66 - Village of Bath

Notice

NY Prize Task 5 Milestone Deliverable:

Village of Bath Final Report

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NYSERDA
New York State Energy Research
and Development Authority

Submit by:
Willdan Energy Solutions
on behalf of the Village of Bath

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Executive Summary

Bath Electric Gas and Water Systems (BEGWS) is proposing a feasibility study to implement a microgrid ("Bath Community Microgrid") that is interconnected with the Bath municipal electric distribution system. BEGWS will act as the Local Gas and Electric Distribution Company for this feasibility study and will be joined by the Village of Bath and by the county seat of Steuben County who are participating as the Local Government.

BEGWS incurs additional cost liability when the community exceeds its NYPA kW and kWh allocation; most recently, Bath incurred over $1,700,000 in 2014, a significant burden for a County seat community with a limited tax base. The excess is largely due to residential electric heaters being operated in the cold winter months. In addition, Bath's radial path distribution system is 70+ years old, exposing the community to risk due to outages and equipment failures. Willdan proposes a 3 MW community microgrid for the Village of Bath, comprised of 2.3 MW of natural gas combined heat and power, 700 kW of combined heat and power run off of anaerobic digester biogas, and state of the art advanced metering. The microgrid will enhance the overall operational reliability of the electrical distribution system for all of the stakeholders, by providing a master controller which has the ability to perform, in real-time, reconfiguration of the microgrid functions, seamless islanding for economic, reliability, or resilience reasons, and optimization of storage and generation resources.

The Village of Bath's critical loads, which include the County Office, the Police Station and Jail, the Fire Department, the Elementary and High School buildings, the BEGWS Office, the County Center for Rehabilitation and Healthcare (CRH) and the municipal wastewater plant (WWTP), will remain powered on while the microgrid is islanded. In addition to providing resiliency for critical loads, Willdan's proposed Bath Community Microgrid could provide economic and reliability benefits for Bath Electric Power's nearly 4,500 residential customers.

The advanced metering phase of the project is underway, and is expected to be complete by the end of 2017. The anaerobic digester project is also underway, but will be phased in over the next two years. The positive results of the benefit cost analysis, along with the urgency and commitment shown by Bath, make this a strong candidate for future development into a full-scale microgrid.

Task 1 – Description of Microgrid Capabilities

Table 1. Bath Community Microgrid – Existing and Proposed Overview

Category	Existing Resources	Proposed/Suggested Improvement	Justification
Load	• Residential Electric Heat • 13.37 MW NYPA allocation • 22 MW Winter Peak	• Building Energy Efficiency • LED Street lighting • Load Curtailment • Winter Peak Shaving	• Resilience Reduced winter load • Reduce inefficiency
Distributed Energy Resources (DERs)	• Backup Generators	• Combined Heat and Power (CHP) • Anaerobic Digestion • Energy Storage	• Demand Response • Resilience • Renewable Sources • Reduced winter load
Electrical and Thermal Infrastructure	• Radial Path 4.16kV & 12.45kV	• High Reliability Distribution System • Self-Healing	• Resilience • Reliability
Master Controller and Building Controls	• Some Building Controls	• Connected Master controller • Upgraded building controls • Smart Charger for Energy Storage	• Resilience • Optimal utilization of Microgrid Assets
IT/Communication Infrastructure	• Manual Meters • Some System Level Load metering	• Advanced Metering Infrastructure (AMI) • 900 MHz mesh network • Fiber optic backbone • Control interface for DER	• Resilience • Reliable real time information • Remote Control

Introduction

The existing technologies that support smart grid and microgrid capabilities will be screened for their application to the Bath Community Microgrid. This involves appropriating the benefits to the specific wants and needs of the stakeholders as well as thinning the list to the reasonable and applicable technologies for the region. The remaining technologies, applications, and revenue streams are then evaluated based on financial and technical feasibility in their application to the Bath Community Microgrid. This primarily consists of detailed research into the existing infrastructure available and compatibility of the proposed technology with this infrastructure and with the other resources available in the microgrid. Finally, the passing technologies are studied in detail, with tools such as the Distributed Energy Resources Customer Adoption Model (DER-CAM), to determine the range of acceptable capacity as well as the rough costs and cost savings.

Community Microgrid

Willdan proposes a community microgrid for the Village of Bath, which will enhance the overall operational reliability of the electrical distribution system. By providing a master controller, the Bath community microgrid would be capable of seamless islanding and resynchronization for economic, reliability, or resilience purposes. Seamless islanding and resynchronization are defined as automatic separation from the grid on loss of utility power and automatic restoration of grid power after an outage on the grid side is cleared, respectively.

Normal operating conditions would see reliability improvements through infrastructure reconfiguration, such as a High Reliability Distribution System (HRDS) which senses and clears faults with virtually no impact on building loads. This would result in a self-healing and more fault tolerant grid. Additional reliability improvements would be seen by reducing the number of single points of failure due to adding redundancy to the electrical and communications networks and by adding alternate sources of generation to serve critical and non-critical loads. In addition to increased reliability, the Bath Community Microgrid would reap economic benefits in the form of added revenue streams from demand response, alternate generation sources, and energy efficiency measures to reduce overall energy costs, as well as by participating in ancillary service markets such as fast regulation and operating reserve markets. Based on the price of electricity and availability of Distributed Energy Resources (DERs), the master controller will optimally dispatch the units to provide the cheapest, cleanest, and most reliable energy possible to the critical and non-critical microgrid facilities.

During emergency operating conditions, the Bath Community Microgrid master controller would optimize generation and load to provide uninterrupted power to critical loads. This is done through the use of DERs and load shedding schemes that ensure safe and reliable operation of the buildings that matter most in emergency situations. Long term outages will be mitigated by large natural gas fed combined heat and power (CHP) plants, which will maintain a black-start capability in the event the outage occurs when the CHP facility is not active. These plant or plants will rely on robust natural gas pipelines and produce enough power to serve all of the critical facilities, public street and security lighting, and some residential load. This added resiliency will keep emergency responders and residents safe and provide the Bath Community Microgrid with heat and power when it needs it most.

Load

Existing Resources

There are approximately 4,500 electric customers in Bath. The Village of Bath is allotted 13.37 megawatts (MW) of hydroelectric power from the New York Power Authority (NYPA) which is adequate to cover the peak loads except for the winter season (November through April). During the winter season, Bath depends on electricity for heating and it needs to purchase additional power to meet the demand. The demand can reach as high as 22MW in the winter season. Figure 1 shows the monthly load in Bath for the recent years.

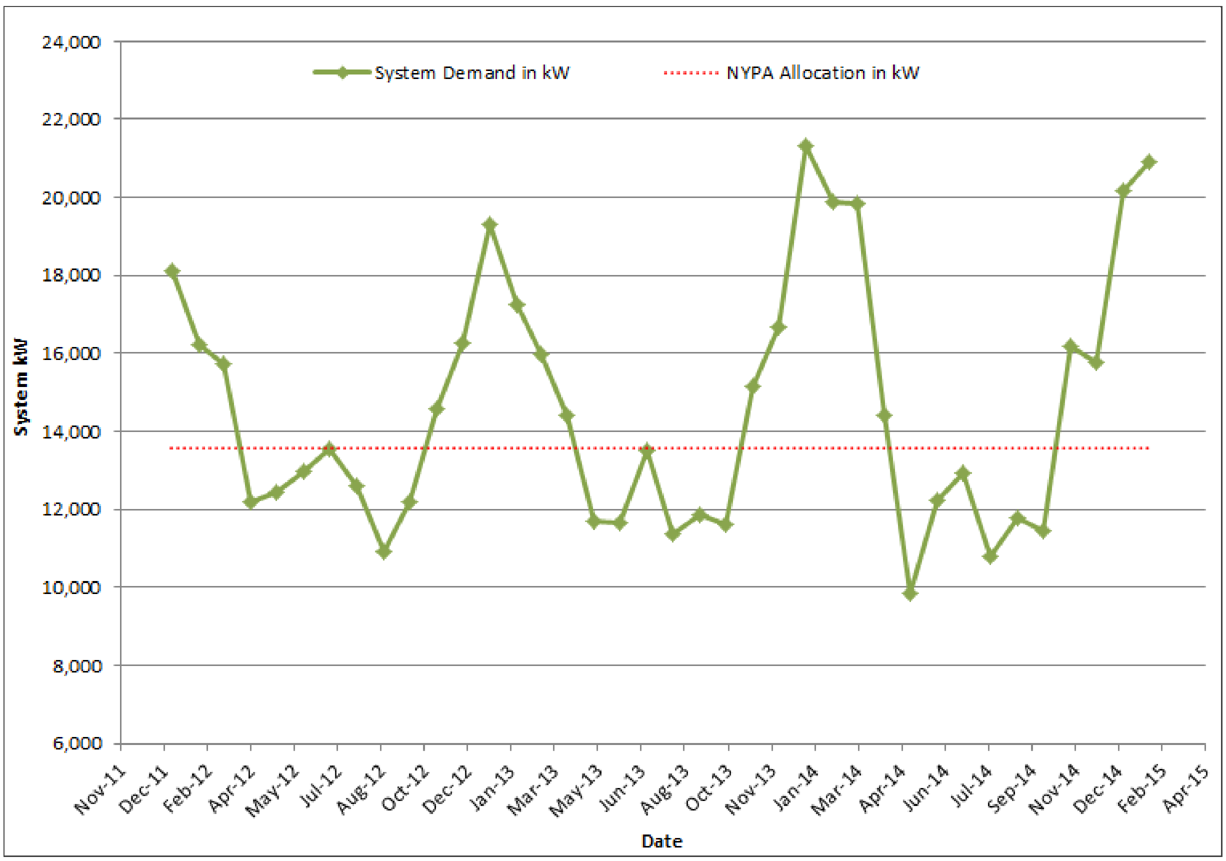


Figure 1. Electric Demand Load Profile in Bath

The Village of Bath's loads can be separated into the broad load categories, critical and non-critical, with critical facilities including the County Office, the Police Station and Jail, the Fire Department, the Elementary and High School buildings, the BEGWS Office, the County Center for Rehabilitation and Healthcare (CRH) and the municipal wastewater plant, and non-critical facilities including the many other businesses and residential customers served by BEGWS. The total critical load demand is about

2.6 MW. The load demand in each facility can be further separated into the following load categories as shown in table 2 to describe the unique nature of, and opportunities available for, the different load types. The thermal loads that are not fed by electric heaters are also considered separately.

Table 2. Electrical Load Type

Type	Description	Opportunities
Lighting	General, task, exits, and stairwells, decorative, parking lot, security, normal, and emergency.	Load curtailment
Transportation	Elevators, dumbwaiters, conveyors, escalators, and moving walkways.	Critical Load
Appliances	Business and copying machines, receptacles for vending machines, and general use	Load curtailment
Data processing	Desktop computers, central processing and peripheral equipment, and uninterruptible power supply (UPS) systems, including related cooling	Critical Load
Space conditioning	Heating, cooling, cleaning, pumping, and air-handling units	Short term Load curtailment and shifting
Food preparation	Cooling, cooking, special exhausts, dishwashing, disposing, and so forth	Load curtailment
Plumbing and sanitation	Water pumps, hot water heaters, sump and sewage pumps, incinerators, and waste handling	Short term load curtailment
Special loads	For equipment and facilities in mercantile buildings, restaurants, theaters, recreation and sports complexes, religious buildings, health care facilities, laboratories, broad casting stations, and so forth	Critical load
Fire protection	Fire detection, alarms, and pumps	Critical Load
Miscellaneous loads	Security, central control systems, communications; audio-visual, snow-melting, recreational, or fitness equipment	Critical load

Consequences

Due to the peak demand during winter, many of Bath's substation feeders for residential customers are operating near or at capacity resulting in momentary overloading of substation transformers serving residential customers. This situation is further exacerbated when multiple residential circuits fails. The residential winter peak also causes significant voltage sags in the 70+ year old system. The system is also entirely reliant on the NYSEG point of connection, which represents the primary resiliency issue, and has previously resulted in severe outages in the system. It would also incur additional cost liability when the

Bath community exceeds its NYPA kW and kWh allocation. Most recently, Bath incurred over $1,700,000 in 2014.

Opportunities

BEGWS will explore placing the microgrid's CHP and distributed generation resources near the worst of the residential load pockets to reduce amperage on the substation feeders/transformers. In addition, BEGWS aims to reduce winter peaks supplied by the bulk power supply and broaden participation in demand-response programs.

Proposed/Suggested Improvements

A community microgrid would be helpful for solving these constraints existing in Bath's system by providing additional capacity and resiliency. New CHP plants and demand response would help in mitigating the reliance on power from the utility grid. Willdan proposes to replace all the existing lighting with high efficient LED (Light Emitting Diode) fixtures. By applying the latest building control technology in each building, BEGWS would be able to have direct control capability on the curtailable and shift-able loads. Willdan recommends educating electric customers to participate in peak-load demand response program.

Benefits

With a community microgrid, Bath would be able to provide more reliable electricity to its electric customers. The critical facilities would remain powered on even in emergency situations when the power supply from the utility grid is lost. The community microgrid would also help Bath to reduce the extra cost caused by purchasing power from the market. By using the more efficient and safe LEDs for public street lighting and residential lighting, both the community and residential customers can reduce maintenance costs and lower electricity bills. With the capability of direct control on the loads, BEGWS would not only be able to improve the reliability of the community distribution system, but also would have the potential to participate in ancillary service markets such as frequency regulation, demand response, capacity markets, etc. Electric customers could achieve better quality of electricity service while cutting electricity bills at the same time.

Barriers

Implementing the community microgrid would require new investments in generation resources. A greater review of the exact equipment that is currently installed must be done to determine any necessary reconfiguration of the existing distribution network and communication system. It would also be necessary to educate electric customers to be involved in demand response programs.

DERs

Existing Resources

Existing DERs located in the proposed Bath Community Microgrid are used primarily as backup generators in the event that utility power is interrupted. They consist of both Diesel and Natural Gas

(NG) Generators, distributed among the critical facilities, and retain about a week of fuel for 2,100 kW of capacity or rely on NG pipelines for slightly less than 1,000 kW of capacity, respectively. Existing DER related to critical loads are shown in figure 2.

Consequences

While the critical loads have an average demand of about 2,500 kW and the DERs total just over 3,000 kW of generation, indicating that there is enough generation to provide critical loads with power in the event of an emergency, most of the generation, 2,000 kW of Diesel generators, is concentrated on the Jail and 911 facility and the County CRH. This means that a number of vital critical facilities, including the fire department, the ambulance, the middle and high schools, and the offices, would be out of power in the event of an emergency, putting the entire Village of Bath in a dangerous position. In addition, the community pays to maintain and test the backup generators, or runs risk of the generators not working when needed, and doesn't see any value added beyond emergency situations. Finally, it is worth noting that over two thirds of the generation runs off of diesel fuel, which is a relatively dirty fuel source that reduces the quality of the air and increases the carbon footprint of the Village of Bath, and must be stored or shipped into the village in the event of an outage.

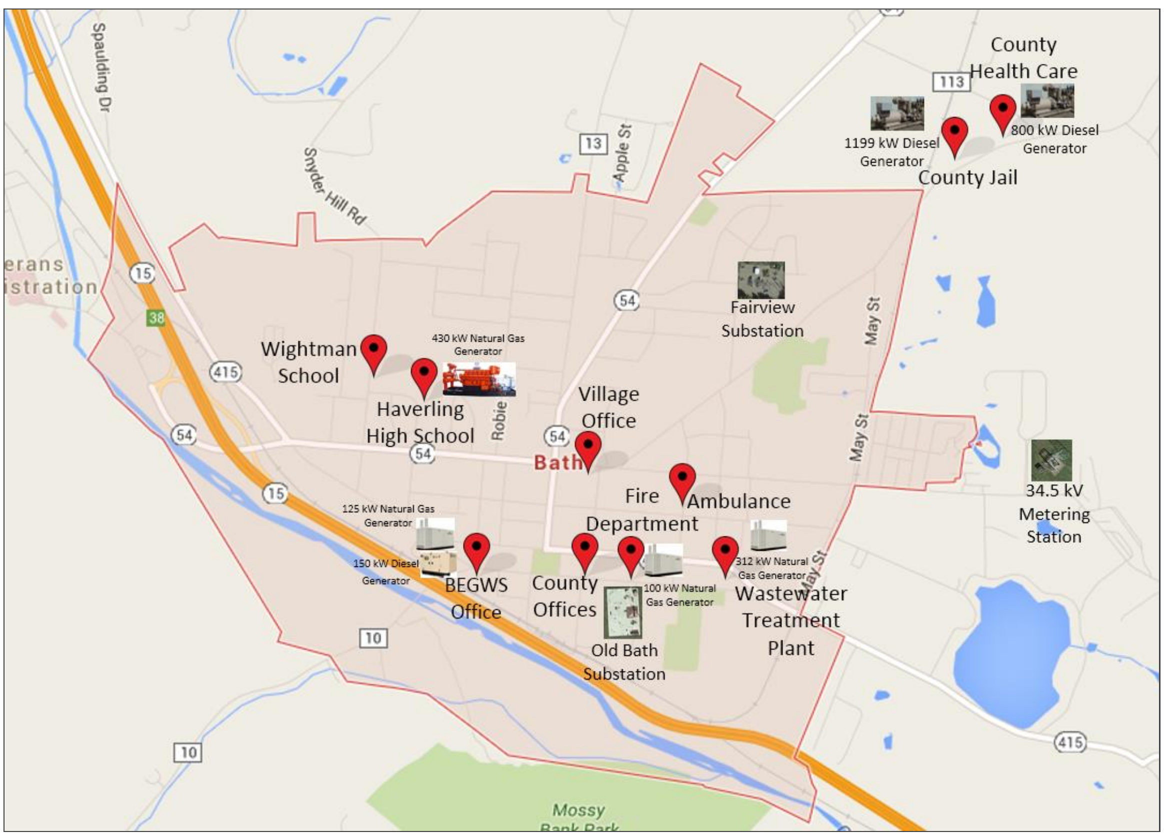


Figure 2. Critical Load, Substation, and Existing DER Map of Bath

Opportunities

The Village of Bath is exploring an anaerobic digester plant as an alternate fuel source that would take advantage of the sludge waste generated by the WWTP. The methane gas produced would feed a combined cycle plant and generate electricity for self-consumption as well as provide heat to the WWTP in the winter. In addition to utilizing the constant flow of municipal waste to produce methane, a process expected to produce about 700 kW of electrical energy, BEGWS is expected to expand the generation potential by supplementing the biogas with natural gas, increasing the electricity production of the CHP to nearly 2 MW. The additional heat capacity provided will be utilized to improve the year-round efficiency of the sludge treatment process, while supplementing local facilities. Bath has also begun to arrange an organics collection program with local businesses and food processers. The waste from these additional facilities will be collected for a fee, and will be used as additional, high-energy feedstock in the anaerobic digester. BEGWS is interested in exploring an expansion of CHP for a number of their critical facilities as well as adding a generation source to their middle and high schools, located across the street from each other. This expansion would allow Bath to participate in Demand Response programs and reduce its dependency on its bulk electric power purchases.

Proposed/Suggested Improvements

DER Technology

Table 3 includes the screened technologies and their barriers and opportunities specific to the Village of Bath.

Table 3. Distributed Energy Resources

Type	Description	Barriers	Opportunities
Combined Heat and Power (CHP)	Natural Gas fired turbines used to generate electricity and provide heat to nearby buildings	Space, Capital Cost, Cost of NG, Heating Infrastructure	Clean and Reliable, Reduce winter peak load, Resiliency
Solar	Renewable energy source powered by the sun	$/kW of solar is greater than electricity price	Clean, Reduce daytime peak load
Electric Storage	Converts electrical energy to chemical or mechanical for rapid dispatch when needed	Space, Capital Cost	Fast Regulation, Provides power during NG spool up
ICE Distributed Generation (ICE DG)	Backup generation	Cost, Range of use, Maintenance	Black Start for CHP, Provides power during NG spool up
Wind	Renewable energy source powered by the wind	Space, Capital Cost, maintenance	Clean Source
Hydro	Renewable energy source powered by the flow of water	Location, Cost, maintenance	Clean Source
Alternative Fuel Sources	Production of fuel from local processes (garbage dump, WWTP)	Supply	Converts waste into electricity

A screening of the available DER technology available to the Bath Community Microgrid favors CHP, Batteries as Energy Storage, Anaerobic Digestion as an Alternate Fuel Source, and ICE DG as black start generators for CHP. Based on initial analyses, due to the low cost of power, along with space required and maintenance/expertise needed, Wind, Solar and Hydro, are not justified economically or in terms of resiliency and do not merit further consideration.

Benefits

The addition of a range of DERs, including long term sources like CHP and Anaerobic Digestion, and short term sources like batteries and ICE DG, would allow the Village of Bath to operate as a microgrid, take advantage of new revenue streams such as Demand Response and Fast Regulation Markets, increase resiliency through on-site generation, and reduce charges associated with high winter heating loads by utilizing generation near residential load pockets. Distribution of these additional resources close to the school system, the Jail and CRH facilities, and the Fire Department and Ambulance will ensure that critical facilities will remain powered on in emergencies, providing the Village of Bath with peace of mind.

Barriers

Additional modeling will be performed to determine exact size and capacity of the proposed units, to ensure feasibility from financial and space requirements. Plant managers for CHP will have to be hired internally or externally and training will be required for maintenance and operators of the proposed DERs.

Electrical and Thermal Infrastructure

Existing Resources

The village of Bath owns and operates the distribution system within the village to serve approximately 4,500 electric customers. Most of the distribution system is a 70+ year old over-head system. Bath owns four substations with total capacity over 30 megawatts for distribution through the system. The four substations are Old Bath substation, Fairview substation, Hodgeman Substation, Faucett substation. Currently, only Old Bath substation and Fairview substation are in use, around 70% loads are supplied by Fairview substation and the rest are supplied by Old Bath substation.

Bath is currently working on an upgrade of the existing distribution system. Once the BEGWS system upgrade is completed, there will be only Fairview Substation with six feeders to supply power to all the loads within the Village of Bath. The Village of Bath's distribution system network after the upgrade is shown in figure 3.

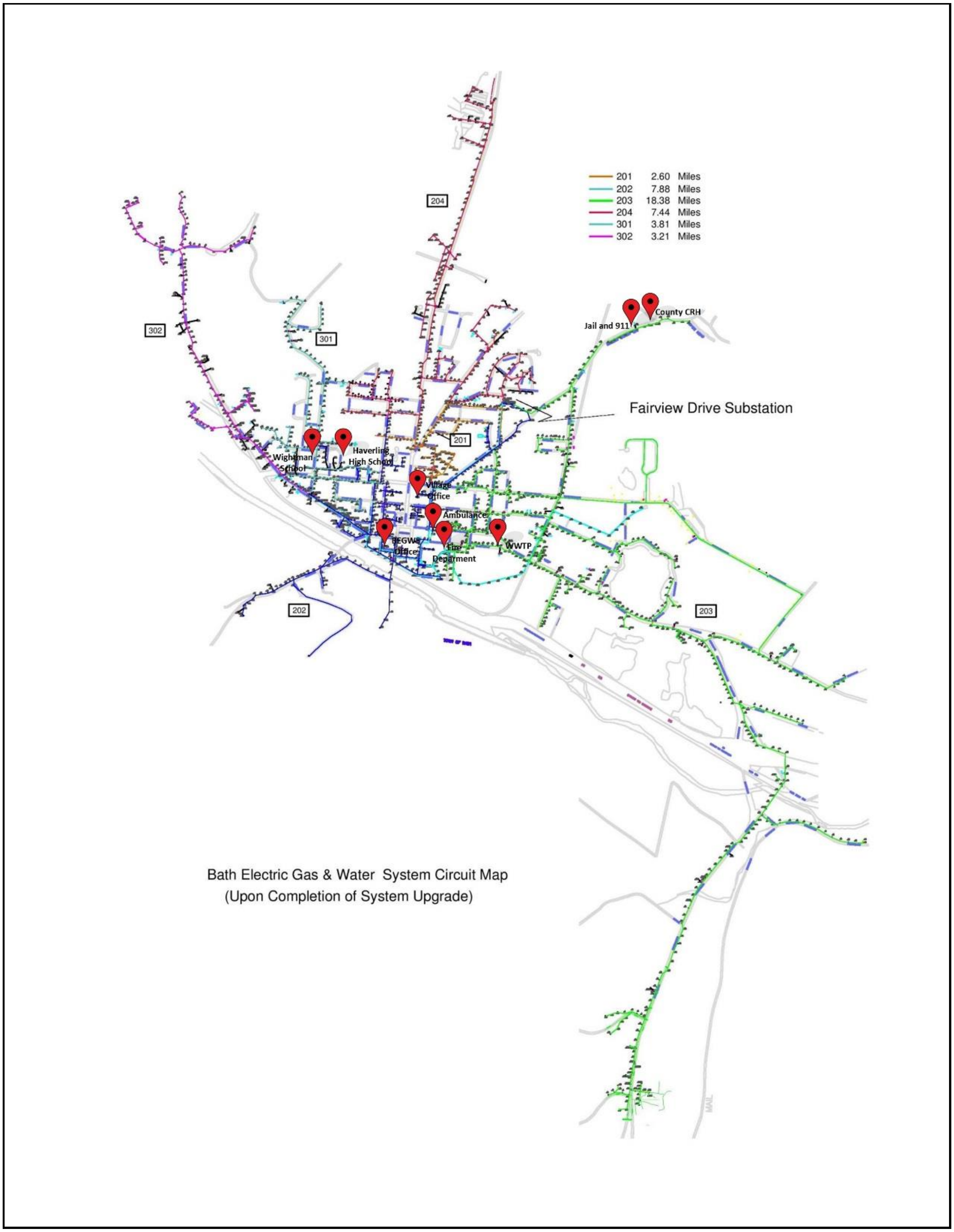


Figure 3. Bath's Distribution System Network after upgrade

Consequences

Many of Bath's substation feeders for residential customers are operating near or at capacity during winter peak loads, resulting in momentary overload of substation transformers serving residential customers. This situation is further exacerbated when multiple residential circuits fail. The residential winter peak would also causes significant voltage sags in the distribution system.

Opportunities

Bath is currently working on an upgrade on the existing distribution system. BEGWS has begun to convert its system to 12.5kV. Bath is also looking forward to utilize the heat produced from planned CHP for heating in building and wastewater treatment plant.

Proposed/Suggested

Willdan proposes a loop-based community microgrid for Bath. This new distribution network has a meshed structure which can operate as loop or radial, though it is normally operated as radial (i.e., with no loop), to make the protection coordination easier (upstream to downstream) and to make the distribution design easier. Also, the Automatic Transfer Switch (ATS) is proposed to be deployed within the community microgrid, which has the capability of network reconfiguration in case of an emergency or outage.

Benefits

The Bath community microgrid can operate in either grid-connected mode or island mode. The distribution network can be easily reconfigured for reliability purposes and for minimizing system loss to 3 to 4 cycles (~40ms). The critical loads can be served by multiple feeders. With the ATS, the community microgrid would be able to automatically isolate those buildings or distribution cables affected by outage, instead of spreading the outage to the whole distribution system.

Barriers

The existing or future distribution network will need further upgrades which may incur extra investment costs. Also, automatic smart switches are needed for fast automatic switching.

Master Controller and Building Controls

Proposed/Suggested Improvements

A major element of the Bath community microgrid is its master controller. The master controller applies hierarchical control via supervisory control and data acquisition (SCADA) software to ensure reliable and economic operation of the Bath community microgrid. It also coordinates the operation of on-site generation, storage, and individual building controllers. Intelligent switching and advanced coordination technologies of the master controller through communication systems facilitates rapid fault assessment and isolation.

Figure 4 shows the community microgrid elements, functions, and control tasks associated with each criterion. In order to achieve optimal economics, microgrids apply coordination with the utility grid and economic demand response in island mode. The short-term reliability at load points would consider microgrid islanding and resynchronization and apply emergency demand response and self-healing in the case of outages. Functionally, three control levels are applied to the Bath community microgrid:

- Primary control which is based on droop control for sharing the microgrid load among DER units.
- Secondary control which performs corrective action to mitigate steady-state errors introduced by droop control and procures the optimal dispatch of DER units in the microgrid.
- Tertiary control which manages the power flow between the microgrid and the utility grid for optimizing the grid-coordinated operation scheme.

The hierarchical secondary control approach would receive the information from loads and power supply entities as well as the information on the status of distribution network and procure the optimal solution via an hourly unit commitment and real-time economic dispatch for serving the load in the normal operation mode and contingencies. Figure 5 shows the hierarchical framework of the Master Controller proposed for Bath's community microgrid project. In figure 5, the monitoring signals provided to the master controller indicate the status of DER and distribution components, while the master controller signals provide set points for DER units and building controllers. Building controllers will communicate with sub-building controllers and monitoring systems to achieve a device level rapid load management.

The hierarchical protection configuration strategy for the community microgrid mainly contains four-level protection: load way, loop way, loop feeder way, and microgrid level.

Benefits

The Bath community microgrid master controller offers the opportunity to eliminate costly outages and power disturbances, supply the hourly load profile, reduce daily peak loads, and mitigate greenhouse gas production. The master controller will include the implementation of additional functions for load shedding and coordinating demand response signals with the other controllers for peak demand reduction. In demand response mode, the utility master controller will shut off loads according to predetermined load priorities. Part of the load shedding will be accomplished by shutting off power to entire buildings through smart switches and the rest will be accomplished by communicating directly with specific loads distributed across the community via the SCADA network and building controllers.

Barriers

In order to implement the proposed community microgrid in Bath, the existing or future distribution network would need a further upgrade which may incur extra investment cost; automatic smart switches are needed for fast automatic switching. The functions of the community microgrid would depend a lot on the implementation of a reliable communication system.

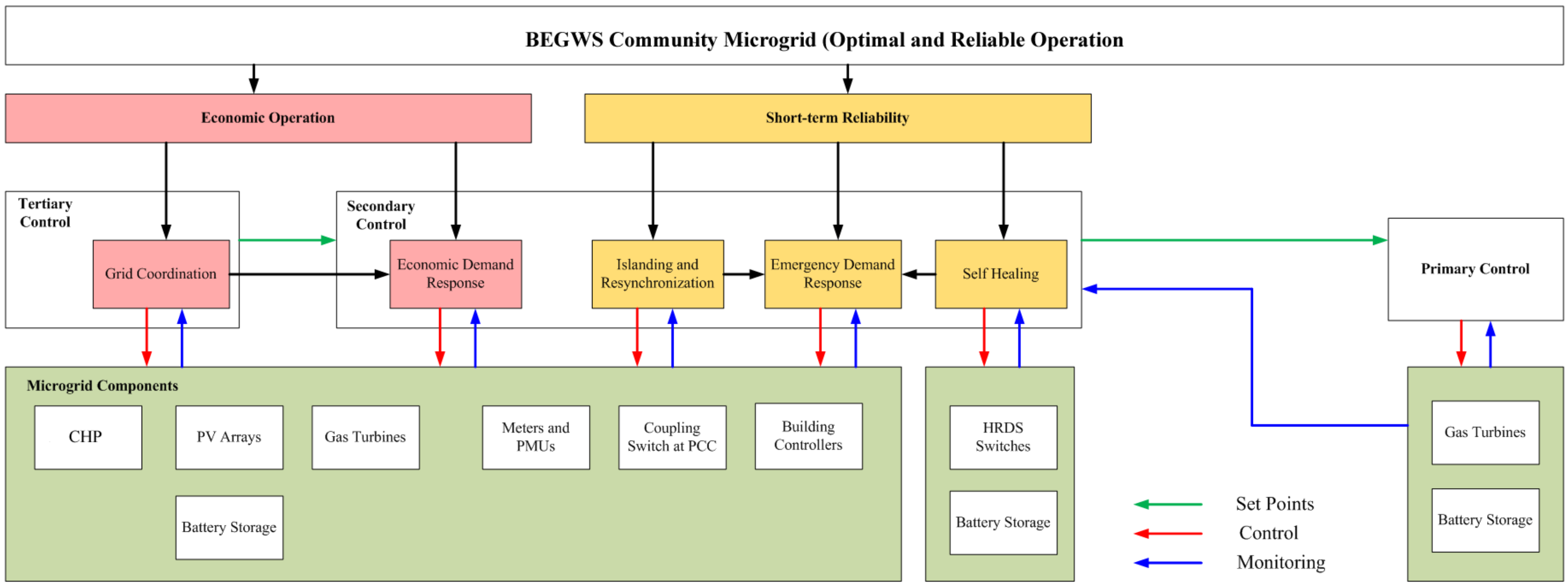
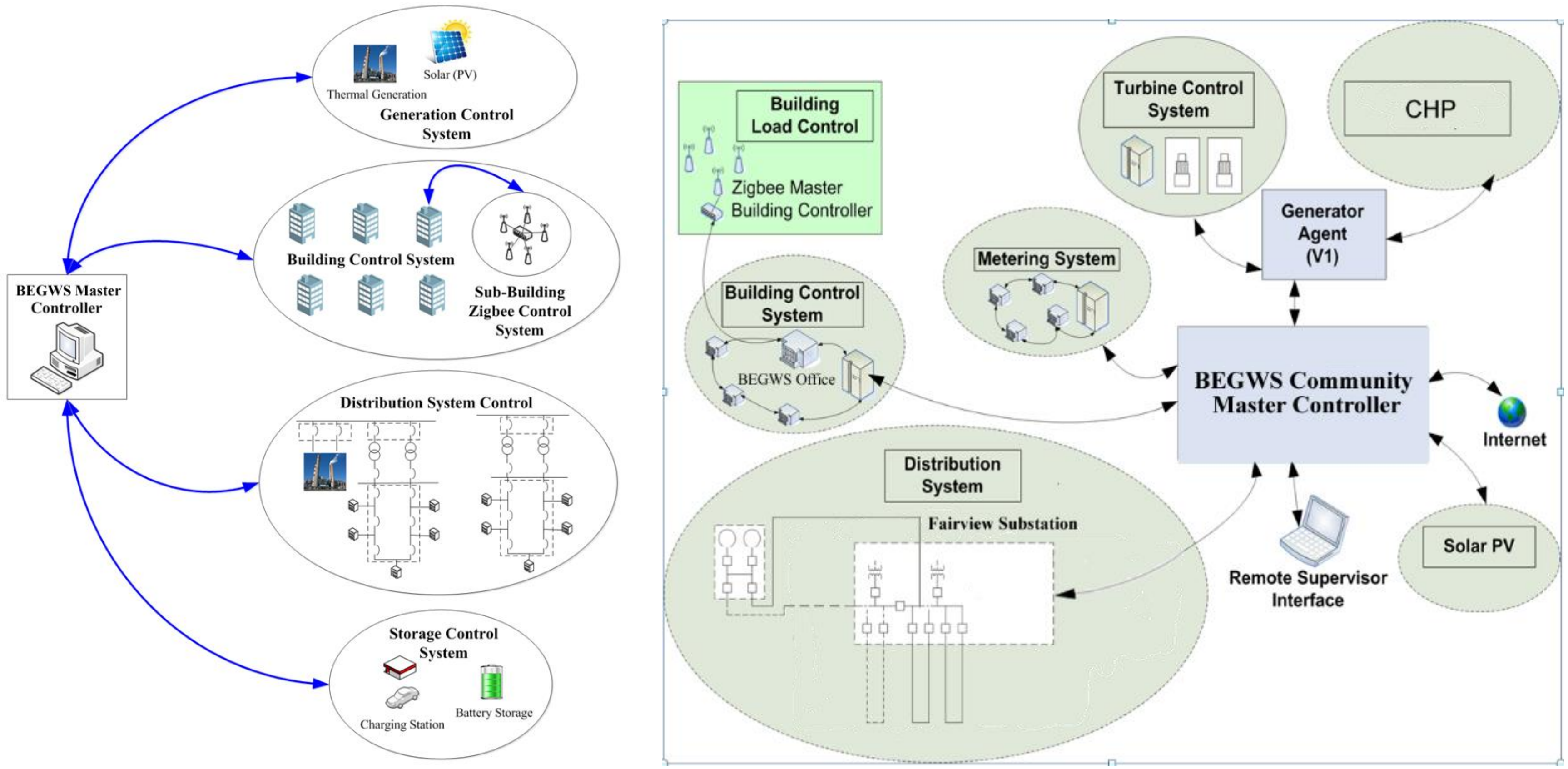


Figure 4. Objectives and functions for the control and operation of the Bath Community Microgrid



(a) (b)

Figure 5. Architecture of master controller for Bath community microgrid

IT/Communication Infrastructure

Any modern utility or system operator relies heavily on their communication infrastructure to monitor and control their grid assets. For a microgrid master controller and microgrid operators, this architecture enables real time control, rapid digestion of critical grid information, and historical data for analysis and reporting. As part of a feasible microgrid, assessment and upgrade of the equipment and protocols used in the microgrid area will be performed.

