrations. Using financial data provided by National Grid, as well as an estimate of the annual kWh generated by each type of DER, the project team will convert capital costs to an annual revenue requirement economic equivalent amount, which can be used to estimate the value or cost per kWh of annual DER generation.

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

Through the BNMC community microgrid's controller, DERMS communications, the Campus will be able to optimize market opportunities through load/generation monitoring, DER aggregation, dispatch optimization, and communications with grid operator(s).

2 DEVELOP PRELIMINARY TECHNICAL DESIGN COSTS AND CONFIGURATION

Task 2.1 - Proposed Microgrid Infrastructure and Operations

Question 1

Provide a simplified equipment layout diagram and a simplified one-line diagram of the proposed microgrid, include location of the distributed energy resources (DER) and utility interconnection points. Identify new and existing infrastructure that will a part of the microgrid.

The Buffalo Niagara Medical Campus (BNMC) is made up of several, large member institutions (each with several buildings) as well as individual corporations that occupy single-buildings.

The BNMC Microgrid Layer 2 Concept (herein referred to as "the microgrid") encompasses a subset of campus buildings that make up the bulk of the thermal and electric loads on campus. Table 2 below outlines the buildings within the microgrid, the affiliated member institution, and the electrical and thermal interconnections.

Table 2-1 Building Considered in Layer 2 BNMC Microgrids

#	Building	Institution	Electrical Interconnection	Thermal Interconnection
1	Buffalo General Hospital	KH	4.16 kV KH Substation	KH Steam + Chilled Water Loops
2	Gates Vascular Institute	KH	4.16 kV KH Substation	KH Steam + Chilled Water Loops
3	High Pointe on Michigan	KH	4.16 kV KH Substation	KH Steam + Chilled Water Loops
4	Clinical & Translational Research Center	UB	4.16 kV KH Substation	KH Steam + Chilled Water Loops
5	HighPointe on Michigan	KH	4.16 kV KH Substation	KH Steam + Chilled Water Loops
6	John R. Oishei Children's Hospital	KH	4.16 kV KH Substation	RPCI Steam + Chilled Water Loops
7	Main Hospital	RPCI	4.16 kV RPCI Substation	RPCI Steam + Chilled Water Loops
8	Gratwick Basic Science Building	RPCI	4.16 kV RPCI Substation	RPCI Steam + Chilled Water Loops
9	Administrative Services Building	RPCI	4.16 kV RPCI Substation	RPCI Steam + Chilled Water Loops
10	Cell & Virus Building	RPCI	4.16 kV RPCI Substation	RPCI Steam + Chilled Water Loops
11	Grace Center Drug Center	RPCI	4.16 kV RPCI Substation	RPCI Steam + Chilled Water Loops
12	Clinical Science Center	RPCI	4.16 kV RPCI Substation	RPCI Steam + Chilled Water Loops
13	University of Buffalo School of Medicine	UB	23 kV Elm Street Substation	*Independent Boiler System*
14	Cleveland Biolabs	*Independent*	5 kV Seneca Substation	*Independent Boiler System*
15	Fruit Belt Residential Neighborhood	*Independent*	5 kV Seneca Substation	*Household Boilers*

Kaleida Health (KH) and Roswell Park (RPCI) are two major campus institutions each with their own "utilities plant" which houses all the major electrical and thermal equipment needed to serve its buildings. Both institutions are fed off of four 23 kV feeders (11E, 12E, 14E, 15E) originating from Elm Street Substation. The respective utility plants each houses four 23-to-4.16 kV transformers. Individual mesh networks are then formed at the 4.16 kV level, allowing electricity to flow freely between all switchgears, bus bars, loads, etc. within each institution. KH's 4.16 kV network serves all KH buildings plus the University at Buffalo (UB) Clinical & Translational Research Center. RPCI's 4.16 kV network serves all RPCI buildings except the Center for Genetic & Pharmacology and no external buildings.

There are individual steam plants and distribution systems at Roswell and Kaleida. These central steam systems supply most of the buildings owned on their respective campuses. Each campus also has some buildings that use hot water boilers or other gas-fired systems within each building. Both Roswell and Kaleida also have chilled water loops on their campuses supplying most of their buildings. For Roswell, chilled water for the north campus is supplied from chillers in the utilities plant with a total capacity of 6,400 tons, while chilled water for the south campus is supplied from chillers in the Cancer Cell Center with a total capacity of 3,500 tons. The chillers in the Kaleida utilities plant total 6,100 tons of capacity. A few other buildings on the campus have separate cooling from within the building, including many air-cooled chillers, packaged rooftop units, and water loop heat pumps. Figures 2.1, 2.2, and 2.3 provide names of the many buildings on the Campus as well as the Fruit Belt Residential Neighborhood. Color coding is used to denote building ownership.

The Roswell Park utilities plant contains three steam boilers that normally run on natural gas. Each boiler has a capacity of 70,000 lbs./hour, resulting in total plant capacity of 210,000 lb./h. Each boiler has its own stack economizer. There is also a full-condensing economizer to pre-heat feed water for the entire boiler system that is primarily used in the winter.

The Kaleida utilities plant contains three water-tube packaged steam boilers with a combined capacity of 150,000 lb./h. Two boilers installed in 1968 run on either natural gas or fuel oil, and a third smaller boiler installed in 1985 that can now only use natural gas. Only the third boiler has a feed water boiler economizer. Updated oxygen trim controls were added in 2001.

The proposed CHP system will offset some of the thermal needs on the campus that are currently being served by the boilers at each site. When the CHP system is installed, a steam connection between the campus will allow loads to offset on both campuses. Some or all of the existing boilers will remain on campus to serve the remainder of the load and to provide redundancy.

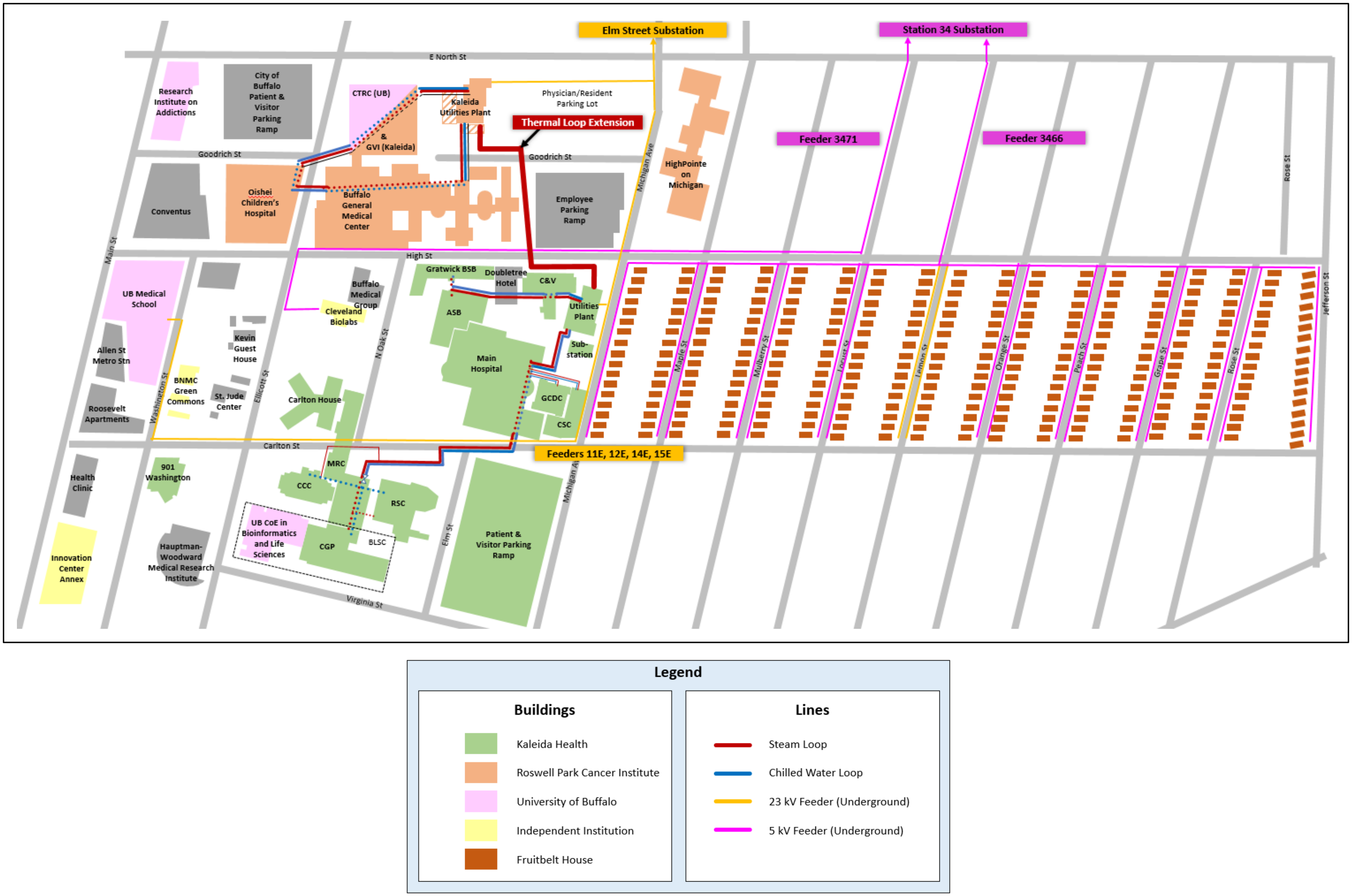

Figure 2.1. BNMC Main Campus + Fruit Belt Residential Neighborhood

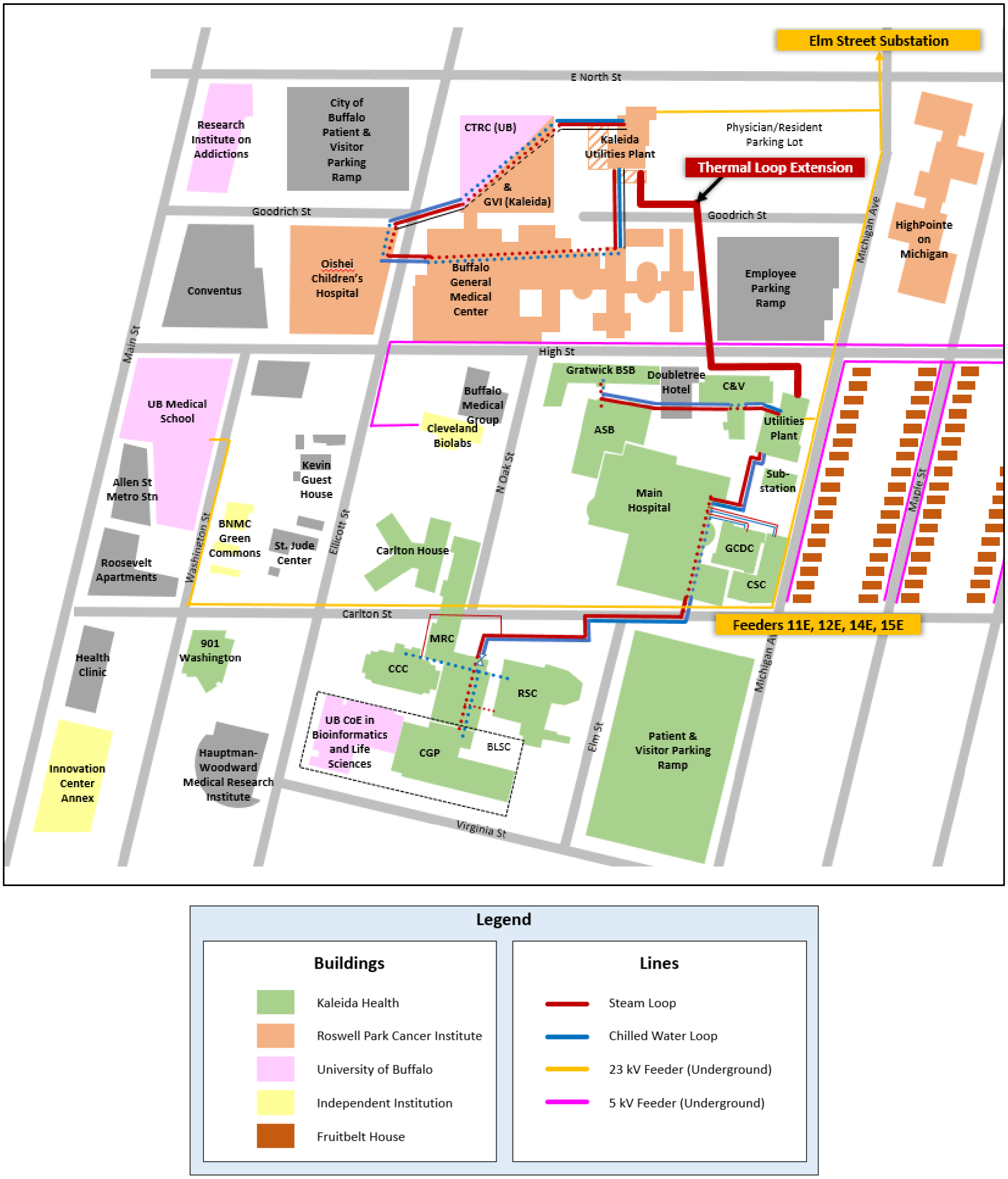

Figure 2.2. BNMC Main Campus

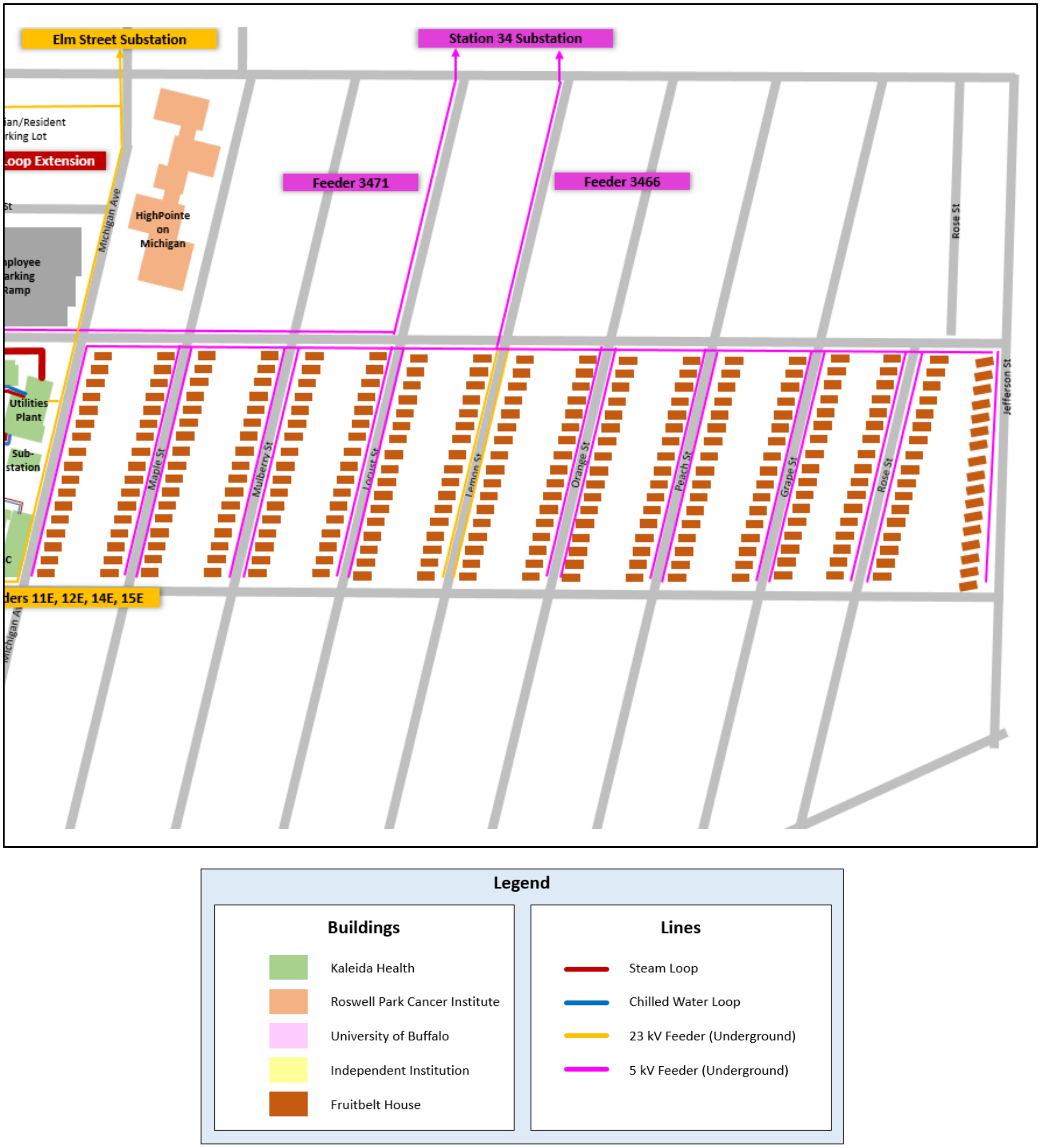

Figure 2.3. Fruit Belt Residential Neighborhood

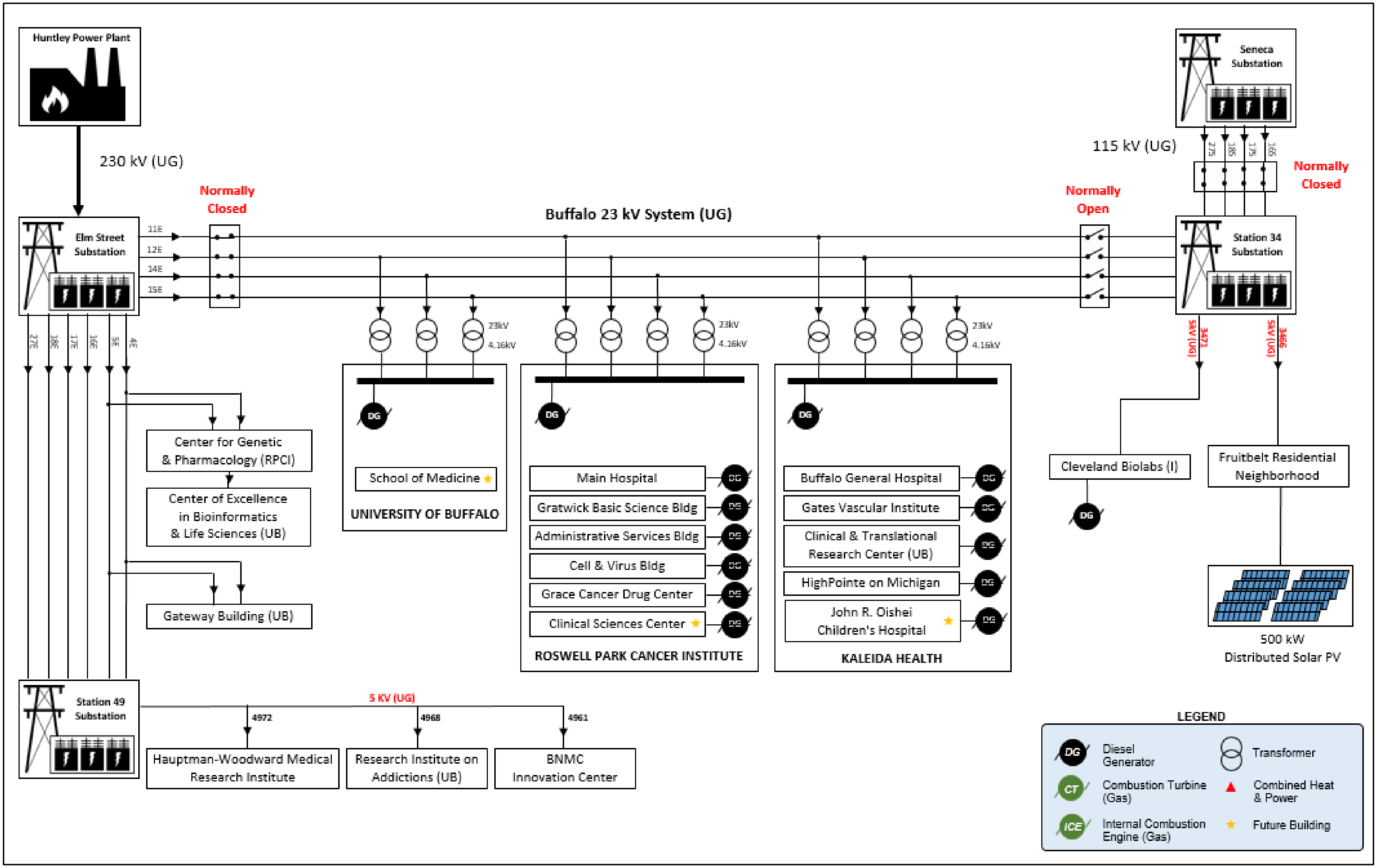

Figure 2.4. Simplified Electrical One-Line – Select 23kV and 5 kV Distribution Systems

Figure 2.4 presents a simplified electrical one-line diagram of the BNMC as it exists today. Huntley Generation Station, a coal-fired power plant, feeds Elm Street Substation via a 230 kV underground feeder. Elm Street Substations steps down the voltage from 230 kV to 23 kV and acts as the central distribution point for most of the BNMC campus buildings. Four 23 kV feeders (11E, 12E, 14E, 15E) serves the three largest loads on campus – Kaleida Health, Roswell Park Cancer Institute, and the University of Buffalo School of Medicine. Elm Street Substation also feeds Station 49, which in turn feeds the Hauptman-Woodward Medical Research Institute, the Research Institute on Addictions (UB), and the BNMC Innovation Center via 5 kV underground feeders. Finally, Elm Street Substation provides direct feeds to the Gateway Building (UB) and the Center for Genetic & Pharmacology (RPCI), with the Excellence in Bioinformatics & Life Sciences (UB) sub-metered.

At the east end of campus, Seneca Substation supplies an intermediate substation – Station 34 – via 115 kV underground feeders. Station 34 subsequently feeds two loads of interest, Cleveland Biolabs and the Fruit Belt Residential Neighborhood.

Note: Figure 2.4 represents all the loads that will be considered under the BNMC 3-layer microgrid concept. However, this NY Prize Stage 1 feasibility study considers only loads at the layer 2 level, which is shown in Figure 2.6.

The proposed microgrid includes 5 main load – KH, RPCI, U.B. School of Medicine, Cleveland Biolabs, and the Fruit Belt Neighborhood. The microgrid is separated into two groups – Group 1 and Group 2. Group 1 constitutes loads normally fed via feeders 11E, 12E, 14E, and 15E from Elm Street substation which are KH, RPCI, and U.B. School of Medicine. Group 2 constitute loads normally fed from Station 34 i.e. Cleveland Biolabs and the Fruit Belt neighborhood. Through Station 34, Group 1 and Group 2 loads can be interconnected by four existing circuit breakers for redundancy or other purposes (e.g. maintenance).

	Loads
Group 1	– Kaleida Health *(multiple buildings)* – Roswell Park Cancer Institute *(multiple buildings)* – U.B. School of Medicine
Group 2	– Cleveland Biolabs – Fruit Belt Neighborhood *(multiple houses)*

Figure 2.5 BNMC Group 1 and Group 2 Configuration

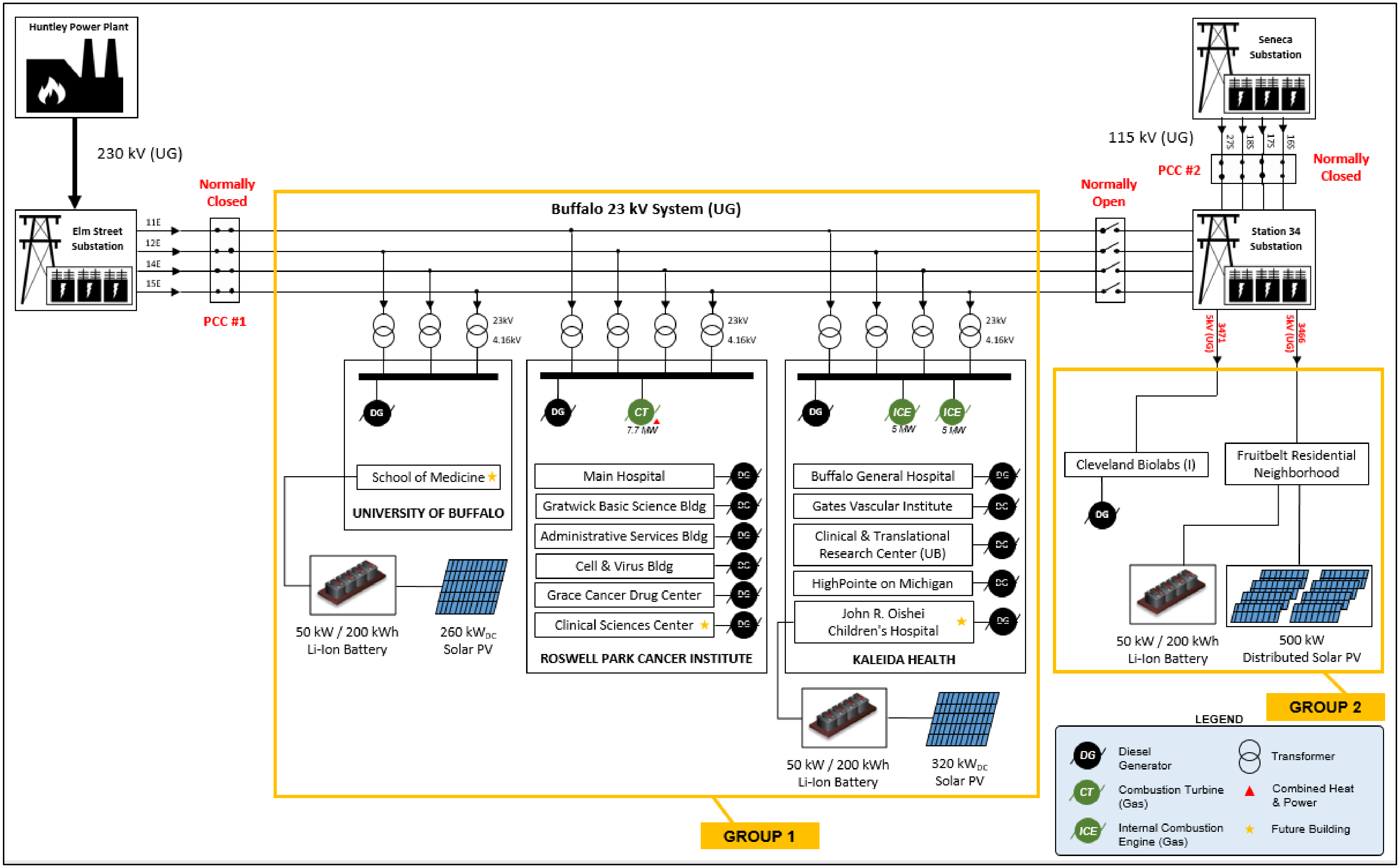

Figure 2.6. Simplified Electrical One-Line – BNMC Microgrid – Layer 2 Concept

Figure 2.6 shows the proposed DERs and their interconnection points. The microgrid will enable Group 1 loads to aggregately draw from on-site distributed energy resources (DER) during normal conditions as well as feed Group 2 loads during outage scenarios. As such, there are two utility points of interconnection as it relates to the microgrid – PCC #1 and PPC #2. PCC#1 are four breakers between Elm Street and Station 34 substations. PCC#2 are four breakers between Seneca and Station 34 substations.

Question 2

Provide a brief narrative describing how the proposed microgrid will operate under normal and emergency conditions. Include description of normal and emergency operations.

- *Normal, Grid-Connected Operations*

Station 34 breakers for the four feeders connected to the Elm Street substation are normally open.

Kaleida Health, Roswell Park Cancer Institute (excluding Genetic & Pharmacology), and UB Medical School buildings are fed from Elm Street substation. Cleveland Biolabs and the Fruit Belt residential neighborhood are normally fed from Seneca substation (via feeders 16S, 17S, 18S, and 27S) through Station 34. From Station 34, the Fruit Belt neighborhood and Cleveland Biolabs are fed via 5 kV feeders 3466 and 3471, respectively. In the proposed approach only a smaller subset of the Fruit Belt area is considered (one out of three 5-kV feeders). 500KW of PV will be installed along this feeder as part of National Grid's Fruit Belt Neighborhood Solar initiative which is a REV Demonstration Project.

The 7 MW CHP unit and the two 5 MW internal combustion engines will be interconnected with the electrical grid and operate in parallel during normal operations. The CHP unit will be connected on the customer side of the PCC at Roswell Park Cancer Institute, and the internal combustion engines will be connected on the customer side of the PCC at Kaleida Health. Steam will be supplied to the campus from the CHP unit at Roswell, and supplementary boilers on both campuses will operate if necessary to meet the load.

- *Islanded Operations*

Under an initial islanding scenario, building loads between Elm Street substation and station 34 (i.e. loads fed by Kaleida Health substation, Roswell Park substation, and UB Medical School substation) will be automatically transferred via breakers near Elm Street substation. Once separated from the grid, the microgrid controller will initiate blackstart sequence to systematically bring generators and loads online. All critical loads (i.e. loads that require uninterrupted power and/or high power quality) will be equipped with uninterruptable power supplies (UPS) in order to provide a "seamless transition."

Figures 2.7, 2.8, and 2.9 illustrates this 3-step grid-connected to islanding transition process.

As part of the design stage of NY Prize, the following scenarios will be evaluated in detail:

- Planned intentional islanding
  - Command planned islanding - Utility or operating entity requests the microgrid transition to an islanded mode at a specific time in the future with sufficient time for planning.
  - Scheduled planned islanding - A scheduled tariff transition or operating agreement dictates that the microgrid transition to an islanded mode at a specific time.

- Unplanned/unscheduled intentional islanding - Supported by the microgrid controller, this function could consist of two scenarios:
  - *Outage-Driven unplanned islanding* - A confirmed grid outage is detected by the recloser or switch at the Point of Common Coupling ("PCC") which would open and start the unplanned/unscheduled islanded mode transition.
  - *Command-Driven unplanned islanding* - A triggering event is detected by the monitoring platform that initiates the island recloser or switch at the PCC to open and start the unscheduled islanding transition. Alternatively, the utility operation center receives notification of the triggering event(s) and works with the Grid Operator to use DMS/SCADA in order to open the recloser.

The boiler plants will receive power during islanded operation and will produce steam as long as natural gas is available. Some boilers on the Kaleida campus can use #2 fuel oil and could remain operational in the event of a natural gas outage.

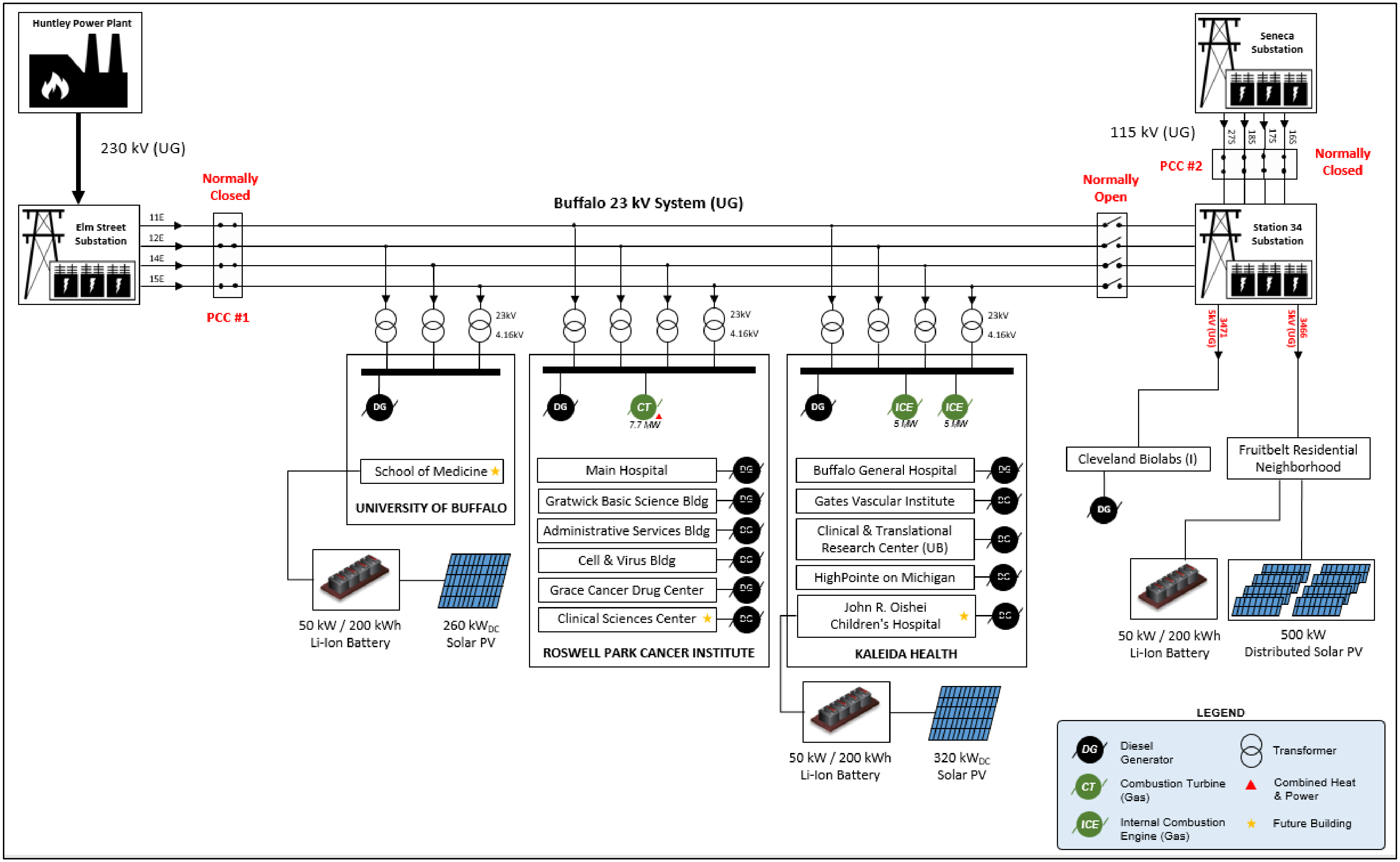

Figure 2.7. Simplified Electrical One-Line – BNMC Microgrid, Grid-Connected State (Layer 2)

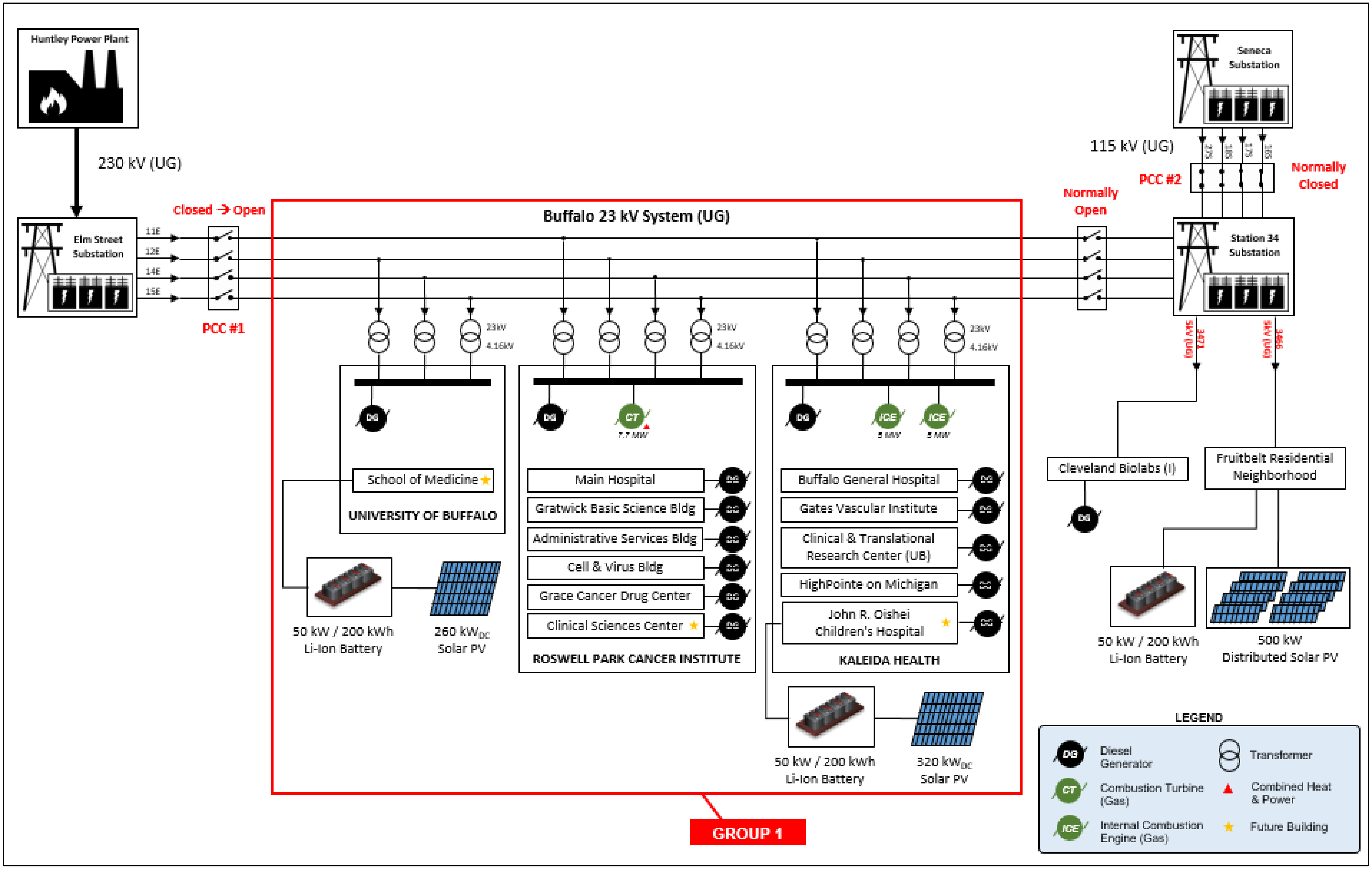

Figure 2.8. Simplified Electrical One-Line – BNMC Microgrid, Initial Islanding State (Layer 2, Group 1)

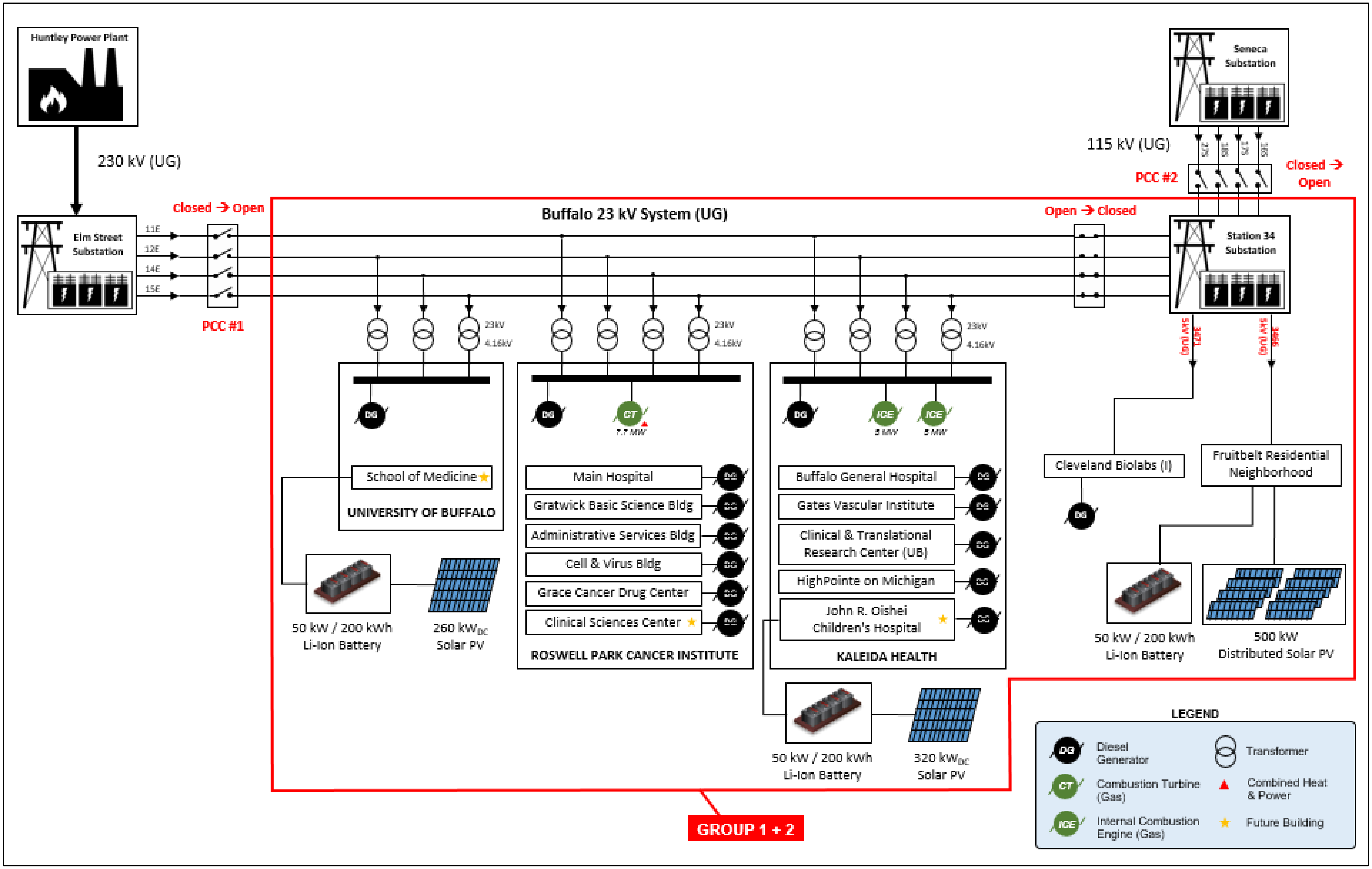

Figure 2.9. Simplified Electrical One-Line – BNMC Microgrid, Final Islanding State (Layer 2, Group 1+2)

Thermal loop extension

While the thermal loads at both Roswell and Kaleida are fairly large with significant base loads in the summer, there would be additional benefit to further combine the thermal loads onto a common distribution system. This, combined with a central CHP plant, could efficiently and cost effectively serve these loads. In order to consolidate loads—i.e., combine thermal distribution systems—the thermal medium (e.g., steam or hot water) and operating conditions (e.g., pressure, cleanliness, and water treatment) must be compatible. In addition, the length and cost of all connections must be understood, and the connection piping must have sufficient capacity to transport heat to all the locations where it is needed. Many factors will influence a decision on such consolidations, including both technical and business issues. On a technical basis both distribution systems operate at similar steam pressures and both have similar standards for steam treatment and cleanliness.

Connect Roswell and Kaleida steam line systems, connecting existing systems in the Gratwick BSB and the Buffalo General Medical Center.

Upgrade Category	Description
Horizontal Extension of Steam Piping	Horizontal Distance of Added Steam Piping ~800 ft.
Vertical Extension of Steam Piping	No change
Buildings/Roads	Would need to cross High St (moderate traffic count: 3,821 vehicles/day).
State of Boiler System	The boilers at Roswell are newer than those in Kaleida and can meet greater demand (installed in1996, total capacity 210,000 lbs./h) and attain higher efficiencies.
Other Issues	With the addition of thermal capacity to the system via the CHP unit, some existing steam boiler systems in Kaleida and Roswell will continue to be used regularly, some will remain in place for redundancy, and some may be removed.

Task 2.2 – Load Characterization

Question 3

Fully describe the electrical and thermal loads served by the microgrid when operating in islanded and parallel modes: Peak KW, Average KW, annual/monthly/weekly KWh, annual/monthly/weekly BTU(consumed and recovered) and identify the location of the electrical loads on the simplified equipment layout and one-line diagrams.

Question 4

Provide hourly load profile of the loads included in the microgrid and identify the source of the data. If hourly loads are not available, best alternative information shall be provided.

1. **Kaleida Health**

   The Kaleida Health Utilities-Building/Substation serves the following buildings via four, networked 4.16 kV circuits:
   - Buffalo General Hospital
   - Gates Vascular Institute
   - University of Buffalo Clinical and Translational Research Center
   - HighPointe on Michigan
   - Children's Hospital

Table 2-2. Monthly & Annual Usage Statistics at Kaleida Health

	Electric			Cooling			Heating		
	Average (kW)	Peak (kW)	Total (kWh)	Average (kW)	Peak (kW)	Total (kWh)	Average (kW)	Peak (kW)	Total (kWh)
Jan	6,145	7,769	4,571,854	451	1,215	335,455	12,950	18,171	9,634,575
Feb	6,169	7,501	4,145,495	400	1,143	268,654	13,460	17,960	9,045,448
Mar	6,128	8,021	4,552,801	734	2,607	545,649	11,098	16,477	8,245,763
Apr	5,869	7,602	4,225,534	1,278	3,320	919,888	8,235	12,782	5,929,239
May	5,761	7,924	4,285,927	2,379	4,470	1,770,120	6,229	10,196	4,634,351
Jun	6,046	8,186	4,353,372	3,126	4,643	2,251,075	5,630	7,846	4,053,471
Jul	5,911	8,345	4,397,550	3,022	4,291	2,248,411	5,484	6,774	4,079,876
Aug	5,703	8,024	4,242,813	3,099	4,545	2,305,702	5,440	6,951	4,047,426
Sep	5,663	7,802	4,077,178	2,508	4,636	1,805,862	6,118	9,120	4,405,046
Oct	5,917	7,719	4,402,284	1,592	3,945	1,184,809	7,397	11,587	5,503,549
Nov	6,006	7,411	4,330,463	952	2,631	686,323	10,061	14,193	7,253,622
Dec	6,039	7,403	4,492,774	506	1,584	376,226	11,169	16,625	8,309,376
Annual	**5,946**	**8,345**	**52,078,045**	**1,671**	**4,643**	**14,698,174**	**8,606**	**18,171**	**75,141,742**

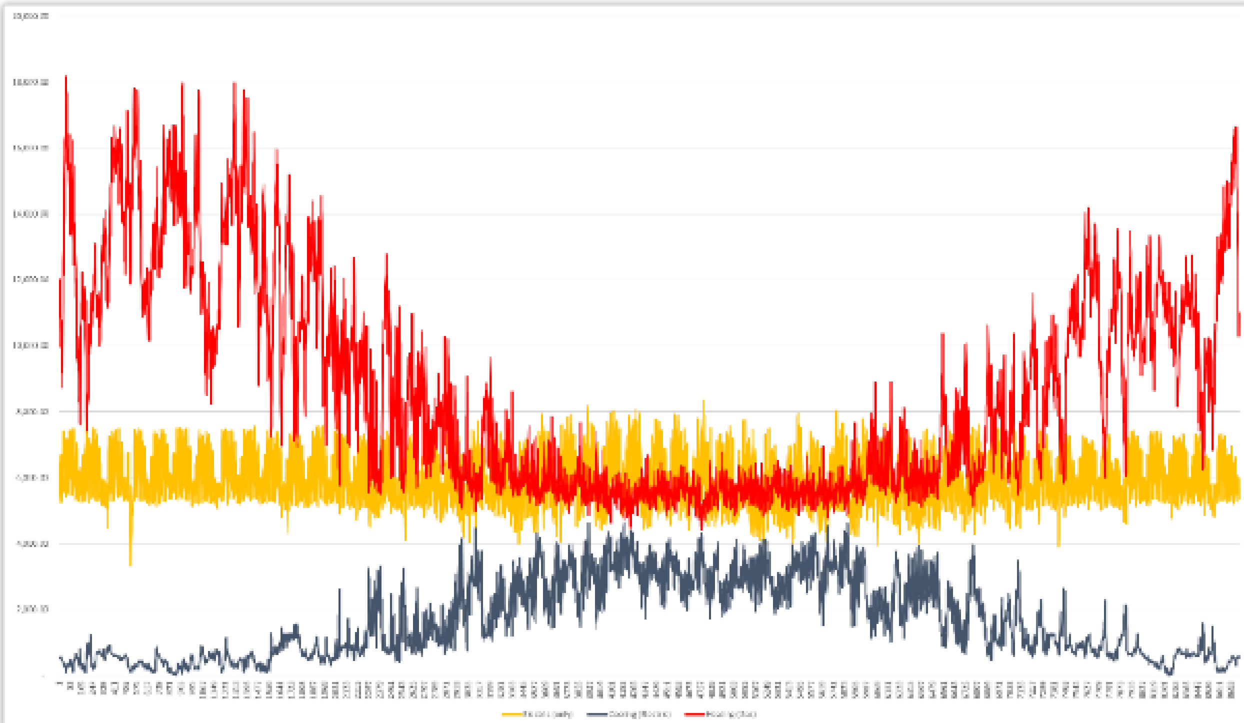

Figure 2.10. Annual Usage Profile

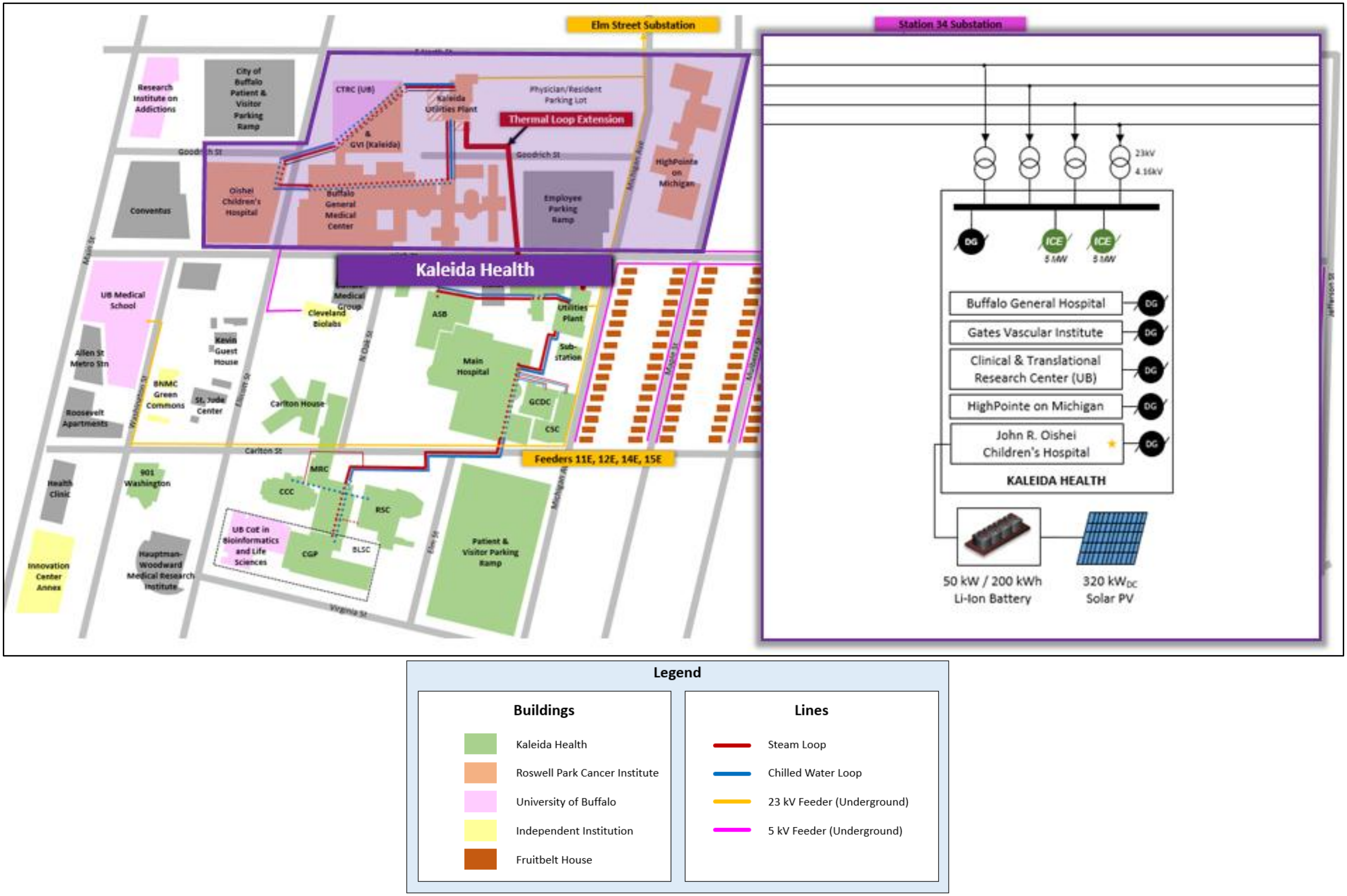

Figure 2.11. Kaleida Health Geographical Map

2. Roswell Park Cancer Institute

The Roswell Park Utilities-Building/Substation serves the following buildings via four, networked 4.16 kV circuits:

- Main Hospital building
- Grace Cancer Drug Center
- Cell & Virus Building
- Gratwick Basic Science Building
- Administrative Services Building
- Clinical Sciences Center

Table 2-3. Roswell Park Building Locations

	Electric			Cooling			Heating		
	Average (kW)	Peak (kW)	Total (kWh)	Average (kW)	Peak (kW)	Total (kWh)	Average (kW)	Peak (kW)	Total (kWh)
Jan	5,917	7,113	4,402,398	34	454	25,031	20,557	29,944	15,294,315
Feb	5,920	7,079	3,978,471	25	240	17,084	21,573	29,358	14,497,242
Mar	5,722	6,962	4,251,433	85	1,630	63,170	17,419	27,366	12,942,203
Apr	5,480	6,745	3,945,463	393	2,236	283,039	12,193	19,856	8,778,934
May	5,407	6,943	4,022,832	1,185	2,926	881,850	8,647	15,149	6,433,012
Jun	5,597	7,666	4,029,979	1,892	3,378	1,362,551	7,415	11,220	5,339,019
Jul	5,627	7,633	4,186,597	1,886	3,199	1,403,456	7,376	9,506	5,487,416
Aug	5,673	7,621	4,220,882	1,898	3,284	1,412,214	7,251	9,787	5,394,827
Sep	5,517	7,189	3,972,317	1,315	3,050	946,990	8,402	13,669	6,049,205
Oct	5,574	6,899	4,147,175	600	2,620	446,507	10,617	16,878	7,899,407
Nov	5,609	6,711	4,044,200	165	1,637	119,135	15,534	23,209	11,200,333
Dec	5,630	6,812	4,188,871	56	905	41,862	17,174	27,707	12,777,702
Annual	**5,640**	**7,666**	**49,390,619**	**795**	**3,378**	**7,002,889**	**12,847**	**29,944**	**112,093,614**

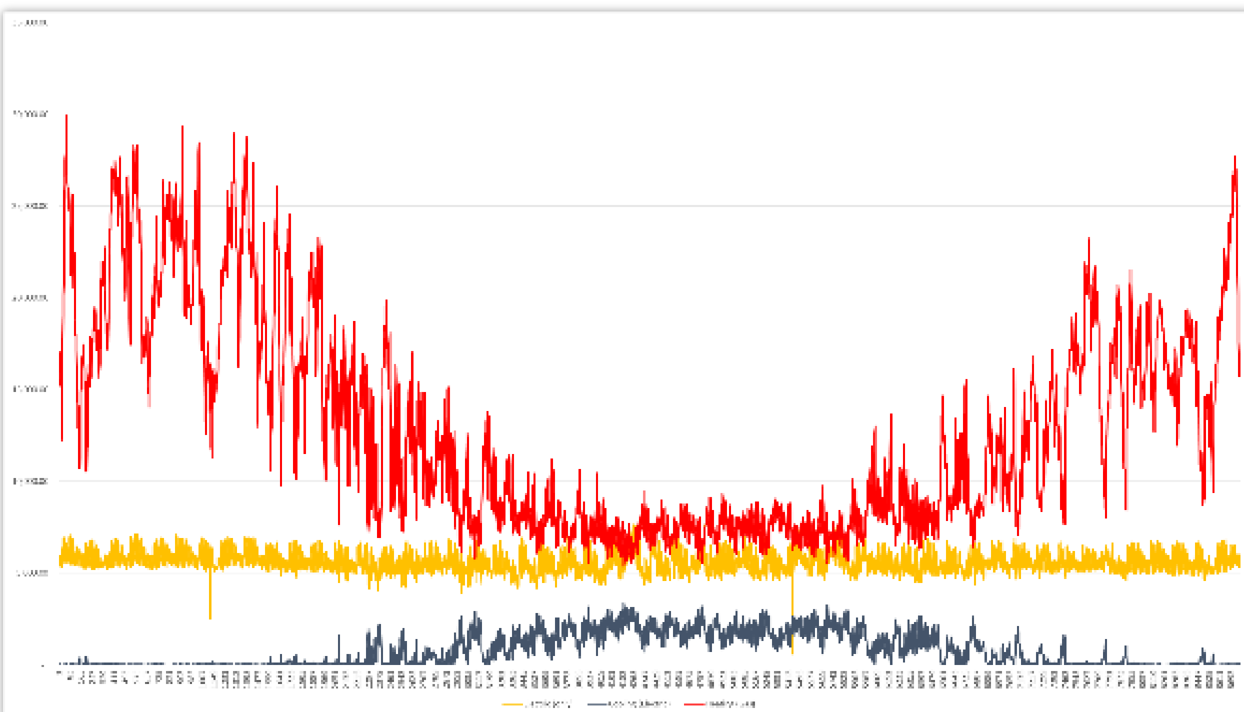

Figure 2.12. Monthly & Annual Usage Statistics at Roswell Park

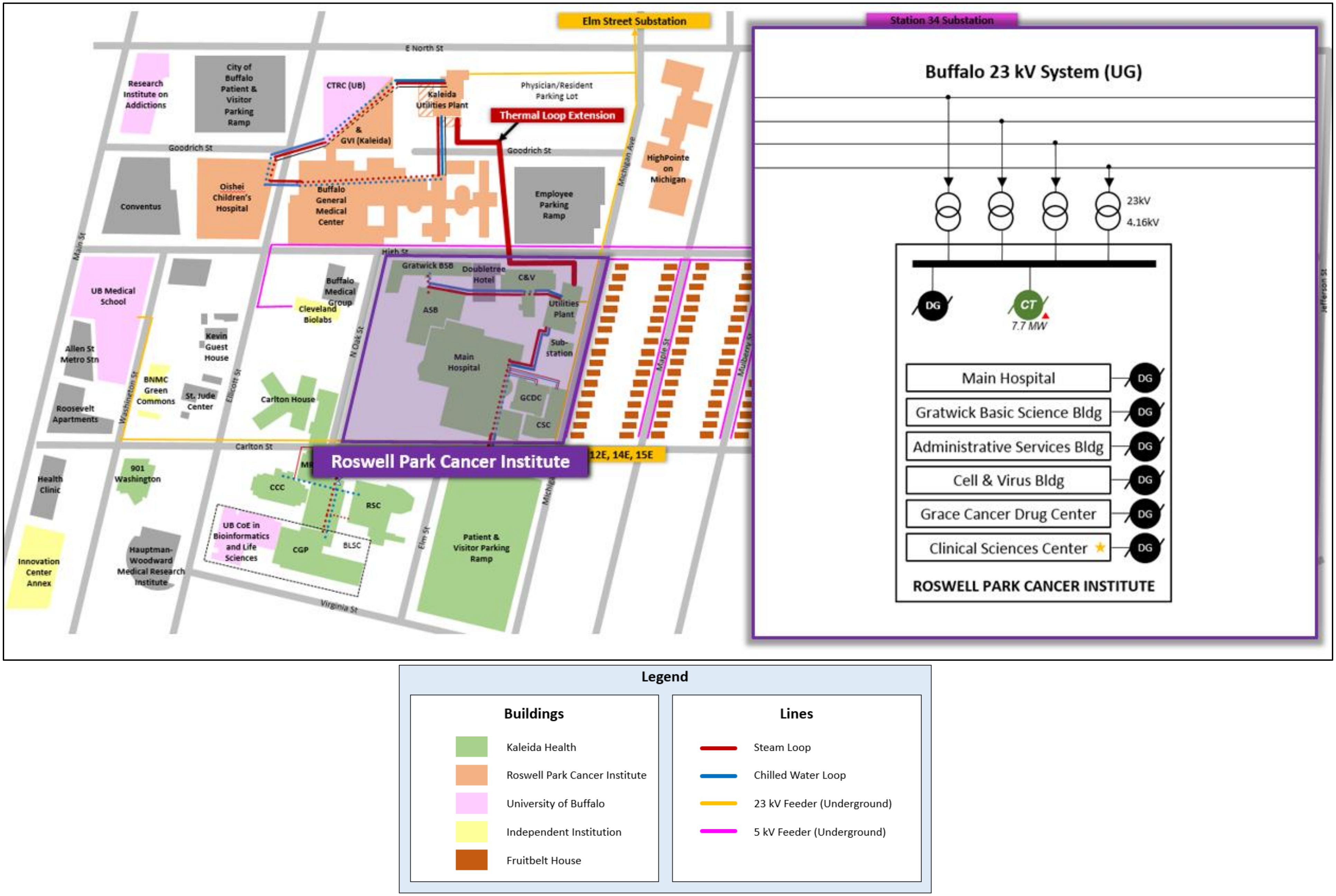

Figure 2.13. Roswell Park Geographical Map

3. University at Buffalo School of Medicine

Note: Loads are simulated based on DOE commercial reference buildings, which are normalized for outdoor temperature, solar irradiance, and square footage.

