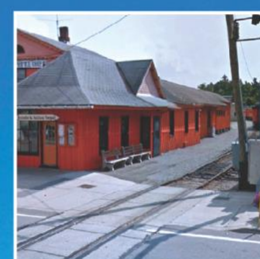
78 - Village of Arcade

August 2016

Notice

NY Prize Task 5 Milestone Deliverable:

Village of Arcade Final Report



Submit to:
NYSERDA
New York State Energy Research and Development Authority

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

Table of Contents

Tables

Figures

Executive Summary

Arcade Electric Department is proposing a feasibility study to implement a microgrid ("Arcade Community Microgrid") that is interconnected with the Arcade municipal electric distribution system. Arcade electric will act as the local electric distribution company, National fuel gas will serve as the gas distribution company during this feasibility study, and they will be joined by the Village of Arcade participating as the Local Government.

Arcade incurs additional cost liability when the community exceeds its NYPA kW and kWh allocation (25,000kW and 12,453,000 kWh respectively); most recently, Arcade incurred over $2,000,000 in 2014, a significant burden for a rural community with a limited tax base. The excess is largely due to residential electric heaters being operated in the cold winter months. In addition, Arcade's radial path distribution system is 50+ years old, exposing the community to risk due to outages and equipment failures. Willdan proposes a community microgrid for the Village of Arcade, which 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 microgrid is planned to be comprised of a 1.25 MW Combined Heat and Power (CHP) generator at the high school, a 600 kW CHP generator at the elementary school, a 500 kW CHP generator at the wastewater plant, and a 250 kW battery storage system at the industrial park. The Village of Arcade's 21 critical loads will remain powered on while the microgrid is islanded. In addition to providing resiliency for critical loads, Willdan's proposed Arcade Community Microgrid could provide economic and reliability benefits for Arcade Electric Power's nearly 2,000 residential customers as well as maintain power for public street lighting and security lighting all across the Arcade area while the microgrid is islanded.

Due to the low cost of power in the Village of Arcade and the long-term reliability of their system, which includes the built-in redundancy of four substations and two separate ties to the macrogrid, this study has found that the costs of developing a full microgrid far outweigh the benefits. However, the study has also identified a potentially viable solar + battery storage project as part of a public private partnership between the Village and two industrial companies located there. Siting one 250 kW battery system paired with 40 kW of solar at each industrial plant, operated by the Village Electric Department, could provide the industrials with much-needed power quality and reliability. The solar + storage system could also provide additional revenue for the Village Electric Department through entry in demand response programs, ancillary service markets, and peak shaving. Section 2.3 outlines the current state of the project and, recommends further analysis be done to discover its full potential.

Task 1 – Description of Microgrid Capabilities

Table 1. Arcade Community Microgrid – Existing and Proposed Overview

Category	Existing Resources	Proposed/Suggested Improvement	Justification
Load	• Residential Electric Heat • 21 Critical facilities (3,020kW) • Monthly 25 MW and12,453MWh NYPA allocation • 41 MW Winter Peak	• Building Energy Efficiency • LED Street lighting • Load Curtailment • Winter Peak Shaving	• Resilience Reduced winter load • Reduce inefficiency
Distributed Energy Resources (DERs)	• 12 Backup Diesel Generators (1,135kW)	• Combined Heat and Power (CHP) • Anaerobic Digestion • Energy Storage • small-scale hydro	• Demand Response • Resilience • Renewable Sources • Reduced winter load
Electrical and Thermal Infrastructure	• Radial Path 8.32kV/12.47kV • Mostly overhead distributed cable	• 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	• SCADA • 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 Arcade 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 Arcade 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 Arcade, which will enhance the overall operational reliability of the electrical distribution system. By providing a master controller, the Arcade 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, 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 Arcade 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 Arcade 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 Arcade community microgrid with heat and power when it needs it most.

Load

Existing Resources

There are approximately 2,071 residents in Arcade[1]. The Village of Arcade is allotted 25 megawatts (MW) 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, Arcade depends on electricity for heating and it needs to purchase additional power to meet the demand. The demand can reach as high as 41 MW in the winter season. Also, the 105MW noble bliss wind farm relies on Arcade's system to deliver its wind power to the bulk grid. Figure 1 shows the monthly load demand in Arcade for the recent years. Figure 2 illustrates monthly kWh consumption profile of the Arcade system. The shape of the monthly kWh usage matches the Heating-Degree-Days (HDD) of the locality.

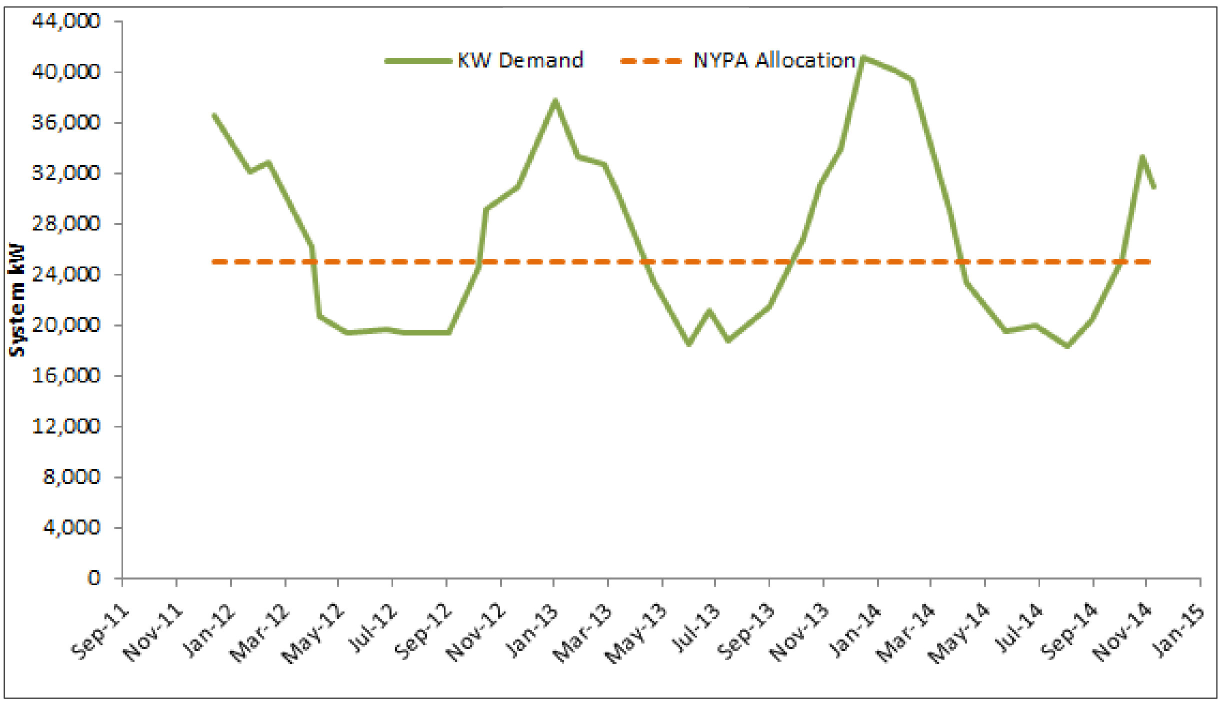


Figure 1. Load Demand Profile in Arcade

[1] 2010 Census, NYSERDA NY Prize Arcade Proposal.

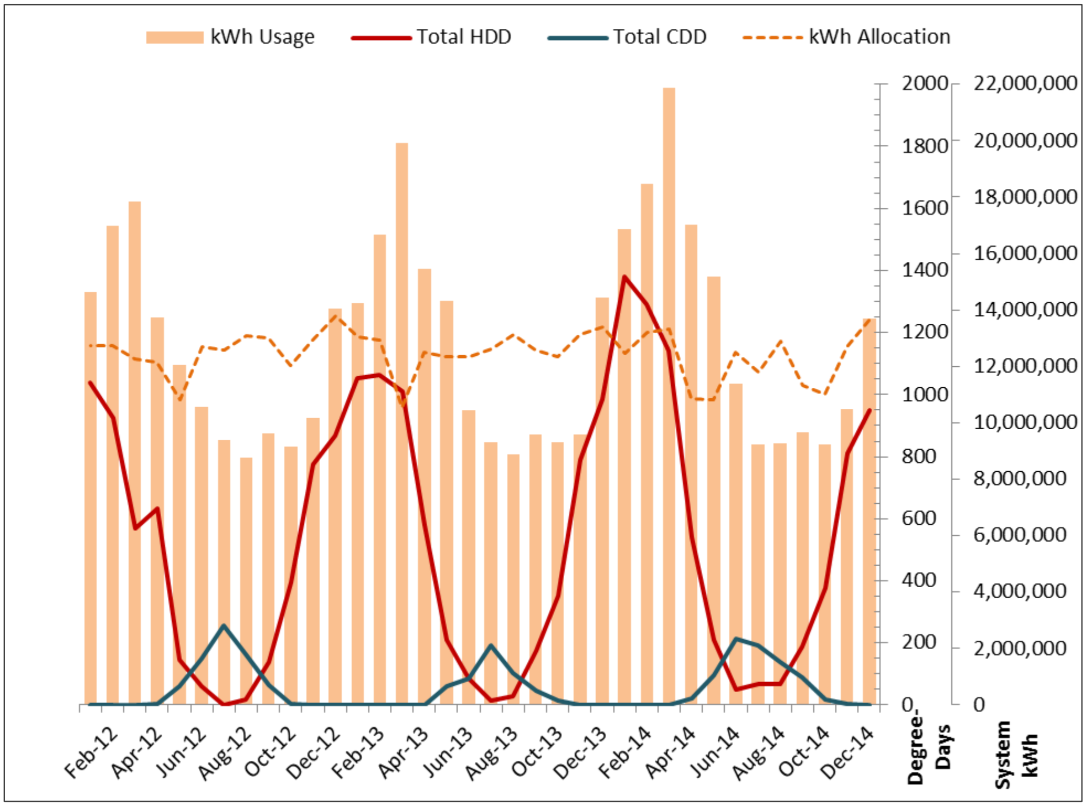


Figure 2. Arcade's Electric System kWh Profile (HDD: Heating-Degree-Days, CDD: Cooling-Degree Days)

The Village of Arcade's loads can be separated into the broad load categories, critical and non-critical, with critical facilities including the Arcade Village Office/Police, Arcade Sewage Plant, Pioneer High School, Arcade Elementary School, Arcade Fire Department, Arcade Sullivan Garage, Arcade Mill St. Garage, Arcade Sullivan Well, Arcade Sandusky Well, Arcade North Lift Station, Arcade West Lift Station, Arcade Manor, Garden Park Apartments, Early Bird Nursery, Rainbow's End Nursery, Yorkshire Fire Department, Town of Arcade Garage, Arcade Communication Tower, Wyoming County Communication Tower, Freedom Cell Tower, and Yorkshire Cell Tower, and non-critical facilities including the many other businesses and residential customers served by Arcade electric. The total critical load demand is about 3.02 MW. The detail load information for all the critical loads are shown in Table 2. The load demand in each facility can be further separated into the following load categories as shown in Table 1 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.

Arcade electric department has completed some energy efficiency projects which include: residential insulation replacement for the Village of Arcade; village-wide appliance replacement program; refrigerator replacement program, and; HVAC and lighting upgrades for residents.

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

Table 3. Critical Loads

Critical Facilities	Max KW	Total KWh
Arcade Village Office/Police	39	172,440
Arcade Sewage Plant	111	760,140
Pioneer High School	2,032	8,493,600
Arcade Elementary School	620	1,918,596
Arcade Fire Department	43	135,960
Arcade Sullivan Garage	39	151,260
Arcade Mill St. Garage	13	50,040
Arcade Sullivan Well	23	31,404
Arcade Sandusky Well	10	45,924
Arcade North Lift Station	0	3,720
Arcade West Lift Station	0	4,572
Arcade Manor	23	87,336
Garden Park Apartments	N/A	N/A
Early Bird Nursery	0	25,116
Rainbow's End Nursery	15	27,864
Yorkshire Fire Department	23	56,004
Town of Arcade Garage	14	36,063
Arcade Comm. Tower	0	20,772
Wyoming County Comm. Tower	0	14,172
Freedom Cell Tower	8	49,800
Yorkshire Cell Tower	7	31,428
Total	**3,020**	**12,116,221**

Consequences

Due to the peak demand during winter, many of Arcade'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 50+ year old system. The system is also entirely reliant on the NYSEG points 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 Arcade community exceeds its NYPA kW and kWh allocation. Arcade purchases retail energy from the whole sale market to cover its extra consumption. In 2014, Arcade incurred additional per-kWh costs at nearly 200% of the energy cost under NYPA allocations, over $2,000,000 in total.

Opportunities

Arcade 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, Arcade aims to reduce winter peaks supplied by the bulk power supply and broaden participation in demand-response programs. By applying Advanced Metering Infrastructure (AMI), it would help consumers by providing real-time monitoring of their utility usage. Energy consumers would be encouraged with variable pricing to shift their use from high demand periods to low demand periods. By decreasing peak demand surges the entire energy infrastructure could be run more efficiently.

Proposed/Suggested Improvements

A community microgrid would be helpful for solving these constraints existing in Arcade's system by providing additional capacity and resiliency. Willdan will evaluate supporting critical facilities with distributed generation resources including CHP generators, locating at least 3,020 kW of generation resources near critical facilities, which will operate in synchronous and island modes to automatically supply facilities in the event of an outage. The proposed generators will be primarily fueled by natural gas. It will also investigate producing and using biogas as a fuel source for CHP generation at the community's WWTP. Willdan will consider additional generation capacity in steps of 250kW to eliminate extra winter consumption for the load pockets near the plant. Small scale hydro generation converting energy of gravity fed water distribution will also be studied for its environmental and economic benefits. 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, Arcade electric department 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, Arcade 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 Arcade 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 cost and electricity bills. With the capability of direct control on the loads, Arcade would not only be able to improve the reliability of the community distribution system, but have the potential to participate in ancillary service market such as, frequency regulation, demand response, etc. For the electric customer, they will have better quality of electricity service while cutting their electricity bill at the same time.

Barriers

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

DERs

Existing Resources

The existing DERs located in the proposed Arcade Community Microgrid are used primarily as backup generators in the event that utility power is interrupted. All the DERs located in Arcade are Diesel Generators, distributed among the critical facilities, and retain about a week of fuel for the 1,135 kW of Existing DER related to critical loads are shown in Figure 3. The detailed location and capacity information of the existing DERS are listed in Table 4.

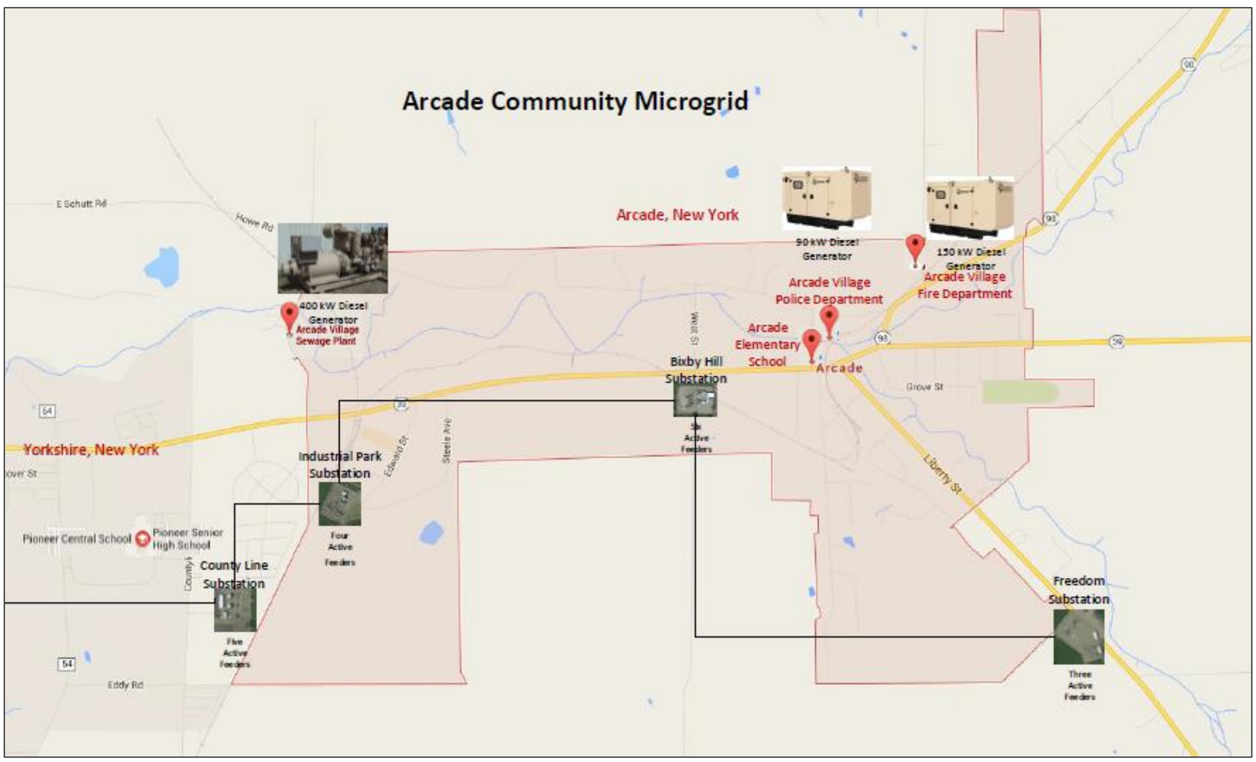


Figure 3. Critical Load, Substation, and Existing DER Map of Arcade

Table 4. Existing Backup Generators

Location	Capacity (kW)	Fuel Type
Arcade Village Office/Police	90	Diesel
Arcade Sewage Plant	400	Diesel
Pioneer High School	N/A	Diesel
Arcade Elementary School	N/A	Diesel
Arcade Fire Department	150	Diesel
Arcade Sullivan Garage	50	Diesel
Arcade Mill St. Garage	20	Diesel
Arcade Sullivan Well	90	Diesel
Arcade Sandusky Well	75	Diesel
Substations/Other	260	Diesel
Total	**1,135**	

Consequences

While the critical loads have a maximum demand of about 3,020 kW, the DERs total just over 1,135kW of generation, indicating that there is not enough generation to provide critical loads with power in the event of an emergency. This means that a number of vital critical facilities, including Arcade North Lift Station, Arcade West Lift Station, Arcade Manor, Garden Park Apartments, Early Bird Nursery, Rainbow's End Nursery, Yorkshire Fire Department, Town of Arcade Garage, Arcade Communication Tower, Wyoming County Communication Tower, Freedom Cell Tower and Yorkshire Cell Tower, would be out of power in the event of an emergency, putting the entire Village of Arcade 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 all the generation runs off of diesel fuel, which is a relatively dirty fuel source that reduces the quality of the air, increases the carbon footprint of the Village of Arcade, and must be stored or shipped into the village in the event of an outage.

Opportunities

Arcade is exploring innovative projects and smart grid circuit isolation to meet its demand and consumption needs such as using combined heat and power (CHP) generation and using biogas as a fuel source for CHP generation at the community's Wastewater Treatment Plant (WWTP). The availability of land at two of Arcade's substations also allows for the assessment of energy storage and CHP at each location. The additional heat capacity provided will be utilized to improve the year-round efficiency of the sludge treatment process, while supplementing local facilities. Arcade 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 Arcade to participate in Demand Response programs and reduce its dependency on its bulk electric power purchases.

Proposed/Suggested Improvements

DER Technology

Table 5 includes the screened technologies and their barriers and opportunities specific to the Village of Arcade.

Table 5. 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 Arcade Community Microgrid favors CHP, Batteries as Energy Storage, Anaerobic Digestion as an Alternate Fuel Source, Solar, 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 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 Arcade to operate as a microgrid and take advantage of new revenue streams such as Demand Response and Fast Regulation Markets. Arcade participates in this program with about 400 kW of diesel generators at municipal buildings. The planned generation capacity and distribution automation capabilities are expected to dramatically increase available capacity for demand-response, 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 fire department, nursery facilities and other critical facilities, will ensure that critical facilities will remain powered on in emergencies, providing the Village of Arcade 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 Arcade electric department owns and operates the distribution system within the village to serve approximately 2,071 residents. Most of the distribution systems are 50+ year old over-head system. Arcade owns four substations with total capacity over 83 MVa for distribution through the system. The four substations are County line substation (24/40 MVa), Industrial park substation (15 MVa), Bixby hill substation (24/32MVa) and Freedom substation (20/25 MVa). Most of the distribution lines are 8.32kV overhead lines (110 miles); Arcade also has 10 miles of 8.32kV underground cable[1]. The length of distribution lines at 12.47kV is 15 miles.

Consequences

Many of Arcade's substation feeders for residential customers are operating near or at capacity during winter peak load resulting in momentary overloading of substation transformers serving residential customers; this situation is further exacerbated when multiple residential circuits fail. The residential winter peak also causes significant voltage sags in the 50+ year-old system.