Existing Resources

BEGWS owns and operates two substations and over 30 miles of distribution lines, serving over 4,500 electric customers. A large majority of those customers are individually metered; however, these meters are read manually every month by a meter reader. At this stage, BEGWS has submitted limited information on their communications and control architecture. They are able to obtain system level load information, but not feeder level or three phase data from their distribution system or their substations.

Consequences

A limited communications architecture can lead to increased frequency and duration of outages if problems must occur and be reported rather than having symptoms trigger notifications to grid operators of location and scope of the issue. Limited information and delay in this information leads to man hours wasted and longer duration of customers without power, putting strain on residential customers and potentially costing commercial customers significant amounts of money. Systems could have telltale signs of issues for weeks, but operators may not discover these until they have caused damage and outages to the electric grid or substations, costing the utility money and potentially endangering employees and customers.

Opportunities

BEGWS is considering a $4-5 million Advanced Metering Infrastructure (AMI) expansion, which would involve adding wireless communication infrastructure throughout each meter in the Village of Bath to allow for automatic and digital meter reads. The key advantage of this expansion would be the network addition, which often utilizes the 900 MHz ISM band and relies on communication between integrated Network Interface Cards (NICs) that form a mesh network, allowing signals to hop between any installed meters to reach their ultimate destination and increases the propagation range of the signal in proportion to the number and dispersion of integrated NIC Smart Meters. The integrated NICs are connected to a local Access Point (AP) that transmits the metering and control signals for the streetlights over a cellular wireless network back to the utility data center, where it can be fed into a Supervisory Control and Data Acquisition (SCADA) platform for use in billing or monitoring the overall grid.

BEGWS-controlled AMI would also provide opportunity for community demand response aggregation, in which BEGWS will be able to remotely control non-critical loads at the customer level to maximize economic benefit and/or reduce strain on the grid.

Proposed/Suggested Improvements

The Bath Community Microgrid would be connected efficiently and productively, through the use of modern communication architectures and equipment, enabling a master controller to optimize the microgrid control and giving operators the tools they need to perform their daily duties. This network would leverage the AMI network and seek to strengthen it through the use of connected LED streetlights, which require half the power of the existing High Pressure Sodium (HPS) fixtures and shorten the overall payback of a street lighting upgrade through the implementation of smart photocells or integrated NICs that individually meter and control each streetlight, seen in figure 6.

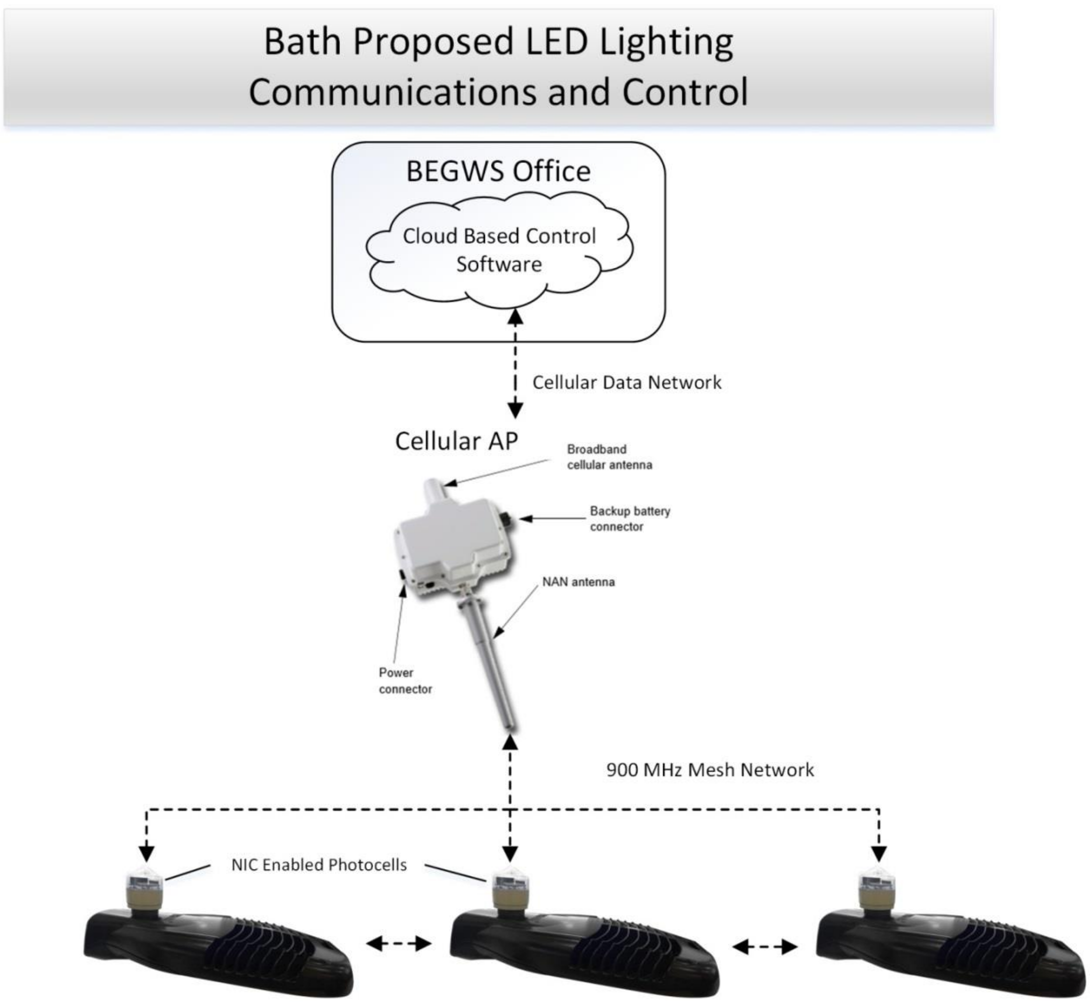


Figure 6. Bath Proposed LED Lighting Communications and Control Diagram

In addition to meters and streetlights, circuit breakers, relays, reclosers and other switchgear are vital to the control of the Bath Community Microgrid. While some distributed switchgear can utilize a similar wireless infrastructure, with data being fed through substations instead of through a cloud network, the control equipment is more vital to the safe operation of the microgrid and would ideally use a fiber optic backbone between the BEGWS data center and the Fairview substation. The substation relays may have to be upgraded to communicate using the DNP3 protocol over TCP/IP, the de facto standard for modern utility communications, which will be used to monitor and control the proposed DER as well.

Once in the data center, the data will be fed into an upgraded or added SCADA system to allow operators to access, visualize, and control, all of the microgrid assets.

Benefits

Utilizing a fully connected microgrid, with every vital piece of equipment monitored and controlled remotely, the master controller will be able to optimize load and generation automatically and in real time, the microgrid operators will be able to view the status, create reports, and plan future developments, and maintenance will be able to quickly assess and address any issues.

Barriers

A more extensive review of existing communications and control equipment needs to be performed to determine the exact quantity and specification of the upgrade; RF testing will need to be performed to determine the layout of the wireless network proposed. Training would have to be done on the SCADA system and the newly implemented relays, and personal may need to be hired to maintain the network and communications equipment. A review of costs of the current system, including streetlight usage and maintenance data, current metering system costs and inaccuracies and outage information will have to be performed to determine exact cost savings of upgrading to the new system.

Task 2 – Develop Preliminary Technical Design Costs and Configuration

Table 4. Bath Community Microgrid Existing and Proposed Overview

Category	Existing Resources	Proposed/Suggested Improvement	Justification
Load	• Residential Electric Heat • 13.37 MW NYPA allocation • 22 MW Winter Peak	• Building Energy Efficiency • LED Street lighting • Load Curtailment • Winter Peak Shaving	• Resilience Reduced winter load • Reduce inefficiency
Distributed Energy Resources (DERs)	• Backup Generators	• Combined Heat and Power (CHP) • Anaerobic Digestion • Energy Storage • Solar (Not applicable)	• Demand Response • Resilience • Renewable Sources • Reduced winter load
Electrical and Thermal Infrastructure	• Radial Path 4.16kV & 12.45kV	• High Reliability Distribution System • Self-Healing	• Resilience • Reliability
Master Controller and Building Controls	• Some Building Controls	• Connected Master controller • Upgraded building controls • Smart Charger/Inverter for Batteries/Solar	• Resilience • Optimal utilization of Microgrid Assets
IT/Communication Infrastructure	• Manual Meters • Some System Level Load metering	• Advanced Metering Infrastructure (AMI) • 900 MHz mesh network • Fiber optic backbone • Control interface for DER	• Resilience • Reliable real time information • Remote Control

Table 5. Serving Critical Loads with Islanding in Peak Load Season (January)

Islanding Days	Load Curtailment (%)	Resilience Weight (%)1	Proposed DER Capacity(kW)	Operation Cost (K$)	Investment Cost (K$)
7	0-40%	100% - 89.41%	1,200-1,400	817.8-1,472.1	1,441-1,741
6	0-40%	86.76% - 76.18%	950-1,450	810.4 - 1,466.3	1441- 1,741
5	0-40%	73.53% - 62.94%	738 – 1,200	807.7 – 1,451.1	856.3 -1,441
4	0-40%	49.71% - 73.53%	738 – 1,200	802 – 1,442.9	856.3 – 1,441
3	0-40%	47.06% - 36.47%	738 – 1,200	796.3 – 1,431.1	856.3 – 1,441
2	0-40%	33.82% - 23.24%	738 – 1,200	790.6 – 1,419.5	856.3 – 1,441
1	0-40%	20.59% - 10%	719 – 1,200	785 – 1,408	848.7 – 1,441

Introduction

Bath Electric Gas and Water Systems (BEGWS) is proposing to implement a microgrid ("Bath Community Microgrid") that is interconnected with the Bath municipal electric distribution system. BEGWS will act as the Local Gas and Electric Distribution Company for this feasibility study and will be joined by the Village of Bath, the county seat of Steuben County, participating as the Local Government.

BEGWS incurs additional cost liability when the community exceeds its NYPA kW and kWh allocation; most recently, Bath incurred over $1,700,000 in 2014, a significant burden for a County seat community with a limited tax base. The excess is largely due to residential electric heaters being operated in the cold winter months. In addition, Bath's radial path distribution system is 70+ years old, exposing the community to risk due to outages and equipment failures.

Willdan proposes a community microgrid for the Village of Bath which will enhance the overall operational reliability of the electric distribution system for all of the stakeholders, which include the Village of Bath, Customized Energy Solutions, Steuben County/Bath Central Schools, and Bath Electric, Gas, and Water Systems, by providing a master controller which has the ability to perform, in real-time, reconfiguration of the microgrid functions, seamless islanding for economic, reliability, or resilience reasons, and optimization of storage and generation resources.

[1] Resiliency weight is introduced based on the maximum number of days that critical load capacity is being responded in the grid outage duration and maximum level of critical load which can be served. We define that the capability of serving critical load with no curtailment for seven days (as customer's requirement) is 100% resiliency and the capability of serving 60% critical load for one day is 10% resiliency.

The Village of Bath's critical loads, which include the County Office, the Police Station and Jail, the Fire Department, the Elementary and High School buildings, the BEGWS Office, the County Center for Rehabilitation and Healthcare (CRH) and the municipal wastewater plant (WWTP), will remain powered on while the microgrid is islanded. In addition to providing resiliency for critical loads, Willdan's proposed Bath Community Microgrid could provide economic and reliability benefits for Bath Electric Power's nearly 4,500 residential customers as well as maintaining power for public street lighting and security lighting all across Steuben County while the microgrid is islanded.

The existing technologies that support smart grid and microgrid capabilities will be screened for their application to the Bath Community Microgrid. This involves appropriating the benefits to the specific wants and needs of the stakeholders as well as thinning the list to the reasonable and applicable technologies for the region. The remaining technologies, applications, and revenue streams are then evaluated based on financial and technical feasibility in their application to the Bath Community Microgrid. This primarily consists of detailed research into the existing infrastructure available and compatibility of the proposed technology with this infrastructure and with the other resources available in the microgrid. Finally, the passing technologies are studied in detail, with tools such as the Distributed Energy Resources Customer Adoption Model (DER-CAM), to determine the range of acceptable capacity as well as the rough costs and cost savings.

Sub Task 2.1 Proposed Microgrid Infrastructure and Operations

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.

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

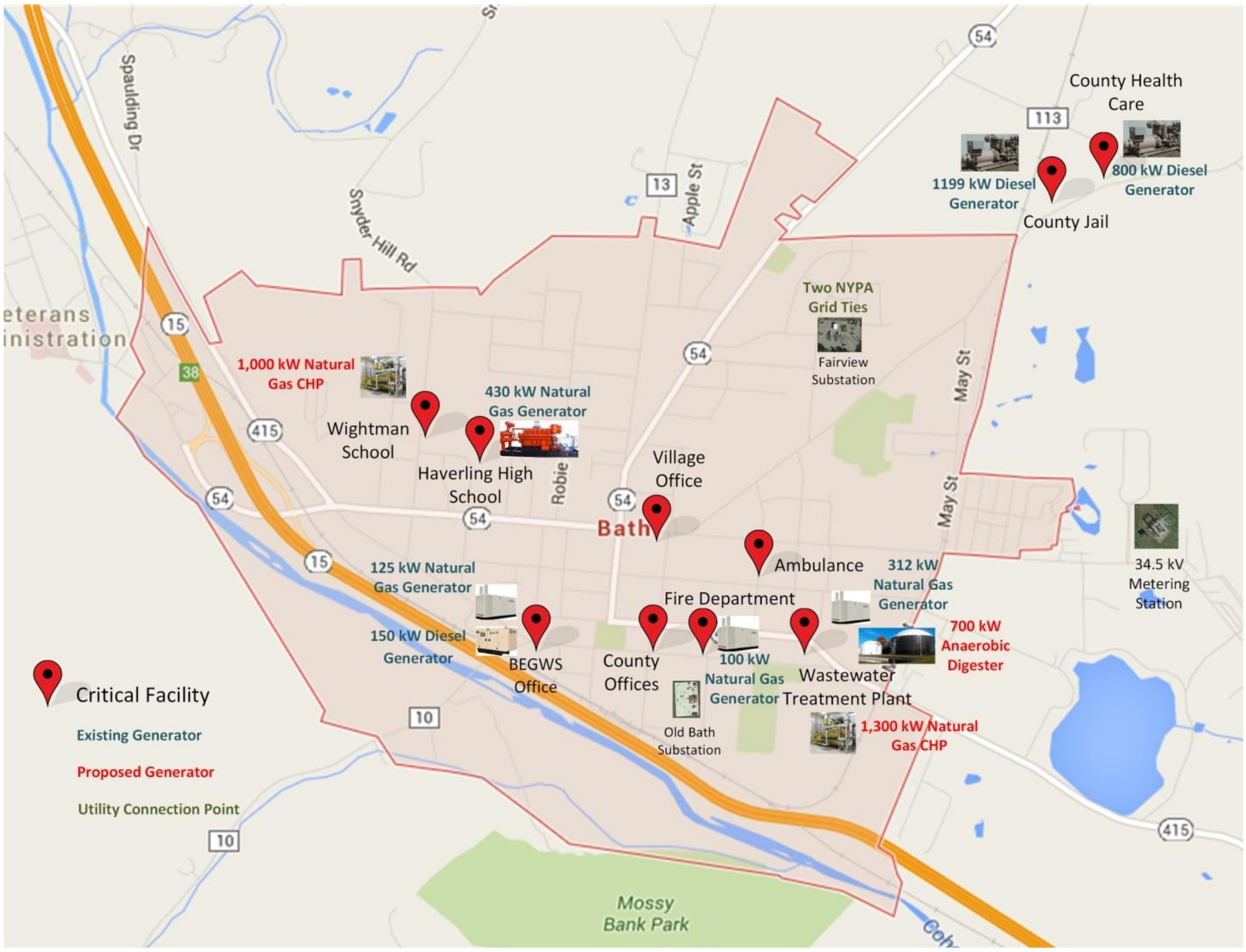


Figure 7. Generation simplified equipment layout diagram

Willdan proposes a community microgrid for the Village of Bath, which will enhance the overall operational reliability of the electrical distribution system. By providing a master controller, the Bath community microgrid would be capable of seamless islanding and resynchronization for economic, reliability, or resilience purposes. Seamless islanding and resynchronization is defined as automatic separation from the grid on loss of utility power and automatic restoration of grid power after an outage on the grid side is cleared.

Normal operating conditions would see reliability improvements through infrastructure reconfiguration, such as a High Reliability Distribution System (HRDS) which senses and clears faults with virtually no impact on building loads. Reliability is also improved to a self-healing and more fault tolerant grid by reducing the number of single points of failure, by adding redundancy to the electrical and communications networks, and by adding alternate sources of generation to serve critical and non-critical loads. In addition to increased reliability, the Bath Community Microgrid would reap economic benefits in the form of added revenue streams from demand response, alternate generation sources, and energy efficiency measures to reduce overall energy costs, as well as participating in ancillary service markets such as fast regulation and operating reserve markets. Based on the price of electricity and availability of Distributed Energy Resources (DERs), the master controller will optimally dispatch the units to provide the cheapest, cleanest, and most reliable energy possible to the critical and non-critical microgrid facilities.

During emergency operating conditions, the Bath Community Microgrid master controller would optimize generation and load to provide uninterrupted power to critical loads, through the use of DERs and load shedding schemes that ensure safe and reliable operation of the buildings that matter most in emergency situations. Long term outages will be mitigated by large natural gas fed combined heat and power (CHP) plants, which will maintain a black-start capability in the event the outage occurs when the CHP facility is not active. These plant or plants will rely on robust natural gas pipelines and produce enough power to serve all of the critical facilities, public street and security lighting, and some residential load. This added resiliency will keep emergency responders and residents safe and provide the Bath Community Microgrid with heat and power when it needs it most.

Sub Task 2.2 Load Characterization

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.

There are approximately 4,500 electric customers in Bath. The Village of Bath is allotted 13.37 megawatts (MW) of hydroelectric power from the New York Power Authority (NYPA) which is adequate to cover the peak loads except for the winter season (November through April). During the winter season, Bath depends on electricity for heating and it needs to purchase additional power to meet the demand. The demand can reach as high as 22MW in the winter season. Table 8 and figure 8 show the monthly load in Bath for recent years.

The Village of Bath's loads can be separated into the broad load categories, critical and non-critical, with critical facilities including the County Office, the Police Station and Jail, the Fire Department, the Elementary and High School buildings, the BEGWS Office, the County Center for Rehabilitation and Healthcare (CRH) and the municipal wastewater plant, and non-critical facilities including the many other businesses and residential customers served by BEGWS. The total critical load demand is about 2.6 MW (figure 8). The load demand in each facility can be further separated into the following load categories as shown in table 6 to describe the unique nature of, and opportunities available for, the different load types. The thermal loads that are not fed by electric heaters are also considered separately.

Table 6. Electrical Load Type

Type	Description	Opportunities
Lighting	General, task, exits, and stairwells, decorative, parking lot, security, normal, and emergency.	Load curtailment
Transportation	Elevators, dumbwaiters, conveyors, escalators, and moving walkways.	Critical Load
Appliances	Business and copying machines, receptacles for vending machines, and general use	Load curtailment
Data processing	Desktop computers, central processing and peripheral equipment, and uninterruptible power supply (UPS) systems, including related cooling	Critical Load
Space conditioning	Heating, cooling, cleaning, pumping, and air-handling units	Short term Load curtailment and shifting
Food preparation	Cooling, cooking, special exhausts, dishwashing, disposing, and so forth	Load curtailment
Plumbing and sanitation	Water pumps, hot water heaters, sump and sewage pumps, incinerators, and waste handling	Short term load curtailment
Special loads	For equipment and facilities in mercantile buildings, restaurants, theaters, recreation and sports complexes, religious buildings, health care facilities, laboratories, broad casting stations, and so forth	Critical load
Fire protection	Fire detection, alarms, and pumps	Critical Load
Miscellaneous loads	Security, central control systems, communications; audio-visual, snow-melting, recreational, or fitness equipment	Critical load

Consequences

Due to the peak demand during winter, many of Bath's substation feeders for residential customers are operating near or at capacity resulting in momentary overload of substation transformers serving residential customers. This situation is further exacerbated when multiple residential circuits fails. The residential winter peak also causes significant voltage sags in the 70+ year old system. The system is also entirely reliant on the NYSEG point of connection, which represents the primary resiliency issue, and has previously resulted in severe outages in the system. It would also incur additional cost liability when the Bath community exceeds its NYPA kW and kWh allocation. Most recently, Bath incurred over $1,700,000 in 2014. See figure 8 for the critical building electric load location and level as well as heating load from Natural Gas in critical facilities.

Opportunities

BEGWS explored placing the microgrid's CHP and distributed generation resources near the worst of the residential load pockets to reduce amperage on the substation feeders/transformers. It can be seen, in figure 8, that there is a high concentration of Electric and heating load surrounding the WWTP, making it an ideal location for the installation of CHP. In addition, the Wightman and Haverling Schools, across the street from each other, have limited existing generation (figure 7) and high electric and heating load (figure 8), which make these critical facilities ideal for a CHP installation. In addition to CHP, BEGWS aims to reduce winter peaks supplied by the bulk power supply and broaden participation in demand-response programs. Finally, the County Jail and County Health Care facilities have similar heating and electric load requirements that could be well satisfied by the installation of a CHP Plant. Any combination of these proposed generators would provide the microgrid's critical facilities with much needed steam for heating as well as electricity in emergency situations. See figures 8-12 and tables 7-9 for additional electric and heating demand and usage information for the Village of Bath.

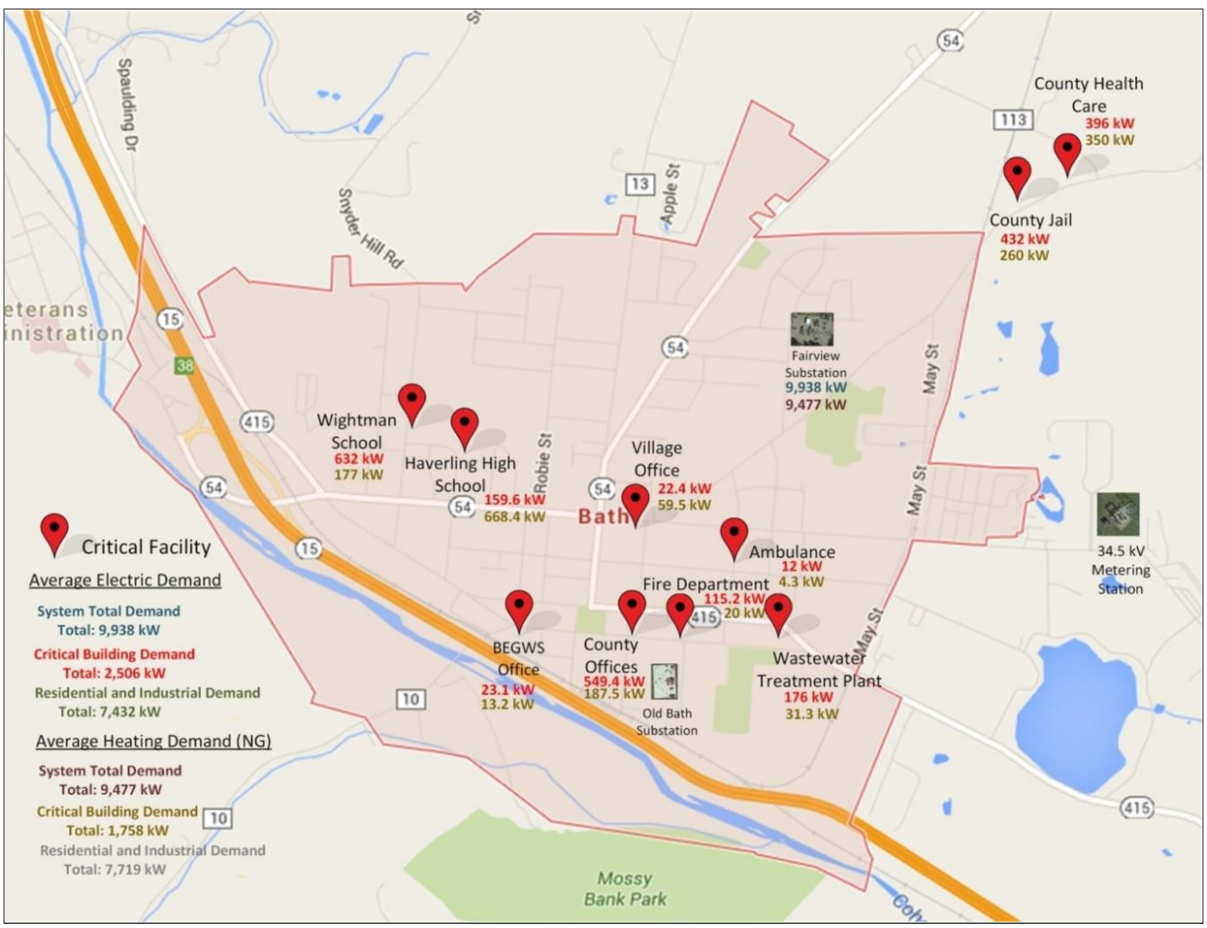


Figure 8. Load simplified equipment layout diagram

Table 7. Demand and Energy for Bath (2014)

Source	Summer Peak	Winter Peak	Annual Energy
Electricity	12,940 kW	21,308 kW	101,091,300 kWh
Natural Gas	0 kW	31,260 kW	83,018,207 kWh

Table 8. Electricity Usage

Month	Energy (kWh)
January, 2014	11,865,940
February, 2014	10,131,283
March, 2014	10,539,564
April, 2014	6,982,641
May, 2014	5,506,812
June, 2014	5,615,353
July, 2014	5,885,019
August, 2014	5,631,405
September, 2014	5,276,337
October, 2014	5,877,363
November, 2014	7,817,523
December, 2014	9,049,008

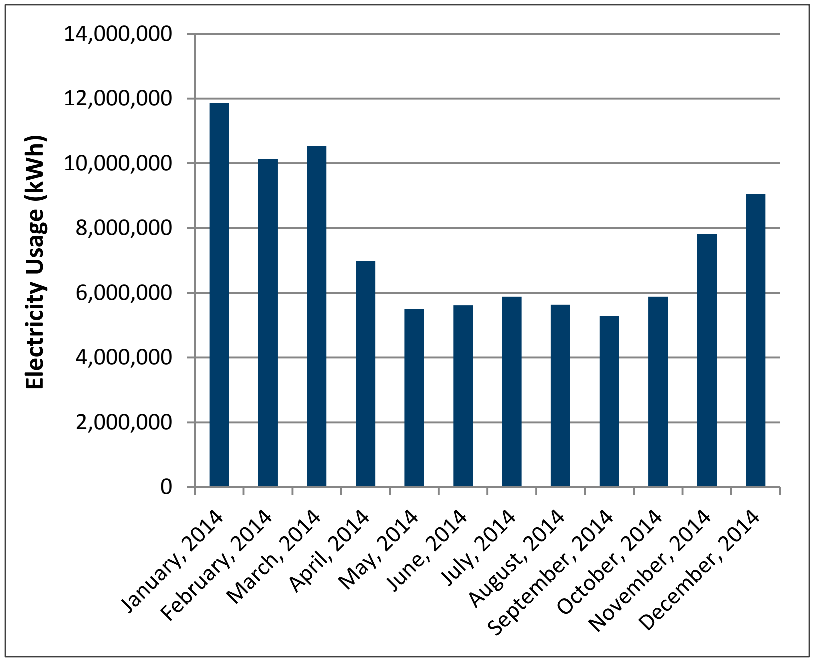


Figure 9. Electricity Usage 2014

Table 9. Natural Gas Usage

Month	Energy (kWh)
January, 2014	20,432,392
February, 2014	15,306,949
March, 2014	13,177,970
April, 2014	5,127,149
May, 2014	818,058
June, 2014	0
July, 2014	0
August, 2014	0
September, 2014	0
October, 2014	4,409,097
November, 2014	7,667,606
December, 2014	16,078,985

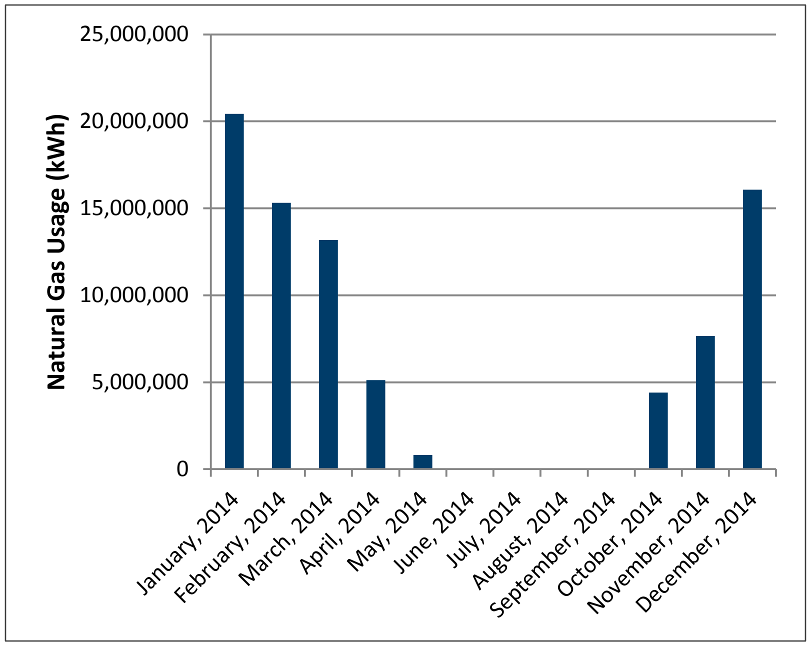


Figure 10. Natural Gas Usage 2014

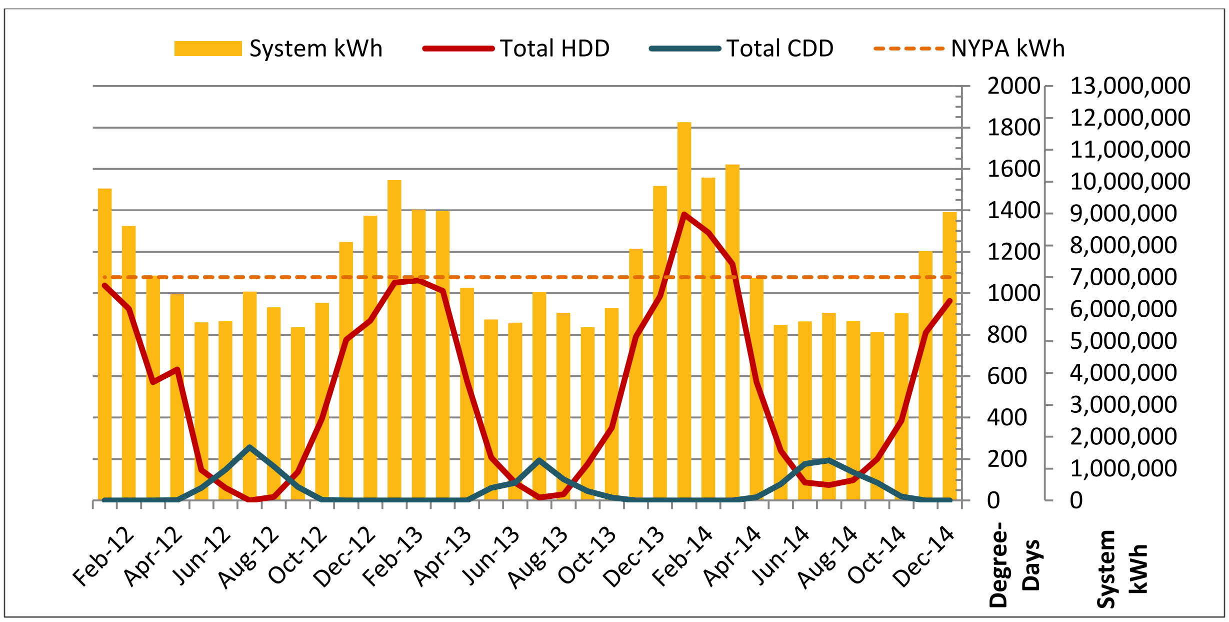


Figure 11. Bath Electric Department System Monthly Energy Profile

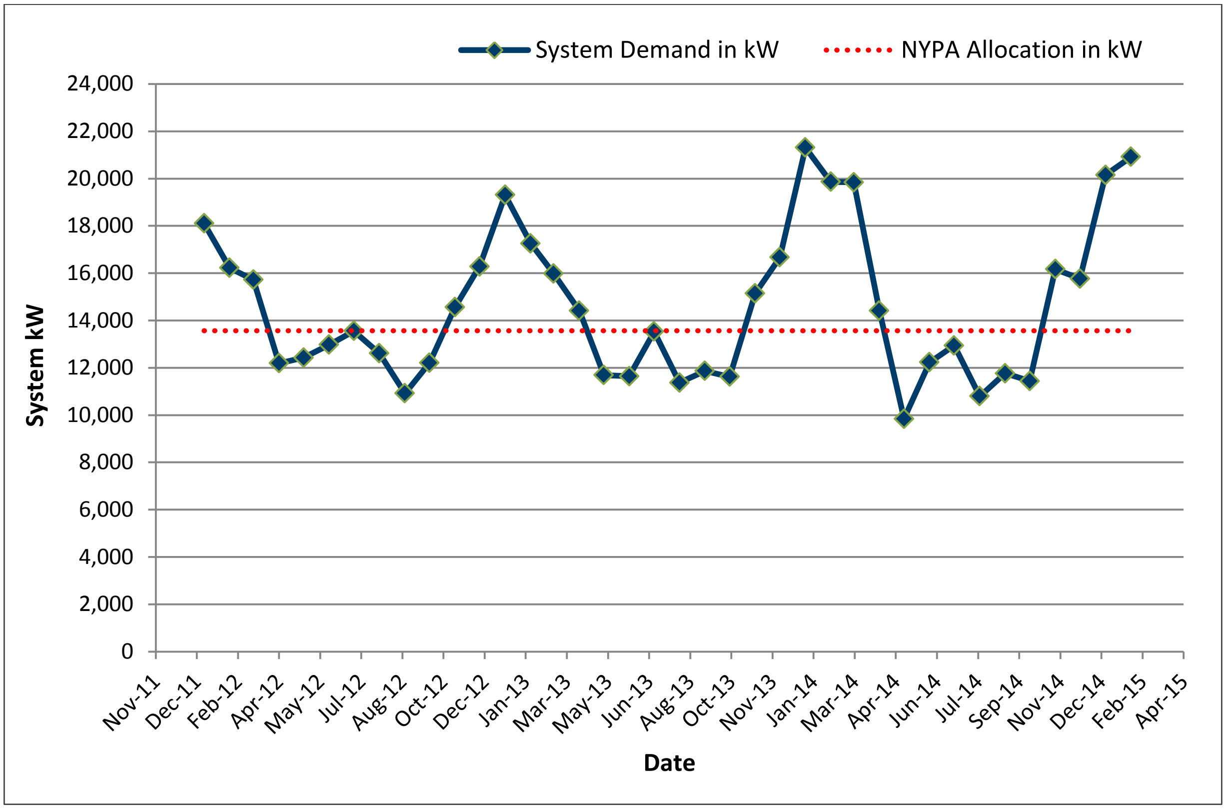


Figure 12. Bath Electric Department System Monthly Demand Profile

Proposed/Suggested Improvements

A community microgrid would be helpful for solving these constraints existing in Bath's system by providing additional capacity and resiliency. New CHP plants and demand response would help in mitigating the reliance on power from utility grid. Willdan proposes to replace all the existing lighting with high efficient LED (Light Emitting Diode) fixtures. By applying the latest building control technology in each building, BEGWS would be able to have the direct control capability on the curtailable and shift-able loads. Willdan recommends educating the residential customers to participate in peak-load demand response program.