Table 2-4. Monthly & Annual Usage Statistics at UB School of Medicine

	Electric			Cooling			Heating		
	Average (kW)	Peak (kW)	Total (kWh)	Average (kW)	Peak (kW)	Total (kWh)	Average (kW)	Peak (kW)	Total (kWh)
Jan	1,778	2,654	1,322,865	557	1,526	414,588	1,821	3,485	1,354,475
Feb	1,762	2,610	1,184,092	501	1,436	336,711	1,860	3,744	1,250,089
Mar	1,721	2,624	1,278,460	875	1,587	649,869	1,519	3,418	1,128,657
Apr	1,661	2,571	1,195,978	1,128	1,583	812,099	1,339	3,039	964,370
May	1,625	2,597	1,209,341	1,413	1,590	1,051,135	1,217	2,549	905,487
Jun	1,613	2,511	1,161,609	1,384	1,595	996,677	1,081	2,092	778,327
Jul	1,602	2,544	1,192,026	1,321	1,594	983,004	962	1,974	715,433
Aug	1,633	2,468	1,214,819	1,375	1,593	1,022,704	1,041	2,003	774,143
Sep	1,565	2,418	1,127,107	1,419	1,597	1,021,887	1,166	2,494	839,200
Oct	1,633	2,538	1,215,070	1,233	1,588	917,534	1,333	2,834	991,439
Nov	1,674	2,538	1,206,803	1,040	1,587	749,846	1,437	3,017	1,036,321
Dec	1,700	2,618	1,264,947	596	1,056	443,192	1,783	3,936	1,326,621
Annual	**1,664**	**2,654**	**14,573,116**	**1,070**	**1,597**	**9,399,248**	**1,380**	**3,936**	**12,064,562**

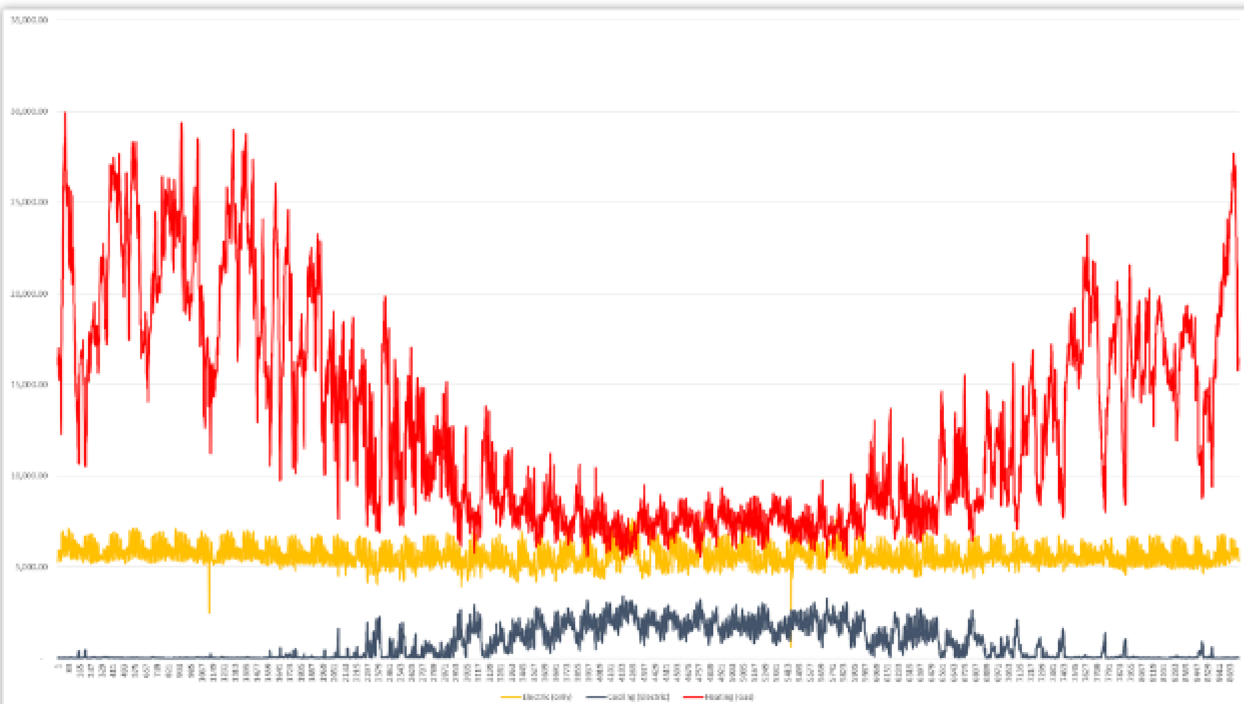

Figure 2.14. UB School of Medicine Location

4. Cleveland Biolabs

Table 2-5. Monthly & Annual Usage Statistics at Cleveland Biolabs

	Electric			Cooling			Heating		
	Average (kW)	Peak (kW)	Total (kWh)	Average (kW)	Peak (kW)	Total (kWh)	Average (kW)	Peak (kW)	Total (kWh)
Jan	67.89	127.43	50,507.89	-	-	-	64.36	446.28	47,880.70
Feb	66.39	127.52	44,611.98	0.00	0.51	0.76	63.07	451.75	42,383.81
Mar	68.05	136.98	50,563.55	2.35	59.07	1,745.66	28.02	391.96	20,815.78
Apr	67.27	132.74	48,437.78	2.48	46.02	1,783.34	10.71	185.16	7,712.97
May	70.41	137.87	52,385.40	13.01	58.43	9,677.40	3.75	54.45	2,786.41
Jun	72.81	139.54	52,424.89	25.89	59.45	18,643.13	1.42	17.83	1,025.46
Jul	72.18	140.08	53,705.60	30.87	61.87	22,964.63	0.84	4.39	627.64
Aug	75.30	139.73	56,025.49	29.59	59.94	22,017.64	1.23	14.92	916.93
Sep	69.12	139.07	49,762.97	20.12	59.64	14,487.94	2.80	48.11	2,014.58
Oct	68.81	137.31	51,195.01	5.37	50.10	3,991.61	10.23	153.49	7,613.39
Nov	66.97	137.53	48,285.77	1.41	46.06	1,013.18	18.55	172.85	13,375.66
Dec	63.84	127.50	47,498.15	0.00	0.00	0.00	54.57	452.06	40,597.43
Annual	**69**	**140**	**605,404**	**11**	**62**	**96,325**	**22**	**452**	**187,751**

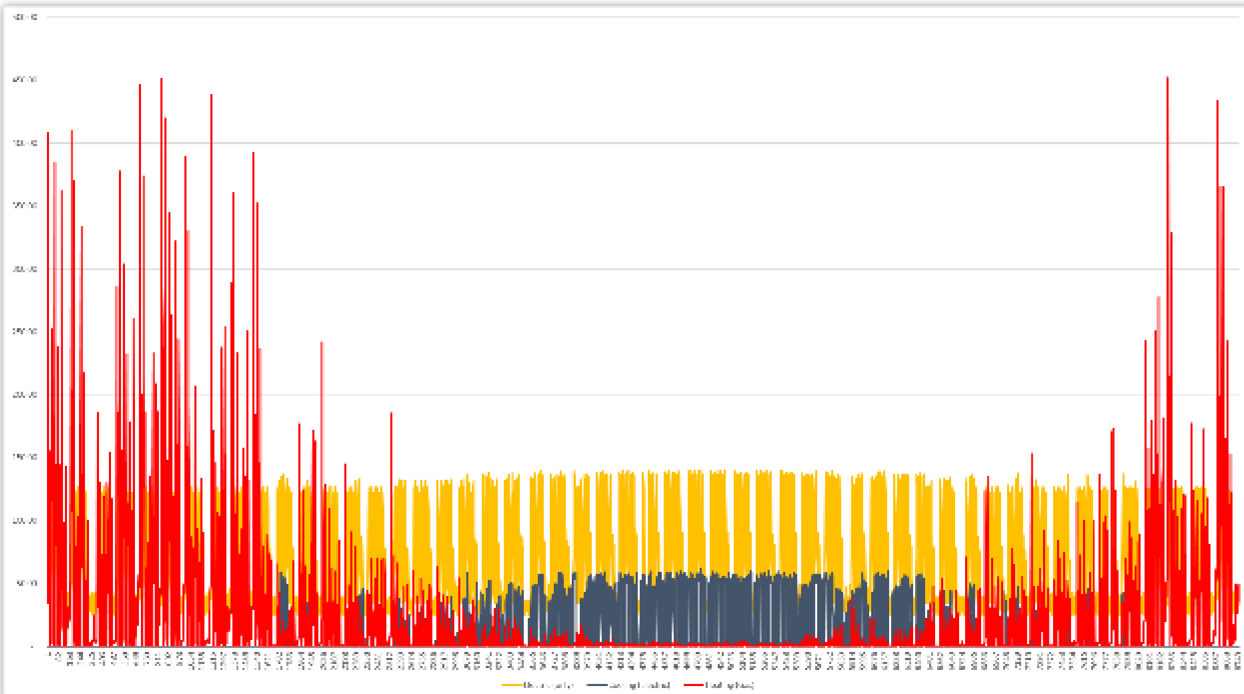

Figure 2.15. Cleveland Biolabs Location

5. Fruit Belt Residential Neighborhood

The entire Fruit Belt neighborhood is served by three 5 kV feeders. The total number of residences served within the Fruit Belt area is approximately 830:

- Feeder 3463 – 249 customers
- Feeder 3466 – 291 customers
- Feeder 3467 – 290 customers

As part of the Fruit Belt NY REV Demonstration Project, 500 kW of distributed PV (paired with micro-inverter with advanced functionality) will be installed on feeder 3466. For the purpose of this study only Feeder 3466 is considered.

Table 2-6. Daily Usage Profile (by Season) of Fruit Belt Residential Neighborhood

	Electric		
	Average (kW)	Peak (kW)	Total (kWh)
Jan	776	1,402	577,244
Feb	761	1,370	511,458
Mar	661	1,226	490,776
Apr	605	1,088	435,722
May	539	1,000	401,366
Jun	486	932	349,989
Jul	525	1,194	390,825
Aug	505	1,222	375,627
Sep	526	1,179	378,857
Oct	603	1,190	448,366
Nov	662	1,334	477,319
Dec	762	1,441	566,773
Annual	**618**	**1,441**	**5,404,322**

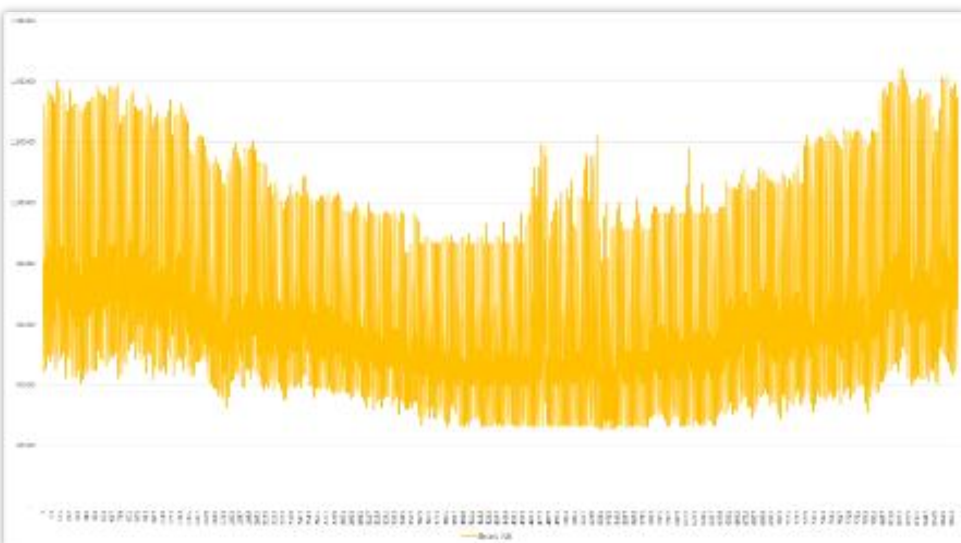

Figure 2.16. Annual Usage Profile (8760 hours) of Fruit Belt Residential Neighborhood

Data sources:

National Grid –

- Kaleida Health substation – 4 x 4.16 kV meters
- Roswell Park Cancer Institute substation – 4 x 4.16 kV meters
- Station 34 substation:
  - Feeder 3466
  - Feeder 3471
- Customer Bills – Cleveland Biolabs (kWh consumption, kW peak demand)

DOE Commercial Reference Buildings

- Large Office
- Hospital

Question 5

Provide a written description of the sizing of the loads to be served by the microgrid including a description of any redundancy opportunities (ex: n-1) to account for equipment downtime.

As can be seen in Figure 2.17 significant electrical redundancy opportunities exist in the campus' relative loading, with dispatchable capacity greatly exceeding the aggregate non-coincident peak loads of 30 MW. Most buildings are also equipped with building energy management systems (BEMS) wherein load shedding schemes within a microgrid can be implemented. The microgrid local controller that will be deployed at the BNMC campus will enable the coordination of load shedding across multiple building loads.

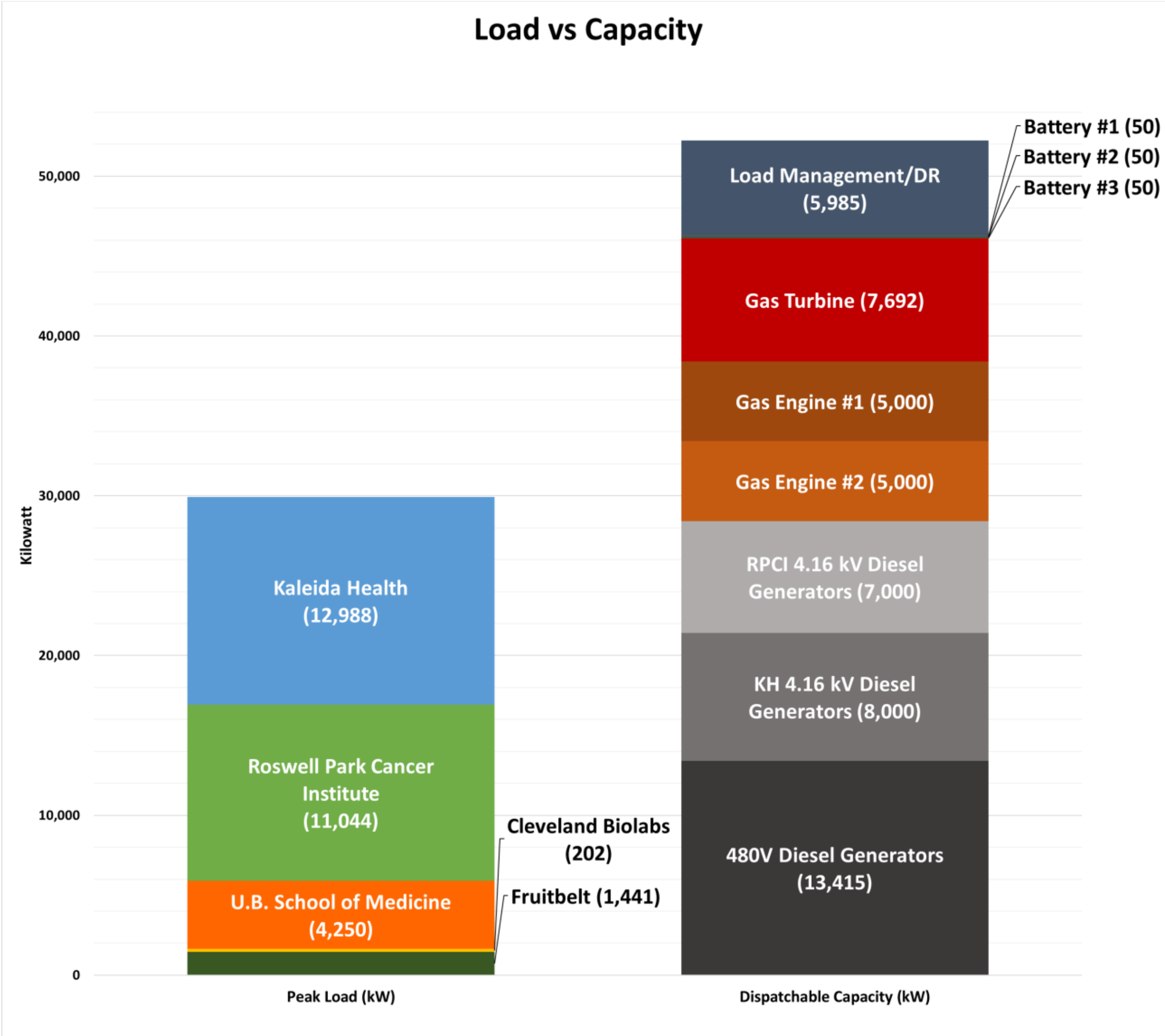

Figure 2.17. Campus Peak Load vs. Dispatchable Capacity

The project team estimates that approximately 20% of the BNMC campus load can be categorized as “non-critical.” A significant amount of the following buildings’ loads estimated be non-critical:

- High Pointe on Michigan – mostly outpatient procedures
- Grace Cancer Drug Center
- Cell & Virus Building
- Gratwick Basic Science Building
- Administrative Services Building

A more detailed load characterization will need to be conducted as part of NY Stage 2 (Detailed Design) to more accurately determine what exact end-use loads can be shed with minimal detriment facility operations as well as how fast the load can be shed.

Through existing and further build out of building energy management systems at each building these non-critical loads can provide for fast load shedding. Fast load shedding is used to account for any unexpected changes in load or generation and acts as operating reserve for the microgrid in islanded mode. Provisions to implements load shedding can be programmed within the microgrid controller.

The li-ion battery at Fruit Belt and at BNMC campus will provide for fast response to minimize demand response requirements due to PV variability. Furthermore, accurate load forecasting and PV forecasting should further minimize the frequency of demand response requirements.

Demand response can be provided by temporally adjusting or shifting building temperature set points (e.g. allow building temperature to rise to offset electric cooling load), shutting off non-critical lighting within certain areas, water pumps

These types of non-critical load shedding should be of minimal and/or temporary impact to building inhabitants and/or operations. Critical loads such as building ventilation, life-support devices, operating rooms, lab refrigeration, data servers, and security systems will not be part of the load shedding demand response. Detailed demand response capacity and capabilities at each building will be further explored in Stage 2.

Task 2.3 Distributed Energy Resources Characterization

Question 6

Provide the following information regarding Distributed Energy Resources (DER) and thermal generation resources that are a part of the microgrid: Type (DG, CHP, PV, boiler, solar water heater, etc.), rating (KW/BTU), and, Fuel (gas, oil etc.).

Tables 2-7 through 2-10 provide information about the existing electrical and thermal assets at each institution/load.

Table 2-7. Existing Kaleida Heath Thermal and Electrical Assets

Diesel Generators

Manufacturer	Model #	Date Installed	Hz	3PH KW	Voltage	AMPS	KVA	RPM	Fuel
Cummins/Onan	DQKAB-A030Y047	-	60	2000	4160	347	2500	1800	Diesel
Cummins/Onan	-	-	60	2000	4160	347	2500	1800	Diesel
Cummins/Onan	-	-	60	2000	4160	347	2500	1800	Diesel
Cummins/Onan	-	-	60	2000	4160	347	2500	1800	Diesel
Onan	750.0DFZ-4XR/25994D	-	60	750	480	1130	937.5	1800	Diesel
Onan	-	-	60	750	480	1130	937.5	1800	Diesel
Masaro	765DR-LR60	-	60	765	480	(1150)	(956)	1800	Diesel
Caterpillar	-	-	60	550	480	-	-	1800	Diesel
Caterpillar	-	-	60	550	480	-	-	1800	Diesel

Boilers

Manufacturer	Model #	Date Installed	Hot Water/ Steam	Steam (lbs/hr)	Hot Water (MMBtu/hr)	Steam Pressure (PSI)	Fuel
B&W	FM-1746	1968	Steam	60,000	n/a	250	Dual
B&W	FM-1747	1968	Steam	60,000	n/a	250	Dual
B&W	FM-3010	1985	Steam	30,000	n/a	250	NG
Harsco	C-2000	2008	Hot Water	n/a	1.92	n/a	NG
Harsco	C-2001	2011	Hot Water	n/a	1.92	n/a	NG
Harsco	C-2002	2011	Hot Water	n/a	1.92	n/a	NG

Chillers

Manufacturer	Model #	Date Installed	Tons	kW	Type
Trane	Centravac	1994	1400	1400	Constant speed
Trane	Centravac	2006	800	800	Constant speed
Trane	Centravac	1985	1500	1500	Constant speed
Trane	Centravac	2011	2400	2400	Variable speed; economizer
McQuay	-	-	250	250	variable-speed centrifugal compressors
McQuay	-	-	250	250	variable-speed centrifugal compressors

Table 2-8. Existing Roswell Park Cancer Institute Thermal and Electrical Assets

Diesel Generators

Manufacturer	Model #	Date Installed	Hz	3PH KW	Voltage	AMPS	KVA	RPM	Fuel
Caterpillar	SR4B-GD	2014	60	2000	4160	347	2500	1800	Diesel
Cummins/Onan	DFMB-5627802	2011	60	1500	480	2255.3	1875	1800	Diesel
Cummins/Onan	1250DFLC-4721	2005	60	1250	480	1879.5	1562.5	1800	Diesel
Cummins/Onan	1250DFLC	1997	60	1250	4160	1879	1563	1800	Diesel
Cummins/Onan	1250DFLC	1996	60	1250	4160	217	1562	1800	Diesel
Cummins/Onan	1250DFLC	1996	60	1250	4160	216	1562	1800	Diesel
Cummins/Onan	1250DFLC	1997	60	1250	4160	216	1562	1800	Diesel
Cummins/Onan	1100DFLB	1996	60	1100	480	1654	1375	1800	Diesel
Cummins/Onan	1000DFJD	1997	60	1000	480	1504	1250	1800	Diesel
Caterpillar	CA_00C27LDWB03279	2013	60	750	480	1127	937	1800	Diesel
Caterpillar	903A	2005	60	600	480	902	750	1800	Diesel
Generac	3723270100	2004	60	350	480	526.2	438	1800	Diesel
Cummins/Onan	175DGFB	1994	60	175	208	609	219	1800	Diesel

Boilers

Manufacturer	Model #	Date Installed	Hot Water/ Steam	Steam (lbs/hr)	Hot Water (MMBtu/hr)	Steam Pressure (PSI)	Fuel
Volcano Internat'l	Duofin D3-70R	1996	Steam	70,000	n/a	250	NG or #2 oil
Volcano Internat'l	Duofin D3-70R	1996	Steam	70,000	n/a	250	NG or #2 oil
Volcano Internat'l	Duofin D3-70R	1996	Steam	70,000	n/a	250	NG or #2 oil
Patterson-Kelley	Modu-Fire FD W2000	2003	Hot Water	n/a	2.0	n/a	NG
Patterson-Kelley	Modu-Fire FD W2000	2003	Hot Water	n/a	2.0	n/a	NG

Chillers

Manufacturer	Model #	Date Installed	Tons	kW	Type
Trane	CenTraVac centrifugal water-cooled chiller	-	800	800	-
Trane	CenTraVac centrifugal water-cooled chiller	-	800	800	-
Trane	CenTraVac centrifugal water-cooled chiller	-	1200	1200	-
Trane	CenTraVac centrifugal water-cooled chiller	-	1200	1200	-
Trane	CenTraVac centrifugal water-cooled chiller	-	1200	1200	-
Trane	CenTraVac centrifugal water-cooled chiller	-	1200	1200	-
Trane	Duplex – dual-compressor CenTraVac chiller	-	2500	2500	-
Trane	Centrifugal Chiller	-	500	500	-
Trane	Centrifugal Chiller	-	500	500	-
Trane	RTAC 1404	-	140	140	-

Table 2-9 Existing UB School of Medicine Assets

Diesel Generators

Manufacturer	Model #	Date Installed	Hz	3PH KW	Voltage	AMPS	KVA	RPM	Fuel
-	-	-	60	2500	480	-	3125	-	Diesel

Boilers

(No Information)

Chillers

Manufacturer	Model #	Date Installed	Tons	kW	Type
-	water-cooled centrifugal chillers	New	1,750	1750	Variable Speed Drive
-	water-cooled centrifugal chillers	New	1,750	1750	Variable Speed Drive
-	heat shift screw chiller (heat recovery)	New	125	125	-

Table 2-10. Existing Cleveland Biolabs Assets

Diesel Generators

Manufacturer	Model #	Date Installed	Hz	3PH KW	Voltage	AMPS	KVA	RPM	Fuel
Cummins/Onan	M07F21017409	-	60	475	480	714	594	1800	Diesel
Cummins/Onan	DFEG-5867861	-	60	350	480	526.2	437.5	1800	Diesel

Boilers

Manufacturer	Model #	Installed	Hot Water/Steam	lbs/hr	MMBtu/hr	Pressure PSI	Fuel
Raypak	H7-0503	-	Hot Water	n/a	0.5	n/a	NG
Raypak	H7-0503	-	Hot Water	n/a	0.5	n/a	NG
Raypak	H7-0503	-	Hot Water	n/a	1.5	n/a	NG
Raypak	H7-0503	-	Hot Water	n/a	1.5	n/a	NG

Chillers

Manufacturer	Model #	Date Installed	Tons	kW	Type
Trane	TRAA 110A	-	110	110	-
Trane	SLHF F60E	-	60	60	-

Table 2-11. Existing On-Site Diesel Fuel Storage

Institution	Storage Type	Storage Capacity (gallons)	Subtotals (gallons)
Kaleida Health	Distributed	19,550*	
	Central	8,500	
	Central	8,500	
	Central	8,500	
	Central	400	**45,450**
Roswell Park	Distributed	16,643*	
	Central	26,000	**42,643**
UB Med School	Central	14,409^	**14,409**
Cleveland Biolabs	Central	4,217^	**4,217**

* Estimated figures – For each existing/planned generator, fuel tanks allow for 5 hour operation at full-load.

^ Estimated figures – For each existing/planned generator, fuel tanks allow for 3 days of operation at full-load.

Solar Resource

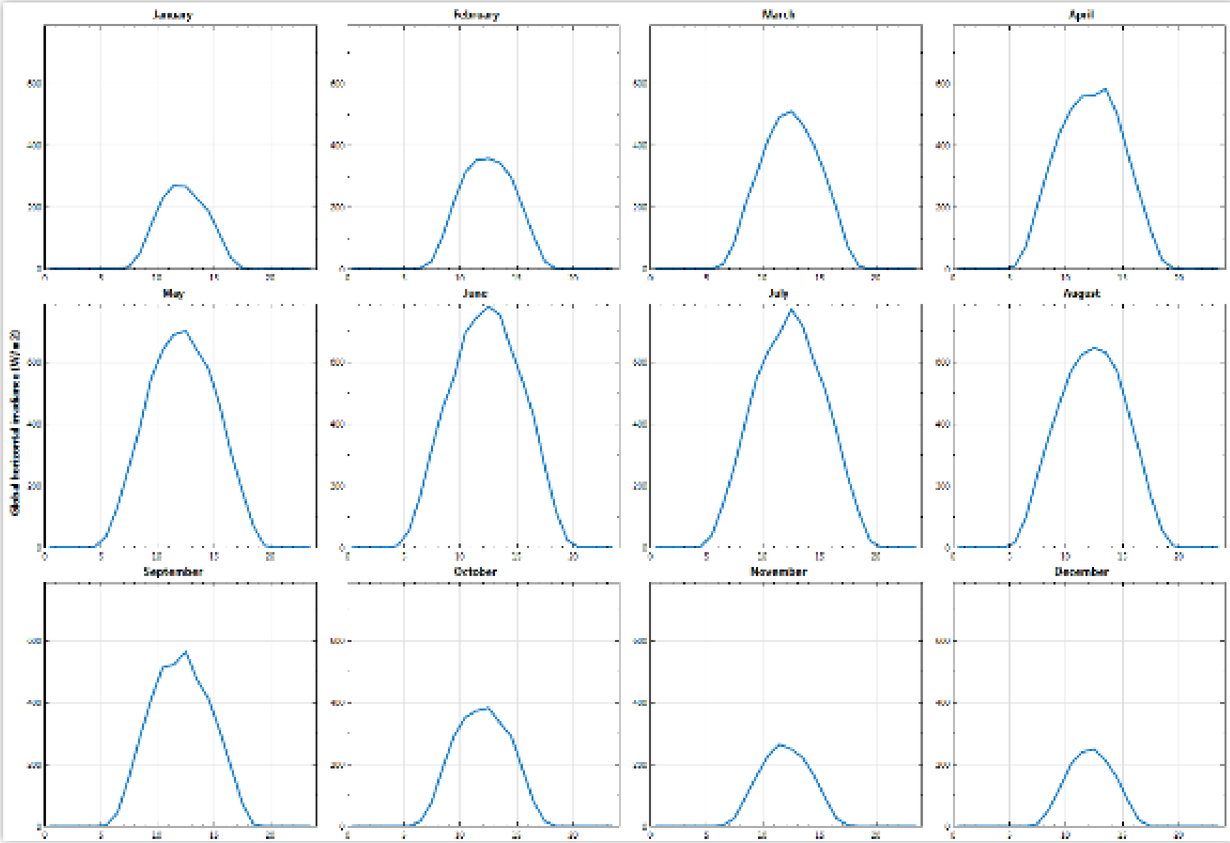

Figure 2.18. Average Monthly Global Horizontal Irradiance for Buffalo, NY[4]

[4] Typical Meteorological Year (NREL TMY3)

Question 7

If new DER or other thermal generation resources are a part of the microgrid, provide a written description of the approximate location and space available. Identify the DERs on the simplified equipment layout and one-line diagrams. Differentiate between new and existing resources.

Figure 2.19. GIS for PV Space Availability5

Table 2-12. Estimated Space Availability and Maximum Capacity for PV

Building	Institution	Area (m^2)	Capacity (kW_{DC})
Employee Parking Garage	BNMC	6,624.00	483.00
Parking Lot near Kaleida Health Utilities Building	Kaleida	9,335.00	680.68
Oishei Children's Hospital	Kaleida	1,096.75	319.89
Buffalo General Medical Center	Kaleida	2,532.85	184.69
HighPointe on Michigan	Kaleida	670.00	48.85
Gates Vascular Institute, UB Clinical & Translational Research Center	Kaleida	503.00	36.68
Roswell Park Cancer Institute	RPCI	4,245.70	309.58
Roswell Park - Clinical Sciences Center	RPCI	-	-
UB Jacobs School of Medicine & Biomedical Science	UB	890.00	259.58
HWI Parking Lot	UB	3,975.00	289.84
Fruit Belt Residential Neighborhood	N/A	N/A	500.00
	Total	**29,872.30**	**3,112.79**

[5] GIS Software: Google Earth Pro

Table 2-13 lists all distributed energy resources that were modeled and evaluated by the DER-CAM and HOMER models.

Table 2-13. Distributed Energy Resources Evaluated

Technology	Type	Fuel	Size/Capacity	CHP
Fossil Fuel Generator	Microturbine	Natural Gas	65, 250, 1000	No
Fossil Fuel Generator	Internal Combustion Engine	Natural Gas	500, 1000, 3500, 5000	No
Fossil Fuel Generator	Internal Combustion Engine	Natural Gas	3500, 5000, 7692	No
Dual-Fuel Generator (Diesel Conversion)	Internal Combustion Engine	Diesel/ Natural Gas	500, 1250, 2000	Yes
Fuel Cell	Hydrogen, Reforming	Natural Gas	300, 1400, 2800	Yes
Heat Recovery Steam Generator	n/a	Heat	Scalable	n/a
PV	Mono-crystalline	Sun	0 - 3113 kW [6]	n/a
Battery	Li-Ion, Lead Acid, Flow	n/a	0 – 1000 kW / 0 – 4000 kWh	n/a
Flywheel	n/a	n/a	0 – 4000 kW / 0 – 1000 kWh	n/a
Supercapacitor	n/a	n/a	0 – 4000 kW / 0 – 1000 kWh	n/a
Inverter	Advanced function (smart)	n/a	Scalable	n/a
Absorption Chiller	Double Effect (2-Stage)	Steam, Gas	0 – 20000 tons	n/a
Ice Storage	n/a	Chilled Water	0 – 20000 tons	n/a

Table 2-14 lists the distributed energy resources that were ultimately chosen to be part of the proposed microgrid. Selection was based on a variety of factors – size & dispatch modeling (i.e. economic optimization), technology characteristics & use cases, electrical & thermal infrastructure interconnection, communications, maintenance, operations, past experience with technology, general engineering judgement, physical/space constraints, policy and regulations (e.g. NYISO market participation, emissions, commercial arrangement), etc. Table 2-14 show the representative capital costs for each of the DER assets chosen.

Table 2-14. Proposed BNMC Microgrid Distributed Energy Resources

Distributed Energy Resource	Nameplate Capacity	Energy Source	Location
Gas Combustion Turbine (Combined Heat & Power)	7,692 kW	Natural Gas	Roswell Park Cancer Institute
Internal Combustion Engine #1	5,000 kW	Natural Gas	Kaleida Health
Internal Combustion Engine #2	5,000 kW	Natural Gas	Kaleida Health
BNMC PV System #1	320 kW_{DC}	Solar	Kaleida Health – Children's Hospital
BNMC PV System #2	260 kW_{DC}	Solar	U.B. School of Medicine
Fruit Belt Distributed PV Systems	500 kW_{DC} – Total	Solar	Fruit Belt Neighborhood
Li-Ion Battery #1	50 kW / 200 kWh	Storage	Fruit Belt Neighborhood
Li-Ion Battery #2	50 kW / 200 kWh	Storage	Kaleida Health – Children's Hospital
Li-Ion Battery #3	50 kW / 200 kWh	Storage	UB School of Medicine

[6] Maximum based on rooftop space constraints outlined in Table 2-12

Table 2-15. Proposed BNMC Microgrid Distributed Energy Resources – Capital Costs

Qty	Component	Capital Cost ($)
1	7692 KW CT CHP	$16,132,192.00
2	5000 kW ICE	$13,326,000.00
1	PV system at KH (320 kW)	$473,600.00
1	PV system at UB (260 kW)	$384,800.00
1	PV system at FB (500 kW distributed)	*REV Demonstration Project*
3	50 kW/ 200 kWh Li-Ion battery	$480,000.00
	Total	**$30,796,592.00**

Question 8

Provide a written description of the adequacy of the DERs and thermal generation resources to continuously meet electrical and thermal demand in the microgrid.

Grid-Connected Operations

Table 2-16 outlines the annual electric load and generation breakdown for the base case (i.e. no microgrid) and the investment case (i.e. proposed microgrid) during grid-connected, "blue sky" operations. The creation of the microgrid would aggregate the electric loads at KH, RPCI, and UB Med School such that any electric import/export would occur behind one "master meter" (commercial and financial arrangements to be detailed in Task 3). Annual grid sales are quite low because the campus has a large amount of base load that cannot be met with on-site DERs instead (i.e. still significant amount of grid purchase).

Note: During grid-connected operations of the microgrid the four breakers between Elm Street substation and Station 34 are open, therefore no power flows from Group 1 DERs to Group 2 loads, vice versa.

Table 2-16. Grid-Connected, Annual Electric Load/Generation

	Base Case (kWh/yr.)	Invest Case (kWh/yr.)
Electric Load (Total)	**153,467,801.31**	**153,472,554.45**
- KH	66,862,520.52	147,360,456.67
- RPCI	56,442,694.02	
- UB Med School	24,050,488.99	
- Cleveland Biolabs	710,494.37	710,494.37
- Fruit Belt	5,401,603.41	5,401,603.41
Grid Purchase (Total)	**152,885,963.78**	**19,016,169.24**
- KH	66,862,521.21	13,485,909.99
- RPCI	56,442,694.95	
- UB Med School	24,050,488.37	
- Cleveland Biolabs	710,503.39	710,503.39
- Fruit Belt	4,819,755.86	4,819,755.86
Grid Sales (Total)	**0.00**	**11,526.83**
On-Site Generation (Total)	**581,848.62**	**134,588,644.69**
- 7692 KW CT CHP	n/a	63,919,399.03
- 2 x 5000 kW ICE	n/a	69,412,451.31
- 260 kW PV System (UB Med School)	n/a	302,561.88
- 320 kW PV System (KH)	n/a	372,383.85
- PV system @ Fruit Belt	581,848.62	581,848.62
- 50 kW/ 200 kWh Li-Ion battery	n/a	0
- 50 kW/ 200 kWh Li-Ion battery	n/a	0
- 50 kW/ 200 kWh Li-Ion battery	n/a	0

Similarly, Table 2-17 outlines the annual heating load and generation breakdown for the base case (i.e. no microgrid) and the investment case (i.e. proposed microgrid) during grid-connected, “blue sky” operations. The extension of the steam loop from KH to RPCI would aggregate the heating loads at the two institutions thereby allowing more efficient operation of the central boilers at both each institution’s utilities plant as well as allow the steam generated by the Combined Heat and Power unit (7692 kW combustion turbine) to be shared. On an annual basis the CHP unit provides for approximately 47% of the heating load, offsetting boiler operation. The remaining heating systems at the UB School of Medicine, Cleveland Biolabs, and within individual Fruit Belt residential houses remain unchanged.

Table 2-17. Grid-Connected, Annual Heating Load/Generation

	Base Case (kWh/yr.)	Invest Case (kWh/yr.)
Heating Load (Total)	**163,505,221.66**	**163,505,238.69**
- KH	61,590,184.75	153,455,959.98
- RPCI	91,865,758.19	
- UB Med	9,893,645.23	9,893,645.23
- Cleveland Biolabs	155,633.49	155,633.49
- Fruit Belt	n/a	n/a
On-Site Generation (Total)	**n/a**	**76,689,678.65**
- 7692 KW CT CHP	n/a	76,689,678.65
Boiler (Total)	**163,505,358.31**	**86,815,695.76**
- KH	61,590,185.89	76,766,282.79
- RPCI	91,865,759.45	
- UB Med	9,893,645.84	9,893,645.84
- Cleveland Biolabs	155,767.13	155,767.13
- Fruit Belt	n/a	n/a

Table 2-18 outlines the annual fuel consumption breakdown for the base case (i.e. no microgrid) and the investment case (i.e. proposed microgrid) during grid-connected as outlined above.

Table 2-18. Grid-Connected, Annual Fuel Consumption

	Base Case	Invest Case
Natural Gas (Total)	**661,328.75**	**1,536,811.92**
- Boiler	661,328.75	351,142.71
- 7692 KW CT CHP	n/a	1,185,669.21
- 2 x 5000 kW ICE	n/a	

For microgrid grid-connected operation, Figures below show weekly dispatch profiles for each season.