Opportunities

A community microgrid would solve these constraints by providing additional capacity and resiliency to the Arcade Electric system. Arcade Electric will explore placing the community grid's CHP distributed generation resources near the worst of the residential load pockets to reduce amperage on the substation feeders/transformers. Arcade is also looking forward to utilize the heat produced from planned CHP for heating in building and wastewater treatment plant.

---

[1] Arcade's Municipal Electric Utilities Annual Report 2013 Available online at http://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId={72D26F3B-A563-432B-8352-9DEEC3136520}

Proposed/Suggested

Willdan proposes a Loop-based community microgrid for Arcade. 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.

Benefits

The Arcade community microgrid can operate in either grid-connected mode or island mode. The distribution network can be easily reconfigured for reliability purposes and minimize the 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 Arcade 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 Arcade 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 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 Arcade 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.

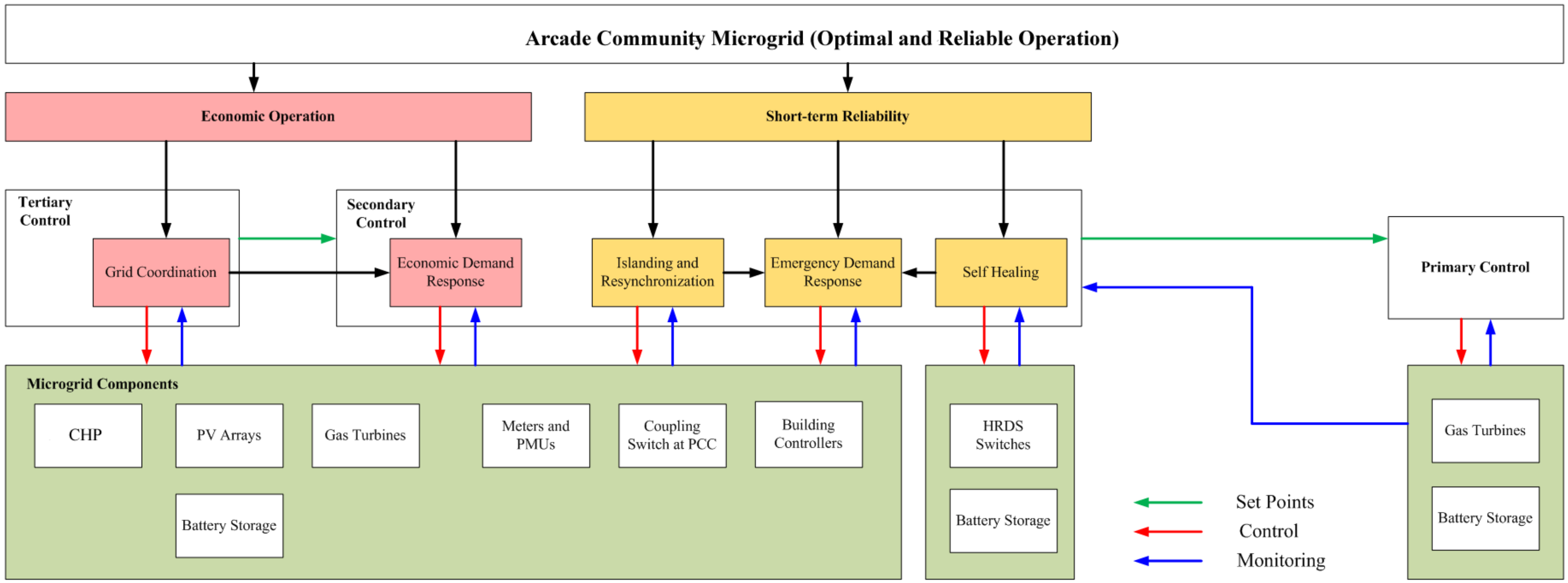
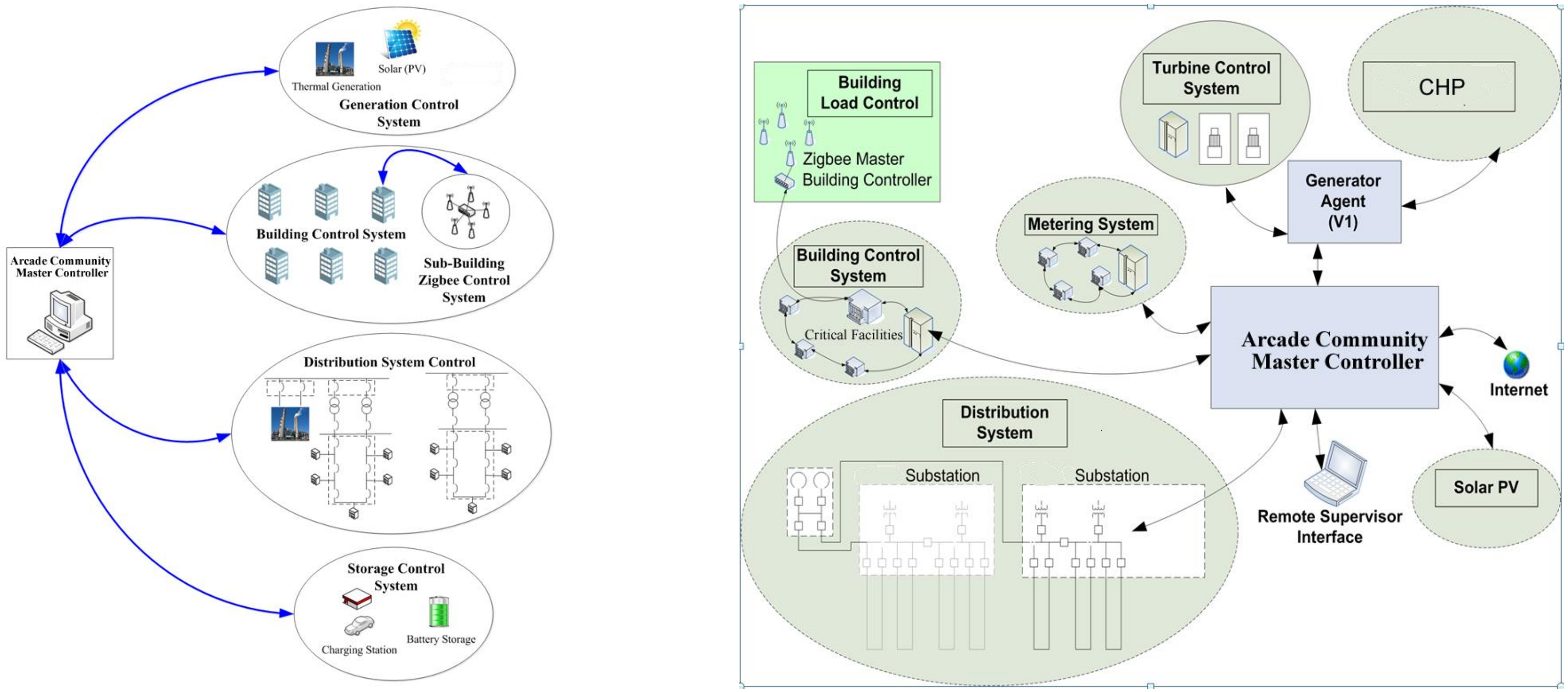


Figure 4. Objectives and functions for the control and operation of the Arcade Community Microgrid



(a) (b)

Figure 5. Architecture of master controller for Arcade community microgrid

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 4 shows the hierarchical framework of the Master Controller proposed for Arcade'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 community microgrid mainly contains four-level protection: load way, loop way, loop feeder way and microgrid level.

Benefits

Arcade 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. 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 shutoff 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 Arcade, the existing or future distribution network would need a further upgrade which may incur extra investment cost, automatic smart switches are needed for fast remote switching. The functions of the community microgrid would depend a lot on the implementation of a reliable communication system.

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

Arcade electric department owns and operates four substations and over 135 miles of distribution lines, serving over 2,000 local residents. A large majority of those customers are individually metered; however, these meters are read manually every month by a meter reader. At this stage, Arcade 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

Arcade is considering an Advanced Metering Infrastructure (AMI) expansion, which would involve adding wireless communication infrastructure throughout each meter in the Village of Arcade 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.

Arcade-controlled AMI would also provide opportunity for community demand response aggregation, in which Arcade 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 Arcade 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.

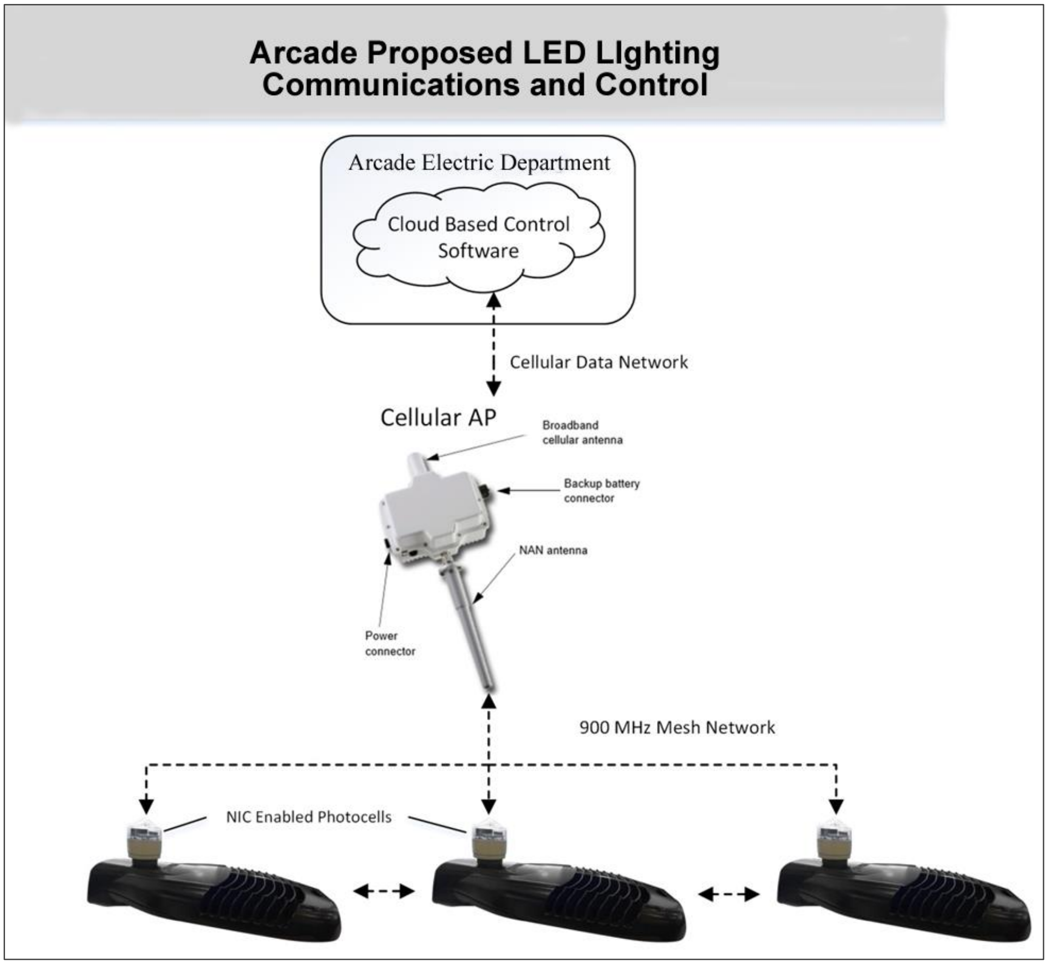


Figure 6 . Arcade Proposed LED Lighting Communications and Control Diagram

In addition to meters and streetlights, circuit breakers, relays, re-closers and other switchgear are vital to the control of the Arcade 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 Arcade data center and the four substations. 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 6. Arcade Community Microgrid Existing and Proposed Overview

Category	Existing Resources	Proposed/Suggested Improvement	Justification
Category	• Existing Resources	• Proposed/Suggested Improvement	• Justification
Load	• Residential Electric Heat • 21 Critical facilities (3,020kW) • Monthly 25 MW and 12.5 GWh allocation • 41 MW Winter Peak	• Building Energy Efficiency • LED Street lighting • Load Curtailment • Winter Peak Shaving	• Resilience Reduced winter load • Reduce inefficiency
Distributed Energy Resources (DERs)	1,135kW existing backup diesel generators	• Combined Heat and Power (CHP) • Anaerobic Digestion • Energy Storage and solar (Refer Sub Task 2.3)	• Demand Response • Resilience • Renewable Sources • Reduced winter load
Electrical and Thermal Infrastructure	• Radial Path 8.32kV/12.47kV • Mostly overhead distributed cable •	• 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	• SCADA • 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 7. 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%	1,350-2,607	529.7 - 897.6	1,621 – 2,923.6
6	0-40%	86.76% - 76.18%	1,350-2,607	528.5 – 896	1,621 – 2,923.6
5	0-40%	73.53% - 62.94%	1,350-2,607	527.6 – 891.4	1,621 – 2,923.6
4	0-40%	49.71% - 73.53%	1,350-2,607	526.3 – 889.6	1,621 – 2,923.6
3	0-40%	47.06% - 36.47%	1,389-2,607	525.9 – 889.5	1,556.6 – 2,923.6
2	0-40%	33.82% - 23.24%	1,350-2,607	523.2 – 886.6	1,621 – 2,923.6
1	0-40%	20.59% - 10%	1,350-2,607	521.2 – 884.0	1,621 – 2,923.6

[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.

Sub Task 2.1 Proposed Microgrid Infrastructure and Operations

Figure 7. Generation simplified equipment layout diagram

Willdan proposes a community microgrid for the Village of Arcade, which will enhance the overall operational reliability of the electrical distribution system. Figure 7 shows the location of the main existing/proposed generation resources, and critical facilities. By providing a master controller, the Arcade 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, to a self-healing and more fault tolerant grid; 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 Arcade 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 Arcade 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 its 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. This 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 Arcade community microgrid with heat and power when it needs it most.

Sub Task 2.2 Load Characterization

There are approximately 2,071 residents in Arcade. The Village of Arcade is allotted 25 megawatts (MW) 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, Arcade depends on electricity for heating and it needs to purchase additional power to meet the demand. The demand can reach as high as 41 MW in the winter season. Also, the 105MW noble bliss wind farm relies on Arcade's system to deliver its wind power to the bulk grid. Figure 8 shows the locations of critical facilities within Arcade. Figure 9 shows the monthly load demand in Arcade for the recent years. Figures 10 and 11 illustrate monthly kWh consumption profile of the Arcade system. The shape of the monthly kWh usage matches the Heating-Degree-Days (HDD) of the locality.

The Village of Arcade's loads can be separated into the broad load categories, critical and non-critical, with critical facilities including the Arcade Village Office/Police, Arcade Sewage Plant, Pioneer High School, Arcade Elementary School, Arcade Fire Department, Arcade Sullivan Garage, Arcade Mill St. Garage, Arcade Sullivan Well, Arcade Sandusky Well, Arcade North Lift Station, Arcade West Lift Station, Arcade Manor, Garden Park Apartments, Early Bird Nursery, Rainbow's End Nursery, Yorkshire Fire Department, Town of Arcade Garage, Arcade Communication Tower, Wyoming County Communication Tower, Freedom Cell Tower, and Yorkshire Cell Tower, and non-critical facilities including the many other businesses and residential customers served by Arcade electric. The total critical load demand is about 3.02 MW. The detail load information for all the critical loads are shown in Table 9. The load demand in each facility can be further separated into the following load categories as shown in Table 8 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 8. 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

Arcade electric department has completed some energy efficiency projects which include: residential insulation replacement for the Village of Arcade; village-wide appliance replacement program; refrigerator replacement program, and; HVAC and lighting upgrades for residents.

Table 9. Critical Loads

Critical Facilities	Max KW	Total KWh
Arcade Village Office/Police	39	172,440
Arcade Sewage Plant	111	760,140
Pioneer High School	2,032	8,493,600
Arcade Elementary School	620	1,918,596
Arcade Fire Department	43	135,960
Arcade Sullivan Garage	39	151,260
Arcade Mill St. Garage	13	50,040
Arcade Sullivan Well	23	31,404
Arcade Sandusky Well	10	45,924
Arcade North Lift Station	0	3,720
Arcade West Lift Station	0	4,572
Arcade Manor	23	87,336
Garden Park Apartments	N/A	N/A
Early Bird Nursery	0	25,116
Rainbow's End Nursery	15	27,864
Yorkshire Fire Department	23	56,004
Town of Arcade Garage	14	36,063
Arcade Comm. Tower	0	20,772
Wyoming County Comm. Tower	0	14,172
Freedom Cell Tower	8	49,800
Yorkshire Cell Tower	7	31,428
Total	**3,020**	**12,116,221**

Consequences

Due to the peak demand during winter, many of Arcade's substation feeders for residential customers are operating near or at capacity resulting in momentary overloads of substation transformers serving residential customers. This situation is further exacerbated when multiple residential circuits fail. The residential winter peak also causes significant voltage sags in the 50+ year old system. The system is also entirely reliant on the NYSEG points 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 Arcade community exceeds its NYPA kW and kWh allocation. Arcade purchases retail energy from the whole sale market to cover its extra consumption. In 2014, Arcade incurred additional per-kWh costs at nearly 200% of the energy cost under NYPA allocations, over $2,000,000 in total.

Opportunities

Arcade 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, Arcade aims to reduce winter peaks supplied by the bulk power supply and broaden participation in demand-response programs. By applying Advanced Metering Infrastructure (AMI), it would help consumers by providing real-time monitoring of their utility usage. Energy consumers would be encouraged with variable pricing to shift their use from high demand periods to low demand periods. By decreasing peak demand surges our entire energy infrastructure could be run more efficiently.