Benefits

With a community microgrid, Bath would be able to provide more reliable electricity to its electric customers. The critical facilities would remain powered on even in emergency situation when the power supply from the utility grid is lost. The community microgrid would also help Bath to reduce the extra cost caused by purchasing power from market. By using the more efficient and safe LEDs for public street lighting and residential lighting, both the community and residential customers can reduce maintenance cost and electricity bill. With the capability of direct control on the loads, BEGWS would not only be able to improve the reliability of the community distribution system, but also BEGWS have the potential to participate in ancillary service market such as, frequency regulation, demand response, etc. Electric customers can achieve better quality of electricity service while cutting their electricity bills at the same time.

Barriers

Implementing a community microgrid would require new investment in generation resources. A greater review of the exact equipment installed must be done to determine any reconfiguration of the existing distribution network and communication systems that must be done. It would also be necessary to educate the electric customers about being involved in the demand response program.

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.

Figure 13 shows the hourly load profile of the total system load that is served by the Bath Community Microgrid. The hourly load is broken down by month to reflect the drastically different usage by month seen in figures 11, 12, and 9 as well as in table 8. It can be seen that the heating load in January causes the daily load profile to be raised to more than double the levels of that in June, as it is seen in many of the other winter months versus summer months. In addition, summer months tend to produce a daily demand curve with one wide peak, starting at 6am, ending at 9pm, and peaking around noon. This wide peak can be attributed to electric air conditioners working hard against the warming rays of the sun. In contrast, many of the winter months have a pronounced twin peak, with one centered around 9 or 10am and one centered around 6pm. These correspond to the commercial industrial daytime peak and the residential evening peak electricity consumption times.

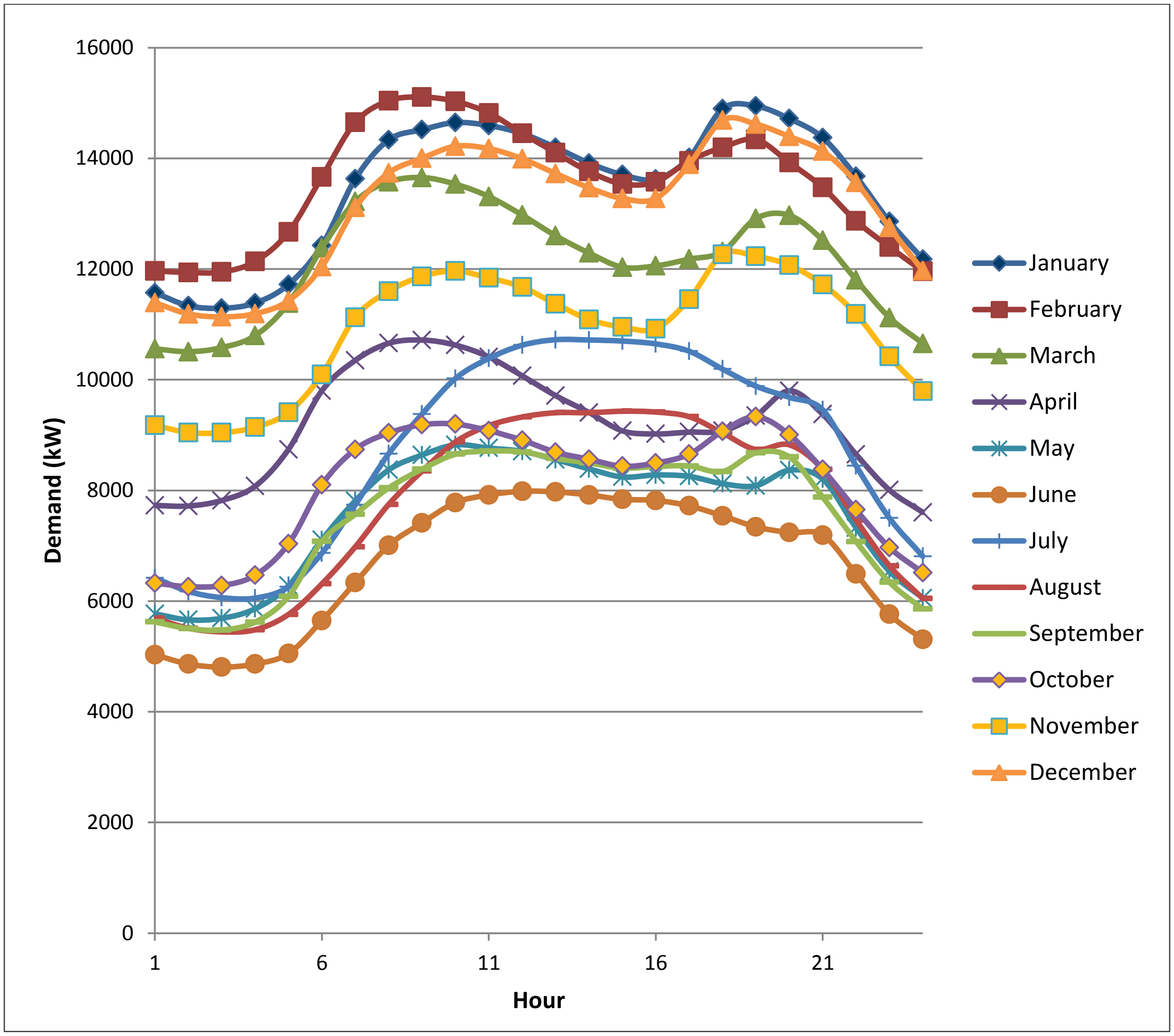


Figure 13.Bath Average Daily Load by Month[1]

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.

The proposed Bath Community Microgrid focuses on providing electricity for the critical buildings while relieving high winter peaks due to electric heating. Shown in figures 11 and 12 are the issues that the Bath community faces during winter electricity spikes. The yellow dotted line in both is the NYPA allocation, which can be seen to be exceeded in almost all of the winter months. Total average critical building demand is about 2,500 kW and average heating demand is about 1,700 kW (figure 8). The installation of 3,000-5,000 kW of CHP would be able to adequately serve the entire load, depending on the level of load shedding implemented.

[1] From Bath Electric Gas and Water Service Hourly Data.

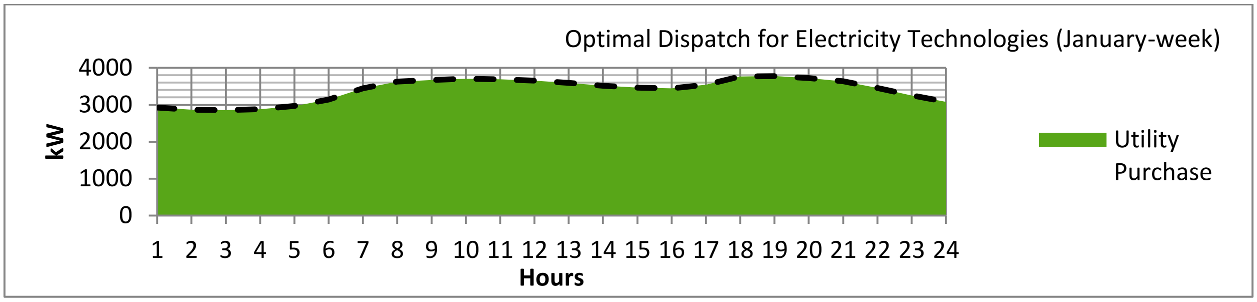


Figure 14. Pre Investment Average Electricity Dispatch

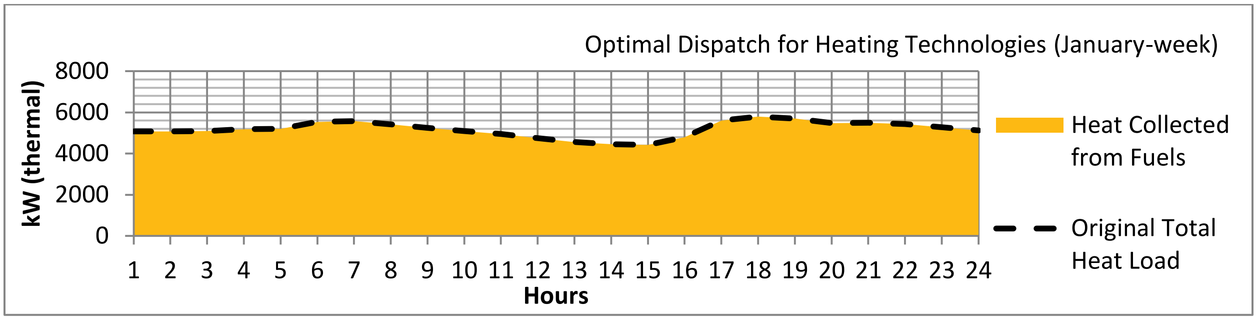


Figure 15. Pre Investment Average Heating Dispatch

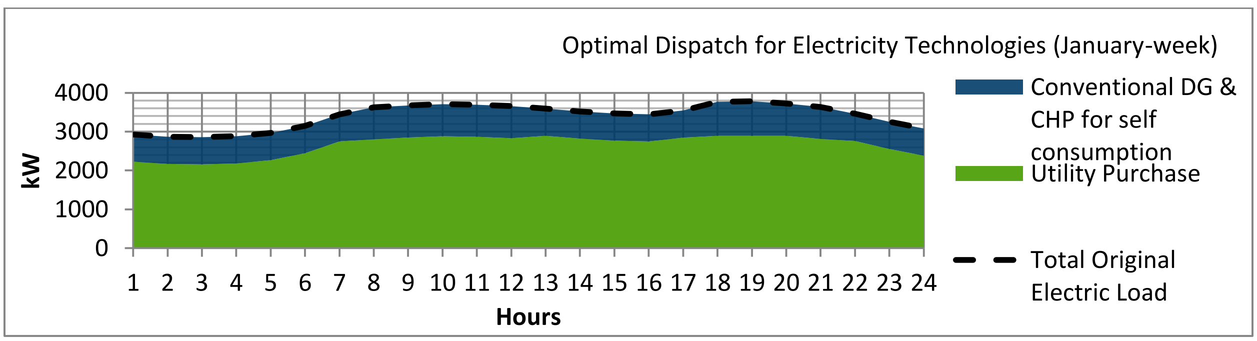


Figure 16. Example Post Investment Average Electricity Dispatch

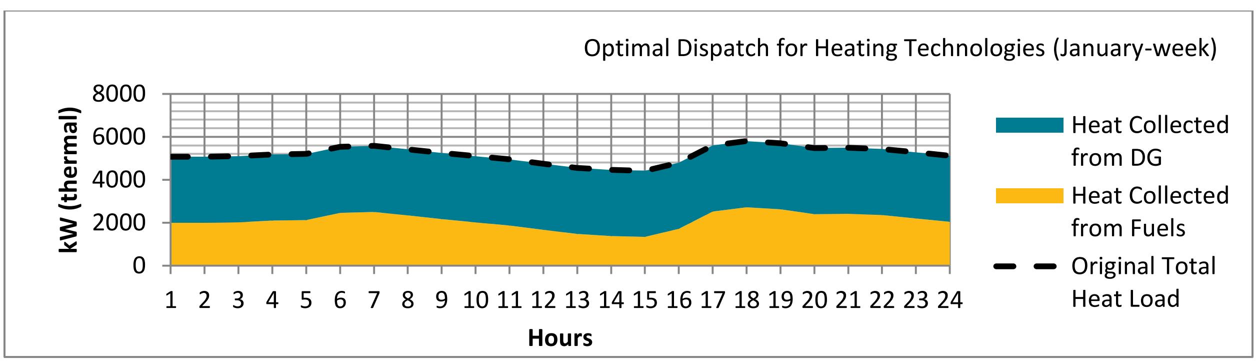


Figure 17. Example Post Investment Average Heating Dispatch

Figures 14 and 15 show DER-CAM simulation results for the critical buildings in the Bath Community Microgrid under normal base conditions with no added generation. It can be seen that there are peaks around 11 am and around 6 pm due to industrial and residential customer's high electricity consumption, respectively. Figures 16 and 17 show the same time period and load being served, but includes the proposed CHP being optimally dispatched throughout the day. It can be seen that the heating load is almost entirely served by heat collected from DG (CHP) and that the electricity curve is flattened throughout the day by the dispatch of the CHP units for electricity for self-consumption.

Sub Task 2.3 Distributed Energy Resources Characterization

Provide the following information regarding Distributed Energy Resources (DER) and thermal generation resources that are a part of the microgrid:

(i) Type (DG, CHP, PV, boiler, solar water heater etc.), (ii) rating (KW/BTU), and,

(iii) Fuel (gas, oil etc.).

Existing Resources

Existing DERs located in the proposed Bath Community Microgrid are used primarily as backup generators in the event that utility power is interrupted. They consist of both Diesel and Natural Gas (NG) Generators, distributed among the critical facilities, and retain about a week of fuel for 2,100 kW of capacity or rely on NG pipelines for slightly less than 1,000 kW of capacity, respectively. Existing DER respective to critical load and substations are shown in figure 7.

Consequences

While the critical loads have an average demand of about 2,500 kW and the DERs total just over 3,000 kW of generation (table 10), indicating that there is enough generation to provide critical loads with power in the event of an emergency, most of the generation, 2,000 kW of Diesel generators, is concentrated on the Jail and 911 facility and the County CRH. This means that a number of vital critical facilities, including the fire department, the ambulance, the middle and high schools, and the offices, would be out of power in the event of an emergency, putting the entire Village of Bath in a dangerous position. In addition, the community pays to maintain and test the backup generators, or runs risk of the generators not working when needed, and doesn't see any value added beyond emergency situations. Finally, it is worth noting that over two thirds of the generation runs off of diesel fuel, which is a relatively dirty fuel source that reduces the quality of the air and increases the carbon footprint of the Village of Bath.

Table 10. Existing Generation and Location

Critical Buildings	Demand (kW)	Existing Generation
Wightman School	632	None
County Offices	549.44	None
Wastewater Plant	176	312 kW - Natural Gas
BEGWS Office	23.14	125 kW - Natural Gas, 110kW - Diesel
Village Office	22.4	None
Ambulance	12	None
High School	159.6	430 kW - Natural Gas
County CRH	432	800 kW - Diesel
Jail and 911	396	1199 kW - Diesel
Fire Department	115.2	100 kW - Natural Gas
Total	**2505.78**	**3076 kW** **967 kW - Natural Gas, 2109 kW - Diesel**

Opportunities

The Village of Bath is exploring an anaerobic digester plant as an alternate fuel source that would take advantage of the sludge waste generated by the WWTP. The methane gas produced would feed a combined cycle plant and generate electricity for self-consumption as well as provide heat to the WWTP in the winter. BEGWS is interested in exploring an expansion of CHP for a number of their critical facilities as well as adding a generation source to their middle and high schools, located across the street from each other. This expansion would allow Bath to participate in Demand Response programs and reduce its dependency on NYPA, its bulk electric power provider.

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

Proposed/Suggested Improvements

A screening of the available DER technology available to the Bath Community Microgrid favors CHP, Batteries as Energy Storage, Anaerobic Digestion as an Alternate Fuel Source, ICE DG as black start generators for CHP, and potentially some Solar. Based on initial analyses, Wind and Hydro potential, along with space required and maintenance/expertise needed, is not adequate to justify the investment and does not merit further consideration.

It can be seen in figure 18 that a 700 kW anaerobic digester is proposed to be installed in the WWTP, as well as a 1,300 kW CHP plant, as there is adequate space available and a number of critical facilities nearby, including the fire department, ambulance, county office, and BEGWS office, that would be served by the proposed generation in the WWTP if the microgrid was islanded. The 700 kW anaerobic digester would be served by the sludge waste from the WWTP, fed in large part by the Kraft food processing plant which produces a steady flow of wastewater.

In addition, the two large schools that are located across the street from each other, including Wightman Middle School and Haverling High school, have a combined average demand of about 800kW, as well as a winter heating demand of 800kW (figure 8). The current generation resource available is a 430kW Natural Gas backup generator, which is not adequate to serve both facilities. As these schools would act as critical emergency shelters in a number of different emergency situations, Willdan proposes that a potential 1,000 kW CHP plant be located here so that it could serve both of these schools heating and electricity needs year round, as well as provide power to these facilities in an emergency.

Based on resiliency and economic requirements, an additional 1,000 kW – 2,000 kW could be installed in already available land near the Jail and 911 and the County CRH. Together, these facilities have an average electric load of 800 kW and an average heating demand of 700 kW (figure 6), which can be served by the proposed CHP. The installation of this generator would be largely redundant as about 2,000 kW (figure 18) of diesel backup generators are installed.

The proposed generation listed above would provide BEGWS with the eligibility to participate in NY State's Demand Response Program and to earn up to $231,000 per year[1] or more in addition to the resilience and economic benefits.

Table 11. Distributed Energy Resources

Type	Description	Barriers	Opportunities
Combined Heat and Power (CHP)	Natural Gas fired turbines used to generate electricity and provide heat to nearby buildings	Space, Capital Cost, Cost of NG, Heating Infrastructure	Clean and Reliable, Reduce winter peak load, Resiliency
Solar	Renewable energy source powered by the sun	$/kW of solar is greater than electricity price	Clean, Reduce daytime peak load
Electric Storage	Converts electrical energy to chemical or mechanical for rapid dispatch when needed	Space, Capital Cost	Fast Regulation, Provides power during NG spool up
ICE Distributed Generation (ICE DG)	Backup generation	Cost, Range of use, Maintenance	Black Start for CHP, Provides power during NG spool up
Wind	Renewable energy source powered by the wind	Space, Capital Cost, maintenance	Clean Source
Hydro	Renewable energy source powered by the flow of water	Location, Cost, maintenance	Clean Source
Alternative Fuel Sources	Production of fuel from local processes (garbage dump, WWTP)	Supply	Converts waste into electricity

[1] http://www.monitoringanalytics.com/reports/PJM_State_of_the_Market/2015/2015q2-som-pjm-sec5.pdf

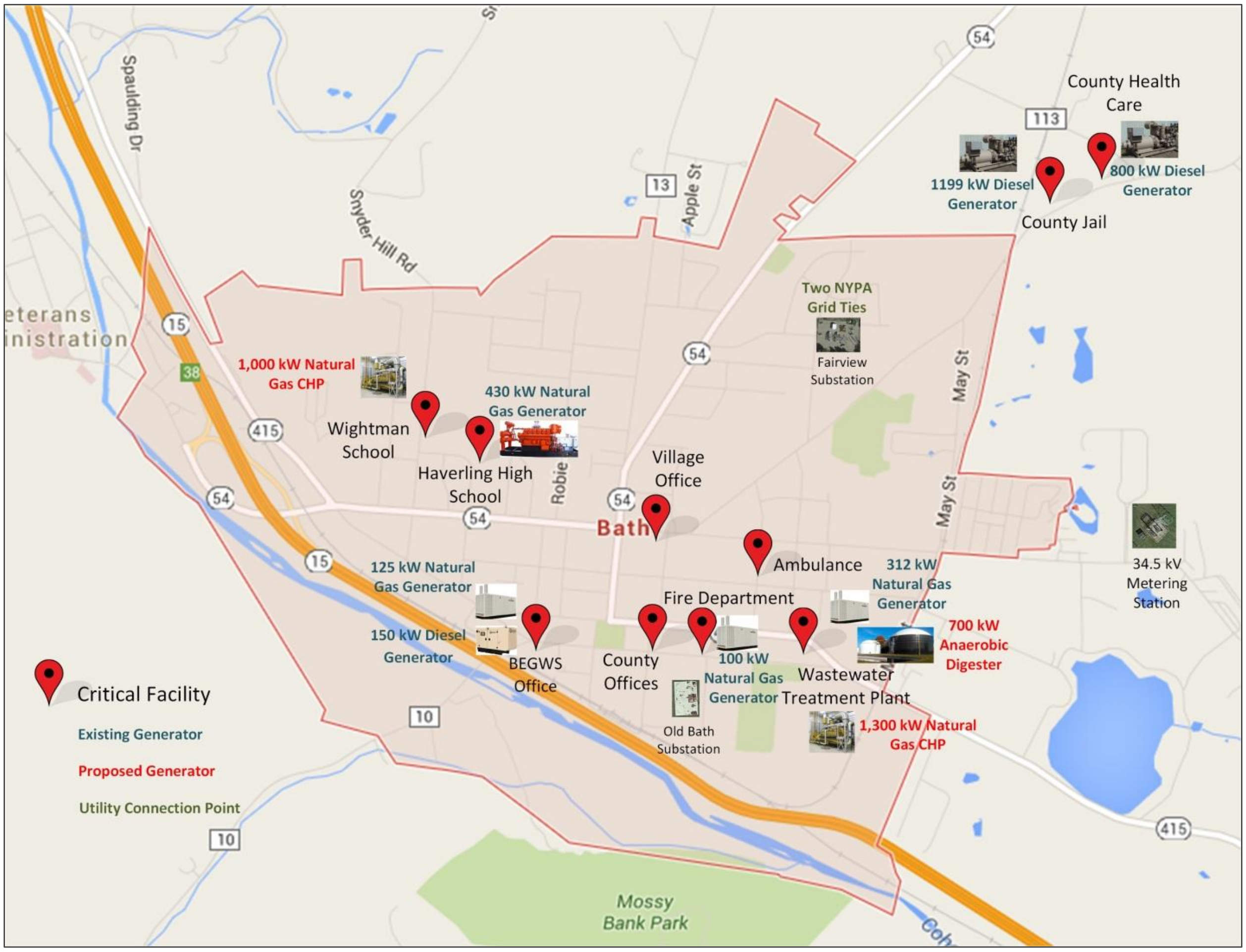


Figure 18. Generation simplified equipment layout diagram

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.)?

Benefits

The addition of a range of DERs, including long term sources like CHP and Anaerobic Digestion, short term sources like Batteries and ICE DG, and renewables like solar would allow the Village of Bath to operate as a microgrid, take advantage of new revenue streams such as Demand Response and Fast Regulation Markets, increase resiliency through on-site generation, and reduce charges associated with high winter heating loads by utilizing generation near residential load pockets. Distribution of these additional resources close to the school system, the Jail and CRH facilities, and the Fire Department and Ambulance will ensure that critical facilities will remain powered on in emergencies, providing the Village of Bath with peace of mind

Barriers

Additional modeling will be performed to determine exact size and capacity of the proposed units, to ensure feasibility from financial and space requirements. Plant managers for CHP will have to be hired internally or externally and training will be required for maintenance and operators of the proposed DERs.

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.

As Natural Gas fed CHP is the most feasible option for the Bath Community Microgrid, the microgrid will rely heavily on Natural gas pipelines to power the facilities. Pipelines are highly resilient to inclement weather, but do have the potential to break down or be damaged. This would have to be monitored closely by BEGWS to prevent any small issues from becoming major problems if there is an interruption in natural gas supply.

Furthermore, based on preliminary sensitivity analysis, the Bath Community Microgrid is highly sensitive to increases in Natural Gas price, with operational costs almost doubling when the price of Natural Gas doubles (figure 19). When Natural Gas markets stabilize, BEGWS may need to consider further diversification of their DERs to include renewables or other forms of generation.

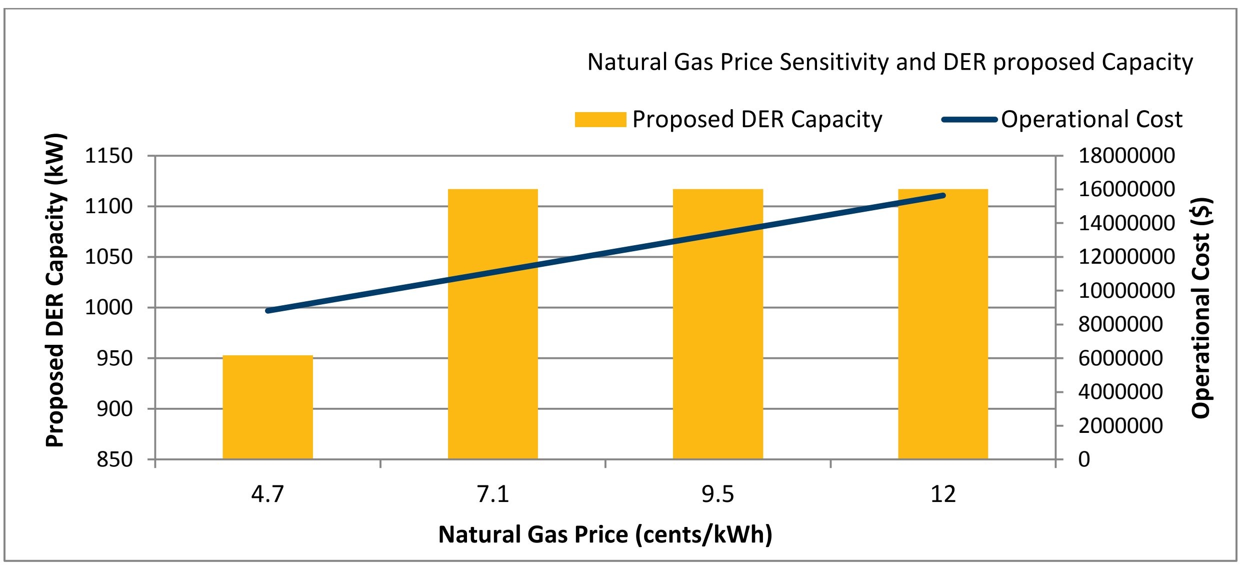


Figure 19. Sensitivity Analysis Results for Natural Gas Price

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.

The Bath Community Microgrid master controller would determine the optimal and reliable operation of microgrid through optimal generation dispatch and load signals. The generation dispatch signals are sent to dispatchable distributed energy resource (DER) units and the load signals are sent to building controllers. An interactive grid-forming control would be used either in island or grid-connected mode. In island mode, DERs apply this control scheme to share the load while in the grid-connected mode; DERs apply this control scheme to regulate the power exchange between the microgrid and the utility grid. In the grid-connected mode, the DER unit with grid-following control follows the microgrid voltage and frequency, which is set by the utility grid in grid-connected mode and other DER units in island mode.

Sub Task 2.4 Electrical and Thermal Infrastructure Characterization

Electrical and Thermal Infrastructure

Most of the Bath's distribution systems are 70+ year old over-head system. Bath Electric Gas and Water Systems (BEGWS) owns and operates the distribution system within the village to serve approximately 4,500 electric customers. BEGWS owns four substations with total capacity over 30 megawatts for distribution through the system. The four substations are Old Bath substation, Fairview substation, Hodgeman Substation, Faucett substation. Currently, only Old Bath substation and Fairview substation are in use, around 70% loads are supplied by Fairview substation and the rest are supplied by Old Bath substation. BEGWS owns the natural gas pipe lines which supply natural gas for around 2,000 customers. 20% of the total gas consumption comes from the top nine customers (Haverling Central School, Steuben Healthcare Center, Steuben County Jail, Steuben County, Wightman School, Tops markets Inc., Steuben city building and Pro action of Steuben & Yates) and the top 20% of customers consume approximately 63% of the total gas usage.

Existing DERs located in Bath Community Microgrid are used primarily as backup generators in case that utility power is interrupted. They consist of both Diesel and Natural Gas (NG) Generators, distributed among the critical facilities, and retain about a week of fuel for 2,100 kW of capacity or rely on NG pipelines for slightly less than 1,000 kW of capacity. Willdan proposed two natural gas fired CHPs along with the BEGWS's planned 700kW anaerobic digester fired CHP. The total proposed capacity would be near 3,000KW which would be enough to supply power for critical loads in winter peak hours. The existing and proposed generation resources are shown in figure 7.

BEGWS is currently working on an upgrade of the existing distribution system, converting its distribution system to 12.5kV. Once the BEGWS system upgrade is completed, there will be only Fairview Substation with six feeders to supply power to all the loads within village of bath. The Village of Bath's distribution system network after the upgrade is shown in figure 20 in which the red pinpoints represent the locations of critical facilities (loads).

Willdan proposes a Loop-based community microgrid for Bath. This new distribution network has a meshed structure which can operate as loop or radial, though it is normally operated as radial (i.e., with no loop) so as to make the protection coordination easier (upstream to downstream) and to make the distribution design easier. Also, the Automatic Transfer Switch (ATS) is proposed to be deployed within the community microgrid, which has the capability of network reconfiguration in case of emergency or outage. The conceptual design of the bath's distribution network for supplying power to the critical loads is shown in figure 21, the square represents the ATS which can operate in three ways to reconfigure the network or isolate the loads.