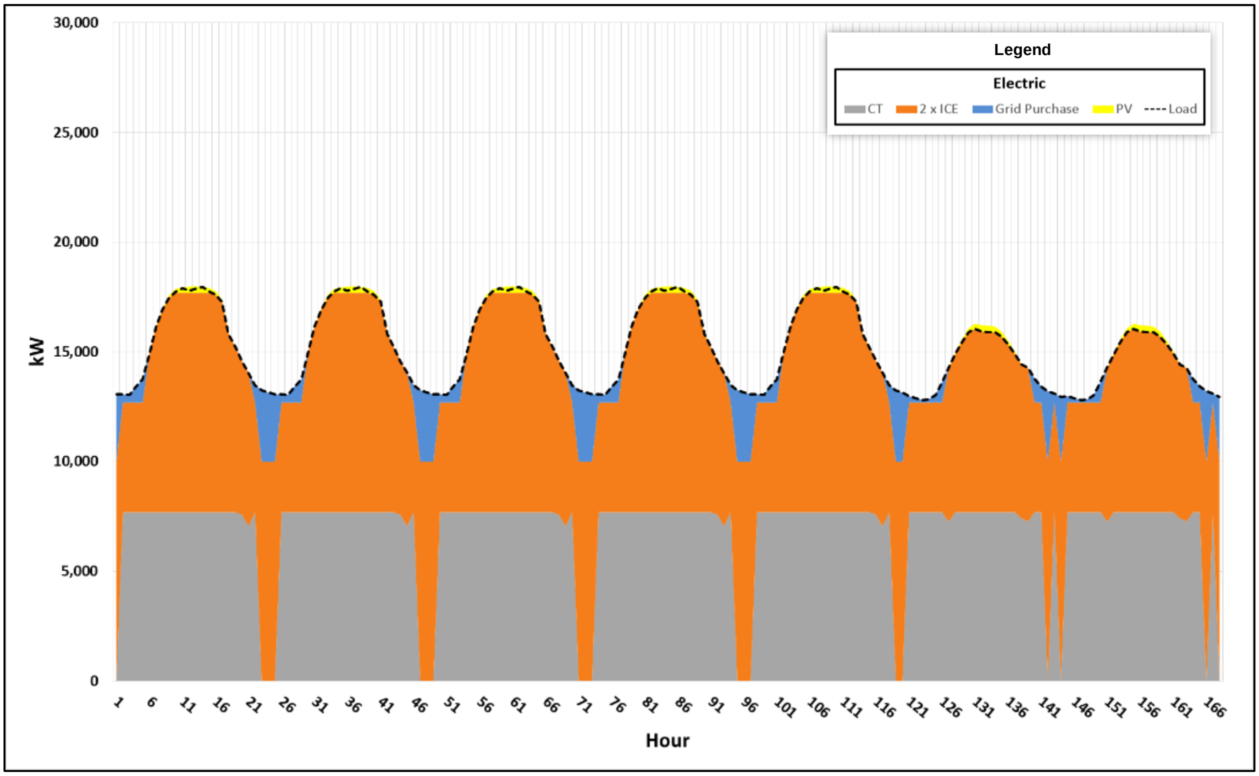

Figure 2.20. Grid-Connected, Electric Dispatch (Spring)

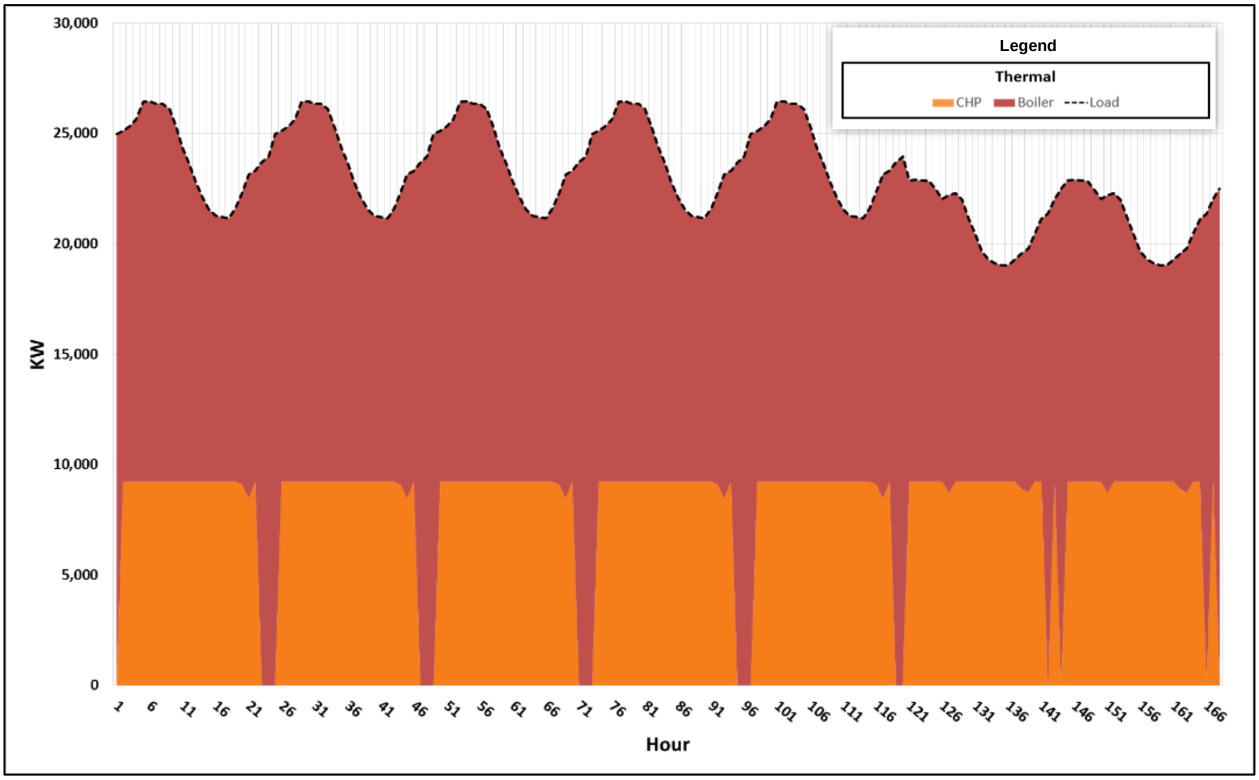

Figure 2.21. Grid-Connected, Thermal Dispatch (Spring)

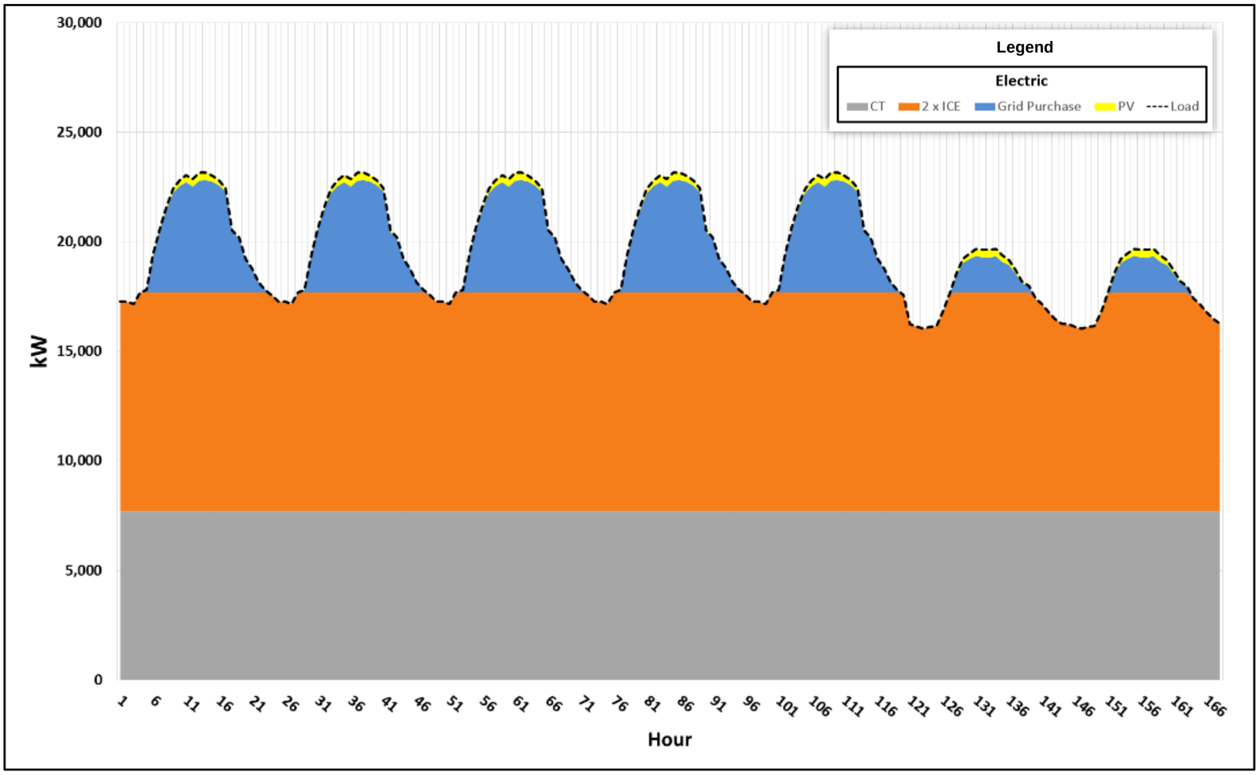

Figure 2.22. Grid-Connected, Electric Dispatch (Summer)

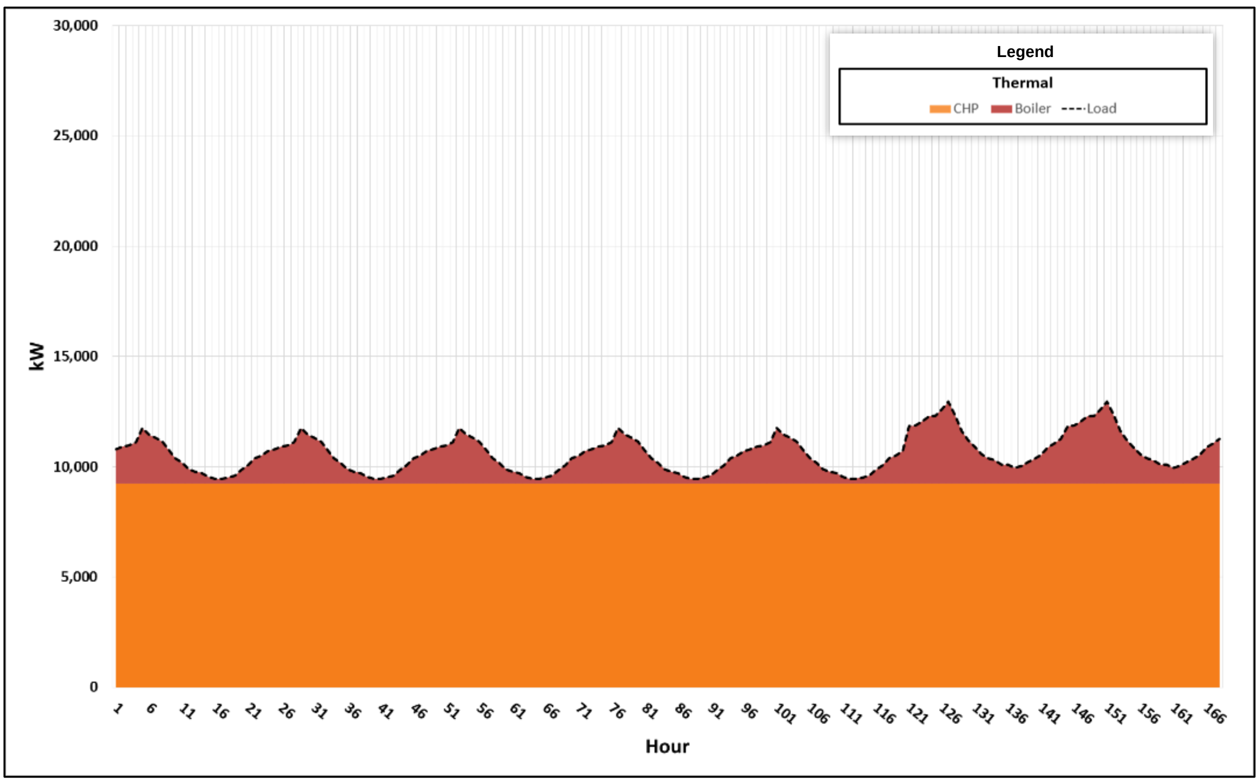

Figure 2.23. Grid-Connected, Thermal Dispatch (Summer)

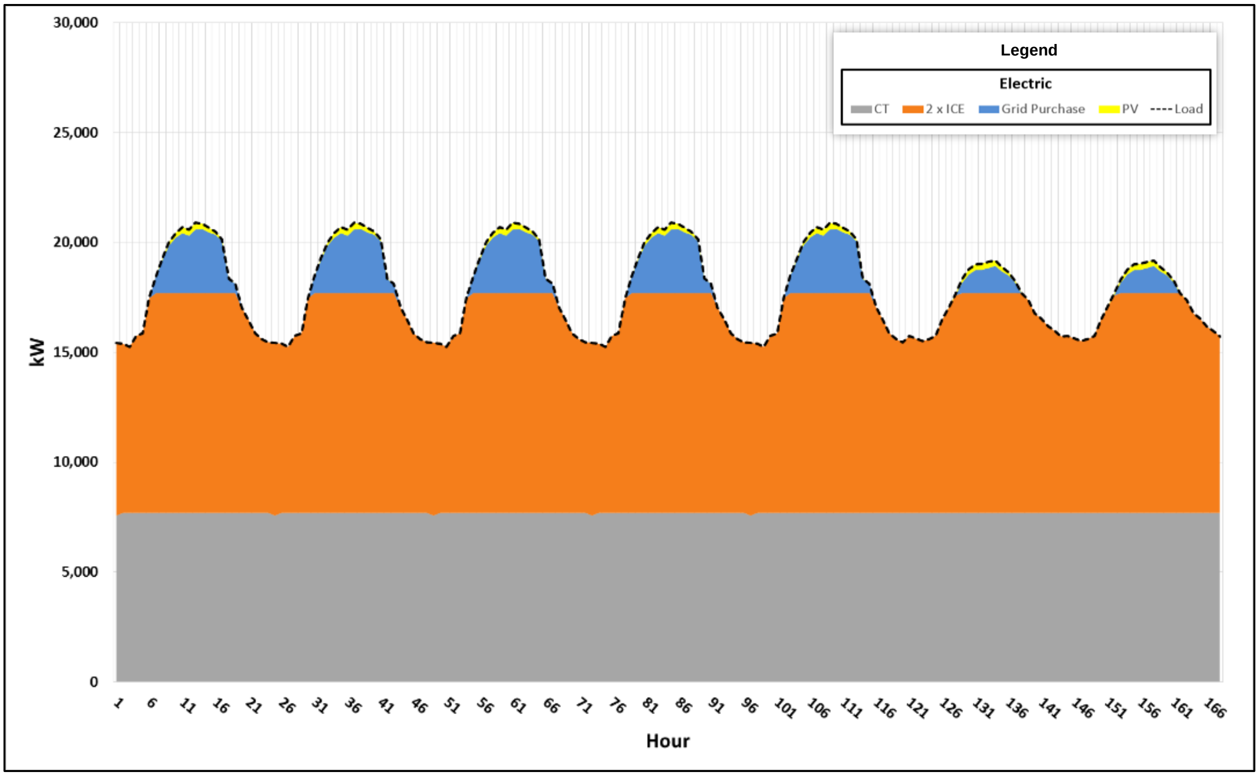

Figure 2.24. Grid-Connected, Electric Dispatch (Fall)

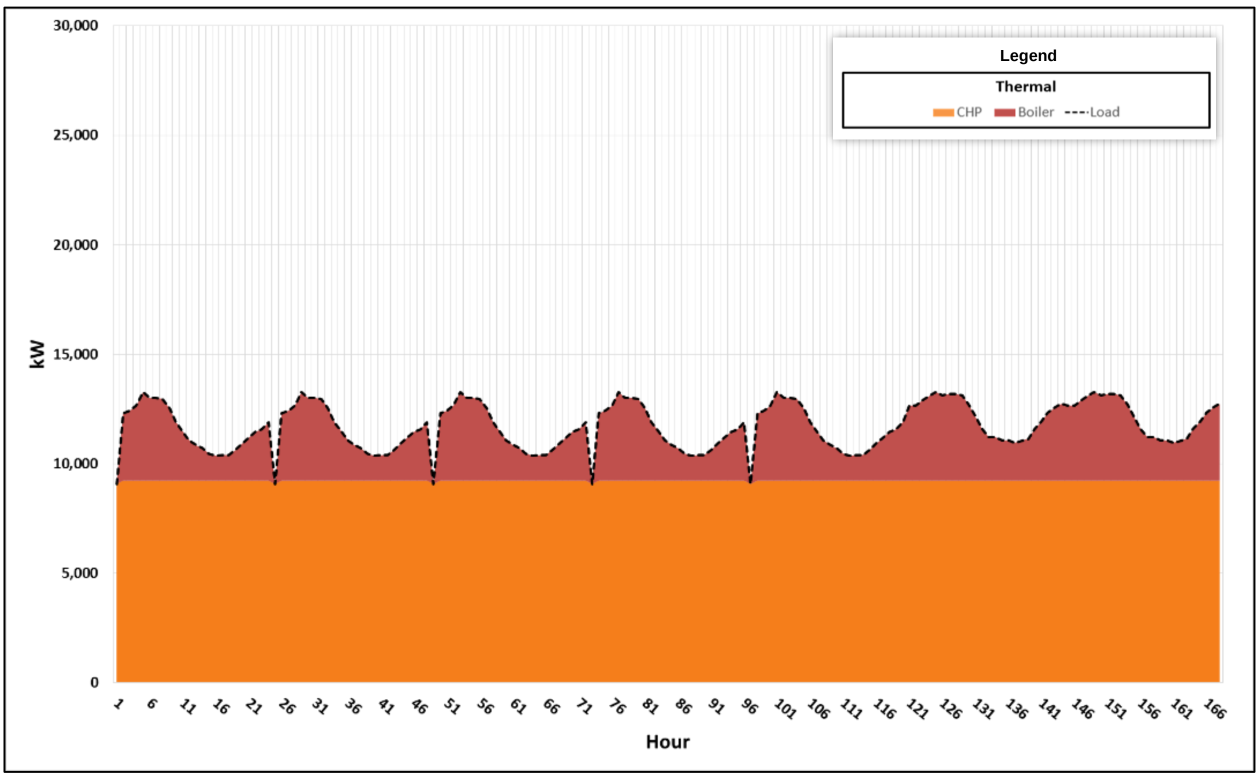

Figure 2.25. Grid-Connected, Thermal Dispatch (Fall)

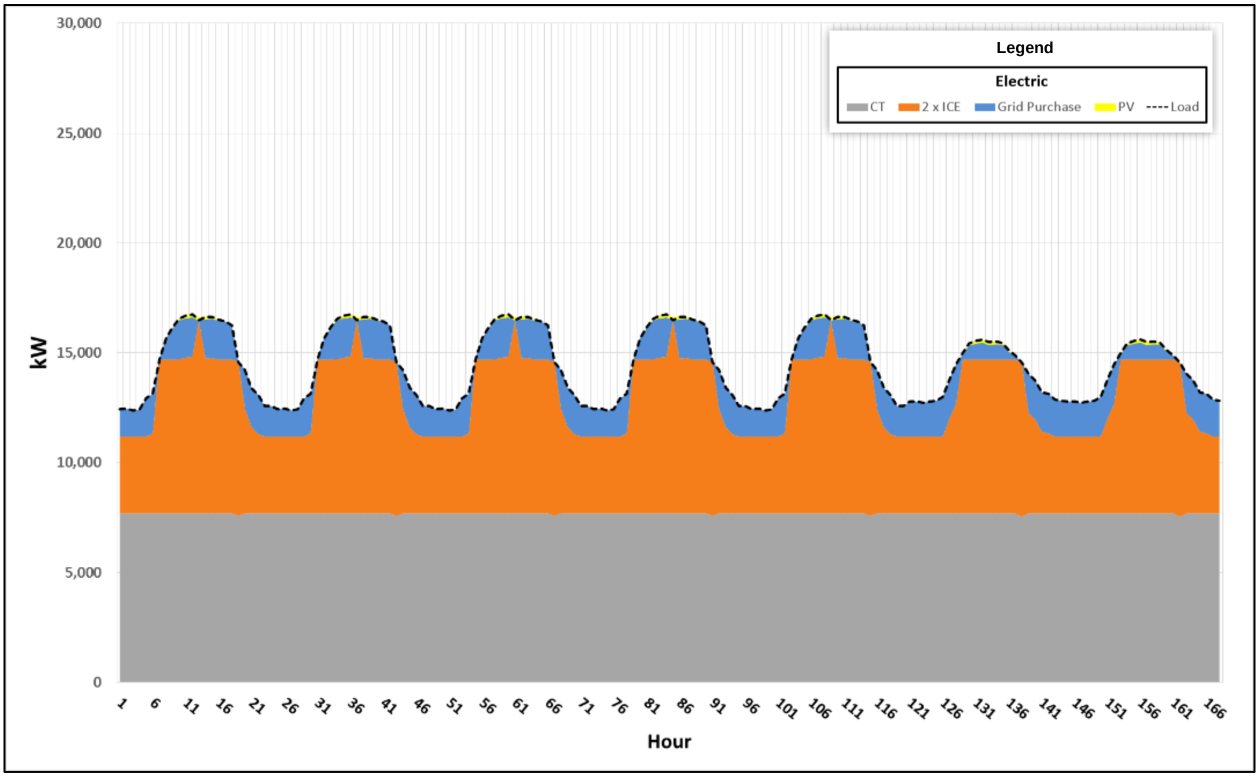

Figure 2.26. Grid-Connected, Electric Dispatch (Winter)

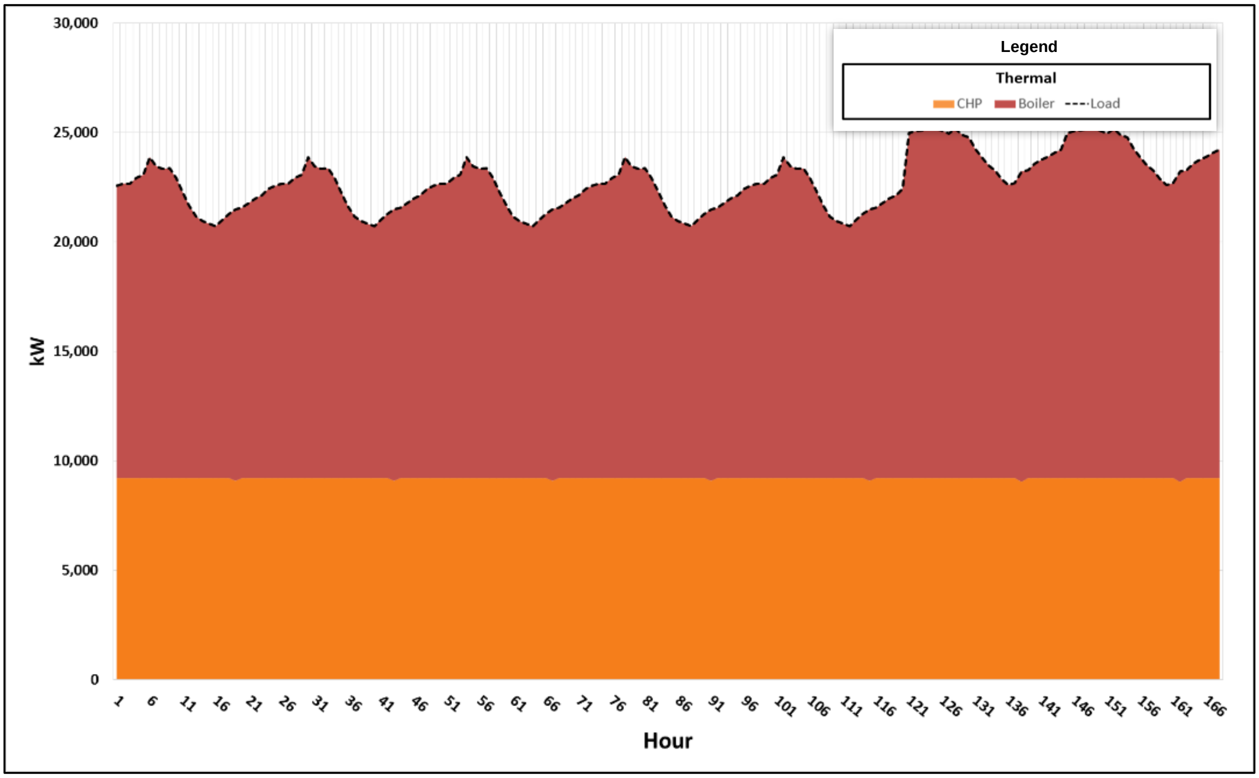

Figure 2.27. Grid-Connected, Thermal Dispatch (Winter) Islanded Operations

The table below outlines the annual electric load and generation breakdown for the base case (i.e. no microgrid) and the investment case (i.e. proposed microgrid) during islanded operations. The creation of the microgrid would allow all electric loads, both Group 1 and Group 2, to be served by microgrid DERs.

Table 2-19. Annual electric load and generation breakdown for the base case (i.e. no microgrid)

	Base Case (kWh/yr.)	Invest Case (kWh/yr.)
Electric Load (Total)	**3,477,809.40**	**3,477,810.00**
- KH	1,567,700.00	
- RPCI	1,314,640.00	
- UB Med School	497,198.00	3,477,810.00
- Cleveland Biolabs	17,564.00	
- Fruit Belt	80,707.40	
On-Site Generation (Total)	**1,016,712.00**	**3,477,809.45**
- 7692 KW CT CHP	n/a	1,292,256.00
- 5000 kW ICE #1	n/a	840,000.00
- 5000 kW ICE #2	n/a	812,603.00
- PV system @ BNMC	n/a	24,401.61
- PV system @ Fruit Belt	0.00	16,921.84
- 50 kW/ 200 kWh Li-Ion battery	n/a	0.00
- 50 kW/ 200 kWh Li-Ion battery	n/a	0.00
- 200 kW Flywheel	n/a	0.00
- Diesel Generators (KH)	399,156.00	268,795.00
- Diesel Generators (RPCI)	412,761.00	222,832.00
- Diesel Generators (UB Med School)	182,247.00	0.00
- Diesel Generator (Cleveland Biolabs)	22,548.00	0.00
Unmet Load (Total)	**2,466,081.40**	**0.00**
- KH	1,168,544.00	0.00
- RPCI	901,879.00	0.00
- UB Med	314,951.00	0.00
- Cleveland Biolabs	0.00	0.00
- Fruit Belt	80,707.40	0.00

Similarly, the table below outlines the annual heating load and generation breakdown for the base case (i.e. no microgrid) and the investment case (i.e. proposed microgrid) during peak week outage operations. The heat generated by the CHP units is able to meet approximately 60% of the heating load, offsetting boiler operation. The remaining heating systems at the UB School of Medicine, Cleveland Biolabs, and within individual Fruit Belt residential houses remain unchanged.

Table 2-20. Grid-Connected, Annual Heating Load/Generation

	Base Case (kWh/yr.)	Invest Case (kWh/yr.)
Heating Load (Total)	2,285,403.00	2,285,402.00
- KH	917,431.00	2,115,558.00
- RPCI	1,198,128	
- UB Med	169,698.00	169,698.00
- Cleveland Biolabs	146.00	146.00
- Fruit Belt	n/a	n/a
On-Site Generation (Total)	**n/a**	**1,367,402.00**
- 7692 KW CT CHP	n/a	1,367,402.00
Boiler (Total)	**2,285,403.00**	**918,000.00**
- KH	917,431.00	748,156.00
- RPCI	1,198,128	
- UB Med	169,698.00	169,698.00
- Cleveland Biolabs	146.00	146.00
- Fruit Belt	n/a	n/a

The table below outlines the annual fuel consumption breakdown for the base case (i.e. no microgrid) and the investment case (i.e. proposed microgrid) during peak week outage operations.

Table 2-21. Grid-Connected, Annual Fuel Consumption

<table>
<tr><th></th><th>Base Case</th><th>Invest Case</th></tr>
<tr><td>Natural Gas (Total)</td><td>282,236.07 m^3</td><td>903,308.07 m^3</td></tr>
<tr><td>- Boiler</td><td>282,236.07 m^3</td><td>113,369.07 m^3</td></tr>
<tr><td>- KH</td><td>113,298.00 m^3</td><td rowspan="2">92,394.00 m^3</td></tr>
<tr><td>- RPCI</td><td>147,963.00 m^3</td></tr>
<tr><td>- UB Med</td><td>20,957.00 m^3</td><td>20,957.00 m^3</td></tr>
<tr><td>- Cleveland Biolabs</td><td>18.07 m^3</td><td>18.07 m^3</td></tr>
<tr><td>- Fruit Belt</td><td>n/a</td><td>n/a</td></tr>
<tr><td>- 7692 KW CT CHP</td><td>n/a</td><td>407,694.00 m^3</td></tr>
<tr><td>- 5000 kW ICE #1</td><td>n/a</td><td>193,932.00 m^3</td></tr>
<tr><td>- 5000 kW ICE #2</td><td>n/a</td><td>188,313.00 m^3</td></tr>
<tr><td>Diesel</td><td>295,437.00 Liters</td><td>138,332.00 Liters</td></tr>
<tr><td>- KH</td><td>115,976.40 Liters</td><td>73,344.00 Liters</td></tr>
<tr><td>- RPCI</td><td>118,139.70 Liters</td><td>64,988.00 Liters</td></tr>
<tr><td>- UB Med</td><td>54,544.00 Liters</td><td>0.00 Liters</td></tr>
<tr><td>- Cleveland Biolabs</td><td>6,776.90 Liters</td><td>0.00 Liters</td></tr>
<tr><td>- Fruit Belt</td><td>n/a</td><td>n/a</td></tr>
</table>

Electricity usage at the campus peaks during the summer when cooling loads are high, therefore, the worst-case outage scenario is a grid outage during the summer (i.e. when electric chillers are consistently operated). In the base case (i.e. no microgrid), with the currently existing diesel generator capacity and on-site fuel storage, a one-week summer would amount to total loss of 1,236,031 kilowatt-hour across all loads within the microgrid boundary. This is equivalent to 68% of unmet load during the outage week. Figure 2.28 shows the 1-week load profiles by season as well as annual peak. Table 2-22 shows the base case modeling results for each outage scenario.

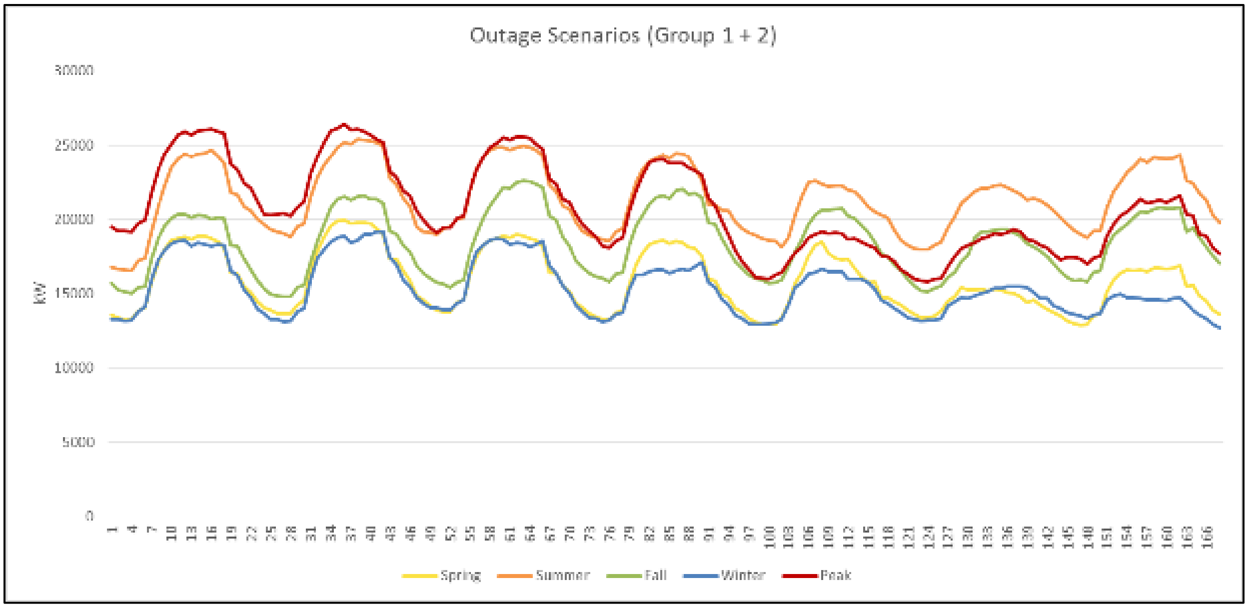

Figure 2.28. Outage Scenarios

Table 2-22. Unmet Load for One-Week Outage Scenarios by Season and Annual Peak

Unmet Load	Outage Scenarios (1 week)									
	Spring		Summer		Fall		Winter		Peak	
Institution	kWh	%	kWh	%	kWh	%	kWh	%	kWh	%
Kaleida Health	745,401	65.1%	1,243,414	75.8%	955,407	70.5%	710,104	64.0%	1,142,702	72.9%
Roswell Park	558,021	57.5%	941,217	69.5%	714,291	63.4%	529,307	56.1%	901,879	68.6%
UB Medical School	243,643	57.3%	328,403	64.4%	335,113	65.1%	222,471	55.1%	316,450	63.6%
Cleveland Biolabs	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Fruitbelt Neighborhood	113,227	100.0%	80,683	100.0%	87,473	100.0%	119,297	100.0%	80,707	100.0%
Total	**1,660,292**	**63%**	**2,513,034**	**70%**	**2,092,284**	**68%**	**1,461,882**	**57%**	**2,361,031**	**68%**

Figures below illustrates the diesel generator dispatch profile under the peak-week outage scenario for each facility load; loads are not aggregated in the base case. Red is equal to unmet load. Cleveland Biolabs is the only building that is able to meet its full electric load in the base case. The original diesel generators were sized for a much larger original load, which has since significantly reduced (i.e. fewer employees working at the facility). In fact, Figures below indicate the, the diesel generator output actually exceeds the load for much of the outage week due to a 30% minimum loading requirement of the generator. No dispatch figure is shown for the Fruit Belt residential loads because (1) no backup diesel generators exist and (2) per IEEE 1547.4 anti-islanding provisions, the distributed rooftop PV systems will not be allow to operate during a grid outage to prevent any unintended circuit energization and back feed.

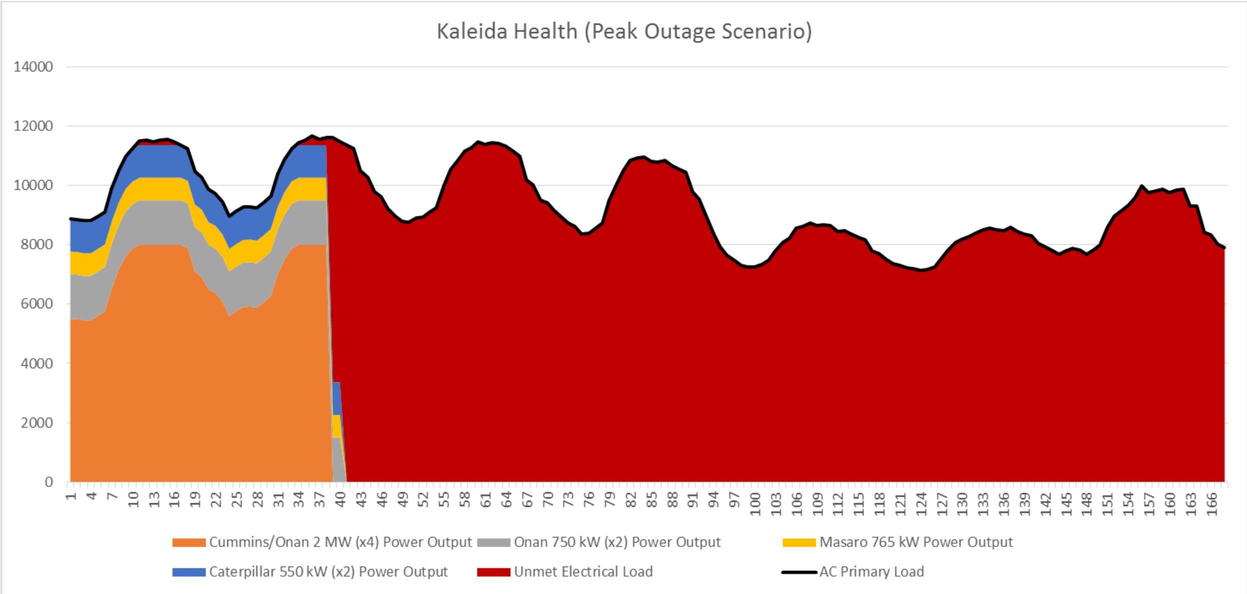

Figure 2.29. Kaleida Health (Base Case, Peak Outage Week)

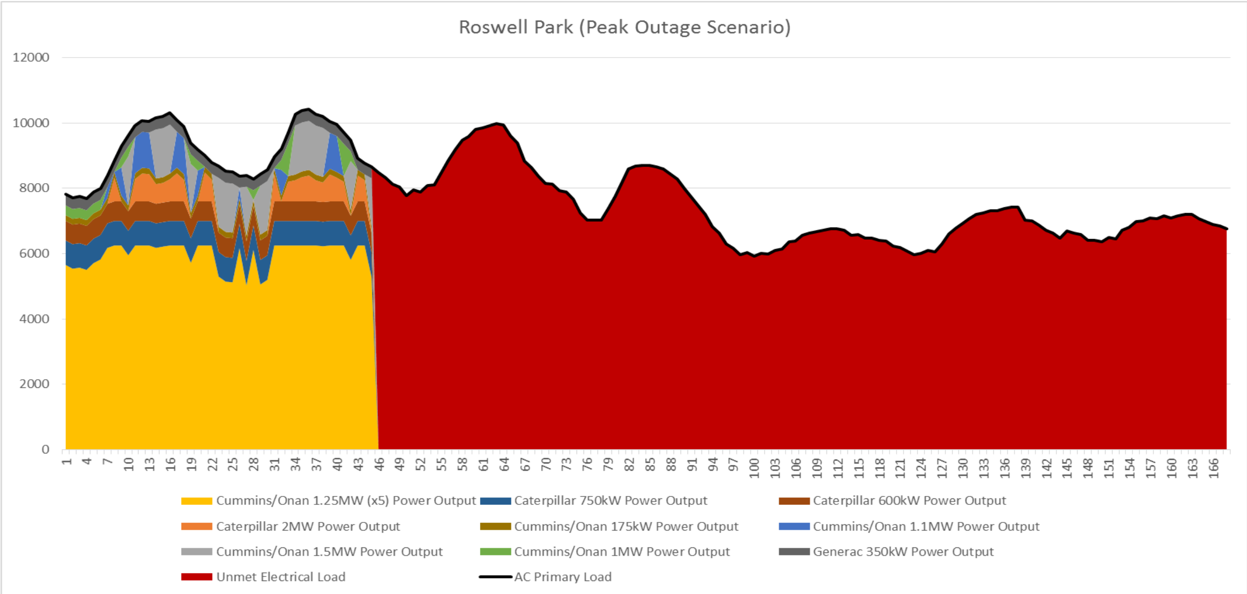

Figure 2.30. Roswell Park Cancer Institute (Base Case, Peak Outage Week)

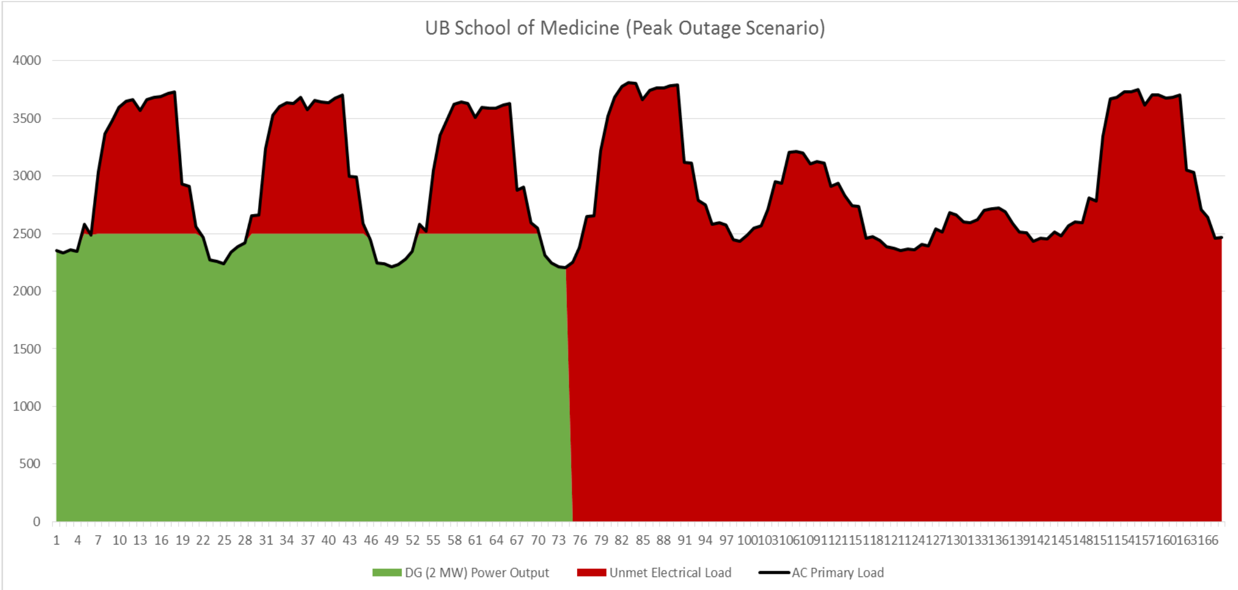

Figure 2.31. UB School of Medicine (Base Case, Peak Outage Week)

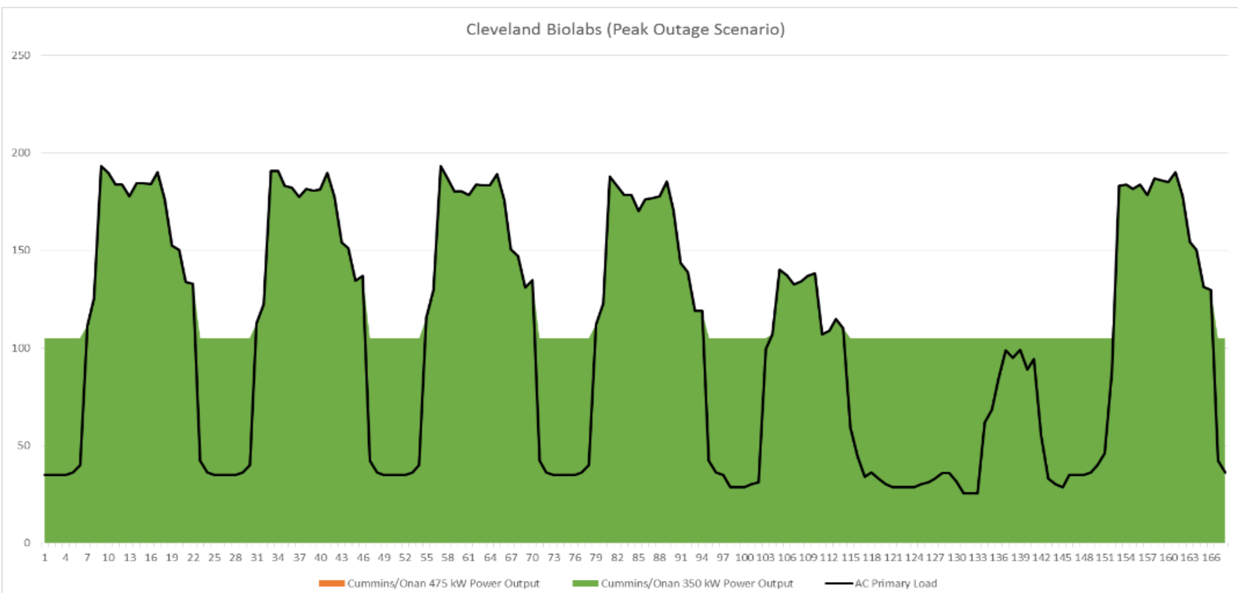

Figure 2.32. Cleveland Bio Labs (Base Case, Peak Outage Week)

Figures 2- 33 and Figures 2- 34 below show the electric and thermal dispatch for the peak outage week with the microgrid.

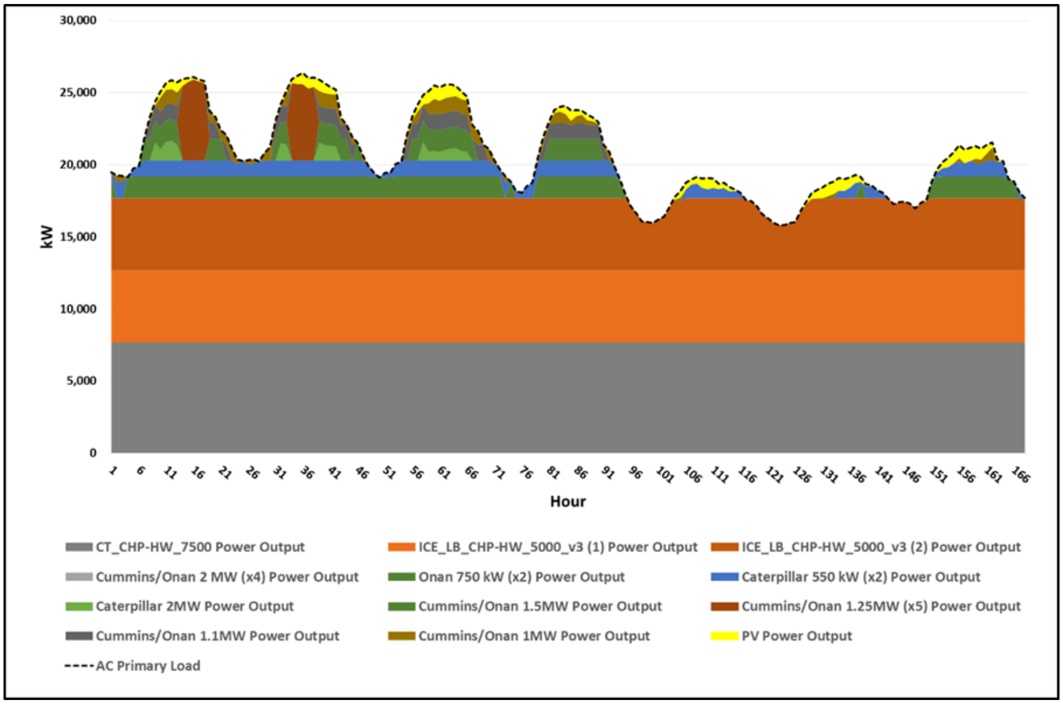

Figure 2.33. Islanded, Electric Dispatch (Peak Outage)

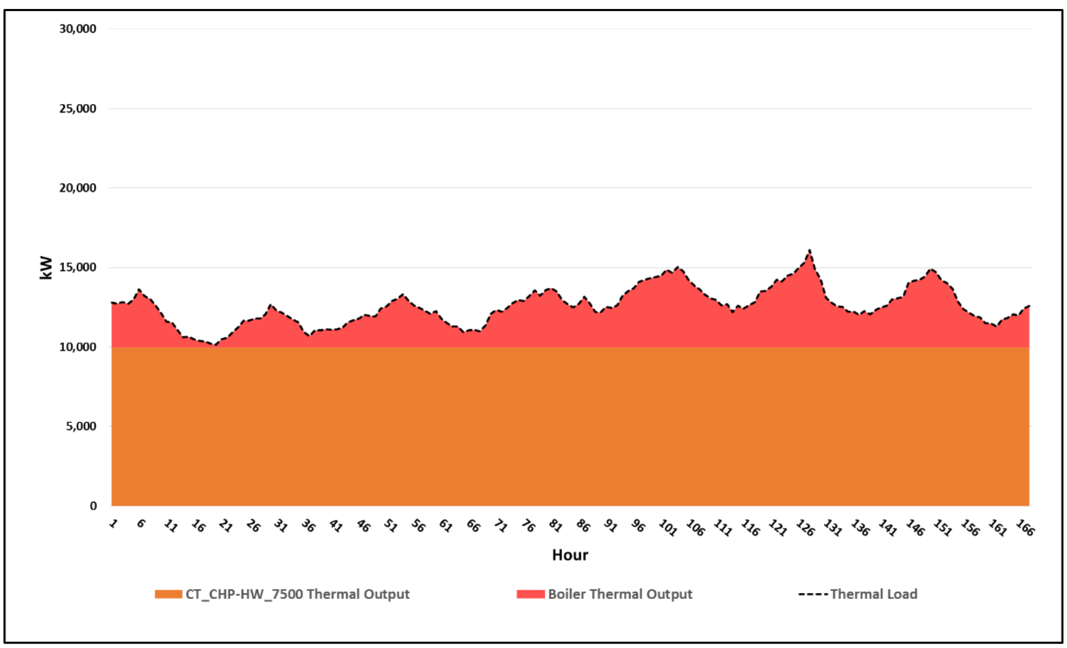

Figure 2.34. Islanded, Thermal Dispatch (Peak Outage)

Question 9

Describe how resilient the DERs and thermal generation resources will be to the forces of nature (severe weather) that are typical to and pose the highest risk to their operation(example, reduced or zero output due to snow cover over PV panels, potential flooding of low lying areas, etc.)?

The Kaleida Health facility (KH) and the Roswell Park Cancer Institute (RPCI) are located close to the Niagara River but not within the 500-year flood plain according to the FEMA map for the area. A detail of this map is shown in Figure 1. "Zone X" refers to the area not being within the 500-year flood plain. The area immediately south of the highlighted area (flood map not shown) is also designated as Zone X.

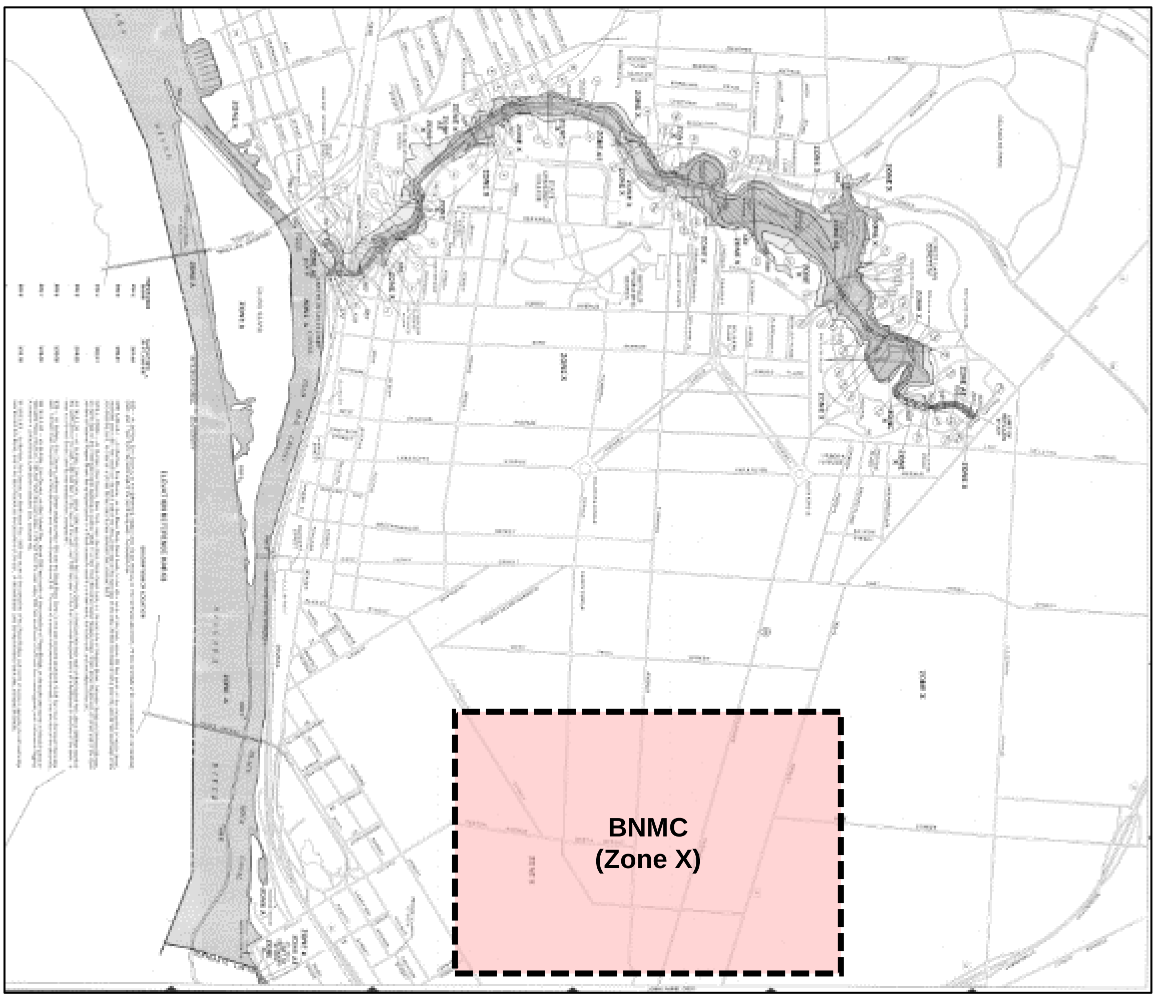

Figure 2.35. FEMA 500-year flood map for Downtown Buffalo, NY (3602300015C)

Existing medium voltage (MV) generators located at KH all above ground-level in the utilities plant building (see Figure below) while those installed in RCPI were located on the 3rd floor of its facility (see Figure below). As these resources are enclosed within facility buildings, they should be unaffected by severe storms and winds. Moreover, they should be unaffected by severe flooding.

MV Generators at KH CUB

MV Generators at RCPI (3rd Floor Plant Electrical Room)

Figure 2.36. MV Generators

Most of the member institutes affiliated with the Buffalo Niagara Medical Campus have one or more low voltage generators (480 volts). While some are located within their facility (KH, for instance), or within an outbuilding (Hauptman-Woodward Institute, for instance) others are located outside and may be enclosed by a cabinet, and sheltered by a building on at least one side.

All newly proposed generators (i.e. one gas combustion turbine, two gas engines) are likely to be similarly enclosed within either the RPCI utilities plant building (space available) or additional build-out shelters near the northwest KH employee parking lot. The cost of shelter build-out (materials, labor) is accounted for in the representative installed system costs utilized in this study. On the other hand, PV systems located at KH and UB School of Medicine building rooftops should not be especially vulnerable to severe weather and battery units will likely be installed indoors, near electrical interconnection points.

Question 10

Provide a description of the fuel sources for DER. Describe how many days of continuous operation of the microgrid can be achieved with current fuel storage capability? If additional fuel storage is required, provide a written description of needs required for this.

Refer to Question 8.

Question 11

Provide a written description of the capability of DERs including, but not limited to the following capabilities; black start, load-following, part-load operation, maintain voltage, maintain frequency, capability to ride-through voltage and frequency events in islanded mode, capability to meet interconnection standards in grid-connected mode.

Automatically connecting to and disconnecting from the grid

When reconnecting a microgrid to a utility distribution system, an important consideration is synchronization of the microgrid to the utility system to avoid disturbances upon reconnection. From most sophisticated to least sophisticated, options to synchronize will be studied as part of the detailed design analysis and could include:

- *Active synchronization*—if the microgrid voltage and frequency can be controlled sufficiently, then the microgrid controller can align the voltage and frequency to the utility power system and then reclose.
- *Sync check*—Reconnection can be blocked by a sync-check relay. The microgrid controller can initiate reclose, and the system should reconnect when the two systems are within synchronization tolerances. If the systems are badly out of sync, reconnection may not be possible.
- *Open transition*—Disturbances are avoided by de-energizing the microgrid and then reconnecting utility power system. Once reconnected, the distributed generation can be restarted if desired. This is the easiest and least expensive option for grid reconnection, but the impacts to loads should be considered (refer to synchronization limits from IEEE 1547-2003). Ability to synchronize is dependent on how well the microgrid can control voltage and frequency. Normally, if there are multiple switches than can be involved in a reconnection, the first switch closed will lock the microgrid into the wider system. One could have multiple microgrids or areas that must be reconnected where this would not apply. Such cases may require sophisticated control.

Black start and load addition

The ability to energize the microgrid from a de-energized state, without help from an external source. This feature will always be present for a microgrid based on back-up generation where the loads go dead and then are energized after the back-up generation starts. Even in microgrids designed for seamless transitions, black starts may be needed in some cases. One example is for a fault on a microgrid. If the generators all trip to clear the fault, the microgrid will have to restart from the de-energized state if the fault is cleared.

Cold-load pickup and inrush are key considerations for black starting. Upon energization, many components draw a high, short-lived inrush; the largest component magnetizes the magnetic material in transformers. Motors also draw inrush. Cold-load pickup is the extra load following an extended interruption due to loss of the normal diversity between customers. Following an interruption, the water in water heaters cools down and refrigerators warm up. When the power is restored, all appliances that need to catch up energize at once. For example, in cold weather, following an extended interruption, heaters all come on at once (this phenomenon is especially bad with high concentrations of resistance heating). In hot weather, houses warm up, so all air conditioners start following an interruption. Cold-load pickup can be over three times the load prior to the interruption. As diversity is regained, the load slowly drops back to normal. This time constant varies depending on the types of loads and the duration of the interruption.

Cold-load pickup and inrush are both considerations for a black start. If the generators are not sized to handle this stepped load, then loads need to be brought online in steps that the generators can handle. Renewable generation is typically not a resource for black-start capability based upon its intermittent nature and lack of frequency support functionality.

As part of the detailed design a thorough analysis will be performed to evaluate the ability of the CHP and ICE units at BNMC to provide the capability. Those systems will be the isochronous masters during the islands.

Maintaining frequency and voltage

Voltage support and regulation is important in a microgrid. Loads expect voltage within certain limits specified by ANSI C84.1-1995. This standard specifies acceptable operational ranges at two locations on electric power systems:

- *Service voltage* — the service voltage is the point where the electrical systems of the supplier and the user are interconnected. This is normally at the meter. Maintaining acceptable voltage at the service entrance is the utility's responsibility.
- *Utilization voltage* — the voltage at the line terminals of utilization equipment. This voltage is the facility's responsibility. Equipment manufacturers should design equipment which operates satisfactorily within the given limits.
- The references above are typical standards for utility service. In the event a local microgrid is created and controlled/operated by a local customer agent, the voltage tolerances within the grid will be the responsibility of the local agent when a microgrid is operating in standalone mode. The standard allows for some voltage drop within a facility, so service voltage requirements are tighter than utilization requirements. This standard also defines two ranges of voltage:
- *Range A* — most service voltages are within these limits, and utilities should design electric systems to provide service voltages within these limits. As the standard says, voltage excursions "should be infrequent." For long-term microgrid operations, this range may be most appropriate.
- *Range B*— these requirements are more relaxed than Range A limits. According to the standard: "Although such conditions are a part of practical operations, they shall be limited in extent, frequency, and duration. When they occur, corrective measures shall be undertaken within a reasonable time to improve voltages to meet Range A requirements." Utilization equipment should give acceptable performance when operating within the Range B utilization limits, "insofar as practical" according to the standard. For short-term microgrid operations for resiliency support during power system outages, this range may be most appropriate.

- In standalone operation, the controller(s) for a microgrid must regulate voltage. In grid-connected mode, the local generators should not try to regulate voltage. For single generators, voltage control is relatively straightforward. For multiple generators, control of voltage becomes more complicated.

If there is other voltage-controlling equipment in a microgrid, these devices must be coordinated with the generators. These include voltage regulators and voltage-controlled capacitor banks. One option is to disable voltage control on these devices when the microgrid is operating in standalone mode. Even in grid-connected mode, it is important to check that the microgrid does not affect voltage profiles and voltage control.

In addition to steady-state voltage control, other voltage characteristics are important. The microgrid must be stiff enough to provide torque to start motors within the microgrid. A utility source is normally stiffer than local generation within a microgrid. One option is to prevent large motors from starting or ensure that such motors have a soft enough start for the microgrid during standalone operation. For 'black start' capability, motor starting is also important. In the event the microgrid trips offline when a utility source is lost. Additional controls may be required on larger motors to prevent an inrush current during microgrid re-energization.