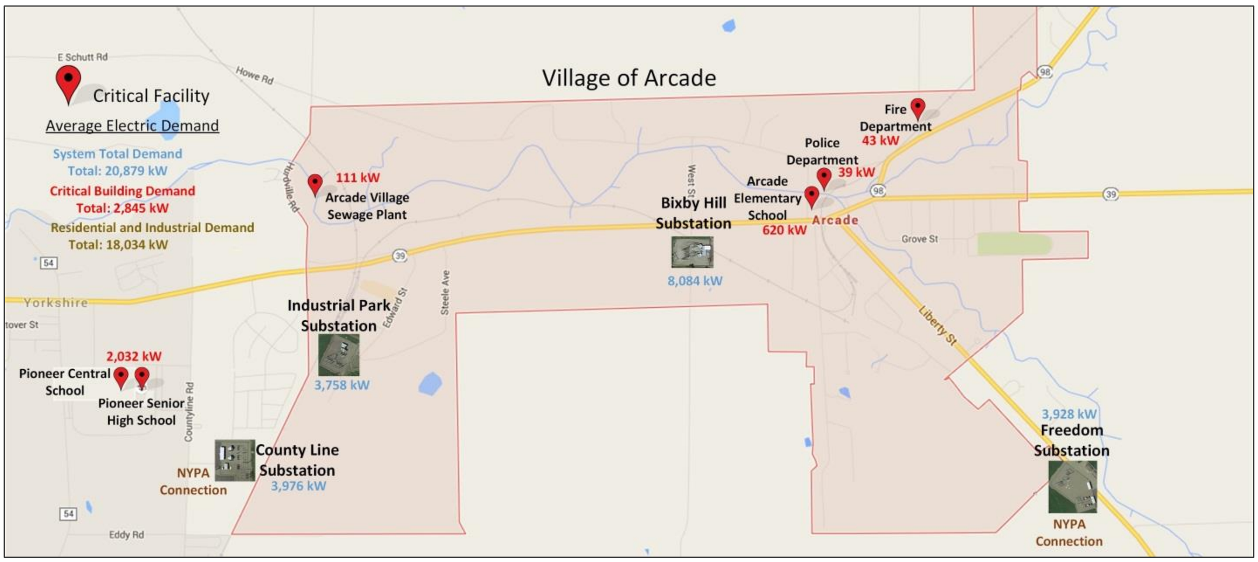


Figure 8. Load simplified equipment layout diagram

Table 10. Demand and Energy for Arcade (2014)

Source	Summer Peak	Winter Peak	Annual Energy
Electricity	29,117 kW	41,115 kW	162,354,715 kWh

Table 11. Electricity Usage 2014

Month	Energy (kWh)
January, 2014	16,850,045
February, 2014	18,458,413
March, 2014	21,865,603
April, 2014	17,021,245
May, 2014	15,200,245
June, 2014	11,369,684
July, 2014	9,224,587
August, 2014	9,266,401
September, 2014	9,645,883
October, 2014	9,252,856
November, 2014	10,486,759
December, 2014	13,712,994

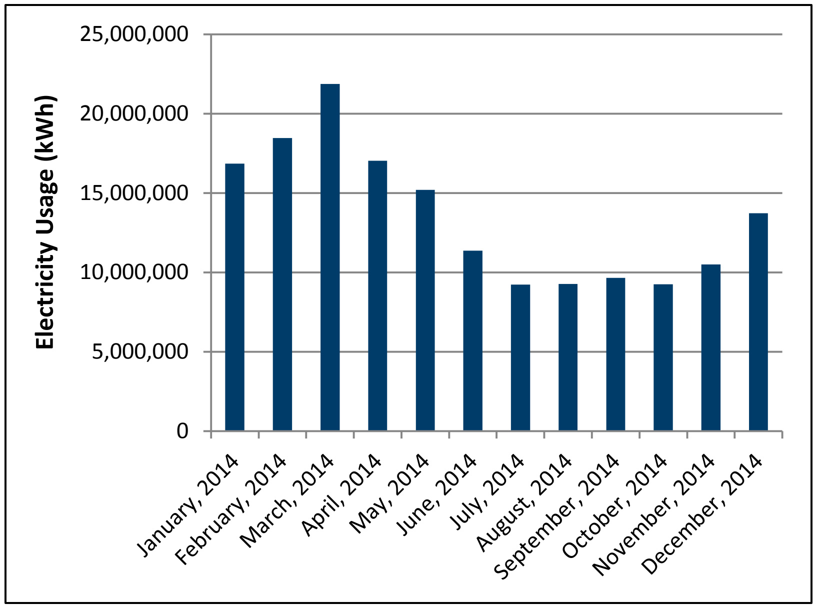


Figure 9. Electricity Usage 2014

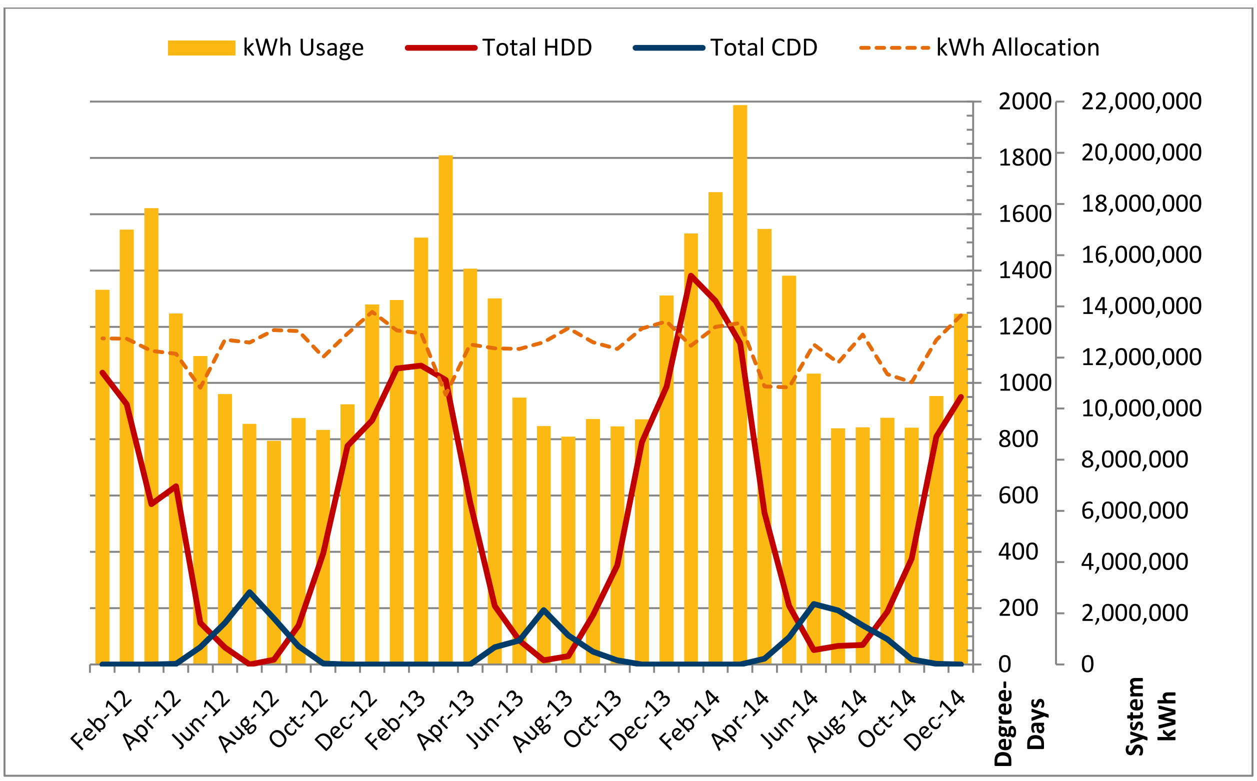


Figure 10. Arcade Electric Department System Monthly Energy Profile

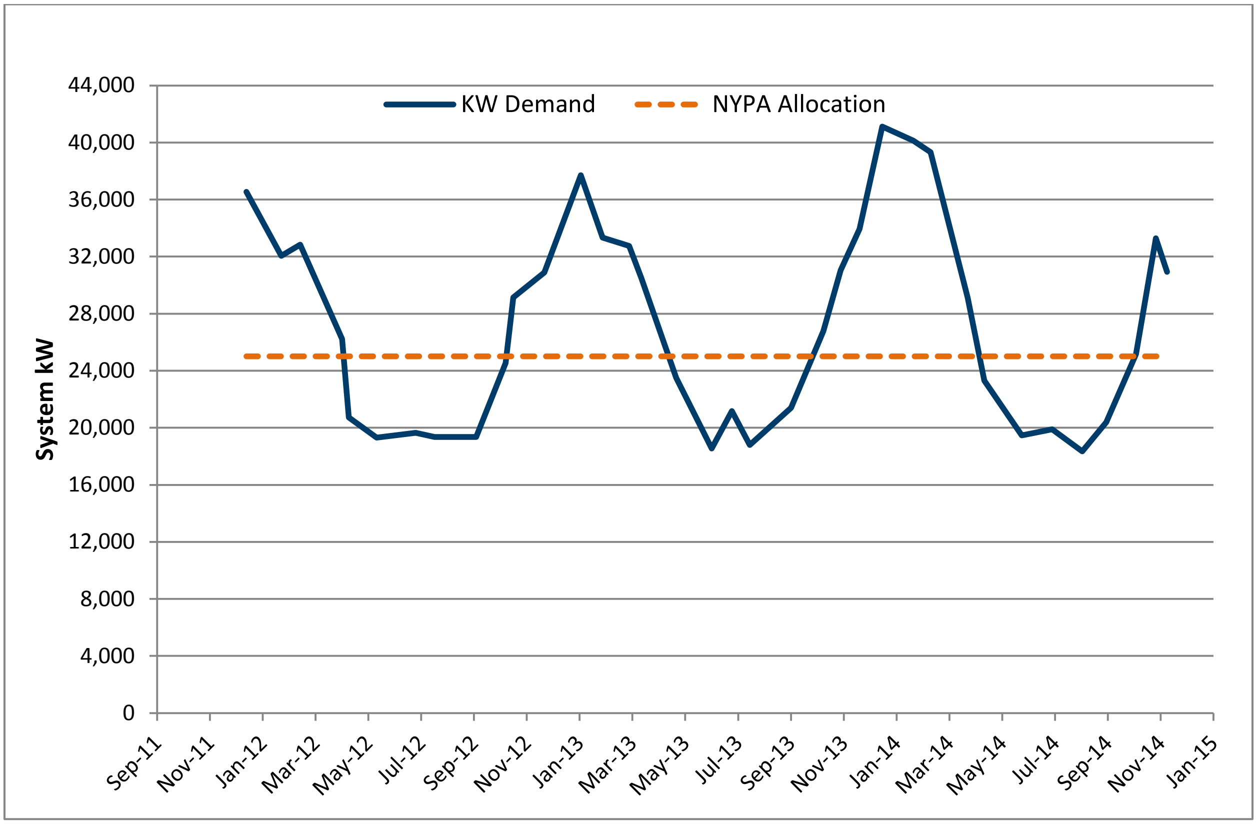


Figure 11. Arcade Monthly Demand Profile

Proposed/Suggested Improvements

A community microgrid would be helpful for solving these constraints existing in Arcade's system by providing additional capacity and resiliency. Willdan will evaluate supporting critical facilities with distributed generation resources including CHP generators, locating at least 3,020 kW of generation resources near critical facilities, which will operate in synchronous and island modes to automatically supply facilities in the event of an outage. The proposed generators will be primarily fueled by natural gas. Willdan will consider additional generation capacity in steps of 250kW to eliminate extra winter consumption for the load pocket near the plant. Small scale hydro generation converting energy of gravity fed water distribution will also be studied for its environmental and economic benefits. 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, Arcade electric department 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, Arcade 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 Arcade 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 costs and electricity bills. With the capability of direct control on the loads, Arcade would not only be able to improve the reliability of the community distribution system, but have the potential to participate in ancillary service markets such as, frequency regulation, demand response, etc. Electric customers would have better quality of electricity service while cutting their electricity bills at the same time.

Barriers

Implementing the community microgrid would require new investment in generation resources. A greater review of the exact equipment installed must be done to determine any necessary reconfiguration of the existing distribution network and communication system. It would also be necessary to educate the electric customer to be involved in the demand response program. Any addition of natural gas fed resources would reduce the overall profit of the Arcade Electric Department and could present a challenge in implementing the community microgrid.

Load Visualization

Figure 12 shows the hourly load profile of the total system load that is served by the Arcade Community Microgrid. The hourly load is broken down by month to reflect the drastically different usage by month seen in Figures 12, 13, and 9 as well as in Table 11. 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, as seen in Figure 17, 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.

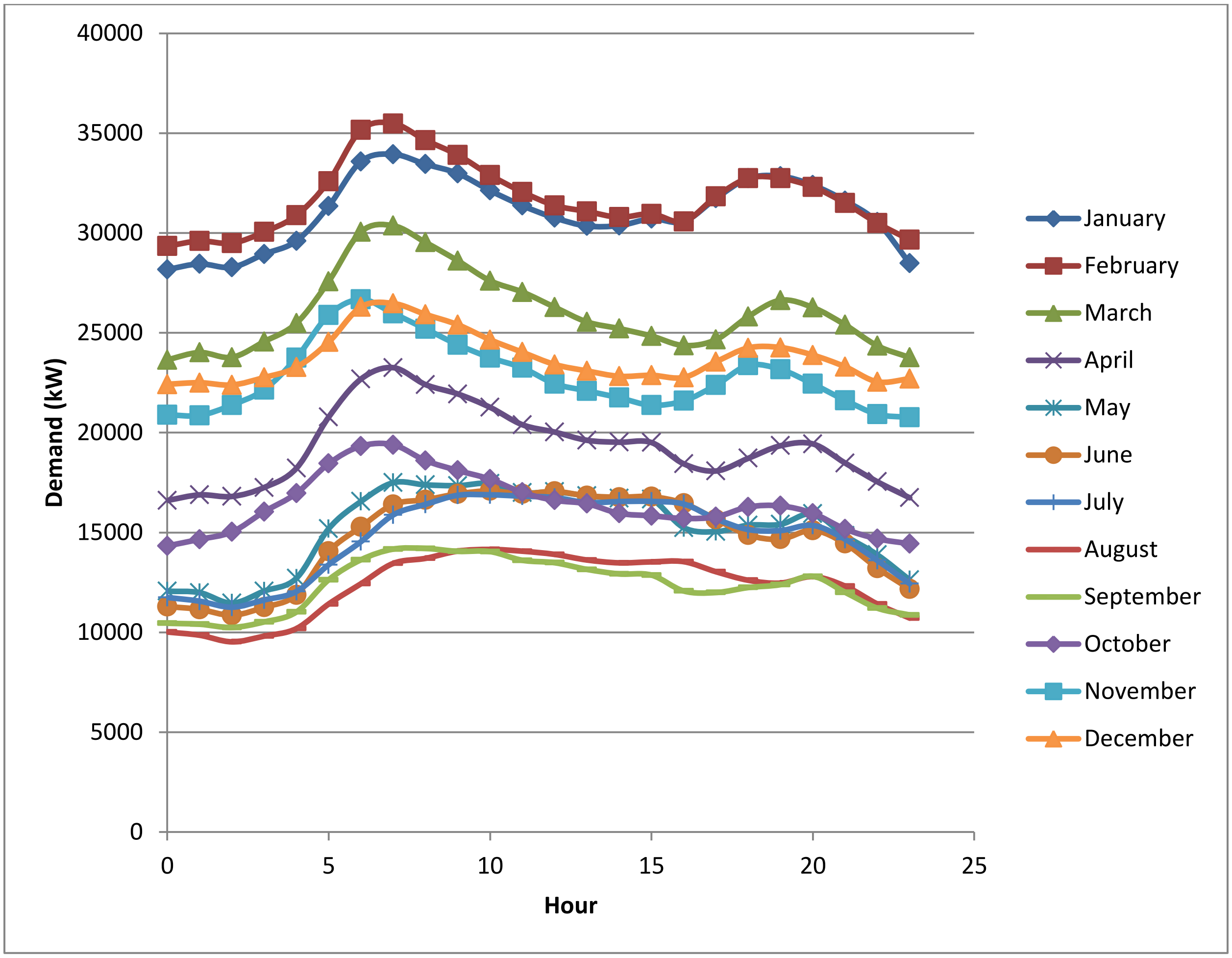


Figure 12. Arcade Average Daily Load by Month[1]

The proposed Arcade Community Microgrid focuses on providing electricity for the critical buildings while relieving high winter peaks due to electric heating. Shown in figures 10 and 11 are the issues that the Arcade 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 3,000 kW (table 9). The installation of 2,350 kW of CHP would be able to adequately serve the entire load, depending on the level of load shedding implemented.

[1] From Arcade Hourly Data.

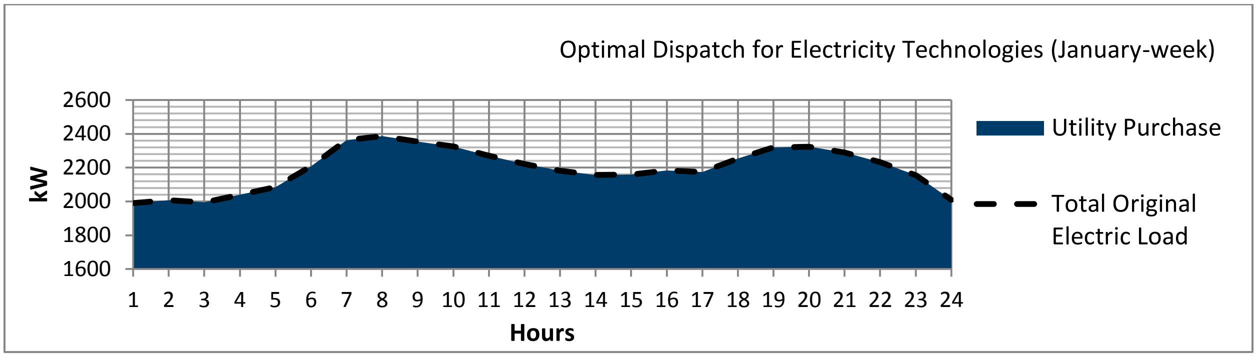


Figure 13. Pre Investment Average Electricity Dispatch

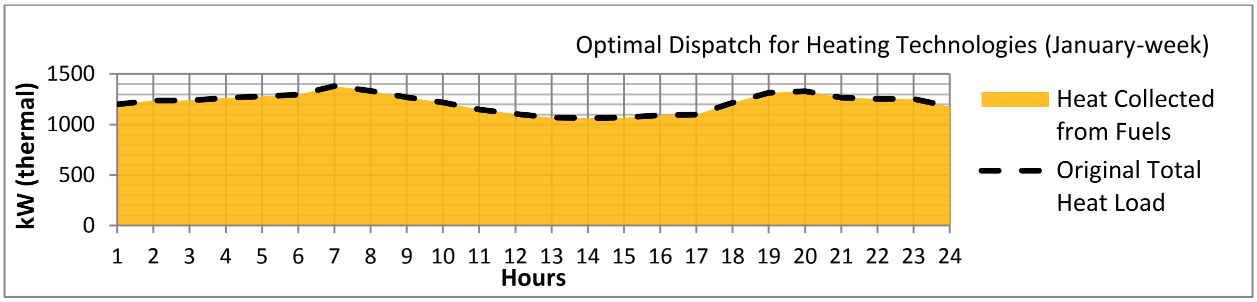


Figure 14. Pre Investment Average Heating Dispatch

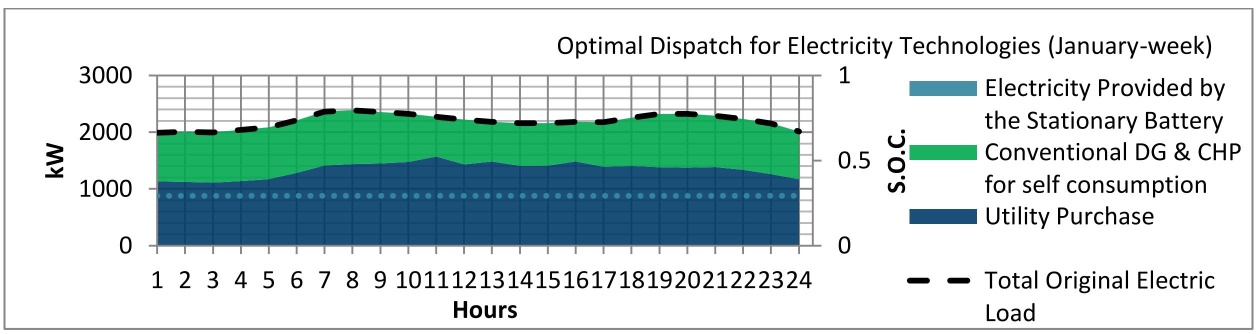


Figure 15. Example Post Investment Average Electricity Dispatch

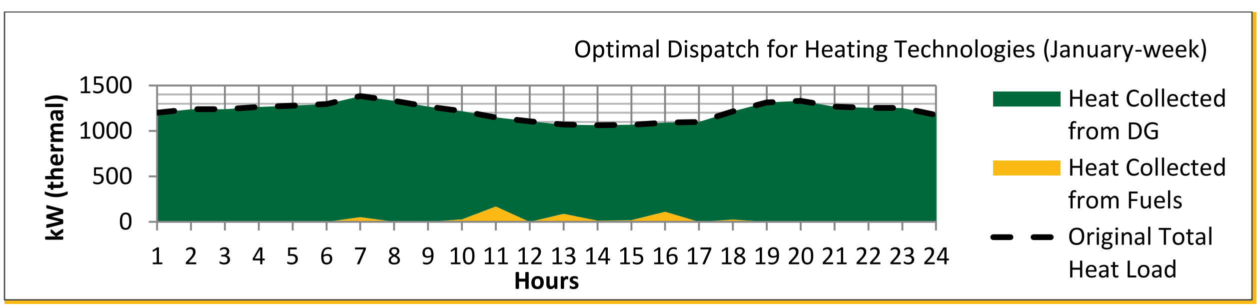


Figure 16. Example Post Investment Average Heating Dispatch

Figures 13 and 14 show DER-CAM simulation results for the critical buildings in the Arcade Community Microgrid under normal base conditions with no added generation. It can be seen that there are peaks around 8 am and around 7 pm due to industrial and residential customer's high electricity consumption, respectively. Figures 15 and 16 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.

Proposed Energy Efficiency Improvements

Willdan proposes an energy efficiency program for Arcade community for the purpose of economics and reliability. By applying a time of use (TOU) electricity price mechanism within Arcade community, the customers can save both on energy cost and peak-demand charge by curtailing energy usage or shifting their energy usage from peak load hours to off-peak load hours, and then reduce the amount of energy bill. For the community, it can minimize the amount of demand and monthly energy usage that beyond the NYPA's allocation, and then less expense on the electricity. By shifting the energy usage from peak load hours to off-peak load hours, the overload on the distribution cables and substations would be mitigated and the reliability of Arcade's distribution system would be improved.

Sub Task 2.3 Distributed Energy Resources Characterization

Existing Resources

Existing DERs located in the proposed Arcade Community Microgrid are used primarily as backup generators in the event that utility power is interrupted. All of the backup generators are diesel generators, distributed among the critical facilities, and retain about a week of fuel for 1,135 kW of capacity. Existing DER respective to critical load and substation are shown in table 12 and the main backup generators are also shown in figure 7.

Consequences

While the critical loads have a maximum demand of about 2,845 kW and the DERs total just over 1,135kW of generation, indicating that there is not enough generation to provide critical loads with power in the event of an emergency. This means that a number of vital critical facilities, including Arcade North Lift Station, Arcade West Lift Station, Arcade Manor, Garden Park Apartments, Early Bird Nursery, Rainbow's End Nursery, Yorkshire Fire Department, Town of Arcade Garage, Arcade Communication Tower, Wyoming County Communication Tower, Freedom Cell Tower and Yorkshire Cell Tower, would be out of power in the event of an emergency, putting the entire Village of Arcade 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 all 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 Arcade, and must be stored or shipped into the village in the event of an outage.