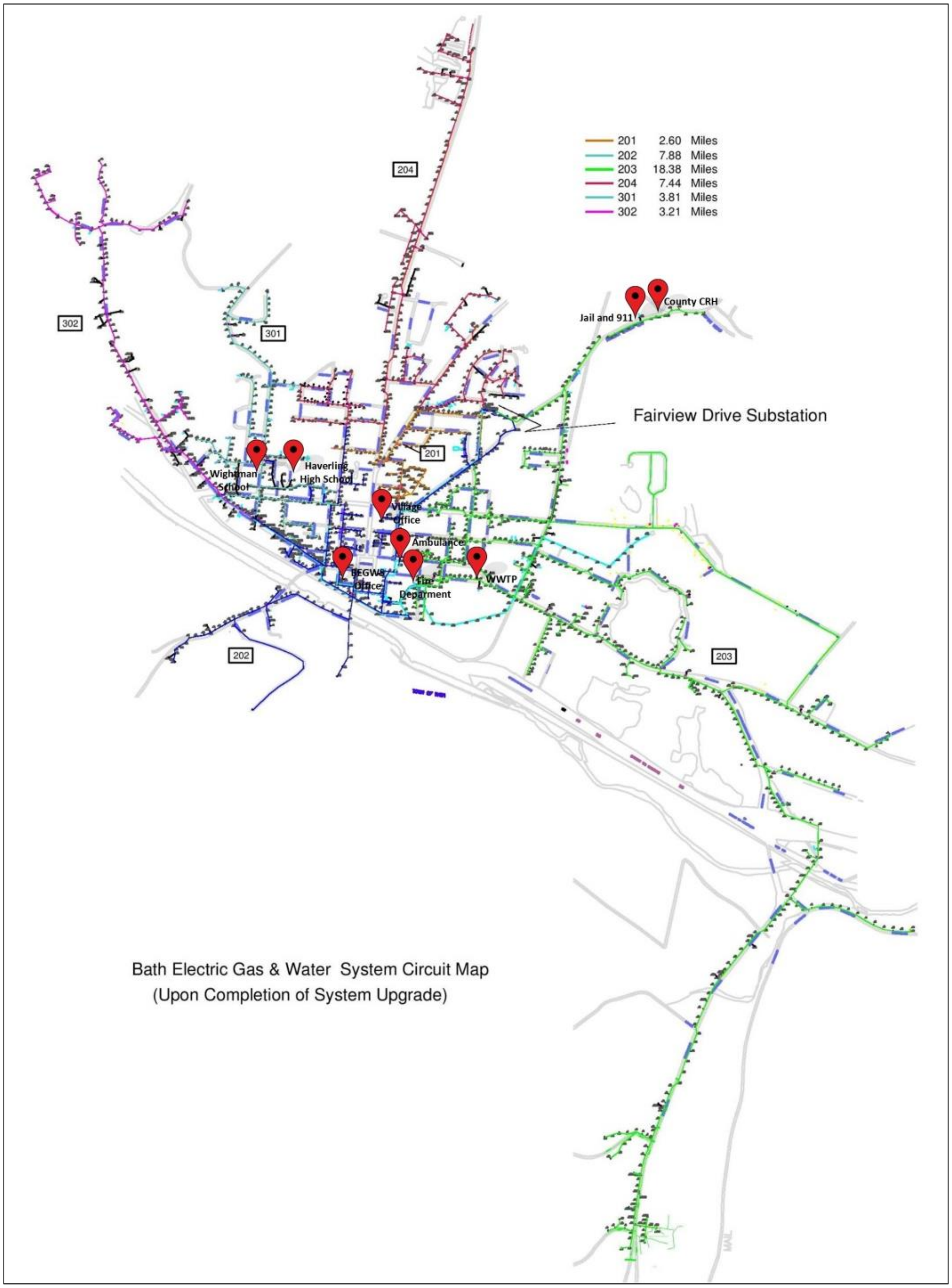


Figure 20. Bath's Distribution System Network after upgrade[1]

[1] BEGWS Circuit Map (Future) Available online: http://documents.dps.ny.gov/public/MatterManagement/CaseMaster.aspx?MatterSeq=24730

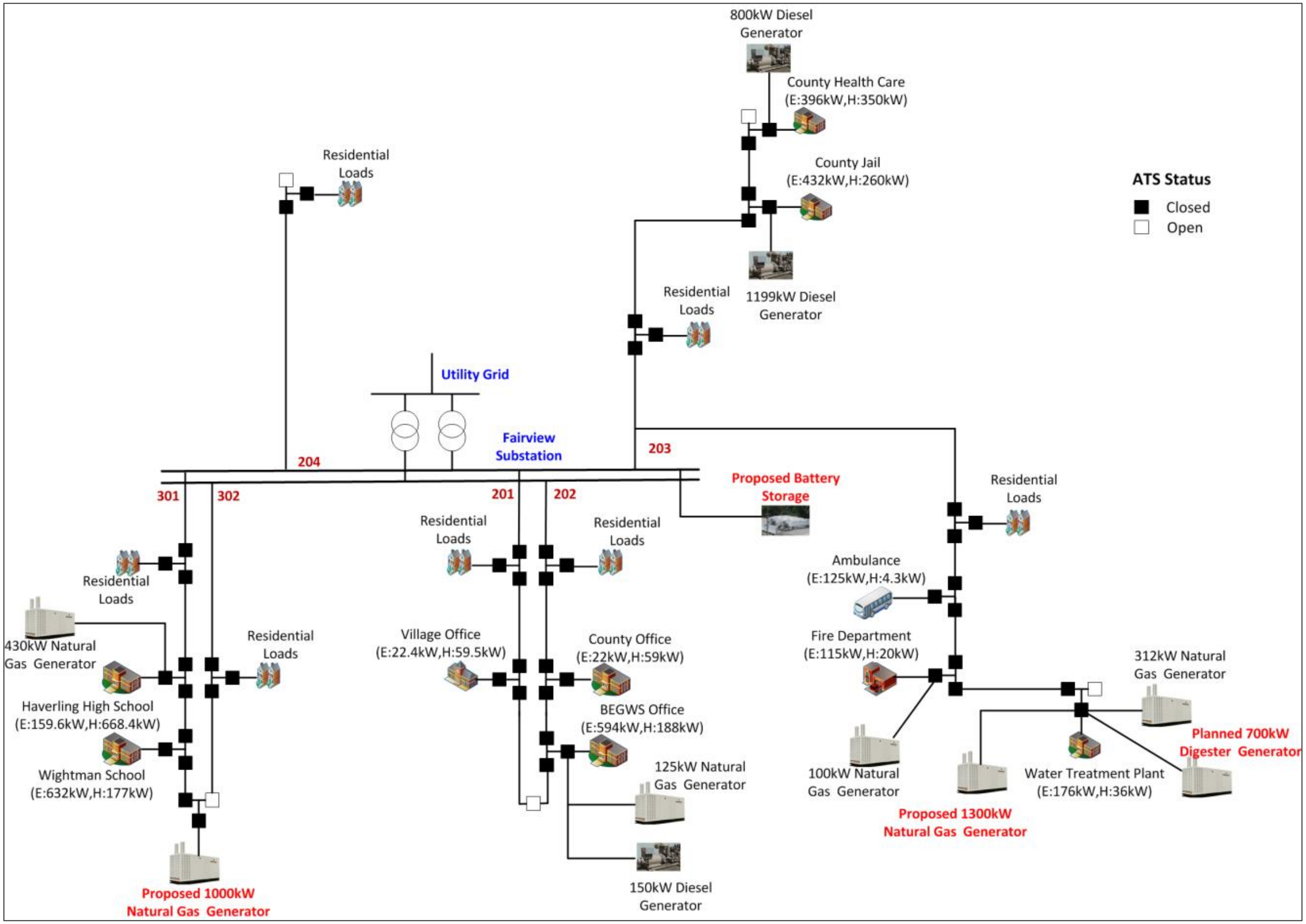


Figure 21. Conceptual Configuration of Bath Community Microgrid

Resilience of the Electrical and Thermal Infrastructure

Resilience refers to the ability of a system or its components to adapt to changing conditions and withstand and rapidly recover from disruptions, i.e., the ability to recover from a disturbance[1]. The electrical and thermal infrastructure is vulnerable to many phenomena, such as, hurricanes, earthquakes, drought, wildfire, flooding, and extreme temperatures, etc. Some extreme weather events have become more frequent and severe in recent years due to the climate change. Snow storms and peak loads due to electric heating appearing in winter season could cause damage or outages to the 70+ year old over-head system in Bath's service territory, also heat waves in summer could affect distribution line conductor sags and any equipment that needs to be cooled off, such as, transformers, battery storage, etc. A wind gust could cause a tower/pole or conductor faults due to trees falling. Considering the threat of hurricanes, it would be necessary to upgrade designs and focus more on emergency planning and restoration. For example, hurricane sandy happened in 2012 which caused the widespread blackout of power system in the eastern seaboard and left millions of homes in the dark from a couple hours to a few weeks. Natural gas disruptions are less likely than electricity disruptions, however, it is relatively more difficult to recover from these outages than electric systems due to the the difficulty to locate and repair the underground breakages. The extreme weather would affect both individual equipment failure and system operations. The damage from such events can impose large costs on the distribution system as well as impact on the local economy.

Many of Bath's substation feeders for residential customers are operating near or at capacity during winter peak load resulting in momentary overload of substation transformers serving residential customers. This situation is further exacerbated when multiple residential circuits fail. The residential winter peak would also causes significant voltage sags in the distribution system.

The Bath community microgrid will explore placing CHP and distributed generation resources near the worst of the residential load pockets to reduce amperage on the substation feeders/transformers. In addition, BEGWS aims to reduce winter peaks supplied by the bulk power supply and broaden participation in demand-response programs. By applying the latest building control technology in each building, BEGWS would be able to have the direct control capability on the curtailable and shift-able loads.

In order to optimize the selection and operation of distributed energy resources, DER-CAM developed by Lawrence Berkeley National Laboratory is applied here for the simulations. The main objective of DER-CAM is to minimize either the annual costs or the CO_2 emissions of providing energy services to the modeled site, including utility electricity and natural gas purchases, plus amortized capital and maintenance costs for any distributed generation (DG) investments. The key inputs into the models are the customer's end-use energy loads, energy tariff structures and fuel prices, and a list of user-preferred equipment investment options, shown in figure 22.

[1] Increasing the Resilience, Reliability, Safety, and Asset Security of TS&D Infrastructure. Available online: http://energy.gov/sites/prod/files/2015/04/f22/QER%20ch2%20final_1.pdf

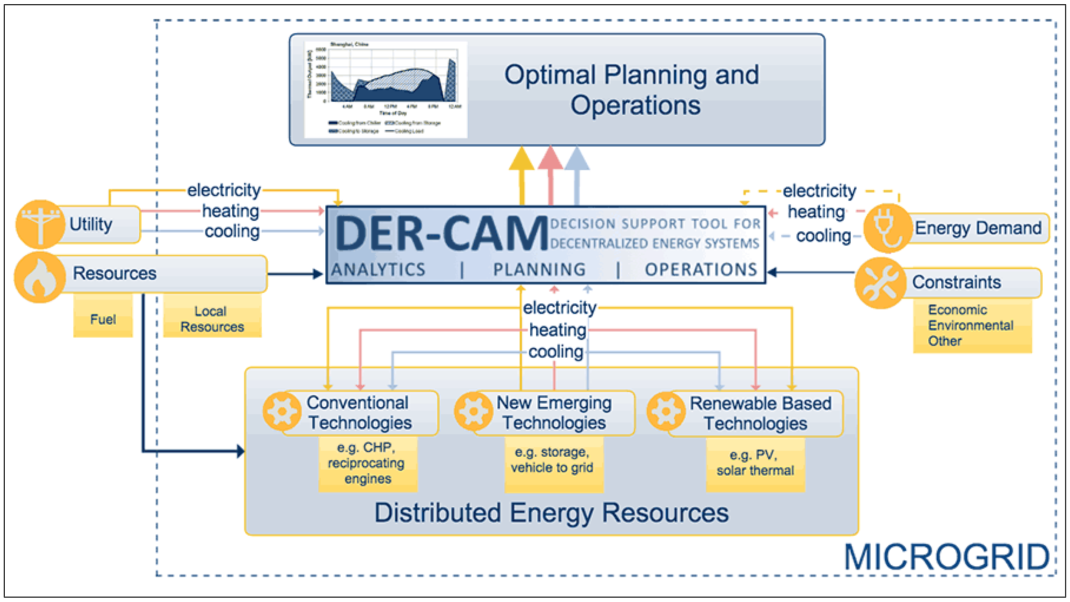


Figure 22. Schematic of information flow in DER-CAM

Two sets of simulation results are selected to be presented here for showing the investment options for addressing the system residence. The first case includes one hour islanding with peak load data from January while trying to keep the whole community's power on. The second case is keeping the critical loads powered on with one week disruption of power supply from utility grid. Table 12 and figures 23-25 present the DER-CAM simulation results for the first scenario (Scenario 1) and table 13 and figures 26-27 demonstrate the simulation results for the second scenario (Scenario 2). In Scenario 1, DER-CAM suggested 2,200kW CHP and 9,433kW battery in order to try to supply power to all the loads. In order to supply power to all the customers, more CHP or battery storage is required (total generation capacity larger or equal than load capacity) resulting in very expensive investment cost, which is not necessarily and economically. In Scenario 2, it's assumed that only critical loads would be satisfied during disruption of utility grid, it can be seen from figure 27 that all the critical loads can be satisfied by the new DERs along with the existing generation resources. The local DERs can also provide power to critical loads during grid-connected mode shown in figure 28 which would improve the energy resilience of the critical facilities.

Table 12. The annual costs savings by the investment for supplying the loads in Bath with islanding in peak load day (January)

	Base Case (no investment)	Investment Case (investment)	Reduction
Total Annual Energy Costs ($)	$ 7,126,035	$ 6,853,018	***$ 273,017***

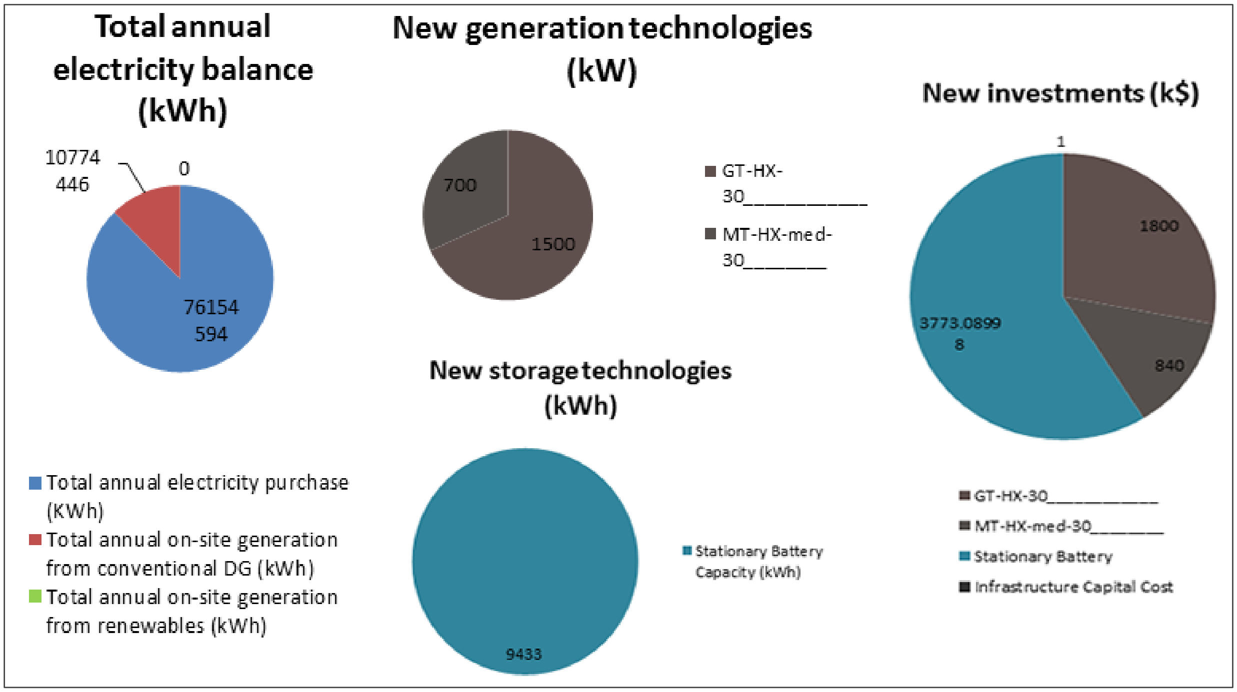


Figure 23. DER-CAM Investment Results – Serving Total Load with Island in Peak Load Hour

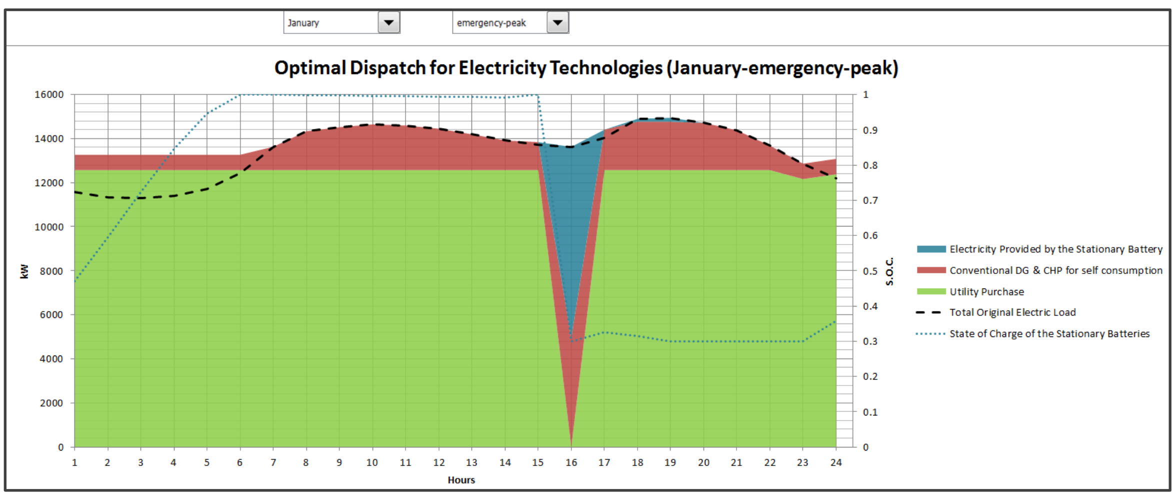


Figure 24. Optimal Dispatch with one hour Islanding

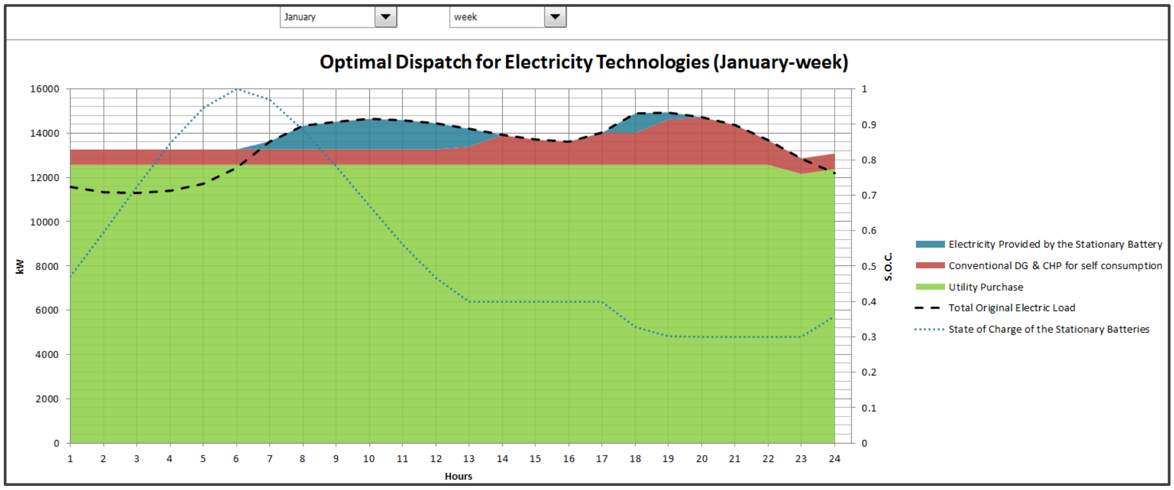


Figure 25. Optimal Dispatch in Grid-Connected Mode

Table 13. The annual costs savings by the investment for supplying power for critical load with one week islanding in peak load season (January)

	Base Case (no investment)	Investment Case (investment)	Reduction
Total Annual Energy Costs ($)	$ 1,635,738	$ 1,472,106	***$ 163,632***

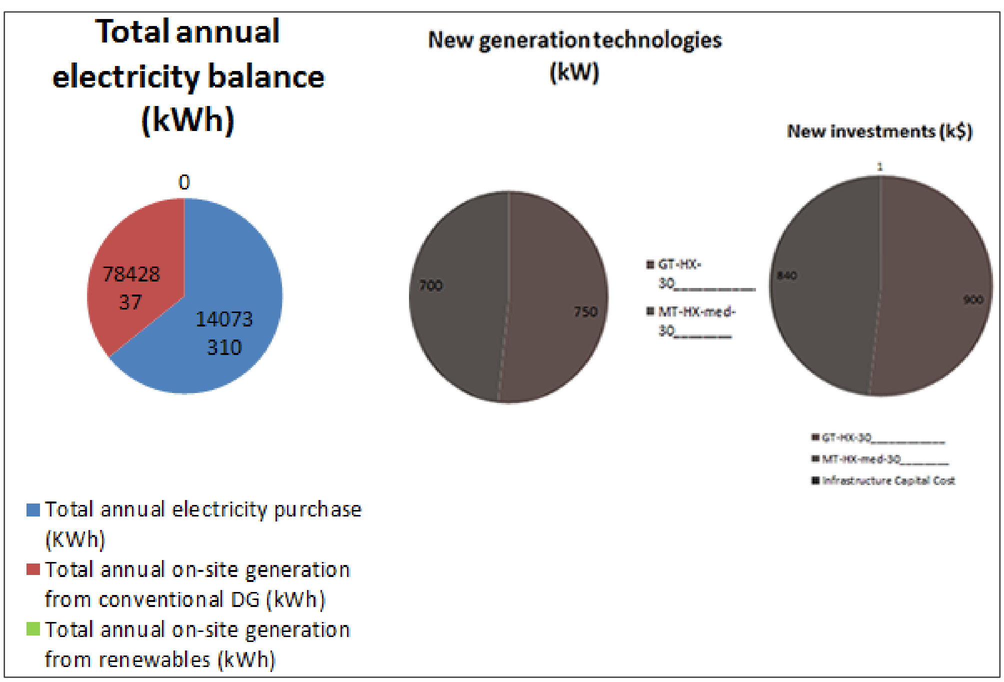


Figure 26. DER-CAM investment results – Serving Critical Load with one week island in January

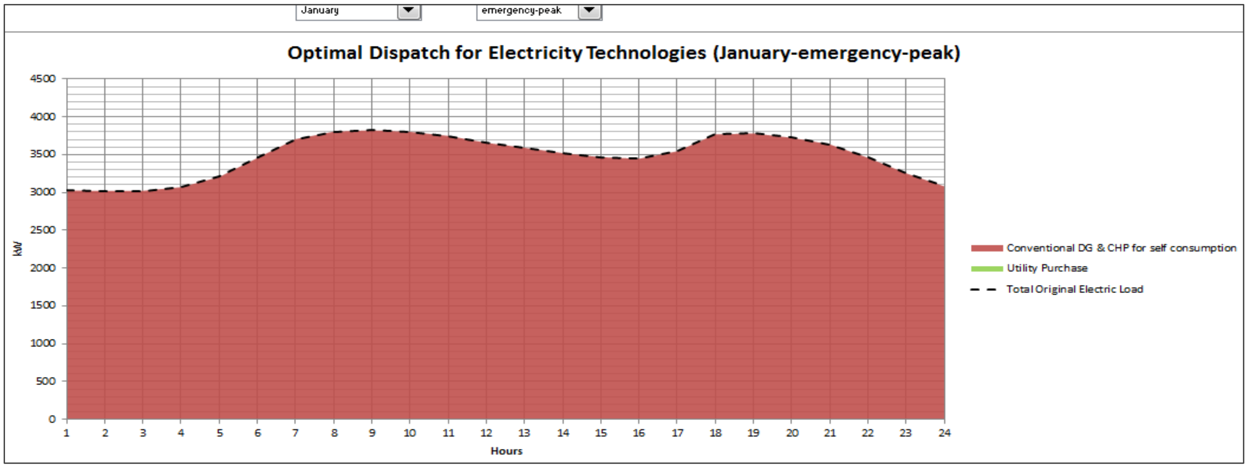


Figure 27. Optimal Dispatch in Islanding Mode

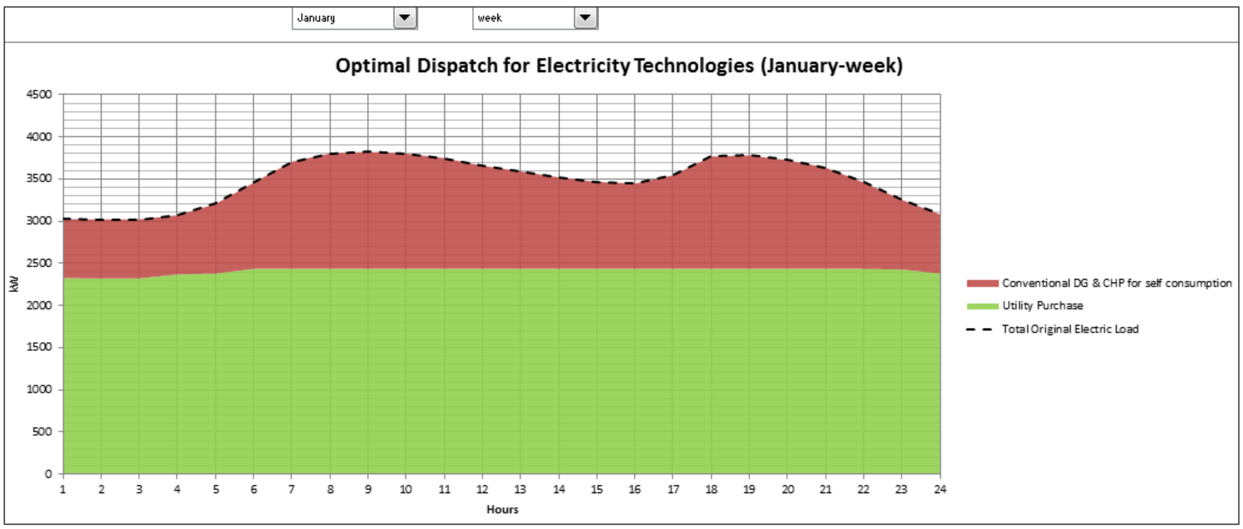


Figure 28. Optimal Dispatch in Grid-Connected Mode

Regarding the critical loads, DER-CAM is applied for the analysis of serving power to critical loads with different islanding time period, from one day to one week, and also different load serving levels are taken into account. The proposed DER capacity and operational cost for serving all the critical loads (100% level) obtained from DER-CAM simulation is shown in figure 29. The proposed new capacity increases from 1,200 kW to 1,450 kW when the island time increases above five days, and the investment cost increases from $1.441 million to $1,741 million. The operational cost would always increase along with the increase of the islanding time period. Figures 30-33 show the simulation results for serving 90%-60% of critical loads, respectively. It can be seen that the less investment would be needed as more load is curtailed, as well as a lower operational costs, which indicate that a higher resilience of critical loads can be achieved through either load management or by adding new generation resources. It was noticed that the operational cost for serving the critical load will always increase along with the island time period in all five scenarios. Resiliency weight is introduced based on the maximum number of days that critical load capacity that is being responded to in the grid outage duration and the maximum level of critical load which can be served. The DER-CAM simulation results are also shown in table 14 based on the order of resiliency weight in which we define that the capability of serving the critical load with no curtailment for seven days (per the customer's requirement) is 100% resiliency and the capability of serving 60% critical load for one day is 10% resiliency.

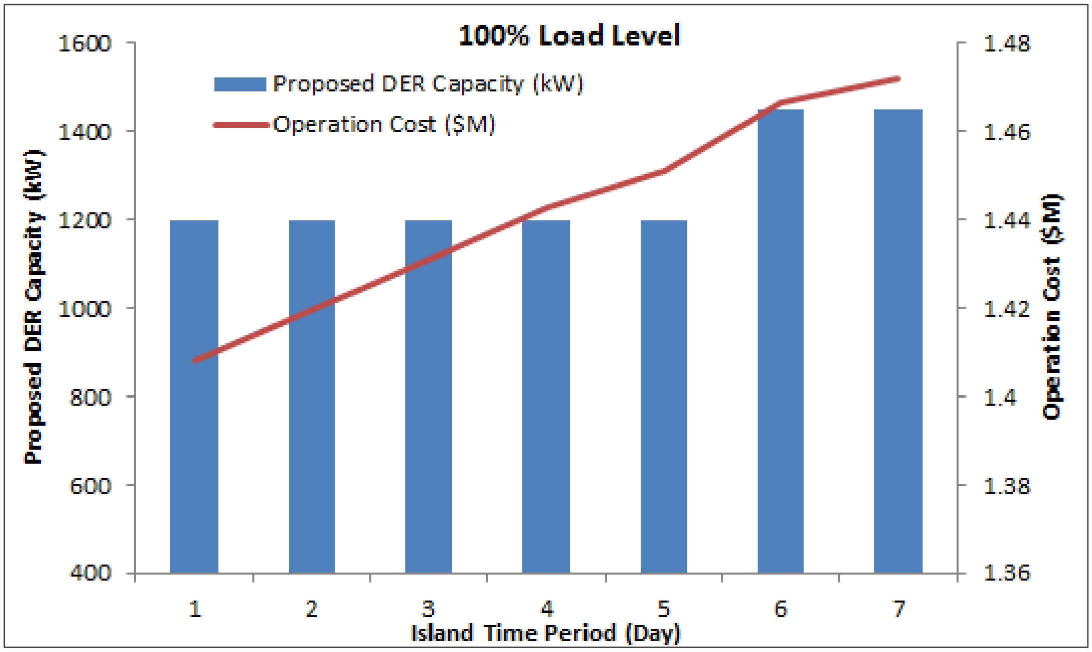


Figure 29. Proposed DER Capacity and Operation Cost for Serving 100% of Critical Loads

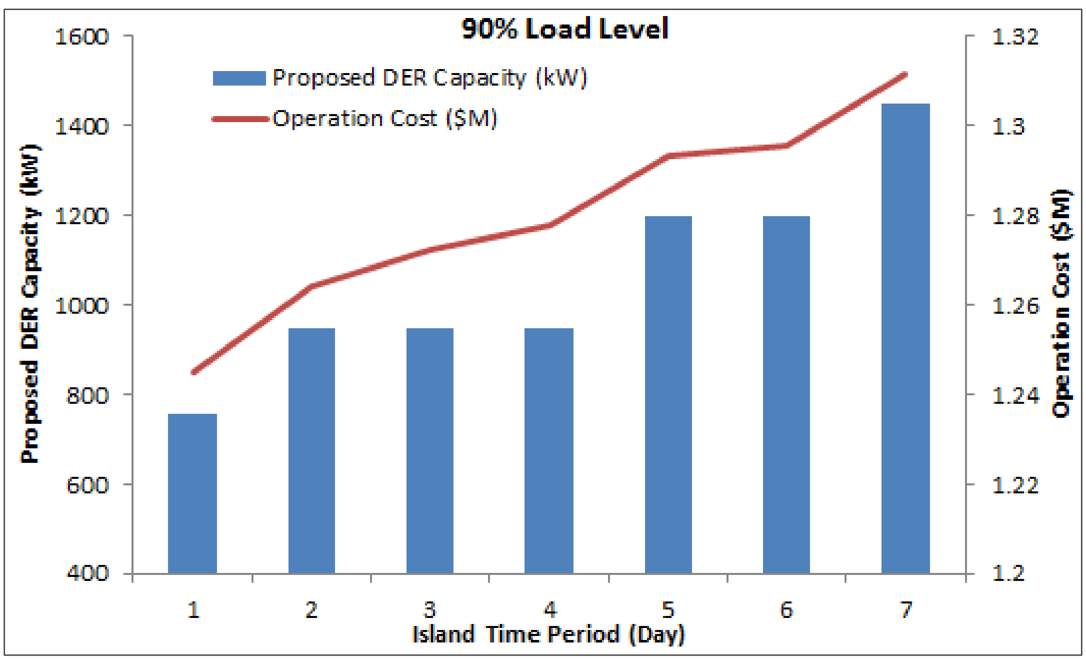


Figure 30. Proposed DER Capacity and Operation Cost for Serving 90% of Critical Loads

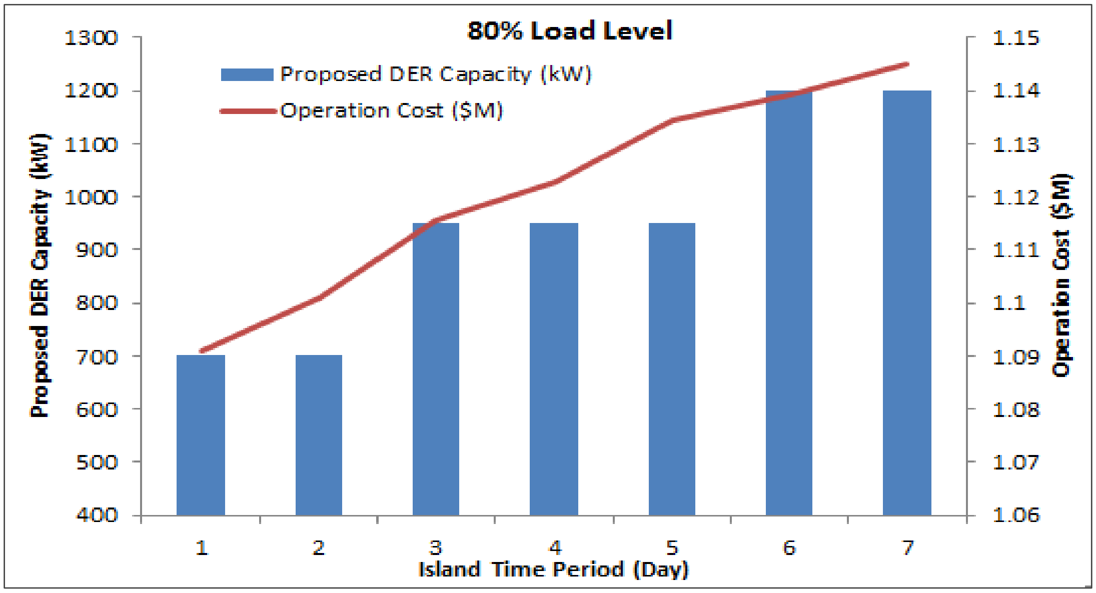


Figure 31. Proposed DER Capacity and Operation Cost for Serving 80% of Critical Loads

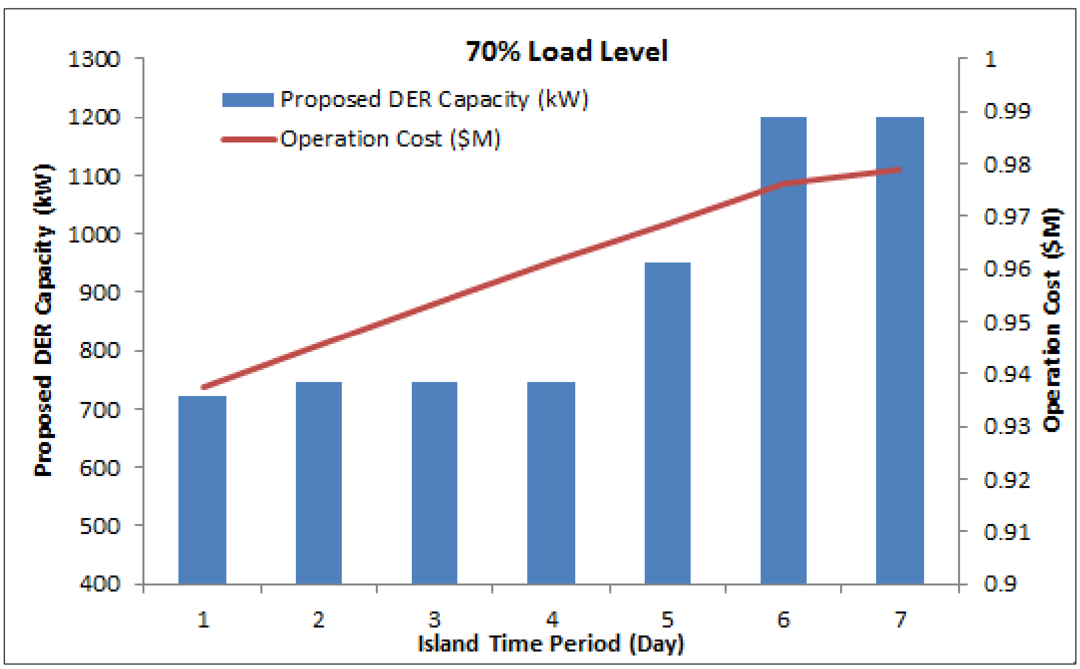


Figure 32. Proposed DER Capacity and Operation Cost for Serving 70% of Critical Loads