The local generation should also provide a stiff enough source to limit voltage unbalance, harmonics, and voltage flicker. Each of these is a function of the stiffness of the generation relative to the size of the load. During resiliency support, voltages with higher-than-normal excursions are likely to be tolerated, but problems will be limited if steady-state voltage, unbalance, harmonics, and voltage flicker can be restrained as much as possible. Sizing generators to have enough voltage support capability for the load is the most straightforward option for managing these.

For microgrids, other options are also available:

- *Load shedding*—"Problem loads" that generate harmonics or flicker can be disconnected.
- *Fast inverter support*—Inverters with fast response can provide additional support quickly to counteract fluctuating loads or harmonic producers. Such support is most beneficial in situations when the system fluctuations can be met by reactive power support. If real power support is needed, energy storage options could provide that.
- To support local loads, the real and reactive power must be controlled to maintain adequate voltage and frequency. The control must match generation with load and accommodate changes in load, including step changes. Under the classic model, real power mismatches first affect frequency of the microgrid system, and reactive-power mismatches affect voltage. IEEE 1547.4-2011 describes several voltage and frequency control approaches. For voltage control:

- *Voltage droop* — the voltage set point of a generator is reduced as reactive load increases.
- *Reactive power sharing* —A master controller adjusts the reactive power output of each generator to match the load.

For frequency control:

- *Speed droop*— the speed set point of a generator is reduced as real-power load increases.
- *Real power sharing*—a master controller adjusts the real power output of each generator to match the load.
- *Isochronous control*—one generator acts as a swing generators, and the other generators may droop against the swing generator and maintain constant power output.
- In a microgrid, load shedding and/or load control is another option to help match generation and load for better voltage and frequency control.

Task 2.4 Electrical and Thermal Infrastructure Characterization

Question 12

Provide a high-level written description of the electrical infrastructure (feeders, lines, relays, breakers, switches, current and potential transformers (CTs and PTs) and thermal infrastructure (steam, hot water, cold water pipes) that are a part of the microgrid. Identify the electrical and thermal infrastructure on the simplified equipment layout (with approximate routing) and one- line diagrams (electrical only). Differentiate between new, updated and existing infrastructure.

At the existing 4 KV switchgear, there will two CHP connections at Kaleida Health and one at RPCI. The point of connection, there will be 4KV switchgear with some existing spare feeders. This is under the assumption that the existing switchgear can handle the combined short circuit currents. From an impact level, the circuit breakers will be rated for CHP size, and at the short circuit level there will be new generation plus local generation. Here, what is needed are new circuit breakers, if the circuit breaker rating is lower than CHP rating, motorize the circuit breakers and protective relays with dual settings since there are lower short circuit level during islanded operation.

At the point of interconnection with the new generation, the existing 4 KV circuit breakers will be connected to the 23/4KV transformers. The assumption here is that the existing switchgear can handle the combined short circuit currents. The impact to the microgrid will be managing bidirectional power flow, setting the right export limits and at the short circuit level, looking at the new generation plus local generation.

For the 23KV circuit breakers at BNMC/Elm station/station 34, serving Kaleida, RPCI and UB Medical School, the point of connection will be the existing 23 KV circuit breakers. This is based on the assumption that the existing switchgear can handle the combine short circuit currents. The impact to the microgrid will be managing bidirectional power flow, setting the right export limits and at the short circuit level, looking at the new generation plus local generation. Here, what is needed are new circuit breakers, if the circuit breaker rating is lower than CHP rating, motorize the circuit breakers and protective relays with dual settings since there are lower short circuit level during islanded operation.

The point of islanding will be the 23 KV circuit breaker at Elm Station. The point of connection will be the existing 23 KV CB feeders. The assumption here is that the existing switchgear can handle the combined short circuit currents. The impact of the microgrid will be around bidirectional power flow and what is needed here are Protection relays to enable bidirectional power flow and protection relays to sense and enable islanding.

Another point of islanding will be the 23 KV circuit breaker at Seneca. . The point of connection will be the existing 23 KV CB feeders. The assumption here is that the existing switchgear can handle the combined short circuit currents. The impact to the microgrid will be managing bidirectional power flow, setting the right export limits and at the short circuit level, looking at the new generation plus local generation. Here, what is needed are new circuit breakers, if the circuit breaker rating is lower than CHP rating, motorize the circuit breakers and protective relays with dual settings since there are lower short circuit level during islanded operation.

Another point of islanding - 23 KV circuit breaker at Station 34. The assumption here is that the existing switchgear can handle the combined short circuit currents. The impact to the microgrid will be managing bidirectional power flow, setting the right export limits and at the short circuit level, looking at the new generation plus local generation. Here, what is needed are new circuit breakers, if the circuit breaker rating is lower than CHP rating, motorize the circuit breakers and protective relays with dual settings since there are lower short circuit level during islanded operation. In addition, modification of existing controls to enable automatic connection and disconnection will be required as well as protective relays with dual settings to lower short circuit levels during islanded operation.

For the PV interconnection, there will be one PV connection at Kaleida Health and one at the University at Buffalo Medical School. The point of connection is the existing 480V distribution in these respective buildings, but the question of spare feeder availability needs to be answered. The feeders need to be rated for PV size and most likely, a spare feeder will be needed.

For seamless islanding and islanded operation, fast load shedding will be required. The point of connection will be all non-critical feeders. The impact to manage is managing the seamless transition of load shedding. What is needed is advance selection of loads to be shed – based on CHP output, programming the fast shedding of loads before CHP unit’s trip, ensuring enough spinning reserve in CHP units to manage sudden drop in utility feed and desensitizing critical feeders so that they do not trip on under voltage.

Tables 2-23 through Table 2-26 outlines the infrastructure upgrades and estimated costs for all buildings and substations within the microgrid boundary with respect to electrical, thermal, controls, and communications components.

Table 2-23. Building Electrical Infrastructure Upgrades & Costs

Infrastructure Upgrade	Component	Kaleida Health	Roswell Park	UB Med School	Cleveland Biolabs	Fruit Belt
CHP connection	4 KV switchgear at CHP location - complete with controls and protection	$200,000.00	$75,000.00	$0	$0	$0
	Matching transformer - to convert CHP voltage to 4 KV - 6000 KVA	$72,000.00	$0	$0	$0	$0
	Matching transformer - to convert CHP voltage to 4 KV - 6000 KVA	$72,000.00	$96,000.00	$0	$0	$0
	2x installation/wiring/testing/commissioning	$100,000.00	$50,000.00	$0	$0	$0
CHP connection to existing 4 KV switchgear	breaker modification work - Converting existing breakers for motorized operation	$80,000.00	$40,000.00	$0	$0	$0
	2x set of CTs	included in above	included in above	$0	$0	$0
	2x set of VTs	included in above	included in above	$0	$0	$0
	2x set of protective relays	included in above	included in above	$0	$0	$0
	2x installation/wiring/testing, commissioning	included in above	included in above	$0	$0	$0
4 KV incoming feeders - between 4KV switchgear and 23 KV transformers	breaker modification work - Converting existing 23KV breakers for motorized operation	$120,000.00	$120,000.00	$0	$0	$0
	set of protective relays	included in above	included in above	$0	$0	$0
	installation/wiring/testing, commissioning	included in above	included in above	$0	$0	$0
5 KV incoming feeders at CB Campus	1x breaker modification work - Converting existing 23KV breakers for motorized operation	$0	$0	$0	$30,000.00	$80,000.00
	1x set of protective relays	$0	$0	$0	included in above	N/A
	1x installation/wiring/testing, commissioning	$0	$0	$0	included in above	included in above
23 KV incoming feeders - before 23 KV transformers	breaker modification work - Converting existing 23KV breakers for motorized operation	$120,000.00	$120,000.00	$90,000.00	$0	$0
	set of protective relays	included in above	included in above	included in above	$0	$0
	installation/wiring/testing, commissioning	included in above	included in above	included in above	$0	$0
PV Interconnection	1x LV switchgear modification	$20,000.00	NA	$20,000.00	$0	$0
	1x installation/wiring/testing,	$5,000.00		$5,000.00	$0	$0

	commissioning					
Switchgear modification work for load shedding - load shedding at 4KV level	Breaker modification work - Converting existing 4KV breakers for motorized operation	$60,000.00	$60,000.00	$60,000.00	$0	$0
	installation/wiring/testing, commissioning	included in above	included in above	included in above	$0	$0
Switchgear modification work for load shedding - load shedding at 480V level	Breaker modification work - Converting existing 480V switches to motorized breakers	$0	$0	$0	$60,000.00	$0
Layer 2 controls - Backbone (PLC, Ethernet)	installation/wiring/testing, commissioning	$0	$0	$0	included in above	$0
	Data acquisition at 23 KV and 4 KV	$200,000.00	$200,000.00	$200,000.00	$75,000.00	$75,000.00
	Layer 2 automation - covering 23 KV and 4 KV	included in above	included in above	included in above	included in above	included in above
	High speed load shedding system	included in above	included in above	included in above	included in above	included in above
	UPS for control system	included in above	included in above	included in above	included in above	included in above
	Critical load desensitization	included in above	included in above	included in above	included in above	included in above
	control cabling	included in above	included in above	included in above	included in above	included in above
	communication network	included in above	included in above	included in above	included in above	included in above
Power Cabling	5 KV cabling work - CHP to 4 KV switchgear	$30,000.00	$20,000.00		$0	$0
	480 V cabling work - PV interconnection	$10,000.00	NA	$10,000.00	$10,000.00	$0
Storage Interconnection	1x 4KV interconnection breaker complete with controls and protection	$0	$0	$0	$0	$80,000.00
	1x interconnection transformer - 200KVA	$0	$0	$0	$0	$15,000.00
	1x installation/wiring/testing, commissioning	$0	$0	$0	$0	included in above
	SUM	**$1,089,000.00**	**$781,000.00**	**$385,000.00**	**$175,000.00**	**$250,000.00**

Table 2-24. Substation Electrical Infrastructure Upgrades & Costs

Infrastructure Upgrade	Component	Capital Costs ($)
23 KV breaker modification work at Elm Street Substation	4x Converting exiting 23KV breakers for motorized operation	$200,000
	4x set of protection relays	included in above
	4x set of control modification work	included in above
	installation/wiring/testing, commissioning	included in above
23 KV breaker modification work at Seneca Substation	4x Converting exiting 23KV breakers for motorized operation	$200,000
	4x set of protection relays	included in above
	4x set of control modification work	included in above
	installation/wiring/testing, commissioning	included in above
23 KV breaker modification work at Station 34 Substation	4x Converting exiting 23KV breakers for motorized operation	$200,000
	4x set of protection relays	included in above
	4x set of control modification work	included in above
	installation/wiring/testing, commissioning	included in above

Table 2-25. Communication Infrastructure Upgrades & Costs

Component	Capital Cost ($)
MG Supervisory Control System	$ 100,000.00
Interface to Utility system	$ 150,000.00
Interface to energy market system	$ 50,000.00

Table 2-26. Total Infrastructure Upgrades & Costs

Electrical Infrastructure	**$ 3,280,000**
Thermal Infrastructure	**$ 1,000,000**
Controls Infrastructure	**$ 300,000**
Total	**$ 4,580,000**

Question 13

Describe how resilient the electrical and thermal infrastructure will be to the forces of nature that are typical to and pose the highest risk to the location/facilities? Describe how the microgrid can remain resilient to disruption caused by such phenomenon and for what duration of time. Discuss the impact of severe weather on the electrical and thermal infrastructure.

The underground nature of natural gas distribution system infrastructure provides exceptional resiliency in the face of severe weather phenomena typically seen in the Western New York area; namely snow, ice, and wind storms. Other types of natural disasters which could potentially have a greater impact on underground pipelines, such as severe earthquakes or flooding, are extremely uncommon in the Western New York area and, as such, pose very little risk to system reliability. In fact, according to the latest Federal Emergency Management Agency (FEMA) flood plain maps, the area around the BNMC and the majority of the City of Buffalo is classified as being outside even the predicted 500 year flood plain[7]. Additionally, gas delivery systems in Western New York have proven resilient in the face of extended periods of extreme cold. In the winters of 2013/2014 and 2014/2015 for example, two of the coldest on record, gas delivery continued with no significant disturbances.

Furthermore, the natural gas delivery system remains reliable even in the event of a significant and widespread grid outage as was concluded in a 2013 Massachusetts Institute of Technology (MIT) study conducted for the Department of Defense (DoD) [8]. This study analyzed the interdependence of the nation’s electric generation and gas delivery systems and concluded as its number one recommendation that:

“DoD installations with large electricity loads should consider installation of natural gas generation or cogeneration plants to increase their energy security from the typical three days using diesel supplies to weeks-to-months using natural gas generation.”.

The Western New York area is also optimally positioned in terms of reliability of natural gas supply. In recent years, nationwide gas production has shifted significantly from traditional offshore rigs in the Gulf of Mexico to shale drilling. Since this time, the portion of the Marcellus shale region found in Northwest Pennsylvania has been one of the most productive regions of the country. This production is also expected to continue into the foreseeable future, as there is currently a backlog of completed wells awaiting the construction of new gathering and transmission pipeline capacity. The Marcellus region also sits directly beneath a network of different interstate, and midstream pipelines, on which National Fuel Gas Distribution Corporation (NFGDC) holds firm capacity, providing redundant delivery routes to NFGDC’s city gate. The BNMC benefits from its proximity to this region of abundant gas supply, and pipeline

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[7] FEMA Flood Map Service Center - https://msc.fema.gov/portal/search?AddressQuery=14216#searchresultsanchor
[8] Interdependence of the Electricity Generation System and the Natural Gas System and Implications for Energy Security - https://www.serdp-estcp.org/News-and-Events/News-Announcements/Program-News/DoD-investigates-reliability-of-natural-gas-fired-generators-during-electric-grid-failures2

capacity in that interstate pipeline constraints which can cause escalated pricing, and limited supply in areas such as New England are not of concern in Western New York. Finally, even in the extremely rare event of a supply shortage and gas curtailment situation, NFGDC's operating procedures dictate that steps be taken to prioritize service to critical care customers such as those being served by the proposed microgrid.

Question 14

Provide a written description of how the microgrid will be interconnected to the grid. Will there be multiple points of interconnection with the grid? What additional investments in utility infrastructure may be required to allow the proposed MG to separate and isolate from the utility grid? Provide a written description of the basic protection mechanism within the microgrid boundary.

Refer to Question 1.

Task 2.5 Microgrid and Building Controls Characterization

Question 15

Provide a high-level written description of the microgrid control architecture and how it interacts with DER controls and Building Energy Management Systems (BEMS), if applicable. Identify the locations of microgrid and building controls on the simplified equipment layout diagram. Differentiate between new and existing controls.

From a technical perspective, the proposed individual generation/storage technologies are close to being mature and capable of supporting microgrid operation. However, to operate a diverse DER portfolio and to achieve the best microgrid benefits, an intelligent and holistic planning and control system with a robust communication backbone will be necessary. As part of this project, a scalable, intelligent local microgrid controller will be implemented at BNMC. The project team will conduct a detailed analysis on the controller features, requirements, communication needs, and information technology (IT) infrastructure at the proposed community. The features of the controller would include the following elements:

- Ability to integrate a diverse technology portfolio, including various distributed generation and storage technologies
- To take full advantage of Combined Heat and Power (CHP) technologies and thermal storage, it must optimally control flow of both electrical and thermal energies.
- Controller is a commercially available technology that has standard capabilities for voltage control, frequency control, grid-connected/island operation and open communication protocols
- Controller is able to connect to National Grid D-SCADA backbone and has features that enable security against cyber-attacks

- Scalability and modularity to easily fit any microgrid facility with any technology portfolio
- Scalability to connect to the individual building management system. Either to command a specific operation or receive and sent signals.
- Adaptability to integrate with National Grid's protective devices at the site including the 23KV switches that will be installed.
- Using open protocols and interfaces, the control architecture will be able to communicate and coordinate with diverse DER of any size and quantity. This will enable simple configuration, deployment, and operation of interfacing with both customer and utility-level control.
- The local controller (or Network Operation Controller, NOC) will communicate with local resources and power monitoring devices (new and legacy) using open standard communication protocols such as DNP3, ModBus, SunSpec, MESA, etc.
- The solution will offer standardized information and communication protocols. The solution will meet all the interoperability, communication, control and will adhere to the interconnection standards, protection, and safety requirements
- The controller communications backbone is constructed with serial-based technology instead of Ethernet
- Ability to identify the operation mode (grid-connected or islanded) and adjust the optimization objectives and constraints to satisfy the relevant operating criteria

The controller proposed for BNMC will follow an open multi-layered distributed architecture, in which control tasks will be distributed among four different layers. The multi-layered control system will ensure stable, reliable, and optimized microgrid operation. The control system that we propose is also the basis for the IEEE 2030.7 standard and will include the four layers shown in figure below.

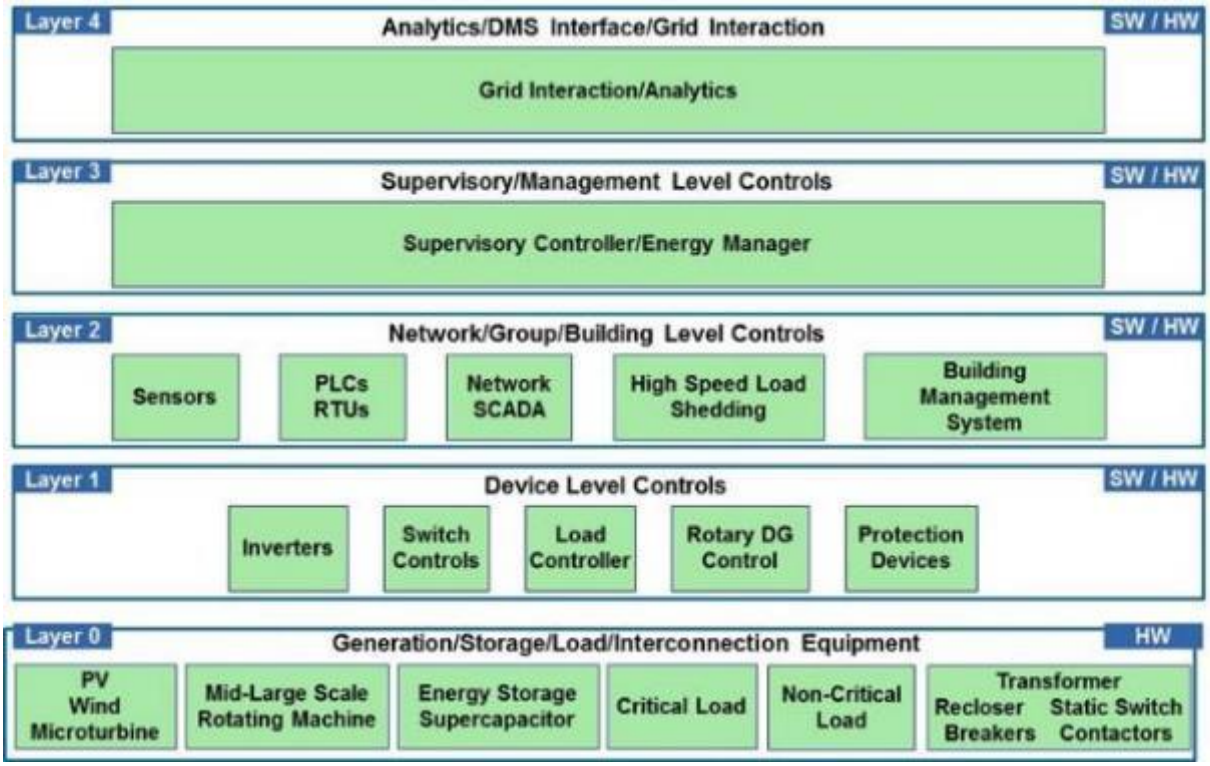

Figure 2.37 Layered Microgrid Architecture from DERS to Grid Interaction [Source: EPRI, LBNL, Microgrid Labs]

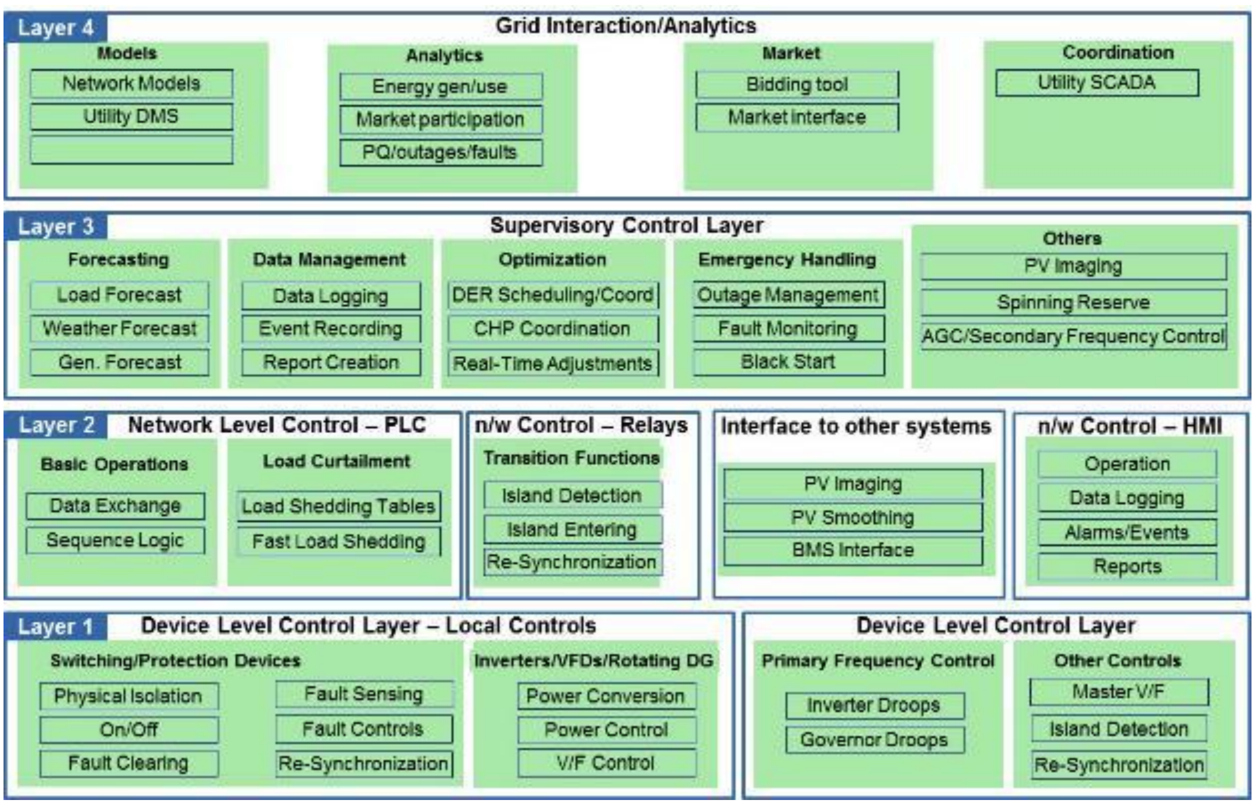

Figure 2.38 DER to Microgrid Controller Functionality [Source: EPRI, LBNL, Microgrid Labs]

The specific layers identified here include device level control, network level control, supervisory control, and grid interactions/analytics, which are further discussed below.

- **Layer 0** captures the DER types and load types and pertains to energy generation (resources) and storage as well as load requirements.
- **Layer 1 (**device level control**)** includes the individual device level control.
- **Layer 2** (network level control) is the control layer which manages DER, including scheduling and dispatching and their network connectivity and where operational commands are sent out.
- **Layer 3** (supervisory control) consists of supervisory control where energy management activities are performed
- **Layer 4** (grid interactions/analytics) provides the grid connectivity to DMS, SCADA, and market.

Layer 1 will be a real-time device level layer acting in micro- to milli- second range that ensures stable and safe operation of the equipment and network. This layer will host controls such as switching devices (physical isolation, fault clearing), protection devices, inverters (V-F control), and primary frequency control (inverter and governor droops). Protection systems for microgrids must be designed in compliance to protection strategies by National Grid. These 23KV switches will be integrated into the microgrid control system.

Layer 2 will be the network level automation and data acquisition layer acting in milliseconds to seconds range. It includes transition functions (e.g. re-synchronization and islanding detection), fast load shedding, load curtailment, network-level automation, and network level monitoring. The medical campus are already equipment with very sophisticated building energy management systems. The microgrid controller will directly interface with the BEMS. Layer 2 also includes functionalities like ramp rate controls and PV smoothing. Substation automation/SCADA systems are widely used in the industry to acquire and monitor data and to automate operations. This will be the main interface to the supervisory controller layer and enables the higher level controller to send commands to the apparatus. This approach makes the system easily scalable and extendable leveraging on the existing data acquisition systems. This, approach is very different from using black box-hardware microgrid controller. Fast controls in layers 1 and 2 form the backbone of the microgrid, and ensure its safe and stable operation in both grid-connected and islanded modes, as well as during transitions.

Layer 3 will be a supervisory controller layer acting in 1 to several minutes that will optimize the operation of the system as a whole, in *grid connected* and *islanded* modes. This layer will host: forecasting (weather, load, and generation forecasting); data management (data logging, event recording, report creation); optimization (DER scheduling, CHP coordination, real-time adjustments); and others (PV imaging, PV smoothing, spinning reserve, secondary frequency control).

Layer 4 will be a grid interface layer that will support grid interactivity and allow data transfer between the National Grid ADMS/NYISO and the microgrid. This layer will host grid interaction and analytics. In this project, the project team is exploring software and hardware interface (SecureNet) technology for real-time energy and capacity telemetry to NYISO, frequency and voltage regulation in an ancillary service market, or synchronous reserves and usage data for demand response. SecureNet will provide real-time bidirectional telemetry for MW, MVAr, kV, MWh, MVArh, breaker and alarm status, dispatch signals for use by generation/storage assets and demand response resources for ISO energy, capacity, regulation and synchronous reserves markets. It will use advanced SecureNet-RT and SCADART systems to interface with the site resources and the NYISO, respectively, using secure real-time communication2. This technology is recognized in multiple US Independent System Operators (ISO).

Existing Building Energy Management Systems (BEMS)

Table 2-27. Existing BEMS

Building	Manufacturer	Comments
Kaleida Health	Siemens	System could be used for DSP. Widley distributed use in the GVI building floors 1-4. Also noted use in the CUB related to various chiller controls and other functions. Very capable asset for load management via setpoint changes, etc. Did not note widespread use of this control scheme in the BGH buildings.
Kaleida Health	Eaton Digital Master Power Command System	Located in CUB building cabinetry, this Programmable Logic Controller based system Used for control of existing generator assets. This system could play a role in switchgear/generator control for a microgrid system or DSP. It might be able to act as a local microgrid controller.
Cleveland Biolabs		Not ready.
HWI	Andover Continium System Local Integrator: U&S Services	BEMS Suitable for potential DSP participation. Used for HVAC control/monitoring of all floors zone controls, the boilers, chillers, fans, etc.
UB CTRC	Siemens	Should be suitable for DSP application. Used for HVAC controls. Appears to be the same hardware as the GVI (in lower portion of complex)
BNMC Innovation Center	Johnson Controls	Used for HVAC control. Could be used for DSP.
BNMC Innovation Center	Metasys	Also have a Johson Control access control system.

Refer to Question 18 for BEMS in the context of the communications infrastructure.

Question 16

Provide a brief written description of the services that could be provided by the microgrid controls including, but not limited to the following:

Services for the microgrid include:

- *Services for the microgrid customer*
  - Reliability and resilience
  - Reduction of overall energy costs – an optimization function
- *Services for the microgrid operator*
  - Grid connected mode
  - Islanded mode
  - Transition grid connected to islanding
  - Transition for grid connected to islanded mode
- *Services for the distribution system operator*
  - Maintain Power Import/Export Limits (Balancing)
  - Prevent unsafe backfeed of the distribution system
  - Protection coordination
  - Peak Demand Reduction
  - Upstream" Power Quality; Prevent equipment located within the microgrid from causing power quality issues on the upstream distribution system
  - Demand Response; Day-Ahead; Real-Time (automatic demand response); Interruptible Load, Utility Event Response
  - Voltage regulation at the PCC
  - Phase Balancing
- *Services for the transmission system operator*
- *Services for the DER owner*

Performing economic dispatch and load following

Dispatch for microgrid includes, but is not limited to:

- While grid-connected, ensuring sufficient resources (e.g. generation and/or energy storage) are operating and available to support the microgrid's seamless transition to island mode.
- While islanded, managing energy resources consistent with ensuring service to the microgrid critical loads for the duration of the islanded state.

Dispatch for environmental performance includes reducing or limiting CO_2 emissions. The microgrid controller dispatch algorithm automatically dispatches assets to meet the current operational criterion including maintaining local survival, supporting economic operations, minimizing environmental impacts and all combinations thereof. When grid connected the controller manages the local resources to ensure high power quality and readiness to island in case of emergency. Economic and environmental objectives issued by internal or external parties are evaluated and supported by dispatching additional assets (or modifying current asset set points) if capacity is available. While islanded, the controller's primary objective is to maintain critical loads and will automatically dispatch or shed generation and load assets as necessary. During extended island operations, the objectives may be modified to maximize survivability or to provide black start support. The allocation of assets is determined by taking an account of each asset's availability, capabilities (e.g., capacity and dynamic responsiveness) and operational constraints and matching these factors to the current list of objectives. Some common factors include active and reactive power capacity, response time, minimum and maximum operating times, calendar constraints, etc. The control environment manages a database of the asset parameters that can be easily updated via a user-interface to accommodate schedule changes or operational changes. The dispatch of assets may be configured to be automatic or to require operator

Resilience and Reliability

Because resilience and reliability are the result of specific system and component design approaches and choices at the planning and implementation stages, increased resilience and reliability cannot be obtained only by means of a specific controller function. However the consequences of operating the BNMC community will provide increased resiliency and reliability within the microgrid.

- Resilience: Backup power during extreme, infrequent, and long-duration outage events
- Resilience – additional services
  - Backup Power for Priority Loads
  - Intelligent Load Shedding
  - Optimize islanding duration
  - Minimize load not served
- Reliability – minimum requirements
  - Uninterrupted Power
- Reliability – additional services
  - Reliability: Backup power during more regular, frequent outages
    - Improvement of SAIDI, SAIFI, CAIDI numbers
- "Downstream" power quality – additional services
  - Mitigation of voltage/frequency sags and surges through load hardening efforts

Reduction of overall energy costs – an optimization function

- Reduction of energy costs by optimizing resource usage
  - Optimize utilization of DER
  - Day-Ahead Bidding and Scheduling
  - Joint management of electricity and heat
- Reduction of losses
  - Voltage profile optimization
  - Loss Minimization
  - Load shifting / time-of-use optimization
- Capture payments on services
  - Ancillary Service Payments
  - Capture Market Credits
  - Capture renewable energy credits
  - Maximize PV/wind/renewable energy resource utilization
  - Capture carbon credits
  - Minimize greenhouse gas emissions

Maintaining frequency and voltage

Please refer to Question 11

PV observability and controllability; forecasting and Storage optimization

Solar forecast will be incorporated into the local controller to optimally dispatch the energy storage in combination with load management. In addition 7-day-ahead solar forecast will be used to create facility pre-cooling/pre-heating and ES dispatch schedule by the local controller. The solar forecast modules will support *standard data communication protocols* for communicating between forecasting software and both the local and system controllers that will be used. It will adapt forecast outputs into formats that are consistent with the SunSpec information and security standards.

Load Forecast: Load forecasting will be incorporated into the system controller and the local controller. The system controller forecast will be based upon the historic circuit load with inputs from weather and solar forecasts to develop daily expected energy and loading requirements. Local controller forecast will utilize similar algorithms to anticipate facility load requirements as well as forecast management of components such PV, ES, and load management to maintain facility load profile. The system controller will maintain operation of the delivery system within requirements. Local controller will utilize available resources of the facilities to manage resources within the system controller forecast. System controller will monitor performance within reliability, safety and power quality requirements and reforecast operations as appropriate.

Coordination of protection settings

In grid-connected mode, proposed generators should coordinate with overcurrent protection on the distribution system. The fault-current contributions from these generators should not cause other equipment to exceed short-circuit limits. In the event utility equipment is compromised due to excessive short circuit currents, the utility may require additional fault-current mitigation measures within the microgrid, and the customer may require fault mitigation to protect their own equipment from the microgrid generator's fault current contributions. The additional fault current supplied by generators should also minimize disruption of distribution relaying. In addition to coordination, the microgrid should be able to separate from the utility in cases of faults or other disturbances either inside or outside of the microgrid zone. Another issue with overcurrent protection on a microgrid is having sufficient fault current to operate protective devices such as relays or fuses. Normally, the utility supplies a stiff source that has significant fault current available. Generators may be weaker sources, which may make some faults more difficult to detect. Inverted-based generators and storage systems can be particularly weak fault current sources. Weak fault sources may require different forms of overcurrent detection and protection.

Data logging features

As part of the detailed design a comprehensive monitoring plan will be developed. Refer to the initial monitoring plan provided in the Operations section

Selling energy and ancillary services

Figure 2-39 outlines the grid services that the BNMC microgrid is *likely* to provide to the various NYISO markets that available currently.

Demand Side Anciliary Services (DSASP)

Market	Service	Day Ahead Energy Market	Real Time Energy Market	Installed Capacity (ICAP) Market	Operating Reserve	Voltage Support Service	Regulation & Frequency Response	Blackstart	Volumetric Charges	Time of Use	Demand Charge	T&D Charges	Wheeling Charges
NYISO (Wholesale)	Energy	X	O										
	Capacity			O									
	Reactive Power					O							
	Regulation						O						
	Reserve				X								
	Blackstart							X					
National Grid (Retail)	Energy								O	O	O		
	Delivery											O	O

O = Microgrid participation
X = No microgrid participation

Figure 2.39. NYISO Wholesale Markets & Grid Services

Question 17

How resilient are the microgrid and building controls? Discuss the impact of severe weather on the microgrid and building controls.

Refer to Question 9 and 13.

Task 2.6 Information Technology (IT)/Telecommunications Infrastructure Characterization

Question 18

Provide a high-level written description of the IT/Telecommunications Infrastructure (wide area networks, access point, ethernet switch, cables etc.) and protocols. Identify the IT and telecommunications infrastructure on the simplified equipment layout diagram. Differentiate between new and existing infrastructure.

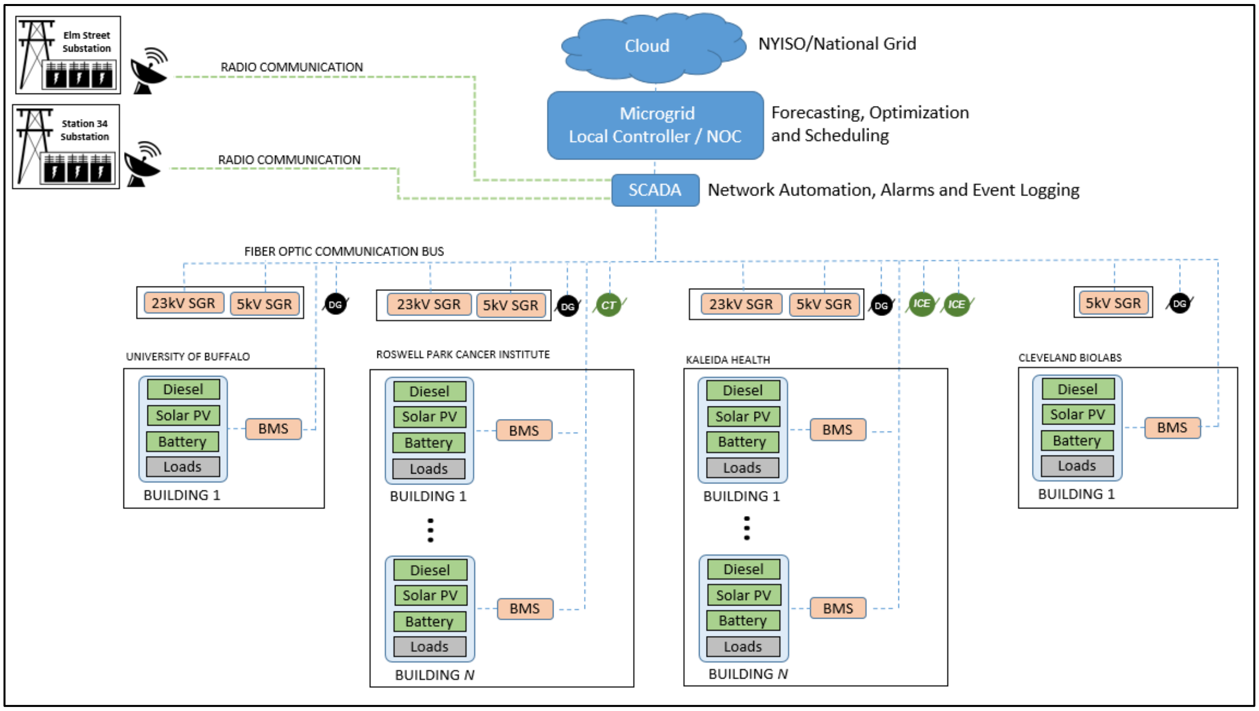

Figure 2.40 High Level IT/Telecom Infrastructure Upgrades Required by BNMC Community

A new IT/communication network will be developed as part of this community. To prevent unauthorized access to the BNMC main information network, a physical separate network of fiber optic cables will be used for the control system infrastructure, which will be isolated from the main network. This prevents accessing the BNMC main information network, which may be connected to other assets, through intrusion into the control network. Local microgrid communications at the BNMC community would be accomplished with underground fiber from the microgrid controller to all the proposed DERs, generators, switches, building management and virtual RTUs.

The microgrid controller would be capable of either local autonomous control or remote control via SCADA. The proposed controller will be designed with open communications standards using an Enterprise Service Bus, DNP3, IEC61850, ModBus, and among others**.** In addition to these protocols, the controller platform will be capable of interfacing with any SCADA, DMS, or DER assets that use open protocols. As part of the design analysis, the overall architecture for the communication backbone will be developed and an audit will be performed to see if the existing assets have the ability to be connected with the microgrid controller at the site. The communication protocols of the proposed microgrid controller will be based on an open architecture to enable integration with existing automation systems to perform network level controls. This enables use of existing power automation and Supervisory Control and Data Acquisition (SCADA) systems as the network control layer, reducing cost of new investment. This will in turn distribute the controller signals to the technologies or interface with the building management system to perform load management based on the microgrid controller commands.

It is also vitally important to ensure security of all equipment sends and receives cyber secure control signals and avoid cyber-attacks. To ensure system security against cyber-attacks, obtaining a Risk Management Framework (RMF) is required. In order to assess the risk of the new/upgraded system, manage/limit the risks, and acquire proper authorization for the site to operate during and after the upgrades, we will work with a RMF assessor consulting company with prior experience in RMF certification. The information gathering process about RMF assessing companies has already been started and we will finalize the contracting as part of the design stage of the project. The controller/site upgrades will be discussed with the RMF experts, and guidelines on how to minimize risk will be sought and followed during the design phase.

The project team will collaborate with the RMF assessor company throughout the design phase and provide them with the pieces of software and control system, gradually, as they become available. Any required part of the system will be tested and verified, either at the site or the assessor company facilities. The controller software will be analyzed by the RMF Company. If there are components within the software which create a security concern, we will address them and replace and/or improve them. Based on our past experience and vision for this project we will consider the main possible points of cyber intrusion to be the following: a) the internet connectivity of the controller in order to obtain weather forecasts; and b) the data transfer for the market participation.

- To prevent/limit the risks associated with these concerns, our tentative design is expected to have the following features:
- Also, to prevent any unauthorized access to the control system infrastructure, all of its outside communications will be encrypted, and all of its gateways will be protected by firewalls. All outside communication will be physically separated from any military networked.
- To prevent component damage through set-point manipulation in case of control network breach, hardware limits will be set on component set-point ranges, which define the secure ranges for the set-points. Moreover, secure limits on frequency and ramp rate of changes will be put in place.
- If the internet connectivity to obtain site weather forecast is not allowed or found not secure by the RMF assessing company, the project team is prepared to install local sensors for onsite weather forecasting to avoid any internet connectivity.

As part of the design analysis, a complete assessment will be made to ensure that the controller communications backbone is constructed with serial-based methods, not Ethernet methods. The serial based methods make the system easier to troubleshoot and provide the utmost in cyber security available today. The data flowing on these channels are segregated into real and non-real time channels to ensure deterministic and prompt delivery of status and controls data. This is a major improvement in cyber security since the serial channel cannot support remote access, and the serial channel only supports one deterministic peer-peer protocol.

Telecom Infrastructure at BNMC:

The telecom infrastructure for the microgrid will require two tiers.

- **Tier 1 is the backhaul and inter-site interconnection.**

  This tier should be closely integrated with existing telecom infrastructure. It is assumed that all the sites will have existing fiber for telephone and Internet services. The following questions will be part of the initial design planning:

  - Is there unused capacity in the existing fiber network? Dark fiber? Wavelengths? Opportunity to create VLANs, VPLS, or pseudo-wires at MPLS level?
  - Is there a common service provider for the entire campus? Is there a single facility where existing fiber is co-located which would enable interconnection of the microgrid network between sites?
  - For sites that cannot be interconnected over existing fiber, other options can be explored:
  - Install new fiber to those sites.
  - Examine opportunities for point to point microwave links between sites. (note possible reliability implications for microwave links in extreme weather conditions)
  - If Internet access is available, create site to site VPN tunnels. (Note possible reliability implications of using public Internet)

- **Tier 2 is the access network.**

  The access network (a.k.a. a Field Area Network or FAN) provides connectivity to the microgrid devices – generation, reclosers, sensors, switches, relays, etc. and provides connection to the management systems.

  - If microgrid devices are in locations with Ethernet already installed, it is the preferred technology for the access networks. VLANs should be employed to isolate and secure the microgrid from other campus networks.
  - The access network can also leverage existing wireless LAN infrastructure. For example, if a campus-wide Wi-Fi network is in place, a virtual SSID and private network can be overlaid to serve the microgrid, and isolate the microgrid network from other users.
  - A new access network can be built out. A Wi-SUN FAN could be deployed across the campus. (Note: further use case analysis will be required, as some microgrid use cases require communications data rate and latency beyond the capability of Wi-SUN)
  - Other FAN technologies in unlicensed or licensed spectrum may be considered

- A combination of access technologies can be used across the Campus.

Question 19

Provide a written brief description of communications within the microgrid and between the microgrid and the utility. Can the microgrid operate when there is a loss in communications with the utility? How resilient are the IT and telecommunications infrastructure?

The BNMC microgrid network will include communications to the National Grid. This can be achieved in several ways

- The microgrid network can be interconnected as part of a utility Field Area Network. In this case the reliability of the microgrid communications is controlled by the utility and the FAN architecture.
- The microgrid can connect to the utility by a VPN tunneled over the public Internet or commercial cellular. In this case the reliability is determined by the service provider.
- For higher reliability and resilience, multiple interconnection paths (e.g. commercial cellular, fixed Internet Service Provider, and utility FAN) can be deployed in parallel, with automatic fail-over to backup technologies in case of communication outages.

Furthermore, the microgrid should be designed for autonomous operation, independent of connection to the utility. Local intelligence and control should enable essential use cases for the microgrid to operate with our without communication to the utility, assuming local communication between the microgrid devices remains available.

3 ASSESSMENT OF MICROGRID'S COMMERCIAL AND FINANCIAL FEASIBILITY

Task 3.1 Commercial Viability – Customers

Question 1

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

The microgrid will serve many critical facilities within the BNMC. The following describes those institutions and the individuals and institutions that would be affected if there were an outage.

Kaleida Health

- **Buffalo General Medical Center**
  - 19 story facility
  - 1,079,870 square feet
  - Patients admitted annually: 21,587
  - Annual Emergency Room Visits: 38,105
  - Annual Clinic Visits: 26,566
  - Annual Ambulatory Surgery Visits: 3,021
  - 16 Operating Rooms
  - 3,311 employees

Buffalo General Medical Center is one of Western New York's Top 5 Employers with an estimated $425 million regional economic impact annually. Buffalo General Medical Center is a 511-bed acute care hospital in the center of the Campus. It is the largest hospital in Upstate New York, and provides nearly 25 percent of all adult medical and surgical services in Erie County. A major affiliate of the State University of New York at Buffalo School of Medicine and Biomedical Sciences, Buffalo General offers medical treatment in 23 clinical inpatient departments and more than 60 outpatient programs. Specialized programs available at Buffalo General are cardiac and orthopedic surgery, lithotripsy/urology, oncology, psychiatry, gynecology/obstetrics, dialysis, gastroenterology, cardiac rehabilitation, rehabilitation medicine, kidney and heart transplantation, neurology and neurosurgery.

- **Gates Vascular Institute**
  - 475,000 square feet
  - 16-bed highly specialized Intensive Care Unit
  - 62-bed short-stay suite
  - 7 Operating Rooms

- 17 interventional labs for cardiac, vascular and neurosurgical procedures
- 4 CT scanners, 4 MRI scanners
- 209 employees which includes staff at the University at Buffalo's Clinical and Translational Research Center (CTRC).

Kaleida Health designed the state-of-the-art Gates Vascular Institute (GVI) facility to be the premier destination for stroke care, cardiac surgery, and vascular services. The $291 million facility brings together Kaleida Health physicians and University at Buffalo researchers in a collaborative effort to deliver leading clinical care, produce major breakthroughs on the causes and treatment of vascular disease, and generate new biotechnology businesses and jobs. The Gates Vascular Institute features four floors dedicated to the surgical and interventional management of cardiac, vascular and neurological conditions.

- **Women's and Children's Hospital** *(a new facility currently under construction to come on-line in 2017)*
  - Patients Admitted Annually: 12,779
  - Annual Emergency Room Visits: 41,107
  - Annual Clinic Visits: 94,203
  - Annual Ambulatory Surgery Visits: 11,669
  - 11 Operating Rooms
  - 200 beds

Combining both comprehensive pediatric health care and complete women's health services for over 100 years, Women & Children's Hospital of Buffalo, a Kaleida Health facility and teaching hospital for the University at Buffalo School of Medicine and Biomedical Sciences, is regarded as the region's center for comprehensive and state-of-the-art pediatric, neonatal, perinatal and obstetrical services.

- **John R. Oishei Children's Hospital** (Women and Children's renamed)

This replacement hospital elevates acute pediatric care in the region, fully integrating Women & Children's into Kaleida Health, the Buffalo Niagara Medical Campus and the University of Buffalo's new medical school.

With the new facility, the hospital will expand its robust neuroscience center while expanding critical care. One floor will be dedicated to Roswell Park Cancer Institute's cancer care program, creating a "hospital within a hospital" for cancer treatment.

Women & Children's Hospital of Buffalo (and the new Oishei Children's Hospital) is the only center with the pediatric specialists (physicians, surgeons, respiratory therapists, nurses, nurse practitioners, social workers, child life, along with trained and compassionate support staff such as aides, housekeepers, dieticians) who can care for all children (0–21) and their families. It is the only access point for pediatric critical care, Level III neonatal intensive care, and Level 1 Pediatric Trauma Centers in and for Western New York. The sickest babies and children come to the hospital for care, either directly or through transfers from other hospitals. Without the resources available at John R. Oishei Children's Hospital, these young patients would have to travel out of area for care.

- 500,000 square feet
- 12 stories
- 185 beds
- 1802 employees (coming from Women's and Children's Hospital)

Roswell Park Cancer Institute

- Employees: 3,181 including 292 faculty members and 618 nurses.
- Patients Admitted in 2015: 4,442
- Outpatient Visits in 2015: 201,491
- Patients under Active Care in 2015: 31,901
- 133 beds

Roswell Park Cancer Institute (RPCI) is a freestanding comprehensive cancer center and the nation's first cancer research, treatment and education center. RPCI is designated as the only Comprehensive Cancer Center in Western and Upstate New York by the National Cancer Institute.

Roswell Park is dedicated to providing the highest quality total care to patients; to conducting research into the causes, treatment and prevention of cancer; and to educating the public and the next generation of those who study and treat cancer. Groundbreaking research by RPCI scientists has led to greater understanding of the nature of cancer and to major advances in cancer diagnosis and treatment that are now in use worldwide. RPCI instituted the nation's first chemotherapy program, pioneered studies on the relationship between smoking and lung cancer and developed photodynamic therapy (PDT) and the prostate-specific antigen (PSA) blood test.

Over the last decade, RPCI has undergone major growth, helping to revitalize the region's economy by adding new jobs, initiating one of the nation's first hospital facilities dedicated to Phase I cancer research studies, and setting itself apart as a leader in immunotherapy and vaccine therapy, surgical robotics, vitamin D research, tumor microenvironment, personalized medicine, cancer genetics and prevention.

RPCI actively seeks to help medically underserved and high-risk populations through its robust diversity program, stop smoking hotline, cancer registries, genetics counseling program, high-risk early detection and surveillance programs. The faculty, combined with strong alliances with local and regional colleges and universities, enables the Institute to provide comprehensive educational opportunities in several fields.

The State University of New York at Buffalo

Since its founding as a medical school in 1846, the University at Buffalo (UB) has been a significant member of the Western New York healthcare system. UB works in partnership with the region's leading hospitals to educate the next generation of caregivers, improve patient outcomes and apply research-based insights to enhance prevention and treatment. UB also collaborates closely with world-renowned research partners Roswell Park Cancer Institute and Hauptman-Woodward Medical Research Institute. The former is home to UB's Roswell Park Cancer Institute Graduate Division; the latter is home to the University's Department of Structural Biology.

UB has six facilities on the Buffalo Niagara Medical Campus: New York State Center of Excellence in Bioinformatics and Life Sciences, Research Institute on Addictions, UB Downtown Gateway, the Ira G. Ross Eye Institute, the Clinical and Translational Research Center located within the Gates Vascular Institute, the Kaleida Health-UB facility, and the Institute for Healthcare Informatics.

- **Jacobs School of Medicine and Biomedical Sciences**

A key facet of the Buffalo Niagara Medical Campus, UB is joining with prestigious research and clinical partners to create the region's first comprehensive academic medical center. This dynamic, multidisciplinary environment will support world-class medical education, research and patient care through innovation and collaboration. Campus partners include Roswell Park Cancer Institute, Kaleida Health and the Hauptman-Woodward Medical Research Institute.

When the facility opens in 2017, it <u>will bring an estimated 2,000 UB faculty, staff and students</u> to the Campus daily. In addition to state-of-the-art research laboratories and classrooms, the facility will house advanced simulation centers for general patient care and surgical and robotic surgery training. The School's upper level walking bridges to adjacent hospitals and other health care facilities will provide streamlined access and promote communication within the medical complex.

- **Clinical and Translational Research Center (CTRC)**

The Clinical and Translational Research Center (CTRC) is located in the same state-of-the-art Kaleida Health-UB facility that houses both the Gates Vascular Institute and the Jacobs Institute. Serving as the integrated academic home for outstanding clinical and translational science and as the central hub of the Buffalo Translational Consortium, the CTRC provides innovative research tools, support, training, resources and coordination.

The CTRC's custom designed office and laboratory space accommodates UB researchers, faculty, and clinicians who seek to improve the health of patients with innovative therapies.

The UB Biosciences Business Incubator, operated by the Office of Science, Technology Transfer and Economic Outreach, is also housed within the CTRC. The Incubator supports researchers with start-up companies involved in translational research.

City of Buffalo's Fruit Belt Residential Neighborhood

Adjacent to the Buffalo Niagara Medical Campus, the City of Buffalo's Fruit Belt Neighborhood comprises approximately 130 acres and roughly 36 city blocks.

The Fruit Belt is a tightly knit, predominantly African-American residential neighborhood, with just under 2000 people living in this well-defined area. It is a mixed-use community of single and multi-family homes, schools, and community centers. Approximately 41% of the occupied homes in the Fruit Belt are owner-occupied, which is slightly lower than the rate of 43% in the city of Buffalo overall (as of the year 2000) and 44% in 2006.[9]

The average household income is approximately $23,000, which is less than half of the Buffalo area median income of $46,000.[10]

Question 2

Identify any direct/paid services generated by microgrid operation, such as ancillary services, or indirect benefits, such as improved operation, to the utility or New York Independent System Operator (NYISO). If yes, what are they?

It is anticipated that the utility, National Grid, or NYISO wholesale market participants will purchase any excess electricity that is generated by the microgrid but not used by the BNMC facilities that are behind a new proposed master meter. Given the interconnection and circuit on which the microgrid will be located, this may be possible in both normal and islanded operation. Furthermore, if National Grid takes delivery of this electricity, then an arrangement would need to be pursued that is allowed and contemplated under the current regulations and which is in the best interest of the BNMC, National Grid, and its other customers.

Also, the current design is such that the microgrid will be large enough in size to participate in wholesale and retail grid services markets. Similarly, if comparable programs are created for distribution markets, the microgrid may also be able to participate in those. Specifically, it is anticipated that the microgrid will be eligible to participate in the wholesale market/programs for capacity, ancillary services and/or demand response. Currently, one of the facilities served by the microgrid, Roswell, already participates in demand response.

Figure 2-39 summarizes the grid services provided by the microgrid. This table represents the most likely configuration of programs in which the microgrid will participate, however it may be possible for the microgrid to participate in any of the programs or services listed. For example,

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[9] Data Set: Census 2000 Summary File 1 (SF-1) 100-Percent Data, GCT-H6. Occupied Housing Characteristics. Data Set: 2006 American Community Survey; S2501. Occupancy Characteristics.