Table 12. Existing Backup Generators and Critical Facilities

Location	Capacity (kW)	Fuel Type	Critical Facilities (Demand kW)
Arcade Village Office/Police	90	Diesel	39
Arcade Sewage Plant	400	Diesel	111
Pioneer High School	N/A	Diesel	2032
Arcade Elementary School	N/A	Diesel	620
Arcade Fire Department	150	Diesel	43
Arcade Sullivan Garage	50	Diesel	
Arcade Mill St. Garage	20	Diesel	
Arcade Sullivan Well	90	Diesel	
Arcade Sandusky Well	75	Diesel	
Substations/Other	260	Diesel	
Total	**1,135**		

Opportunities

Arcade is exploring innovative projects and smart grid circuit isolation to meet its demand and consumption needs such as using combined heat and power (CHP) generation and using biogas as a fuel source for CHP generation at the community's Wastewater Treatment Plant (WWTP). The availability of land at two of Arcade's substations also allows for the assessment of energy storage and CHP at each location. The additional heat capacity provided will be utilized to improve the year-round efficiency of the sludge treatment process, while supplementing local facilities. Arcade 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 Arcade to participate in Demand Response programs and reduce its dependency on its bulk electric power purchases.

Proposed/Suggested Improvements

A screening of the available DER technology (Table 13) available to the Arcade 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.

Arcade is interested in putting two new battery storages close to its industrial park in order to improve the power quality and the distribution system reliability. It can be seen in figure 7 that a total of 1,000kW battery storage is proposed to be installed in industrial park area in order to improve the power quality and reliability for two industrial customers who are sensitive to the power quality and reliability, as well as 100 kW Solar panel. There is adequate space available and a number of critical facilities nearby that would be benefit from the proposed battery storage when there is a disturbance in the distribution system.

There is no information available at the time of preparing this report regarding the backup generators for Pioneer High School and Arcade Elementary School. These schools would act as critical emergency shelters in a number of different emergency situations. Willdan proposes that a potential 2,000 kW CHP for Pioneer High School and 600kW CHP for Arcade Elementary School or replacing its existing diesel backup generators, so that it could serve both of these schools heating and electricity needs year round, and provide power to these facilities in an emergency.

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

Table 13. 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

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 Arcade 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, and the Fire Department and Ambulance will ensure that critical facilities will remain powered on in emergencies, providing the Village of Arcade 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.

As Natural Gas fed CHP is the most feasible option for the Arcade 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 Arcade to prevent any small issues from becoming major problems if there is an interruption in natural gas supply.

Furthermore, based on preliminary sensitivity analysis for the critical facilities, the Arcade Community Microgrid is highly sensitive to the increases of Electricity price (figure 17). When Electricity price fluctuates, Arcade may need to consider further diversification of their DERs to include renewables or other forms of generation. The levelized cost of energy (LCOE) for solar is around 12.5 Cent/kWh in which the LCOE is calculated as (Total life Cycle Cost/Total Lifetime Energy Production)[1]. The electricity price in Arcade shown in figure 17 is much cheaper than the Solar's LCOE, so the DER-CAM will not propose any solar installation.

[1] http://solarcellcentral.com/cost_page.html

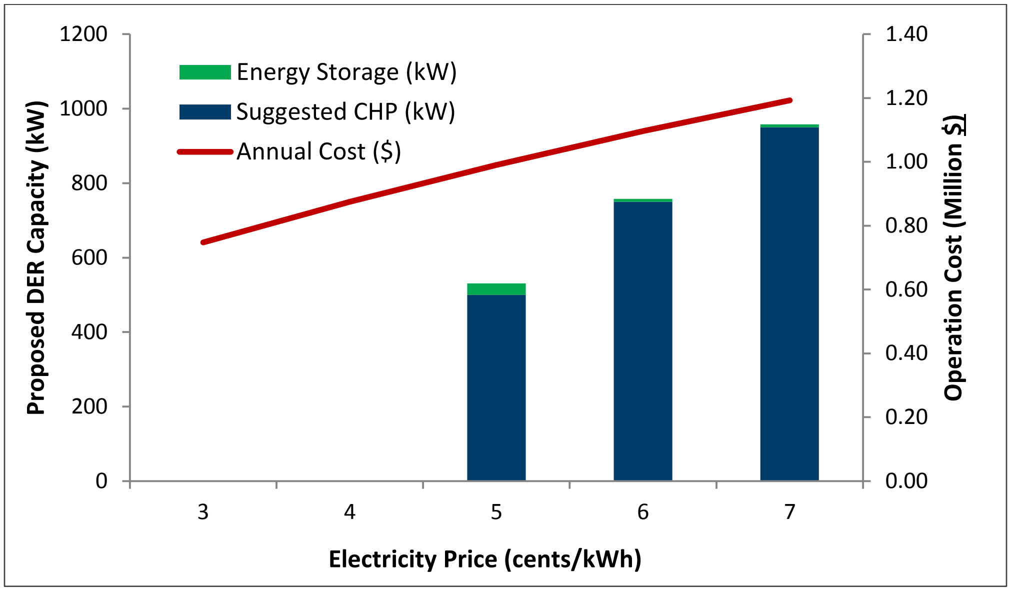


Figure 17. Sensitivity Analysis Results for Electricity Price

The Arcade Community Microgrid master controller would determine the optimal and reliable operation of the 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.

Battery Installation for Power Quality Improvements

Arcade is interested in installing battery storage units for two of its industrial customers (API Heat Transfer Inc. and Prestolite of NY Inc.) in order to improve the power quality on these two sites. Along with the battery storage, 50kW solar panel is also planned for each of the facilities.

Energy Cost and Environment benefit

It's assumed that the two facilities depend on electricity for heating during winter seasons. For API, the annual energy costs (including the annual capital cost) are $503,678 and $520,776 without/with battery storage and solar panel. For Prestolite, the annual energy costs (including the annual capital cost) are $578,468 and $590,021 without/with battery and solar. The detailed simulation results are summarized as in Table 14.

Table 14. API and Prestolite With/Without Battery and Solar

Cases	Annual Cost ($)[1]	Electricity Purchase (kWh)	Electricity Cost ($)	Onsite Generation (kW)	Annual Capital Cost ($)	CO2 Emission (kg)
API without Battery and Solar	503,678	8,534,651	421,805	0	0	4,967,133
API With Battery and Solar	520,776	8,481,373	408,589	56,148	29,839	4,940,020
Prestolite without Battery and Solar	578,468	9,807,497	485,501	0	0	5,707,926
Prestolite With Battery and Solar	590,021	9,754,193	470,739	56,148	29,839	5,680,797

As shown in table 14, the incremental total cost for both Industrial customers are due to the annualized capital cost of battery and solar. With the installation of the proposed battery and solar, the electricity cost (including energy cost and demand cost) would drop ($421,805 to $408,589 for API and $485,501 to $470,739 for Prestolite) and the proposed battery and solar would help in reducing the CO2 emission (27,113kg for API and 27,129kg for Prestolite) which would benefit the environment. In the estimation, the lifetime of battery and solar panel are assumed as 30 year and 15 year, respectively.

Using API as an example, figure 18 shows the energy dispatch in peak load time period in January. The battery could help shift the peak load to off-peak load hours, which would help in reducing the total Arcade community load demand and relieve some capacity constraints on the substations.

[1] Annual cost is estimated based on the available demand and price information which includes electricity cost, fuel cost and annual capital cost.

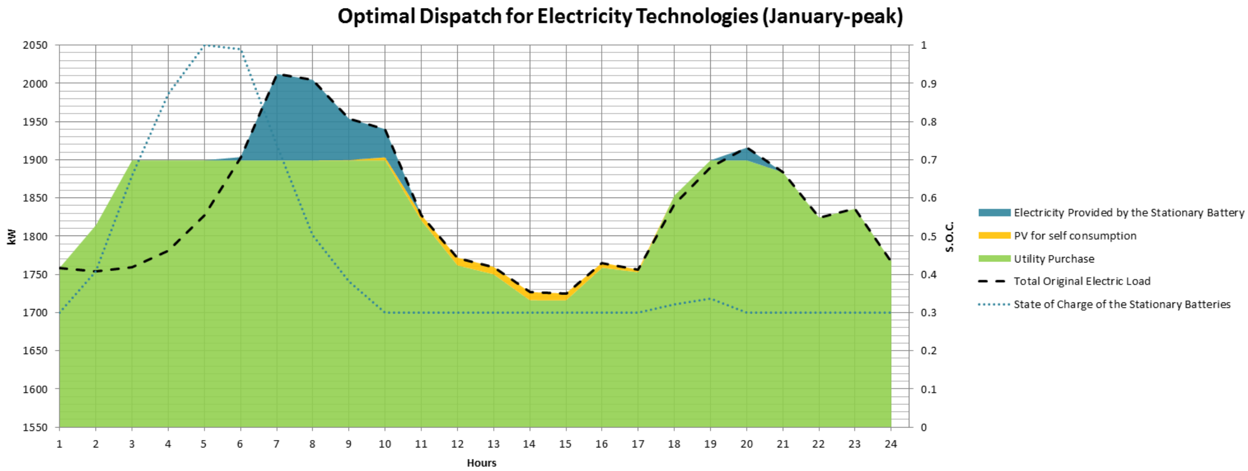


Figure 18. Energy Dispatch in January Peak for API with Battery and Solar

Fast Regulation Revenue Opportunity

For the proposed battery, except improving the power quality for the two customers, there is a chance for them to participate in the New York ISO (NYISO)'s capacity market, regulation market and load demand response service. The averaged capacity price, regulation price and energy demand response price are \$8.96/kW-month[1], \$12.87/MWh[2] and \$500/MWh[3] respectively. Assumed that half of the capacity of the proposed battery is able to participate in the capacity, regulation and demand response market, i.e., 250kW and 500kWh on average. So the total annual revenue would be 12*(250*8.96)+365*0.5*12.87+365*0.5*500= \$120,479. Taking into account the 15 year lifetime of battery, the return of investment (ROI) would approximately be 4.038.

Power Quality Improvement Benefit

With the proposed battery storage, the power quality for the API and Prestolite would be improved significantly. It's expected that the battery would totally remove the existing "blink" or "brown out" phenomena. An event such as this could cause \$50,000 loss for API and a one-minute event could cause \$100,000 loss for Prestolite. Assuming there are three outages on average for each customer per year, the annual loss would be around \$450,000. The proposed battery would help these two customers to avoid these outage losses.

---

[1] http://www.nyiso.com/public/markets_operations/market_data/icap/index.jsp

[2] 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)

[3] http://www.nyiso.com/public/webdocs/markets_operations/services/market_training/workshops_courses/Training_Course_Materials/NYMOC_MT_ALL_201/Demand_Response.pdf, Page 45-46

Sub Task 2.4 Electrical and Thermal Infrastructure Characterization

Electrical and Thermal Infrastructure

Most of the Arcade's distribution system consists of a 50+ year old over-head system. Arcade Electric department owns and operates the distribution system within the village to serve approximately 2,071 residents. Arcade owns four substations with total capacity over 83 MVA for distribution through the system. The four substations are County line substation (24/40 MVA), Industrial park substation (15 MVA), Bixby hill substation (24/32MVA) and Freedom substation (20/25 MVA). Most of the distribution lines are 8.32kV overhead lines (about 110 miles); Arcade also has 10 miles of 8.32kV underground cable. The length of distribution lines at 12.47kV is 15 miles.

Existing DERs located in Arcade Community are used primarily as backup generators in the event that utility power is interrupted. They are all diesel Generators, distributed among the critical facilities, and retain about a week of fuel for 1,135 kW of capacity. Willdan proposes 2,350kW CHP and 250kW battery energy in order to supply power to critical facilities in case of grid outage and improve the reliability and resiliency of the Arcade's distribution system. Along with the existing backup generator, the total generation capacity would be enough to supply power for critical loads in winter peak hours.

Willdan proposes a Loop-based community microgrid for Arcade. This new distribution network has a meshed structure which can operate as loop or radial, though it would normally operate 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, Automatic Transfer Switches (ATS) are proposed to be deployed within the community microgrid, which have the capability of network reconfiguration in case of emergency or outage. The conceptual design of the Arcade's distribution network for supplying power to the critical loads is shown in Figure 19, the square represents the ATS which can operate in three ways to reconfigure the network or isolate the loads. Once the existing distribution system network is available, a more detailed design will be presented for Arcade community microgrid.

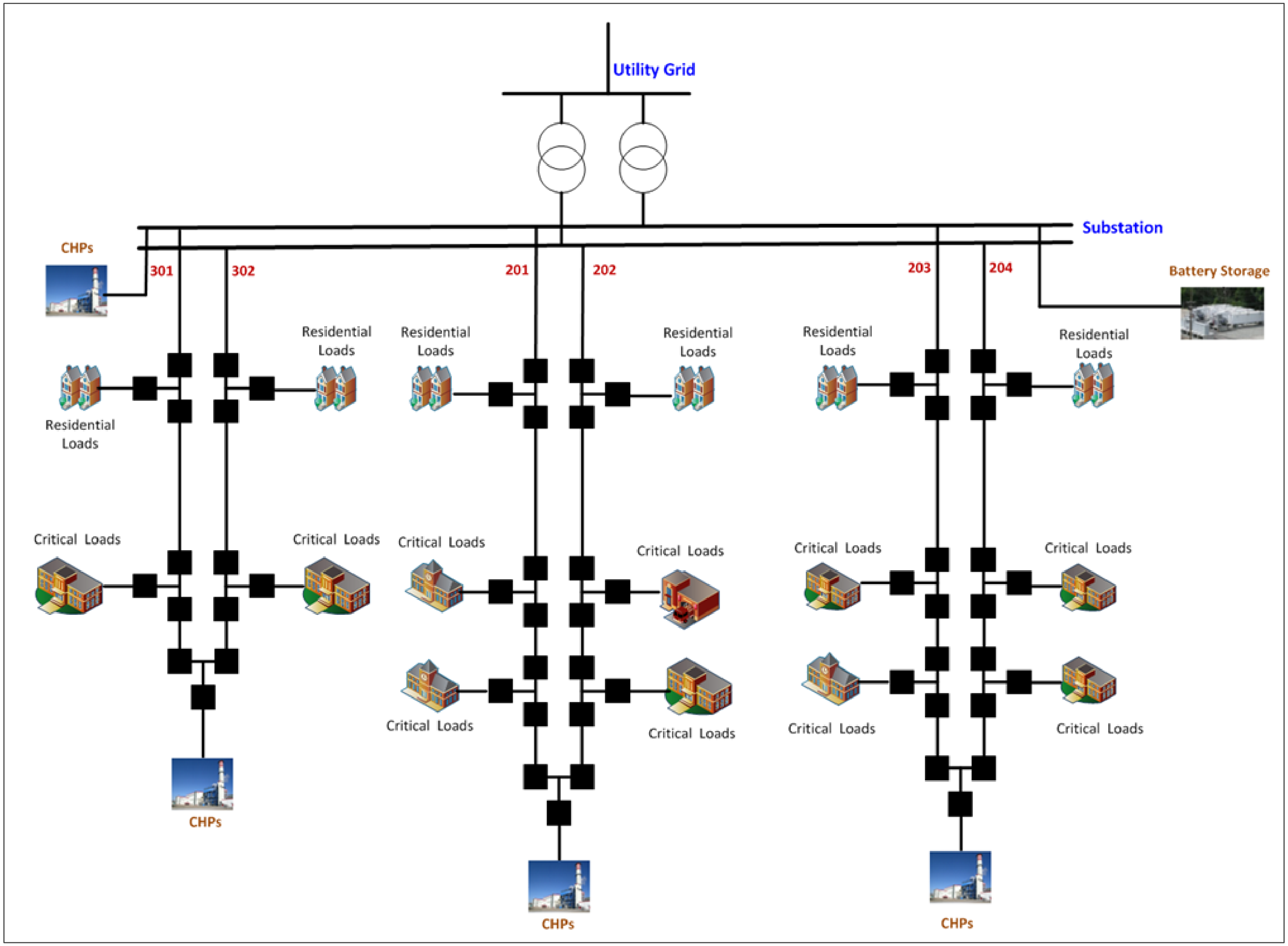


Figure 19. Conceptual Design of Arcade Community Microgrid

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 frequent and severe in recent years due to climate change. Snow storms and peak loads due to electric heating use in winter seasons could cause damages or outages on the 50+ year old overhead system in the Village of Arcade. 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 tower/pole and conductor faults due to trees falling. Considering the frequent hurricanes in this area, it would be necessary to upgrade designs and focus more on emergency planning and restoration. For example, hurricane sandy occurred in 2012, which caused a widespread blackout of the 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 the outages than electric systems because of the difficulty to locate and repair the underground leakages. The extreme weather would affect both individual equipment failure and system operations. The damage from such events can impose large costs on distribution system as well as severe impact on the local economies.

Many of Arcade'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 also causes significant voltage sags in the 50+ year-old system.

Arcade Electric will explore placing the community grid's CHP distributed generation resources near the worst residential load pockets to reduce amperage on the substation feeders/transformers. A community microgrid would solve any constraints by providing additional capacity and resiliency to the Arcade Electric system.

In order to optimize the selection and operation of distributed energy resources, DER-CAM, developed by Lawrence Berkeley National Laboratory, is applied here for microgrid 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 20.

[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

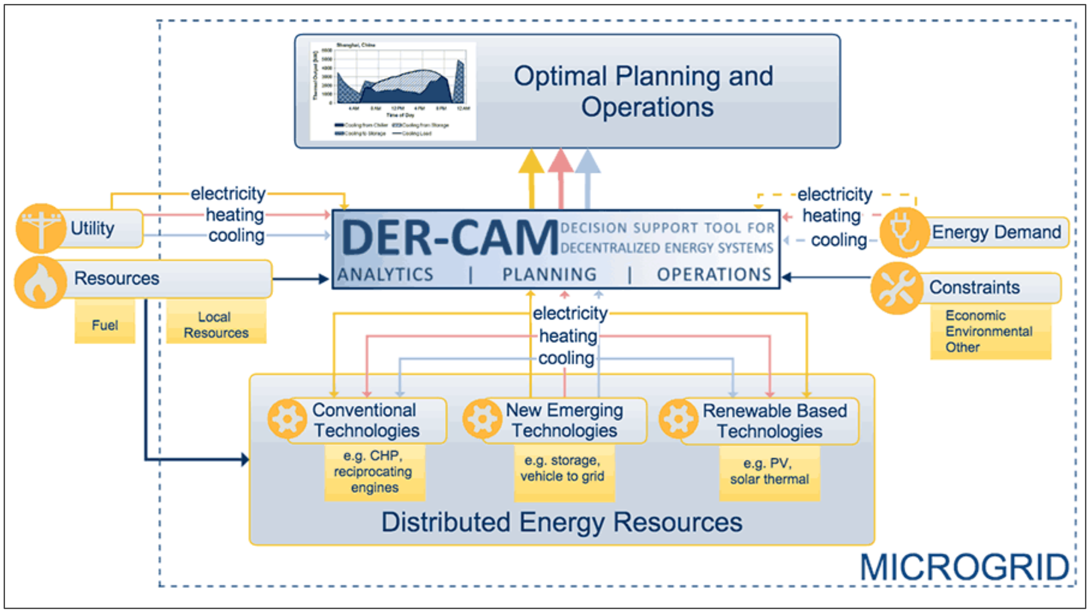


Figure 20. Schematic of information flow in DER-CAM

Two sets of simulation results are selected to be presented here to show the investment options for addressing the system resilience. The first case is the one-hour islanding during peak load in January, while trying to keep the whole community powered on. The second case is maintaining the critical load's power with a one-week disruption of power supply from the utility grid. Table 15 and figures 21-23 present the DER-CAM simulation results for the first scenario (Scenario 1) and table 16 and figures 24 - 26. demonstrate the simulation results for the second scenario (Scenario 2). In Scenario 1, DER-CAM suggested 9,000kW CHP and 37,236kWh battery in order to try to supply power to all the loads. In order to supply power to all the customers, more CHP units or battery storage are required (total generation capacity larger or equal than load capacity) resulting in very expensive investment cost, which is not necessarily and economically beneficial, this case is just to get a total required generation resources figure. In Scenario 2, it's assumed that only critical loads would be satisfied during disruption of utility grid, it can be seen from figure 25 that all the critical loads can be satisfied by the new added DERs along with the existing generation resources. The local DERs can also provide power to critical loads during grid-connected mode shown in figure 26 which would improve the energy resilience of the critical facilities.