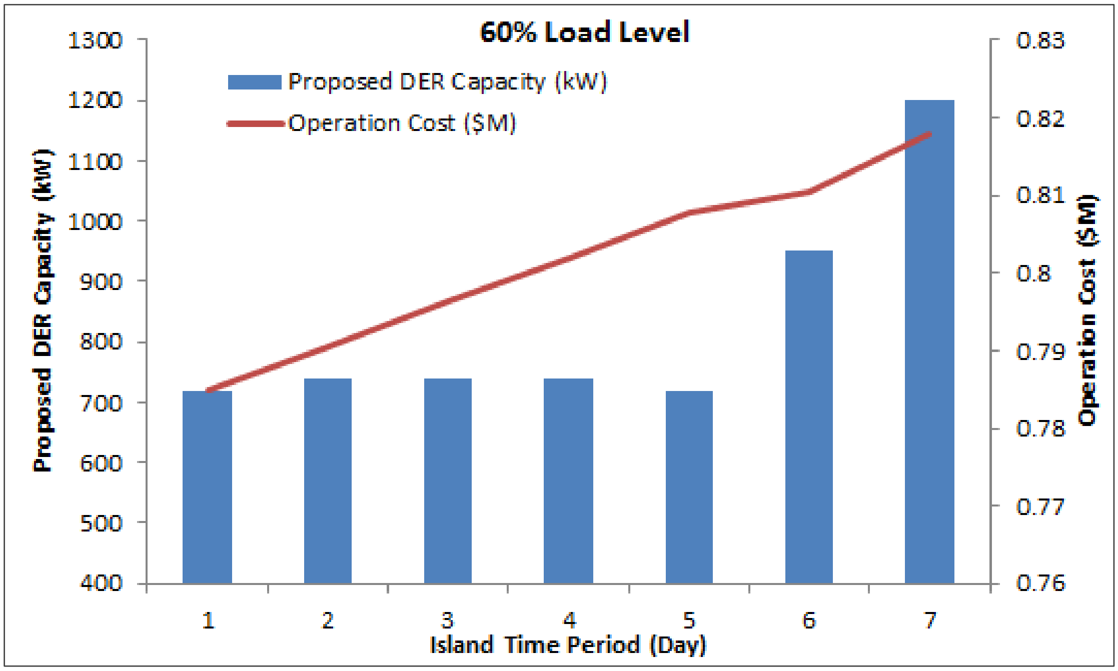


Figure 33. Proposed DER Capacity and Operation Cost for Serving 60% of Critical Loads

Table 14. Serving Critical Loads with Islanding in Peak Load Season (January)

Islanding Days	Load Curtailment (%)	Resilience Weight (%)	Proposed DER Capacity(kW)	Operation Cost ($)	Investment Cost ($)
7	0	100%	1,450	1,472,106	1,741,000
	10%	97.35%	1,450	1,311,312	1,741,000
	20%	94.71%	1,200	1,144,947	1,441,000
	30%	92.06%	1,200	978,859	1,441,000
	40%	89.41%	1,200	817,863	1,441,000
6	0	86.76%	1,450	1,466,329	1,741,000
	10%	84.12%	1,200	1,295,777	1,441,000
	20%	81.47%	1,200	1,139,116	1,441,000
	30%	78.82%	1,200	976,130	1,441,000
	40%	76.18%	950	810,391	1,141,000
5	0	73.53%	1,200	1,451,098	1,441,000
	10%	70.88%	1,200	1,293,186	1,441,000
	20%	68.24%	950	1,134,485	1,141,000
	30%	65.59%	950	968,593	1,141,000
	40%	62.94%	738	807,695	856,346
4	0	60.29%	1,200	1,442,863	1,441,000
	10%	57.65%	950	1,277,599	1,141,000
	20%	55.00%	950	1,122,810	1,141,000
	30%	52.35%	745	961,253	858,904
	40%	49.71%	738	801,952	856,346

Table 14. Serving Critical Loads with Islanding in Peak Load Season (January) - Continued

Islanding Days	Load Curtailment (%)	Resilience Weight (%)	Proposed DER Capacity(kW)	Operation Cost ($)	Investment Cost ($)
3	0	47.06%	1,200	1,431,073	1,441,000
	10%	44.41%	950	1,272,180	1,141,000
	20%	41.76%	950	1,115,533	1,141,000
	30%	39.12%	745	953,340	858,904
	40%	36.47%	738	796,287	856,346
2	0	33.82%	1,200	1,419,542	1,441,000
	10%	31.18%	950	1,264,273	1,141,000
	20%	28.53%	751	1,101,046	861,462
	30%	25.88%	745	945,428	858,904
	40%	23.24%	738	790,622	856,346
1	0	20.59%	1,200	1,408,011	1,441,000
	10%	17.94%	758	1,245,059	864,019
	20%	15.29%	751	1,090,887	861,462
	30%	12.65%	723	937,599	850,019
	40%	10.00%	719	785,028	848,730

Willdan proposes a loop-based network which has the capability of supplying power to critical loads from two feeders in order to improve the energy resilience of critical facilities. In cases of extreme weather events, if one feeder fails, the building can still get power from another feeder. From figure 20 and 21, it can been seen that we can use feeder 302 to supply power for Wightman School and Haverling High School in emergency situations while using feeder 301 for serving power in normal conditions. With the new proposed natural gas generator, these two building can be served power even if both feeders 301 and 302 have failed by opening the switch in downstream and upstream.

For the critical loads located at Feeder 201 and 202, by adding the tie-line and ATS between these two feeders, and by opening and closing all the ATS on these two feeders in an emergency situation, all three of the critical facilities (Village office, county office, and BEGWS Office) can still get power from at least one feeder. In case of failures on both feeder 201 and 202 from substation, the 125kW natural gas generator and 150kW diesel generator are still able to serve the most important portion of loads within these three buildings such as emergency lighting, security devices, server rooms, etc.

It was seen in figure 20 that Feeder 203 is more physically scattered. It would be a large benefit to the community if tie-lines and ATS can be applied to connect the Feeder 203 and 202 at the center of the village of Bath (close to Fire Department and County office).In addition, the distance is suitable for the tie-line based on the map shown in figure 20. As a result, for the loads located at Feeder 201 and Feeder 202, it is possible to utilize the abundant generation resource located at the waste water treatment plant. The ambulance, fire department, and water treatment plant have plenty of generation resources with the proposed 700kW digester generator and 1,300kW CHP generator, and they can still be powered on even if feeder 203 from the substation fails.

The county jail and county health care facility are relatively far away from other feeders or generation resources and it may be not economical to build a tie-line with ATS to connect to another feeder in order to get power from two feeders. This is especially true when one considers that the two facilities have their own backup generation whose capacity (Total 2,000kW) is enough to cover the peak load (total 828kW). In the case of a lost connection to the substation, these two backup generators could be coordinated to complement each other to supply the loads, achieving a higher resilience as a result[1]. In order to have un-interruptible power supply, an energy storage system would be necessary and have strong benefits.

Connecting the Bath Community Microgrid with Grid and Microgrid Protection

Currently, only the Old Bath substation and Fairview substation are in use. Once the BEGWS system upgrade is completed, there will be only the Fairview Substation with six feeders to supply power to all the loads within the village of bath. Thus, the Fairview substation would be the point of common coupling (PCC) where the Bath community microgrid could be isolated from the utility grid in order to operate in island mode in case of emergency, and resynchronize with the utility grid in order to operate in grid-connected mode.

A hierarchical protection configuration strategy is proposed to for the Bath community microgrid protection which mainly contains four-level protection: load way, loop way, loop feeder way and microgrid level. Each level is equipped with protection devices, and the four levels are coordinated. The protection devices and operational rules in each level are summarized in table 15. The load-shedding and other control schemes could also be implemented on the load-way protection level based on under/over voltage and under/over frequency functions of these relays. The hierarchical strategy aims at addressing the challenges in isolating various faults in time from loop based microgrids. The performance of microgrid protection is as summarized as follow.

- Detect and isolate faults both inside and outside of microgrids
- Detect and isolate faults inside the microgrid in both grid-connected and islanded mode
- Detect and immediately isolate faults of the loads and DGs
- Prime protection and backup protection for protective device malfunction
- Compromise between selectivity and speed.

[1] http://www.sdge.com/newsroom/press-releases/2015-06-01/microgrid-powers-borrego-springs-avoid-major-outage

Table 15. The Protection Devices and Operation Rules at Each Protection Level[1]

Protection Level	Protection Devices and Operation Rules in Grid-Connected and Island Modes
Load-way protection	Directional Overcurrent (DOC) digital relay with adaptive relay setting (responding to lower fault current in island mode): —Operates only in load-way faults (DOC and auto reclosing).
Loop protection	DOC digital relay with adaptive relay setting: —Operates in loop faults [primary and backup permissive overreach transfer trip (POTT) Schemes —Backup protection for load-way protection.
Loop-feeder protection	Non-direction Overcurrent (OC) relay: —Operates to isolate the faulted loop only when the load-way and loop protections have failed within the loop.
Microgrid-level protection	OC relay and PCC switch: In grid-connected mode: —Unintentional islanding operation due to external fault or disturbance based on the signal from the MC —OC relay (backup protection for the entire microgrid) —Intentional islanding operation based on the islanding command from the MC. In island mode: —Resynchronization initiated by a command from the MC.

Sub Task 2.5 Microgrid and Building Controls Characterization

Bath Community Microgrid Control Architecture

Figure 34 shows the community microgrid elements, functions, and control tasks associated with each criterion. In order to achieve the optimal economics, microgrids apply coordination with the utility grid and economic demand response in island mode. The short-term reliability at load points would consider microgrid islanding and resynchronization and apply emergency demand response and self-healing in the case of outages. Functionally, three control levels are applied to the Bath community microgrid:

- Primary control which is based on droop control for sharing the microgrid load among DER units.
- Secondary control which performs corrective action to mitigate steady-state errors introduced by droop control and procures the optimal dispatch of DER units in the microgrid.
- Tertiary control which manages the power flow between the microgrid and the utility grid for optimizing the grid-coordinated operation scheme.

[1] Adaptive Protection System for Microgrids: Protection practices of a functional microgrid system. http://ieeexplore.ieee.org/xpl/articleDetails.jsp?arnumber=6774516

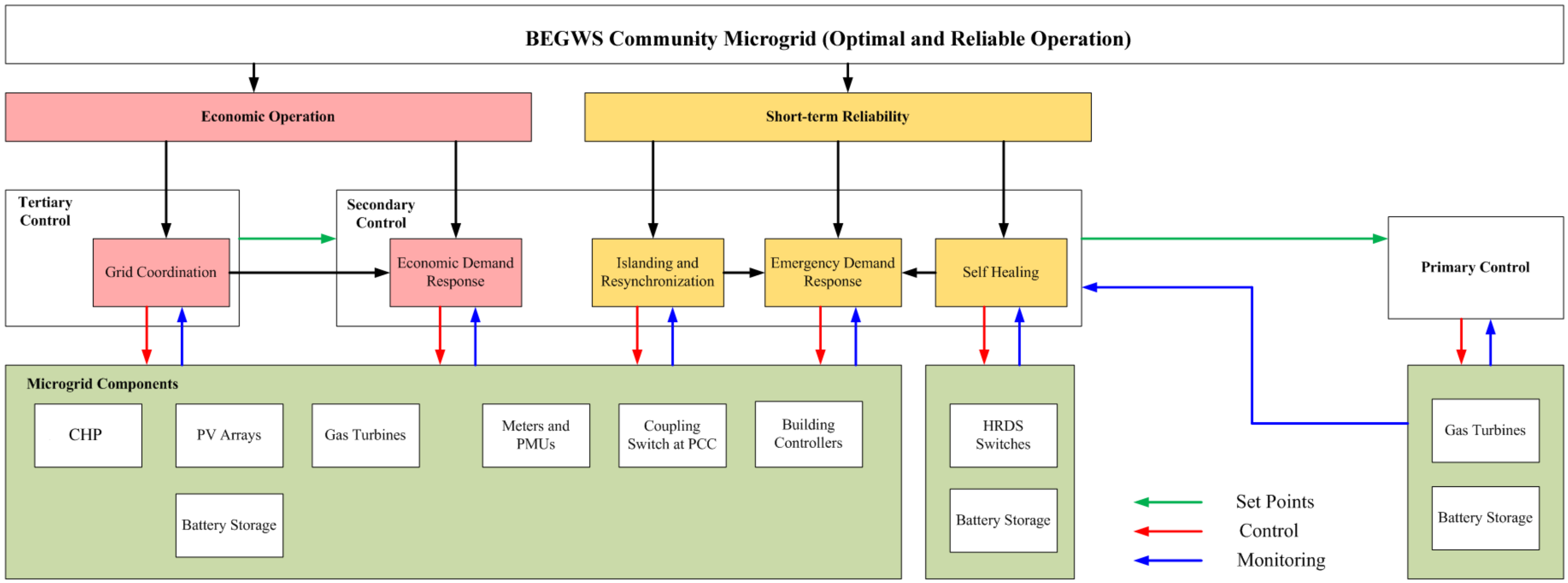


Figure 34. Objectives and functions for the control and operation of the Bath Community Microgrid

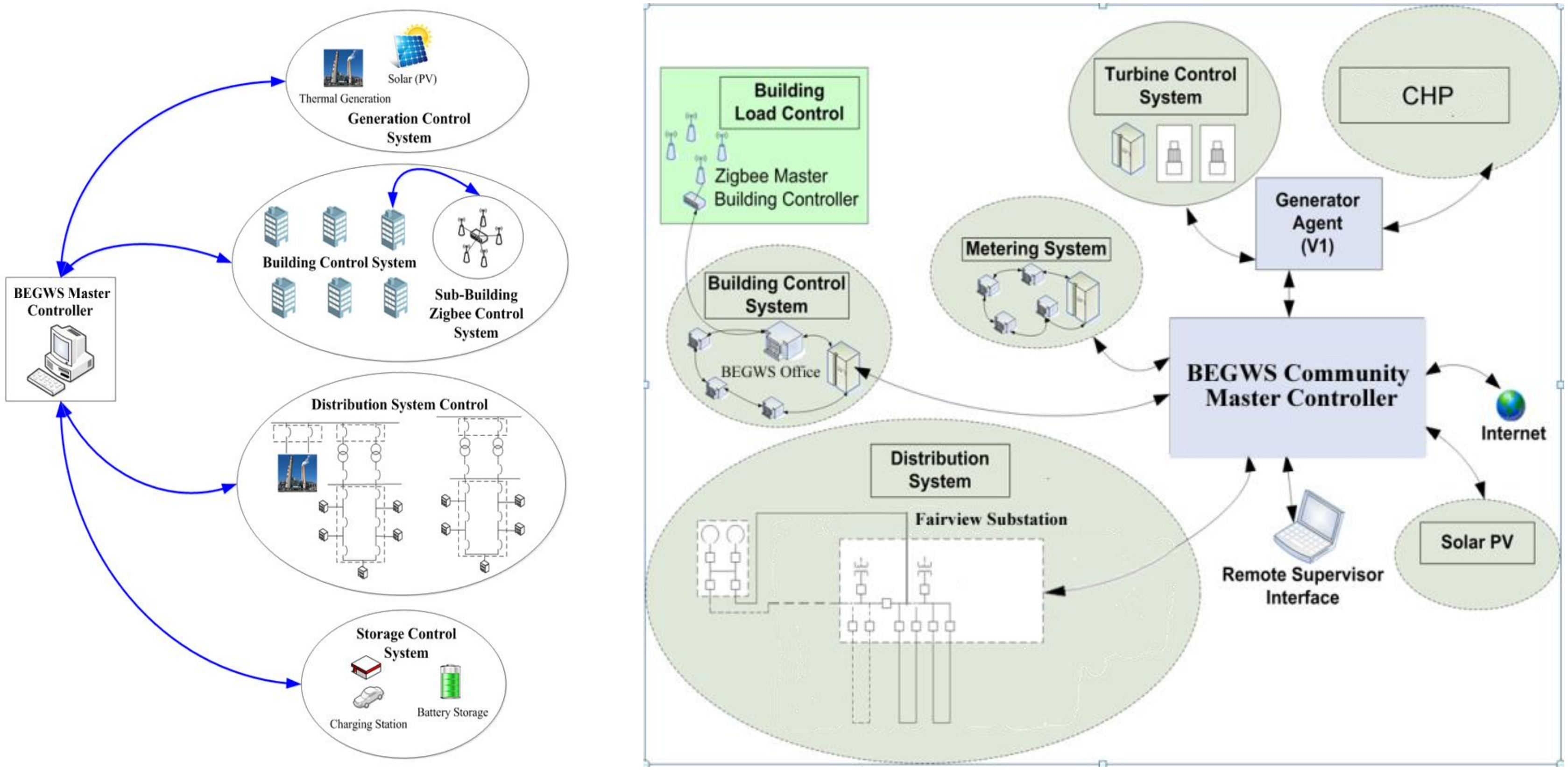


Figure 35. Architecture of master controller for Bath community microgrid

A major element of the Bath community microgrid is its master controller. The master controller applies hierarchical control via supervisory control and data acquisition (SCADA) software to ensure reliable and economic operation of the Bath community microgrid. It also coordinates the operation of on-site generation, storage, and individual building controllers. Intelligent switching and advanced coordination technologies of master controller through communication systems facilitates rapid fault assessments and isolations.

The hierarchical secondary control approach would receive the information from loads and power supply entities as well as the information on the status of the distribution network and procure the optimal solution via an hourly unit commitment and real-time economic dispatch for serving the load in the normal operation mode and contingencies. Figure 35 shows the hierarchical framework of the Master Controller proposed for Bath's community microgrid project. In figure 35, the monitoring signals provided to the master controller indicate the status of DER and distribution components, while the master controller signals provide set points for DER units and building controllers. Building controllers will communicate with sub-building controllers and monitoring systems to achieve a device level rapid load management.

The master controller would be deployed in BEGWS office. The master controller would collect the real-time data and send out set-point information through the SCADA system. Most of the time, the master controller would operate in autonomy mode based on predefined rules while keeping the reliability and economics of the whole community microgrid. In case of an emergency, the operator would utilize the master controller to isolate the community from the utility grid and operate in island mode, or this could be done automatically through settings in the master controller. Within the community microgrid, the non-critical load could be curtailed or disconnected through smart meters or ATS, local distribution networks are reconfigured so the local DERs can supply power to the critical loads.

Services and Benefits of Bath Community Microgrid

The Bath community microgrid would be operated locally in grid-connected and island modes and can provide black start operation, frequency and voltage support, and active and reactive power control. The proximity of power generation to microgrid components could result in improved power quality, lower power losses, better voltage stability, and higher reliability (fewer customer outages) by engaging fewer components, and eliminating additional transmission services. With the added DERs, ATS and other smart devices, the proposed community microgrid could significantly improve the reliability indices which include the system average interruption frequency index (SAIFI), system average interruption duration index (SAIDI), customer average interruption duration index (CAIDI), customer average interruption frequency index (CAIFI), expected energy not supplied (EENS), and loss of load expectation (LOLE). The main services and benefits which Bath community microgrid could provide are summarized as follows.

1. *Increase safety and resiliency*

   The Bath community microgrid will be able to automatically island the electric system, energize critical facilities, and allow a portion of the system to be energized in the event of a bulk system outage. A CHP-driven microgrid will also introduce additional redundancy into the existing Bath thermal system, allowing the main boilers to be shut down in the summer for regular maintenance, which will improve the safety of the overall system.

   The Reliability would be improved in normal operating conditions through infrastructure reconfiguration, such as a High Reliability Distribution System (HRDS) which senses and clears faults with virtually no impact on building loads. Improvements would be seen as a self-healing and more fault tolerant grid, by reducing the number of single points of failure, by adding redundancy to the electrical and communications networks, and by adding alternate sources of generation to serve critical and non-critical loads.

   During emergency operating conditions, the Bath Community Microgrid would be able to provide uninterrupted power to critical loads, through the use of DERs and load shedding schemes that ensure safe and reliable operation of the buildings that matter most in emergency situations. Long term outages will be mitigated by large natural gas fed combined heat and power (CHP) plants, which will maintain a black-start capability in the event the outage occurs when the CHP facility is not active. These plant or plants will rely on robust natural gas pipelines and produce enough power to serve all of the critical facilities, public street and security lighting, and some residential load. This added resiliency will keep emergency responders and residents safe and provide the Bath Community Microgrid with heat and power when it needs it most.

2. *Reduce energy cost uncertainties and exposure to market fluctuations*

   Additional heat generation electricity from a centrally located CHP plant would allow Bath to meet its summer/winter heat load without the expense of operating its main boiler or electricity purchase, resulting in a savings of over $1.7 million per year on the purchase of electricity from the electricity market. These savings would then be passed along to Bath's customers and members in the form of lower energy bills and membership costs.

   By using the more efficient and safe LEDs for public street lighting and residential lighting as well as smart home appliances in with the proposed community microgrid, would not only enable the capability of load shedding and load shifting, but also help both the community and residential customers to reduce maintenance costs and electricity bills.

   The Bath Community Microgrid would reap economic benefits in the form of added revenue streams from demand response, alternate generation sources, and energy efficiency measures to reduce overall energy costs, as well as participating in ancillary service markets such as fast regulation and operating reserve markets. Based on the price of electricity and availability of Distributed Energy Resources (DERs), the master controller will optimally dispatch the units to provide the cheapest, cleanest, and most reliable energy possible to the critical and non-critical microgrid facilities.

3. *Integrate distributed energy resources (DER) into system operations*

   Bath will analyze replacing some or all of the non-CHP backup generators with black-start capable interconnected natural gas fired CHP generators strategically distributed at the critical facilities, on vacant or unused land. The heat output from the CHP would be utilized year round, capitalizing on Bath's existing piping and distribution infrastructure to serve thermal loads.

4. *Resolve existing system constraints*

   The proposed community microgrid would be able to address and mitigate the existing system constraints facing the Bath's current distribution system. Due to the peak demand occurring during the winter season, Bath's substation feeders for residential customers are operating near or at capacity resulting in momentary overloading of substation transformers serving residential customers. This situation is further exacerbated when multiple residential circuits fail. The residential winter peak can also cause significant voltage sags in the distribution system. The system is entirely reliant on the NYSEG point of connection, which represents the primary resiliency issue, and has previously resulted in severe outages in the system. BEGWS incurs additional cost liability when the Bath community exceeds its NYPA kW and kWh allocation. With the electricity and heat produced by local CHP, the power imported from the grid could be reduced, which is helpful in mitigating the demand and dependency on the grid, and will also result in reliability, resilience, and economic benefits.

5. *Capitalize on new value streams*

   The community microgrid would enable Bath to have the capability of participating in the load curtailment, demand management, and demand response with the newly available resources.

6. *Job creation*

   The operational requirement of a new CHP plant andmicrogrid system in the Village of Bath is expected to require the creation of new professional-level jobs. Current evaluations estimate that 8 new jobs may be required to operate the CHP and microgrid systems proposed in this report.

Sub Task 2.6 Information Technology (IT)/Telecommunications Infrastructure Characterization

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.

IT/Communication Infrastructure

Any modern utility or system operator relies heavily on their communication infrastructure to monitor and control their grid assets. For a microgrid master controller and microgrid operators, this architecture enables real time control, rapid digestion of critical grid information, and historical data for analysis and reporting. As part of a feasible microgrid, assessment and upgrade of the equipment and protocols used in the microgrid area will be performed.

Existing Resources

BEGWS owns and operates two substations and over 30 miles of distribution lines, serving over 4,500 electric customers. A large majority of those customers are individually metered; however, these meters are read manually every month by a meter reader. At this stage, BEGWS has submitted limited information on their communications and control architecture. They are able to obtain system level load information, but not feeder level or three phase data from their distribution system or their substations. Currently, advanced metering infrastructure pilots are underway at 60 meters throughout the village. Soon, a decision will be made on which product will be used in a full system retrofit of all meters in the Bath system. The project is expected to be completed over 2 years, costing $4.5 million with a 4.7 year payback time.

Consequences

A limited communications architecture can lead to increased frequency and duration of outages if problems must occur and be reported rather than having symptoms trigger notifications to grid operators of location and scope of the issue. Limited information and delay in this information leads to man hours wasted and longer duration of customers without power, putting strain on residential customers and potentially costing commercial customers significant amounts of money. Systems could have telltale signs of issues for weeks, but operators may not discover these until they have caused damage and outages to the electric grid or substations, costing the utility money and potentially endangering employees and customers.

Opportunities

BEGWS is considering an Advanced Metering Infrastructure (AMI) expansion, which would involve adding wireless communication infrastructure throughout the Village of Bath to allow for automatic and digital meter reads. The key advantage of this expansion would be the network addition, which often utilizes the 900 MHz ISM band and relies on communication between integrated Network Interface

Cards (NICs) that form a mesh network, allowing signals to hop between any installed meters to reach their ultimate destination and increases the propagation range of the signal in proportion to the number and dispersion of integrated NIC Smart Meters. The integrated NICs are connected to a local Access Point (AP) that transmits the metering and control signals for the streetlights over a cellular wireless network back to the utility data center, where it can be fed into a Supervisory Control and Data Acquisition (SCADA) platform for use in billing or monitoring the overall grid.

Proposed/Suggested Improvements

The Bath Community Microgrid would be connected efficiently and productively, through the use of modern communication architectures and equipment, enabling a master controller to optimize the microgrid control and giving operators the tools they need to perform their daily duties. This network would leverage the AMI network and seek to strengthen it through the use of connected LED streetlights, which require half the power of the existing High Pressure Sodium (HPS) fixtures and shorten the overall payback of a street lighting upgrade through the implementation of smart photocells or integrated NICs that individually meter and control each streetlight, seen in figure 36.

In addition to meters and streetlights, circuit breakers, relays, reclosers and other switchgear are vital to the control of the Bath Community Microgrid. While some distributed switchgear can utilize a similar wireless infrastructure, with data being fed through substations instead of through a cloud network, the control equipment is more vital to the safe operation of the microgrid and would ideally use a fiber optic backbone between the BEGWS data center and the Fairview substation. The substation relays may have to be upgraded to communicate using the DNP3 protocol over TCP/IP, the de facto standard for modern utility communications, which will be used to monitor and control the proposed DER as well.

Once in the data center, the data will be fed into an upgraded or added SCADA system to allow operators to access, visualize, and control, all of the microgrid assets.

Benefits

Utilizing a fully connected microgrid, with every vital piece of equipment monitored and controlled remotely, the master controller will be able to optimize load and generation automatically and in real time, the microgrid operators will be able to view the status, create reports, and plan future developments, and maintenance will be able to quickly assess and address any issues.

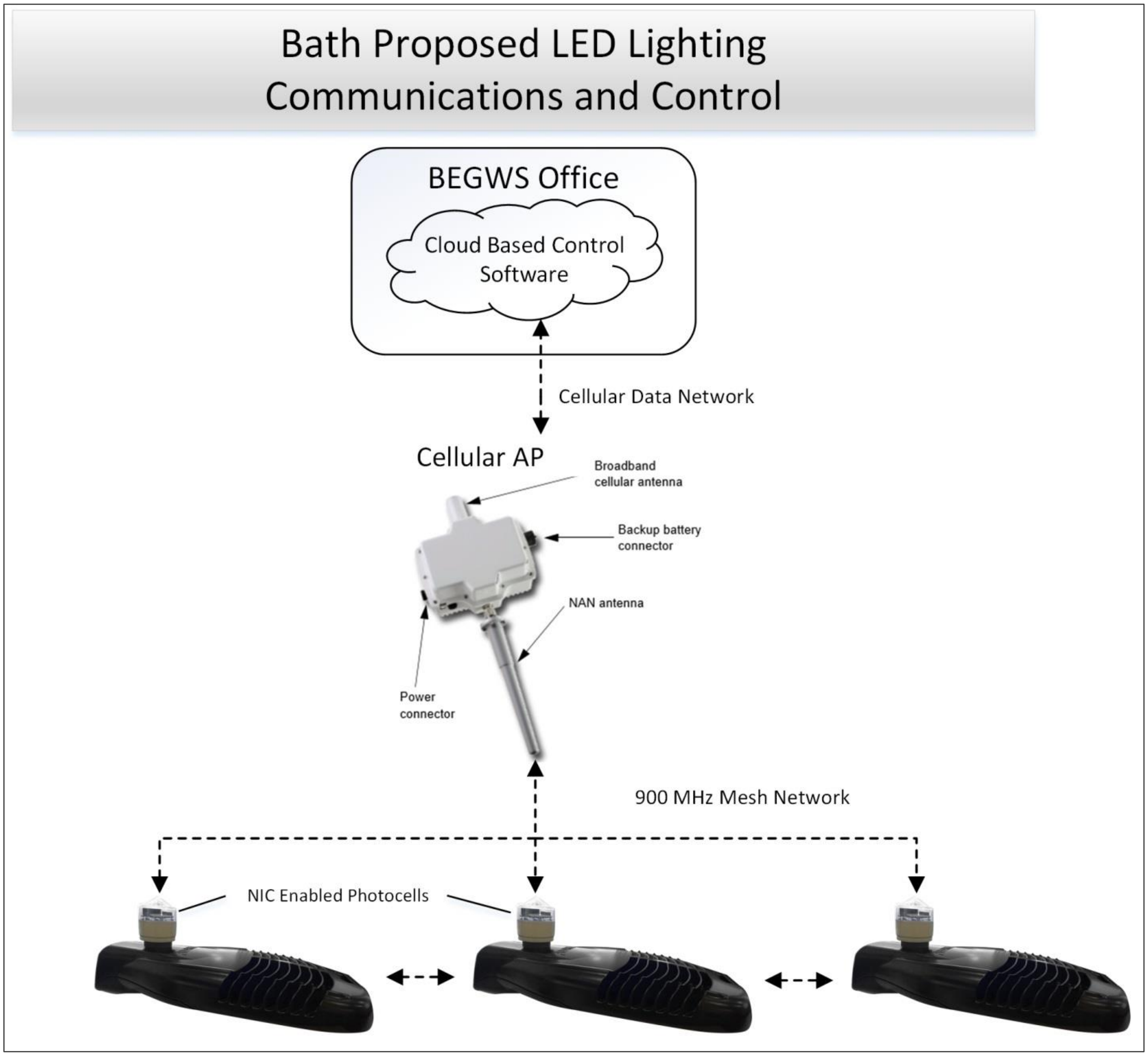


Figure 36. Bath Proposed LED Lighting Communications and Control Diagram

Barriers

A more extensive review of existing communications and control equipment needs to be performed to determine the exact quantity and specification of the upgrade; RF testing will need to be performed to determine the layout of the wireless network proposed. Training would have to be done on the SCADA system and the newly implemented relays, and personal may need to be hired to maintain the network and communications equipment. A review of costs of the current system, including streetlight usage and maintenance data, current metering system costs and inaccuracies and outage information will have to be performed to determine exact cost savings of upgrading to the new system.

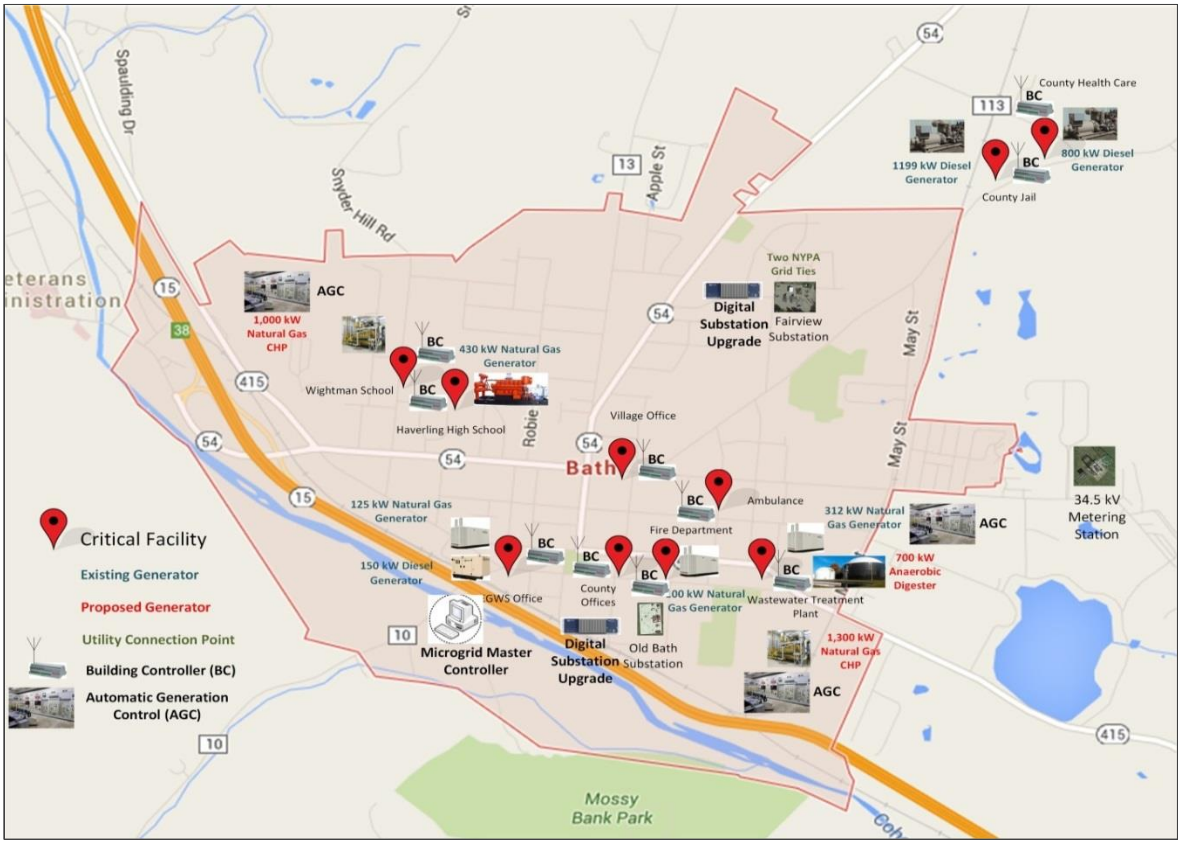


Figure 37. Network Equipment simplified layout diagram

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?

As BEGWS is the proposed owner/operator for the Bath Community Microgrid, the Master controller would be located in the BEGWS office data center that houses Bath's existing or proposed SCADA system. While the master controller would automatically communicate with the Bath SCADA system as well as with the field devices such as the building controllers (BCs) and automatic generation controllers (AGCs), BEGWS operators would regulate access and control to the microgrid. This means that any loss in communications that disrupts the microgrid would need to be between building controllers and the master controller/utility data center and that this loss would only prevent communication with one building, while the rest of the microgrid would maintain normal operation.