[10] Buffalo Niagara Medical Campus with Sasaki Associates and Madden Planning Group, March 2009, Fruit Belt Neighborhood Strategy, Figure 5 Average Household Income, pg. 6

it is expected it would not be ideal for the microgrid to participate in day-ahead markets as it would need to commit energy that it might otherwise need if it were to island. Similarly, the microgrid would want to retain blackstart capability for its own use rather than for participation in markets.

The microgrid will also provide other indirect, or "non-monetizable," benefits to the utility and ISO including improved visibility of the microgrid's operations, load and distributed generation (DG) aggregation and smoothing, deferral of transmission and distribution upgrades and improved customer service. Also, a parallel study is in the process of being conducted to assess the impact of the microgrid on the Campus' overall power quality.

Question 3

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

The primary paying customers for this microgrid are the Campus member institutions. The three largest institutions to participate in this microgrid are Roswell Park Cancer Institute, the University at Buffalo School of Medicine, and Kaleida Health. There are also other smaller buildings and research centers that are expected to be served by the microgrid. A full description of how these facilities are served by the microgrid can be found within Task 2.

While all of these customers are expected to be served by the microgrid's electric generation, only two facilities, Roswell Park Cancer Institute and Kaleida Health, are expected to initially receive/purchase thermal energy.[11] Studies are currently underway to determine if there are other thermal loads on the Campus that could be served cost-effectively.

The secondary customer is the entity, either National Grid or a participant in NYISO wholesale market, who will purchase any excess electric generation from the microgrid. Since the microgrid is connected to National Grid's distribution system, it will need to work with National Grid to develop an agreement for this sale of excess generation. Under current regulations, if National Grid were the counterparty, they would pay wholesale for this power. However, in the future, National Grid may be able to negotiate a different rate. If National Grid does not purchase the excess electricity, an agreement would be needed with National Grid to determine how the power would be delivered to a different purchaser given the interconnection to National Grid's distribution system.

Given the location of the microgrid on the electric distribution system, it is possible that, during islanded operation, electric generation in excess of what the BNMC institutions need could be sent to National Grid to potentially serve its customers located adjacent to the BNMC campus in the Fruit Belt neighborhood. This neighborhood primarily consists of residential customers, of which most are Low-to-Moderate income according to current Census data, as well as some community centers.

[11] It is technically possible to extend service to a third party if it has a large enough thermal load across the year and is physically close to the existing steam system. At this point, no such facilities have been identified.

In this scenario, the customers in the Fruit Belt neighborhood would not directly purchase electricity from the microgrid, but would be served by the electricity that is delivered to National Grid when the microgrid generates in excess of what is needed by the BNMC institutions. As such, National Grid is the primary recipient the microgrid's excess generation. Furthermore, National Grid, in coordination with the microgrid controller, would need to determine how much excess electricity would be available. The available electricity will be determined by the design, the operating conditions required by the BNMC, and the arrangement agreed upon between National Grid and the microgrid owner.

Also, to the extent that the microgrid participates in NYISO markets, entities purchasing the microgrid's grid services via the ISO would be considered customers of the microgrid as well. The services that may be sold via the ISO are defined in Question 2. Similarly, a future DSP provider could pay for grid services as well.

Question 4

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

There are several other stakeholders that may be positively affected by the installation of this microgrid. First, the local community and, more specifically, the patients, clients, and tenants of the Campus member institutions, would be able to be served during islanded operation, as described in Question 1. Similarly, with the additional savings expected to be generated by the microgrid during "blue sky" operations, the Campus member institutions would be afforded the opportunity to invest those savings into other programs and initiatives that may help to better serve their patients, clients, and stakeholders.

Secondly, aside from acting as the interconnecting utility and possibly the customer of the microgrid's excess generation, National Grid would also be indirectly affected by the installation and operation of the microgrid. For example, National Grid's capacity resource planning has noted several upgrades within its Capital Investment Plan that will be required in the future and for which the microgrid may be able to help defer costs. Also, as part of REV, a Demonstration Project is currently being scoped to determine what value customer-owned DER assets could provide to the utility's operations and electric distribution planning. To the extent that National Grid is subject to changes under REV, it is possible that this microgrid could help demonstrate or support REV principles.

National Fuel would also be affected by the installation of this microgrid as the proposed CHP plant would result in increased gas consumption throughout the Campus. This increased consumption would stand to benefit all ratepayers in that the utility's fixed costs would be spread over a greater volume, resulting in reduced per unit costs.

Similarly, third parties with product and service offerings geared towards microgrids stand to benefit from this market opportunity.

Additionally, the City of Buffalo and the County of Erie would be positively affected by the proposed microgrid to the extent that it supports policy objectives and/or serves their common populations. Once more, the ability of the Campus to provide emergency services during electric outages and catastrophic events helps to serve the public good.

The concept of mutual aid support is well established and is considered “standard of care” in most emergency response disciplines. Any community is susceptible to disaster, both natural and man-made. Preparation and response to catastrophic circumstances starts locally. In many instances, outside assistance cannot be expected for a minimum of 72 hours. For this reason, it is imperative for hospitals and health systems to prepare to manage these situations without outside assistance. The ability of the Campus to provide emergency services during electric outages and catastrophic events can serve the broader community of hospital and health care facilities. Those include the Erie County Medical Center, Sister’s Hospital and any number of regional locations of the Catholic Health System.

Question 5

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

As described in Question 46, the owner of the microgrid LLC may be the collective BNMC, individual member institutions, National Grid and/or a third-party investor.

The BNMC, Inc.’s preferred arrangement would be that the microgrid is owned by a special purpose entity (SPE) which is then jointly owned by the Campus’ three largest member institutions: Roswell Park Cancer Institute, Kaleida Health, and the University at Buffalo. As such, the owner(s) of the microgrid will be the same or closely associated with the largest purchaser of energy from the microgrid: the Campus member institutions. In this way, the member institutions will be able to socialize the costs and benefits of its microgrid investments as well as balance the economic objectives of the proposed microgrid with their individual needs and wants.

In 2011, the Campus collectively approached National Grid seeking its expertise in meeting their anticipated energy needs and transportation challenges. As a result, the *energizeBNMC* Partnership was formed and a *5-Year Energy Innovation Plan* to complement the Campus’s *2010 Master Plan* was developed.

Under the proposed ownership of the BNMC’s member institutions, National Grid would continue to act as the utility, though additional agreements would be needed for interconnection and delivery of and/or payment for any excess energy. If National Grid is a financier of part, or all, of the microgrid project, then National Grid will continue acting as the interconnecting utility, but would also have an interest in ensuring that the microgrid meets its financial objectives and/or obligations. Thirdly, if National Grid were the owner of the microgrid, then the relationships would be similar to today in that the institutions would purchase all energy from National Grid or an Energy Supply Company (ESCO).

If a third-party investor is the owner of the microgrid, then it may have no existing relationship with the aforementioned customers of the microgrid. BNMC has reached out to and/or has had initial discussions with multiple prospective investors and financing partners as part of this feasibility. Going forward into Stage 2, BNMC will select a primary partner to gain access to capital and/or a portfolio of investors with multiple sources of capital.

In all cases, it is contemplated that a microgrid controller would be utilized by a microgrid controller operator/administrator who would be responsible for acting as the fiduciary of the owner(s) to ensure that the microgrid meets its stated financial objectives as well as complies with the criteria and requirements set by the purchasers of the energy.

Question 6

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

The Group 1 buildings of Roswell Park Cancer Institute, Kaleida Health, and University at Buffalo would be electrically served by the microgrid in both normal and islanded operation. During islanded operation - and not until the microgrid is adequately stabilized in serving Group 1, the microgrid could additionally serve the Group 2 buildings of Cleveland Biolabs as well as portions of the adjacent Fruit Belt Neighborhood. While these Group 2 buildings are typically served by a different substation (Substation 34) than the Group 1 buildings (Elm Street Substation) during normal operation, their breakers could potentially be switched during islanded operation such that Substation 34 substation would also be islanded with the Group 1 facilities. This arrangement is further described within Task 2.

Also, of the remaining facilities that are served both in normal and islanded operation, the relative electric usage of each off taker of the microgrid may be manipulated during islanded operation in order to serve critical loads and ensure adequate balance between generation and load.

Question 7

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

It is expected that the microgrid SPE (as described in Question 46) will contract with specific customers (described in Question 3) for the sale of electricity and thermal energy. Possible option invested are shown in Figure 3-1. The contract for the sale of energy is contemplated to be a Power Purchase Agreement (PPA), or a similar arrangement, whereby the microgrid LLC agrees to provide energy supply and the aforementioned customer(s) agree(s) to purchase a certain quantity of energy (electric or thermal). In this way, the microgrid would act in a similar capacity as a small utility through setting “rate-like” cost allocations that its customers would agree to pay in both normal and islanded operation.

Regardless of the owner or the form of agreement, it is important that the contract clearly delineate the rights and responsibilities of each party, and ensure that the projects costs and revenues are defined, quantified, and secured. The agreements will need to address how much each customer is expected to receive and pay and the mechanisms by which the energy is delivered and metered (as described in Question 37). This would be addressed through one or more agreements between the customers of the microgrid (primarily Campus member institutions and National Grid) and the microgrid controller administration (as described in Question 5).

It should also be noted that the microgrid's point of interconnection will also dictate the type(s) of contracts required. In particular, the agreements will need to address how the member institutions will receive the energy and/or credits for the purchase and how the payment for the delivered amount will be split between each of the customers. The current working plan is to install a new master meter for the Campus such that the microgrid is behind-the-meter of the Campus, but not necessarily each of the facilities. In this way, the Campus microgrid controller will be able to control all activity of the microgrid behind its meter. Also as such, additional permits and contracts would be required from National Grid to allow the microgrid to use National Grid-owned distribution infrastructure that will now be located behind-the-meter and within the Campus.

Whichever the interconnection and metering arrangement is, BNMC will need to closely coordinate its plans with National Grid to ensure that the agreement complies with all applicable regulations. As the distribution utility, National Grid must treat any purchased power as a pass-through to its customers such that its customers do not pay any premium cost that other customers do not pay. Some options for contracting may include negotiated rates for the power (which is expected to be the same for normal and islanded operation) or, simply, National Grid purchasing the excess generation at the basic service or wholesale rates.

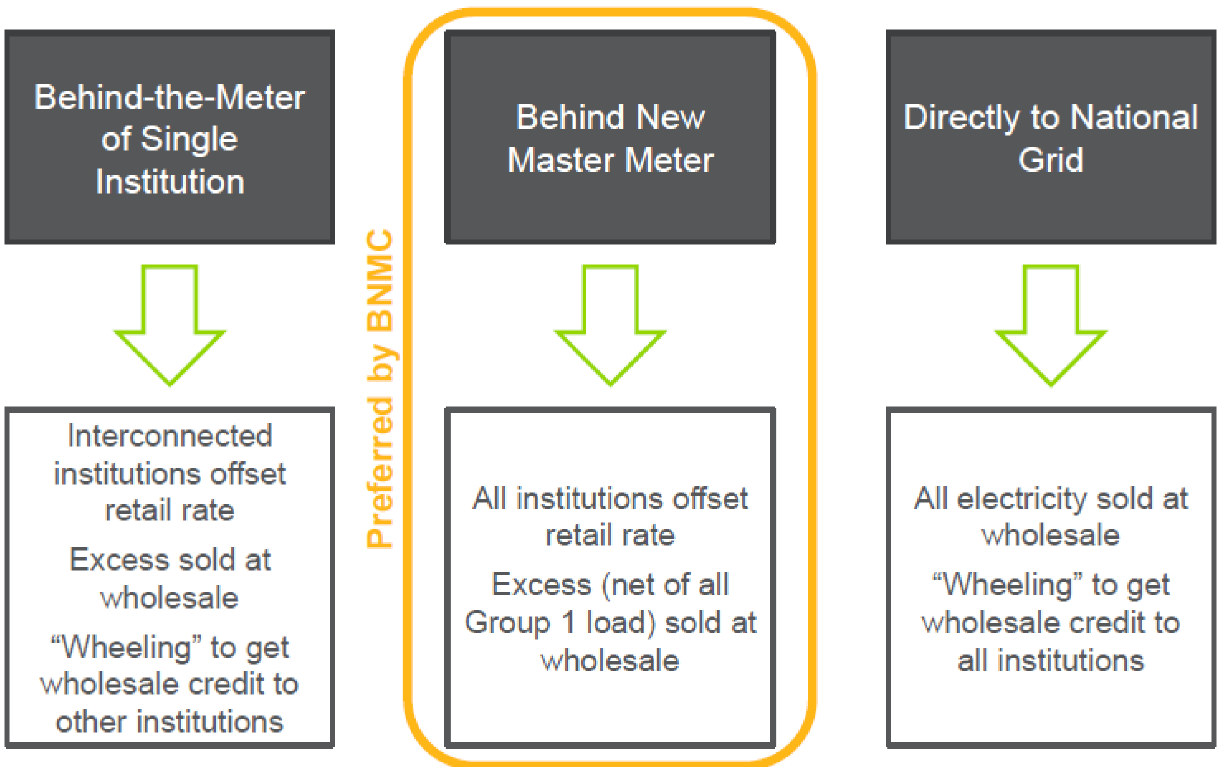

Figure 3.1. Technical Implications of Commercial and Financial Structures

Question 8

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

As described in Question 3, there are three main groups of customers potentially served by the microgrid: the BNMC member institutions, Cleveland Biolabs (islanded only), other National Grid customers, and the NYISO.

For the Campus member institutions, the BNMC, Inc. is in the process of conducting several studies related to this microgrid project, including this NY Prize feasibility study. The technical analysis that has been conducted to-date has served to inform the BNMC, Inc. and the feasibility study team as to what is technically feasible. The team has subsequently outlined possible strategies to accomplish the objectives of the proposed microgrid and will compare the economic and non-economic (e.g. resiliency) costs and benefits of each. Upon conclusion, the BNMC, Inc. plans to present the team's findings and recommendations to the executive teams of its member institutions.

As National Grid is currently part of the project team assessing the feasibility of this microgrid, including contractual arrangements, their potential relationship as a primary customer of the microgrid has begun to be explored. To the extent that additional conversations are required with other National Grid stakeholders, it is expected that the National Grid project team members will lead these discussions.

Finally, for the NYISO as a customer, the microgrid controller operator (or other identified project fiduciary) will be responsible for following the prescribed steps necessary to apply for and participate in wholesale market opportunities.

Question 9

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

The current microgrid design includes a combined heat and power plant which will generate steam for use by the Campus member institutions (primarily Roswell Park Cancer Institute and Kaleida Health). Chilled water was also considered in design but was deemed uneconomical.

Task 3.2 Commercial Viability - Value Proposition

Question 10

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

The larger community is expected to residually benefit from the BNMC member institutions meeting their energy needs, both in normal and islanded operation, more efficiently.

In normal operation, the microgrid controller will utilize economic optimization to generate additional revenue and/or savings for the Campus collectively, ensure that other critical Campus needs, such as power quality, are maintained, and provide an added layer of redundancy and reliability. The economic optimization will net back to Campus member institutions additional funds that could be invested in their existing and future facilities and other initiatives. Also, with the microgrid in operation, Campus facilities will better operate at peak performance with a second set of redundancy.

Through its improved economic and electrical performance supported by the microgrid, the Campus member institutions will be better able to serve their community as medical facilities. Similarly, if there is a widespread power outage, the Campus would be a candidate to serve as a shelter for the local community as a result of this microgrid.

The community may also benefit indirectly from the project itself, in addition to the benefit accrued through the Campus. To the extent that the project uses more efficient – rather than conventional - CHP technology and/or renewable energy, overall emissions may be reduced. Also, the construction of the project may induce local economic development, including job creation, both during construction and once the microgrid is operational.

Finally the community may also benefit indirectly as a result of the microgrid support the local electrical grid. First, it can strengthen the central grid and provide relief to strained systems during periods of high electricity demand. Also, it may enhance community economics in several ways including attracting new businesses or reducing or delaying infrastructure investment (costs), both of which are especially in this digital age where power quality and reliability are key elements in growth. Finally, advanced software and control capabilities with access to multiple sources of power generation can help in the deployment of renewable energy because there with less risk due to the variability of their output (as compared to installations without such controls).

During the construction and operation of the project, the local community may experience some indirect costs. For example, during construction, the community may be subject to noise and/or other disruptions caused by the construction. Also, while CHP may have less overall emissions than conventional power plants, local Campus generation may create a local source point of emissions that previously did not exist.

Question 11

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

This project is expected to provide some benefit to National Grid, but it may also require some cost. The possible direct benefits to the utility's operations include deferral of future capital investment, the ability to provide additional reliability and resiliency to its customers, and/or load/DG aggregation. In the case of capital deferral, the utility or NYISO may be able to defer investment in additional generation sources (especially in the case where some coal plants may be retired) and/or transmission and distribution to this area through its support of customer distributed energy investment. Also, in terms of reliability and resiliency, by adding another layer of redundancy, National Grid can be assured that in the case of a catastrophic outage, the BNMC microgrid would be too able to self-serve its needs. Finally, as the microgrid is expected to be located behind a new master meter, it will be the microgrid's responsibility to balance load and generation, thus providing only a single metering point on National Grid's distribution system.

The project may also provide some indirect benefits to National Grid. For example, the project is expected to inform National Grid as to what strategies and/or business model could be can used to deploy similar projects in other areas within its electric service territory. Similarly, by participating in this project, National Grid will be seen as an innovator in these areas as well as a source for technical services and support to other customers who are seeking to deploy similar types of projects. Finally, National Grid's support of such projects helps to foster good will between the utility, its customers, and its regulators and to improve overall customer satisfaction.

With respect to costs, the level of financial investment by National Grid will be determined by which parts of the microgrid National Grid will own as well as how much excess generation will be delivered from the microgrid to National Grid. Throughout the microgrid's development and construction, National Grid will also be asked to leverage staff support to help assess the microgrid's design and to provide guidance on regulatory issues.

Question 12

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

The business model for this microgrid hinges on capturing a level of economic benefit and payback during normal "blue sky" operations that generates a return for the collective Campus, as well as individual member institutions, on investments made in generation and microgrid assets, such as system upgrades, controls, communications and infrastructure.

For the microgrid project to be commercially viable, it must provide a positive value proposition to its customers and stakeholders. Similarly, to be financially viable, the business model for the microgrid must generate enough revenue to cover all operating costs, pay back any debt capital and still provide an acceptable risk-adjusted return to asset owners and financial investors. In the case of this microgrid, the interests of the customers and owners are aligned, as they are one in the same. The member institutions' shared objective is to design the microgrid such that it can provide savings during blue sky operations but also resiliency during islanding.

Similarly, the interests of the microgrid owner are aligned with National Grid's regulated mandate to serve its customers "at a just and reasonable cost". To ensure that the microgrid can be designed to ensure fair compensation to both the microgrid and National Grid for their respective value contributions to the project, some special permissions and/or changes in regulation may be required to allow for such a configuration and compensation model.

The following diagrams summarize the microgrid's business model. The first is a Community Resilient Microgrid Commercial Ecosystem diagram which depicts the various stakeholders, the roles they play, and the value exchanges between them. The business model's commercial and financial components are further outlined in the brown and green tables. Finally, the last table provides a SWOT analysis of the business model.

These below figures, taken together, illustrate the strength of the integrated strategy offered by proposed business model. The key components of the strategy include:

- Strong alignment of interests between load, asset owner, operator and distribution grid
- Pre-existing entity available to aggregate load, capital, liability, obligation, and asset operating control in order to optimize asset dispatch to meeting financial, reliability, resiliency, grid operation and other objectives
- Pre-existing infrastructure and assets leveraged to reduce capex
- Pre-existing operating and financial arrangements leveraged to reduce operating expense
- Pre-existing strategic relationship with distribution utility to optimize value creation and revenue
- Deployment of new assets with technology, configuration and operating control optimized for maximum overall benefit to owners, financiers, off-takers and distribution grid

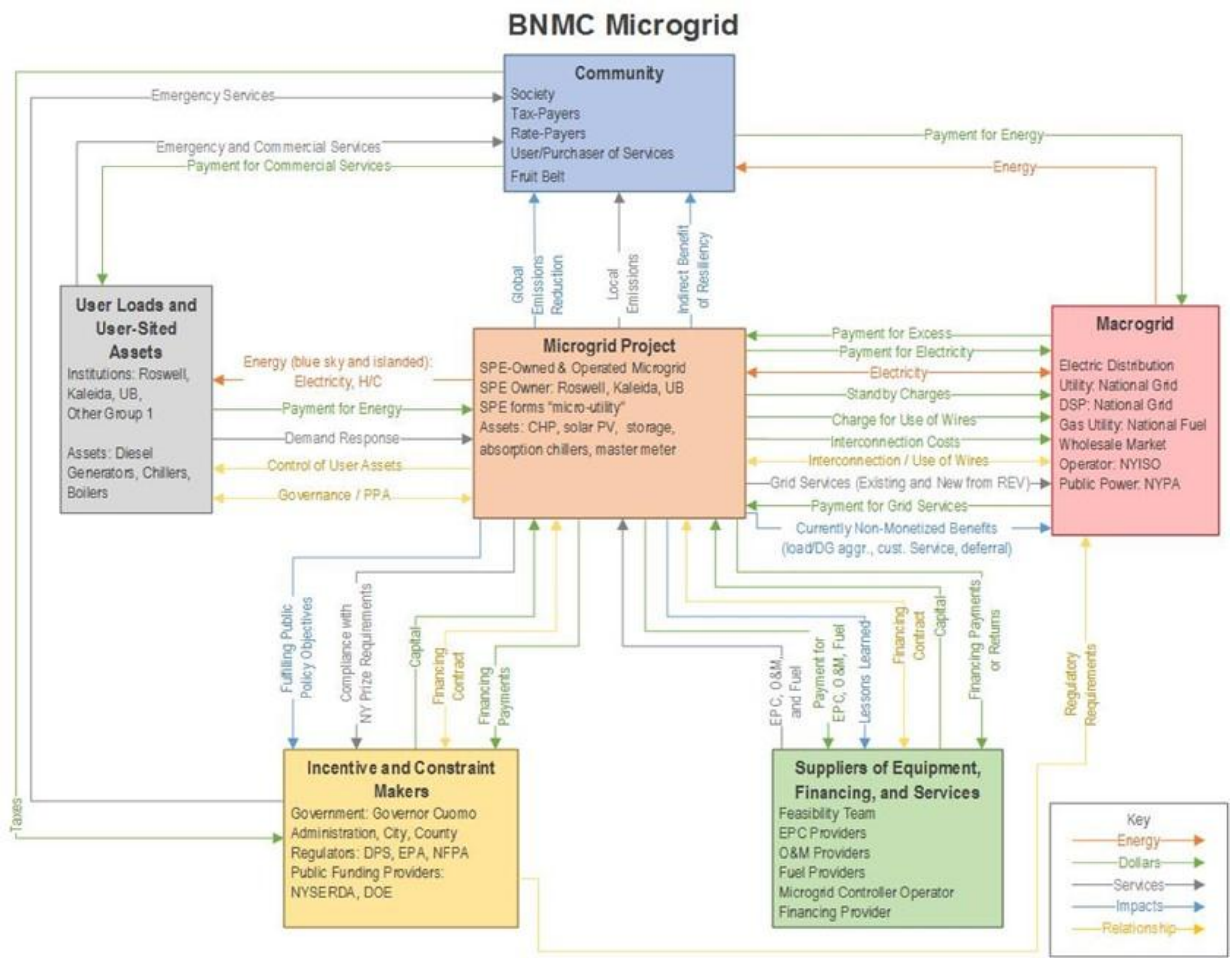

Figure 3.2. Commercial Ecosystem Diagram of BNMC Microgrid

		Team	Creating Value	Value Proposition	Delivering Value	Customer
Commercial	Stakeholders / Roles / Value Streams	*Current* • BNMC *(project lead)* • National Grid *(electric utility)* • National Fuel *(gas utility)* • EPRI *(electrical design, CBA)* • CDH *(CHP design)* • Navigant *(commercial/financial)* • Wendel *(technical advisor)* • UB *(technical advisor)* • E.Co *(comm/fin advisor)* • NYSERDA *(feasibility funder)* • DOE *(controller study funder)* *Future* • BNMC *(project lead, owner / administrator of microgrid SPE)* • Member Institutions *(investors in project)* • Others TBD	*Roles* • Owner of Microgrid: SPE owned by three largest institutions • Feasibility Assessor: *Current Team (left)* • EPC Provider: TBD • O&M Provider: TBD • Fuel Suppliers: National Fuel • Public Funding Provider: NYSERDA, DOE • Financing Provider: Roswell, Kaleida, UB, third-party financing *Value Streams to Create Value* • Feasibility Assessment, EPC and O&M Equipment and Services from providers • Fuel from fuel suppliers • Payment to electric utility and fuel suppliers for electricity, fuel, charges, fees and use of infrastructure • Capital to microgrid from public funding and financing providers • Financing payments and/or returns to financing providers • Contracts with all providers	*Needs / Wants* • BNMC: help meet energy plan and serve institution • Member Institutions: economic optimization during blue sky operation; improved resiliency for outage/islanding • Fruit Belt: electricity due to coincidentally sharing feeder • Community: access to facilities and services during outage and possible pass through of blue sky savings to fund other initiatives • Electric Utility: customer satisfaction, potentially investment deferral, and potential value under REV • Gas Utility: fixed costs spread over larger rate-base • NYISO: grid services such as demand response • NYSERDA: example of replicable/scalable microgrid • State Gov't / PSC: exemplifying of REV principles • Vendors: sales, experience and lessons learned from project	*Roles* • Controller: NOC Operator, specific entity TBD • Asset Manager: NOC operator and owner, specific entity TBD • Electric Utility: National Grid • Gas Utility: National Fuel • Wholesale Market Operator: NYISO • Public Power: NYPA *Value Streams to Deliver Value* • Energy • Grid Services • Impacts • Control of institutions assets and demand response • Payment to microgrid for energy and grid services • Contracts with customers for sale of energy and services and with utilities for interconnection and/or use of infrastructure	*Paying Customers of Microgrid* • Group 1 and 2 Member Institutions *(main customers in blue sky and islanded operation)* • National Grid *(as purchaser of excess generation and distribution grid services in blue sky and islanded operation)* • NYISO *(grid services in blue sky operation)* *Stakeholders* • Other member institutions • National Fuel and its customers • National Grid's customers, including, specifically, the Fruit Belt neighborhood • Local residents *(as beneficiary/customer of BNMC's institutions' services)* • City and County *(as providers of emergency services)* • PSC, State Gov't, NYSERDA, & DOE *(for policy and funding)* • Vendors *(who receive increased market penetration and experience)*
	Assessment	• Interest Alignment: team is cohesive with desired interests of seeing this project be a success • Qualifications: team has strong qualifications in all areas of feasibility assessment and design	• Securing Team: feasibility team is assembled, but team for future stages TBD • Next steps: engage member institutions as financiers • Incentives and Constraints: Regulatory approval, changes, or special agreements will be needed to allow master meter on campus and microgrid use of electric infrastructure	• Need Alignment: Many needs from the stakeholders are complimentary to one another which supports commercial viability • Value to Need Alignment: proposed value streams primarily support the value proposition to paying customers and, secondarily, other stakeholders	• Securing Customers: National Grid has been engaged, but other customers are only partially, if at all, aware of the project • Next steps: engage member institutions as customers, review existing and future grid services markets • Incentives and Constraints: Value delivery and monetization dependent on approval and/or changes in regulations	• Interest alignment: Under a master meter arrangement, the interest of the institutions can be met with minimal impact on National Grid. Also, minimal conflict between NYISO and National Grid for grid services • Contracts: Rate agreements with institutions; excess will be sold to National Grid at wholesale, maybe more in future; Grid services under NYISO and/or DSP programs

Figure 3.3. Commercial Components of BNMC Microgrid Business Model

		Capital	Costs	Revenue
Financial	Specific Value Streams	• Debt • Equity • Incentives *(e.g., NY Prize)*	• Equipment *(electric, thermal generation, storage, distribution, software, IT infrastructure)* • EPC *(design, engineering, procurement, integration, construction, installation)* • Professional Services *(legal, advisory)* • Fees *(permitting, interconnection, insurance)* • Energy *(fuel, electricity, standby power, wheeling)* • O&M Fees *(hardware, software, fixed, variable)* • Financial *(debt/equity, depreciation, taxes, insurance)* • Service Fees *(legal, advisory, IT, aggregation)* • Contract Fees *(e.g., penalties for non-compliance)* • Property *(rent, mortgage)* • Taxes *(property, income, sales)*	• Electricity Revenue *(grid, off-takers)* • Thermal Energy Revenue *(grid, off-takers)* • Grid Services *(FR, capacity, DR, backup/island power)* • Future Monetized Grid Services *(customer service, load aggregation, load smoothing)* • RECS, Emissions Allowances, Net Metering Credits • Service Fees *(development, aggregation)*
	Support	• Capital Access and Agreements • Financing Agreement • Ownership Agreement • Incentives Agreements	• Supplier Contracts & Warranties • Service Contracts *(e.g., O&M)* • Interconnection Agreement • Bilateral/Miultilateral Offtake Agreements • Ownership Agreement • Rate Tariffs • Regulations *(public utilities, environmental, safety)* • Permits *(environmental, land, building, local, electrical)*	• Bilateral/Multilateral Offtake Agreements *(e.g., PPA)* • Contracts, Permits, and Bids for ad hoc Energy & Services *(e.g., FR, RECS)* • Ownership Agreement • Rate Tariffs • Regulations *(public utilities, environmental, safety)*

Figure 3.4. Financial Components of BNMC Microgrid Business Model

Table 3-1. Summary Table

Strengths	**Weaknesses**
• Private customers, who can "move at the speed of business," resulting in cost and time savings; • Complimentary interests between team members; • Complimentary needs and wants between customers and stakeholders; • Existing BNMC governance structure allows the BNMC, Inc. to represent the Campus member institutions and undertake the complex contracting required between owners, off-takers, investors and the connected grid; • Existing electrical and thermal infrastructure for use by the microgrid helps minimize installed costs; • CHP offers favorable economics to the member institutions, with or without islanding capabilities; • Microgrid will act as aggregator of all load and generation and be balanced by microgrid controller thereby providing load management at the nodal level that will benefit the future DSP	• Financials are not verified and dependent on negotiated rate agreements with member institutions; • Master meter arrangement and associated value exchanges between BNMC and National Grid will require regulatory and/or legislative change to implement and ensure fair compensation; • Excess generation delivered to National Grid from master meter is only sold at wholesale rate (under current rules); • BNMC (or a hired entity) has yet to define rates and contracts with each member institution
Opportunities	**Threats**
• The microgrid could serve as a replicable, scalable model for other medical campuses; • Revenue from National Grid and/or DSP from the provision of new grid services as a result of REV (such as load/DER aggregation, load smoothing); • National Grid may be able to defer future capital investments due to microgrid; • Opportunity to island entire feeder and, if in instances where there is excess generation, sell electricity to National Grid to serve portions of the Fruit Belt Neighborhood that share the same feeder	• Since this is only a feasibility-level analysis, additional details will emerge and need to be assessed in the detailed design phase; • Special approvals and/or changes in regulations may not occur or be unfavorable to the desired arrangement; • Specific institutions may not agree to terms and conditions explored in this study; • Member institutions may not agree to relinquish control of their energy assets to the microgrid controller

Question 13

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

The site for this project is much like many other hospitals and medical campuses within the State—i.e. a collection of independent buildings and owners located within a geographically contiguous site, all served by a common single substation, and located in an urban environment with limited space for additional energy asset development. Similar sites would also be any area where there are multiple institutions (large building loads) that are geographically proximate neighbors but do not share facilities. One specific example of another project that has been done on a similar site is the Utica Burrstone microgrid, which includes St. Luke's hospital, a nursing home and Utica college. As such, the site for this proposed project at BNMC, as a medical campus, is not particularly unique and, thus, provides for a replicable design in other similar areas.

There are aspects of the site that are unique and may provide an advantage to this microgrid project. The first is that the Campus has an existing thermal loop system which allows for easy distribution of the thermal energy to be generated by CHP. Similarly, the existing electrical infrastructure is underground which is far more resilient than above-ground wires. Because this infrastructure is pre-existing, this project would be up-and-running in a shorter timeframe and at a comparatively lesser cost.

Also, though not specific to the physical attributes of the site, the fact that the BNMC, Inc. acts as an umbrella organization for the member institutions helps to provide a single point of contact and administration for the project and is expected to help in the future development of agreements for microgrid ownership and energy sales. This also facilitates a replicable business model in which several urban entities are able to come together and build a project of this scale.

Of the technology selections being assessed and considered for this project, many of the technologies have been installed, demonstrated, and proven previously. This includes the proposed generating assets (CHP and renewable generation), metering infrastructure, and distribution assets. In this way, any new technology risk is minimized.

The one area of technology that will be new for this project is the controls. The microgrid controller will act as a local controller to manage assets within the microgrid and communicate with other devises, such as smart inverters. During its operation, the microgrid controller will serve to aggregate all of the Campus-based DER assets to balance energy supply and demand and improve the utilization of DERs (i.e., solar forecasting). This dispatch optimization, islanding and resynchronization will also aid in balancing voltage and current.

Questions 12 and 14 also provide additional descriptions of how this project will promote new technologies and business models in part by leveraging the unique characteristics of the site and planned technology deployment. It is this combination of unique technology and site characteristics, deployment approach and business and commercial model innovation together that provides a valuable and potentially replicable microgrid deployment strategy.

Question 14

What makes this project replicable? Scalable?

The project is replicable for other similar sites, customers, technologies and development teams. First, the project site and customers are similar to other campuses across the State and beyond, as described in Question 13. Secondly, as also described in Question 13, this microgrid uses proven generation asset and distribution technologies. The only new technology to be used in the system is the controller, though the controller in-and-of-itself will be designed to be replicable in other projects regardless of the number of inputs or dispatch scenarios. Finally, this project is being developed through a process and with a team which may be replicated on any other microgrid or DER project. The process will define the appropriate sequence of steps such that risks and opportunities are identified and addressed in a timely manner. This process also includes having a strong team of subject matter experts and a single coordinating entity, the BNMC, Inc., which acts on behalf of the customers.

While all microgrids are by their nature unique to the specific place and case context in which they are developed (including such on the ground particulars as legacy assets, technology and infrastructure, nodal location within the distribution grid, pre-existing relationships between and among asset owners, off-taker customers, load taking facilities and distribution utility, and the various commercial, financial and operating interests of the project's various stakeholders, to name a few), there are higher-level themes and approaches that can be directly replicable to other similarly situated but still unique projects. For this BNMC project, there are several tangible elements of replicability. These include:

- The use of a centralized business entity to house off-taker, finance, ownership and distribution grid obligation contracts can be used in any circumstance where multiple entities wish to jointly develop common assets and operations;
- The development of a close, strategic relationship, governed by an MOU, between this centralized business entity and distribution utility is a mutually beneficial channel through which value can be optimally created and fairly compensated while cutting through traditional bureaucracy, red-tape and organizational silos that often hinders development on both sides of the meter.
- The development of a grid services arrangement at the nodal level to benefit the future DSO is an innovative, yet copy-able design element of potentially great value if widely replicated across each DSO network
- The use of a centralized network operations center to operate and optimize assets owned by multiple entities to achieve complex and time varying dispatch objectives for maximum economic, environmental, reliability, resiliency and grid stability benefit in

general terms can be replicated to any collection of assets in a campus or community setting

- The formation and use of a cross-functional, cross-entity development team to align interests and optimize around the myriad design objectives and constraints is a potential best practice replicable across all projects generally
- The identification and leveraging of pre-existing sources of value including legacy generation assets, distribution infrastructure, and thermal loads is another best practice replicable across projects with similar such legacy value sources.

The project is scalable both within this project as well as in other future projects. For this study, the project is contemplating that the microgrid will serve the Campus and the feeder to which it is interconnected. It is also being contemplated, however, that the microgrid scope could be expanded to also serve other neighboring areas and, potentially, larger Buffalo. This in-project scalability will be dependent on the technical feasibility of a larger project as well as the agreements that would be needed between the microgrid project, National Grid, and the City of Buffalo. Similarly, a larger project scope could be envisioned on other campuses that have more available space and funding for larger projects. In this respect, project scalability is more of a function of project-specific technical feasibility, financial appetite, and commercial complexity rather than limitations of the technology specifically.

Question 15

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

The primary purposes for this project are resiliency in islanded operation and economic optimization and value creation during normal “blue sky” operation. Because the facilities served by this microgrid are medical facilities and research centers, it is important that they maintain power and high power quality at all times. Similarly, in order to ensure that the project is financially viable and that potential investors make the necessary investments to secure this project, the microgrid is designed to also operate during non-islanded times to provide additional revenue and savings to the project. Blue-sky optimization through operations, controls and communication will provide load aggregation and high energy utilization thus ensuring that the project operates as economically as possible. Through installing this microgrid, the member institutions will be able to have an extra layer of reliability and resiliency to meet their needs and thus encourage investment.

While this area of the electric distribution grid currently does not have pronounced reliability issues, it remains important to the Campus member institutions to ensure a high level of local reliability. One such example of a type of weather event that could cause such a problem is an ice storm or any other system event that could disable the transmission lines that feed this area. If that were to occur, the local distribution equipment installed for reliability and resiliency would be severely compromised. Conversely, with the proposed microgrid operational, it would be able to serve Campus facilities in their daily operations as well as potentially provide shelter to others that have lost power. Assuming that the Campus' gas supply is not interrupted during such an event, this microgrid could provide power at 65% of peak load indefinitely, and full peak load for 15 days with gas and diesel fuel sources. Refer to Question 9.

Question 16

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

The following table summarizing the value proposition to each customer and stakeholder, as further described in the other responses within Task 3.

Table 3-2 Value Propositions for Different Stakeholders

Customer / Stakeholder	Value Proposition
BNMC, Inc.	By supporting, leading, and investing in the development of this microgrid project, BNMC, Inc. is able to help meet the needs of its member institutions and their jointly shared energy plan.
Member Institutions	By investing in and contracting with the microgrid project, the member institutions will be able to generate new revenues and savings as well as secure vital energy resources and power quality that are needed during grid outages.
Fruit Belt Neighborhood	By supporting the development of the microgrid project, the Fruit Belt neighborhood may benefit from excess electricity generated by the microgrid and delivered to National Grid such that portions of the Neighborhood may be powered during a grid outage.
National Grid	By supporting the development and operation of the microgrid project, National Grid will help the BNMC, Inc. and its member institutions achieve their project objectives, help to potentially defer future grid investments, and gain from lessons learned that may be used to inform/support other projects in the future.
National Fuel	By supplying gas to the microgrid CHP plant, National Fuel will gain a large new customer.
NYISO	By receiving grid services from the microgrid (including demand response, capacity or other), NYISO will be able to utilize the microgrid as an additional resource to support their grid operations, including potentially reducing congestion or deferring transmission and/or generation upgrades.
Local Community (City of Buffalo)	By supporting the microgrid project, the local community will indirectly receive benefits of the project that accrue to the BNMC member institutions as well as potentially utilizing Campus facilities in the case of a severe grid outage.
Broader Community (County, State, Society-at-Large)	By indirectly funding and benefiting from the microgrid project, the broader community and society supports policy objectives of REV: 1) increased customer knowledge; 2) market animation; 3) system wide efficiency; 4) fuel

	and resource diversity; 5) System reliability and resilience and 6) reducing carbon emissions. Key learnings from the project will support the foundation for other microgrids throughout New York State and beyond.

Question 17

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

The following table described the new revenue, savings and cost streams that each of the microgrid's customers will receive. These value streams are also depicted in the following Ecosystem Diagram in Question 12.

For this analysis, we distinguish between the member institutions as customers/purchasers of energy from a third party microgrid special purpose entity (SPE) and the owner of or investors in the microgrid SPE (which could also be one or several member institutions). As such, this table represents revenue, savings, and costs realized by the member institutions as customers/purchasers. Under this structure, the microgrid SPE will realize additional revenue from blue sky optimization, such as revenue from participation in wholesale markets, which are then used to "buy down" the investment so that the microgrid SPE may offer its customers a lower rate for electricity sold.

Table 3-3 Additional Value Streams

Customer	**Value Stream**	**Basis**	**Revenue / Savings / Cost?**
Member Institutions Served by Microgrid	Payment for energy (thermal and electric, including any volumetric, demand or other charges imposed by microgrid SPE) from microgrid versus utilities	Rate to be negotiated	Savings
Member Institutions	Revenue from customers (i.e. patients/insurance) during islanded operations	Rates charged for services during islanded operation	Revenue
National Grid	Standby charges	Per tariffs	Revenue
National Grid	Payment for use of wires	Rate to be negotiated	Revenue
National Grid	Interconnection fees and costs	Per tariffs, based on required upgrade costs	Revenue
National Grid	Payment for excess electricity	Wholesale electricity rates (under current rules)	Cost
National Grid	Reduction in volumetric	Retail rate times load	Loss of revenue

	energy payment	now served by microgrid	
National Grid	Removal of future payments for infrastructure upgrades	Based on required upgrade costs	Savings
National Grid	Payment for grid services (TBD)	Value of service	Costs
NYISO	Payment for grid services (demand response, capacity)	Market price	Costs

Question 18

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

Though the analysis for this report is specifically designed and conducted to address the objectives of NY Prize, it is also indirectly addresses other state policy objectives including those of REV such that NY Prize is a program within REV. Since REV is the overarching policy vehicle for all State energy-related policies, this microgrid project addresses multiple REV goals, as described in the following table.

Table 3-4 Potential to Promote State Policy Objectives

NY REV Goal	How This Project Supports the Goal
Making energy more affordable for all New Yorkers	This project will help Campus member institutions of BNMC have more affordable energy via savings and new revenue streams. This project could also help make energy more affordable for National Grid's customers to the extent that it can help defer other infrastructure investment.
Building a more resilient energy system	The microgrid's primary purpose is to provide additional resiliency for the Campus member institutions and, as a result, also serve the local community.
Empowering New Yorkers to make informed energy choices	By providing additional monitoring, insight and control of the load and generation within the microgrid, the Campus member institutions are able to make more informed decisions about how to dispatch their inventory of DERs. This project may also encourage DER deployment by Campus member institutions and/or community.
Creating new jobs and business opportunities	This microgrid project will create local development and construction jobs as well as invite new business and investment opportunities for entities and organizations in and outside of the State.
Improving our existing initiatives and infrastructure	By providing feedback to the State and National Grid regarding this projects and lessons learned from its

	development, existing energy initiatives can be improved and areas for infrastructure improvement can be identified.
Supporting cleaner transportation	While clean transportation is not a direct focus of this project, it is contemplated that the microgrid infrastructure may enable additional EV charging stations to be installed on the Campus.
Cutting greenhouse gas emissions by 80% by 2050	By employing energy efficient-CHP and renewable energy resources, both of which will reduce the Campus' dependence on diesel back-up generation for resiliency, this microgrid project will help reduce greenhouse gas emissions from conventional power sources.
Protecting New York's natural resources	To the extent that this projects helps to reduce greenhouse gas emission, it may help in combating climate change and thus indirectly helping to protect natural resources
Helping clean energy innovation grow	This project will be a new, innovative development for both the BNMC as well as National Grid. The lessons learned from this project will help to encourage additional innovation on other future projects.

Question 19

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

While most of the technologies considered within this microgrid's project scope have been proven and used elsewhere (see Question 13), the application, dispatch and control of the technology in different scenarios and configurations is what is new for this project. In the case of battery storage, this commercialized technology is being analyzed by this study to determine how the battery should best be used within the microgrid's configuration.

The newest technology to be used and promoted through this project is the microgrid controller, as described in Question 13. This controller will be integral in designing and selecting the dispatch mode that will achieve the best project economics while meeting the critical needs of the Campus.

Questions 12 and 14 also provide additional descriptions of how this project will promote new technologies and business models in part by leveraging the unique characteristics of the site and planned technology deployment. It is this combination of unique technology and site characteristics, deployment approach and business and commercial model innovation together that provides a valuable and potentially replicable microgrid deployment strategy.

Task 3.3 Commercial Viability - Project Team

Question 20

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

The local municipal government, i.e. the City of Buffalo, provided a Letters of Support for this project during the application phase and it continues to support the development of this project. The BNMC, Inc. project manager meets regularly with his peers at the City and County levels to ensure that this project is aligned with other area initiatives. Similarly, many of the team members on this project are also supporting the City of Buffalo's microgrid project.

National Grid engages regularly with community groups and its local customers and will share the details of this project as needed and appropriate.

Question 21

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

The following diagram table describes the current and future team as well as their role in the development up until this point and potential roles they may play in future development, construction and operation of the project. Current and known future roles are identified in plain font while contemplated (but not yet agreed upon or contracted) roles are identified in brackets and italic.

Table 3-5 Role of Individual Team Members

Team Member	**Current Development Role**
BNMC, Inc.	Lead, project manager, and advisor; Representative of institutions
EPRI	Consultant evaluating electrical, communications, and controls design feasibility
CDH Energy	Consultant evaluating thermal design feasibility
Navigant Consulting	Consultant evaluating commercial and financial feasibility
National Grid	Advisor on electric interconnection and regulatory issues
National Fuel Gas	Advisor on gas supply issues
Wendel	Advisor on local issues and design
Campus Member Institutions	Represented by BNMC, Inc.
Fruit Belt Neighborhood	Represented by National Grid team members

The following diagram depicts the proposed structure for the design phase of the project.

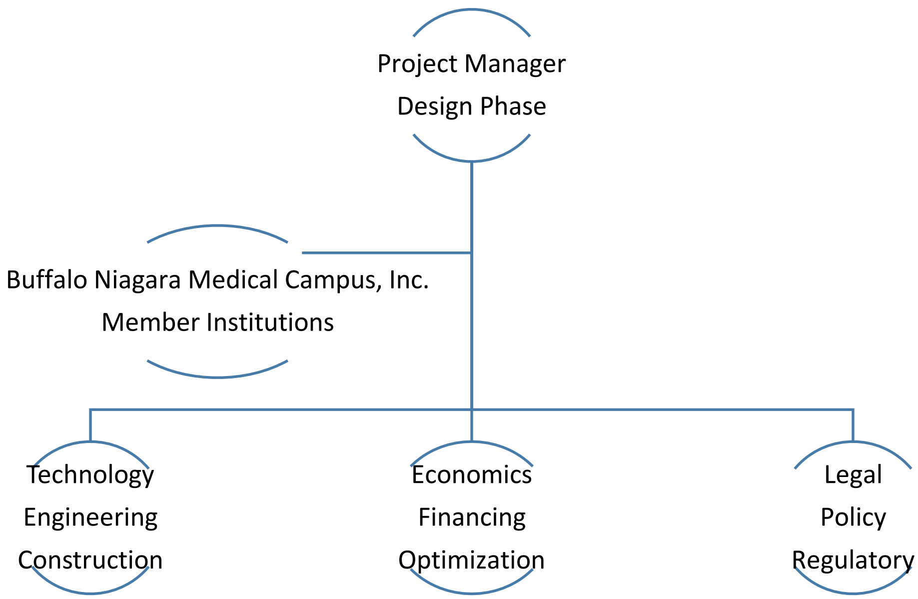

Figure 3.5. Proposed Structure of the BNMC Project During Design Phase

The following list identifies committed and potential partners, technical advisors and subject matter experts who will drive, own, support and contribute to the three focus areas described above.

- Buffalo Niagara Medical Campus, Inc.
  - Kaleida Health
  - Roswell Park Cancer Institute
  - State University of New York at Buffalo
- Electric Power Research Institute (EPRI)
- Gas Technology Institute (GTI)
- Navigant
- CDH Energy (as a subsidiary of GTI)
- National Grid
- National Fuel Gas
- Schneider Electric
- General Electric
- US Grid Co
- EKO Capital
- Wendel Companies
- New York Power Authority (NYPA)
- C Power
- State University of New York at Buffalo - School of Engineering

Question 22

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

The BNMC microgrid project has earned support from several local public offices, as described in Question 20. It is expected that this public support will continue to the extent that this project serves the local community.

Additionally, this project will use public funding, to the extent available, to support the development and construction of the project.

Question 23

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

The following links provide information on the financial strength of the member institutions which are proposed to own the microgrid.

Roswell Park Annual Report

University at Buffalo At A Glance

Overview of Financial Activities University at Buffalo 2013 -14

We Are Kaleida Health

Question 24

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

The following table summarizes the qualifications for the existing team members.

Table 3-6 Team Members Qualifications

Team Member	**Relevant Qualifications**
BNMC, Inc.	The Buffalo Niagara Medical Campus, Inc. (BNMC Inc.) is a self-sustaining social enterprise successfully combining innovation, job creation, and urban revitalization. The BNMC Inc. serves as the umbrella organization of the anchor institutions that make up the Buffalo Niagara Medical Campus located within a 120-acre campus bordering Allentown, the Fruit Belt and Downtown Buffalo. The BNMC Inc. fosters conversation and collaboration among its member institutions, its partners and the community to address critical issues impacting them including energy, entrepreneurship, access and transportation, workforce and procurement, neighborhoods, and healthy communities. As part of that work, the BNMC Inc., its member institutions, the surrounding neighborhoods and other key stakeholders partnered to develop an *Energy Innovation Plan* that supports economic development and growth in the Greater Buffalo Niagara Region. The *Plan* integrates energy efficiency, grid modernization, alternative transportation and renewable energy to foster a sustainable, growing community. Elements of that plan focus on developing the Campus and surrounding areas as a self-sustainable energy hub able to offset utility outages or natural disasters through enhancing reliability and resiliency. That would also empower the Campus member institutions to optimize their priorities with respect to reliability, cost and sustainability while actively coordinating their distributed energy resources in a market that compensates them for providing system benefits.
National Grid	National Grid USA is a global energy company with transmission and distribution networks which serve over 3.4 million customers in New York, Massachusetts and Rhode Island. They currently own and operate 4.6 MW's of solar generation in Massachusetts. Recently National Grid and the BNMC partnered to develop an *Energy Innovation Plan* to support growth in the region. The plan is focused on securing current and future Campus, as well as adjoining community, energy needs in a leadership role that demonstrates innovation as the Campus grows both physically and in terms of its impact to overall regional development.
National Fuel Gas Distribution Corporation	National Fuel Gas Distribution Company is an integrated energy company with $7.1 billion in assets, including the following five operating segments: Exploration and Production, Pipeline and Storage, Gathering, Utility, and Energy Marketing. Its Utility segment, National Fuel Gas Distribution Corporation, sells or transports natural gas to more than 727,000 customers through a local distribution system located in Western New York and Northwestern Pennsylvania.
EPRI	EPRI conducts research and development relating to the generation, delivery and use of electricity for the benefit of the public. An independent, nonprofit organization, EPRI brings together its scientists and engineers as well as experts from academia and industry to help address challenges in electricity, including reliability, efficiency, affordability,

	health, safety, and the environment. EPRI also provides technology, policy, and economic analyses to drive long-range research and development planning, and supports research in emerging technologies. EPRI members represent 90% of the electric utility revenue in the United States with international participation in 35 countries. EPRI has been a leader and contributor in several industry wide efforts to support the integration of variable and distributed resources with planning and operations of the grid at all levels. EPRI brings 1) Thought Leadership in identifying issues, technology gaps and broader needs of the industry, 2) Industry Expertise to address these issues and gaps and 3) Collaborative Approach to include utilities, the broad technical community and other stakeholders to develop and implement new technologies and solutions. As part of its thought leadership for the future, EPRI initiated its Integrated Grid Research in a three-phase initiative to provide stakeholders with information and tools that is integral to our collaboration and very much aligned with the REV objectives. The development of a consistent framework supported by data from a global technology demonstration and modeling program will support cost effective, prudent investments to modernize the grid and the effective, large-scale integration of DER into the power system. Also, the development of a large collaborative of stakeholders will help the industry move in a consistent direction to achieve an Integrated Grid. In addition to its national and international research, EPRI has conducted numerous research projects specific to New York and New York utilities. EPRI has a working knowledge of the REV proceedings and is participating on numerous task forces and projects for the DPS, NYSERDA and utilities associated with the REV proceedings. EPRI has been actively engaged in research supporting REV activities for the DPS, NYSERDA, Joint Utilities and individual utilities from REV's inception. EPRI continues to support Con Edison in its non wires alternative project for the Brooklyn Queens Demand Management project (BQDM). EPRI is also working with Con Edison and other utilities on advanced modeling case studies for both hosting capacity assessments and locational value of distributed resources.
CDH Energy Corp.	CDH Energy Corp. is an energy consulting firm located in Cazenovia, New York that specializes in the evaluation of energy technologies. With 20 years of experience performing energy consulting work for a range of government, commercial, and industrial clients, CDH has broad experience evaluating the technical and economic impact of energy-related improvement and new technologies in residential, commercial, institutional and industrial applications. A core area of expertise at CDH includes combined heat and power (CHP) and distributed generation (DG). CDH has a long history collecting detailed, field-monitored data to quantify the performance of these systems in actual building applications. CDH analyzes these data to evaluate the efficacy of new technologies, evaluate performance of

	systems to prove compliance for incentive programs, and identify ways to improve or optimize the performance of existing systems. CDH has completed numerous feasibility studies to assess the economic and technical potential of CHP at specific customer facilities; completing detailed hour-by-hour annual analysis to consider seasonal variations in buildings loads and equipment performance as well as the impact that electric standby rates have on electric savings and project economics. CDH has already worked on CHP projects in New York State that serve multiple entities electrically and thermally. Since 2009, CDH developed and has been operating an automated dispatch system at Burrstone that integrates facility performance data, hourly utility pricing, and NYISO export pricing to select the most cost-effective operating scenario for each hour. The 3,600 kW system has four engines serving 3 facilities on different utility rates. CDH also worked with OBG in 2014 to assess the potential of CHP on the SUNY Albany campus. The campus uses high temperature water and is fed by 6 redundant feeders from the nearby OGS substation. CDH looked at CHP options to meet thermal loads and inject power back into multiple 13.2 kV feeders or backfeed power into the substation to offset other loads on this shared substation. Blackstart options were also considered to supply feeders to the residential areas in the event of a power outage.
Navigant	Navigant is a specialized, independent consulting firm combining deep industry expertise and integrated solutions to assist companies in enhancing stakeholder value, improving operations, and addressing conflict, performance, and risk related challenges. Navigant's energy practice is comprised of over 450 professional staff that includes technology experts, mechanical and electrical engineers, project managers, project developers, economists, natural resource scientists, regulatory and public policy strategists, environmental permitting and compliance specialists, air quality modelers, and legislative and regulatory specialists, each of whom combines firsthand industry experience with his or her consulting expertise. Moreover, many of Navigant's consultants have held staff or management positions in utilities, government research labs, energy equipment manufacturers, financing companies, and diversified energy companies. This pool of talent enables Navigant to quickly assemble an interdisciplinary team capable of identifying efficient solutions to project assessment and development issues. Navigant has also provided support to NYSERDA to develop its commercial and financial viability assessment approach and information request requirements for NY Prize Task 3 requirements. Navigant advised NYSERDA on what information it should seek from each Stage 1, Feasibility Assessment awardee and why and how to use that information to assess each feasibility study report for potential design stage funding. However, NYSERDA has not disclosed its specific evaluation criteria to Navigant, and instead has positively encouraged Navigant to support feasibility study teams in order to help ensure NYSERDA receives high quality feasibility

	study reports.
Wendel	Wendel is a 75-year old professional services organization that is headquartered in Buffalo, NY. As a nationally recognized and award winning firm, Wendel is dedicated to the betterment of the communities and businesses it serves. Wendel provides integrated services that include architecture, engineering, energy management, project and construction management, commissioning, and grants and incentives services. In addition to design services, Wendel offers complete construction and project management services to developers, industrial and commercial clients. Offering a unique mix of knowledge, talent and project experience, Wendel delivers seamless transitions through the study, design and construction process. Wendel provides consulting services to clients who are as diverse as our range of services. Primary market sectors include healthcare, state and local government agencies and municipalities, private development, education, and public transportation. Wendel is committed to its clients, and it is shown through a history of top performance in their field. Collaborative partnerships are an important piece of Wendel's success. Wendel works closely with several State entities providing technical assistance, including National Grid, NYSERDA, and NYPA. Wendel has been a technical assistance consultant to NYSERDA since 1994, and continues to hold a variety of term contracts to support NYSERDA's energy initiatives. Under these programs, Wendel assisted over 500 public and private entities across the State. Wendel has also been qualified through the U.S. Department of Energy's List of Qualified Energy Services Companies.
The State University of New York at Buffalo	University at Buffalo is the largest of the state universities of New York. The University at Buffalo is poised to address the most complex environmental issues of our age with the launch of the UB RENEW (Research and Education in eNergy, Environment and Water) initiative. A campus-wide, multidisciplinary research institute - one of the largest initiatives launched by the university in recent history - RENEW reflects UB's commitment to the fundamental mission of a public research university: Bringing great minds together to meet critical challenges facing society. The University's strengths in the area of sustainability provide a concrete foundation for this ambitious institute, which will encourage the collaboration of the more than 100 faculty across 34 departments who are already engaged in sustainability-related research. The breadth and depth of their combined expertise places UB at the cutting edge of research and education focused on energy, environment and water, with the ultimate goal of unearthing innovative solutions to our most pressing global problems.