Table 15.The annual costs savings by the investment for supplying the loads in Arcade with islanding in peak load day (January)

	Base Case (no investment)	Investment Case (investment)	Increase
Total Annual Energy Costs ($)	10,388.9	11,769	***1,380***

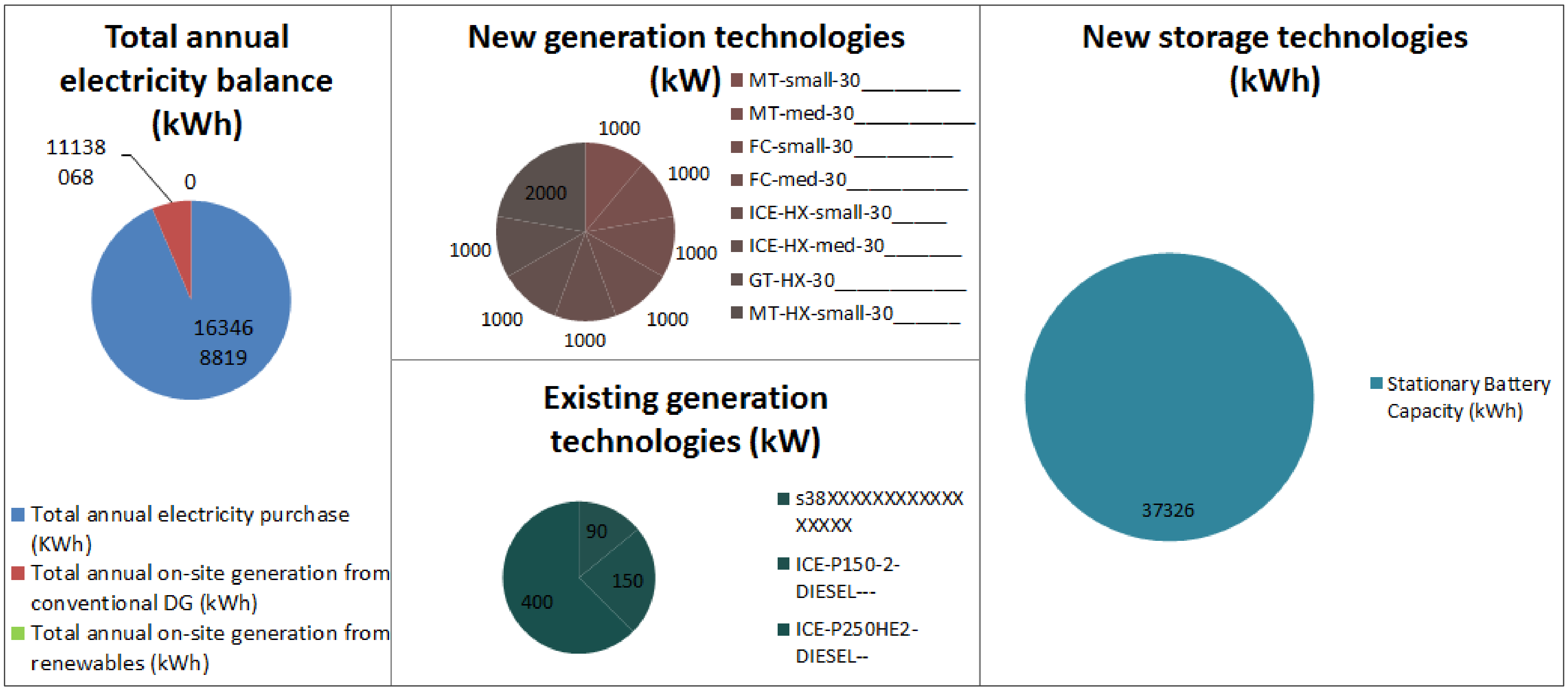


Figure 21. DER-CAM investment results – Serving Total Load with island in Peak Load Hour

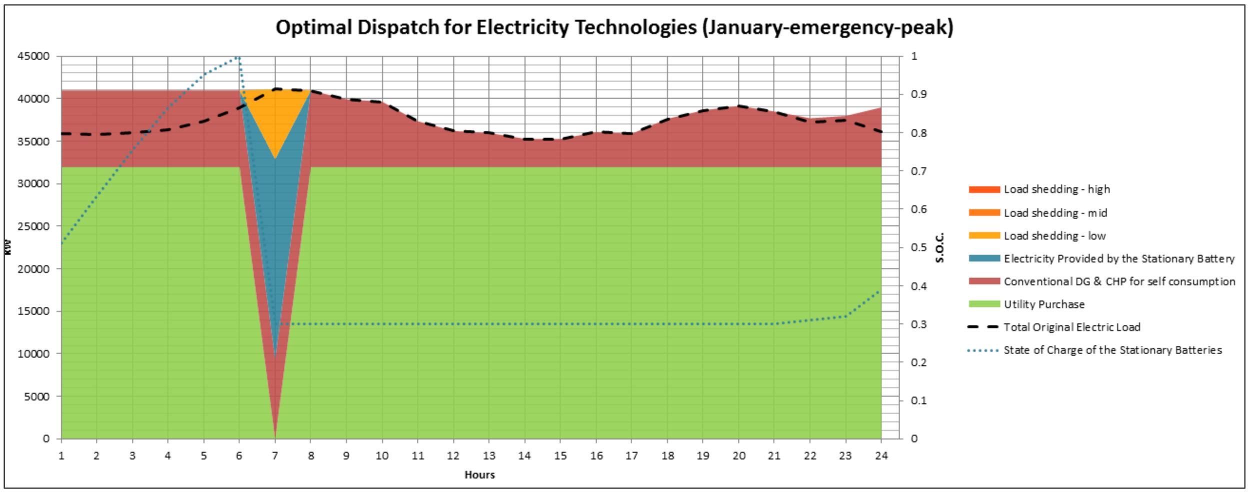


Figure 22. Optimal Dispatch with one hour Islanding

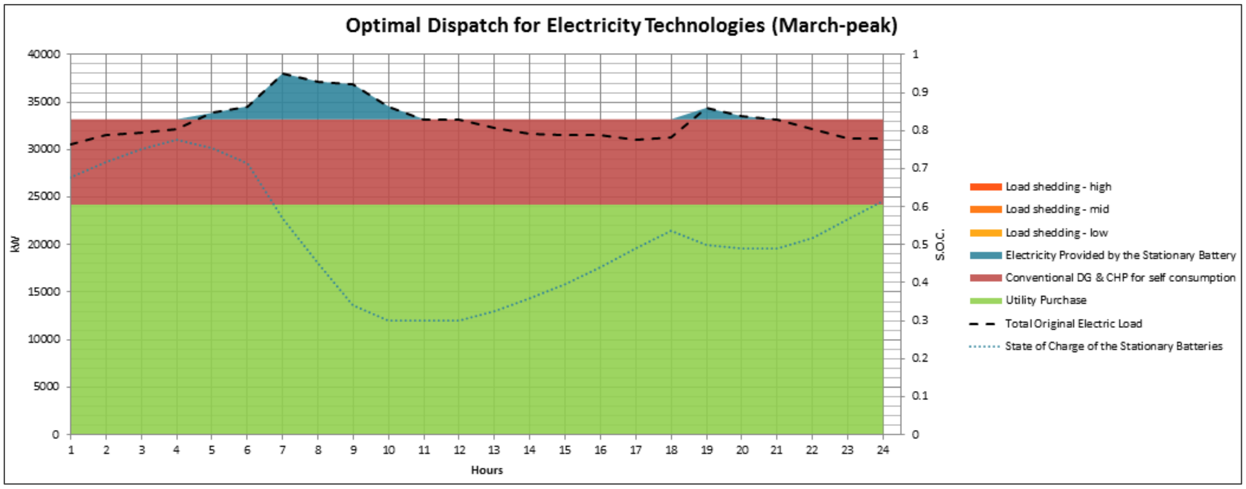


Figure 23. Optimal Dispatch in Grid-Connected Mode

Table 16.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)	Increment
Total Annual Energy Costs ($)	$ 755,783	$ 897,596	***$ 141,813***

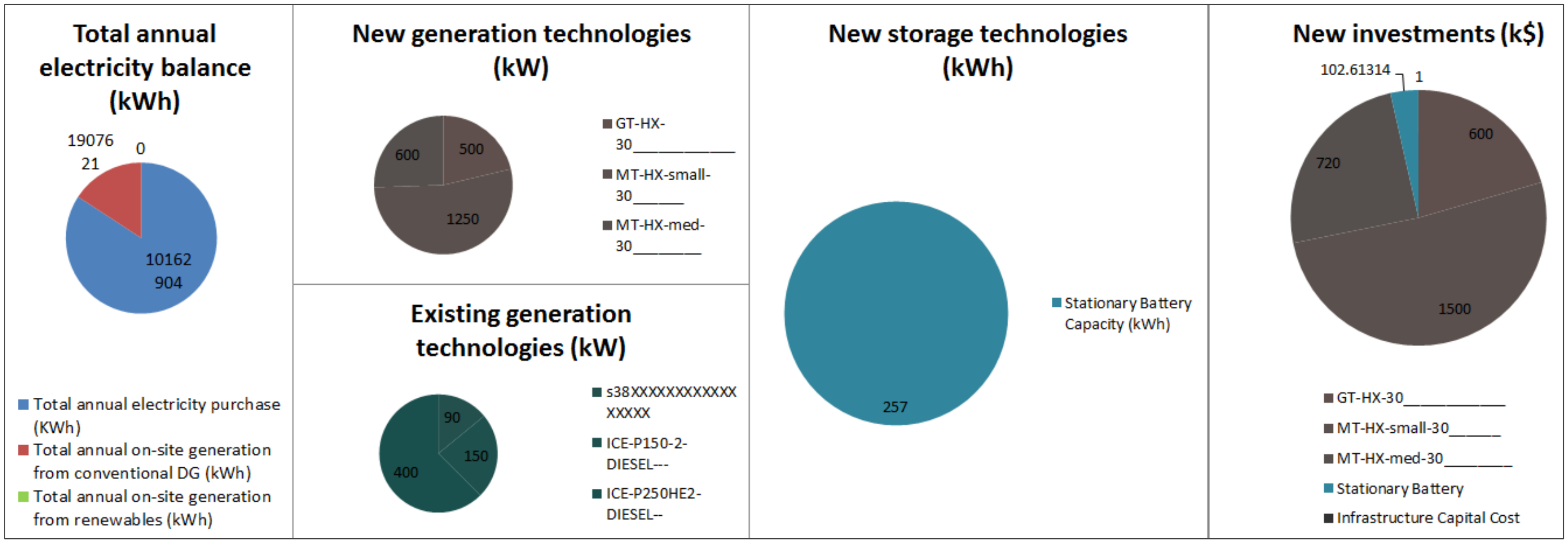


Figure 24. DER-CAM investment results – Serving Critical Load with One-week Island in January

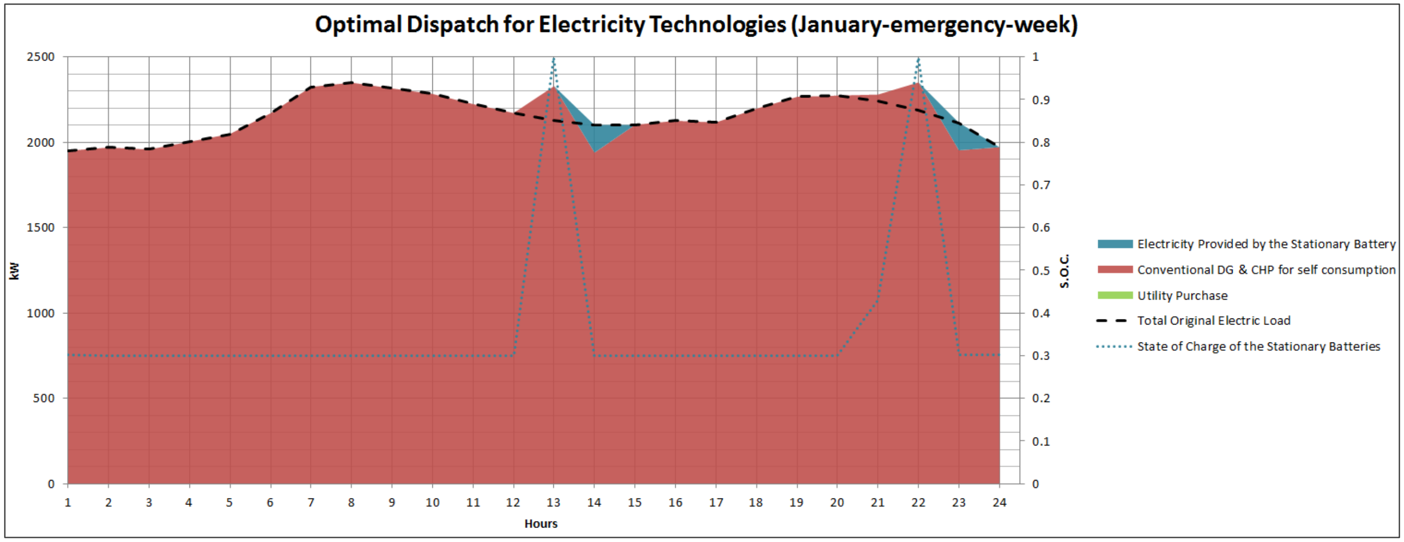


Figure 25. Optimal Dispatch in Islanding Mode

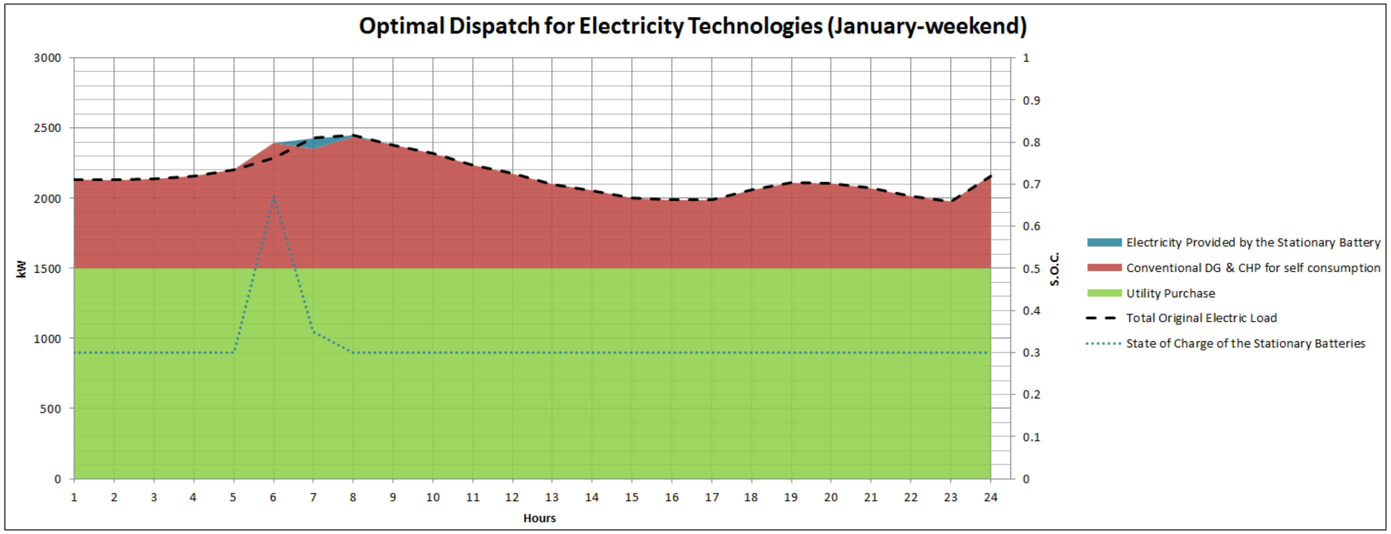


Figure 26. Optimal Dispatch in Grid-Connected Mode

Regarding the critical loads, DER-CAM is applied for the analysis of serving power to critical loads with different islanding time periods, from one day to one week, and also different load levels are taken into account. The proposed DER capacity and operational costs to serve all the critical loads (100% level) obtained from DER-CAM simulation are shown in Figure 20. The proposed new capacity would depend on the peak critical load and doesn't change along with the islanding time period. The operational cost would always increase along with the increase of islanding time period in the 100% load level. Figures 2.4.8-2.4.11 show the simulation results for serving 90%-60% of critical loads, respectively. It can be seen that lower investments would be needed as more load is curtailed, just as the operational costs are reduced, which indicate that higher resilience of critical loads can be achieved through either load management or adding new generation resources. It was noticed that the operational cost for serving the critical load increases along with the island time period in most of the cases. While, in some scenarios, the operational cost decreases a little bit as islanding time increase (80% load level and islanding time period from 3 days to 5 days shown in Figure 22, as an example), the reason for this is that the point shown as the final solution is not the theoretical optimum in DER-CAM, but rather is the first point found within the tolerance level. The DER-CAM simulation results are also shown in Table 17 and Table 18 based on the order of resilience in which we define that the capacity serving critical load without any disruption for seven days as 100% resiliency and the capacity of serving 60% critical load for one day as 10% resiliency.

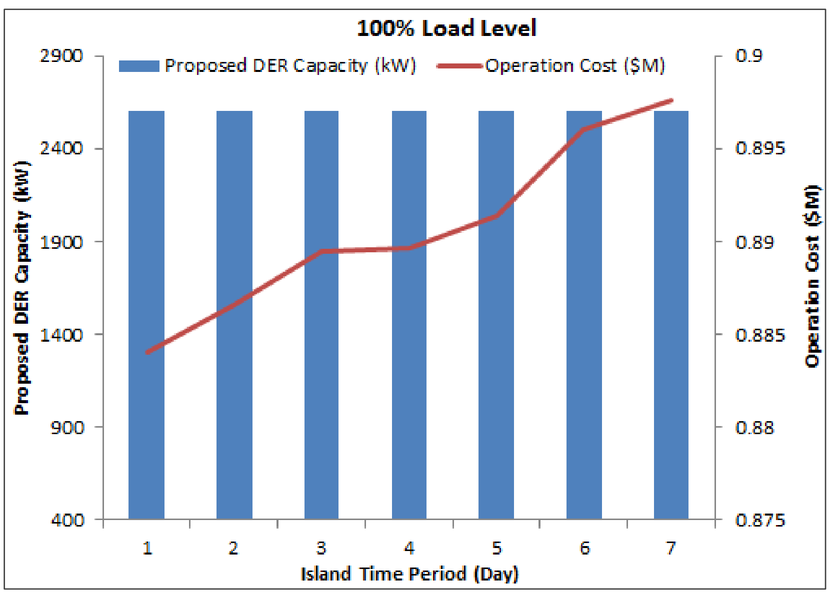


Figure 27. Proposed DER Capacity and Operation Cost for Serving 100% of Critical Loads

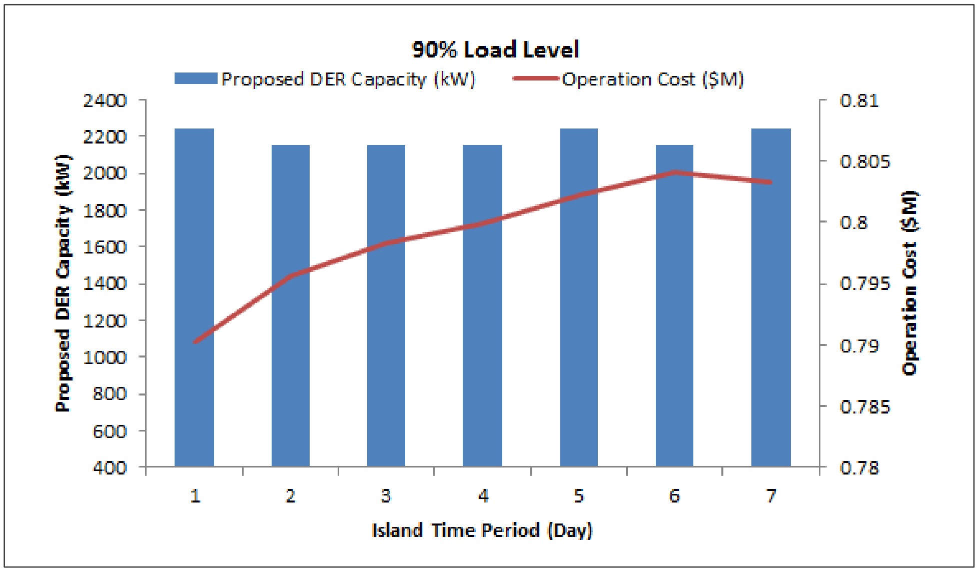


Figure 28. Proposed DER Capacity and Operation Cost for Serving 90% of Critical Loads