Willdan's proposed Bath Community Microgrid would rely heavily on the robust fiber optic backbone and the 900 MHz mesh network for monitoring and control. This system remains extremely resilient in the face of inclement weather due to the fiber optic being underground and the mesh networked being formed by above ground, but heavily redundant, mesh radios. Similar to the building controllers above, if one smart meter or streetlight is unable to communicate, the rest of the lights and meters would remain on the network and leverage each other to maintain a strong network connection.

Task 3 – Commercial and Financial Feasibility

Sub Task 3.1 Commercial Viability – Customers

BEGWS currently serves about 5,500 residents within its service territory, providing water and wastewater, electricity, and gas services. Other critical facilities in the area include a jail, schools, fire hall, police station, and government buildings. In the event of a storm or other major outage, with no microgrid, all of these customers go unserved. For example, the Valentine's Day 2014 event, when the NYSEG transmission line went down, no part of Bath had power. All residents were without heat or electricity. Thousands of people stayed in their houses for all 5-6 hours of the event, while nearly 2,000 more packed into the school and fire hall where backup generators kept lights and small heaters running. Depending on the length of the outage, much of the village population could be kept warm in the few emergency facilities, though in the event of an extended outage, there currently exists no backup option if a generator should fail or run out of fuel.

Direct Services

In addition to increased reliability, the Bath Community Microgrid would reap economic benefits in the form of: (i) potential revenue streams from participating in demand response programs; ancillary service markets such as blackstart, regulation, and operating reserve markets; retail and wholesale generation sales; (ii) reduced consumption through energy efficiency measures; and (iii) deferring system upgrades. Based on the price of electricity and availability of Distributed Energy Resources (DERs), the master controller will optimally dispatch the generation assets to provide the cheapest, cleanest, and most reliable energy possible to the critical and non-critical microgrid facilities.

Indirect Services

Utilizing a fully connected microgrid, with every vital piece of equipment able to be remotely monitored and controlled, the master controller will be able to optimize load and generation automatically and in real time, the microgrid operators will be able to view the status, create reports, and plan future developments, and maintenance personnel will be able to quickly assess and address any issues.

The Bath community microgrid will be able to automatically island the electric system, energize critical facilities, and allow a portion of the system to be energized in the event of a bulk system outage. A CHP-driven microgrid will also introduce additional redundancy into the existing Bath thermal system, allowing the main boilers to be shut down in the summer for regular maintenance, which will improve the safety of the overall system.

System reliability would be improved in normal operating conditions through infrastructure reconfiguration, such as a High Reliability Distribution System (HRDS) which autonomously senses and clears faults with virtually no impact on building loads, to a self-healing and more fault tolerant grid, by reducing the number of single points of failure by adding redundancy to the electrical and communications networks, and by adding alternate sources of generation to serve critical and non-critical loads.

Depending on ultimate size and configuration, during emergency operating conditions, the Bath Community Microgrid would be able to provide uninterrupted power to a portion of critical loads, through the use of DERs and load shedding schemes that ensure safe and reliable operation of the buildings that matter most in emergency situations. Long term outages will be mitigated by 3 MW of natural gas fed combined heat and power (CHP) plants, which will maintain a black-start capability in the event the outage occurs when the CHP facility is not active. These plants will rely on robust natural gas pipelines and produce enough power to serve all of the critical facilities, public street and security lighting, and some residential load. This added resiliency will keep emergency responders and residents safe and provide the Bath Community Microgrid with heat and power when it needs it most.

By using the more efficient and safe LEDs for public street lighting and residential lighting as well as using smart home appliances in the proposed community microgrid, Bath would not only have the capability of load shedding and load shifting, but both the community and residential customers could reduce maintenance costs and electricity bills.

Each current account with BEGWS is expected to continue purchasing power from the microgrid in blue sky conditions. While in island mode, only critical facilities including the school, fire hall, jail, and government facilities are guaranteed to be provided with service with additional capacity moving to provide additional services where needed in order of importance.

Residential customers are likely to have the opportunity to participate in the microgrid through load shedding or demand response aggregation. This participation would come with a monetary benefit in the form of bill reductions or credits toward monthly billing. Steuben County government buildings have also approached Bath suggesting installing DG on their property now that smart grid integration and market participation may be available through the Bath microgrid. Regional industrial plants may also be affected by the construction of the Bath microgrid, as the BEGWS wastewater plant could provide a new and cheaper waste disposal option. In this agreement, the industrial plants would receive low-cost tipping fees while Bath would benefit from additional capacity entering into the anaerobic digester to produce biogas.

The microgrid owner is BEGWS, who currently owns the grid. The purchasers of the power are the account holders in BEGWS territory. The relationship between BEGWS and its customers can expand with the offering of new services enabled by the microgrid and AMI.

Each current account with BEGWS is expected to continue purchasing power from the microgrid in blue sky conditions. While in island mode, only critical facilities including the school, fire hall, jail, and government facilities are guaranteed to be provided with service with additional capacity to provide additional services where needed in order of importance. These lists are different because the total amount of generation proposed under the microgrid is less than the total demand of the BEGWS service area. The generation is sized to provide economic dispatch in peak times when BEGWS surpasses its

NYPA power allocation, while also providing enough capacity to provide power for all critical services in the event of a major outage event.

The primary contract that shall be required in the proposed microgrid is a DR aggregation/Load Curtailment agreement with each BEGWS customer, allowing BEGWS to utilize the AMI for economic and power management purposes. Critical loads may also enter into contracts with BEGWS to formalize participation as a served load in islanded events, though this will likely only occur in 2-3 cases, since many of the facilities are already owned by the municipality.

Since BEGWS is adding capacity to the service territory they already own and operate, current customers of BEGWS will continue as normal under the BEGWS microgrid.

Methane produced by the proposed Anaerobic Digestion system installed at the WWTP will be utilized in local distributed generation to provide heat and power for self-consumption or to surrounding critical facilities. Heat produced by the CHP plants installed throughout the microgrid will be transported and sold to critical facilities and potentially large commercial or industrial customers by way of newly installed thermal transport infrastructure.

Sub Task 3.2 Commercial Viability - Value Proposition

Utility Costs

BEGWS would be faced with the initial investment costs of upgrading their electrical infrastructure to a High Reliability Distribution System (HRDS) including Automatic Transfer Switches (ATS), upgrading Circuit Breakers and Relays, upgrading/adding natural gas and storage infrastructure, improving communication infrastructure, including fiber optic and wireless RF, as well as training CHP plant operators and network and controls engineers for configuration and management of the newly upgraded system. Overall operating costs would be optimally managed by providing real time remote operation and control and real time monitoring of the entire electrical system, reducing errors, issues, and waste in their electrical distribution maintenance.

Microgrid development will be funded through feasibility by NYSERDA grants. Development and construction will be funded through available grants, private equity (where possible) and bond issuance. An Engineering, Procurement, and Construction (EPC) contract will be used as a vehicle for performance through the commercial operation date (COD). An operating contract will be executed to cover operations and maintenance upon commercial in-service. Appropriate warranties will be obtained from technology providers and cover each key component of the microgrid. The project will be structured to ensure that any financial obligations are met and BEGWS receives its regulated rate of return (ROR) through incorporation of microgrid assets into its ratebase. The Bath Community microgrid will be owned by the Village's municipal utility, BEGWS. Potential Project team members may include bond counsel, private equity advisors, DOE LGO, NYMPA, EPC Contractor, Consulting Engineer, Operator, Permitting Consultant, Environmental Consultant, CNG, NYPA, ratepayers, Village Council, stakeholders, and technology providers. Table 16 presents the SWOT analysis.

Table 16. SWOT Analysis

Parameter	Strengths	Weaknesses	Threats	Opportunities
Technology	State of the Art	Unproven-- Lack of performance history, in particular in emergency conditions	Disruptive next generation versions or replacements (rapid obsolescence)	Maximize operational efficiency
	Resilient	Expensive	Failure (potentially catastrophic)	Reduce environmental impacts
	Smart	Complicated	Potentially steep price reductions over near-term (6 months)	Leverage revenue and mitigate cost exposure to power purchases
	Efficient	Difficult to obtain private financing absent performance guarantee	Deployment challenges and supporting infrastructure requirements (e.g., AMI IT)	Enhance security and resiliency
	New	Limited vendors, lack of standardization (married to technology choice)	Vendor attrition	Economic benefits (enhanced sales, business continuity, rapid recovery, security, load shaping, etc.)
Regulatory	Complies with REV	Violates strict cost-of-service principles	Ratebase recovery disallowance	Advance next-generation energy resources
	Environmental benefits	May not comply with market restructuring rules	Movement toward vertical integration	Increase efficiency, optimize loads, enhance resilience
	Enhances grid/energy security	May not comply with franchise arrangements	Stakeholder rejection	Establish rate/recovery precedents
	Enhances ability to provide emergency services	May not comply with permitting requirements	Permitting hurdles, obstacles, and timing	Enhanced compliance with civic obligations for safety and emergency services
	Supports new technology development	Must go through NYPA to reach NYISO markets	Market rules/access to markets	Tariff and market reforms (NYPA, NYISO)

Table 16. SWOT Analysis – Continued

Parameter	Strengths	Weaknesses	Threats	Opportunities
Financial	Facilitates load management	Requires subsidy/guarantee from host/DOE/NYSERDA	Non-performance of vendor/technology	Cost reduction/peak shaving load shaping
	Creates new revenue streams	Revenue streams generally neither guaranteed nor predictable	Increased deployment may limit market opportunities and/or revenue stream values	Establishing new client base and service offerings
	Fuel supply price (natural gas)	Fuel supply availability during winter peak can be constrained	Fuel supply price and availability subject to supply/demand competition	Enhancing alternative fuel penetration/markets
	Municipal utility ownership and potential bonding/ ratebase recovery	Low cost of BEGWS power supply	Cost competition from low-cost Niagara hydro allocations	Replacement of obsolete/ aging infrastructure
	Village of Bath current credit ratings	Length of timing for development/deployment	Municipal financing may jeopardize ratings and solvency	Revising rate structures and cost of service study to account for microgrid
	Enhanced metering accuracy for revenue recovery	Load management can reduce revenue	Data loss or hacking/privacy concerns	New customer service offering and market products
Construction/ Operation	EPC turnkey with performance guarantees	Unproven technology/ lack of operating history	Performance shortfalls or failures	Dynamic system optimization
	Independent construction monitor/engineer	Reliance on third parties	Delays in completion and COD	Enhancing/upgrading distribution infrastructure
	Municipal ownership	Location (cheap power, grid dynamics)	Fuel supply interruption	Improved billing accuracy
	Existing utility and associated infrastructure for metering and billing and distribution	Legacy systems may be old and obsolete	Technology training and additional infrastructure	Improved cost recovery
	Enhanced services especially during emergencies	Stakeholder outreach and education	Compatibility with billing and existing systems	Enhanced customer service and interface

BEGWS is one of the few municipal utilities in the state that provide all utilities to customers in its territory. The provision of gas, water, and wastewater service to customers, on top of electric service makes this location unique, and there are two additional project components related to this fact that set this project apart. First, BEGWS is in the process of selecting and installing multi-functional AMI across its service territory. The meters will be capable of tracking, and remote control, of electric, gas, and water usage. This will provide unprecedented control and efficiency within the BEGWS service territory, allowing BEGWS to identify issues more quickly, and provide new services, such as demand aggregation and load curtailment for customers within the service territory. The second unique component of this project is the Bath Resource Recovery Hub, which is a public-private partnership between BEGWS and numerous commercial and industrial entities. The Bath wastewater treatment plant is undergoing a massive renovation which includes the construction of a two tank anaerobic digestion system. Bath is in the process of securing formal partnerships for commercial and industrial waste removal and processing. The waste will be processed at the digester and the resulting biogas will be utilized at the proposed CHP plant on-site. The plant will produce enough gas to power 700kW of CHP, however the CHP plant will be oversized to 2 MW and supplemented with pipeline gas to provide additional electric and heat capacity at the site. Since BEGWS owns and operates all components of the system – gas, AD, CHP, electric – fixed and variable costs will be kept to a minimum.

The Bath community microgrid will be replicable to locations that own and operate wastewater services. The project will showcase one entity's ability to develop a closed loop wastewater-AD-biogas-CHP system, while taking advantage of commercial and industrial partnerships for added capacity through waste feedstock. The AMI and distribution upgrades are replicable to any entity owning and operating its own electric system.

The project is scalable for two reasons. First, the AD is oversized to encourage additional waste processing, which will result in a higher proportion of biogas utilized for on-site CHP. Bath also has excess natural gas capacity on the system, allowing BEGWS or its customers to develop additional DG capacity in the future. Secondly, the AMI project can be expanded to additional customers if there are new developments within the BEGWS system. This possibility is currently being explored with Steuben County, since the County is pursuing the construction of a new County Facility within the Village of Bath.

BEGWS incurs additional cost liability when the community exceeds its NYPA kW and kWh allocation; most recently, Bath incurred over $1,700,000 in 2014, a significant burden for a County seat community with a limited tax base. The excess is largely due to the use of residential electric heaters in the cold winter months. In addition, Bath's radial path distribution system is 70+ years old, exposing the community to risk due to outages and equipment failures.

Many of Bath's substation feeders for residential customers are operating near or at capacity during winter peak load resulting in momentary overload of substation transformers serving residential customers; this situation is further exacerbated when multiple residential circuits fail. To resolve this, BEGWS can place the microgrid's CHP distributed generation resources near the worst of the residential load pockets to reduce amperage on the substation feeders/transformers. The residential winter peak also causes significant voltage sags in the 70+ year old system. The system is also entirely reliant on the NYSEG point of connection, which represents the primary resiliency issue, and has previously resulted in severe outages in the system. A microgrid would solve these constraints by providing additional capacity and resiliency to the BEGWS system.

Willdan proposes a Loop-based community microgrid for Bath. This new distribution network has a meshed structure which can operate as loop or radial, though it is normally operated as radial (i.e., with no loop) so as to make the protection coordination easier (upstream to downstream) and to make the distribution design easier. Also, the Automatic Transfer Switch (ATS) is proposed to be deployed within the community microgrid, which has the capability of network reconfiguration in case of emergency or outage.

Currently, there are no permanent generation resources anywhere in Bath's system. Nearly 3 MW of backup generators are the only available distributed energy resources and do not provide sufficient capacity to support critical electric loads. As part of the feasibility study, Bath can replace some or all of the non-CHP backup generators with black-start capable interconnected natural gas fired CHP generators strategically distributed at the critical facilities and load pockets. This will ensure that the community of Bath will be more prepared to weather power outages in emergency situations.

BEGWS explored placing the microgrid's CHP and distributed generation resources near the worst of the residential load pockets to reduce amperage on the substation feeders/transformers. There is a high concentration of Electric and heating load surrounding the WWTP, making it an ideal location for the installation of CHP. In addition, the Wightman and Haverling Schools, across the street from each other, have limited existing generation and high electric and heating load, which make these critical facilities ideal for a CHP installation. In addition to CHP, BEGWS aims to reduce winter peaks supplied by the bulk power supply and broaden participation in demand-response programs. Finally, the County Jail and County Health Care facilities have similar heating and electric load requirements that could be well satisfied by the installation of a CHP Plant. Any combination of these proposed generators would provide the microgrid's critical facilities with much needed steam for heating as well as electricity in emergency situations.

Presently, Bath is contracted with NYPA to supply its bulk power and purchases kWh on the retail market through its membership in the New York Municipal Power Agency (NYMPA) to purchase excess consumption. Due to reliance on electricity for heating, bulk system disruptions during the winter can create dangerous hardships. Such an event occurred in February 2014, leaving residents without heat/electricity for hours. A microgrid that would allow the system to island and indefinitely energize residential feeders automatically, even on a rotating basis, would dramatically improve Bath's resiliency.

Table 17. Stakeholder Value Proposition

Stakeholder	Value Proposition
Electricity Purchaser	The Bath Community Microgrid will ensure a constant reliable source of heat and electricity to the communities critical facilities, ensuring that emergency shelters and police and fire stations remain fully operational in the event of an emergency while, at the same time, lowering the overall cost of electricity purchases by passing along savings from new sources of revenue and cost savings gained by the electric utility
Critical Facilities	In the event of an emergency the critical facilities would see uninterrupted flow of heat and electricity and maintenance of the full extent of the facility's operation. During normal operation, the financial benefits to the critical facilities would increase the money available for other community improvements while lowering costs for the critical facilities
Utility	The Utility would have new sources of revenue and see cost reduction through energy efficiency programs, selling or using the methane produced in the Anaerobic Digester, collecting demand response payments, removing power purchases over the NYPA allocation, and more efficient grid operation
Suppliers and Partners	Bath Electric Gas and Water Service (BEGWS) would purchase more Natural Gas from their NG Supplier that they would use for CHP for Heat and Power, provide safety and reliability to the residents of Steuben County, and build a stronger and more resilient community in central New York
NY State	Bath would more readily honor its contract with NYPA if it did not exceed its allocation by almost double in the winter months, reducing the strain on the power authority to provide reliable service to the many communities with the same problem, NYISO would benefit from having another Demand Response participant that it could call on in times of need with grid balancing, and finally the state of New York would prosper as a technically advanced and resilient community grows and develops under its guidance.

Based on the owner/operators chosen business model, the power purchasers, commercial, residential, and Industrial customers, will have the unique opportunity to participate in a potential real-time pricing program, encouraging electricity use off of peak hours and savings for willing participants. While customers could see short term increases in rates to realize some of the additional smart grid benefits, over time the average electricity prices would fall due to the increased revenue and reduced costs for the electric utility due to a reduction in the number of times Bath will exceed its NYPA allocation.

NY REV seeks to transform the state's energy distribution system toward cleaner and more local power, and will change its utilities' business model and regulatory framework. Although the target is investor owned utilities, for now, this project helps the Bath municipal utility to consider how microgrids, distributed generation, and increasing amounts of renewables might all fit together and help NY state to reach to its goals.

Financially feasible, commercially viable, and more established or mature technology services or components were primarily considered to allow more financing opportunities for the overall project investments and to mitigate risk of emerging or early stage technologies being incorporated into the Bath Community Microgrid. With the exception of natural gas-fired turbine technology, each major component proposed is a new (i.e., emerging or young) technology.

Sub Task 3.3 Commercial Viability - Project Team

Local community groups and the municipal government are existing stakeholders to the microgrid project. BEGWS has planned to notify residents of new opportunities available to them through the AMI upgrade shortly before installation of the project to garner support for a DR aggregation program. The other aspects of the community microgrid have already been approved by the municipality and have overwhelming local support. Residents approve of the microgrid, since the massive outage of 2014 is still fresh in their memory.

BEGWS will serve as the primary applicant, owner and operator through all phases of the project. Willdan is serving and as energy and engineering expertise, with additional team members added as needed to support the construction and financing of the project. LeChase Engineering and ClearCove Systems are partnering on the Design/Construction of the wastewater plant, Verizon and Nighthawk are under consideration for AMI, while NG DG suppliers have yet to be identified.

One of the major aspects of this project is the development of the wastewater plant into a resource recovery hub. The AD/CHP combination allows BEGWS to form contractual agreements with industrial/commercial customers to dispose of their waste at very low cost, while utilizing the organic material for biogas production in the AD facility. This will benefit the project with low- to no-cost power, and potentially additional revenue from the tipping fees from any waste disposal customers.

BEGWS is a municipal utility with a strong financial record, though it is located within a municipality with a limited tax base a stagnant economic growth. Bath's recent $6.9M General Obligation Bond issue, received a Kroll Insured rating of AA+, S&P Insured rating of AA, and S&P Underlying Rating of A+ (in each case Stable Outlook).

Additional Partners and suppliers will be identified in future rounds of NY Prize. The primary team members include BEGWS and Willdan Energy Solutions. BEGWS has decades of experience owning, operating, and upgrading the Bath electric system and will continue in this capacity once the microgrid is in place. Willdan is a 51 year old company that provides energy and engineering expertise and professional services to thousands of municipalities across the country. Willdan has recently been awarded 8 NY Prize awards and is a growing force in the microgrid market.

To this point only the contractors for the wastewater project have been identified. LeChase Engineering and ClearCove Systems are partnering on the Design and Construction of the AD/CHP facility. For the AMI, Verizon and Nighthawk are being evaluated as suppliers. Additional support may be required by BEGWS to complete the design and construction of the microgrid in the form of hardware and software companies that will demonstrate control systems that may be used in the microgrid. Willdan will support BEGWS in the decision-making process, though final decisions are to be made by BEGWS as to the selection of assets, hardware, and software.

Multiple investors are being evaluated at the moment. Both private and public financing is being evaluated for this project, with multiple offers already having been received by Willdan and BEGWS. With multiple funding streams available, the Willdan-BEGWS team will be evaluating options to find the most economical approach to project financing and development.

As of now, the legal and regulatory support is being provided by subject experts within Willdan. Moving forward additional support is being sought from NYSERDA, as well as other industry professionals to support the development of this project. Willdan's existing relationship with Brookhaven National Laboratories is expected to provide assistance in this area as well. Appropriate SMEs will be incorporated into the team as appropriate in the next rounds.

Sub Task 3.4 Commercial Viability - Creating and Delivering Value

Selection Process

The existing technologies that may be considered to support smart grid and microgrid capabilities have been screened for their application to the Bath Community Microgrid. This involved appropriating the benefits to the specific wants and needs of the stakeholders as well as refining the list to the reasonable and applicable technologies for the region. The remaining technologies, applications, and revenue streams were then evaluated based on financial and technical feasibility in their application to the Bath Community Microgrid. This primarily consisted of detailed research into the existing infrastructure available and compatibility of the proposed technology with this infrastructure and with the other resources which will be available in the microgrid. Finally, the passing technologies were studied in detail to determine the range of acceptable capacity as well as the fit for the Microgrid owner/operator's requirements.

Benefits

The addition of a range of DERs, including long term sources like CHP and Anaerobic Digestion/Generation Plants and short term sources like Batteries and ICE DG, would allow the Village of Bath to operate as a microgrid, take advantage of new revenue streams generated by microgrid assets such as Demand Response and Fast Response Regulation Markets, increase resiliency through on-site generation, and reduce charges associated with high winter heating loads by utilizing generation near residential load pockets. Distribution of these additional resources close to the school system, the Jail and County facilities, and the Fire Department and Ambulance will ensure that critical facilities will remain powered on in emergencies, providing the Village of Bath with greater resiliency to natural and macro-grid events.

Challenges

Additional modeling will be performed to determine the exact size, cost, benefits, and capacity of the proposed units, to ensure that they are financially feasible and that the space and personnel requirements are met. Plant managers for CHP will have to be hired internally or externally and training will be required for maintenance personnel and operators of the proposed DERs.

As Natural Gas fed CHP is the most feasible option for the Bath Community Microgrid, the microgrid will heavily rely on Natural gas pipelines to power the facilities. Pipelines are highly resilient to inclement weather, but do have the potential to break down or be damaged. This would have to be monitored closely by BEGWS to prevent any small issues from leading to major problems if there is an interruption in natural gas supply. However, since BEGWS currently owns and operates the gas distribution system with a high grade of reliability, there is not expected to be any additional burden with regard to gas system maintenance.

Existing Resources

Bath Electric Gas and Water Systems (BEGWS) own and operate the electric distribution system within the village to serve approximately 4,500 electric customers. A large majority of those customers are individually metered; however, these meters are read manually every month by a meter reader. They are able to obtain system level load information, but not feeder level or three phase data from their distribution system or their substations.

BEGWS is pursuing an Advanced Metering Infrastructure (AMI) expansion, which would involve adding wireless communication infrastructure throughout the Village of Bath to allow for automatic and digital meter reads. Two pilot projects of 100 meters each are currently underway using GE and NightHawk AMI products. The pilots will be completed within the next month, at which point BEGWS will make a decision on which product to move forward with. The project will provide BEGWS with network data on gas, water, and electric consumption as well as additional control that had not existed previously. BEGWS expects to begin the AMI install in June of 2016, starting with the largest electric users and continuing through the summer and fall until all BEGWS meters have been upgraded.

BEGWS owns four substations with total capacity over 30 megawatts (MW) for distribution through the system. The four substations are Old Bath substation, Fairview substation, Hodgeman Substation, Faucett substation. Currently, only Old Bath substation and Fairview substation are in use, around 70% loads are supplied by Fairview substation and the rest are supplied by Old Bath substation. BEGWS owns the natural gas pipe lines which supply natural gas for around 2,000 customers. BEGWS is currently working on an upgrade of the existing distribution system, converting its distribution system to 12.5kV. Once the BEGWS system upgrade is completed, only the Fairview Substation will be operational, with six feeders to supply power to all the loads within Village of Bath. This upgrade was commissioned to update the old system and solve existing voltage issues in the Village.

Existing DERs located in Bath Community Microgrid are used primarily as backup generators in case that utility power is interrupted. They include 2,100 kW of Diesel and 1,000 kW of Natural Gas (NG)

Generators, distributed among the critical facilities. Existing DER respective to critical load and substation is shown in figure 38.

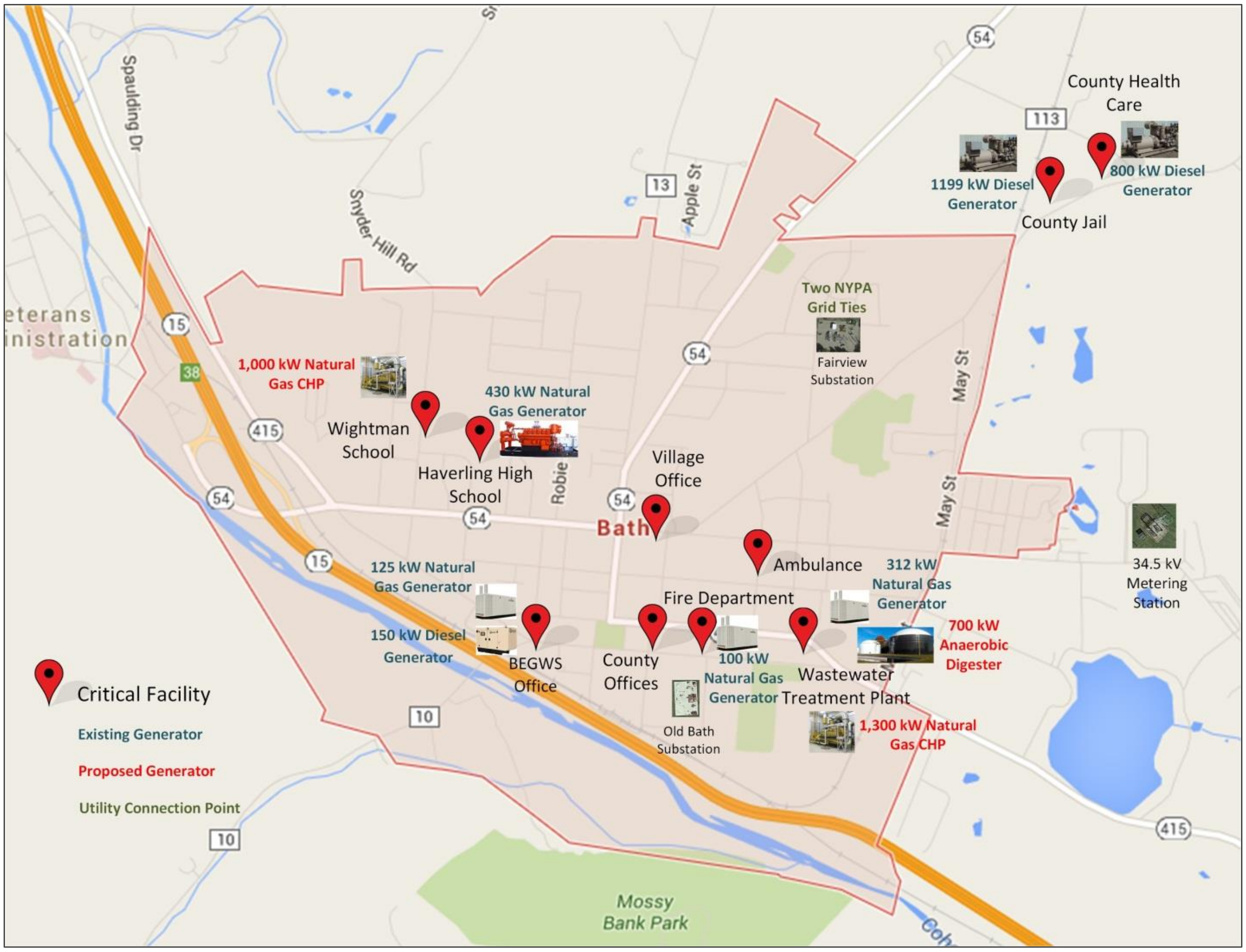


Figure 38. Generation simplified equipment layout diagram

The Bath community microgrid master controller would determine the optimal and reliable operation of microgrid through optimal generation dispatch and load schedule signals. The generation dispatch signals are sent to dispatchable distributed energy resource (DER) units and the load schedule signals are sent to building controllers. An interactive grid-forming control would be used either in island or grid-connected mode. In island mode, DERs apply this control scheme to share the load, while in the grid-connected mode; DERs apply this control scheme to regulate the power exchange between the microgrid and the utility grid. In the grid-connected mode, the DER unit, with grid-following control, follows the microgrid voltage and frequency, which is set by the utility grid in grid-connected mode and other DER units in island mode. BEGWS already operates the distribution grid, and have assured the project team of their capability to operate the microgrid. The proposed generation will be located at Village- and BEGWS-owned buildings, on BEGWS' existing network, with the master controller at BEGWS headquarters where the system is already operated, ensuring smooth operation of the microgrid.

Permits are required for the anaerobic digester and wastewater plant upgrades, and permission may be required for the installation of additional DG though these are likely to be similar for any project. Unique to this project would be the speed at which permissions are received, as the municipality owns both the electric system and all proposed assets. Additional air or discharge permits may also be required, thought this will be studied in greater detail in the next phase.

BEGWS is leading the project development with the assistance of Willdan Energy Solutions. A project charter that outlines the path forward for the BEGWS microgrid has been established by BEGWS and Willdan. The general process will proceed from feasibility assessment to design and construction in phases beginning with the wastewater plant AD/CHP upgrade, followed by AMI, and concluding with the master controller installation and commissioning. The AD/CHP project is designed and shovel-ready, poised to begin this month or in January 2016. AMI is expected to follow by March 2016 with all assets and controls in place by the end of 2017.

The Bath Community Microgrid will ensure a constant reliable source of heat and electricity to the community's critical facilities, ensuring that emergency shelters and police and fire stations remain fully operational in the event of an emergency, which may otherwise be disastrous with the absence of power, while, at the same time, lowering the overall cost of electricity purchases by passing along savings from new sources of revenue and cost savings gained by the electric utility. These include economic dispatch to avoid overage charges when demand surpasses the NYPA allocation especially during the winter, and DR aggregation for all AMI customers.

Assuming that Bath revises its rates and tariff structures accordingly and deploys AMI, power purchasers, and commercial, residential, and Industrial customers, may participate in the new unique opportunity of a real-time and time of use (TOU) pricing programs that encourage off-peak electricity use in return for pricing concessions. While customers could see short term increases in rates to realize some of the additional smart grid benefits, over time, energy efficiency and intelligent management programs should enhance and optimize consumption patterns to control costs while increasing resiliency and efficiency.

The ClearCove system that will be implemented at the wastewater plant is new to the market. All other pieces of the microgrid generation, hardware and software are expected to come from on the-market, proven solutions. LeChase Engineering, who is participating in the AD/CHP upgrade at the wastewater plant, has completed dozens of CHP installations across New York State. BEGWS is currently evaluating both Verizon and Nighthawk AMI systems, each with extensive market history, including installations around the country. In terms of the master controller, Willdan is evaluating potential options, with preference being given to those solutions that have been previously installed and financed in existing microgrids.

All final decisions and responsibilities lie with the owner/operator/developer of the project, BEGWS. Willdan shall support the project development and performance guaranteed, backstops, and warranties will be sought out where necessary. Project development will proceed with BEGWS selecting a Design firm followed by pursuing construction and financing support. Willdan will support the BEGWS decision making process with technical expertise and the project team will work to ensure all processes proceed as expected. BEGWS has undertaken many projects in the past and has decades of experience owning and operating the Bath grid, providing a high confidence level for the project's success.

BEGWS will continue to administer utility billing for electricity. Existing metering, where possible, and future AMI will be used for metering.

The project is municipal in nature, and while the project may be replicable across the State in other municipalities, there are no additional commercialization plans for any piece of this project.

Given the location of the Bath Community microgrid project, barriers to entry are significant due to regional power market characteristics and the availability of low cost hydropower.

BEGWS understands its path forward – using a municipal model and seeking grants and loan guarantees.

Sub Task 3.5 Financial Viability

Potential Revenue Streams

Potential revenue streams and/or savings will be highly dependent upon the final configuration of the microgrid, factors affecting power prices in the New York Independent System Operator's (NYISO's) markets, and natural gas markets, among other items. Assuming the microgrid includes natural gas-fired CHP, potential revenue sources may include energy sales to BEGWS customers, Demand Response related revenues and Ancillary Service payments from NYISO, and potential revenues from other municipalities, for example, the Town of Bath. Generation technology would also enable demand reduction during the winter months, when BEGWS exceeds its monthly allocation of hydropower, and potentially displace energy purchases during peak summer months. Assuming the microgrid incorporates anaerobic digestion co-located at the WWTP; generation can offset operating energy costs, in particular for sludge drying. General estimates of these costs follow. Should the Bath Community microgrid proceed to the next round, detailed information on actual technology and detailed production cost modeling would be necessary to quantify expected revenue streams.

Demand Response Revenues

Any behind-the-meter generation associated with the Bath Community microgrid could potentially participate in the NYISO market through NYPA, a Market Participant. Such participation would therefore be compensated under NYPA's tariffs. Currently, NYPA offers demand response rates for Government Customers under three options: Option 1 is for energy reductions, Option 2 is for peak reduction within NY City, and Option 3 is for capacity (fixed) and energy (variable).[1]

Table 18 illustrates potential Option 3 capacity revenues assuming 2 MW of generation under the NYPA Option 3 tariff, pursuant to which capacity payments are based on 85% of the average monthly NYISO

[1] http://www.nypa.gov/PLM/PLMgovernment3.html.

auction clearing price. Customers can enroll based on summer (May-Oct) or winter (Nov-Apr) participation. Based on these estimates, revenues of approximately $93,000 would result from capacity payments for 12-months of participation. According to the Official Statement for Bath's recent $6.9M General Obligation Bond issue, future plans associated with the microgrid include 5MW of either CHP or DERs.[1] Using this higher capacity would increase projected revenues to $252,000.