Question 25

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

Beyond the current team members described in Question 21 there are no other contractors or suppliers identified at this time. Furthermore, though the type of technologies for the microgrid have been evaluated and selected in this study, the BNMC, Inc. and project team have not yet made any definitive selection of equipment vendors.

The table in Question 21 also identified types of future team members that may be required. As project lead, the BNMC, Inc. will be responsible for selecting the team members with which it wants to engage. However, the BNMC Inc. may elect to assign project management responsibilities to another entity or team member, in which case the selection and contracting with the new team members would be the responsibility of the new project manager.

Question 26

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

It is currently contemplated that the primary financiers and investors in the project will be the three main member institutions of the BNMC (see Question 46). Since the BNMC, Inc. is the governing entity which acts on behalf of the member institution, the relationship between the applicant (BNMC, Inc.) and the institutions is very close. More specifically, each of the member institutions sits on the Board of the BNMC, Inc.

It is also contemplated that other entities may provide some investment in the project as well.

Other potential financiers and investors that are not currently part of the project team will be engaged as the opportunity presents itself and/or as is needed. For example, to the extent that government funds may be used to fund this project, the BNMC, Inc. team will seek and apply for those funds as they become available.

Question 27

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

At this stage in the project development, the legal and regulatory advisors are the consultants and other team members, to the extent that they can each speak to their area of expertise and experience. For example, EPRI and Navigant are providing support on regulatory issues that may arise given the project’s contemplated design. National Grid is also able to provide insight on issues that may arise from their prospective as the interconnecting utility and local, regulated distribution company. National Fuel Gas is providing insights on the CHP design and other design elements. These team members and their qualifications are described above in Question 24.

As the development and design of this project continues, additional legal and regulatory professionals may be required and engaged. This may include legal counsel for the Campus member institutions, the financiers (if outside BNMC), and National Grid. To the extent that any of these entities require additional services beyond those that they can provide for themselves, they will be responsible for engaging such support.

Task 3.4 Commercial Viability - Creating and Delivering Value

Question 28

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

EPRI and CDH have been the technical leads responsible for selecting the specific technologies to be employed in this microgrid.

The CHP is the "anchor" generating asset of the microgrid. The CHP generator equipment and size was selected to optimally serve the expected future thermal and electrical load profiles of the Campus. The selection achieves the greatest electrical and overall efficiencies and the highest annual cost savings when compared with other equipment.

Refer to Task 2 Question 7.

The following table summarizes the technologies selected and their associated benefits and challenges.

Table 3-7 Technologies Proposed for BNMC Microgrid

Technology / Resources	Benefit	Challenge
Diesel	Exist at each institution	Not grid paralleled High emissions
Electric chillers	High efficiency with economizer Exist at each institution	
Boilers	High efficiency Exist at each institution	
Gas Turbine with HRSG	Serves thermal and electrical needs on campus, good fit for both loads; Natural-gas fired, reliable energy source in grid outages; Efficient use of energy and cost-effective	Electrical interconnection issues (because of the size); To combine thermal loops, will need to put in additional connecting steam infrastructure
Solar at Fruit Belt w/ smart inverter	Green generation with voltage regulation support and advanced functions	Ideal set points Communication and interface with National Grid's DSO
Solar at institutions w/ smart inverters	Green generation with voltage regulation support and advanced functions	Ideal set points Communication and interface with National Grid's DSO
Electric storage (mixed use type)	Smooth power variability. Voltage support, ramp rate controls, and other grid market services	Cost Communication and interface
Microgrid Controller	Generation-load balance and resource optimization Centralized controls of assets	Communication and interface Connectivity with BEMS and protection devices and DERs
BEMS	Enable demand response, load monitoring	Does not have supervisory control capabilities. Various vendors platforms and proprietary API interface
DR	Fast load and generation balancing. Minimize larger energy storage systems	Not built around load forecasting. Critical loads will need to be segregated.
Solar Forecasting	Enables optimal dispatch of storage	High cost, not proven technology

Question 29

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

The following table summarizes the pre-existing assets that may be used as part of the microgrid. The owners and remaining life of the assets are used to identify those entities with which the microgrid owner would need to identify as well as how long these assets could be relied upon.

Table 3-8 Existing Assets List

Asset	Owner	Size (MW)
8 x Diesel Generator	Kaleida Health	9.975
3 x Boiler	Kaleida	150,000 lb./hr.
13 x Diesel Generator	Roswell Park Cancer Institute	13.725
3 x Boiler	Roswell	210,000 lb./hr.
2 x Diesel Generator	Cleveland Bio Labs	.825
1 x Diesel Generator	UB Medical School	2.5
Diesel storage tank	(each facility)	103,700 gal
9 Chiller	Roswell	10,000
4 Chiller	Kaleida	6000
2 chiller	Cleveland Bio labs	170
2 chiller	UB med school	3500
Solar PV Fruit Belt	National Grid	.025
Thermal Distribution System		
Electrical Distribution assets	National Grid	N/A

Question 30

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

Under the current design, the microgrid should be able to serve the Campus as well as other loads on the neighboring substation serving portions of the Fruit Belt Neighborhood and Cleveland Biolabs. As described in Question 36, the microgrid controller operator would be responsible for dispatching the generation and demand response assets as appropriate to balance generation and load, particularly in islanded operation.

Similarly, National Grid would be responsible for managing the generation and load in their distribution system that is outside the scope of the microgrid controller operator. However, during islanded operation, National Grid may agree to allow the microgrid controller to also manage the feeder on which it is located, subject to regulatory considerations.

Question 31

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

The assessment of the BNMC Microgrid's Commercial and Financial Feasibility takes into account the permitting and special permissions that may be required to construct the project. Although there are permits specific to the City of Buffalo and regional utilities, the type of permits identified below may be required of any microgrid project located within New York State. Additional considerations, such as backup power requirements for critical care facilities are addressed in the Task 2 preliminary assessment. As the project moves into subsequent phases and design progresses, the list will be further refined.

Permitting Required of Microgrids – The following permits are not unique to the BNMC project and would be required of any microgrid.

a. National Fuel and National Grid utility agreements for interconnection into systems.
b. Air emission permit through NYSDEC Title V to operate the generators.
c. Electrical Permitting from the City of Buffalo for installation.
d. Demolition and excavation permitting.
a. City of Buffalo Site Plan review.
b. Franchise/Revocable Consent for street cut permit for new access points across rights of way.
c. Zoning Review – Zoning permit and variance may depend on placement of system equipment. Projects within the City of Buffalo are subject to the current code; however, the adoption of the GreenCode may impact the variance/permitting process.
d. State Environmental Quality Review.
e. City of Buffalo Water and Buffalo Sewer Authority sewer approvals for water, fire protection, sanitary and storm service connections.
f. Building permit – Certificate of completion may be required. A certain level of code interpretation is anticipated and will be assessed as the project moves forward.

Additional Considerations

Special Conditions

The permitting and special permission evaluation has assumed load displacement only for the BNMC project and not subject to requirements of an independent power producer or to have excess power sold back to the grid.

Federal Energy Regulatory Commission

A threshold issue for a small generator project is dependent on whether the project falls under the NYISO's or the local Transmission Owner's interconnection process. Two basic factors determine the jurisdiction of the small generator project: the type of facility to which the project proposes to interconnect, and whether the output of the generator would only serve local load, or whether all or some of the output of the generator may be available for wholesale sales under a FERC-approved tariff. As the project calls for connecting to National Grid's network, which is a non-FERC network, and the BNMC will not be selling back in the wholesale market under a FERC tariff but will be consuming the power locally, no NYISO interaction is anticipated.

Healthcare Standards

Some member institutions at the BNMC maintain healthcare standards with organizations such as The Joint Commission and/or NYS Department of Health. These standards may or may not be impacted by a microgrid project. Specifics will be identified and reviewed in more detail during the design phase.

Question 32

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

The proposed approach for developing, constructing and operating this project relies on a strong team of stakeholders, customers, and industry experts. Particularly at the development phase, this approach is crucial to anticipating risks and opportunities for this project in order to address them early on in the process and avoid costs or missed revenue opportunities in future stages of the project.

During this stage of feasibility assessment (i.e. early development), the BNMC, Inc. is acting as the project manager for the project. In this way, they can coordinate all the various experts as well as act on behalf of the customers of the microgrid – the Campus member institutions. To complete the majority of the analysis of feasibility, BNMC, Inc. has contracted with three consulting firms - EPRI, CDH, and Navigant, to assess the electrical, thermal, and commercial/financial feasibility, respectively. BNMC has also compiled a team of expert advisors to share their experience and perspectives on whether or not the findings of the consulting teams are founded and appropriate for this project. By compiling the collective knowledge of the various team members, BNMC is able to ensure that a robust analysis is completed at this early stage.

In the next stage of detailed design (i.e. late development), the BNMC, Inc. may continue to be the project manager or they may seek another team member (existing or new) to act as the project manager to ensure that all the various tasks are completed to obtain a full design, commercial / financial plan, and detailed benefit-cost analysis. In similar arrangement to this feasibility study, the project manager will assemble a team of hired consultants as well as supporting advisors to develop the study and assess its overall strengths and weaknesses. Also at this time, the BNMC, Inc. and/or the project manager will start to solicit, in a more formal way, investors in the project based on the planned system design and commercial business arrangements. Similarly, the BNMC, Inc. and/or the project owner will finalize all contractual arrangements with the customers of the microgrid.

During construction, the majority of the effort will be coordinated by a construction project manager who will be responsible for purchasing all of the equipment and subcontracting to each of the trades needed to support the project. It may be possible that the consultants used during the development and design of the project will continue to support by overseeing the construction to ensure that it is completed in accordance with the design plans. Also, during construction, all financing arrangements will be finalized and any other contractual arrangements managed to ensure major milestones are met.

Finally, during operation of the project, the microgrid controller operator will be responsible for the day-to-day operation, maintenance, and financial management of the microgrid. This will require the microgrid controller operator to review all contractual arrangements to set the dispatch scenarios such that they meet the obligations under those agreements, optimize non-contracted revenue, and meet any other needs not explicitly expressed within the contracts. Finally, the microgrid controller operator will then report regularly on the performance of the system to the microgrid owner(s).

Question 33

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

The benefits and costs to the community from this project are described in Question 10.

Question 34

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

As the regulated utility, National Grid will continue to be responsible for ensuring that all of their customers, which may include also customers of the microgrid, are able to be served safely, reliably and at a reasonable cost. This will require that National Grid continue to support the development of this project in an advisory role in order to provide their perspectives, expertise, and insights on design and regulatory issues that may affect their customers. They may also provide ideas and identify opportunities where they may create value for the microgrid, its customers, and the community.

During the development of this project, National Grid will need to continue to work with the BNMC, Inc. to address any policy, regulatory or legal issues that may arise. For example, National Grid and/or its regulator may need to review existing regulatory orders to allow BNMC, Inc. to add a new master meter and to use the existing distribution infrastructure which is owned and operated by National Grid.

For any investment made by National Grid to support this project, they will need to determine how to justify the costs being rate-based. More specifically, National Grid will need to determine if investment in the microgrid’s assets aids in deferring or avoiding other infrastructure investment. If that is the case, National Grid may be able to spread the costs across their entire rate-base. If not, National Grid will need to determine other means of cost recovery.

Also, during operation of the microgrid (both in normal and islanded operation), National Grid will be responsible for maintaining the stability of their distribution grid, including any distribution assets within the campus. This will require close coordination with the microgrid controller operator who has control of the microgrid assets. Also, it may be possible that National Grid offers additional services to the microgrid owner and/or microgrid controller operator to help with the operation of the system.

Question 35

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

Many of these microgrid technologies have been used and demonstrated before. The following table provides some examples of previous projects as well as overall lessons learn from the project team members on these technologies from their experience.

7692 kW Gas Combustion Turbine with heat recovery

2 x 5000 kW Gas Internal Combustion Engine with heat recovery

3 x 50 kW/200kWh Li-Ion battery (two at BNMC, one at Fruit Belt)

2 x 500 kW PV (central at BNMC, distributed at Fruit Belt)

Table 3-9 Technology Readiness

Technology	Relevant Project Example	Lessons Learned
Storage	EPRI Southern Company battery demonstration	Battery technology is mature; however the key is integration to the grid. Proper attention to protection, communication protocols and connectivity to utility back office will need to developed before installation
PV with smart inverter	DOE Smart Inverter project	Smart inverter functionalities are relatively new. No specific set points exist. Site and feeder development. Communication with DERMS and DSCADA still being developed
CHP	St. Joseph's Hospital Health Center (Syracuse), SUNY Albany	CHP microgrids are a good fit on campuses with steam systems, because waste heat

		from generating electricity onsite is used in the thermal loops, increasing overall efficiency, reducing greenhouse gas emissions, and reducing overall energy costs.

Question 36

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

As identified in Question 5 and in other responses herein, it is expected that a microgrid controller will be established as part of this project and that it will be the responsibility of the microgrid controller operator to determine the appropriate operational schemes such that all technical, financial, and contractual obligations are met through moment-to-moment decision-making. In this way, the microgrid controller operator will be responsible for becoming acquainted and informed about all of the technical functionality and limitations of each asset within the microgrid.

The microgrid controller operator will also be responsible for knowing the proposed financial outlook and targets for the project. Similarly, the operator will also be responsible managing all contractual obligations that the microgrid has to each of its customers. Finally, the microgrid controller operator should also be aware of any implicit wants and needs of the microgrid owner, customer(s) and/or stakeholders to ensure that the microgrid is operated in a way that satisfies the needs of each entity. The Commercial Ecosystem Diagram in Question 12 depicts the proposed commercial and financial value streams that will need to be understood and monitored by the microgrid controller operator.

The microgrid controller operator will also design the dispatch scenarios, thresholds and criteria of the microgrid controller to balance all of the diverse interests and obligations of the microgrid owner, customer(s) and/or stakeholders. As an example, the controller might be programmed to use 80% of available resources for economic optimization for the purposes of generating new revenue and/or savings, while the remaining 20% of available resources would be reserved as back-up power capacity. In contrast, for the purposes economic optimization, the controller may be programmed to meet contractual obligations first (e.g. sale of power to member institutions) then to allocate any excess generation or capacity for participation in wholesale programs.

Finally, the microgrid controller operator will be responsible for completing or contracting for operations and maintenance (O&M) as well as measurement and verification (M&V) of the microgrid. For O&M, the microgrid controller operator will be responsible for establishing and executing a preventative maintenance plan. Similarly, it will be responsible for monitoring all obligatory assets and responding to any error codes that may arise. For M&V, the microgrid controller operator will be responsible for generating periodic reports to assess how it is performing compared to budget. These reports will be transmitted to the owner(s) of the microgrid so that they may see if their investment is earning the returns they expected.

In summary, it is the responsibility of the microgrid controller operator, acting also as the asset manager, to ensure that the system operates as expected. It will accomplish this through familiarity with project commercial and financial goals, programming the microgrid controller for the appropriate dispatch scenarios, and conducting routine O&M and M&V of the microgrid.

Question 37

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

There are two forms of energy that the microgrid will provide: thermal and electric. The way in which the customers will be charged will be in accordance with any contracts, permits and agreements, as described in Question 7.

For the electricity delivered from the microgrid, the metering and, consequently, the billing arrangement will depend on how the generators are interconnected to the facilities and/or National Grid’s distribution system. Since all of the generating assets that are being proposed would to be behind a new master meter, the customer(s) they serve, as determined by the microgrid controller, will be charged at a predetermined rate as negotiated between the microgrid owner and the customer.

However, if the master meter arrangement is determined to not be possible, then contract arrangements will need to with National Grid to transfer any excess electricity to the other facilities’ accounts. Similarly, if the generating assets are interconnected directly to National Grid’s distribution system with the intention of serving facilities within the Campus, these assets will be metered by National Grid and special contract arrangements will need to be made for the sale of power to National Grid and/or to the facilities via National Grid.

Finally, since the thermal energy from the CHP is expected to feed each facility independently, it is anticipated that the delivered energy will be metered at each delivery point and billed to each customer at a predetermined rate.

Question 38

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

Commercialization and replication plans will be necessary to ensure that the lessons learned from this project are codified so that the concepts, technologies and processes used in this project may be replicated and scaled in other projects in the future, as described in Question 14. The most appropriate business/commercialization plans relate to the commercialization of the microgrid controller and the multi-customer approach, while the replication plan would be used to guide others in the future on how to develop microgrid projects using the same processes and approach as used in this project.

The commercialization plan for the microgrid controller would be focused on assessing the market for microgrid controllers as well as the specific value proposition of this microgrid controller which would give it a strategic advantage in the market over other options. Such a study would address the following questions:

- What is the microgrid controller and what value does it provide?
- How developed is the market for microgrid controllers today, and potentially after the BNMC project?
- What is needed to make the microgrid controller a commercially-viable solution?
- If such needs are addressed, what is the forecasted market for microgrid controller sales?

Similarly, the business model for this project may present economic value and opportunities for the various team members. As such, each team member may be able to use lessons learned from this project to better define their service offerings and value added services to customers based on experiences gained from this project. Also, either a team member from this project or an outside entity may determine that the business model for this project provides superior value as compared to other microgrid business models and they may deem it appropriate to assess the commercial viability of the business model by addressing similar questions to those four listed above.

Finally, the approach, processes and procedures used to develop this project should be memorialized in a replication plan which would serve as a guide to future, similar microgrid projects. This replication guide would identify best practices related to, among other things, project team member selection, scope of work definition, and scheduling of activities. It would also identify risks and opportunities specific to similar projects in which there is a campus and/or multiple different institutions and customers. By creating this guide, the lessons learned from this project will be used to support the replicability of the project.

Question 39

How significant are the barriers to market entry microgrid participants?

For the team members of this microgrid project, the barriers to entry into the microgrid market are relatively low. Many of the team members have experience in designing, evaluating, and advising on similar energy projects, and thus microgrids are a logical continuation of their service offerings in this area. Similarly, many of the team members have been active in the microgrid market for an extended period, so identified barriers to market entry have already been assessed and addressed.

The same assessment is generally true for the technology companies that are being considered for the design of the microgrid. The one exception would be the microgrid controller which is being developed for this project. While it is envisioned that the controller would be designed in such a way that it would be flexible enough to be used in other projects in the future, this will require plans on behalf of the controller company for how to enter the commercial market.

Given the high amount of upfront investment that would be required to design the microgrid controller in such a way that is adaptable to any project design, as well as given the relatively unclear market for such a product or service, the barriers to market entry and commercial adoption may be higher than some of the other products and services which the microgrid and its team members will consider.

Question 40

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

For the largest barriers to market adoptions – i.e. those for the microgrid controller – the controller provider should develop a commercialization study and plan, as described in Question 38. This will help identify and address major market risks and opportunities for the controller technology.

Task 3.5 Financial Viability

Question 41

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

Refer to Chapter 4

Question 42

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

The BNMC, Inc. plans to apply for and make use of any grants and incentives that are available to support this project. This may include NYSERDA programs, DOE FOAs, federal Investment Tax Credits, and/or accelerated asset depreciation.

There are also other programs available from electric and gas suppliers and distribution companies (National Grid, NYPA, and National Fuel) for which this microgrid may be eligible. Similarly, since many of these entities are part of this project team, it may be possible to receive additional project support.

In all cases, it is important that the timeline requirements of each existing program be considered. The contemplated grants may be on different timelines from those outlined in NY Prize Community Microgrid Competition. Alternatively, there may be future programs for which the microgrid’s timeline is in alignment.

Also, it is important to carefully evaluate the eligibility requirements of each program to ensure that they are compatible with one another. For example, if two programs each provide an incentive for a certain type of asset, it will be necessary to check that they may be used together and are not considered “double-dipping.”

Question 43

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

Refer to Chapter 2 Question 7 and Task 4.

Question 44

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

Given that the emphasis of this project is on economic optimization leading to a positive return on investment from blue sky operations (see Question 12), it is expected that the project will be profitable. Unlike other microgrid business models which may rely on selling premium power and services at a premium price, the business model of this project is expected to generate savings for the microgrid’s customers which, in turn, would motivate them to continue their contractual arrangement(s) with the microgrid SPE. Furthermore, since the Campus member institutions are regarded as the owners of the microgrid, it would be in their best interest to ensure that the microgrid is profitable.

Also, such a business model is meant to recover the costs of all investments, including those specific to islanding capability, through normal operation. As such, the project is expected to be profitable even if islanding events rarely occur.

To ensure that this plan is realized, the specific rates and agreements for costs and revenues to the microgrid SPE still must be negotiated to ensure the project economics are profitable. Upon completion of this feasibility design, the BNMC, Inc. will present this contemplate design and business model to its member institutions, which are considered both the microgrid’s main customers and the potential owners, and, more formally, to National Grid. If the business model appears favorable to its key stakeholders, discussions surrounding rate and contracts details will resume informing the next, detailed design, phase.

Question 45

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

During the development of this project, the BNMC, Inc. has and will be securing funding for the feasibility and design studies. The BNMC, Inc. will also pursue any available grant or incentive funding, to support the financing of these development studies.

At the time of construction, it is expected that BNMC will compile funding/financing from a variety of sources. Sources of financing may include the BNMC, Inc., the Campus member institutions, National Grid, NY Prize, grants, incentives, and private investment.

It is also likely that the ultimate selection of funding sources will come from the entities that will be the designated owners of the microgrid SPE, as described in Question 46. Similarly, the financing for the long-term operation of the project will be arranged by the owner(s) of the microgrid SPE.

Task 3.6 Legal Viability

Question 46

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

It is currently contemplated that a special purpose entity (SPE), such as a limited liability company (LLC) would be created to formally own the microgrid assets. This SPE would be responsible for contracting with any of the off-takers of the microgrid for the purchase of electric or thermal energy.

Under the current plan, the three largest member institutions – Roswell Park Cancer Institute, Kaleida Health, and the University at Buffalo – would be the owners of the microgrid SPE. However, the BNMC, Inc. is in the process of conferring with its member institutions to confirm that they would be interested in owning the microgrid. Some other owners that are being considered are the BNMC, Inc. (which is the representative body of the collective body of member institutions), National Grid and/or third-party investors.

Should a third-party investor require ownership as a condition of investment, that investor would most likely establish an SPE to contain the investment. The large member institutions and National Grid could take advantage of this structure to reduce their respective project risk, requiring the SPE to hold the necessary construction, EPC and O&M contracts, along with all deadline and performance guarantees. It would be typical in this scenario for the built assets to be transferred to the payees (the Campus member institutions and/or National Grid) after the investment payback period has been satisfied, to avoid stranding the assets.

Question 47

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

As described in Question 46, the currently contemplated owners are the three largest member institutions. The BNMC, Inc. is in the process of evaluating this and other options based on the outcomes of the technical feasibility study. It is anticipated the BNMC, Inc. will present the findings of this study to its Board, which includes representatives of the member institutions, and pursue the ownership options that is in the best interest of its member institutions.

Question 48

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

The BNMC, Inc., as the project lead, has limited rights to Campus property that could be used for the installation of the microgrid generating assets. To the extent that any area is specifically owned by one of the member institutions, the BNMC, Inc. will explore securing access to that site.

For the distribution assets that may extend beyond the bounds of the Campus proper, it is anticipated that these are and will be owned by National Grid as part of their existing system. For distribution assets within the Campus, including those that may become behind the meter if a master meter is installed, it is still to be determined if those would be owned by the microgrid SPE or by National Grid. If National Grid will own these assets that become behind a master meter, the microgrid SPE will need to secure permission for their use from National Grid.

Question 49

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

The Campus member institutions will need to be made aware of any privacy rights issues so that they can determine the level of privacy protection they require in their agreements with the microgrid SPE. At a minimum, it is expected that individual non-disclosure agreements (NDAs) will be required with each of the participating member institutions and with the BNMC, Inc. National Grid will also maintain the privacy rights of customers served through their distribution system as a result of this microgrid. Similarly, in designing the microgrid controller, it will be important to design for adequate cybersecurity and protections.

Question 50

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

There are several potential regulatory hurdles and issues to address in order for this project to proceed as currently envisioned. These regulatory issues can generally be categorized into three areas: ownership of the microgrid assets, excess generation from the microgrid, and outcomes of the NY REV Proceeding.

Regarding ownership, there are several issues to consider including which assets would it be best for National Grid versus the microgrid SPE to own, how National Grid will recover the costs of investments made on the behalf of this project, what will be done to guarantee these assets are not stranded at the conclusion of contracts, and what responsibility will National Grid have for assets that they currently own that will become part of the microgrid (e.g. distribution assets within the Campus). Current regulation will dictate who can own the generating versus distribution assets of the microgrid; however, given the proposed financial and commercial structures contemplated in this project, it may be beneficial for the utility to own or finance generation and/or the microgrid SPE which would require special permissions from the PSC or changes to the regulation. If National Grid were to own or make an investment in the project, they would need to determine if and how they would socialize the costs via rate base. Also, depending on who owns the project, the utility may be responsible for ensuring that the assets do not become stranded, especially after the term of the agreements. Finally, since the scope of the microgrid, including the point of interconnection, are still being evaluated, it is possible that certain distribution assets that are currently owned by National Grid may become “behind-the-meter" of the microgrid's master meter. In this case, it is unclear who would retain ownership or operation of those assets.

Regarding excess generation, it will be important to determine the interconnection point of the microgrid's master meter and/or individual assets to determine what potential excess generation would be exported to National Grid's distribution system. Also, National Grid and microgrid SPE will need to agree upon the structure and rate that will be used to value any excess generation. Similarly, for any electricity generated behind an institution's meter, National Grid and the microgrid SPE will need to determine the appropriate structures to share that generation with other microgrid off-takers. Also, given all of these considerations, National Grid will need to determine if there is any standby charges required to maintain service to the Campus. Finally, given the decisions and regulations on these matters, the BNMC, Inc. will need to determine what effect these rates and charges will have on the project economics as well as any steps they can take to ensure the highest economics possible.

Finally, this project can and should align all of its operations and objectives with REV. As opposed to the issues discussed above, REV provides an opportunity to reexamine current rules and regulations with the objective of rendering more mutually beneficial outcomes for all stakeholders. Similarly, new market opportunities are expected to be created through REV that could provide new revenue streams for the Project that could potentially minimize the dependence on revenues from energy sales to the member institutions and/or National Grid.

4 BENEFIT – COST ANALYSIS SUMMARY

As part of NYSERDA's NY Prize community microgrid competition, the Buffalo Niagara Medical Campus, a consortium of nine health care, life sciences research, and medical education institutions in downtown Buffalo, has proposed development of a microgrid that would enhance the resiliency of electric service for four of its campus institutions and approximately 2,000 residential customers in the surrounding neighborhood. The facilities to be served by the microgrid are:

- Roswell Park Cancer Institute (RPCI), which is one of the nation's premier cancer research, treatment, and educational facilities, and comprises six separate buildings;
- Kaleida Health, which includes the Buffalo General Medical Center, Gates Vascular Institute, Buffalo Clinical and Translational Research Center, and Women & Children's Hospital;
- The University at Buffalo (UB) School of Medicine;
- Cleveland Biolabs; and
- Nearly 300 residential homes in the Fruit Belt neighborhood.

The microgrid would combine natural gas-fired generators, a combined heat and power (CHP) system, solar arrays, and battery storage to provide base load power. The system would be centered around a 7.7 MW natural gas-fired CHP generator, located at RPCI, which would supply roughly half of the microgrid's power under normal operating conditions. Two 5 MW natural gas-fired internal combustion engines, both located at Kaleida Health, would contribute substantially to the system's output. Two solar photovoltaic (PV) arrays with a combined nameplate capacity of 580 kW would supply additional power. A set of 22 existing diesel generators at Kaleida Health and RPCI would complement the microgrid, providing power only in islanded mode during major power outages.[12] In addition, three 50 kW batteries would be incorporated into the microgrid. The system as designed would have sufficient generating capacity to meet average demand for electricity from all included facilities during a major outage. Project consultants also indicate that the system would be capable of providing frequency regulation, reactive power support, and black start support to the grid.

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

[12] An additional three generators are currently available to supply backup power to the UB School of Medicine and Cleveland Biolabs, but are not expected to operate following development of the 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.

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.[13] It also calculates an annualized estimate of costs and benefits based on the anticipated engineering lifespan of the system's equipment. Once a project's cumulative benefits and costs have been adjusted to present values, the model calculates both the project's net benefits and the ratio of project benefits to project costs. The model also calculates the project's internal rate of return, which indicates the discount rate at which the project's costs and benefits would be equal. All monetized results are adjusted for inflation and expressed in 2014 dollars.

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

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 nine 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.[14]
- Scenario 3: 1-day average annual duration of major power outages.
- Scenario 4: 2-day average annual duration of major power outages.
- Scenario 5: 3-day average annual duration of major power outages.
- Scenario 6: 4-day average annual duration of major power outages.
- Scenario 7: 5-day average annual duration of major power outages.
- Scenario 8: 6-day average annual duration of major power outages.
- Scenario 9: 7-day average annual duration of major power outages.

Results

Table 4-1 summarizes the estimated net benefits, benefit-cost ratios, and internal rates of return for the scenarios described above. The results indicate that if there were no major power outages over the 20-year period analyzed (Scenario 1), the project's costs would exceed its benefits. In order for the project's benefits to outweigh its costs, the average duration of major outages would need to equal or exceed 0.3 days – or approximately seven hours – per year (Scenario 2). The discussion that follows provides additional detail on these findings.

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[14] 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.

Table 4-1 BCA Results (Assuming 7 Percent Discount Rate)

ECONOMIC MEASURE	ASSUMED AVERAGE DURATION OF MAJOR POWER OUTAGES	
	SCENARIO 1: 0 DAYS/YEAR	SCENARIO 2: 0.3 DAYS/YEAR
Net Benefits - Present Value	-$21,400,000	$1,050,000
Benefit-Cost Ratio	0.9	1.0
Internal Rate of Return	0.03%	7.1%

Scenario 1

Figure 4-1 and Table 4-2 present the detailed results of the Scenario 1 analysis.

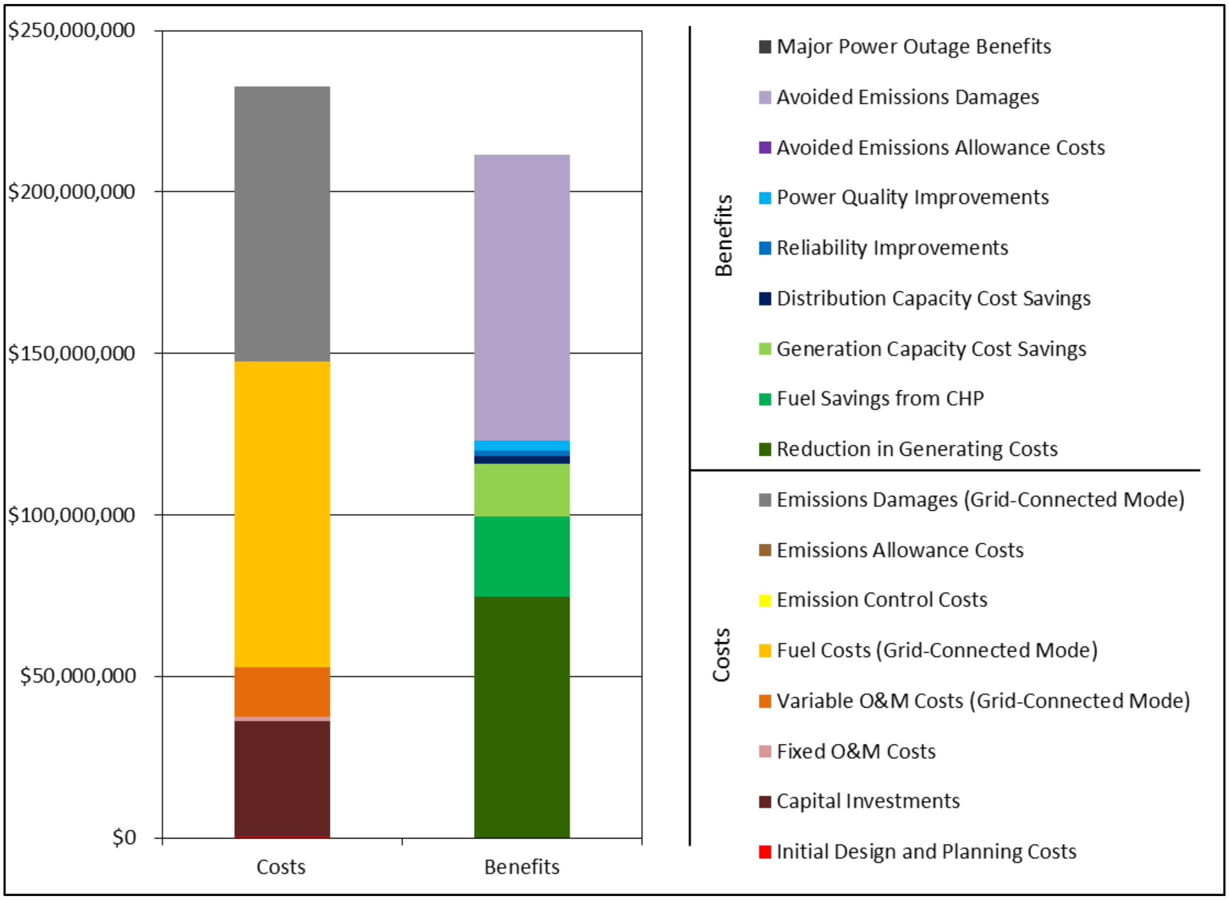

Figure 4.1. Present Value Results, Scenario 1 (No Major Power Outages; 7 Percent Discount Rate)

Table 4-2 Detailed BCA Results, Scenario 1 (No Major Power Outages; 7 Percent Discount Rate)

COST OR BENEFIT CATEGORY	PRESENT VALUE OVER 20 YEARS (2014$)	ANNUALIZED VALUE (2014$)
Costs		
Initial Design and Planning	$328,000	$28,900
Capital Investments	$35,800,000	$3,160,000
Fixed O&M	$1,270,000	$112,000
Variable O&M (Grid-Connected Mode)	$15,600,000	$1,370,000
Fuel (Grid-Connected Mode)	$94,500,000	$8,340,000
Emission Control	$0	$0
Emissions Allowances	$0	$0
Emissions Damages (Grid-Connected Mode)	$85,300,000	$5,570,000
Total Costs	**$233,000,000**	
Benefits		
Reduction in Generating Costs	$74,800,000	$6,600,000
Fuel Savings from CHP	$24,700,000	$2,180,000
Generation Capacity Cost Savings	$16,400,000	$1,450,000
Distribution Capacity Cost Savings	$2,280,000	$201,000
Reliability Improvements	$1,850,000	$164,000
Power Quality Improvements	$3,040,000	$268,000
Avoided Emissions Allowance Costs	$45,500	$4,010
Avoided Emissions Damages	$88,300,000	$5,760,000
Major Power Outage Benefits	$0	$0
Total Benefits	**$211,000,000**	
Net Benefits	**-$21,400,000**	
Benefit/Cost Ratio	**0.9**	
Internal Rate of Return	**0.03%**	

Fixed Costs

The BCA relies on information provided by the project team to estimate the fixed costs of developing the microgrid. The present value of the project's capital costs is estimated at approximately $35.8 million, including costs associated with the new CHP system, internal combustion engines, PV arrays, and batteries, as well as other electrical, thermal, and control infrastructure. The project team notes that this capital cost figure includes several costs associated with planning, design, installing, testing, and commissioning the microgrid's equipment. The project team's best estimate of all remaining design and planning costs is approximately $328,000. The present value of the microgrid's fixed operations and maintenance (O&M) costs (i.e., O&M costs that do not vary with the amount of energy produced) is estimated at approximately $1.27 million, or $112,000 annually.

Variable Costs

The most significant variable cost associated with the proposed project is the cost of natural gas to fuel operation of the system's CHP generator and internal combustion engines. To characterize these costs, the BCA relies on estimates of fuel consumption provided by the project team and projections of fuel costs from New York's 2015 State Energy Plan (SEP), adjusted to reflect recent market prices.[15] The present value of the project's fuel costs over a 20-year operating period is estimated to be approximately $94.5 million.

The BCA also considers the project team's best estimate of the microgrid's variable O&M costs (i.e., O&M costs that vary with the amount of energy produced). The present value of these costs is estimated at approximately $15.6 million, or $10.24 per MWh for the microgrid as a whole.

In addition, the analysis of variable costs considers the environmental damages associated with pollutant emissions from the distributed energy resources that serve the microgrid, based on the operating scenario and emissions rates provided by the project team and the understanding that none of the system's generators would be subject to emissions allowance requirements. In this case, the damages attributable to emissions from the microgrid's natural gas generators are estimated at approximately $5.57 million annually. The majority of these damages are attributable to the emission of CO_2. Over a 20-year operating period, the present value of emissions damages is estimated at approximately $85.3 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 $74.8 million; this estimate assumes the microgrid provides base load power, consistent with the operating profile upon which the analysis is based. Additional benefits would result from fuel savings due to the new CHP system; the BCA estimates the present value of fuel savings over the 20-year operating period to be approximately $24.7 million. The reduction in demand for electricity from bulk energy suppliers and for heating fuel would also avoid emissions of CO_2, SO_2, NO_x, and particulate matter, yielding emissions allowance cost savings with a present value of approximately $45,500 and avoided emissions damages with a present value of approximately $88.3 million.[16]

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

[16] Following the New York Public Service Commission's (PSC) guidance for benefit-cost analysis, the model values emissions of CO_2 using the social cost of carbon (SCC) developed by the U.S. Environmental Protection Agency (EPA). [See: State of New York Public Service Commission. Case 14-M-0101, Proceeding on Motion of the Commission in Regard to Reforming the Energy Vision. Order Establishing the Benefit Cost Analysis Framework.

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.[17] The project team estimates the capacity available for the provision of peak load support to be approximately 18 MW per year, based on estimates of the availability during system peak of the new CHP system, natural gas-fired generators, PV arrays, and batteries. The project team also expects development of the microgrid to reduce the conventional grid's demand for generating capacity by an additional 1.4 MW as a result of new demand response capabilities. Based on these figures, the BCA estimates the present value of the project's generating capacity benefits to be approximately $16.4 million over a 20-year operating period. The present value of the project's potential distribution capacity benefits is estimated to be approximately $2.28 million.

The project team has indicated that the proposed microgrid would be designed to provide ancillary services, in the form of frequency regulation, reactive power support, and black start support, to the New York Independent System Operator (NYISO). Whether NYISO would select the project to provide these services depends on NYISO's requirements and the ability of the project to provide support at a cost lower than that of alternative sources. Based on discussions with NYISO, it is our understanding that the markets for ancillary services – particularly black start support – are highly competitive, and that projects of this type would have a relatively small chance of being selected to provide support to the grid. In light of this consideration, the analysis does not attempt to quantify the potential benefits of providing these services.

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 $164,000 per year, with a present value of $1.85 million over a 20-year operating period. This estimate is developed using the U.S. Department of Energy's Interruption Cost Estimate (ICE) Calculator, and is based on the following indicators of the likelihood and average duration of outages in the service area:[18]

- System Average Interruption Frequency Index (SAIFI) – 0.96 events per year.
- Customer Average Interruption Duration Index (CAIDI) – 116.4 minutes.[19]

The estimate takes into account the number of residential and small and large commercial or industrial customers the project would serve; the distribution of these customers by economic sector; average annual electricity usage per customer, as provided by the project team; and the

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January 21, 2016.] Because emissions of SO_2 and NO_x from bulk energy suppliers are capped and subject to emissions allowance requirements in New York, the model values these emissions based on projected allowance prices for each pollutant.

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

[18] www.icecalculator.com.

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

prevalence of backup generation among these customers. It also takes into account the variable costs of operating existing backup generators, both in the baseline and as an integrated component of a microgrid. Under baseline conditions, the analysis assumes a 15 percent failure rate for backup generators.[20] 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.

Power Quality Benefits

The power quality benefits of a microgrid may include reductions in the frequency of voltage sags and swells or reductions in the frequency of momentary outages (i.e., outages of less than five minutes, which are not captured in the reliability indices described above). The analysis of power quality benefits relies on the project team's best estimate of the number of power quality events that development of the microgrid would avoid each year. The project team estimates that the facilities served by the microgrid would avoid an average of approximately one such event annually. The model estimates the present value of avoiding these events to be approximately $3.04 million over a 20-year operating period.[21] In reality, some customers for whom power quality is important (e.g., the hospital) may already have systems in place to protect against voltage sags, swells, and momentary outages. If this is the case, the BCA may overstate the power quality benefits the project would provide.

Summary

The analysis of Scenario 1 yields a benefit/cost ratio of 0.9; i.e., the estimate of project benefits is approximately 90 percent that of project costs. Accordingly, the analysis moves to Scenario 2, taking into account the potential benefits of a microgrid in mitigating the impact of major power outages.

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

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

Scenario 2

Benefits in the Event of a Major Power Outage

The estimate of reliability benefits presented in Scenario 1 does not include the benefits of maintaining service during outages caused by major storm events or other factors generally considered beyond the control of the local utility. These types of outages can affect a broad area and may require an extended period of time to rectify. To estimate the benefits of a microgrid in the event of such outages, the BCA methodology is designed to assess the impact of a total loss of power – including plausible assumptions about the failure of backup generation – on the facilities the microgrid would serve. It calculates the economic damages that development of a microgrid would avoid based on (1) the incremental cost of potential emergency measures that would be required in the event of a prolonged outage, and (2) the value of the services that would be lost.[22,23]

The proposed microgrid would serve four facilities at BNMC and a residential neighborhood during an extended outage. In the BCA model, several factors influence the costs that facilities would incur during an outage, including the following:

- Whether or not backup generation currently exists at the facility;
- The ability of the facility to operate when using backup power;
- The ability of the facility to operate during a complete loss of power;
- The cost of operating existing generators;
- The extent to which the facility incurs costs for emergency measures (e.g., an increase in staff); and
- The economic value of the services that the facility would cease to provide during an outage.

Table 4-3 summarizes these parameters for the customers served by BNMC's proposed microgrid:

- **Roswell Park Cancer Institute –** RPCI is currently served by 13 diesel backup generators with a total nameplate capacity of nearly 14 MW. In the event of a major outage, when operating on backup power, RPCI would double its staff to maintain service and handle likely increases in call volume and patient visits. This increase in staff would cost approximately $1.34 million per day. At the same time, both RPCI and

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

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

Kaleida Health would be forced to evacuate approximately 70 percent of their patients, based on the level of service that can be supported by the facilities' currently existing backup generators. These evacuation costs are estimated at approximately $328,000; the BCA assumes this cost is evenly divided between RPCI and Kaleida Health. For outages lasting three days or longer, additional costs would be incurred by RPCI and Kaleida Health to provide food to additional onsite staff; the BCA similarly assumes that this cost (approximately $43,500 per day) is divided evenly across the two facilities.

- In the event of a complete loss of power, both RPCI and Kaleida Health would evacuate all of their patients, at a total cost of $463,000. The BCA assumes this cost is evenly divided between the two facilities. The project team estimates the overall value of service provided by RPCI based on its annual operating budget.

- **Kaleida Health –** Kaleida Health is currently equipped with nine diesel backup generators with a total nameplate capacity of more than 11 MW. As described above, when operating on backup power, Kaleida Health would incur costs associated with patient evacuation and, for outages lasting longer than three days, additional supplies of food. Kaleida Health would also incur costs associated with doubling its staff, similar to RPCI; these costs are estimated at approximately $1.68 million per day. In addition, Kaleida Health would be able to sustain only 27 percent of its inpatient and outpatient services. In the event of a complete loss of power, Kaleida Health would evacuate all patients, and would close down all inpatient and outpatient services.

- The analysis calculates the impact of an outage on Kaleida Health's emergency department and EMS capabilities using standard FEMA methodologies. To estimate the value of inpatient and outpatient services, the analysis relies on cost estimates from the World Health Organization, as provided by the project team.[24]

- **University at Buffalo School of Medicine –** The UB School of Medicine is currently equipped with one 2.5 MW backup generator. UB is able to maintain approximately 36 percent of its operations on backup generation, but loses all functionality when backup generation is not available. The overall value of service for UB is determined using the ICE Calculator.[25]

- **Cleveland Biolabs –** Cleveland Biolabs is currently equipped with two backup generators, and is able to maintain its normal level of service when operating on backup power. The facility loses all functionality when backup generation is not available. The overall value of service for Cleveland Biolabs is also determined using the ICE Calculator.[26]

- **Residents of the Fruit Belt Neighborhood** – The extent to which residents of the Fruit Belt neighborhood have equipped their homes with emergency generators is

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[24] http://www.who.int/choice/country/country_specific/en/.
[25] www.icecalculator.com.
[26] www.icecalculator.com.

unknown, but in most cases such generators would likely be capable of providing only limited service. For simplicity, the analysis assumes that an outage would result in a complete loss of power for all residents. The analysis calculates the impact of an outage on Fruit Belt residents using the standard FEMA methodology for electric service losses.

In all cases, backup generators are assumed to have a 15 percent chance of failing, and the supply of fuel necessary to operate the backup generators is assumed to be maintained indefinitely.

Table 4-3 Summary of Major Power Outage Parameters, Scenario 2

FACILITY	VALUE OF SERVICE		PERCENT LOSS IN SERVICE CAPABILITIES DURING AN OUTAGE		GENERATOR COSTS		OTHER EMERGENCY COSTS, WITH BACKUP POWER		OTHER EMERGENCY COSTS, WITHOUT BACKUP POWER	
	VALUE PER DAY	BASIS	WITH BACKUP POWER	WITHOUT BACKUP POWER	ONE-TIME	DAILY	ONE-TIME	DAILY	ONE-TIME	DAILY
Roswell Park Cancer Institute	$1.59 million	Annual operating budget, scaled to an average daily value	69%	100%	$0	$6,940	$164,000	$1.34 million	$232,000	$0
Kaleida Health	FEMA methodologies (emergency department and EMS); WHO values for inpatient and outpatient services		73%	83%	$0	$6,820	$164,000	$1.98 million	$232,000	$415,000
University at Buffalo School of Medicine	$369,000	ICE Calculator	64%	100%	$0	$3,210	$0	$0	$0	$0
Cleveland Biolabs	$80,800	ICE Calculator	0%	100%	$0	$398	$0	$0	$0	$0
Fruit Belt Neighborhood	FEMA methodology		N/A	100%	N/A	N/A	N/A	N/A	N/A	N/A

Summary

Figure 4-2 and Table 4-4 present the results of the BCA for Scenario 2. The results indicate that the benefits of the proposed project would equal or exceed its costs if the project enabled the facilities it would serve to avoid an average of 0.3 days – or approximately seven hours – per year without power. If the average annual duration of the outages the microgrid prevents is less than this figure, its costs are projected to exceed its benefits.

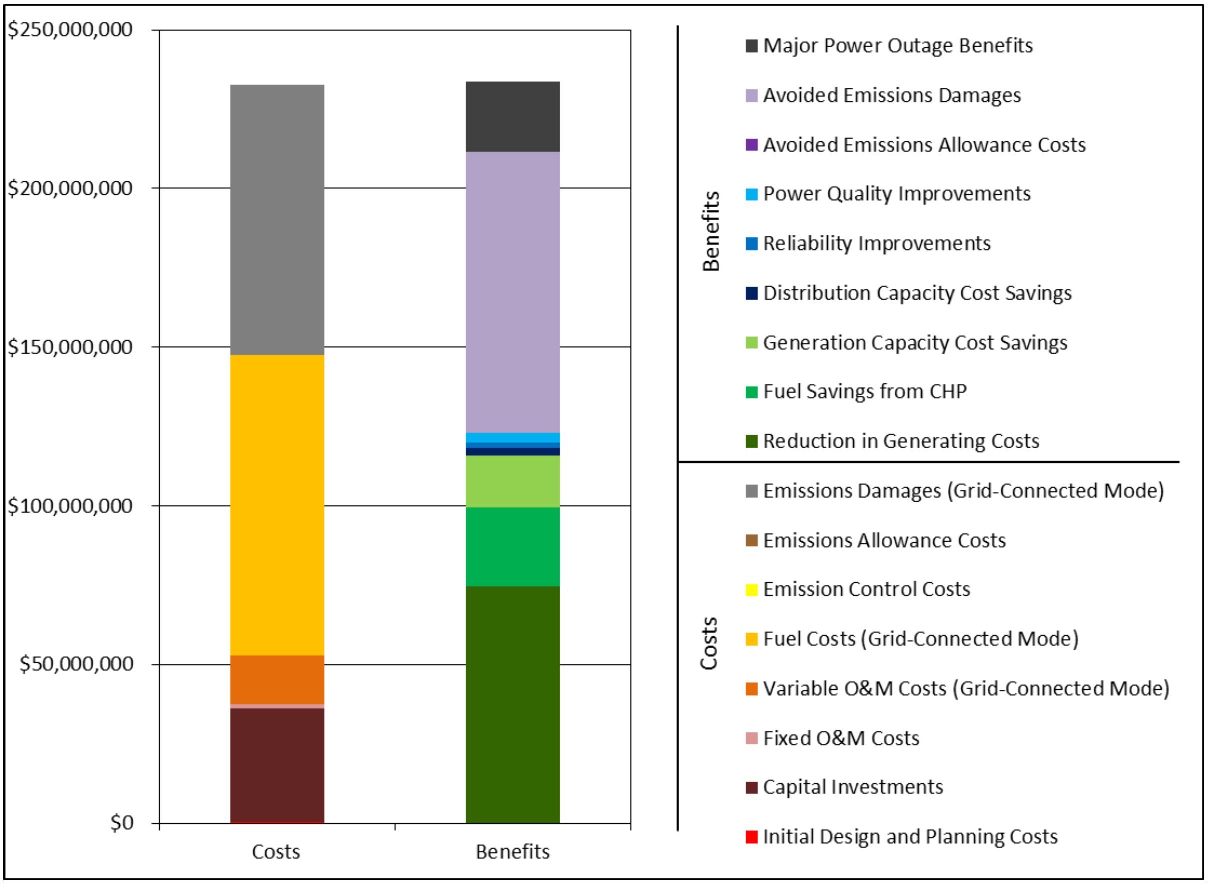

Figure 4.2. Present Value Results, Scenario 2 (Major Power Outages Averaging 0.3 Days/Year; 7 Percent Discount Rate)

Table 4-4 Detailed BCA Results, Scenario 2 (Major Power Outages Averaging 0.3 Days/Year; 7 Percent Discount Rate)

COST OR BENEFIT CATEGORY	PRESENT VALUE OVER 20 YEARS (2014$)	ANNUALIZED VALUE (2014$)
Costs		
Initial Design and Planning	$328,000	$28,900
Capital Investments	$35,800,000	$3,160,000
Fixed O&M	$1,270,000	$112,000
Variable O&M (Grid-Connected Mode)	$15,600,000	$1,370,000
Fuel (Grid-Connected Mode)	$94,500,000	$8,340,000
Emission Control	$0	$0
Emissions Allowances	$0	$0
Emissions Damages (Grid-Connected Mode)	$85,300,000	$5,570,000
Total Costs	**$233,000,000**	
Benefits		
Reduction in Generating Costs	$74,800,000	$6,600,000
Fuel Savings from CHP	$24,700,000	$2,180,000
Generation Capacity Cost Savings	$16,400,000	$1,450,000
Distribution Capacity Cost Savings	$2,280,000	$201,000
Reliability Improvements	$1,850,000	$164,000
Power Quality Improvements	$3,040,000	$268,000
Avoided Emissions Allowance Costs	$45,500	$4,010
Avoided Emissions Damages	$88,300,000	$5,760,000
Major Power Outage Benefits	$22,400,000	$1,980,000
Total Benefits	**$234,000,000**	
Net Benefits	**$1,050,000**	
Benefit/Cost Ratio	**1.0**	
Internal Rate of Return	**7.1%**	

Scenarios 3-7

Scenarios three through seven extends the cost-benefit analysis from a 0.3-day annual major power outage duration to the microgrid design event of a 7-day outage. Figure 4-3 below shows the benefit-cost ratio and project net benefits[27] (i.e. net benefits minus net costs) as outage duration increases. Table 4-5 presents the same metrics, with the addition of the project internal rate of return (not show in figure). The IEc results indicate that under the microgrid design event of 7-days of major outages per year over the 20-year microgrid operating period the benefit-cost ratio is 2.79 with net benefits exceeding $417 million.