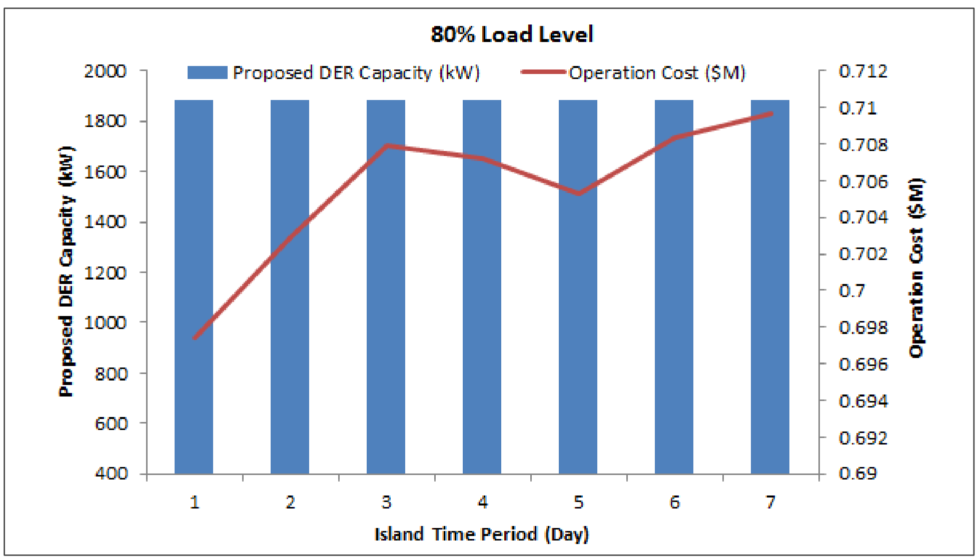


Figure 29. Proposed DER Capacity and Operation Cost for Serving 80% of Critical Loads

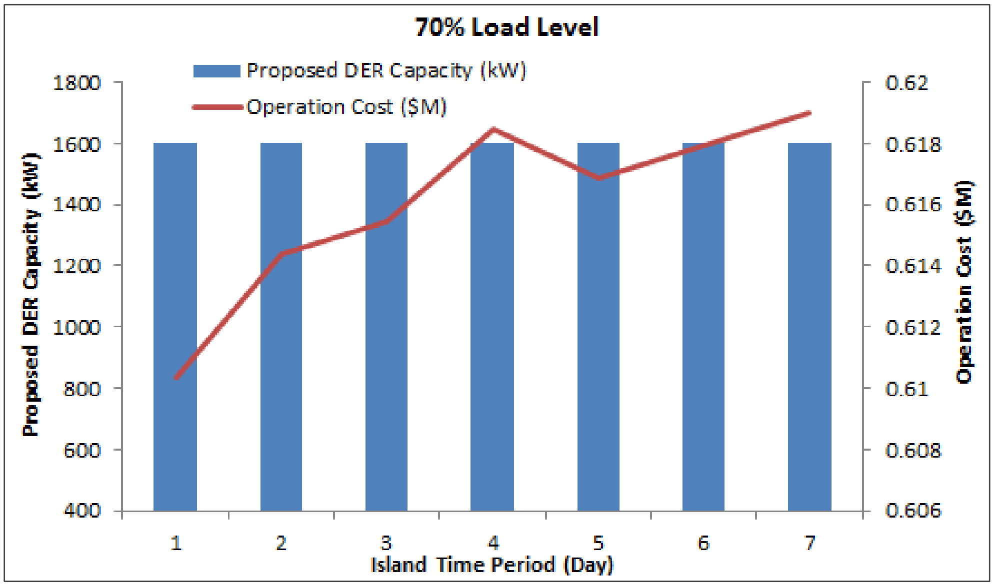


Figure 30. Proposed DER Capacity and Operation Cost for Serving 70% of Critical Loads

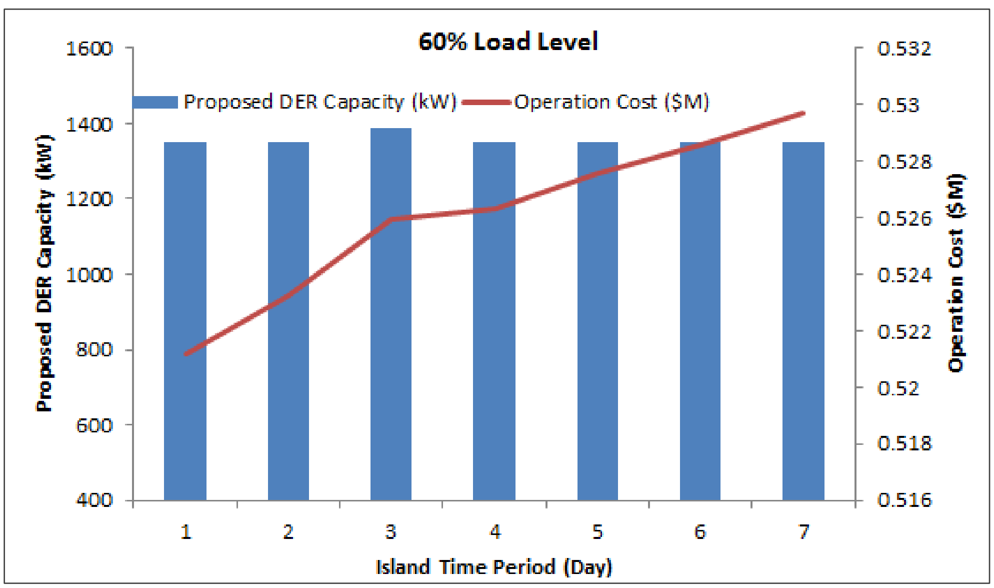


Figure 31. Proposed DER Capacity and Operation Cost for Serving 60% of Critical Loads

Table 17.The annual costs savings by the investment for supplying power for critical load with one week islanding in peak load season (January)

Islanding Days	Load Curtailment (%)	Resilience (%)	Proposed DER Capacity(kW)	Operation Cost ($)	Investment Cost ($)
7	0	100%	2,607	897,596	2,923,613
	10%	97.35%	2,245	803,252	2,579,050
	20%	94.71%	1,887	709,697	2,235,829
	30%	92.06%	1,600	618,983	1,921,000
	40%	89.41%	1,350	529,694	1,621,000
6	0	86.76%	2,607	896,000	2,923,613
	10%	84.12%	2,151	804,041	2,581,318
	20%	81.47%	1,887	708,316	2,235,829
	30%	78.82%	1,600	617,952	1,921,000
	40%	76.18%	1,350	528,582	1,621,000
5	0	73.53%	2,607	891,400	2,923,613
	10%	70.88%	2,245	802,267	2,579,050
	20%	68.24%	1,887	705,329	2,235,829
	30%	65.59%	1,600	616,872	1,921,000
	40%	62.94%	1,350	527,599	1,621,000
4	0	60.29%	2,607	889,656	2,923,613
	10%	57.65%	2,151	799,903	2,581,318
	20%	55.00%	1,887	707,183	2,235,829
	30%	52.35%	1,600	618,452	1,921,000
	40%	49.71%	1,350	526,334	1,621,000
3	0	47.06%	2,607	889,500	2,923,613
	10%	44.41%	2,151	798,303	2,581,318
	20%	41.76%	1,887	707,932	2,235,829
	30%	39.12%	1,600	615,458	1,921,000
	40%	36.47%	1,389	525,949	1,556,671
2	0	33.82%	2,607	886,613	2,923,613
	10%	31.18%	2,151	795,665	2,581,318
	20%	28.53%	1,887	702,971	2,235,829
	30%	25.88%	1,600	614,380	1,921,000
	40%	23.24%	1,350	523,241	1,621,000
1	0	20.59%	2,607	884,044	2,923,613
	10%	17.94%	2,245	790,314	2,579,050
	20%	15.29%	1,887	697,407	2,235,829
	30%	12.65%	1,600	610,391	1,921,000
	40%	10.00%	1,350	521,189	1,621,000

Table 18. 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%	1,350-2,607	529.7 - 897.6	1,621 – 2,923.6
6	0-40%	86.76% -76.18%	1,350-2,607	528.5 – 896	1,621 – 2,923.6
5	0-40%	73.53% - 62.94%	1,350-2,607	527.6 – 891.4	1,621 – 2,923.6
4	0-40%	49.71% - 73.53%	1,350-2,607	526.3 – 889.6	1,621 – 2,923.6
3	0-40%	47.06% - 36.47%	1,389-2,607	525.9 – 889.5	1,556.6 – 2,923.6
2	0-40%	33.82% - 23.24%	1,350-2,607	523.2 – 886.6	1,621 – 2,923.6
1	0-40%	20.59% - 10%	1,350-2,607	521.2 – 884.0	1,621 – 2,923.6

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 wheatear events, if one feeder fails, the building will still receive power feed from the other feeder.

Connecting Arcade Community Microgrid with Grid and Microgrid Protection

The four substations located in Arcade community would be the point of common coupling (PCC) where the Arcade 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 Arcade 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 device and the four levels are coordinated. The protection devices and operational rules in each level are summarized in Table 19. 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 performances of microgrid protection are as summarized as follow.

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

[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.

Table 19. 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

Arcade Community Microgrid Control Architecture

Figure 25 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 Arcade 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

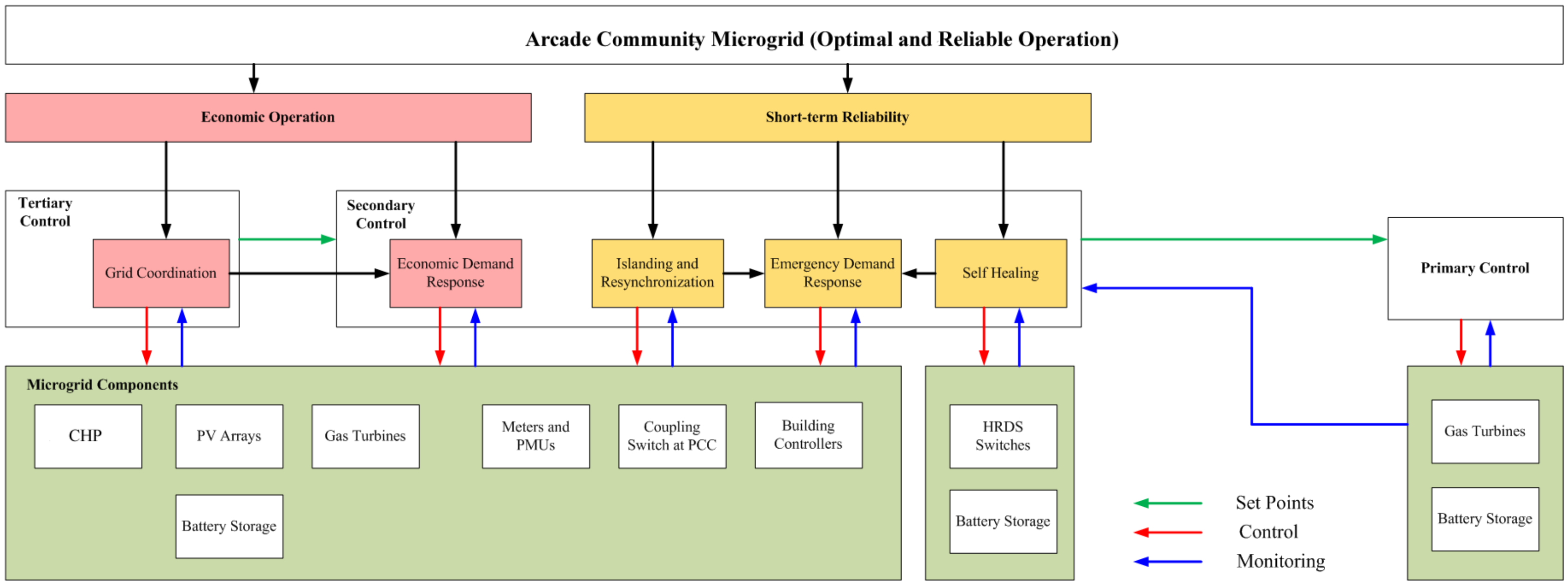
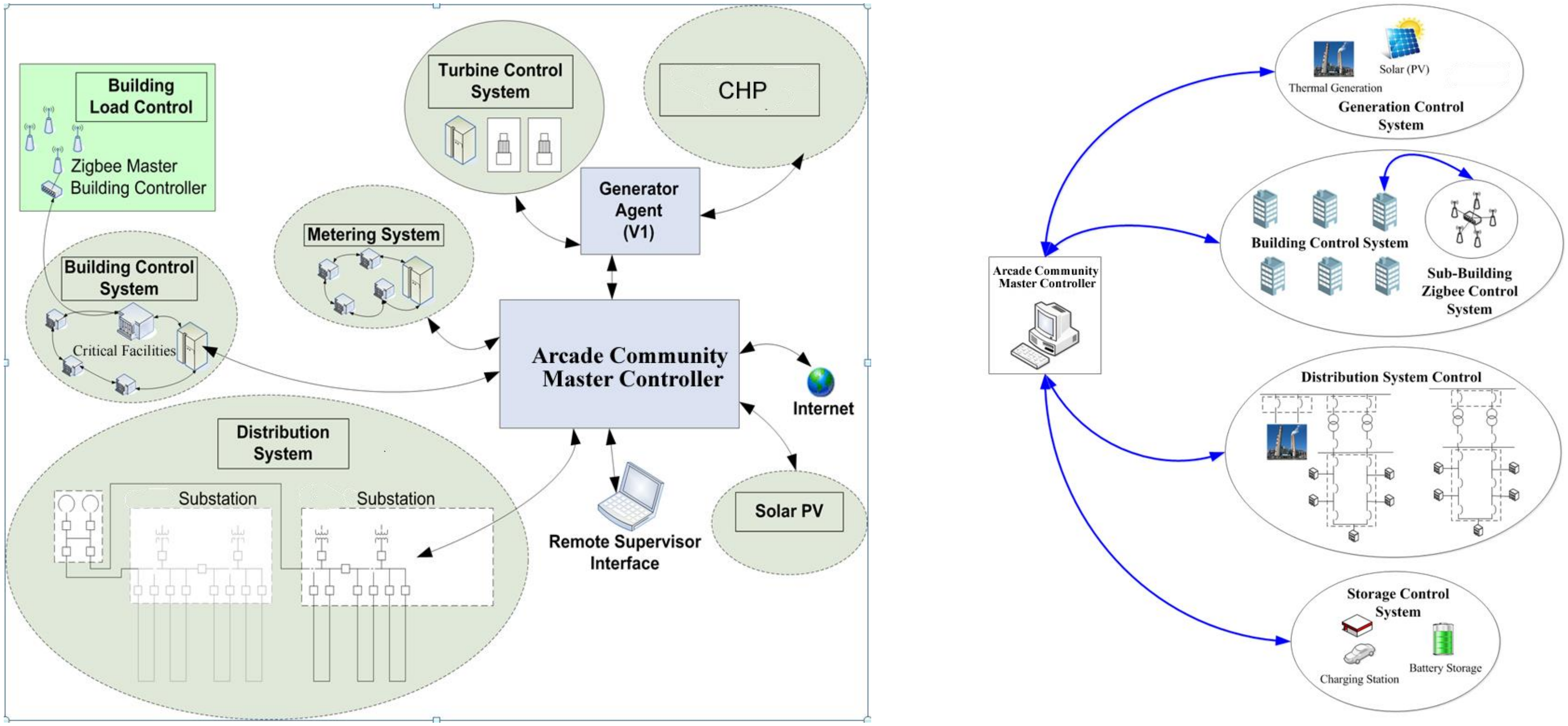


Figure 32. Objectives and functions for the control and operation of the Arcade Community Microgrid



(a) (b)

Figure 33. Architecture of master controller for Arcade community microgrid

A major element of the Arcade 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 Arcade 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 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 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 25 shows the hierarchical framework of the Master Controller proposed for Arcade's community microgrid project. In Figure 26, 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 Arcade's electric department office. The master controller would collect the real-time data and send out set-point information through the SCADA application.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 the case of emergencies, the controller would utilize the master controller to isolate the community from the utility grid and operate in island mode. Within the community microgrid, the non-critical load could be curtailed or disconnected through smart meters orswitches, local distribution network are reconfigured so the local DERs can supply power to the critical loads.

Services and Benefits of Arcade Community Microgrid

The Arcade community microgrid would be operated locally in grid-connected and island modes and can provide black start operation, frequency and voltage support, active and reactive power control. The proximity of power generation to microgrid consumptions 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 Arcade community microgrid could provide are summarized as follows.

1. *Increase safety and resiliency*

   The Arcade 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 Arcade 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, 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.

   During emergency operating conditions, the Arcade 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) plant, 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 Arcade 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 Arcade 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 Arcade's customers and members in the form of lower energy bills and membership costs.

   By using the more efficient and safe LEDs microgrid for public street lighting and residential lighting and smart home appliances along with the proposed community microgrid, it can not only enable the capability of load shedding and load shifting, but also both the community and residential customers can reduce maintenance cost and electricity bills.

   Arcade 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*

   Arcade 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, vacant or unused land. In any case, the heat load from the CHP would be utilized year round, capitalizing on Arcade's existing piping and distribution infrastructure to deliver thermal loads.

4. *Resolve existing system constraints*

   The proposed community microgrid would be able to address and mitigate the existing system constraints faced by Arcade's current distribution system. Due to the peak demand during winter season, Arcade'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 fail. The residential winter peak also causes significant voltage sags in the distribution 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 Arcade community exceeds its NYPA kW and kWh allocation. With the electricity and heat produced by local CHPs, the power import from the grid could curtailed and which is helpful in mitigating the demand and depend grid, and then result in reliability and resilience improvements in addition to economic benefits.

5. *Capitalize on new value system*

   The community microgrid would enable Arcade to have the capability of participating in the frequency regulation market by locating energy storage resources at critical points in the microgrid, and the potential for load curtailment, demand management, and demand response with all available resources. In the case of distributed energy storage resources, Arcade will evaluate various ownership models to optimize the economic benefit to the system, including purchase, leasing and third-party ownership.

6. *Job creation*

   The operational requirement of a new CHP plant, battery storage and microgrid system in the Village of Arcade 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 application.

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

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

Arcade Electric Department owns and operates four substations and over 30 miles of distribution lines, serving nearly 2,000 customers. A large majority of those customers are individually metered; however, these meters are read manually every month by a meter reader. Arcade Electric Department controls and operates its electrical distribution network using a CG Automation Supervisory Control and Data Acquisition (SCADA) software platform. This software connects to the substation and various switchgear, primarily over the Arcade fiber optic network; however, a few devices utilize a cellular backhaul. The equipment in Arcade Electric's distribution network communicates using DNP3 over TCP/IP from remote Schweitzer Engineering Laboratory (SEL) Real-Time Automation Controller (RTAC) Remote Terminal Units (RTUs) in the substations back to the Master Station, which is Arcade Electric Department. From the substation RTU, various SEL relays and some ABB and Basler relays are tied into the system using primarily DNP3, while some few are limited to Modbus.

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

Arcade Electric Department would benefit from an Advanced Metering Infrastructure (AMI) expansion, which would involve adding wireless communication infrastructure throughout the Village of Arcade 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 the SCADA platform for use in billing or monitoring the overall grid.

Proposed/Suggested Improvements

The Arcade 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. Exact upgrades or additions to existing communications infrastructure will need to be determined in a Phase 2 design. 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 27.

In addition to meters and streetlights, circuit breakers, relays, reclosers and other switchgear are vital to the control of the Arcade 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 Arcade Electric Department data center and the substations. 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.