Table 18. Illustrative Example of NYPA Option 3 Capacity Revenues

	May	Jun	Jul	Aug	Sep	Oct
Price ($/kW-Month)	$10.50	$9.87	$9.08	$8.44	$8.40	$8.35
Capacity (MW)	2	2	2	2	2	2
NYPA Capacity Payment ($)	$17,850	$16,779	$15,436	$14,348	$14,280	$14,195
	Nov	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**
Price ($/kW-Month)	$3.78	$3.75	$3.80	$3.75	$3.74	$3.70
Capacity (MW)	2	2	2	2	2	2
NYPA Capacity Payment ($)	$6,426	$6,375	$6,460	$6,375	$6,358	$6,290
TOTAL						**$92,888**

Energy payments under NYPA's Option 3 tariff are based on the greater of $500/MWh or 100% of the NYISO market price. Over the past five years, upstate or statewide curtailment occurred an average of 10 hours;[2] participants are also paid for 1 hour of monthly testing.[3] Assuming 22 hours of revenues, the microgrid would earn $27,500 in energy over 12 months. Increasing the capacity to 5MW would increase projected revenues to $55,000.

Ancillary Services

Microgrid generation may potentially participate in other NYISO Ancillary Services Markets, however the extent to which resources can take advantage of these potential revenue streams is not clear as NYPA does not currently have tariffs in place. For example, NYPA lacks a tariff for regulation service. To participate in the regulation market, Bath Community microgrid generation resources would bid available capacity into the market, but may not be dispatched. A unit could only bid *available* capacity allowing for scheduled maintenance and forced outages and adjusting for reserve capacity. Typical availability factors range from 60% to 85% or more depending on technology and maintenance routines. Furthermore, when offering regulation service into the market the portion so committed could not be used for generation (i.e., to sell retail power).

[1] http://emma.msrb.org/EP852423-EP659831-EP1061513.pdf
[2] Demand Response, New York Market Orientation Course, November 5, 2015, NYISO.
[3] NYISO guarantees a minimum payment of 4 hours.

Assuming that the units can regulate and clear the auction, potential revenue streams could range from perhaps $56,370 to $79,000 (25% to 35%)[1] *but could be significantly lower or higher*. This range would increase to between $140,000 to $198,000 for 5MWs of capacity.

The CHP units may be able to participate in the NYISO Demand-Side Ancillary Services Program (DSASP) for which NYISO provides a minimum of $75/MWh. However, FERC is ruling on the eligibility of behind-the-meter generation (Docket #EL13-74-000) and, according to NYISO's recent semi-annual update, there has been no activity for the past several years.[2] At this time revenue streams from this market seem marginal.

Should the microgrid configuration ultimately include energy storage, additional revenue streams from sales of ancillary service may be possible. Again, such revenues would be predicated upon potential revisions to NYPA's tariff structures.

Revenues from Other Municipals

The Village of Bath currently provides fire protection and emergency aid to the Town of Bath and the Bath Volunteer Fire Department, Inc. The Bath Community Microgrid may allow upgrading the level and/or nature of services provided in return for additional revenues. The level of such additional revenues cannot be quantified at this time.

Purchased Power Savings

BEGWS receives allocations of low-cost hydroelectric power from NYPA. BEGWS is a partial requirements customer; winter heating loads cause BEGWS to exceed its monthly allocation from November to April. Table 19 illustrates monthly peak demands versus Niagara allocations for 2013-2015. As can be seen from these data, January and February average excess demands were 6.74MW and 5.9MWs, respectively—well over 5 MW. The cost of such excesses can be significant. In 2014, for example, such overages cost BEGWS nearly $1.7M. Although installation of 2MW of behind-the-meter generation could potentially mitigate a portion of this cost exposure, a minimum combination of approximately 6.75MW generation and load reduction would be required to reduce peak monthly demand below its NYPA Niagara allocations limit of 13.38 MW.

[1] http://www.nyiso.com/public/webdocs/markets_operations/documents/Studies_and_Reports/Reports/Market_Monitoring_Unit_Reports/2014/NYISO2014SOMReport___5-13-2015_Final.pdf, Page 12. The calculation is based on Regulation payments of $12.87/MWh.

[2] New York Independent System Operator, Semi-Annual Reports on New Generation Projects and Demand Response Programs (Docket Nos. ER03-647-000 and ER01-3001-000) dated June 1, 2015, Attachment II, page 1.

Table 19. BEGWS Actual Peak Demands Vs. NYPA Niagara Allocations by Month (2013-2015)

	NYPA Allocation[1] (kW)	Actual Peak Monthly Demand (kW)[2]				Excess/ (Margin) (kW)
		2013	2014	2015	Average	
January	13,380	19,230	21,022	20,102	20,118	**6,738**
February	13,380	17,219	19,721	20,849	19,263	**5,883**
March	13,380	15,861	19,781	19,048	18,230	**4,850**
April	13,380	14,225	14,330	13,422	13,992	**612**
May	13,380	11,651	9,792	10,308	10,584	(2,796)
June	13,380	12,828	11,627	12,167	12,207	(1,173)
July	13,380	13,547	13,446	12,934	13,309	(71)
August	13,380	12,566	11,228	10,770	11,521	(1,859)
September	13,380	10,868	11,861	11,662	11,464	(1,916)
October	13,380	12,113	11,596	11,398	11,702	(1,678)
November	13,380	14,525	15,124	16,123	15,257	**1,877**
December	13,380	16,260	16,664	15,702	16,209	**2,829**

In addition to peak shaving, BEGWS would earn retail sales revenues when system power purchases are displaced by behind-the-meter generation. Table 20 illustrates its current rates by customer class. Production modeling would be required to determine the load that would be replaced and resultant retail revenues received. Depending on capacity and configuration, BEGWS may enter into bilateral Power Purchase Agreements (PPA) for portions of the generation output, so long as such contracts do not conflict with other obligations. The potential revenues realized from such PPAs cannot be quantified at this time and may include both fixed and variable components.

Table 20. BEGWS Electric Rates by Customer Class

BEGWS Current Rates by Customer Class		
Service Classification No. 1 – Residential	**May to October**	**November to April**
Customer Service Charge ($/Month)	3.3600	3.3600
Energy Charge - 1,000 kWh or less ($ per kWh)	0.0360	0.0360
Over 1,000 kWh - 2,400 ($ per kWh)	0.0360	0.0570
Over 2,400 kWh ($ per kWh)	0.0360	0.0618
Minimum Charge per month ($ per meter)	3.3600	3.3600

[1] Preference power sales are limited to 74,508,109 kWh. Source: *Niagara Power Project Power Allocations, Rates, And Opportunities, Prepared for: New York Power Authority,* The Brattle Group, August 2005, Table A-1. Copyright © 2005 New York Power Authority.

[2] Source: Municipal Electric Utilities Annual Report of Bath Electric, Gas, & Water Systems for the Years Ended May 31, 2013-2015 to the State of New York Public Service Commission, page 400.

Table 20. BEGWS Electric Rates by Customer Class (Continued)

BEGWS Current Rates by Customer Class		
Service Classification No. 2 - Small Commercial (Under 20 KW demand)	**May to October**	**November to April**
Customer Service Charge ($/Month)	4.2200	4.2200
Energy Charge first 2,400 kWh ($ per kWh)	0.0499	0.0609
Energy Charge over 2,400 kWh ($ per kWh)	0.4990	0.0625
Minimum Charge per month per meter ($ per meter)	4.2200	4.2200
Service Classification No. 3 - Commercial (20 KW to 75 KW demand)		
Energy Charge ($ per kWh)		0.0241
Demand Charge - first 20 KW or less ($/kW-Month)		112.25
Over 20 KW ($ per kW-Month)		5.61
Service Classification No. 4 - Industrial (Over 75 KW demand)		
Energy Charge ($ per kWh)		0.0241
Demand Charge - first 75 KW or less ($/kW-Month)		374.20
Over 75 KW ($ per kW-Month)		4.99
Service Classification No. 5 - Outdoor Lighting		
175W MV - 150W HP ($ per month per light)		9.16
250W HPS ($ per month per light)		11.59
400W MV/HPS ($ per month per light)		17.41

Energy Savings from Anaerobic Digestion

Assuming the microgrid incorporates anaerobic digestion co-located at the WWTP; generation can offset operating energy costs, in particular for sludge drying. Additional technical analysis would be required to quantify the level of savings.

Additional Infrastructure

Certain components of the microgrid will require upgrades to existing and installation of new infrastructure (e.g., distribution system, natural gas pipelines, storage). The timing of these resources will impact the microgrid, in particular potential permitting requirements. For example, the microgrid requires deployment of Advanced Metering Infrastructure (AMI). The Village of Bath is currently proceeding with deployment of roughly $4.5M in AMI. Project development will be impacted by any delay in AMI roll out. Natural gas infrastructure would likely require upgrades and installation of new assets. Historic problems with lost and unaccounted for gas associated with anomalies in Corning

Natural Gas Corporation's (CNG's) metering and related equipment would require resolution or an alternative supply.[1]

Funding

Microgrid development will depend on access to financing and cost of capital. As with any capital investment, the cost and availability of funding will reflect the risk profile of the venture. In the case of microgrids, the Willdan Team expects first tier risks—that may drive financing terms, where available, or under certain circumstances prevent access to capital markets—to include technology risk, regulatory risk, lack of a proven track record, and market risk. The regulatory regime will affect microgrid projects in three ways: rate recovery methodology/treatment, potential revenue streams (e.g., power pool market rules, limitations on generation ownership, emissions limits, operating restrictions, technology constraints), and project structure/ownership (for example prohibitions on distribution utilities owning generation assets).

Project Guarantees/Financing Backstops

The microgrid may require additional guarantees to secure financing and rate recovery. The availability, cost and timing of such guarantees may impact development. Microgrid technology is emerging and unproven. It offers great possibility and, under the correct circumstances, should be highly attractive to private equity. However, given the risks discussed above, any project's access to private capital will ultimately depend on the guarantor and or backstop underpinning the project. Put another way, with unproven technology in an emerging market, private equity will seek to insulate investors from risk assuming a worst-case scenario to offer capital at a reasonable price. Pension funds and other desirable funding sources will require adequate de-risking of the venture.

Classifying microgrid assets as Critical Infrastructure Protection assets under NERC or security assets under Homeland Security may open avenues to external funding from state and federal sources and/or facilitate use of these entities as backstops or ultimate guarantors. Additionally, on August 24, 2015, President Obama announced that the Department of Energy's Loan Programs Office issued guidance for Distributed Energy Projects, making microgrids potentially eligible for DOE's Loan Guarantees Program. Due to the fees and costs associated with such guarantees, this program is typically cost effective for projects of $25 M or more. The DOE would consider packaging projects together to create a cost-effective critical mass. It is currently unclear the feasibility of such an approach; however the New York Municipal Power Agency may be a potential vehicle for such consolidation. Additional research is warranted in the next phase.

Depending on the ultimate configuration of the microgrid, additional capital and operating costs may exist, though primary components are outlined as follows:

- Infrastructure upgrades to accommodate microgrid—very limited since substation and distribution network are recently upgraded;

[1] On April 13, 2015 the Village of Bath petitioned the NYPSC for ratepayer recovery of nearly $650,000 associated with lost and unaccounted for gas.

- AMI—$4.5M capital, operating costs minimal since a full-time employee is currently on staff as Metering Coordinator to operate AMI;
- Master controller and communications infrastructure—costs uncertain, though cost will be less than the cost of the generation assets, currently estimated from $1 – $2 million;
- Natural gas system upgrades— at least 2 MW of CHP installed, estimated around $6 million, with potential for 1.2 MW more natural DG at key locations for another estimated $2 million;
- Natural Gas Cost – variable cost based on biogas production at anaerobic digester and total operating time of DG, estimated at $1 – $2 million per year.
- Permitting costs—need to consult experts regarding air permitting of new resources.

Microgrid development will be funded through feasibility by NYSERDA grants. Development and construction will be funded through available grants, private equity (where possible) and bond issuance. An Engineering, Procurement, and Construction (EPC) contract will be used as a vehicle for performance through the commercial operation date (COD). An operating contract will be executed to cover operations and maintenance upon commercial in-service. Appropriate warranties will be obtained from technology providers and cover each key component of the microgrid.

Sub Task 3.6 Legal Viability

The Bath Community microgrid will be owned by the Village's municipal utility, BEGWS. Potential Project team members may include bond counsel, private equity advisors, DOE LGO, NYMPA, EPC Contractor, Consulting Engineer, Operator, Permitting Consultant, Environmental Consultant, CNG, NYPA, ratepayers, Village Council, stakeholders, and technology providers.

BEGWS currently owns all land, sites and infrastructure in this proposed project. However additional rights-of-way and sites may be required to fully accommodate the final microgrid configuration. Additional design information that will be developed as part of the next phase is required to further identify these sites.

AMI infrastructure has the ability to protect customer privacy. Outcomes will be entirely dependent on the technology chosen as well as the implementation and operation. It will be incumbent upon BEGWS to ensure compliance with such requirements, though since BEGWS is the existing power provider with an existing privacy protocol, continuing the protocol is expected to be straightforward.

Depending on the total effect of the microgrid operation, there may be discussions with NYPA regarding the power allocation to Bath. We have confirmation from NYPA that installing assets in Bath is acceptable, though if there is a drastic change in the average system demand or load factor, there may be grounds for discussions around the type or magnitude of the allocation. In order to avoid any setbacks, NYPA is being consulted regularly by the project team.

Task 4 – Develop Information for Cost Benefit Analysis

Additional information regarding projects related to the Bath microgrid can be found in Section G of the Microgrid Questionnaire. Bath intends to install AMI at each account in the next calendar year, allowing greater information and control of water, gas, and electric meters. This efficiency savings, along with potential load shedding and demand response savings are expected to total $750,000-$1,000,000 per year in benefits to Bath.

Sub Task 4.1 Facility and Customer Description

The list and description of these facilities is provided in Section A, table 1 of the Microgrid Questionnaire. All 16 of the potential microgrid facilities are owned and operated by local municipalities. The largest energy users on the Bath system also happen to be those facilities that provide emergency services, such as the Jail/911 Center, the County Center for Rehabilitation and Healthcare, the High School, and the County Offices. The High School, Jail/911, and County Offices are also well-suited and sited for CHP on the Bath system.

The Village of Bath has very little industrial load to speak of, with 98% of the system accounts and 93% of all energy going to residential and small and large commercial accounts. In fact, within the system, the primary loads are municipal in nature. This profile is not expected to change, and may strengthen, if anything. Steuben County is planning an expansion of its current facility within the Village of Bath. They are currently in the design phase for a new building and have been in discussions with BEGWS as to the potential for installing a 1-1.5MW CHP generator at the new facility. The location of the facility is acceptable for integration onto the Bath system, and the Bath microgrid team is continuing discussions with the County to gather additional information.

Due to the low cost of power in Bath, the design of the microgrid was never intended to support every account on the Bath system. The cost to purchase enough generation to put on the system greatly outweighed the marginal benefit of doing so, particularly since Bath is not incentivized to generate energy when the system load is below the NYPA allocation. The design of the system adds around 3 MW of new generating assets, along with 2-3MW of load shedding capabilities, to provide BEGWS with flexibility and value in blue-sky conditions as well as enough power in island mode to support their critical loads with heat and electricity.

Sub Task 4.2 Characterization of Distributed Energy Resources

Section A, Question 2 of the Microgrid Questionnaire Characterizes the DER of the proposed microgrid. The proposed DERs seek to keep the primary users, which are also providers of emergency services, online in the event of a major power outage. The proposal includes 2.3 MW of Natural Gas CHP split between a facility on Feeder 301 (1 MW), and Wastewater Plant (1.3 MW), along with another 700 kW generator at the Wastewater plant to be run on biogas from the anaerobic digester.

The 700 kW biogas generator at the wastewater plant is expected to operate 24/7/365 as a continuous asset for heat and power at local facilities. The wastewater plant is owned and operated by BEGWS, meaning that in addition to being a net-zero emission generator, the energy from the biogas will offset natural gas purchases, saving BEGWS thousands of dollars per year. The 1.3 MW system is also expected to be located at the wastewater plant, but will be powered by natural gas from the BEGWS system. The electricity can be used year-round to supply reliable power to critical facilities, while the heat will be used by the anaerobic digester to improve the biological conditions and increase efficiency.

Sub Task 4.3 Capacity Impacts and Ancillary Services

Section B, Questions 3-8 estimate the impact that the proposed microgrid will have on the capacity and ancillary services. Essentially, Bath has offered that most, if not all, of the existing generators could be enrolled to provide peak support in extreme events or in the case that it becomes economically efficient. Bath is also open to enroll assets in demand response in the event that doing so makes economic sense. To this point, Bath does not have any assets enrolled in demand response. In addition to enrolling existing generators in peak support or demand response, any new generator will be examined for participation as well.

The primary dispatchable services on the Bath microgrid will be related to the AMI system Bath is in the process of installing. The AMI will be able to monitor and control gas, water, and electric usage at each account, giving BEGWS control of nearly 3 MW of load shedding potential. This energy savings comes primarily from electric heating systems, water heaters, and other smart appliances that BEGWS will be able to cycle during peak events. This idea is part of the larger demand aggregation strategy being implemented by BEGWS to lower bulk power purchases and peak events, which are the most costly portions of the BEGWS annual budget.

BEGWS is just completing a distribution upgrade to their system, which is expected to improve reliability and control of the system. In addition, the primary substation in Bath has plenty of open capacity available for the upcoming generation projects. While demand response does not currently play a role on the BEGWS system, Bath fully expects to become a participant once new resources and controls come on line.

Sub Task 4.4 Project Costs

Section C of the Microgrid Questionnaires provides information about the costs of the proposed generators and other microgrid assets. The estimates came from the DER-CAM library, and discussions with ClearCove, LeChase Engineering, and EC4B. For aspects of the project that successfully move past Phase 1 of NY Prize, more precise numbers may be sought out at a later time. All numbers presented in the study are based on past experience, similar projects, or data provided by Bath from actual bids.

The natural gas system in Bath is underground and highly resistant to the types of weather events typically experienced in Bath. While the 700 kW generator at the wastewater plant is to be run on biogas, the other 2.3 MW of CHP generation is to be run on natural gas. In the event of a major outage, such as the one in February of 2014, the natural gas system remaining on line during a full power outage. The microgrid will increase the electric resiliency of the Bath system and the CHP system will serve as a reliable source of heat and power in all scenarios.

The costs for the project come primarily from Guy Hallgren, Director of Municipal Utilities in Bath. We supplemented the projects costs he provided with data collected from other contractors who had done similar projects in the region. For example, LeChase and EC4B were able to provide installed cost estimates for the CHP system, while Guy provided the AMI cost directly from bid documents. CHP cost estimates were on the order of $2,750 - $3,000 per installed kW, depending on the exact piece of equipment that may be chosen in the final selection. The AMI project is expected to switch out all 4,000+ meters on the Bath system within the next few years, costing around $4.5 million.

Sub Task 4.5 Costs to Maintain Service during a Power Outage

The first six bullets are answered in Section I, table 1 of the Facility Questionnaire. Most of this information came from the first two deliverables under the NY Prize scope of work, and has been refined into the data found within table 1. The final bullet is answered in the two tables of Section II of the Facility Questionnaire. The latter costs are difficult to determine, and are estimations based on research involving LBNL outage cost estimates, and the size of the population and load of the facility.

Building managers for the critical facilities in Bath expressed an interest in the microgrid project for a variety of reasons. First, they were excited to hear that Bath was moving to ensure the major outage in 2014 never happened again. Interestingly, the second reason was the expense and difficulty of maintaining the on-site diesel generators. While some facilities, such as the County Offices, do not have any form of backup power currently, most other critical facilities have oversized diesel generators. The issues raised by the managers included the expense of maintaining a supply of fuel, the cost and difficulty of running periodic testing on the generators, and the worry that the generator may not reliably support the building when called upon to do so. The 3 MW of generation on the microgrid would support the majority of the critical loads in Bath by itself, but would also enable the facilities to install their own natural gas generators, or even CHP, as supplements for their individual loads. This would enable them to improve reliability while lower cost and hassle.

Sub Task 4.6 Services Supported by the Microgrid

Section III of the Facility Questionnaire describes the services supported by the microgrid, and how they would operate with or without backup power. These estimates came from discussions with the municipal operators of the facilities and research into typical scenarios for similar facilities. In typical scenarios, if the larger grid around Bath (a municipal utility) goes down, all residents will lose power. This has happened numerous times, as recently as early 2016, and most severely in the winter of 2014.

Bath is a village with many low-income residents and a large percentage of homes heated with electric heaters. Outages, particularly in the winter, pose a serious hazard to the residents in Bath.

The microgrid may not support each individual home in the event of a major outage, but it would keep most critical services in Bath online, unlike in the outage of 2014. At that time, only one facility stayed online, the High School, and nearly 1,000 people congregated in the gymnasium to stay warm. The development of the microgrid would provide a dozen different locations on the Bath system with heat and power, even in the worst outage.

Steuben County will be a key partner as this project moves to the next phase. The benefit cost analysis shows that without bearing any additional costs, the County has by far the most to gain through the development of a microgrid in Bath. The County has its Jail, 911 Center, Rehab and Healthcare Center, and Offices in the Village, and represents the largest commercial user of power in Bath. Additionally, all of their facilities provide critical services for the Village and County and can serve as shelters in times of emergency. Recent discussions with the County have shown that the County is interested in supporting the BEGWS microgrid, and may be interested in developing generation assets of their own. Currently, the County offices have no backup power, and due to financial constraints, there have been no recent developments on the issue. However, as the County moves to construct new facilities nearby, the issue has been raised in new light and may be easier and less expensive to develop at this point in time.

Benefit-Cost Analysis Summary Report

Village of Bath

Project Overview

As part of NYSERDA's NY Prize community microgrid competition, the Village of Bath has proposed development of a microgrid that would enhance the resiliency of electric service for a variety of critical facilities located within the village and neighboring areas. These include:

- Haverling High School and Vernon E. Wightman Primary School;
- The offices and pit garage of Bath Electric Gas and Water Systems (BEGWS), the village's municipal utility;
- The village's wastewater treatment plant and sewer pump;
- Key elements of the village's water supply system (the Maple Heights Water Tank, the Mt. Washington Tank, and Well #6);
- The Steuben County Office Building, the Bath Municipal Building (which houses the Bath Police Department), and the Bath Village Street Department;
- The Steuben County Jail and 911 Call Center, located in the county's Public Safety Building;
- The Bath Volunteer Fire Department;
- Bath Ambulance Corporation; and
- The Steuben Center for Rehabilitation and Health Care.

The microgrid would also provide service to an estimated 3,000 residential customers and 170 non-critical commercial or industrial customers in Bath and the surrounding area.

The primary source of energy for the microgrid would be two new natural gas combined heat and power (CHP) units: a 1.3 MW system that would be sited at the wastewater treatment plant, and a 1.0 MW system that would likely be sited at the jail. In addition, the microgrid would incorporate a 700 kW generator powered by biogas from an anaerobic digester, which would be sited at the wastewater treatment plant. The operating scenario submitted by the project's consultants indicates that these systems together would produce 25,200 MWh of electricity per year. In addition, the microgrid would incorporate three diesel and three natural gas-fired emergency generators currently based at several of the critical facilities listed above; these generators would operate only in the event of a power outage or during periods of extreme peak demand. The capacity of all generators combined would be 5.764 MW, enough to meet approximately 40 percent of the average energy requirements of customers on the microgrid circuit. In the event of an outage, BEGWS would implement rolling blackouts, providing energy for 30 to 50 percent of the circuit's customers at a time. This would be sufficient during the winter to enable residential customers to keep their homes adequately heated until full power is restored.[1]

[1] James Post, "Cuomo: Bath utility gets $100K to study microgrid," The Leader, April 30, 2015.

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

Methodology and Assumptions

In discussing the economic viability of 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. The model analyzes a discrete operating scenario specified by the user; it does not identify an optimal project design or operating strategy.

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

With respect to public expenditures, the model's purpose is to ensure that decisions to invest resources in a particular project are cost-effective; i.e., that the benefits of the investment to society will exceed its costs. Accordingly, the model examines impacts from the perspective of society as a whole and does

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

not identify the distribution of costs and benefits among individual stakeholders (e.g., customers, utilities). When facing a choice among investments in multiple projects, the "societal cost test" guides the decision toward the investment that produces the greatest net benefit.

The BCA considers costs and benefits for two scenarios:

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

Results

Table 21 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 0.1 days per year (Scenario 2). The discussion that follows provides additional detail on these findings.

Table 21. BCA Results (Assuming 7 Percent Discount Rate)

Economic Measure	Assumed Average Duration of Major Power Outages	
	Scenario 1: 0 Days/Year	Scenario 2: 0.1 Days/Year
Net Benefits - Present Value	-$2,690,000	$3,040,000
Benefit-Cost Ratio	0.9	1.1
Internal Rate of Return	4.1%	8.4%

[1] 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.

Scenario 1

Figure 39 and table 22 present the detailed results of the Scenario 1 analysis.

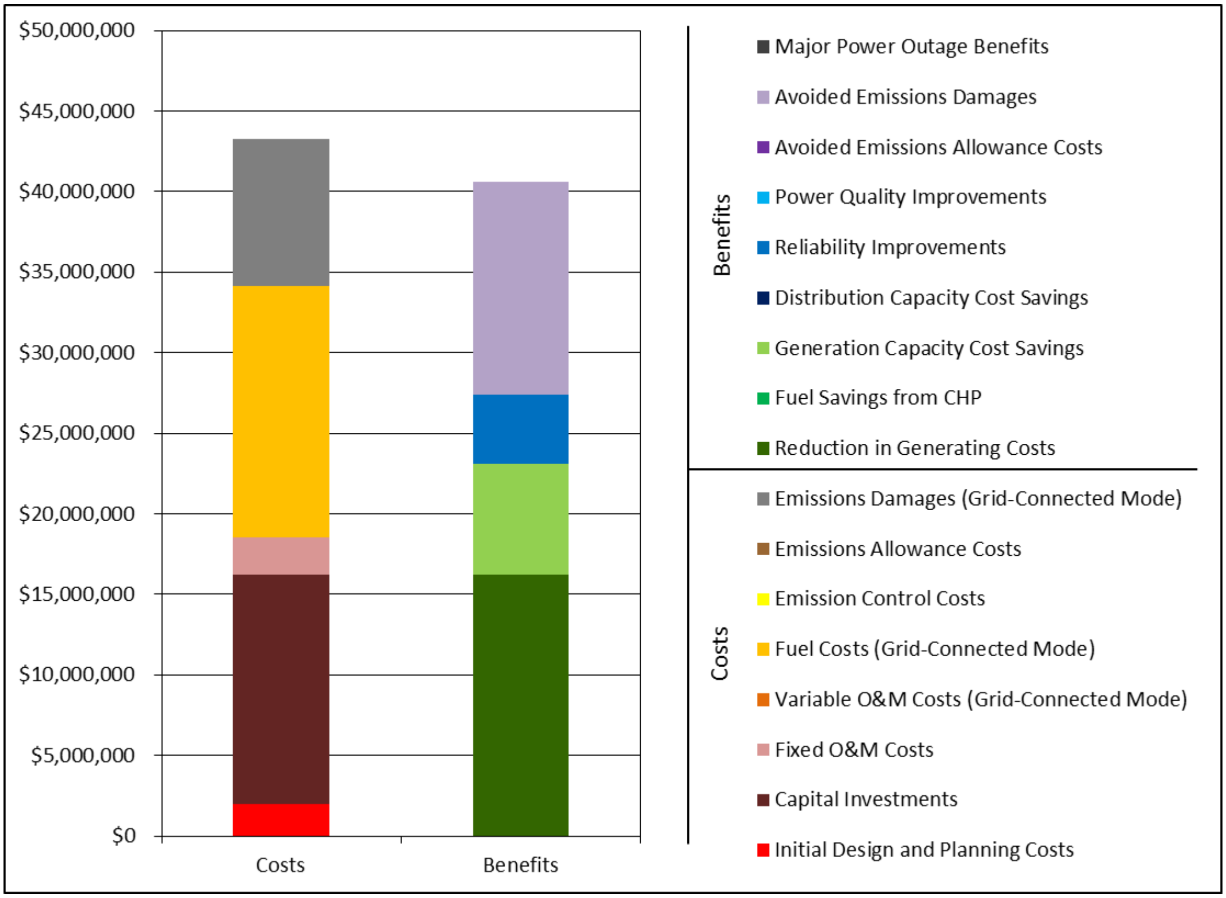


Figure 39. Present Value Results, Scenario 1 (No Major Power Outages; 7 Percent Discount Rate)

Table 22. 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	$2,000,000	$176,000
Capital Investments	$14,300,000	$1,160,000
Fixed O&M	$2,270,000	$200,000
Variable O&M (Grid-Connected Mode)	$0	$0
Fuel (Grid-Connected Mode)	$15,600,000	$1,380,000
Emission Control	$0	$0
Emissions Allowances	$0	$0
Emissions Damages (Grid-Connected Mode)	$9,160,000	$598,000
Total Costs	**$43,300,000**	
Benefits		
Reduction in Generating Costs	$16,200,000	$1,430,000
Fuel Savings from CHP	$0	$0
Generation Capacity Cost Savings	$6,920,000	$611,000
Distribution Capacity Cost Savings	$0	$0
Reliability Improvements	$4,250,000	$375,000
Power Quality Improvements	$0	$0
Avoided Emissions Allowance Costs	$8,890	$784
Avoided Emissions Damages	$13,200,000	$862,000
Major Power Outage Benefits	$0	$0
Total Benefits	**$40,600,000**	
Net Benefits	**-$2,690,000**	
Benefit/Cost Ratio	**0.9**	
Internal Rate of Return	**4.1%**	

Fixed Costs

The BCA relies on information provided by the project team to estimate the fixed costs of developing the microgrid. The project team's best estimate of initial design and planning costs is approximately $2.0 million. The present value of the project's capital costs is estimated at approximately $14.3 million, including costs associated with installing the two new CHP units, the biogas unit and anaerobic digester, associated microgrid infrastructure (controls, communication systems, information technology, etc.), and AMI meters for all customers on the microgrid circuit. 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 $2.3 million, based on an annual cost of $200,000.

Variable Costs

A significant variable cost associated with the proposed project is the cost of natural gas to fuel operation of the system's two CHP units.[1] 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.[2] Based on these figures, the present value of the project's fuel costs over a 20-year operating period is estimated to be approximately $15.6 million.

In addition to fuel costs, the analysis of variable costs considers the environmental damages associated with pollutant emissions from the distributed energy resources (DERs) 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 DERs are estimated at approximately $598,000 annually. The majority of these damages are attributable to the emission of CO_2. Over a 20-year operating period, the present value of emissions damages is estimated at approximately $9.2 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 $16.2 million; this estimate takes into account both the electricity that the microgrid's DERs would produce and an anticipated reduction in annual electricity use at the facilities the CHP units would serve.[3] The reduction in demand for electricity from bulk energy suppliers would also reduce their pollutant emissions, yielding emissions allowance cost savings with a present value of approximately $9,000 and avoided emissions damages with a present value of approximately $13.2 million.[4]

In addition to the savings noted above, development of a microgrid could yield cost savings by avoiding or deferring the need to invest in expansion of the conventional grid's energy generation or distribution capacity.[5] Based on the capacity of the system's backup generators, the application of standard capacity factors to the CHP and biogas units, and the anticipated impact of the AMI meters, the analysis estimates the present value of the project's generating capacity benefits to be approximately $6.9

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[1] The biogas generator would be fueled by gas produced by the anaerobic digester, at no additional cost.

[2] 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.

[3] The project's consultants estimate the annual reduction in electricity consumption at approximately 1,000 MWh.

[4] Following the New York Public Service Commission's (PSC) guidance for benefit cost analysis, the model values emissions of CO_2 using the social cost of carbon (SCC) developed by the U.S. Environmental Protection Agency (EPA). [See: State of New York Public Service Commission. Case 14-M-0101, Proceeding on Motion of the Commission in Regard to Reforming the Energy Vision. Order Establishing the Benefit Cost Analysis Framework. January 21, 2016.] Because emissions of SO_2 and NO_x from bulk energy suppliers are capped and subject to emissions allowance requirements in New York, the model values these emissions based on projected allowance prices for each pollutant.

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

million over a 20-year operating period. The analysis anticipates no impact on distribution capacity requirements.

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 $375,000 per year, with a present value of $4.2 million over a 20-year operating period. This estimate was 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:[1]

- System Average Interruption Frequency Index (SAIFI) – 1.03 events per year.
- Customer Average Interruption Duration Index (CAIDI) – 118.2 minutes.[2]

The estimate takes into account the number of customers the project would serve; the distribution of these customers by economic sector; average annual electricity usage per customer, as provided by the project team; and the prevalence of backup generation among these customers. In the case of the Bath microgrid, it also takes into account the limits of the system's generating capacity, which would supply roughly 40 percent of the average energy requirements of the customers on the circuit. In addition, the analysis considers the variable costs of operating backup generators at critical facilities, 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.[3] It assumes that establishment of a microgrid would reduce the rate of failure to near zero.

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

Summary

The analysis of Scenario 1 yields a benefit/cost ratio of 0.9; 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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[1] www.icecalculator.com.
[2] The analysis is based on DPS's reported 2014 SAIFI and CAIDI values for New York State Electric and Gas.
[3] http://www.businessweek.com/articles/2012-12-04/how-to-keep-a-generator-running-when-you-lose-power#p1.

Scenario 2

Benefits in the Event of a Major Power Outage

As previously noted, the estimate of reliability benefits presented in Scenario 1 does not include the benefits of maintaining service during outages caused by major storm events or other factors generally considered beyond the control of the local utility. These types of outages can affect a broad area and may require an extended period of time to rectify. To estimate the benefits of a 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.[1,2]

Bath's proposed microgrid project would serve a number of critical facilities during an extended outage. The project's consultants indicate that at present, several of these facilities are equipped with backup generators, while several others would rent them. Table 22 summarizes the estimated cost of operating these generators; the estimate of daily operating costs includes the cost of fuel as well as other daily costs of operation. Table 22 also indicates the expected loss in service capabilities while relying on these units, and the loss in service capabilities that would occur should these units fail. The critical facilities that are not listed in table 22 are not equipped with backup generators, and were not identified as likely to rent a backup generator in the event of an outage. The project team indicates that these facilities would experience a total loss in service capabilities during an outage.