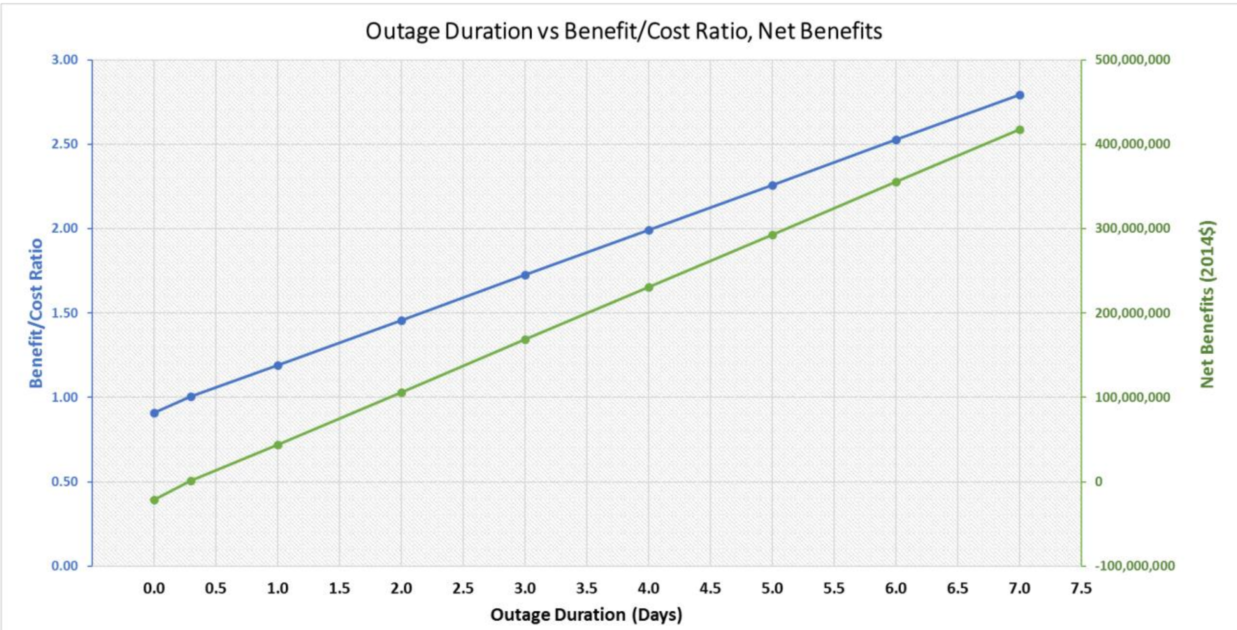

Figure 4.3. Outage Duration versus Project Benefit/Cost Ratio and Net Benefits

Table 4-5 Metrics of Outage Duation versus Benefit/Cost and IRR Ratios

Total Duration of Outage (Days)	Annual Probability of Outage (Percent)	Present Value of Major Power Outage Benefits (2014$)	Net Benefits (2014$)	Benefit/Cost Ratio	Internal Rate of Return
0.0	100%	-	(21,396,624.67)	0.91	0.00%
0.3	100%	22,449,350.10	1,052,725.42	1.00	7.05%
1.0	100%	65,623,890.74	44,227,266.06	1.19	20.32%
2.0	100%	127,301,805.94	105,905,181.26	1.45	44.60%
3.0	100%	190,237,373.52	168,840,748.85	1.73	83.64%
4.0	100%	252,334,506.18	230,937,881.51	1.99	152.51%
5.0	100%	314,431,638.84	293,035,014.17	2.26	306.99%
6.0	100%	376,528,771.51	355,132,146.83	2.53	958.15%
7.0	100%	438,625,904.17	417,229,279.50	2.79	N/A***

*** Internal rate of return value is too large for Microsoft Excel IRR function to calculate.

The detailed IEc model results for scenario 9 (corresponding to the microgrid design event of 7 days) are shown in Table 4-6 and Figure 4-4 below. The remaining detail results for scenarios (3, 4, 5, 6, 7, 8) are provided in Appendix B.

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[27] Net present value, discounted at 7%

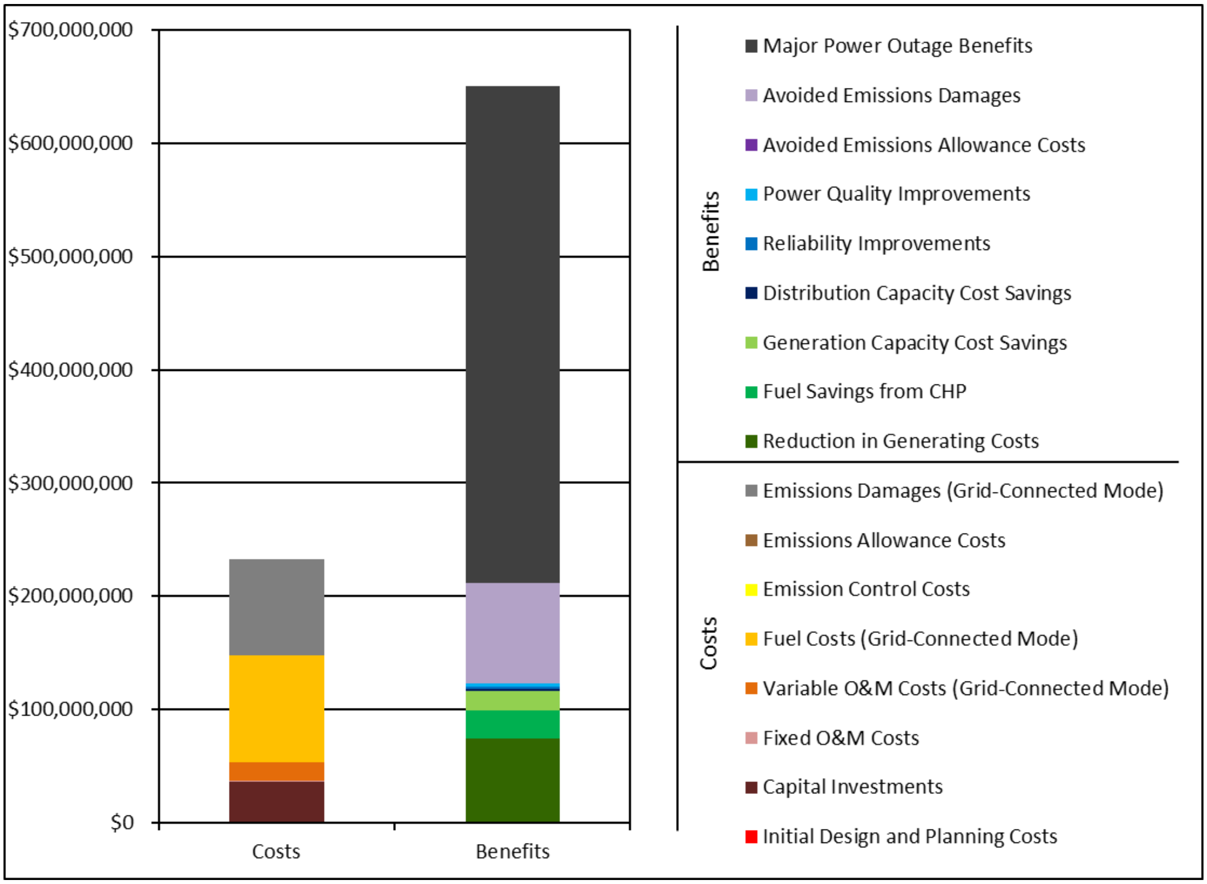

Figure 4.4. Present Value Results, Scenario 9 (Major Power Outages Averaging 7 Days/Year; 7 Percent Discount Rate)

Table 4-6 Detailed BCA Results, Scenario 9 (Major Power Outages Averaging 7 Days/Year; 7 Percent Discount Rate)

COST OR BENEFIT CATEGORY	PRESENT VALUE OVER 20 YEARS (2014$)	ANNUALIZED VALUE (2014$)
Costs		
Initial Design and Planning	$328,000	$28,900
Capital Investments	$35,800,000	$3,160,000
Fixed O&M	$1,270,000	$112,000
Variable O&M (Grid-Connected Mode)	$15,600,000	$1,370,000
Fuel (Grid-Connected Mode)	$94,500,000	$8,340,000
Emission Control	$0	$0
Emissions Allowances	$0	$0
Emissions Damages (Grid-Connected Mode)	$85,300,000	$5,570,000
Total Costs	**$233,000,000**	
Benefits		
Reduction in Generating Costs	$74,800,000	$6,600,000
Fuel Savings from CHP	$24,700,000	$2,180,000
Generation Capacity Cost Savings	$16,400,000	$1,450,000
Distribution Capacity Cost Savings	$2,280,000	$201,000
Reliability Improvements	$1,850,000	$164,000
Power Quality Improvements	$3,040,000	$268,000
Avoided Emissions Allowance Costs	$45,500	$4,010
Avoided Emissions Damages	$88,300,000	$5,760,000
Major Power Outage Benefits	$439,000,000	$38,700,000
Total Benefits	**$650,000,000**	
Net Benefits	**$417,000,000**	
Benefit/Cost Ratio	**2.79**	
Internal Rate of Return	***Range Exceeded***[28]	

[28] Internal rate of return value is too large for Microsoft Excel IRR function to calculate.

5 FINAL WRITTEN DOCUMENTATION

"The challenge is that the day before something is truly a breakthrough, it's a crazy idea. And crazy ideas are very risky to attempt", Peter Diamandis.

Much has gone into assessing both the feasibility and viability in our overall perspective of a smart grid asset including of course the work here. NY Prize served as a further catalyst in moving from concept, assumption and discussion to a more developed, tactical set of options or plan(s). It certainly has focused our attention and positioned the BNMC very well to address the *risk* in our *crazy idea*.

Executive Summary

What Does Success Look Like

The Buffalo Niagara Medical Campus (BNMC) is dedicated to leveraging demand management, energy efficiency, grid modernization, alternative transportation, and distributed energy resources in fostering a sustainable, growing community.

Initiatives currently underway concentrate on developing the Campus and adjacent neighborhoods as a self-sustainable energy hub enabling this dynamically managed portfolio to disconnect and island during weather or system-related events and optimize during "blue sky" days.

The integration of portfolio-level command, control and distributed energy resources with the underground distribution grid infrastructure linking customer to utility will position the collective BNMC portfolio to serve as a robust smart grid asset.

We Strive To Be A Pro-sum-er

A collection of electric consumers that proactively attains maximum economic and environmental benefits by leveraging information, technology, distributed generation, and storage resources to successfully reduce and reshape energy demand on the grid.

What Do We See As Trends

The emergence and viability of customer-sited distributed generation, renewables and storage.

Intelligent loads; advances in building automation, enhanced connectivity to and communication with those loads and command/control infrastructure.

Microgrids and aggregated dynamically managed portfolios of distributed assets integrated with /contributing back to the larger grid through two-way power flow management.

Consortiums of service/technology providers and public/private financing responding to robust market animation

A key consideration, from both an economic and reliability perspective, in the build-out of a robust, optimized microgrid is the inherent advantage an underground network provides in enhancing resiliency as well as functionality. The BNMC Community Microgrid, as outlined in this report, takes a tiered approach building upon an *existing underground network*, back-up generation assets already in place, and energy-efficient facilities amongst other standing distributed energy resources. These elements enable the Campus to ramp-up quickly.

Further buildout of this dynamic portfolio that leverages existing resources and scoped assets will provide a platform for BNMC member institutions and adjoining community members to optimize their energy flexibility based on individual priorities with respect to reliability, cost, and sustainability while actively coordinating their collective distributed energy resources (DERs) in a market that compensates them for providing such system benefits (i.e. market animation). Other elements of the BNMC Community Microgrid strategy that will drive this dynamically managed, optimized grid asset include:

Advanced metering functionality

- Enable two-way communication between meters and the central system

Smart buildings

- Capable of modulating consumption/demand against economic, sustainability, or comfort goals and operational constraints

Data display, communications infrastructure, and information management

- Enable analysis and visualization
- Establish a reliable and secure communication link between demand-side resources and the distribution utility to enable real-time information exchange
- Potentially serve as a single nodal interface of a customer aggregation with a DSP
- Help inform customer investment decisions

Command and control

- Integrate campus-level command/control capabilities with the distribution grid infrastructure linking customer-to-utility
- Enable the collective BNMC portfolio to serve as a smart grid asset
- Empower actionable microgrid processes such as DER performance settings, deployment and network configuration through existing infrastructure

On-site power generation with storage options and the ability to switch or export

- Respond to system events (i.e. provision of base load or peaking power) and price signals

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- Flexible, diverse localized generation that enhances reliability, manages load variability, and generates savings

Market interface

- Deploy software to facilitate participation in existing ISO markets and/or future distribution-level markets and to manage measurement, verification and reconciliation processes

Optimization platform

- Maximize economic value (i.e., revenue, savings, avoided spend) for the BNMC through the efficient use of distributed energy resources such as co-generation, renewables, storage, alternative fuel / generation resources, and controllable loads
- Maximize functional and economic value for the distribution grid through layering the topology of campus DER's with forecasted load, generation and constraints to create a dynamic, forward-looking dispatch schedules

Islanding

- Increase system resiliency
- Protection against catastrophic events
- Serve as the community safe haven.
- Black Start capabilities

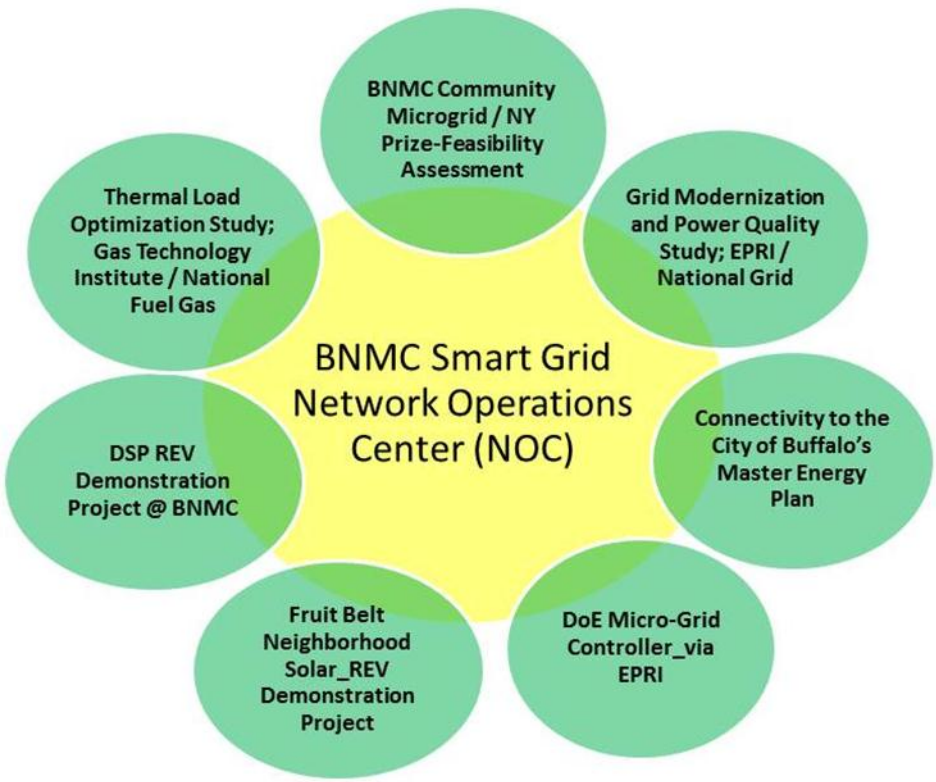
Demand response

- Provide load reduction or management services (bid-based or via a bi-lateral arrangement with the ISO or DSP market operator) as a collective Campus portfolio that appears as a single dispatchable load

The BNMC is well-positioned and arguably closer to effectively contributing to market animation than many other areas of the State. There is a current level of diversity and potential for greater diversity, in terms of load type, fuel source, control capability, and automation amongst other elements within the Campus' footprint alone to demonstrate the vision REV is driving towards:

"Climate change also compels reform. Electric system planning must include carbon reduction, storm hardening of infrastructure and dynamic system management to accommodate the needs of a low carbon generation fleet", *Case 14-M-0101, Reforming the Energy Vision (REV) Order Adopting Regulatory Policy Framework and Implementation Plan issued February 26th, 2015*.

In general the connectivity of the BNMC Community Microgrid strategy with REV initiatives as well as other State efforts is very straightforward and well aligned. While all these assorted initiatives are about the technology, they are also very much about the strategy. We have taken a very holistic approach to this project and others currently evolving to focus on building projects that are scalable and replicable, as the figure below illustrates:



Smart Grid Network Operations Center (NOC). Provide a platform for BNMC member institutions and adjoining community members to optimize their energy flexibility based on individual priorities with respect to reliability, cost, and sustainability while actively coordinating their collective distributed energy resources (DERs) in a market that compensates them for providing such system benefits.

BNMC Community Microgrid / NY Prize-Feasibility Assessment. The BNMC Inc., its member institutions, the surrounding neighborhoods and other key stakeholders, most notably National Grid, partnered to develop an Energy Innovation Plan that supports economic development and growth in the greater Buffalo Niagara Region. The plan integrates demand management, energy efficiency, grid modernization, alternative transportation and renewable energy to foster a sustainable, growing community. Elements of that plan focus on developing the campus and surrounding areas as a self-sustainable energy hub (Community Micro-Grid) able to offset utility outages or natural disasters enhancing reliability and resiliency. That would also empower our members to optimize their priorities with respect to reliability, cost and sustainability while actively coordinating their distributed energy resources in concert with and on behalf of the local distribution utility to provide overall system benefits.

DoE Microgrid Controller_FOA 997. The United States (U.S.) Department of Energy (DOE) – National Energy Technology Laboratory (NETL), on behalf of the Office of Electricity Delivery and Energy Reliability (OE), sought applications for research and development (R&D) and testing of advanced commercial-grade microgrid controllers capable of managing/controlling microgrid systems. EPRI was one of the awardees and will utilize the BNMC project to develop a commercially-viable standardized microgrid controller that can allow a community to provide continuous power for critical loads. Standardizing functionality will ensure that the controller can be easily adapted for a wide range of electric grid characteristics and allow grid operators to leverage distribution assets to support both islanded and grid-connected operation.

Electric Power Research Institute (EPRI) Study that focuses on grid modernization and power quality. The study is funded by NYSERDA and National Grid. Specifically, the objectives of the project are to:

- Monitor the power system characteristics for various voltage levels and benchmark the existing power quality and reliability environment.
- Identify power quality and energy efficiency optimization possibilities throughout the local power grid and within BNMC customer facilities
- Analyze results in the context of improving electric power for end users by combining attributes of both the grid and distributed energy resources.
- Determine the benefit of innovative systems such as micro-grids and renewable energy sources to improve the reliability, sustainability, and quality of the power system
- Determine feasibility of implementing a self-sustainable energy hub for the BNMC campus and surrounding areas

The Gas Technology Institute (GTI) and National Fuel have funded a complementary thermal load optimization study in parallel. CDH Energy, a wholly owned subsidiary of GTI is driving the work building an assessment of cogeneration / combined heat power (CHP) options that might serve multiple entities on the campus.

The Fruit Belt Neighborhood Solar project is a National Grid REV Demonstration supported by the BNMC, Inc. In an effort to bolster the neighborhood's strengths, build a replicable model, and regenerate investment, the proposed Fruit Belt Community Solar Project seeks to engage and benefit the neighborhood through the installation of (100) residential PV systems. This project acknowledges the inherent link between energy efficiency and distribution efficiency. In utilizing comprehensive energy efficiency and geographically targeted – and organized – Distributed Energy Resources (DER) as its model, this project will study gains in grid efficiency through the reduction of energy losses, voltage control, and the monitoring and control of reactive power.

DSP REV Demonstration seeks to test and develop a DSP nodal model, that have independent, multiple points communicating to core services, and the desired objectives of the DSP as noted in the Commission's February 26, 2015 Order Adopting Regulatory Policy Framework and Implementation Plan ("REV Track One Policy Order") within the motivated market of the BNMC to determine what price signals and/or revenue opportunities motivate its member institutions to provide the DSP with electric distribution system services at the nodal level.

As you can see, elements in all our projects that speak to market animation, system efficiency, fuel/resource diversity, peak reduction, energy efficiency, and new business model development.

Where Are The Challenges

The core challenge really is how you utilize a customer to grid asset, fostering participation, with a level of control that allows all these pieces to make the whole system work. Like real estate location is key. Microgrids success is tied to regulation and incentives or effective market animation.

While some challenges maybe unique to this project most are truly issues that need to be considered regardless of geography if scale is to be achieved. Explored in more detail within Task 3 and elsewhere in this document the key challenges high-lighted here include:

The roles, rights and responsibilities of electric utilities are protected by a long established set of regulations that have yet to adapt to a changing power supply landscape. While some efforts do support microgrid development most legacy regulation supports the build-out of large interconnected power networks rather than pockets of high-reliability, flexible systems. There is no regulatory concept for commercial, multi-user microgrids. There are three key issues in this conversation.

1. Utility franchise rights and the ability of a microgrid to cross a right-of-way to distribute electricity.
2. Insufficient definition of a microgrid which may label a microgrid a utility. That places the entity under the regulation and ratemaking authority of the public service commission.
3. Interconnection rules, time and cost impacts to the developer.

We are dealing with a resource that unlike its peers, who are either generators or load management resources, can simultaneously provide multiple services although market rules prevent them from doing so. Akin to market rules is the discussion around new market opportunities. For example, the microgrid at BNMC has assumed a master meter (virtual or real) will be established on the four feeders out of Elm Street substation that serve the major

BNMC customers, including Kaleida and RPCI. This new master meter would effectively place the majority of the microgrids generation and load behind the meter providing the best economic value to the member institutions and the best potential ‘DSP Node Management’ value to the future DSP. The BNMC in effect would be using utility owned infrastructure to wheel power between on-campus buildings. That would enable for equitable, but not arbitrary or unfair, cost/benefit allocation. Most immediate and important is the ability of the campus to have a new master meter.

One of the foundational DER elements within our study is CHP. The economics of the CHP system depend on the marginal value of electricity displaced by on-site generation during “blue sky” conditions. The economic analysis has assumed that the generated electricity will be valued at a price near the retail cost currently paid by the facilities (i.e., 6-8 cents per kWh). The value of the CHP project depends on the marginal value of generation being near these retail values – as opposed to wholesale rates of simply exporting power to the grid. The regulatory and administrative arrangements with National Grid for the master meter must preserve the value of on-site generated power to ensure the overall project is viable.

It is also critical a methodology be developed that can account for T & D deferral from DER’s such as a microgrid. Establishing the value of ‘D’ will open up new markets and revenue streams for grid services at the distribution level that would allow a microgrid to capture more ‘blue sky’ revenue including the option to sell excess generation above the wholesale rate to account for system benefits.

Recommendations

Microgrid investments provide important value streams for which there is presently no functional mechanism to monetize. With proper monetization opportunities available an aggregated, dynamically managed portfolio of varied resources where different distributed energy assets could contribute effectively at different times, for different durations and in different fashions, but none the less collectively, to grid optimization. This type of a dynamically managed portfolio could provide targeted congestion relief and grid support via frequency regulation, voltage support and potentially black start capabilities. There is enough diversity and potential for diversity in terms of load types, fuel sources, control capability and automation amongst other elements to demonstrate this provided it is supported with the right price signals. We need transactional models thinking from the customer perspective out.

In order to truly maximize opportunities the process must account for the full value of the DER; its contribution or impact to multiple needs such as demand, energy efficiency, avoided infrastructure spend, reliability, carbon reduction, etc. While a useful cost benefit analysis tool was developed as part of this study a more expanded version should be developed.

The commercial design and technical design are inherently tied together and must be developed iteratively and in an integrated fashion. The current process assumes that a technical design can be completed before the commercial design is started which is a less than optimal approach from our perspective. We will continue to incorporate those teams together moving forward in our work.

There is need to develop standard models/approaches to ensure effective integration with existing utility distribution networks particularly for the likely increasing number of more complex configurations. Those configurations will have multiple DER, and multiple points of common coupling with the utility system and/or secondary networks.

With respect to the process in this phase of NY Prize perhaps the line between feasibility and design could have been defined as some questions could not be answered in meaningful depth absent a yet to be scoped detailed design.

Project Lessons Learned

The BNMC is a 'built' environment without a central or singular point of governance as each member institution is independent which creates both advantages and challenges. That said because the institutions are private we were able to work at the 'pace of business'. Similarly early and ongoing collaborative involvement by the utility was key to crafting a menu of effective solutions.

With multiple microgrid scenarios possible the economic case for reconfiguring resources was challenging but because of existing physical infrastructure of the site, electrical and thermal (underground wiring and some district thermal distribution) we were able to minimize overall project cost.

Collaboration between the technical and commercial/financial teams proved invaluable providing additional and very robust insights from different perspectives. That was helpful now in this phase but will also pay dividends moving forward as we plan for future opportunities and address challenges as they arise.

Prior to working through the feasibility process we may have under-estimated the implications and relationship between technical choices and commercial/financial structures including ownership models.

Environmental and Economic Benefits

We designed for blue sky optimization providing the greatest economic benefit both from a cost and savings/revenue perspective. That was done of course driven by the core need to address the resiliency requirements of these critical facilities. Certainly incorporating a renewable resource with a storage element creates a significant environmental benefit but enhanced information management and expanded command/control capabilities (automation) will enable a heightened level of demand control and energy efficiency. That benefits the BNMC but also the system as a whole.

With the proper amount of support, access to resources, and stakeholder focus, the BNMC stands ready to deliver in an accelerated fashion the replicable, functioning community microgrid and grid-interactive 'blue sky' optimization capabilities envisioned by REV, this New

York Prize Microgrid Competition, and the proposed DSP REV Demonstration Project in partnership with National Grid.

In Conclusion

Leveraging Buffalo's Medical Assets

The Buffalo Niagara Medical Campus is a dynamic consortium of world class hospitals and health care organizations, exceptional educational institutions and innovative research facilities. The Medical Campus is home to hundreds of physicians, clinicians, scientists and researchers many of whom are world-renowned in the practice of oncology, neurosurgery, immunology, vascular surgery, cardiology, and beyond.

Collaboration among the Campus member institutions combined with significant research and clinical capabilities has served to spark a wave of entrepreneurship that has led to the creation or co-location of more than 100 public/private companies. These include a growing cluster of life sciences, bioinformatics, health care technology, manufacturing, *energy*, social innovation and not-for profit organizations.

BNMC at a Glance

6.5 million square feet of existing clinical, research and support space today, with 4.5 million square feet in the development footprint.

More than 2 million square feet under construction driving an investment of $1.4 billion in private/public funding by 2017.

12,000 people working here today, rising to nearly 17,000 in 2017, making the Campus one of the largest employment centers in the region.

In the heart of the City of Buffalo, a new approach to economic and social development is taking hold. The Campus is building on its existing assets as a world class Medical Campus to support its mission of furthering regional economic growth, igniting urban revitalization and building a strong, thriving community.

We at the BNMC, in synch with New York's REV initiative, are thinking differently about energy issues. Using our MutualCity methodology to leverage the assets of multiple institutions and our community partners, we are collaborating with a vast network of diverse partners, sharing our resources and working on innovative ways to improve our city and the region.

A APPENDIX

NY Prize Benefit-Cost Analysis: Microgrid Questionnaire

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

A. Project Overview, Energy Production, and Fuel Use

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

   - **Facility name:** Please enter the name of each facility the microgrid would serve. Note that a single **facility** may include multiple **customers** (e.g., individually-metered apartments within a multi-family apartment building). When this is the case, you do not need to list each customer individually; simply identify the facility as a whole (see Table 1, "Main Street Apartments," for an example).

   - **Rate class:** Select the appropriate rate class for the facility from the dropdown list. Rate class options are residential, small commercial/industrial (defined as a facility using less than 50 MWh of electricity per year), or large commercial/industrial (defined as a facility using 50 or more MWh of electricity per year).

   - **Facility/customer description:** Provide a brief description of the facility, including the number of individual customers at the facility if it includes more than one (e.g., individually-metered apartments within a multi-family apartment building). For commercial and

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

Facility Name	Rate Class	Facility/Customer Description (Specify Number of Customers if More Than One)	Economic Sector Code	Average Annual Electricity Usage Per Customer (MWh)	Peak Electricity Demand Per Customer (MW)	Percent of Average Usage Microgrid Could Support During Major Power Outage	Hours of Electricity Supply Required Per Day During Major Power Outage
Kaleida Health	Large Commercial/Industrial (>50 annual MWh)	• Buffalo General Hospital (Hospital) • Gates Vascular Institute (Medical Research Center) • University of Buffalo Clinical & Translational Research Center (Medical Research Center) • Women & Children's Hospital (Hospital)	All other industries	66,862.521	11.820	100%	24
Roswell Park Cancer Institute	Large Commercial/Industrial (>50 annual MWh)	• Roswell Park Cancer Institute (Cancer care & research center) One Institution, Multiple Buildings: ▪ Main Hospital ▪ Gratwick Basic Science Building ▪ Administrative Services Building ▪ Cell & Virus Building ▪ Grace Cancer Drug Center ▪ Clinical Sciences Center	All other industries	56,442.694	10.415	100%	24
University at Buffalo School of Medicine	Large Commercial/Industrial (>50 annual MWh)	(Medical School)	All other industries	24,050.490	4.004	100%	24
Cleveland Biolabs	Large Commercial/Industrial (>50 annual MWh)	(Biology Research Center)	All other industries	710.494	0.199	100%	24
Fruit Belt Neighborhood	Residential	(291 x Low-Income Residential Houses)	Residential	5,401.603	1.441	100%	24

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

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

Distributed Energy Resource Name	Facility Name	Energy Source	Nameplate Capacity (MW)	Average Annual Production Under Normal Conditions (MWh)	Average Daily Production During Major Power Outage (MWh)	Fuel Consumption per MWh	
						Quantity	Unit
Gas Combustion Turbine (Combined Heat & Power)	Roswell Park Cancer Institute	Natural Gas	7.692 MW	63,919.40	184.61	**Normal Conditions** 9.1502 **Outage Conditions** 9.95	MMBtu/MWh
Internal Combustion Engine #1	Kaledia Health	Natural Gas	5.000 MW	34,706.23	120.00		
Internal Combustion Engine #2	Kaledia Health	Natural Gas	5.000 MW	34,706.23	116.09		
BNMC PV System #1	Kaleida Health – Childern's Hospital	Solar	0.320 MW_{DC}	372.38	1.92	0	N/A
BNMC PV System #2	U.B. School of Medicine	Solar	0.260 MW_{DC}	302.56	1.08	0	N/A
Fruitbelt Distributed PV Systems	Fruitbelt Neighborhood	Solar	0.500 MW_{DC}	581.85	2.42	0	N/A
Li-Ion Battery #1	Fruitbelt Neighborhood	Other - Battery	50 kW / 200 kWh	0	0	0	N/A
Li-Ion Battery #2	Kaleida Health – Childern's Hospital	Other - Battery	50 kW / 200 kWh	0	0	0	N/A
Li-Ion Battery #3	UB School of Medicine	Other - Battery	50 kW / 200 kWh	0	0	0	N/A
Cummins/Onan Cummins/Onan Cummins/Onan Cummins/Onan Onan Onan Masaro Caterpillar Caterpillar	Kaledia Health	Diesel	2.00 MW 2.00 MW 2.00 MW 2.00 MW 0.750 MW 0.750 MW 0.765 MW 0.550 MW 0.550 MW	0	Invest Case 38.40	Invest Case 10.03	MMBtu/MWh
Caterpillar Cummins/Onan Cummins/Onan Cummins/Onan Cummins/Onan Cummins/Onan Cummins/Onan Cummins/Onan Cummins/Onan Caterpillar Caterpillar Generac Cummins/Onan	Roswell Park Cancer Institute	Diesel	2.00 MW 1.500 MW 1.250 MW 1.250 MW 1.250 MW 1.250 MW 1.250 MW 1.100 MW 1.000 MW 0.750 MW 0.600 MW 0.350 MW 0.175 MW	0	Invest Case 31.83	Invest Case 10.72	MMBtu/MWh
Diesel Generator –Unknown Manufacturer	UB School of Medicine	Diesel	2.500 MW	0	Invest Case 0	Invest Case 0	MMBtu/MWh
Cummins/Onan Cummins/Onan	Cleveland Biolabs	Diesel	0.475 MW 0.350 MW	0	Invest Case 0	Invest Case 0	MMBtu/MWh

B. Capacity Impacts

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

☐ No – proceed to Question 6

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

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

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

Provision of Peak Load Support

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

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

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

Distributed Energy Resource Name	Facility Name	Available Capacity (MW/year)	Does distributed energy resource currently provide peak load support?
Gas Combustion Turbine (Combined Heat & Power)	Roswell Park Cancer Institute	7.692 MW	☐ Yes
Internal Combustion Engine #1	Kaledia Health	5.000 MW	☐ Yes
Internal Combustion Engine #2	Kaledia Health	5.000 MW	☐ Yes
BNMC PV System #1	Kaleida Health – Children's Hospital	0.320 MW	☐ Yes
BNMC PV System #2	U.B. School of Medicine	0.260 MW	☐ Yes
Fruitbelt Distributed PV Systems	Fruitbelt Neighborhood	0.500 MW	☐ Yes
Li-Ion Battery #1	Fruitbelt Neighborhood	50 kW	☐ Yes
Li-Ion Battery #2	Kaleida Health – Children's Hospital	50 kW	☐ Yes
Li-Ion Battery #3	UB School of Medicine	50 kW	☐ Yes

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

Participation in a Demand Response Program

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

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

Facility Name	Capacity Participating in Demand Response Program (MW/year)	
	Following Development of Microgrid	Currently

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

☐ Yes – proceed to Question 7

☒ No – proceed to Section C

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

Impact of Microgrid on Utility Transmission Capacity	Unit
To determine the effects of the unavailability of the Huntley plant and/or the Dunkirk plant, National Grid and the NYISO conducted a coordinated assessment of reliability impacts on the local transmission system as well as the Bulk Power System. National Grid's determination is that the reliability of the local transmission system and the Bulk Power System can be maintained through at least 2020 if Dunkirk is mothballed and Huntley is retired. Voltage reliability issues in the Huntley area primarily due to 23kV load connected to the 230kV system. These issues can be mitigated in the short term with the installation of 230kV capacitor banks in the Huntley area along with potential reconfigurations and/or relay setting modifications at a 23kV distribution station. The estimated cost to install the two capacitor banks is $7.5 million, and the expected in-service date is June 1, 2016. National Grid has proposed adding series reactors to the most constraining 230 kV lines north of Huntley, with a planned in-service date of June 1, 2016, to improve the total Niagara Power Project and Ontario import energy deliverability. An important operational consideration related to the proposed retirement of Huntley and mothballing of Dunkirk is the impact to the Niagara Power Project and Ontario import energy deliverability under normal day-to-day transfer criteria. NYISO studies indicate that the total Niagara Power Project and Ontario import energy deliverability would be reduced to approximately 2,000 MW under forecast peak load conditions, a reduction of over 800 MW compared to the existing system. These constraints would be much greater under transmission outage (N-1-1) conditions. The series reactors would improve the total Niagara Power Project and Ontario import energy deliverability, but there would still be a reduction compared to the levels of energy deliverability that exist today with Dunkirk Unit 2 and both Huntley units available. This reduction in energy deliverability will persist until permanent solutions are in place, to be addressed in response to the Western New York Public Policy Transmission Need. In the interim, the NYISO and National Grid are considering a temporary operating procedure to allow the constraining National Grid 230 kV lines to be secured to the higher short-term emergency ratings, similar to the existing NYPA Niagara runback procedure, thus improving Niagara Power Project and Ontario import energy deliverability.	5% MW/year

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

Impact of Microgrid on Utility Distribution Capacity	Unit
National Grid's Elm Street substation provides power to the majority of Downtown Buffalo and local distribution stations via underground 23kV circuits. Resiliency is built in the system as it presently exists, with the Huntley coal-fired plant providing power via underground cables to the Elm Street Sub, which delivers power to customers via underground conductors, and beyond, from the Elm Street Sub to the Seneca Terminal via underground cables. With the present emphasis on resiliency, climate change, and the expectation of a greater frequency of more severe weather conditions, it is important to note the level of reliability and resiliency that is already built into the Huntley-Elm Street substation configuration.	MW/year

C. Project Costs

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

Capital Costs

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

Capital Component	Installed Cost ($)	Component Lifespan (round to nearest year)	Description of Component
Electrical Infrastructure	$3,280,000	20+	
Controls Infrastructure	$300,000	20+	
Thermal Infrastructure	Initial Capital = $1,000,000 National Fuel CHP Incentive = $1,000,000 **Net Capital = $0**	20+	
Gas Combustion Turbine (Combined Heat & Power)	$16,353,192.00	20+	Gas combustion turbine with Heat Recovery Steam Generator. Steam feeds steam loop feeding both Roswell Park and Kaleida Health. Sheltered within existing Roswell Park utilities plant.
Internal Combustion Engine #1	$6,663,000.00	20+	Internal combustion engine. Price includes shelter build out near Kaleida Health utilities plant.
Internal Combustion Engine #2	$6,663,000.00	20+	Internal combustion engine. Price includes shelter build out near Kaleida Health utilities plant.
BNMC PV System #1	$473,600.00	20+	320 kW PV system; interconnected at 480 V; utilizes central inverters w/ advanced functions
BNMC PV System #2	$384,800.00	20+	260 kW PV system; interconnected at 480 V; utilizes central inverters w/ advanced functions
Fruitbelt Distributed PV Systems	0	20+	Distributed PV systems with aggregate capacity of 500 kW; utilizes micro-inverters w/ advanced functions
Li-Ion Battery #1	160,000.00	10	Battery system that can be used for both power (i.e. fast acting) as well as energy (i.e. long duration) applications.
Li-Ion Battery #2	160,000.00	10	Battery system that can be used for both power (i.e. fast acting) as well as energy (i.e. long duration) applications. Used for Fruitbelt peak shaving at the substation level.
Li-Ion Battery #3	160,000.00	10	Battery system that can be used for both power (i.e. fast acting) as well as energy (i.e. long duration) applications. Used for Fruitbelt peak shaving at the substation level.

Initial Planning and Design Costs

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

Initial Planning and Design Costs ($)	What cost components are included in this figure?
10% of the total capital cost $3,280,000 x 10% = $328,000	• Design Intent – Qualitative description of the project and define performance criteria • Design Basic – Design narrative, design rationale, microgrid operational sequence and use cases • Power System Design analysis – Conduct steady state and dynamic analysis • Concept One-line diagram layout for all the equipment at each facility • PQ Audit at each facility and outline the reliability and PQ requirements at each facility • Monitoring Plan and identifying all the points within the proposed system • Protection Study to outline the additional needs of protective devices • Engineering design study to identify how the information at the proposed site can be linked with NG SCADA system • Control and communications Needs at the site • DER Needs at the site • Site adequacy for installing DER • Functional specs of proposed assets

Fixed O&M Costs

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

☒ No – proceed to Question 12

☐ Yes – proceed to Question 13

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

Fixed O&M Costs ($/year)	What cost components are included in this figure?
Estimated at 2% of Infrastructure Capital Costs: $4,580,000 x 2% = **$91,600**	O&M – Electrical Infrastructure, Thermal Infrastructure, Communications Infrastructure Periodic system-wide testing & audits, database maintenance, solar forecasting subscription, software licenses & services, NYISO market participation fees, other operational costs, etc.
Included in variable O&M (Q14)	Internal Combustion Engine #1 – Fixed O&M
Included in variable O&M (Q14)	Internal Combustion Engine #2 – Fixed O&M
Included in variable O&M (Q14)	Combustion Turbine (w/ CHP) O&M – Fixed O&M
$20/kW/yr x 320 kW = **$6,400 / yr**	BNMC PV System #1 O&M
$20/kW/yr x 260 kW = **$5,200 / yr**	BNMC PV System #2 O&M
Covered by National Grid	Fruitbelt Distributed PV Systems O&M
$15/kWh/yr x 200 kWh = **$3,000 / yr**	Li-Ion Battery #1 O&M
$15/kWh/yr x 200 kWh = **$3,000 / yr**	Li-Ion Battery #2 O&M
$15/kWh/yr x 200 kWh = **$3,000 / yr**	Li-Ion Battery #3 O&M
$34,449 /yr – Kaledia Health DGs $41,650 / yr – Roswell Park DGs $5,400 / yr– U.B. School of Medicine DGs $4,745 / yr – Cleveland Biolabs DGs	Diesel Generators ***O&M costs remain the same for base case (i.e. no microgrid) and investment case.***

Please proceed to Question 14.

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

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

Variable O&M Costs (Excluding Fuel Costs)

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

Variable O&M Costs ($/Unit of Energy Produced)	Unit	What cost components are included in this figure?
12.236	$/MWh	Combustion Turbine (w/ CHP) – **Fixed & variable O&M costs** HRSG maintenance and inspection, Standby inspections (e.g. servicing the battery system, changing filters, checking oil and water levels, cleaning relays, and checking device calibrations), Running inspections (e.g. speed, load, fired starts, fired hours, temperature, pressure, vibration, generator performance, startup time), combustion inspections, parts planning, etc.
8.5	$/MWh	Internal Combustion Engine #1 – **Fixed & variable O&M costs** Standby inspections (e.g. servicing the battery system, changing filters, checking oil and water levels, cleaning relays, and checking device calibrations), Running inspections (e.g. speed, load, fired starts, fired hours, temperature, pressure, vibration, generator performance, startup time), combustion inspections, parts planning, etc.
8.5	$/MWh	Internal Combustion Engine #2 – **Fixed & variable O&M costs** Standby inspections (e.g. servicing the battery system, changing filters, checking oil and water levels, cleaning relays, and checking device calibrations), Running inspections (e.g. speed, load, fired starts, fired hours, temperature, pressure, vibration, generator performance, startup time), combustion inspections, parts planning, etc.

Fuel Costs

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

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

Distributed Energy Resource Name	Facility Name	Duration of Design Event (Days)	Quantity of Fuel Needed to Operate in Islanded Mode for Duration of Design Event	Unit
Internal Combustion Engine #1	Kaleida Health	7	6,848,655.22	Cubic feet
Internal Combustion Engine #2	Kaleida Health	7	6,650,221.78	Cubic feet
Combustion Turbine (w/ CHP)	Roswell Park Cancer Institute	7	14,397,601.42	Cubic feet
BNMC PV System #1	Kaleida Health – Children's Hospital	7	n/a	n/a
BNMC PV System #2	UB School of Medicine	7	n/a	n/a
Fruitbelt Distributed PV Systems	Fruitbelt Neighborhood	7	n/a	n/a
Li-Ion/Lead Acid Battery #1	Fruitbelt Neighborhood	7	n/a	n/a
Li-Ion/Lead Acid Battery #2	Kaleida Health – Children's Hospital	7	n/a	n/a
Flywheel	UB School of Medicine	7	n/a	n/a
Kaleida Health Diesel Generators (11,365 kW)	Kaleida Health	7	19,375.44	Gallons
Roswell Park Diesel Generators (13,725 kW)	Roswell Park Cancer Institute	7	17,168.02	Gallons
UB School of Medicine Diesel Generators (2,500 kW)	UB School of Medicine	7	0	Gallons
Cleveland Biolabs Diesel Generators (825 kW)	Cleveland Biolabs	7	0	Gallons

For Reference Only:

		Capacity (kW)	Fuel (Gallons)	Electric (kWh)
KH	Cummins/Onan	2000	-	-
	Cummins/Onan	2000		
	Cummins/Onan	2000		
	Cummins/Onan	2000		
	Onan	750	11,031.57	153,748.00
	Onan	750		
	Masaro	765	-	-
	Caterpillar	550	8,343.88	115,047.00
	Caterpillar	550		
	Total	**11,365.00**	**19,375.44**	**268,795.00**
RPCI	Caterpillar	2000	1,551.75	19,289.00
	Cummins/Onan	1500	4,772.01	62,724.00
	Cummins/Onan	1250	4,772.01	53,178.00
	Cummins/Onan	1250		
	Cummins/Onan	1250		
	Cummins/Onan	1250		
	Cummins/Onan	1250		
	Cummins/Onan	1100	3,688.90	48,446.00
	Cummins/Onan	1000	3,074.17	39,195.00
	Caterpillar	750	-	-
	Caterpillar	600	-	-
	Generac	350	-	-
	Cummins/Onan	175	-	-
	Total	**13,725.00**	**17,858.83**	**222,832.00**
UB	Unknown	2500	-	-
	Total	**2,500.00**	**-**	**-**
CB	Cummins/Onan	475	-	-
	Cummins/Onan	350	-	-
	Total	**825**	**0**	**0**

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

☒ Yes – proceed to Question 17

☐ No – proceed to Question 18

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

Type of Fuel Offset by New CHP System	Annual Energy Savings Relative to Current Heating System	Unit
Natural gas	Boiler (Base Case) = 679,845.95 MMBtu Boiler (Invest Case) = 360,974.71 MMBtu **Difference = 318,871.24 MMBtu**	MMBtu
Choose an item.		Choose an item.
Choose an item.		Choose an item.
Choose an item.		Choose an item.
Choose an item.		Choose an item.

For reference only:

Normal, grid-connected operations, annual consumption.

	Base Case	Investment Case
- 7692 KW CT CHP - 2 x 5000 kW ICE	*Does Not Exist*	1,218,867.95 MMBtu
Boiler	679,845.95 MMBtu	360,974.71 MMBtu
Total	**679,845.95 MMBtu**	**1,579,842.66 MMBtu**

Emissions Control Costs

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

Cost Category	Costs ($)	Description of Component(s)	Component Lifespan(s) (round to nearest year)
Capital Costs ($)			
Annual O&M Costs ($/MWh)			
Other Annual Costs ($/Year)			

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

☐ Yes

☒ No

D. Environmental Impacts

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

	7692 KW CT CHP	5000 kW ICE #1	5000 kW ICE #2	Diesel Gensets			
				KH	RPCI	UB Med	Cleveland Biolabs
Units	Metric Tons/ MWh	Metric Tons/ MWh	Metric Tons/ MWh	Metric Tons/ MWh	Metric Tons/ MWh	Metric Tons/ MWh	Metric Tons/ MWh
NOx	0.00028814	0.000032	0.000032	0.007815	0.007815	0.007815	0.007815
CO	0.00029185	0.000091	0.000091	0.001347	0.001347	0.001347	0.001347
UHC	0.00016715	-	-	-	-	-	-
NMHC	-	-	-	-	-	-	-
VOC	0.00003338	0.000045	0.000045	0.000025	0.000025	0.000025	0.000025
PM10/PM2.5	0.00007960	-	-	0.000207	0.000207	0.000207	0.000207
SO2	0.00001804	-	-	-	-	-	-
CO2	0.63145672	0.448603	0.448603	0.660630	0.660630	0.660630	0.660630

Note: Diesel generators would only operate during islanded mode.

E. Ancillary Services

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

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

NY Prize Benefit-Cost Analysis: Facility Questionnaire

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

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

I. Current backup generation capabilities.

II. The costs that would be incurred to maintain service during a power outage, both when operating on its backup power system (if any) and when backup power is down or not available.

III. The types of services the facility provides.

I. Backup Generation Capabilities

1. Do any of the facilities that would be served by the microgrid currently have backup generation capabilities?

   a. ☐ No - proceed to Question 4

   b. ☒ Yes - proceed to Question 2

2. For each facility that is equipped with a backup generator, please complete the table below, following the example provided. Please include the following information:

   a. **Facility name:** For example, “Main Street Apartments.”

   b. **Identity of backup generator:** For example, “Unit 1.”

   c. **Energy source:** Select the fuel/energy source used by each backup generator from the dropdown list. If you select “other,” please type in the energy source used.

   d. **Nameplate capacity:** Specify the nameplate capacity (in MW) of each backup generator.

   e. **Standard operating capacity:** Specify the percentage of nameplate capacity at which the backup generator is likely to operate during an extended power outage.

   f. **Average electricity production per day in the event of a major power outage**: Estimate the average daily electricity production (MWh per day) for the generator in the event of a major power outage. In developing the estimate, please consider the unit’s capacity, the daily demand at the facility it serves, and the hours of service the facility requires.

g. **Fuel consumption per day:** Estimate the amount of fuel required per day (e.g., MMBtu per day) to generate the amount of electricity specified above. This question does not apply to renewable energy resources, such as wind and solar.

h. **One-time operating costs:** Please identify any one-time costs (e.g., labor or contract service costs) associated with connecting and starting the backup generator.

i. **Ongoing operating costs:** Estimate the costs ($/day) (e.g., maintenance costs) associated with operating the backup generator, excluding fuel costs.

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

Facility Name	Generator ID	Energy Source	Nameplate Capacity (MW)	Capacity Factor (%) for 1 Week Outage	Avg. Daily Production During Power Outage (MWh/Day)	Fuel Consumption per Day		One-Time Operating Costs ($)	Ongoing Operating Costs ($/Day)
						Quantity	Unit		
Kaleida Health	Cummins/Onan	Diesel	2000 kW	19.93%	9.57	99.03	MMBtu/ Day	0	0
	Cummins/Onan	Diesel	2000 kW	19.93%	9.57	99.03	MMBtu/ Day	0	0
	Cummins/Onan	Diesel	2000 kW	19.93%	9.57	99.03	MMBtu/ Day	0	0
	Cummins/Onan	Diesel	2000 kW	19.93%	9.57	99.03	MMBtu/ Day	0	0
	Onan	Diesel	750 kW	23.21%	4.18	39.12	MMBtu/ Day	0	0
	Onan	Diesel	750 kW	23.21%	4.18	39.12	MMBtu/ Day	0	0
	Masaro	Diesel	765 kW	23.21%	4.26	39.90	MMBtu/ Day	0	0
	Caterpillar	Diesel	550 kW	23.21%	3.06	28.68	MMBtu/ Day	0	0
	Caterpillar	Diesel	550 kW	23.21%	3.06	28.68	MMBtu/ Day	0	0
Roswell Park Cancer Institute	Caterpillar	Diesel	2000 kW	4.91%	2.36	25.06	MMBtu/ Day	0	0
	Cummins/Onan	Diesel	1500 kW	10.71%	3.86	38.31	MMBtu/ Day	0	0
	Cummins/Onan	Diesel	1250 kW	25.54%	7.66	76.31	MMBtu/ Day	0	0
	Cummins/Onan	Diesel	1250 kW	25.54%	7.66	76.31	MMBtu/ Day	0	0
	Cummins/Onan	Diesel	1250 kW	25.54%	7.66	76.31	MMBtu/ Day	0	0
	Cummins/Onan	Diesel	1250 kW	25.54%	7.66	76.31	MMBtu/ Day	0	0
	Cummins/Onan	Diesel	1250 kW	25.54%	7.66	76.31	MMBtu/ Day	0	0
	Cummins/Onan	Diesel	1100 kW	5.84%	1.54	15.48	MMBtu/ Day	0	0
	Cummins/Onan	Diesel	1000 kW	3.50%	0.84	9.01	MMBtu/ Day	0	0
	Caterpillar	Diesel	750 kW	26.79%	4.82	45.14	MMBtu/ Day	0	0
	Caterpillar	Diesel	600 kW	26.79%	3.86	36.11	MMBtu/ Day	0	0
	Generac	Diesel	350 kW	26.79%	2.25	21.06	MMBtu/ Day	0	0
	Cummins/Onan	Diesel	175 kW	26.79%	1.13	10.53	MMBtu/ Day	0	0
University of Buffalo School of Medicine	Unknown Manufacturer	Diesel	2000 kW	54.24%	26.04	268.83	MMBtu/ Day	0	0
Cleveland Biolabs	Cummins/Onan	Diesel	475 kW	0%	0	0	MMBtu/ Day	0	0
	Cummins/Onan	Diesel	350 kW	38.35%	3.22	33.40	MMBtu/ Day	0	0
Fruitbelt Neighborhood	*No backup; Existing PV cannot operate*	Choose an item.						0	0

For reference only: calculation & Unit Conversion:

	Genset	MMbtu/day		Capacity Factor
KH	Cummins/Onan 2 MW (x4)	99.03		19.93%
	Onan 750 kW (x2)	39.12		23.21%
	Masaro 765 kW	39.90		23.21%
	Caterpillar 550 kW (x2)	28.68		23.21%
RP	Caterpillar 2MW	25.06		4.91%
	Cummins/Onan 1.5MW	38.31		10.71%
	Cummins/Onan 1.25MW (x5)	76.31		25.54%
	Cummins/Onan 1.1MW	15.48		5.84%
	Cummins/Onan 1MW	9.01		3.50%
	Caterpillar 750kW	45.14		26.79%
	Caterpillar 600kW	36.11		26.79%
	Generac 350kW	21.06		26.79%
	Cummins/Onan 175kW	10.53		26.79%
UB	DG (2 MW)	268.83		54.24%
CB	Cummins/Onan 475 kW	-		0.00%
	Cummins/Onan 350 kW	33.40		38.35%

Comments on Modeling Outage

For the peak week outage, the unmet load (energy) under the no microgrid case is denoted in the very last column (right). As a whole, BNMC will lose 68% of its load during this outage, leaving only 32% of loads served.