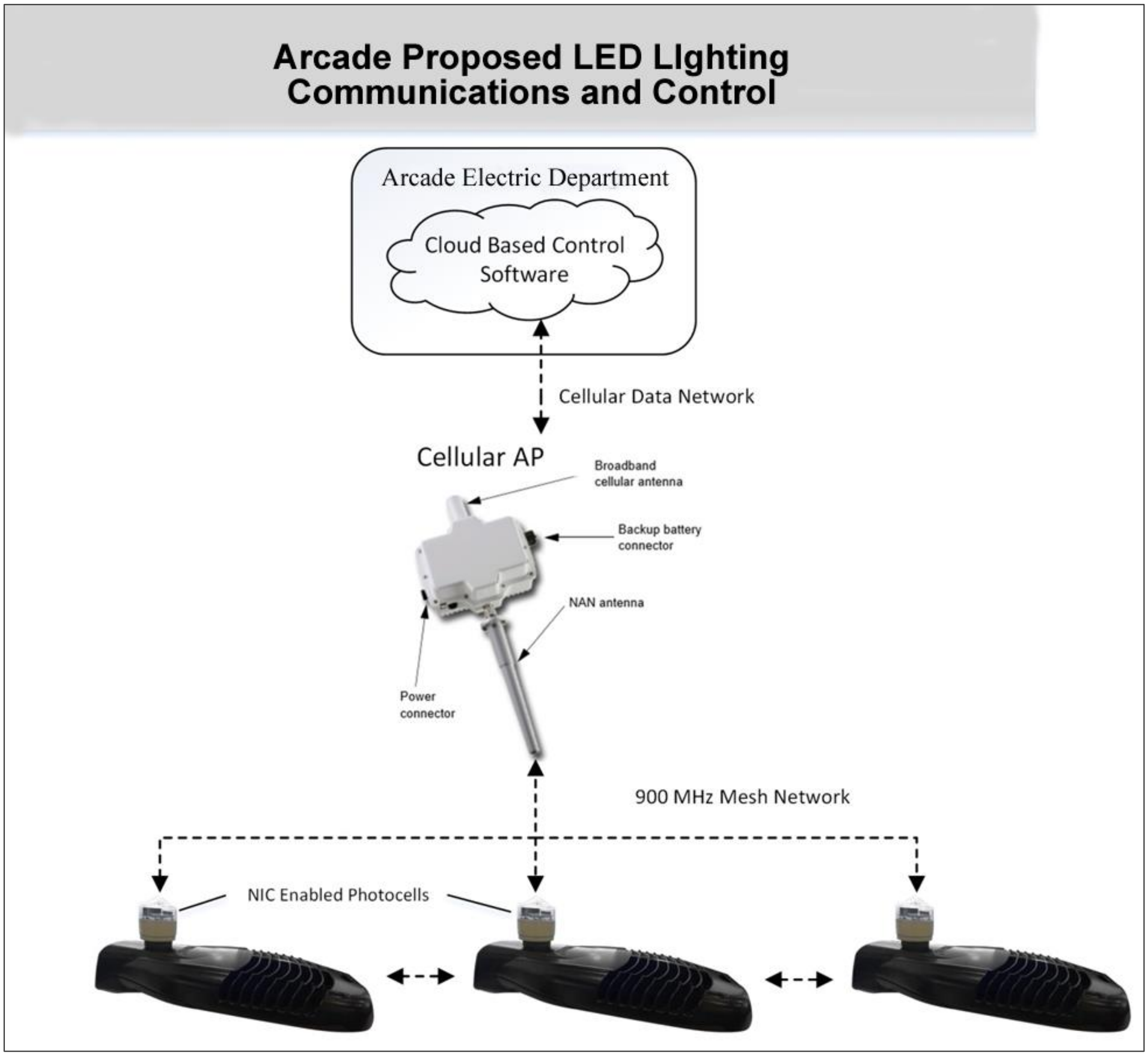


Figure 34. Arcade Proposed LED Lighting Communications and Control Diagram

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, inaccuracies, and outage information will have to be obtained to determine exact cost savings of upgrading to the new system.

Figure 35. Network Equipment simplified layout diagram

As Arcade Electric Department is the proposed owner/operator for the Arcade Community Microgrid, the Master controller would be located in the Arcade Electric Department office data center that houses Arcade's existing SCADA system. While the master controller would automatically communicate with the Arcade SCADA system as well as with the field devices such as the building controllers (BCs) and automatic generation controllers (AGCs), Arcade Electric Department 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 Arcade 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

In the event of a major outage in Arcade, approximately 7,500 residents would be without power. Critical loads include the Wastewater treatment and Clean Water plants, Village offices, police and fire departments, schools, and a hospital. Every resident of Arcade would be affected in the event of a major outage.

Microgrid generation may potentially participate in 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, Arcade 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).

Assuming that the units can regulate and clear the auction, potential revenue streams could range from perhaps $114,500 to $160,250 (25% to 35%)[1] *but could be significantly lower or higher*.

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.

Additional revenue streams from sales of storage as ancillary services may be possible. Again, such revenues would be predicated upon potential revisions to NYPA's tariff structures.

The schools are the only critical facilities served by the microgrid that are not owned by the Village, meaning it will be the only customer purchasing additional services from the microgrid in outage situations.

Two major industrials are located within the Village of Arcade and represent a significant load. These customers will likely see greater reliability and better power quality with the installation of a microgrid. The microgrid will also cut the peak load of the Arcade system, saving residents hundreds of dollars per year in energy costs.

[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.

The Village of Arcade Electric Department will own, operate and use all power generated on the microgrid.

Under normal operation the Village of Arcade will serve all customers on its system as normal. Under islanded operation, the microgrid will serve only 3-4 MW of critical facilities and emergency services.

Only one additional facility contract may be necessary and that is with Pioneer Central Schools. The Schools are the only critical facilities not owned by the Village, but are an excellent location for combined heat and power. The Arcade Electric Department would likely own and operate the system in that scenario, necessitating some arrangement for use of space at the School facilities.

The Arcade Electric Department will continue to serve all of its normal customers in blue sky mode, and will control the critical facilities in islanded mode.

No additional commodities are expected to be provided by the microgrid at this time.

Sub Task 3.2 Commercial Viability - Value Proposition

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 the Village of Arcade receives its regulated rate of return (ROR) through incorporation of microgrid assets into its ratebase. The Arcade Community Microgrid will be owned by the Village’s municipal utility. Potential Project team members may include bond counsel, private equity advisors, DOE LGO, NYMPA, EPC Contractor, Consulting Engineer, Operator, Permitting Consultant, Environmental Consultant, NYPA, ratepayers, Village Council, stakeholders, and technology providers. Table 20 below presents the SWOT analysis.

Table 20. 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 & supporting infrastructure requirements (e.g., AMI IT)	Enhance security & 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 20. 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 power supply	Cost competition from low-cost Niagara hydro allocations	Replacement of obsolete/ aging infrastructure
	Village of Arcade 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

The control system will be operated by a municipal electric utility allowing the microgrid to economically dispatch at peak times to shave cost for Arcade even in blue sky conditions. The proposed generation assets and infrastructure are well known throughout the industry, though the fact that they are being paired together for resiliency and economic reasons is unique.

Arcade is a small NY Community, like many other NY Communities. Also, Arcade is only slightly above average in terms of the size of its electric department. These factors make this project replicable in small communities across the state that own their own water and wastewater systems, as well as in municipal electric utilities. The project is not seeking to be scalable in and of itself, as there is a limit to the amount of generation able to be installed on the Arcade system, and the system is of a finite size. However, aggregation of multiple microgrids across the state for economic purposes could be an option for scalability.

The Arcade Electric system serves customers over three counties and ten total municipalities, making this project unique. Also, if the larger grid outside Arcade loses power, all 7,500+ residents lose power. This is a possibility, particularly in the dead of winter when Arcade experiences extreme snow events for days at a time. The microgrid, using underground gas lines for on-site chp, and battery storage on-site, is expected to be resilient to the most typical extreme weather events in the area.

Sub Task 3.3 Commercial Viability - Project Team

The Village of Arcade, Wyoming County, and the Arcade Electric Department are championing this project. It is through the collaboration between the Village and primary stakeholders that additional local and regional partners will be sought. The Village expects this project to lower the average annual residential energy bill, making the support from residents much easier to acquire when the time comes.

The Arcade Electric Department is the owner, operator and applicant on this project. They have secured Willdan to complete the technical work, and will decide on suppliers and partners in the near future when full benefits and costs have been established for the project.

The Village of Arcade is a municipal utility with a good financial record and low debt burden, although it is located within a municipality with a limited tax base and stagnant economic growth. The most recent rating information for Arcade is a rating of A3 from Moody's in April of 2012.[1]

To this point, the NY Prize program is the first microgrid effort for both Arcade and Willdan. However, Willldan is leading 8 NY Prize studies, and has been consulting in energy for over 50 years.

There has been interest from numerous financiers and investors, though none have been chosen to this point. Willdan and Arcade are collaborating to determine the best path forward for the Electric Department and expect to choose a financing partner for this project within the next year. For the

[1] The Village of Arcade's bond rating was downgraded in 2012 from A2 to A3: http://www.municipalbonds.com/bonds/moodys_report/17219/

second phase of NY Prize, additional engineering design support will be required, though Willdan may be able to cover these services as well.

Willdan has a network of legal and regulatory advisors, and Arcade has advisors for legal and regulatory matters as well. Additional support may be sought for Phase 2 when additional detail around permitting and financing is required.

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 Arcade 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 Arcade 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 Plants and short term sources like Batteries, would allow the Village of Arcade 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 critical facilities will ensure that critical facilities will remain powered on in emergencies, providing the Village of Arcade 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.

Batteries seem to be a good option for Arcade in combination with the local industrial facilities who could benefit from improved reliability and power quality. As natural gas fed CHP is also an option for the Arcade 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 Arcade to prevent any small issues from leading to major problems if there is an interruption in natural gas supply. National Fuel Gas currently operates the local gas network, and while some learning on the part of Arcade may be necessary, there is not expected to be any major issues with regard to gas system maintenance.

The Arcade 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. The Arcade Electric Department 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-owned buildings on Arcade's existing network, with the master controller at the Electric Department headquarters where the system is already operated, ensuring smooth operation of the microgrid.

Additional permitting for on-site generation and emissions may be required, though a more detailed analysis of the specific type and cost with wait until the next phase of this project.

The Village of Arcade 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 Arcade Community Microgrid project, barriers to entry are significant due to regional power market characteristics and the availability of low cost hydropower. The Village of Arcade retail power rates are so low that they challenge development of conventional energy resources. Emerging resources fare even worse.

Using a municipal model and seeking grants and loan guarantees will ensure that the project meets its profitability goals.

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 Arcade Electric's customers, Demand

Response related revenues and Ancillary Services payments from NYISO, and potential revenues from other public authorities. Generation technology would also enable demand reduction during the winter months, when the Village of Arcade exceeds its monthly allocation of hydropower, and potentially displace energy purchases during NYISO peak summer months. General estimates of these costs follow. Should the Arcade 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 Arcade 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]

Figure 30 illustrates potential Option 3 capacity revenues assuming 3.25 MW of generation and storage under the NYPA Option 3 tariff, pursuant to which capacity payments are based on 85% of the average monthly NYISO auction clearing price. Customers can enroll based on summer (May-Oct) or winter (Nov-Apr) participation. Based on these estimates, revenues of approximately $57,300 would result from capacity payments for 12-months of participation.

Table 21. Illustrative Example of NYPA Option 3 Capacity Revenues

	May	Jun	Jul	Aug	Sep	Oct
Price ($/kW-Month)[2]	$3.96	$3.73	$3.54	$3.35	$3.17	$3.00
Capacity (MW)	3.25	3.25	3.25	3.25	3.25	3.25
NYPA Capacity Payment ($)	$10,939.50	$10,304.13	$9,779.25	$9,254.38	$8,757.13	$8,287.50
	Nov	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**
Price ($/kW-Month)[3]	$0.66	$1.48	$1.72	$1.75	$0.75	$0.50
Capacity (MW)	3.25	3.25	3.25	3.25	3.25	3.25
NYPA Capacity Payment ($)	$1,823.25	$4,088.50	$4,751.50	$4,834.38	$2,071.88	$1,381.25
TOTAL						**$57,321.88**

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

[1] http://www.nypa.gov/PLM/PLMgovernment3.html.
[2] NYISO, Summer 2015 Monthly Auction Results for UCAP, Auction Starting 05/2015, Posted Date: 04/14/2015 12:01 PM, NYCA. http://www.nyiso.com/public/markets_operations/market_data/icap/index.jsp .
[3] NYISO, Winter 2015-2016 Monthly Auction Results for UCAP, Auction Starting 10/2015, Posted Date: 10/14/2015 12:03 PM, NYCA. http://www.nyiso.com/public/markets_operations/market_data/icap/index.jsp

10 hours[1], participants are also paid for 1 hour of monthly testing.[2] Assuming 22 hours of revenues, the microgrid would earn $35,750 in energy over 12 months assuming 3.25 MW of capacity.

Total annual payments under NYPA's Option 3 Tariff would be around $93,000.

Revenues from Other Public Authorities

The Village of Arcade currently receives approximately $69,000 in electric revenues from sales to other public authorities[3]. The Arcade 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

The Village of Arcade receives allocations of low-cost hydroelectric power from NYPA, and winter heating loads cause it to exceed its monthly allocation from November to April. The cost of such excesses can be significant. In 2014, for example, such overages cost the Village of Arcade nearly $2M.

In addition to peak shaving, the Village of Arcade would earn retail sales revenues when system power purchases are displaced by behind-the-meter generation or injections from storage. Production modeling would be required to determine the load that would be replaced and resultant retail revenues received. Depending on capacity and configuration, the Village of Arcade 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.

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 expansion of the natural gas service through the Village off of National Fuel's main transmission network. Metering infrastructure would likely require upgrades and installation of new assets as well.

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

[1] Demand Response, New York Market Orientation Course, November 5, 2015, NYISO.
[2] NYISO guarantees a minimum payment of 4 hours.
[3] Source: Municipal Electric Utilities Annual Report of the Village of Arcade for the Year Ended May 31, 2015 to the State of New York Public Service Commission, page 300.

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 $25M 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 below.

- Infrastructure upgrades to accommodate microgrid;
- AMI;
- Master controller and communications infrastructure;
- Natural gas system upgrades;
- Natural Gas Cost
- Permitting costs—need to consult experts regarding air permitting of new resources.

The project will be structured to ensure that any financial obligations are met and the Village of Arcade electric department receives its regulated rate of return (ROR) through incorporation of microgrid assets into its ratebase. The Village of Arcade's ratebase was $8.4 M as of May 31, 2015 and its ROR was around 4%.[1]

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 Arcade Community Microgrid will be owned by the Village's municipal utility. 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.

The Village of Arcade will be the owner of the Arcade Community Microgrid and the applicant. The Arcade Electric Department is the municipal utility for the Village of Arcade.

The project applicant and microgrid owner currently owns, or has access to, all sites in this proposal. 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 the Village of Arcade to ensure compliance with such requirements, though since the Arcade Electric Department is the existing power provider with an existing privacy protocol, continuing and expanding the protocol to the new system is expected to be straightforward.

The amount of generation on Arcade's system allowed by NYPA may be a hurdle to this project, although recent discussions with NYPA indicate they may support the current microgrid proposals under NY Prize.

---

[1] Source: Municipal Electric Utilities Annual Report of Village of Arcade for the Year Ended May 31, 2015 to the State of New York Public Service Commission.

Task 4 – Develop Information for Cost Benefit Analysis

Additional information regarding potential spin-off battery storage projects at the Arcade Industrial Park can be found in Section 2.3 and Section G of the Microgrid Questionnaire. We find that adding a small amount of solar + battery storage at one or both industrial sites may be an intriguing option for the Industrial Facilities, due to the potential increase in reliability and power quality for a small annual cost ($12,000 - $17,000).

The final results of the benefit cost analysis are in line with the independent calculations completed by the project team. Due to the lack of substantial natural gas infrastructure in the Village of Arcade, the potential for microgrid development is significantly hindered. Expansion of the natural gas network is possible, since there is a National Fuel transmission pipeline just north of the village. However, the Village of Arcade Public Works Department only controls electric, water, and sewer utilities, and any expansion of the natural gas network for heat or electric use will cut into the Village's utility revenue.

There has been discussion of expanding the gas network to the village so businesses and residences can choose to switch to natural gas heating system, which would reduce the extreme peaks the Village experiences in the winter months due to the prevalence of electric heat. Further analysis is required to determine whether the cost to the Village of a) expanding the network and b) losing electric revenue in the winter, outweighs the benefits of reduced peak load in the heating season. It is clear that the cost of expanding the network on top of the capital investment of generation and controls for a microgrid makes the project cost prohibitive.

A long-term possibility for solving the peak issues in the winter would be for the Village Public Works Departments to form a natural gas municipal utility attached to the Electric Department. In this scenario, the Village would take control of the gas network within the Village and form a contract with the gas utility, National Fuel, similar to those operated by the Village of Arcade or Jamestown Public Utilities. This would allow the Village to develop gas for electric peak support, residential heating, and resiliency. This possibility would also have to be discussed with the Village Board and National Fuel before further analysis is completed.

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 21 of the potential microgrid facilities are owned and operated by local municipalities. Clearly the largest energy users are the schools and wastewater plant, which require nearly 3 MW of power at peak.

Arcade is a unique municipal utility because is spans over 100 square miles and touches 10 separate municipalities, including three counties. Unfortunately, this feature also leads to the geographic separation of the critical facilities, which makes microgrid development much more difficult and costly. Should this project be taken forward in the future, a multi-node approach may change the results of the analysis slightly, though under current cost constraints, any project is expected to be prohibitively expensive.

The focus of the microgrid design in this report is to ensure the operation of the largest critical loads on the Arcade system: the High School, Elementary School, and Sewage Plant. The industrial park also has generation located on site in the proposal due to the economic potential of this project and the multi-faceted benefits.

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 2.35 MW of Natural Gas CHP split between the High School (1.25 MW), Elementary School (600 kW), and Wastewater Plant (500 kW), and 250 kW of Battery Storage located near the Industrial Complex.

As mentioned at the beginning of this task, in reality the natural gas development is much more complicated than simply siting new CHP generators at the critical facilities. It is unlikely that any new natural gas generators will be installed in the near future, but this proposal was optimized to show what could benefit the Village in the event that higher natural gas penetration is experienced. Despite the drastic winter peaks experienced in Arcade, and the need for additional generation to curb the 16 MW gap between the NYPA allocation and peak, the analysis still only recommends a 2.6 MW microgrid.

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, Arcade 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. Arcade is also open to enroll assets in demand response in the event that doing so makes economic sense. To this point, only the generator located at the Arcade Village Offices is 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 Arcade Electric Department has hoped to develop battery storage resources on their distribution network for some time. This study has identified one possible project that may allow the Village to do so. Developing battery storage systems at the industrial sites would allow Arcade to utilize the batteries for peak shaving, demand response, as well as additional ancillary markets that may be available.

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 Arista Power, LeChase Engineering, and EC4B. For aspects of the project that may move past Phase 1 of NY Prize, such as the battery storage project at the industrial park, more precise numbers may be sought out at a later time. All numbers presented in the study are based on past experience and similar projects.

Arista power provided estimates for the cost of installing a solar + storage system at the industrial sites in Arcade. In all, the estimates show that Arcade could develop solar for as little as $0.75 per watt and battery storage for as little as $1 per watt if the projects are done together. The CHP estimates came from discussions with EC4B, who has constructed CHP projects in the region, and result in a cost of under $3,000 per kW.

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.

The costs to maintain service during an outage with no microgrid is significant for the Village. Officials from Arcade mentioned the high cost of operating and maintaining diesel generators at critical facilities, while some critical facilities have no backup power at all. Due to the large geographic area covered by the Arcade system, providing emergency services to all residents in an outage is very difficult. Finding shelter and food across the service area could result in overcrowded facilities and resource shortages. The situation is made much worse in the winter, because many facilities rely on electric heat, which may not be available during an outage. Developing CHP at some facilities will help mitigate the worst circumstances for the Village.

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 Arcade (a municipal utility) goes down, all residents will lose power. Fortunately, Arcade has multiple transmission ties to the National Grid System, and 4 separate substations providing some redundancy and a high average reliability.

In Arcade, many of the facilities providing emergency services do not have any form of backup power. For example, the High School and Elementary School would experience a total loss in the event of a power outage, as would the fire station in the neighboring town of Yorkshire. Some lift and pump stations in the water and sewer network would also go down in the event of a major outage. Other facilities, such as the Arcade fire, police, and Village Offices, would be fully supported even in a total system outage.

A particularly worrisome fact is that the only medical facility in the Village would lose most of its services in the event of an outage, and the next closest medical center is 14 miles away. This study has calculated that over 7,500 people are served by the local medical services, meaning most of them could go unserved in the event of an outage. This study recommends that additional resources be sought, even if no microgrid is developed, to ensure medical services to the Arcade service territory in the event of a power failure.

Benefit-Cost Analysis Summary Report

Village of Arcade

Project Overview

As part of NYSERDA's NY Prize community microgrid competition, the Village of Arcade has proposed development of a microgrid that would enhance the resiliency of electric service for the following critical facilities in this Wyoming County community:

- The Arcade Village Office and Police Department;
- The Arcade Sewage Plant and its North and West Lift Stations;
- Pioneer High School and Arcade Elementary School, both of which are designated as community shelters in the event of an emergency;
- The Arcade and Yorkshire Fire Departments;
- Three municipal garage facilities (Sullivan Garage, Mill St. Garage, and Arcade Town Garage);
- Two water supply units, Sullivan Well and Sandusky Well;
- Arcade Manor, a 24-unit senior housing facility;
- Garden Park Apartments, a 40-unit affordable housing development;
- Two day care and preschool facilities, Early Bird Nursery and Rainbow's End Nursery;
- The Arcade and Wyoming County Communications Towers; and
- The Freedom and Yorkshire Cell Towers.

The microgrid would be powered by three new natural gas combined heat and power (CHP) units: a 1.25 MW system at Pioneer High; a 600 kW system at Arcade Elementary; and a 500 kW system at the sewage plant. The operating scenario submitted by the project's consultants indicates that the CHP systems together would produce approximately 19,740 MWh of electricity per year, roughly 1.6 times the amount required to meet the average annual demand of the facilities listed above; this energy would be sold to the grid. During a major outage, the project's consultants indicate that the CHP systems would supply approximately 60 percent of average electricity use at the facilities served by the microgrid.[1]

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:

[1] As noted, the capacity of the generators appears sufficient to supply 100 percent of average daily electricity use at the facilities listed above.