[1] 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.

[2] 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.

Table 23. Costs and Level of Service Maintained by Current Backup Generators, Scenario 2

Facility	Operating Costs ($/Day)		Percent Loss In Service Capabilities During An Outage	
	One-Time ($)	Ongoing ($/Day)	With Backup Power	Without Backup Power
Bath Volunteer Fire Department	$300	$273	40%	100%
Bath Wastewater Treatment Plant	$300	$900	40%	100%
V.E. Wightman School[1]	$500	$2,800	40%	100%
Haverling High School	$300	$843	40%	100%
Steuben County Office Building	$300	$1,200	40%	100%
BEGWS Administrative Offices[2]	$600	$699	40%	100%
Bath Municipal Building/Bath Police Department	$300	$700	40%	100%
Steuben Center for Rehabilitation and Health Care	$500	$2,159	20%	100%
Steuben County Jail and 911 Call Center	$300	$3,186	20%	100%

The project team has identified two additional emergency measures that may be necessary in the event of an outage. First, the backup generator at Haverling High School lacks sufficient capacity to heat the building adequately. As a result, the school is unable to serve as an emergency shelter during heating season (October through March). Any residents who require shelter during this period would need to be evacuated to a shelter in another community. The estimated cost of such an evacuation is $1,500. Second, the generator at the Steuben Center for Rehabilitation and Health Care is also too small to heat the facility. As a result, the residents of the Center would require evacuation during heating season, at an estimated cost of $1,500.

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

- The facilities listed in table 23 would rely on their existing backup generators or on rented generators, experiencing the specified loss in service capabilities while these generators operate. If their backup generators fail, these facilities would experience a total loss of service.
- The remaining critical facilities would experience a 100 percent loss in service capabilities.
- The high school would be capable of sheltering residents only while its backup generator operates, and even then only during outages that occur from April through September. If an outage occurs during heating season – or if the backup generator fails at any time – all residents who require shelter would be evacuated, at a one-time cost of $1,500.

[1] It would only be necessary to operate the generator at the Wightman School on weekdays. Because the analysis models the impact of an outage on Haverling High School in its capacity as an emergency shelter, it assumes that the generator at the high school would operate seven days a week.

[2] The BEGWS facility is equipped with two backup generators. The costs reported here include those for operating both.

- Similarly, the rehabilitation center would be able to house its residents only while its backup generator operates, and even then only during outages that occur from April through September. If an outage occurs during heating season – or if the backup generator fails at any time – its residents would be evacuated, at a one-time cost of $1,500.
- In all cases, the supply of fuel necessary to operate the backup generators would be maintained indefinitely.
- In all cases, there is a 15 percent chance that the backup generator would fail.

The consequences of a major power outage also depend on the economic costs of a sustained interruption of service at the facilities the microgrid would serve. The analysis calculates the impact of a loss in fire, emergency medical, police, wastewater treatment, and water supply services using standard FEMA methodologies. For Haverling High School, the analysis assigns a cost of approximately $25,000 per day. This figure is based on an estimate of the facility's shelter capacity (500 people) and American Red Cross data on the cost of providing overnight shelter ($50/person/day).[1] The impact of a loss in service at other facilities is based on the value of service estimates shown in table 4. These figures were estimated using the Department of Energy's ICE Calculator.[2] The values are based on the following factors:

- For critical facilities – the nature of the facility, its estimated annual use of electricity, and the presence or absence of a backup generator at the site;
- For non-critical loads – 3,000 residential customers, 100 medium/large commercial and industrial customers, and 70 small commercial and industrial customers, with average annual electricity consumption set to the ICE Calculator's New York State default value for each sector.
- For all non-critical commercial and industrial customers – use of the ICE Calculator's state-specific default values for the distribution of customers by industry and the percentage of customers equipped with backup generators.

[1] American Red Cross, Fundraising Dollar Handles for Disaster Relief Operations, Revised March 2014 – based on FY14 Figures.
[2] http://icecalculator.com/

Table 24. Value of Maintaining Service, Scenario 2

Facility	Value Per Day
V.E. Wightman School	$140,000
Steuben County Office Building	$113,000
BEGWS Administrative Offices	$32,700
Bath Municipal Building	$30,500
Steuben Center for Rehabilitation and Health Care	$123,000
Steuben County Jail and 911 Call Center	$122,000
Bath Village Street Department	$26,900
BEGWS Pit Garage Room	$33,100
Residential Customers	$131,000
Other Large/Medium Commercial & Industrial Customers (Non-Critical)	$1,180,000
Other Small Commercial & Industrial Customers (Non-Critical)	$9,930,000

As previously noted, the Bath project's distributed energy resources would only be capable of supporting approximately 40 percent of the average energy requirements of customers on the microgrid circuit. The analysis takes this into account in evaluating the benefits of the project in the event of an extended outage. It estimates these benefits at approximately $5.0 million per day.

Summary

Figure 40 and table 25 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 0.1 days per year without power. If the average annual duration of the outages the microgrid prevents is less than this figure, its costs are projected to exceed its benefits.

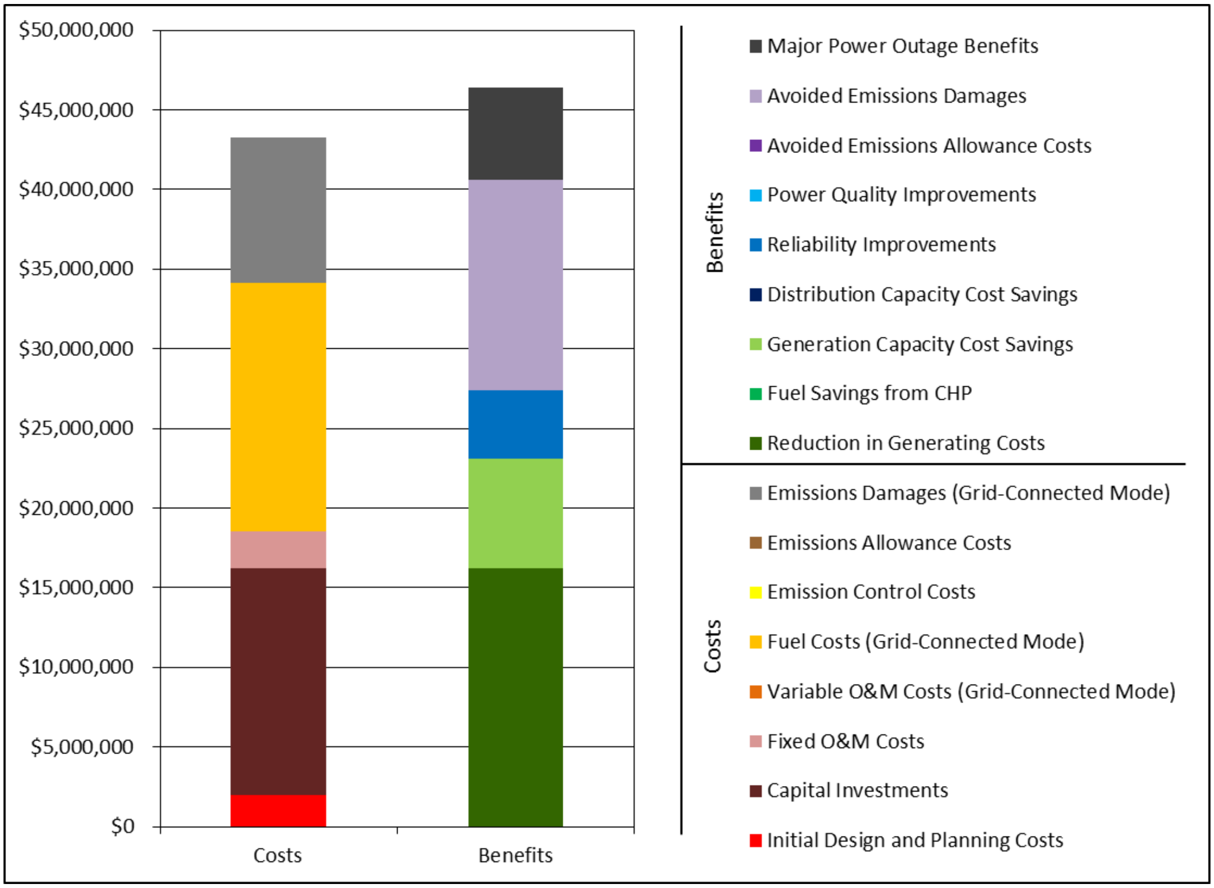

Figure 40. Present Value Results, Scenario 2 (Major Power Outages Averaging 0.1 Days/Year; 7 Percent Discount Rate)

Table 25. Detailed BCA Results, Scenario 2 (Major Power Outages Averaging 0.1 Days/Year; 7 Percent Discount Rate)

Cost or Benefit Category	Present Value Over 20 Years (2014$)	Annualized Value (2014$)
Costs		
Initial Design and Planning	$2,000,000	$176,000
Capital Investments	$14,300,000	$1,160,000
Fixed O&M	$2,270,000	$200,000
Variable O&M (Grid-Connected Mode)	$0	$0
Fuel (Grid-Connected Mode)	$15,600,000	$1,380,000
Emission Control	$0	$0
Emissions Allowances	$0	$0
Emissions Damages (Grid-Connected Mode)	$9,160,000	$598,000
Total Costs	**$43,300,000**	
Benefits		
Reduction in Generating Costs	$16,200,000	$1,430,000
Fuel Savings from CHP	$0	$0
Generation Capacity Cost Savings	$6,920,000	$611,000
Distribution Capacity Cost Savings	$0	$0
Reliability Improvements	$4,250,000	$375,000
Power Quality Improvements	$0	$0
Avoided Emissions Allowance Costs	$8,890	$784
Avoided Emissions Damages	$13,200,000	$862,000
Major Power Outage Benefits	$5,740,000	$506,000
Total Benefits	**$46,300,000**	
Net Benefits	**$3,040,000**	
Benefit/Cost Ratio	**1.1**	
Internal Rate of Return	**8.4%**	

Conclusions and Recommendations

Observations and Findings

The conclusion of this NY Prize Phase 1 Feasibility Study is a clear recommendation that the Village of Bath pursue the development of a full-scale microgrid. The existence of a project champion, Guy Hallgren, and projects that are underway or shovel-ready, greatly increase the likelihood of the project's success. At the onset of the project, Bath had already approved the construction of an anaerobic digester at the wastewater plant, an AMI pilot project, and a complete distribution system upgrade. The pieces have been in place from the beginning, and have facilitated a smooth transition from multiple electric system projects into one larger system-wide microgrid project that combines the existing upgrades.

The project team has observed two primary leverage points that have made this project successful in terms of planning and public buy-in. First and foremost is the recent history of extreme events and long outages. The residents and officials in Bath are well aware of the consequences of poor network resiliency. This has led to an outpouring of public support for the project and additional input to the reports that have been very valuable to the project team. The second point is the existence of pre-planned, shovel-ready projects in the Village. Guy Hallgren and the BEGWS staff have pursued numerous cost-saving and resiliency improving initiatives in Bath since it became clear in 2014 that network upgrades were necessary. The NY Prize program provided a platform for the village to pursue a system-level marriage of these projects into a viable microgrid that will be controlled by the very entity that already controls the local distribution network. It is highly recommended that this project move forward in future rounds of planning, design, and construction to determine the project's full potential.

Results and Lessons Learned

The results of this project are a recommendation for the Village of Bath to construct a 3 MW CHP-driven microgrid. The anaerobic digester is key to the whole project due to the efficiency improvement over the current wastewater system and the production of renewable biogas to be used in one of the microgrid generators. In addition to the 700 kW biogas generator at the wastewater plant, another 1.3 MW natural gas CHP generator will be sited there as well, necessitated by the electric and heating requirements of the wastewater plant and nearby loads. A final 1 MW natural gas CHP generator will be sited at one of the other critical facilities, though the exact location has yet to be decided. Possible options include the High School, Jail, or County Facilities.

A key lesson learned in this project was that a community energy project such as this takes a significant time and cost commitment up front to get the project moving. Data collection can be costly when data is not available in the current system, and meetings for information and public support take time to plan and schedule. Identifying key players early on in the project is crucial, and will aid in the overall efficiency in creating the final product. In time and cost constrained projects it is also imperative to maintain focus on the main points of the projects to ensure they get completed. For example, in Bath it was important to get detailed information on the existing plans for the wastewater plant and CHP development, so the project team sacrificed the ability to explore additional options for solar and energy storage at a few local sites. These smaller, less critical options may be explored as a separate project, or as part of Phase 2 of NY Prize.

Project Benefits and Implementation Scenarios

Without the assumption of additional outage time in Bath, the Bath Community Microgrid is extremely close to economic viability on its own. Also, the additional benefits provided by the AMI project are expected to open new business options for BEGWS as a demand aggregator for their service area. This additional benefit is difficult to quantify, but could easily swing the project into economic viability if the plan is enacted.

Possibly the most important benefit of this project is a piece of mind for the people of the Village. Reliance on electric heat and a lack of backup power in the Village has left a key pain point in the Village unaddressed. Because of this, outages in Bath remain a serious public safety hazard, and the Bath Community Microgrid will solve most, if not all, of the existing resiliency issues.

Portions of this project are expected to proceed as planned with or without the support of additional grant funding. These include the anaerobic digester, including the 700 kW biogas generator on-site, and the AMI upgrade. However, the construction of the full microgrid project, including the additional CHP generators and the master controller, and the societal benefits that come with it, will likely be dependent on the additional grant support from the NY Prize program or similar grant programs. This dependence is primarily due to the low income nature of the Village, as well as the limited tax base that is the result of serving as the County seat of Steuben County.

Disclaimer

The intent of this analysis report is to assess the technical, legal, and financial feasibility of community microgrid and estimate energy savings and additional revenue generation associated with the recommended upgrades to your facilities. Appropriate detail is included to help you make decisions about building community microgrid. However, this report is not intended to serve as a detailed engineering design document, as the improvement descriptions are diagrammatic in nature only, in order to document the basis of cost estimates and savings and to demonstrate the feasibility of constructing the improvements. Detailed design efforts may be required to fully understand the benefits and challenges you may encounter and to implement several of the improvements evaluated as part of this analysis.

While the recommendations in this report have been reviewed for technical accuracy, and we believe they are reasonable and accurate, the findings are estimates and actual results may differ. As a result, Willdan Energy Solutions is not liable if projected, estimated savings or economies are not actually achieved. All savings and cost estimates in the report are for informational purposes and are not to be construed as design documents or guarantees.

In no event will Willdan Energy Solutions be liable for the failure of the customer to achieve a specified amount of savings, for the operation of customer's facilities, or for any incidental or consequential damages of any kind in connection with this report or the installation of the recommended measures.

Acknowledgement

This project is financially supported by the New York State Energy Research and Development Authority. On behalf of the members of this project, Willdan would like to thank Mike Razanousky, NYSERDA Project Manager, for making this work possible. Willdan would also like to thank the Bath Electric Department project sponsors and staff that supported this project as well as the Village of Bath. The cost benefit analysis portion of the project was completed by Industrial Economics Inc. The many tasks of this work could not have been completed without the dedicated effort of Schuyler Matteson, Project Manager, Mehdi Ganji, Technical Lead, Patrick Burgess, Technical Project Manager, Dr. Wei Tian, Lead Engineer, Lisa Vedder, Financial and Regulatory Lead.

Appendix

Microgrid Questionnaire

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**

B. **Capacity Impacts**

C. **Project Costs**

D. **Environmental Impacts**

E. **Ancillary Services**

F. **Power Quality and Reliability**

G. **Other Information**

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

Microgrid site: 66. Village of Bath

Point of contact for this questionnaire:

Name: Guy Hallgren, Bath Electric Gas & Water Systems

Address: Bath, NY 14810

Telephone: 607-776-3072

Email: ghallgren@begws.com

A. Project Overview, Energy Production, and Fuel Use

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

- **Facility name:** Please enter the name of each facility the microgrid would serve. Note that a single **facility** may include multiple **customers** (e.g., individually-metered apartments within a multi-family apartment building). When this is the case, you do not need to list each customer individually; simply identify the facility as a whole (see Table 1, "Main Street Apartments," for an example).
- **Rate class:** Select the appropriate rate class for the facility from the dropdown list. Rate class options are residential, small commercial/industrial (defined as a facility using less than 50 MWh of electricity per year), or large commercial/industrial (defined as a facility using 50 or more MWh of electricity per year).
- **Facility/customer description:** Provide a brief description of the facility, including the number of individual customers at the facility if it includes more than one (e.g., individually-metered apartments within a multi-family apartment building). For commercial and industrial facilities, please describe the type of commercial/industrial activity conducted at the facility.
- **Economic sector:** Select the appropriate economic sector for the facility from the dropdown list.
- **Average annual usage:** Specify the average annual electricity usage (in MWh) **per customer**. Note that in the case of facilities with multiple, similar customers, such as multi-family apartment buildings, this value will be different from average annual usage for the facility as a whole.
- **Peak demand:** Specify the peak electricity demand (in MW) **per customer**. Note that in the case of facilities with multiple, similar customers, such as multi-family apartment buildings, this value will be different from peak demand for the facility as a whole.
- **Percent of average usage the microgrid could support in the event of a major power outage:** Specify the percent of each facility's typical usage that the microgrid would be designed to support in the event of a major power outage (i.e., an outage lasting at least 24 hours that necessitates that the microgrid operate in islanded mode). In many cases, this will be 100%. In some cases, however, the microgrid may be designed to provide only enough energy to support critical services (e.g., elevators but not lighting). In these cases, the value you report should be less than 100%.
- **Hours of electricity supply required per day in the event of a major power outage:** Please indicate the number of hours per day that service to each facility would be maintained by the microgrid in the event of a major outage. Note that this value may be less than 24 hours for some facilities; for example, some commercial facilities may only require electricity during business hours.

Facility Name	Rate Class	Facility/Customer Description (Specify Number of Customers if More Than One)	Economic Sector Code	Average Annual Electricity Usage Per Customer (kWh)	Peak Electricity Demand Per Customer (kW)	Percent of Average Usage Microgrid Could Support During Major Power Outage	Hours of Electricity Supply Required Per Day During Major Power Outage
VE Wightman School	*Large Commercial/Industrial (>50 annual MWh)*	*School*	*Residential*	2,588,800	632	*40%*	*8 hours winter, 12 hours summer*
Haverling High School	Large Commercial/Industrial (>50 annual MWh)	School	*All other industries*	556,480	160	*40%*	*8 hours winter, 12 hours summer*
BEGWS Maple Heights Water Tank	Small Commercial/Industrial (<50 annual MWh)	Municipal Services	*All other industries*	134	5	*40%*	*8 hours winter, 12 hours summer*
BEGWS Well #6	Large Commercial/Industrial (>50 annual MWh)	Municipal services	*All other industries*	61,240	26	*40%*	*8 hours winter, 12 hours summer*
Steuben County Office Bldg	*Large Commercial/Industrial (>50 annual MWh)*	*Government Building*	*All other industries*	1,554,800	549	*40%*	*8 hours winter, 12 hours summer*
Bath Village Street Department	Large Commercial/Industrial (>50 annual MWh)	*Government Building*	*All other industries*	54,840	16	*40%*	*8 hours winter, 12 hours summer*
BEGWS Pit Garage Room	Large Commercial/Industrial (>50 annual MWh)	Municipal services	*All other industries*	88,480	20	*40%*	*8 hours winter, 12 hours summer*

Facility Name	Rate Class	Facility/Customer Description (Specify Number of Customers if More Than One)	Economic Sector Code	Average Annual Electricity Usage Per Customer (kWh)	Peak Electricity Demand Per Customer (kW)	Percent of Average Usage Microgrid Could Support During Major Power Outage	Hours of Electricity Supply Required Per Day During Major Power Outage
BEGWS Administrative Offices	Large Commercial/Industrial (>50 annual MWh)	Municipal services	*All other industries*	85,757	23	*40%*	*8 hours winter, 12 hours summer*
Bath Municipal Building	Large Commercial/Industrial (>50 annual MWh)	Municipal services	*All other industries*	73,440	22	*40%*	*8 hours winter, 12 hours summer*
Steuben Ctr for Rehab & Healthcare	Large Commercial/Industrial (>50 annual MWh)	Healthcare	*All other industries*	1,917,600	432	*40%*	*8 hours winter, 12 hours summer*
Steuben County Jail & 911 Call Ctr	Large Commercial/Industrial (>50 annual MWh)	Emergency	*All other industries*	1,858,800	396	*40%*	*8 hours winter, 12 hours summer*
BEGWS Mt. Washington Tank	Small Commercial/Industrial (<50 annual MWh)	Municipal services	*All other industries*	648	4	*40%*	*8 hours winter, 12 hours summer*
Wastewater Treatment Plant	Large Commercial/Industrial (>50 annual MWh)	Municipal services	*All other industries*	1,233,200	176	*40%*	*8 hours winter, 12 hours summer*
Bath Volunteer Fire Dept	Large Commercial/Industrial (>50 annual MWh)	Emergency	*All other industries*	237,880	115	*40%*	*8 hours winter, 12 hours summer*
Bath Ambulance Corporation	Small Commercial/Industrial (<50 annual MWh)	Government	*All other industries*	20,759	12	*40%*	*8 hours winter, 12 hours summer*

Facility Name	Rate Class	Facility/Customer Description (Specify Number of Customers if More Than One)	Economic Sector Code	Average Annual Electricity Usage Per Customer (kWh)	Peak Electricity Demand Per Customer (kW)	Percent of Average Usage Microgrid Could Support During Major Power Outage	Hours of Electricity Supply Required Per Day During Major Power Outage
BEGWS Sewer Pump	Small Commercial/Industrial (<50 annual MWh)	Municipal services	*All other industries*	5,949	10	*40%*	*8 hours winter, 12 hours summer*
Total				**10,338,807**	**2,567.00**	**40%**	

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
New Generator	*Proposed 301 Feeder CHP*	*Natural Gas CHP*	*1000 kW*	*8400 MWh*	*24*	*10.1*	*Mcf*
New Generator	Proposed 203 Feeder CHP	Natural Gas CHP	1300 kW	10920 MWh	31.2	10.1	Mcf
New Generator	Proposed 203 Digester	Anaerobic Digester Biogas	700 kW	5880 MWh	16.8	10.1	Mcf
Existing Gen 1	High School	Natural Gas	430 kW	1.5 MWh	10.3	11	Mcf
Existing Gen 2	BEGWS Office	Diesel	110 kW	.5 MWh	2.6	70	Gallons
Existing Gen 3	BEGWS Office	Natural Gas	125 kW	.5 MWh	3	11	Mcf
Existing Gen 4	County CRH	Diesel	800 kW	3 MWh	19.2	70	Gallons
Existing Gen 5	Jail/911	Diesel	1199 kW	5 MWh	28.8	70	Gallons
Existing Gen 6	Fire Dept.	Natural Gas	100 kW	.5 MWh	2.4	11	Mcf

[1] Source for Diesel Consumption: Cummins specifications and sizing chart www.cumminspower.com and http://www.dieselserviceandsupply.com/Diesel_Fuel_Consumption.aspx

[2] Source for Natural Gas Consumption: http://www.dieselserviceandsupply.com/Natural_Gas_Fuel_Consumption.aspx. Fuel consumption is based on 1015 Btu/standard ft^3 natural gas

[3] Source for CHP Natural Gas Consumption: http://www.epa.gov/sites/production/files/2015-07/documents/fuel_and_carbon_dioxide_emissions_savings_calculation_methodology_for_combined_heat_and_power_systems.pdf

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?
New Generator	*Proposed 301 Feeder CHP*	*1000 kW*	☐ Yes
Backup Generator	High School	430 kW	☐ Yes
Backup Generator	*BEGWS Office*	*110 kW*	☐ Yes
Backup Generator	*BEGWS Office*	125 kW	☐ Yes
Backup Generator	County CRH	800 kW	☐ Yes
Backup Generator	Jail and 911	1199 kW	☐ Yes
New Generator	Proposed 203 Feeder CHP	1300 kW	☐ Yes
New Generator	Proposed 203 Digester	700 kW	☐ Yes
Backup Generator	Fire Department	100 kW	☐ Yes
			☐ Yes
			☐ Yes

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

Participation in a Demand Response Program

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

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

Facility Name	Capacity Participating in Demand Response Program (MW/year)	
	Following Development of Microgrid	Currently
Proposed 301 Feeder CHP	*1000 kW*	
High School	430 kW	
BEGWS Office	*110 kW*	
BEGWS Office	125 kW	
County CRH	800 kW	
Jail and 911	1199 kW	
Proposed 203 Feeder CHP	1300 kW	
Proposed 203 Digester	700 kW	
Fire Department	100 kW	

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

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

Impact of Microgrid on Utility Distribution Capacity	Unit

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
3 MW CHP	$8,000,000	25	7 days Islanded Mode, 40% load curtailment, 2300 kW CHP, 700 kW Digester
4000 AMI meters	$4,500,000	25	Switching all meters to AMI
Infrastructure Upgrade	$1,750,000	20	Master Controller and additional substation upgrades

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?
$2,000,000	Planning, engineering design, permits

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?
200,000	operation and maintenance

Please proceed to Question 14.

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

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).

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 (12x7xMBtu/hr, 60%efficiency)	Unit
New Generator	*Proposed 301 Feeder CHP*	*7*	*764232*	MMBtu
New Generator	Proposed 203 Feeder CHP	Indefinite	993552	MMBtu/week
New Generator	Proposed 203 Digester	Indefinite	535080	MMBtu/week
Existing Gen 1	High School	.5	23484	MMBtu
Existing Gen 2	BEGWS Office	.5	6012	MMBtu
Existing Gen 3	BEGWS Office	.5	6828	MMBtu
Existing Gen 4	County CRH	.5	43680	MMBtu
Existing Gen 5	Jail/911	.5	65460	MMBtu
Existing Gen 6	Fire Dept.	.5	5460	MMBtu

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

☒ Yes – proceed to Question 17

☐ No – proceed to Question 18

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

Type of Fuel Offset by New CHP System	Annual Energy Savings Relative to Current Heating System	Unit
Diesel	1200.2	MMBtu
Natural gas	857.5	MMBtu
Choose an item.		Choose an item.
Choose an item.		Choose an item.
Choose an item.		Choose an item.

Emissions Control Costs

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

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

☐ Yes

☒ No

D. *Environmental Impacts*

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

Emissions Type	Emissions per MWh	Unit (Ton/hr of operation of 3MW microgrid)
CO_2	4835	Ton/hr
SO_2	228.08	Ton/hr
NO_x	6.39	Ton/hr
PM		Choose an item.

E. *Ancillary Services*

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

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

F. *Power Quality and Reliability*

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

☐ Yes – proceed to Question 23

☒ No – proceed to Question 24

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

24. The benefit-cost analysis model will characterize the potential reliability benefits of a microgrid based, in part, on standard estimates of the frequency and duration of power outages for the local utility. In the table below, please estimate your local

utility's average **outage frequency per customer** (system average interruption frequency index, or SAIFI, in events per customer per year) and average **outage duration per customer** (customer average interruption duration index, or CAIDI, in hours per event per customer).

For reference, the values cited in the Department of Public Service's 2014 Electric Reliability Performance Report are provided on the following page. If your project would be located in an area served by one of the utilities listed, please use the values given for that utility. If your project would be located in an area served by a utility that is not listed, please provide your best estimate of SAIFI and CAIDI values for the utility that serves your area. In developing your estimate, please *exclude* outages caused by major storms (a major storm is defined as any storm which causes service interruptions of at least 10 percent of customers in an operating area, and/or interruptions with duration of 24 hours or more). This will ensure that your estimates are consistent with those provided for the utilities listed on the following page.[1]

Estimated SAIFI	Estimated CAIDI
1.34	2.97

[1] The DPS service interruption 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 Con Edison's underground network system). SAIFI and CAIDI 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. The BCA model treats the benefits of averting lengthy outages caused by major storms as a separate category; therefore, the analysis of reliability benefits focuses on the effect of a microgrid on SAIFI and CAIDI values that exclude outages caused by major storms.

SAIFI and CAIDI Values for 2014, as reported by DPS

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

G. *Other Information*

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

The proposed microgrid includes 700 kW of CHP that will be fed exclusively from the anaerobic digester located at the Bath wastewater treatment plant/resource recovery hub. Also, the AMI systems are to be used for load shedding and demand response aggregation to create additional savings of $750,000 - $1,000,000 per year for BEGWS. The negligible cost of fuel for the 700 kW CHP and the cost savings from AMI are important parameters to the benefit cost model for this microgrid.

Facility Questionnaire

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.

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

Microgrid site: 66. Village of Bath

Point of contact for this questionnaire:

Name: Guy Hallgren, Bath Electric Gas & Water Systems

Address: Bath, NY 14810

Telephone: 607-776-3072

Email: ghallgren@begws.com

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)	Standard Operating Capacity (%)	Avg. Daily Production During Power Outage (MWh/Day)	Fuel Consumption per Day		One-Time Operating Costs ($)	Ongoing Operating Costs ($/Day)
						Quantity	Unit		
Haverling High School	Unit 1	Natural Gas	430 kW	100	10.3	104	mcf	$300	$100
BEGWS Office	*Unit 2*	*Diesel*	*110 kW*	*100*	*2.6*	*182*	*Gl/ Day*	$300	$100
BEGWS Office	*Unit 3*	Natural Gas	125 kW	100	3	30	mcf	$300	$100
County CRH	Unit 4	Diesel	800 kW	100	19.2	1344	Gl/day	$300	$100
Jail and 911	Unit 5	Diesel	1199 kW	100	28.8	2016	Gl/day	$300	$100
Fire Department	Unit 6	Natural Gas	100 kW	100	2.4	24	mcf	$300	$100

"Typical availability factors range from 60% to 85% or more depending on technology and maintenance routines. Furthermore, when offering regulation service into the market the portion so committed could not be used for generation (i.e., to sell retail power)."

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?
Haverling High School	*One-Time Measures*	*Evacuating and moving residents (uo to 500 people)*	*1,500*	*$*	*Only necessary during winter months (October through March) because existing backup generator is not able to provide sufficient heating*
Haverling High School	*Ongoing Measures*	*Housing residents at alternative facilities*	*5,000*	*$/day*	*Only necessary during winter months (October through March) because existing backup generator is not able to provide sufficient heating*

Facility Name	Type of Measure (One-Time or Ongoing)	Description	Costs	Units	When would these measures be required?
Steuben Ctr for Rehab & Healthcare	*One-Time Measures*	*Evacuating and moving residents*	*1,500*	*$*	*Only necessary during winter months (October through March) because existing backup generator is not able to provide sufficient heating*
Steuben Ctr for Rehab & Healthcare	*Ongoing Measures*	*Housing residents at alternative facilities*	*5,000*	*$/day*	*Only necessary during winter months (October through March) because existing backup generator is not able to provide sufficient heating*

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.

Facility Name	Type of Measure (One-Time or Ongoing)	Description	Costs	Units	When would these measures be required?
VE Wightman School	*One-Time Measures*	*Hooking up additional portable generator*	*500*	*$*	*Year-round, but only necessary five days per week*

Facility Name	Type of Measure (One-Time or Ongoing)	Description	Costs	Units	When would these measures be required?
VE Wightman School	*Ongoing Measures*	*Renting additional portable generator*	*2,800*	*$/day*	*Year-round, but only necessary five days per week*
Haverling High School	*One-Time Measures*	*Hooking up additional portable generator*	*300*	*$*	*Year-round, but only necessary five days per week*
Haverling High School	*Ongoing Measures*	*Renting additional portable generator*	*1,560*	*$/day*	*Year-round, but only necessary five days per week*
Steuben County Office Bldg	*One-Time Measures*	*Hooking up additional portable generator*	*300*	*$*	*Year-round*
Steuben County Office Bldg	*Ongoing Measures*	*Renting additional portable generator*	*1,200*	*$/day*	*Year-round*
BEGWS Administrative Offices	*One-Time Measures*	*Hooking up additional portable generator*	*300*	*$*	*Year-round*
	Ongoing Measures	*Renting additional portable generator*	*600*	*$/day*	*Year-round*
Bath Municipal Building	*One-Time Measures*	*Hooking up additional portable generator*	*300*	*$*	*Year-round*
	Ongoing Measures	*Renting additional portable generator*	*700*	*$/day*	*Year-round*
Steuben Ctr for Rehab & Healthcare	*One-Time Measures*	*Hooking up additional portable generator*	*500*	*$*	*Year-round*
	Ongoing Measures	*Renting additional portable generator*	*2,800*	*$/day*	*Year-round*
Steuben County Jail & 911 Call Ctr	*One-Time Measures*	*Hooking up additional portable generator*	*500*	*$*	*Year-round*
	Ongoing Measures	*Renting additional portable generator*	*9,000*	*$/day*	*Year-round*
Wastewater Treatment Plant	*One-Time Measures*	*Hooking up additional portable generator*	*300*	*$*	*Year-round*
	Ongoing Measures	*Renting additional portable generator*	*900*	*$/day*	*Year-round*

Facility Name	Type of Measure (One-Time or Ongoing)	Description	Costs	Units	When would these measures be required?
Bath Volunteer Fire Dept	*One-Time Measures*	*Hooking up additional portable generator*	*300*	*$*	*Year-round*
	Ongoing Measures	*Renting additional portable generator*	*500*	*$/day*	*Year-round*

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.

Facility Name	Percent Loss in Services When Using Backup Gen.
Haverling High School	40%
BEGWS Office	40%
BEGWS Office	40%
County CRH	20%
Jail and 911	20%
Wastewater Plant	40%
Fire Department	40%

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 Using Backup Gen.
VE Wightman School	100%
Bath Ambulance Corporation	100%
Bath Municipal Building	100%
Steuben County Office Bldg	100%

B. *Questions for facilities that provide**: Fire Services***

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

12500

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

25%

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

Kanona Fire Department: 4.7 miles, Savona Fire Department: 6.2 miles

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

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

6500

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:

30%

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

Rural/Metro Medical Services 26 miles , Yates County Emergency Management: 26 miles

D. Questions for facilities that provide: Hospital Services

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

6500

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

St James Mercy Hospital (aprox 32 miles)

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

15000

E. Questions for facilities that provide: Police Services

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

6500

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

☐ Metropolitan Statistical Area

☐ Non-Metropolitan City

☒ Non-Metropolitan County

19. Please estimate:

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

17

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

10

c. The <u>percent reduction</u> in service effectiveness during an outage.

50%

F. Questions for facilities that provide: Wastewater Services

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

8000

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?

8000

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.)?

Residential, apartments, nursing facilities, healthcare facilities, jail

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).

6500