This can be interpreted in two ways.

Note: 1 week = 168 hours

Unmet Load	Outage Scenarios (1 week)									
	Spring		Summer		Fall		Winter		Peak	
Institution	**kWh**	**%**	**kWh**	**%**	**kWh**	**%**	**kWh**	**%**	**kWh**	**%**
Kaleida Health	745,401	65.1%	1,243,414	75.8%	955,407	70.5%	710,104	64.0%	1,142,702	72.9%
Roswell Park	558,021	57.5%	941,217	69.5%	714,291	63.4%	529,307	56.1%	901,879	68.6%
UB Medical School	243,643	57.3%	328,403	64.4%	335,113	65.1%	222,471	55.1%	316,450	63.6%
Cleveland Biolabs	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Fruitbelt Neighborhood	113,227	100.0%	80,683	100.0%	87,473	100.0%	119,297	100.0%	80,707	100.0%
Total	**1,660,292**	**63%**	**2,513,034**	**70%**	**2,092,284**	**68%**	**1,461,882**	**57%**	**2,361,031**	**68%**

Scenario	Description	Incurred Cost
1	100% of load is served for 32% of the outage duration (i.e. 53.76 hours)	• 100% x On-going Operating Costs x 2.5 days • 100% x One-Time Costs Evacuation (on day 3) • 100% x Cost of Outage x 4.5 days (on day 3)
2	32% of load is served for the 100% of the outage duration (i.e. 168 hours)	• 70% One-Time Costs Evacuation • 70% x Cost of Outage x 7 days • 30% x On-going Operating Costs x 7 days

II. Costs of Emergency Measures Necessary to Maintain Service

We understand that facilities may have to take emergency measures during a power outage in order to maintain operations, preserve property, and/or protect the health and safety of workers, residents, or the general public. These measures may impose extraordinary costs, including both one-time expenditures (e.g., the cost of evacuating and relocating residents) and ongoing costs (e.g., the daily expense of renting a portable generator). The questions below address these costs. We begin by requesting information on the costs facilities would be likely to incur when operating on backup power.

We then request information on the costs facilities would be likely to incur when backup power is not available.

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

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

    a. One-time emergency measures (total costs)

    b. Ongoing emergency measures (costs per day)

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

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

    As a guide, see the examples the table provides.

Facility Name	Type of Measure (One-Time or Ongoing)	Description	Costs	Units	When would these measures be required?
All BNMC	One-Time Measures	*See explaination 1*	174,034.8 0	$	Any outage
Kaleida Health	Ongoing Measures	*See explaination 2*	70,026.96	$/hr	Any outage
Roswell Park Cancer Institute	Ongoing Measures	*See explaination 2*	55,693.48	$/hr	Any outage
For Kaleida Health and Roswell Medical Services	One-Time Measures	Evacuating and moving patients to nearest hospital *(see calculation below)* *See explaination 3*	$450k	$	Year-round. Total evacuation cost for ALL patient beds. ~70% of this cost for 30% level of service from backup OR full cost on third day once fuel reserves are depleted. See scenarios below for clarification

Explaination 1

Many emergency measures (both one-time and ongoing) can be performed by increasing staff (accounted for in subsequent calculations). The only additional cost that we quantified was food needed for additional staff

	One-Time				Ongoing
	Assess	**Implement**	**Notify**	**Procure**	**Maintain**
	Staff Resources	De-energize circuit breakers	Fire department EMS and ambulance providers on alert	Supplies to maintain functioning of emergency generators (i.e. fuel parts etc.)	Increased hospital emergencies
	Medicine storage	Shed non-critical loads	Local emergency management/EOC	Loan equipment	Hospital communication systems
	Power conservation measures	Increased facility security	Department of Health	Food supplies	Patient assessments, prioritization of medical & human resources
	Emergency power supply	Activate backup generators	Hospital Emergency Operation Center	Additional medication	Labortory experiment condition
	Critical care device functionality	Activate alternate utilities and other systems	County		Patient risk/case, weather conditions
	Hospital infrastructure - e.g. heating/cooling, water pumps, elevator	Activiate backup communication systems			Facility security - e.g. limited visitation policy
		IT - Restoration (e.g. communication systems, hospital electronic records)			Maintain backup IT communication systems
		Shut down experiments that involve hazardous materials			Monitor - e.g. medical supplies, food supply, backup generator fuel, indoor temperature
					Track costs/expenditures/lost revenue
Covered by Increased Staffing & Overtime Costs?	Yes	Yes	Yes	No	Yes

Sources:

http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3879211/
http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3879211/table/d35e864/
http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3879211/figure/d35e854/
https://www.researchgate.net/publication/7503016_The_Effect_of_an_18-Hour_Electrical_Power_Outage_on_an_Urban_Emergency_Medical_Services_System
https://www.getprepared.gc.ca/cnt/rsrcs/pblctns/pwrtgs-wtd/pwrtgs-wtd-eng.pdf
http://www.bucknell.edu/public-safety/emergency-response-manual/power-failure.html
http://www.healthcare-informatics.com/article/be-prepared-lessons-extended-outage-hospital-s-ehr-system

Explaination 2
Both Kaleida Health & Roswell Park work on three-shift cycles. During normal operations it is expected that 1/3 of all staff will be at the hospital at any given time. During emergency operations (with backup power), it is expected that the number of staff must double (i.e. 2/3) in order to account for emergency measures needed as well as items such as increased call volume and patient visits (e.g. from nearby hospitals).

This is quantified by using the following information:

- Kaleida & Roswell employees & positions

Kaleida Health				
Job Class	**Employee Count**	**Category**	**Pay ($/hr)**	**Overtime Pay ($/hr)**
Administrative	268	Hospital Administrator	12,370.89	18,556.34
Aides	10	Medical Secretary	120.00	180.00
Asbestos Workers local #4	2	Facility Maintenance Technician	33.54	50.31
Carpenters Local 289	28	Facility Maintenance Technician	469.57	704.36
Certified Medical Assistants	112	Medical Assistant	1,680.38	2,520.56
Clinical Support	14	Medical Assistant	210.05	315.07
Director	18	Hospital Administrator	830.88	1,246.32
Executive	4	Hospital Administrator	184.64	276.96
Family Pharmaceutical UC30	14	Hospital Administrator	646.24	969.36
Home Care Manager/Supv	1	Hospital Administrator	46.16	69.24
Home Care Professional-Clinical	10	Hospital Administrator	461.60	692.40
Information Systems	3	Facility Maintenance Technician	50.31	75.47
Licensed Practical Nurse	22	Registered Nurse	594.00	891.00
Maintenance	35	Facility Maintenance Technician	586.97	880.45
Manager	36	Facilities Manager	1,466.96	2,200.44
Medical Assistant	44	Medical Assistant	660.15	990.22
Nurse Practitioners	66	Registered Nurse	1,782.00	2,673.00
Nursing Manager	18	Registered Nurse	486.00	729.00
Nursing Supervisor	17	Registered Nurse	459.00	688.50
Painters District Local 4	12	Facility Maintenance Technician	201.25	301.87
Patient Support Associate	53	Facility Maintenance Technician	888.84	1,333.25
Personal Care Aides	152	Medical Assistant	2,280.51	3,420.76
Physicians	41	Doctor	3,937.87	5,906.80
Plasterers/Cement Masons #9	12	Facility Maintenance Technician	201.25	301.87
Professional Admin	72	Hospital Administrator	3,323.52	4,985.28
Professional Clinical Other	91	Doctor	8,740.14	13,110.21
Professional Laboratory	68	Research Scientist	2,576.21	3,864.32
Professional Pharmacy	53	Pharmacist	838.05	1,257.07
Professional Rehabilitation	46	Medical Assistant	690.15	1,035.23
Radiology/RT/Perfusionists	205	Medical Assistant	3,075.69	4,613.53
Registered Nurse	1,084	Registered Nurse	29,268.00	43,902.00
Residents and Interns	3	Hospital Administrator	138.48	207.72
Scheduling Secretary	5	Medical Secretary	60.00	90.00
Security	26	Security Guard	236.70	355.06
Senior Director	6	Hospital Administrator	276.96	415.44
Senior VP	3	Hospital Administrator	138.48	207.72
Service	364	Medical Assistant	5,461.22	8,191.83
Service Supervisors	5	Hospital Administrator	230.80	346.20
Supervisor Administration	12	Hospital Administrator	553.92	830.88
Supervisor Clinical	5	Hospital Administrator	230.80	346.20
Technical Administration	18	Hospital Administrator	830.88	1,246.32
Technical Clinical	175	Doctor	16,807.97	25,211.95
Plant Operations	5	Mechincal Engineer	143.62	215.43
Unit Secretary	26	Medical Secretary	312.00	468.00
US Plumbers/Steamfitters #22	10	Facility Maintenance Technician	167.70	251.56
Vice President	6	Hospital Administrator	276.96	415.44
Grand Total	**3,280**		**105,027.30**	**157,540.96**
			$/hr	$/hr

Roswell Park				
Job Class	**Employee Count**	**Category**	**Pay ($/hr)**	**Overtime Pay ($/hr)**
ADMINISTRATIVE SUPPORT	343	Medical Secretary	4,116.00	6,174.00
ADMINISTRATORS/DIRECTORS	94	Hospital Administrator	4,339.04	6,508.57
ADVANCED PRACTICE PRACTITIONERS	104	Registered Nurse	2,808.00	4,212.00
CLINICAL SUPPORT	205	Medical Assistant	3,075.69	4,613.53
EXECUTIVE MANAGEMENT	44	Hospital Administrator	2,031.04	3,046.56
FACILITIES MANAGEMENT	164	Facility Maintenance Technician	2,750.36	4,125.54
FISCAL ADMINISTRATION	104	Financial Analyst	2,347.60	3,521.40
FOOD & NUTRITION STAFF	41	Medical Secretary	492.00	738.00
HUMAN RESOURCES STAFF	26	Medical Secretary	312.00	468.00
INFORMATION TECHNOLOGY STAFF	122	IT Support Technican	2,640.33	3,960.50
LEGAL STAFF	17	Doctor	1,632.77	2,449.16
MARKETING STAFF	47	Medical Assistant	705.16	1,057.74
OTHER ADMINISTRATIVE PROFESSIONALS	26	Medical Secretary	312.00	468.00
OTHER CLINICAL PROFESSIONALS	146	Medical Assistant	2,190.49	3,285.73
PHARMACY STAFF	47	Pharmacist	743.17	1,114.76
PHYSICIANS	175	Doctor	16,807.97	25,211.95
RESEARCHERS	123	Research Scientist	4,659.91	6,989.87
RESEARCH SUPPORT	115	Medical Secretary	1,380.00	2,070.00
NURSES	552	Registered Nurse	14,904.00	22,356.00
STUDENTS/TRAINEES	189	Medical Assistant	2,835.63	4,253.45
TECHNICIANS/TECHNOLOGISTS	504	IT Support Technican	10,907.60	16,361.40
THERAPISTS (OT, PT, RADIATION)	57	Registered Nurse	1,539.00	2,308.50
Grand Total	**3,245**		**83,529.77**	**125,294.66**
			$/hr	$/hr

- Typical wages & salaries

Buffalo, NY		
Work Hours	2087	hr/year
	Hourly Rate	**Overtime Rate (1.5x)**
Position	**$/hr**	**$/hr**
Registered Nurse	27.00	40.50
Medical Assistant	15.00	22.51
Doctor	96.05	144.07
Mechincal Engineer	28.72	43.09
Software Engineer	27.75	41.62
IT Manager	38.27	57.41
IT Support Technican	21.64	32.46
Financial Analyst	22.57	33.86
Firefighter	12.46	18.69
Paramedic	17.82	26.73
EMT	14.37	21.56
Security Guard	9.10	13.66
Facilities Manager	40.75	61.12
Facility Maintenance Technician	16.77	25.16
Hospital Administrator	46.16	69.24
Medical Secretary	12.00	18.00
Research Scientist	37.89	56.83
Pharmacist	15.81	23.72

And using the following formula

Percentage of Staff needed during Emergency Operations x Wages (w/ overtime)

Minus

Percentage of Staff needed during Normal Operations x Wages (w/o overtime)

Kaleida Health			**Roswell Park**		
Assumption: Hospital runs 24 hours a day			*Assumption: Hospital runs 24 hours a day*		
Normal Operations			**Normal Operations**		
Percentage of Staff Needed	33.33%		Percentage of Staff Needed	33.33%	
Operating Costs	35,005.60	$/hr	Operating Costs	27,840.47	$/hr
Emergency Operations			**Emergency Operations**		
Percentage of Staff Needed	66.67%		Percentage of Staff Needed	66.67%	
Operating Costs (w/ overtime)	105,032.56	$/hr	Operating Costs (w/ overtime)	83,533.95	$/hr
Difference	**70,026.96**	**$/hr**	**Difference**	**55,693.48**	**$/hr**
Outage Duration	168	hours	Outage Duration	168	hours
Cost of Outage	**$ 11,764,528.46**	**Total**	Cost of Outage	**$9,356,504.19**	**Total**

Explaination 3

Kaleida Health and Roswell:
684 beds * 80% occupancy * $824/patient = ~$450,000 ($2012)

($/patient) = $824/patient ($2012)

(Reference: http://www1.nyc.gov/site/fdny/about/resources/policy-and-agreements/fee-schedule.page. In $2012: $704 Ambulance Fee for basic life support service w/ oxygen *+ $12/mile + $60 for Oxygen.)*

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

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

   a. One-time emergency measures (total costs)

   b. Ongoing emergency measures (costs per day)

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

   As a guide, see the examples the table provides.

We estimate that without power (including backup) only the emergency room at Kaleida Health will remain partially operational (see Question 6). All other services are lost and all patients must be evacuated.

Facility Name	Type of Measure (One-Time or Ongoing)	Description	Costs	Units	When would these measures be required?
For Kaleida Health and Roswell Medical Services	One-Time Measures	Evacuating and moving patients to nearest hospital	$450k	$	Year-round. Total evacuation cost for ALL patient beds. ~70% of this cost for 30% level of service from backup OR full cost on third day once fuel reserves are depleted. See scenarios below for clarification

684 beds * 80% occupancy * $824/patient = ~$450,000 ($2012)

($/patient) = $824/patient ($2012)

(Reference: http://www1.nyc.gov/site/fdny/about/resources/policy-and-agreements/fee-schedule.page. In $2012: $704 Ambulance Fee for basic life support service w/ oxygen *+ $12/mile + $60 for Oxygen.)*

III. Services Provided

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

*A. Questions for: **All Facilities***

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

Modeling Results

Unmet Load	Outage Scenarios (1 week)									
	Spring		Summer		Fall		Winter		Peak	
Institution	kWh	%	kWh	%	kWh	%	kWh	%	kWh	%
Kaleida Health	745,401	65.1%	1,243,414	75.8%	955,407	70.5%	710,104	64.0%	1,142,702	72.9%
Roswell Park	558,021	57.5%	941,217	69.5%	714,291	63.4%	529,307	56.1%	901,879	68.6%
UB Medical School	243,643	57.3%	328,403	64.4%	335,113	65.1%	222,471	55.1%	316,450	63.6%
Cleveland Biolabs	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Fruitbelt Neighborhood	113,227	100.0%	80,683	100.0%	87,473	100.0%	119,297	100.0%	80,707	100.0%
Total	**1,660,292**	**63%**	**2,513,034**	**70%**	**2,092,284**	**68%**	**1,461,882**	**57%**	**2,361,031**	**68%**

Facility Name	Percent Loss in Services When Using Backup Gen.
Kaleida Health	72.9%
Roswell Park Cancer Institute	68.6%
University of Buffalo School of Medicine	63.6%
Cleveland Biolabs	0.0%
Frutibelt Neighborhood	100.0%

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

Facility Name	Percent Loss in Services When Backup Gen. is Not Available
Kaleida Health	83.11%
Roswell Park Cancer Institute	100.0%
University of Buffalo School of Medicine	100.0%
Cleveland Biolabs	100.0%
Frutibelt Neighborhood	100.0%

Emergency room vistis account for 56% of all visits to the facility. We estimate that a loss of power would reduce the level of service the emergency room down to ~30%. All non-emergency-room services are lost.

30% services * 56% of visits = 16.8%

This represents the level of service that is able to be provided by the facility's emergency room during an outage. Finally, Kaledia Health is the only facility on the BNMC campus that has an emergency room.

B. Questions for facilities that provide: Fire Services

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

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

Click here to enter text.

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

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

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

250,000

~25% of Erie county population of 920,000 or the population of the city of Buffalo = 258,703

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

☒ Urban

☐ Suburban

☐ Rural

☐ Wilderness

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

Click here to enter text.

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

5 miles

The closest hospital would be Erie County Hospital served via Seneca substation. An outage at the substation level would bring down both BNMC and the Erie County hospital.

Mercy Hospital of Buffalo is the closest hospital not interconnected to the BNMC via 23 kV feeders. Mercy is 5 miles away.

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

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

250,000

~25% of Erie county population of 920,000 or the population of the city of Buffalo = 258,703

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

5 miles

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

55,500

Mercy Hospital of Buffalo

Mercy receives ~22% of the number of inpatients that BNMC does.

Visits at Mercy: 8,429
Vists at BNMC: 38,000

8429 / 38,000 = 22%

22% x 250,000 population of Erie County = ~55,500

<u>E. Questions for facilities that provide: **Police Services**</u>

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

Click here to enter text.

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

☐ Metropolitan Statistical Area

☐ Non-Metropolitan City

☐ Non-Metropolitan County

19. Please estimate:

a. The <u>number</u> of police officers working at the station under normal operations.

Click here to enter text.

b. The <u>number</u> of police officers working at the station during a power outage.

Click here to enter text.

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

Click here to enter text.

F. Questions for facilities that provide: Wastewater Services

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

Click here to enter text.

21. Does the facility support (check one):

☐ Residential customers

☐ Businesses

☐ Both

G. Questions for facilities that provide: Water Services

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

Click here to enter text.

23. Does the facility support (check one):

☐ Residential customers

☐ Businesses

☐ Both

H. Questions for: Residential Facilities

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

Mix between single and multi-family homes

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

2,000

We have estimated the value of providing additional services at the hospital beyond what is calculated using the FEMA methodology as follows:

- **Value of Inpatient Services = $330,000 /day [$2008]**

  (calculated from stats below)
  (Methodolgy Reference: http://www.who.int/choice/country/country_specific/en/)

  - $/bed/day = *$727 ($2008) (calculated from inputs below)*
    - **What is the occupancy rate of inpatient service beds at BNMC (%)?**

      = 80%
      (Source: BNMC)

    - **What is the average length of stay at inpatient service beds at BNMC?**

      Kaleida = 5.8 days (34,366 Patients)
      Roswell = 8.6 days (4,442 Patients)
      Weighted Average = 6.1 days
      (Source: BNMC)

    - **What is the total number of inpatient admissions per year at BNMC?**

      Buffalo GMC = 21,587/yr;
      Women's & Children's Hospital = 12,779/yr
      Roswell Cancer Institute = 4,442/yr
      Total = 38,808/yr
      (Source = BNMC)

    - **What is the number of inpatient service beds at BNMC?**

      = 457
      (Source = BNMC)

- **Value of Outpatient Services = $50,000 /day [$2008]**

  (calculated from stats below)
  (Methologdy Reference: http://www.who.int/choice/country/country_specific/en/)

  - **Cost per outpatient visit:**
    Kaleida = $96/visit
    Roswell = $64/visit

    (calculated from below)

    - **What is the number of outpatient visits at BNMC per year?**
      Kaleida = 54,253/yr
      Roswell = 201,491/yr
      (Source: BNMC)

    - **What is the average number of visits per provider [GPs,nurses, etc] of outpatient visits per day at BNMC (visits/provider/day)?**
      Kaleida = 4 visit/provider/day *(Source: BNMC)*
      Roswell = 9.5 visit/provider/day *(Source:default from WHO)*

    - **What is the ownership structure of BNMC - Public, Private, or NGO?** Kaleida = Private
      Roswell = Public

    - **Is BNMC a Rural or Urban location?**
      = Urban

  - **What are the total number of outpatient visits per day?**
    Kaleida: 54,253/356= 148 visits/day
    Roswell: 201,491/365=552 visits/day
    (reference above)

We also estimate the value of research facilities and other services using the following logic:

- **Value of Research and Other Services = $1,594,811 /day**

  Methodology: We will assume that the value preventing a major power outage to these research and other institutions is equivalent to the level of funding needed to operate them on a daily basis. Using operating costs is a more conservative estimate than the total operating revenue.

  - ***What are the annual operating expenses for the following facilities?***
  - ***How many days per year does each institution operate?***

    - Roswell Park Cancer Institute
      - Annual Operating Expenses ($/yr) = $582,106,000
      - Days of Operation (days/yr) = 365

        (Source: https://www.roswellpark.org/sites/default/files/section203-budget-filing-fy-2015-2016-final.pdf)

        $582,106,000 / 365 days = **$1,594,811 / day**

There are other areas of major research at the BNMC, the values of which were not able to be quantified because of we could not get access to financial statements.

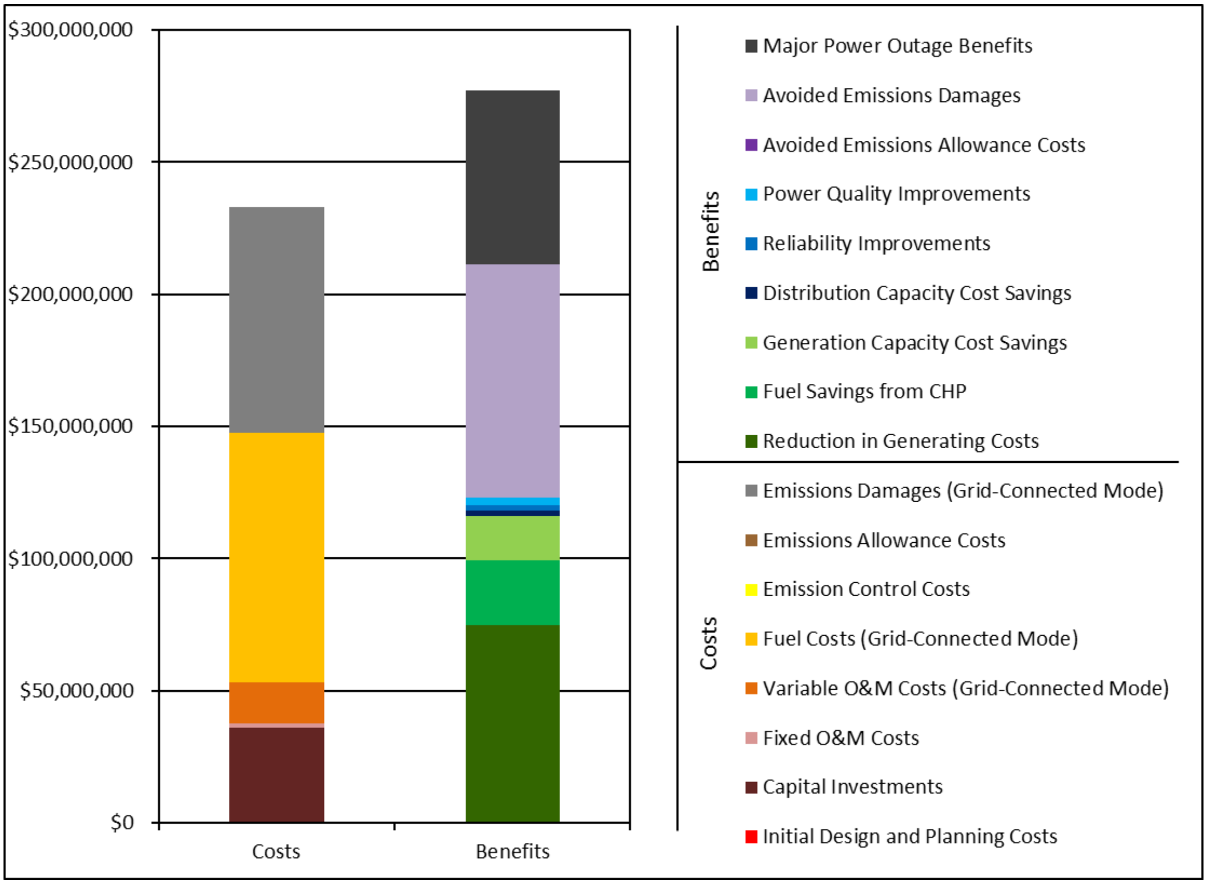
- University of Buffalo (School of Medicine)
  - Annual Operating Expenses ($/yr) = *Unknown*
  - Days of Operation (days/yr) = *Unknown*

- Clinical and Translational Research Center
  - Annual Operating Expenses ($/yr) = *Unknown*
  - Days of Operation (days/yr) = *Unknown*

- Gates Vascular Institute
  - Annual Operating Expenses ($/yr) = *Unknown*
  - Days of Operation (days/yr) = *Unknown*

- Cleveland Biolabs
  - Annual Operating Expenses ($/yr) = *Unknown*
  - Days of Operation (days/yr) = *Unknown*

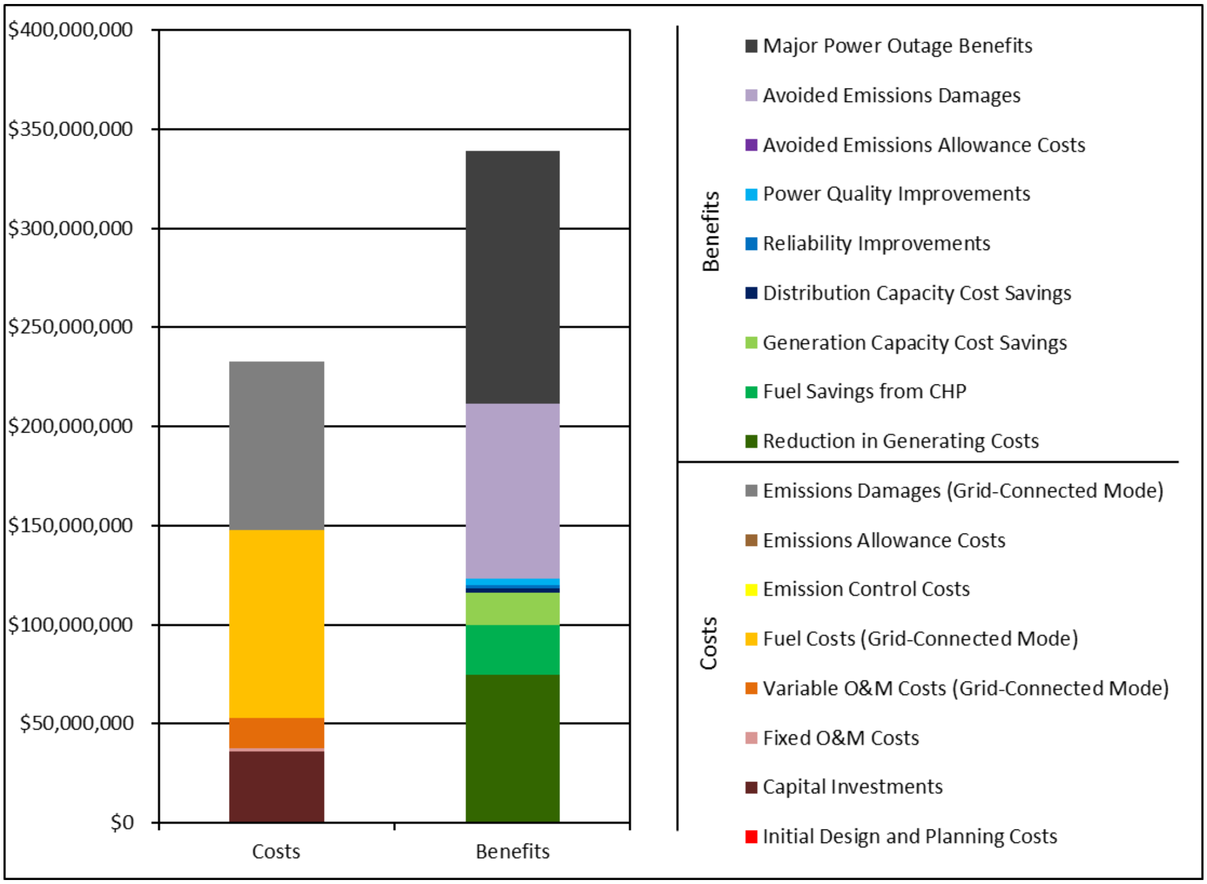
B APPENDIX



Present Value Results, Scenario 3 (Major Power Outages Averaging 1 Days/Year; 7 Percent Discount Rate)

Detailed BCA Results, Scenario 3 (Major Power Outages Averaging 1 Days/Year; 7 Percent Discount Rate)

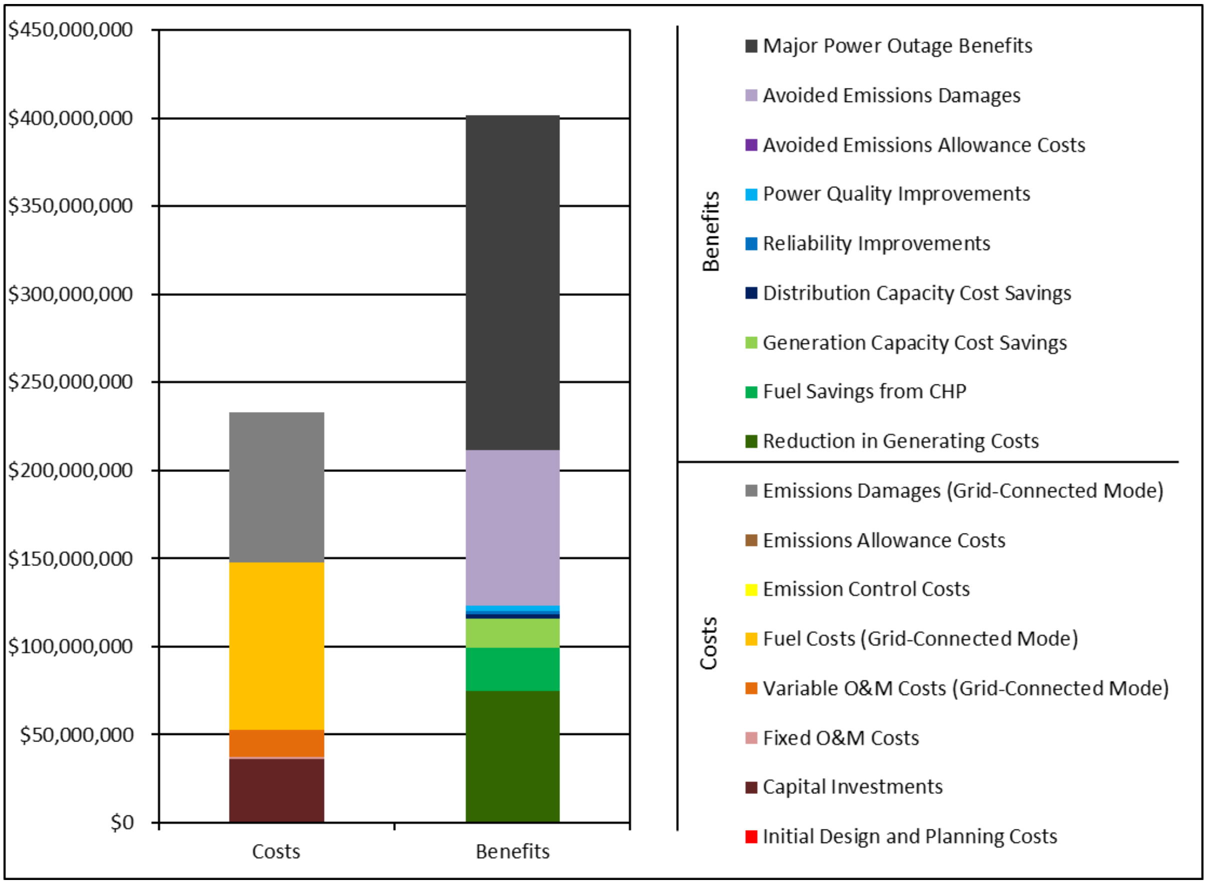
COST OR BENEFIT CATEGORY	PRESENT VALUE OVER 20 YEARS (2014$)	ANNUALIZED VALUE (2014$)
Costs		
Initial Design and Planning	$328,000	$28,900
Capital Investments	$35,800,000	$3,160,000
Fixed O&M	$1,270,000	$112,000
Variable O&M (Grid-Connected Mode)	$15,600,000	$1,370,000
Fuel (Grid-Connected Mode)	$94,500,000	$8,340,000
Emission Control	$0	$0
Emissions Allowances	$0	$0
Emissions Damages (Grid-Connected Mode)	$85,300,000	$5,570,000
Total Costs	**$233,000,000**	
Benefits		
Reduction in Generating Costs	$74,800,000	$6,600,000
Fuel Savings from CHP	$24,700,000	$2,180,000
Generation Capacity Cost Savings	$16,400,000	$1,450,000
Distribution Capacity Cost Savings	$2,280,000	$201,000
Reliability Improvements	$1,850,000	$164,000
Power Quality Improvements	$3,040,000	$268,000
Avoided Emissions Allowance Costs	$45,500	$4,010
Avoided Emissions Damages	$88,300,000	$5,760,000
Major Power Outage Benefits	$65,600,000	$5,800,000
Total Benefits	**$277,000,000**	
Net Benefits	**$44,200,000**	
Benefit/Cost Ratio	**1.19**	
Internal Rate of Return	**20.3%**	



Present Value Results, Scenario 4 (Major Power Outages Averaging 2 Days/Year; 7 Percent Discount Rate)

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

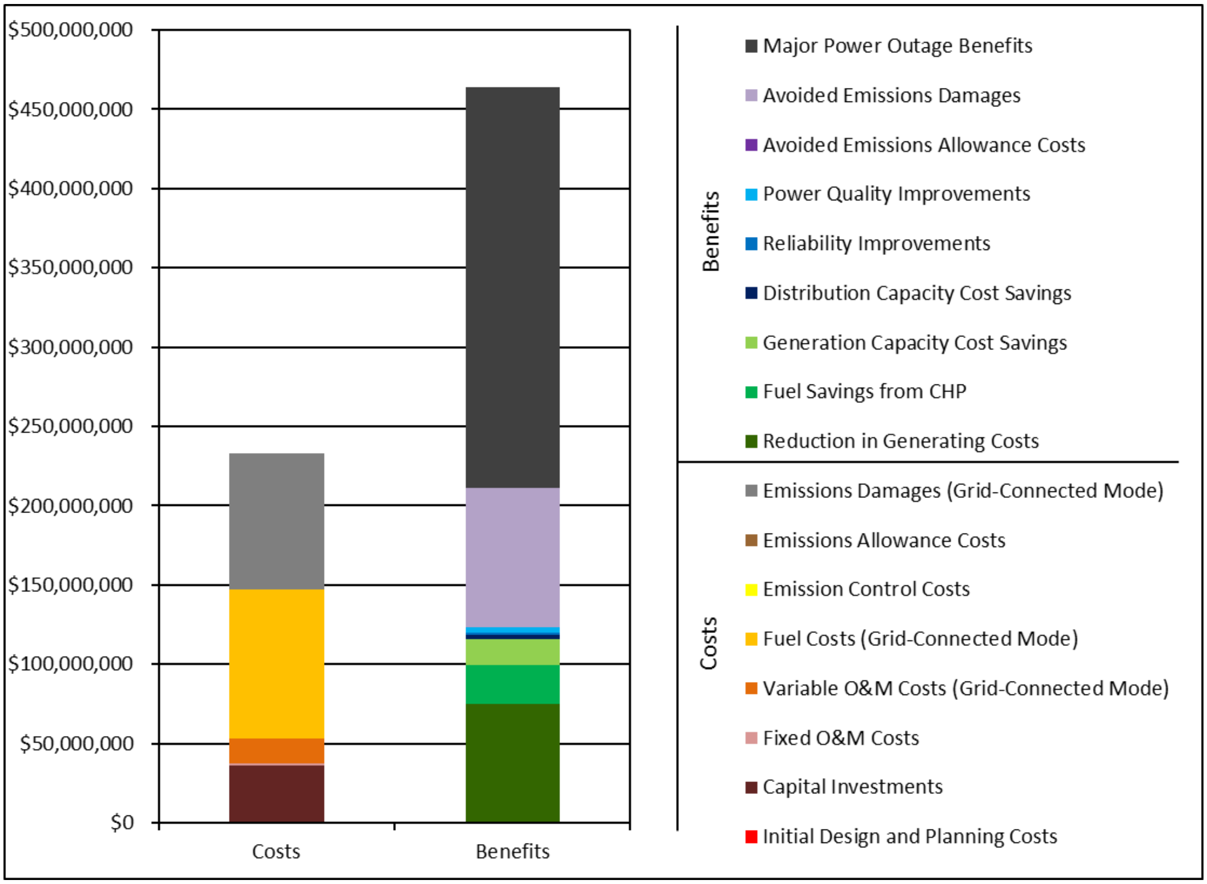
COST OR BENEFIT CATEGORY	PRESENT VALUE OVER 20 YEARS (2014$)	ANNUALIZED VALUE (2014$)
Costs		
Initial Design and Planning	$328,000	$28,900
Capital Investments	$35,800,000	$3,160,000
Fixed O&M	$1,270,000	$112,000
Variable O&M (Grid-Connected Mode)	$15,600,000	$1,370,000
Fuel (Grid-Connected Mode)	$94,500,000	$8,340,000
Emission Control	$0	$0
Emissions Allowances	$0	$0
Emissions Damages (Grid-Connected Mode)	$85,300,000	$5,570,000
Total Costs	**$233,000,000**	
Benefits		
Reduction in Generating Costs	$74,800,000	$6,600,000
Fuel Savings from CHP	$24,700,000	$2,180,000
Generation Capacity Cost Savings	$16,400,000	$1,450,000
Distribution Capacity Cost Savings	$2,280,000	$201,000
Reliability Improvements	$1,850,000	$164,000
Power Quality Improvements	$3,040,000	$268,000
Avoided Emissions Allowance Costs	$45,500	$4,010
Avoided Emissions Damages	$88,300,000	$5,760,000
Major Power Outage Benefits	$127,000,000	$11,200,000
Total Benefits	**$339,000,000**	
Net Benefits	**$106,000,000**	
Benefit/Cost Ratio	**1.45**	
Internal Rate of Return	**44.6%**	



Present Value Results, Scenario 5 (Major Power Outages Averaging 3 Days/Year; 7 Percent Discount Rate)

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

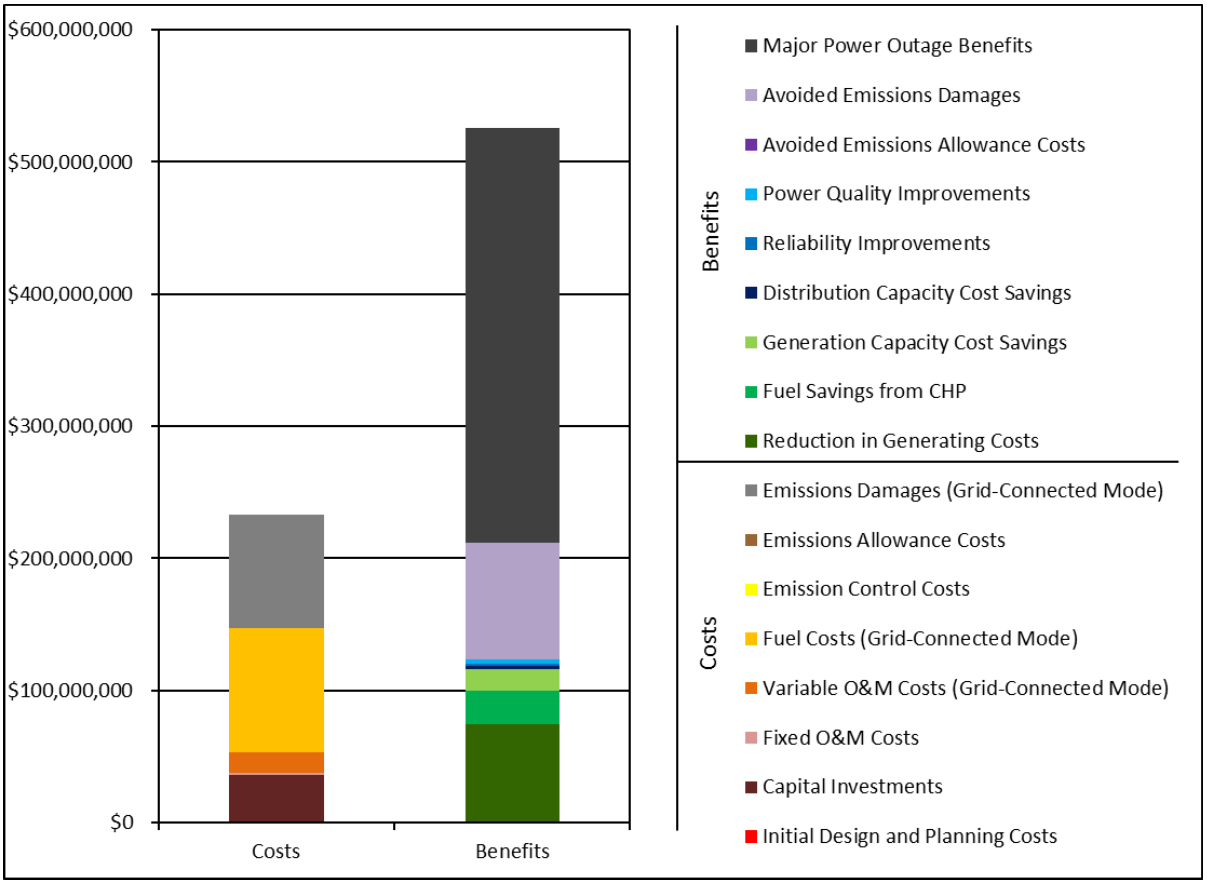
COST OR BENEFIT CATEGORY	PRESENT VALUE OVER 20 YEARS (2014$)	ANNUALIZED VALUE (2014$)
Costs		
Initial Design and Planning	$328,000	$28,900
Capital Investments	$35,800,000	$3,160,000
Fixed O&M	$1,270,000	$112,000
Variable O&M (Grid-Connected Mode)	$15,600,000	$1,370,000
Fuel (Grid-Connected Mode)	$94,500,000	$8,340,000
Emission Control	$0	$0
Emissions Allowances	$0	$0
Emissions Damages (Grid-Connected Mode)	$85,300,000	$5,570,000
Total Costs	**$233,000,000**	
Benefits		
Reduction in Generating Costs	$74,800,000	$6,600,000
Fuel Savings from CHP	$24,700,000	$2,180,000
Generation Capacity Cost Savings	$16,400,000	$1,450,000
Distribution Capacity Cost Savings	$2,280,000	$201,000
Reliability Improvements	$1,850,000	$164,000
Power Quality Improvements	$3,040,000	$268,000
Avoided Emissions Allowance Costs	$45,500	$4,010
Avoided Emissions Damages	$88,300,000	$5,760,000
Major Power Outage Benefits	$190,000,000	$16,800,000
Total Benefits	**$402,000,000**	
Net Benefits	**$169,000,000**	
Benefit/Cost Ratio	**1.73**	
Internal Rate of Return	**83.6%**	



Present Value Results, Scenario 6 (Major Power Outages Averaging 4 Days/Year; 7 Percent Discount Rate)

Detailed BCA Results, Scenario 6 (Major Power Outages Averaging 4 Days/Year; 7 Percent Discount Rate)

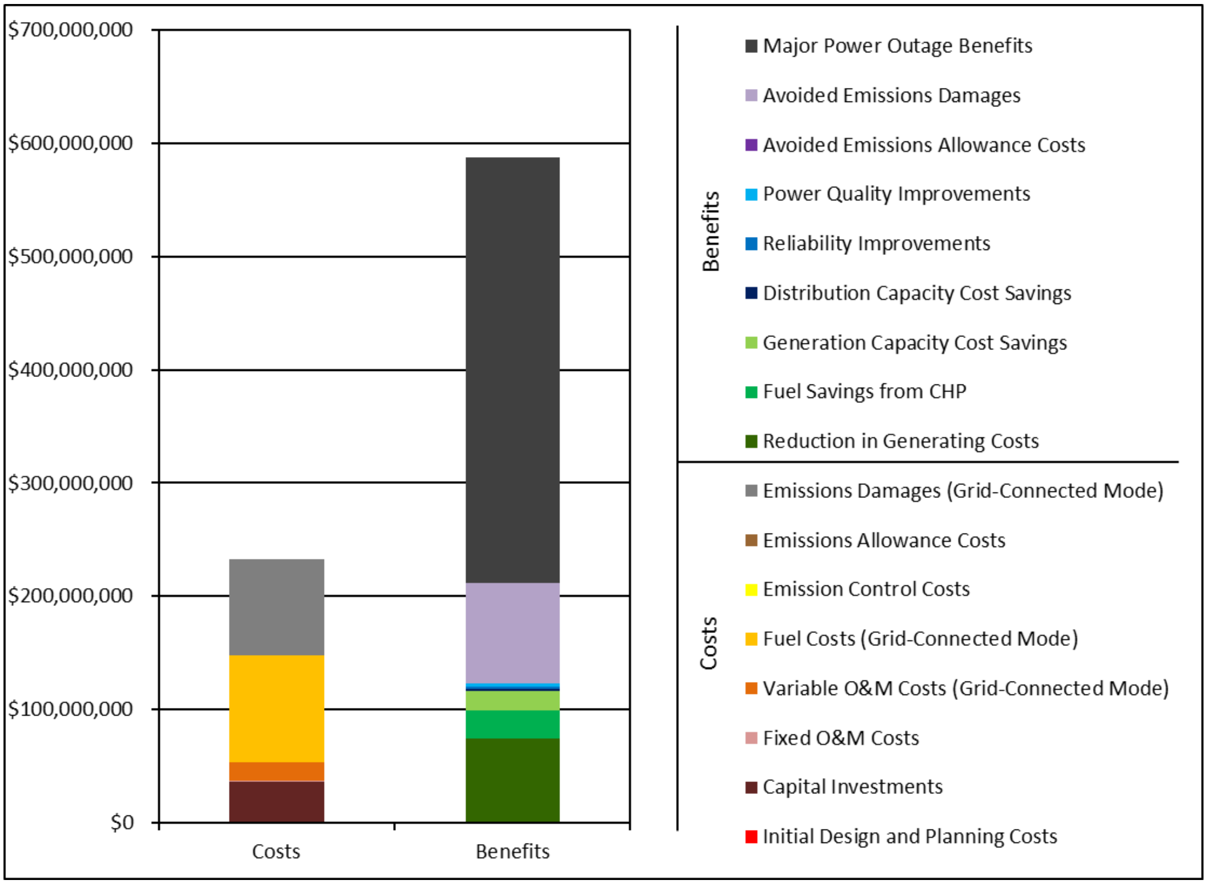
COST OR BENEFIT CATEGORY	PRESENT VALUE OVER 20 YEARS (2014$)	ANNUALIZED VALUE (2014$)
Costs		
Initial Design and Planning	$328,000	$28,900
Capital Investments	$35,800,000	$3,160,000
Fixed O&M	$1,270,000	$112,000
Variable O&M (Grid-Connected Mode)	$15,600,000	$1,370,000
Fuel (Grid-Connected Mode)	$94,500,000	$8,340,000
Emission Control	$0	$0
Emissions Allowances	$0	$0
Emissions Damages (Grid-Connected Mode)	$85,300,000	$5,570,000
Total Costs	**$233,000,000**	
Benefits		
Reduction in Generating Costs	$74,800,000	$6,600,000
Fuel Savings from CHP	$24,700,000	$2,180,000
Generation Capacity Cost Savings	$16,400,000	$1,450,000
Distribution Capacity Cost Savings	$2,280,000	$201,000
Reliability Improvements	$1,850,000	$164,000
Power Quality Improvements	$3,040,000	$268,000
Avoided Emissions Allowance Costs	$45,500	$4,010
Avoided Emissions Damages	$88,300,000	$5,760,000
Major Power Outage Benefits	$252,000,000	$22,300,000
Total Benefits	**$464,000,000**	
Net Benefits	**$231,000,000**	
Benefit/Cost Ratio	**1.99**	
Internal Rate of Return	**153.0%**	



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

Detailed BCA Results, Scenario 7 (Major Power Outages Averaging 5 Days/Year; 7 Percent Discount Rate)

COST OR BENEFIT CATEGORY	PRESENT VALUE OVER 20 YEARS (2014$)	ANNUALIZED VALUE (2014$)
Costs		
Initial Design and Planning	$328,000	$28,900
Capital Investments	$35,800,000	$3,160,000
Fixed O&M	$1,270,000	$112,000
Variable O&M (Grid-Connected Mode)	$15,600,000	$1,370,000
Fuel (Grid-Connected Mode)	$94,500,000	$8,340,000
Emission Control	$0	$0
Emissions Allowances	$0	$0
Emissions Damages (Grid-Connected Mode)	$85,300,000	$5,570,000
Total Costs	**$233,000,000**	
Benefits		
Reduction in Generating Costs	$74,800,000	$6,600,000
Fuel Savings from CHP	$24,700,000	$2,180,000
Generation Capacity Cost Savings	$16,400,000	$1,450,000
Distribution Capacity Cost Savings	$2,280,000	$201,000
Reliability Improvements	$1,850,000	$164,000
Power Quality Improvements	$3,040,000	$268,000
Avoided Emissions Allowance Costs	$45,500	$4,010
Avoided Emissions Damages	$88,300,000	$5,760,000
Major Power Outage Benefits	$314,000,000	$27,800,000
Total Benefits	**$526,000,000**	
Net Benefits	**$293,000,000**	
Benefit/Cost Ratio	**2.26**	
Internal Rate of Return	**307.0%**	



Present Value Results, Scenario 8 (Major Power Outages Averaging 6 Days/Year; 7 Percent Discount Rate)

Detailed BCA Results, Scenario 8 (Major Power Outages Averaging 6 Days/Year; 7 Percent Discount Rate)

COST OR BENEFIT CATEGORY	PRESENT VALUE OVER 20 YEARS (2014$)	ANNUALIZED VALUE (2014$)
Costs		
Initial Design and Planning	$328,000	$28,900
Capital Investments	$35,800,000	$3,160,000
Fixed O&M	$1,270,000	$112,000
Variable O&M (Grid-Connected Mode)	$15,600,000	$1,370,000
Fuel (Grid-Connected Mode)	$94,500,000	$8,340,000
Emission Control	$0	$0
Emissions Allowances	$0	$0
Emissions Damages (Grid-Connected Mode)	$85,300,000	$5,570,000
Total Costs	**$233,000,000**	
Benefits		
Reduction in Generating Costs	$74,800,000	$6,600,000
Fuel Savings from CHP	$24,700,000	$2,180,000
Generation Capacity Cost Savings	$16,400,000	$1,450,000
Distribution Capacity Cost Savings	$2,280,000	$201,000
Reliability Improvements	$1,850,000	$164,000
Power Quality Improvements	$3,040,000	$268,000
Avoided Emissions Allowance Costs	$45,500	$4,010
Avoided Emissions Damages	$88,300,000	$5,760,000
Major Power Outage Benefits	$377,000,000	$33,300,000
Total Benefits	**$588,000,000**	
Net Benefits	**$355,000,000**	
Benefit/Cost Ratio	**2.53**	
Internal Rate of Return	**958.0%**	

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