- *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 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).

[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].

- 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 22 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 1.2 days per year (Scenario 2). The discussion that follows provides additional detail on these findings.

Table 22. BCA Results (Assuming 7 Percent Discount Rate)

Economic Measure	Assumed Average Duration of Major Power Outages	
	Scenario 1: 0 Days/Year	Scenario 2: 1.2 Days/Year
Net Benefits - Present Value	-$3,880,000	$306,000
Benefit-Cost Ratio	0.9	1.0
Internal Rate of Return	-0.1%	6.2%

Scenario 1

Figure 29 and Table 23 present the detailed results of the Scenario 1 analysis.

[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.

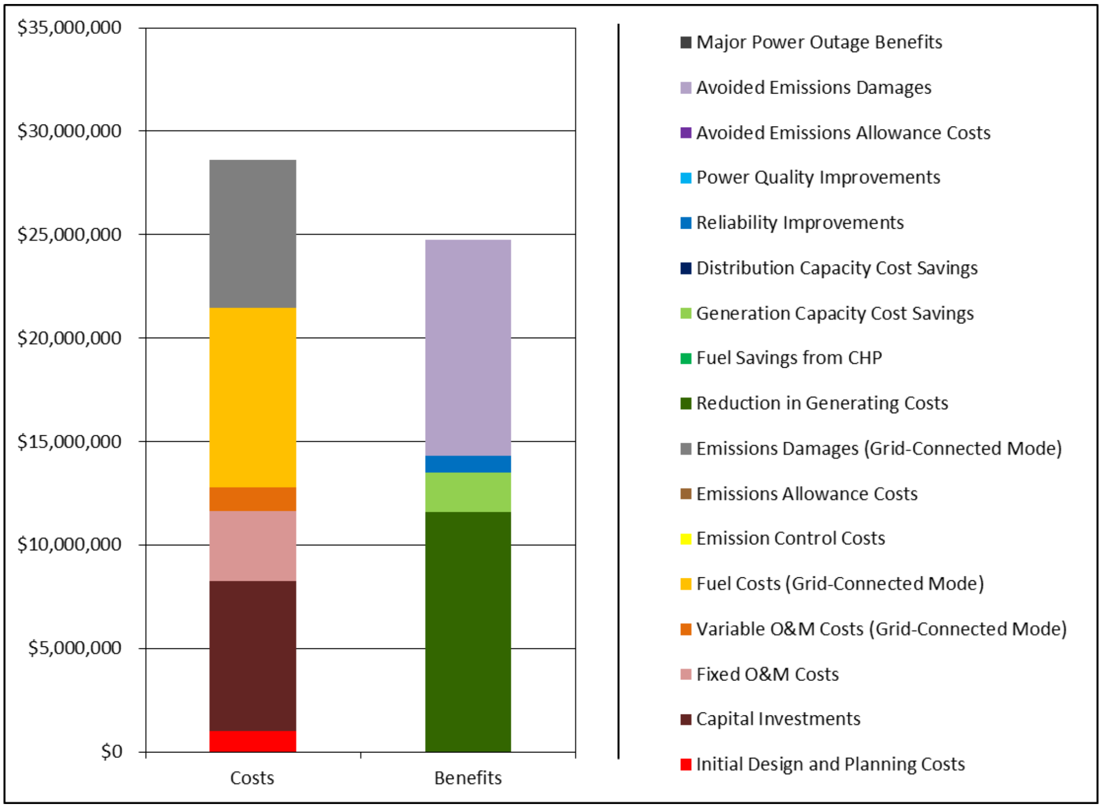


Figure 36. Present Value Results, Scenario 1 (No Major Power Outages; 7 Percent Discount Rate)

Table 23. 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	$1,000,000	$88,200
Capital Investments	$7,250,000	$591,000
Fixed O&M	$3,400,000	$300,000
Variable O&M (Grid-Connected Mode)	$1,120,000	$98,700
Fuel (Grid-Connected Mode)	$8,700,000	$767,000
Emission Control	$0	$0
Emissions Allowances	$0	$0
Emissions Damages (Grid-Connected Mode)	$7,170,000	$468,000
Total Costs	**$28,600,000**	
Benefits		
Reduction in Generating Costs	$11,600,000	$1,020,000
Fuel Savings from CHP	$0	$0
Generation Capacity Cost Savings	$1,920,000	$169,000
Distribution Capacity Cost Savings	$0	$0
Reliability Improvements	$809,000	$71,400
Power Quality Improvements	$0	$0
Avoided Emissions Allowance Costs	$7,030	$621
Avoided Emissions Damages	$10,500,000	$682,000
Major Power Outage Benefits	$0	$0
Total Benefits	**$24,800,000**	
Net Benefits	**-$3,880,000**	
Benefit/Cost Ratio	**0.9**	
Internal Rate of Return	**-0.1%**	

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 $1.0 million. The present value of the project’s capital costs is estimated at approximately $7.3 million, including costs associated with installing the three new CHP units, the master controller, and other infrastructure upgrades necessary to link the microgrid to the local distribution network. 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 $3.4 million, based on an annual cost of $300,000.

Variable Costs

A significant variable cost associated with the proposed project is the cost of natural gas to fuel operation of the system’s three CHP units. 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.[1] Based on these figures, the present value of the project's fuel costs over a 20-year operating period is estimated to be approximately $8.7 million.[2]

The analysis also considers O&M costs that are likely to vary with the amount of energy the microgrid produces. In this case, the project team estimates a cost of $5 per MWh for system maintenance and upkeep. Based on the system's projected production, this translates to an additional $98,700 per year in O&M costs. The present value of these costs over a 20-year period is approximately $1.1 million.

In addition, the analysis of variable costs considers the environmental damages associated with pollutant emissions from the distributed energy resources that serve the microgrid, based on the operating scenario and emissions rates provided by the project team and the understanding that none of the system's generators would be subject to emissions allowance requirements. In this case, the damages attributable to emissions from the microgrid's CHP units are estimated at approximately $468,000 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 $7.2 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 $11.6 million; this estimate takes into account both the electricity that the microgrid's CHP units 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 the emissions of air pollutants from these facilities, yielding emissions allowance cost savings with a present value of approximately $7,000 and avoided emissions damages with a present value of approximately $10.5 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

[1] 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.

[2] Based on information submitted by the project's consultants, the estimate of fuel costs assumes that the CHP systems consume only 5.687 MMBtu of natural gas per MWh of electricity produced. If the systems are less efficient than assumed, fuel costs would be higher.

[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.

capacity.[1] Based on application of standard availability factors for the CHP units, the analysis estimates the present value of the project's generating capacity benefits to be approximately $1.9 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 $71,400 per year, with a present value of $809,000 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:[2]

- System Average Interruption Frequency Index (SAIFI) – 0.96 events per year.
- Customer Average Interruption Duration Index (CAIDI) – 116.4 minutes.[3]

The estimate takes into account the number of residential and small or large commercial or industrial customers the project would serve; the distribution of commercial or industrial customers by economic sector; average annual electricity usage per customer, as provided by the project team; and the prevalence of backup generation among these customers. It also takes into account the variable costs of operating existing backup generators, both in the baseline and as an integrated component of a microgrid. Under baseline conditions, the analysis assumes a 15 percent failure rate for backup generators.[4] 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.

[1] 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.
[2] www.icecalculator.com.
[3] The analysis is based on DPS's reported 2014 SAIFI and CAIDI values for National Grid.
[4] 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]

The Village of Arcade's proposed microgrid project would serve a number of critical facilities during an extended outage. The project's consultants indicate that at present, seven of these facilities are served by backup generators. Table 24 summarizes the estimated cost of operating these generators, assuming 12 hours of operation over a 24-hour period; the estimate of daily operating costs includes the cost of fuel as well as other daily costs of operation. Table 24 also indicates the loss in service capabilities that occurs while relying on these units, and the loss in service capabilities that would occur should these units fail.

Table 24. 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
Arcade Village Office/Police	$400	$365	0%	50%
Arcade Sewage Plant	$1,000	$935	0%	100%
Arcade Fire Department	$600	$476	0%	50%
Arcade Sullivan Garage	$400	$292	0%	100%
Arcade Mill St. Garage	$400	$237	0%	100%
Arcade Sullivan Well	$400	$365	0%	100%
Arcade Sandusky Well	$400	$338	0%	100%

[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.

In the event of a generator failure, each of the facilities listed above would need to rent a portable generator to maintain service. The costs of hooking up these generators would range from $200 to $300 at each facility. Once connected, the cost of operating these generators would range from $240 to $1,560 per day. The availability of rental units, however, is uncertain, particularly in the event of a prolonged outage.

In addition to the seven facilities that are currently equipped with backup generators, the microgrid would serve 14 other facilities. The project team did not identify the presence of a backup generator at any of these facilities, nor did it indicate the facilities would rent a generator in the event of an outage. The team indicates that most of these facilities would experience a complete loss in service capabilities in the event of an outage. The only exceptions, the two nurseries, would operate at 50 percent of their normal capabilities.

The information provided above serves as 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 Village Office/Police Department and the Arcade Fire Department would rely on their existing backup generators, experiencing no loss in service capabilities while these generators operate. If their backup generators fail, these facilities would experience a 50 percent loss in service capabilities.
- The sewage plant, Sullivan Garage, Mill St. Garage, Sullivan Well, and Sandusky Well would rely on their existing backup generators, experiencing no loss in service capabilities while these generators operate. If their backup generators fail, these facilities would experience a total loss of service.
- With the exception of the two nurseries, an outage would cause all other facilities to experience a total loss in service capabilities; the nurseries would experience a 50 percent loss.
- Should they lose power, the schools would be incapable of serving as emergency shelters. Any residents in need of shelter would be evacuated, at a one-time cost of $3,000.
- 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 of interest. The analysis calculates the impact of a loss in the village's police, fire, sewage, water supply, and emergency medical services using standard FEMA methodologies.[1] It also relies on FEMA's standard methods to value the loss of residential electric service at Arcade Manor and Garden Park Apartments. The impact of a loss in service at other facilities is based on the value of service estimates shown in Table 25. For the two schools, the figures are based on an estimate of each facility's shelter capacity – 500 residents at Arcade Elementary, 1,000 at Pioneer High – and American Red Cross data on the cost of providing overnight shelter ($50/person/day).[2] In all

[1] The Arcade and Yorkshire Fire Departments provide ambulance and emergency medical services to the Arcade area.
[2] American Red Cross, Fundraising Dollar Handles for Disaster Relief Operations, Revised March 2014 – based on FY14 figures.

other cases, these figures were estimated using the ICE Calculator, taking into account the nature of each facility, its estimated daily use of electricity, and the extent of service (hours/day) each would require during an outage.[1]

Table 25. Value of Maintaining Service, Scenario 2

Facility	Value Per Day
Arcade Elementary School	$25,000
Pioneer High School	$50,000
Arcade Sullivan Garage	$8,400
Arcade Mill Street Garage	$13,000
North Lift Station	$5,300
West Lift Station	$5,500
Early Bird Nursery	$6,600
Rainbow's End Nursery	$6,700
Town of Arcade Garage	$6,900
Arcade Communication Tower	$6,500
Wyoming County Communication Tower	$6,200
Freedom Cell Tower	$7,100
Yorkshire Cell Tower	$6,800

Based on these values and the other assumptions outlined above, the analysis estimates that in the absence of a microgrid, the average cost of an outage for the facilities of interest is approximately $308,000 per day.

Summary

Figure 37 and table 26 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 1.2 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.

[1] http://icecalculator.com/

Figure 37. Present Value Results, Scenario 2 (Major Power Outages Averaging 1.2 Days/Year; 7 Percent Discount Rate)

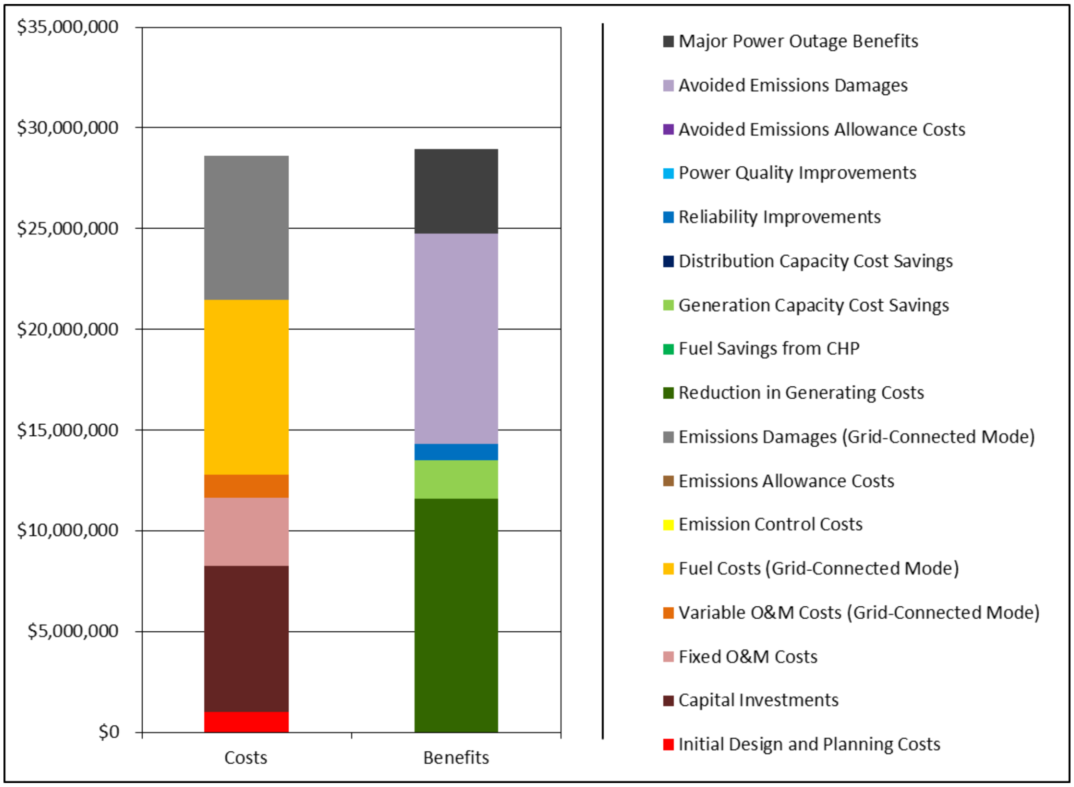


Table 26. Detailed BCA Results, Scenario 2 (Major Power Outages Averaging 1.2 Days/Year; 7 Percent Discount Rate)

Cost or Benefit Category	Present Value Over 20 Years (2014$)	Annualized Value (2014$)
Costs		
Initial Design and Planning	$1,000,000	$88,200
Capital Investments	$7,250,000	$591,000
Fixed O&M	$3,400,000	$300,000
Variable O&M (Grid-Connected Mode)	$1,120,000	$98,700
Fuel (Grid-Connected Mode)	$8,700,000	$767,000
Emission Control	$0	$0
Emissions Allowances	$0	$0
Emissions Damages (Grid-Connected Mode)	$7,170,000	$468,000
Total Costs	**$28,600,000**	
Benefits		
Reduction in Generating Costs	$11,600,000	$1,020,000
Fuel Savings from CHP	$0	$0
Generation Capacity Cost Savings	$1,920,000	$169,000
Distribution Capacity Cost Savings	$0	$0
Reliability Improvements	$809,000	$71,400
Power Quality Improvements	$0	$0
Avoided Emissions Allowance Costs	$7,030	$621
Avoided Emissions Damages	$10,500,000	$682,000
Major Power Outage Benefits	$4,180,000	$369,000
Total Benefits	**$28,900,000**	
Net Benefits	**$306,000**	
Benefit/Cost Ratio	**1.0**	
Internal Rate of Return	**6.2%**	

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 Arcade Electric Department project sponsors and staff that supported this project as well as the Village of Arcade. 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:

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: 78. Village of Arcade78. Village of Arcade78. Village of Arcade78. Village of Arcade

Point of contact for this questionnaire:

Name: Larry Kilburn, Superintendent of Public Works, Village of Arcade

Address: 17 Church Street Arcade, NY 14009

Telephone: (585) 492-1111 x 113

Email: larrykilburn@villageofarcade.org

Name: Larry Kilburn, Superintendent of Public Works, Village of Arcade

Address: 17 Church Street Arcade, NY 14009

Telephone: (585) 492-1111 x 113

Email: larrykilburn@villageofarcade.org

ade

Address: 17 Church Street Arcade, NY 14009

Telephone: (585) 492-1111 x 113

Email: larrykilburn@villageofarcade.org
Name: Larry Kilburn, Superintendent of Public Works, Village of Arcade

Address: 17 Church Street Arcade, NY 14009

Telephone: (585) 492-1111 x 113

Email: larrykilburn@villageofarcade.org
Name: Larry Kilburn, Superintendent of Public Works, Village of Arc

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
Arcade Village Office/Police	Large Commercial/Industrial (>50 annual MWh)Large Commercial/Industrial (>50 annual MWh)Large Commercial/Industrial (>50 annual MWh)Large Commercial/Industrial (>50 annual MWh)	*Government Building*	*All other industriesAll other industriesAll other industriesAll other industries*	172,440	39	*60%*	*12 hours*
Arcade Sewage Plant	Large Commercial/Industrial (>50 annual MWh)Large Commercial/Industrial (>50 annual MWh)Large Commercial/Industrial (>50 annual MWh)Large Commercial/Industrial (>50 annual MWh)	Municipal services	*All other industriesAll other industriesAll other industriesAll other industries*	760,140	111	*60%*	*12 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**
Pioneer High School	Large Commercial/Industrial (>50 annual MWh)Large Commercial/Industrial (>50 annual MWh)Large Commercial/Industrial (>50 annual MWh)Large Commercial/Industrial (>50 annual MWh)	*School*	*All other industriesAll other industriesAll other industriesAll other industries*	8,493,600	2,032	*60%*	*12 hours*
Arcade Elementary School	*Large Commercial/Industrial (>50 annual MWh)Large Commercial/Industrial (>50 annual MWh)Large Commercial/Industrial (>50 annual MWh)Large Commercial/Industrial (>50 annual MWh)*	*School*	*All other industriesAll other industriesAll other industriesAll other industries*	1,918,596	620	*60%*	*12 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
Fire Department	Large Commercial/Industrial (>50 annual MWh)Large Commercial/Industrial (>50 annual MWh)Large Commercial/Industrial (>50 annual MWh)Large Commercial/Industrial (>50 annual MWh)	Emergency	*All other industriesAll other industriesAll other industriesAll other industries*	135,960	43	*60%*	*12 hours*
Arcade Sullivan Garage	*Large Commercial/Industrial (>50 annual MWh)Large Commercial/Industrial (>50 annual MWh)Large Commercial/Industrial (>50 annual MWh)Large Commercial/Industrial (>50 annual MWh)*	Municipal services	*All other industriesAll other industriesAll other industriesAll other industries*	151,260	39	*60%*	*12 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**
Arcade Mill St. Garage	*Large Commercial/Industrial (>50 annual MWh)Large Commercial/Industrial (>50 annual MWh)Large Commercial/Industrial (>50 annual MWh)Large Commercial/Industrial (>50 annual MWh)*	Municipal services	*All other industriesAll other industriesAll other industriesAll other industries*	50,040	13	*60%*	*12 hours*
Arcade Sullivan Well	*Small Commercial/Industrial (<50 annual MWh)Small Commercial/Industrial (<50 annual MWh)Small Commercial/Industrial (<50 annual MWh)Small Commercial/Industrial (<50 annual MWh)*	Municipal services	*All other industriesAll other industriesAll other industriesAll other industries*	31,404	23	*60%*	*12 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
Arcade Sandusky Well	*Small Commercial/Industrial (<50 annual MWh)Small Commercial/Industrial (<50 annual MWh)Small Commercial/Industrial (<50 annual MWh)Small Commercial/Industrial (<50 annual MWh)*	Municipal Services	*All other industriesAll other industriesAll other industriesAll other industries*	45,924	10	*60%*	*12 hours*
Arcade North Lift Station	*Small Commercial/Industrial (<50 annual MWh)Small Commercial/Industrial (<50 annual MWh)Small Commercial/Industrial (<50 annual MWh)Small Commercial/Industrial (<50 annual MWh)*	Municipal Services	*All other industriesAll other industriesAll other industriesAll other industries*	3,720	5	*60%*	*12 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**
Arcade West Lift Station	*Small Commercial/Industrial (<50 annual MWh)Small Commercial/Industrial (<50 annual MWh)Small Commercial/Industrial (<50 annual MWh)Small Commercial/Industrial (<50 annual MWh)*	Municipal Services	*All other industriesAll other industriesAll other industriesAll other industries*	4,572	5	*60%*	*12 hours*
Arcade Manor	*Large Commercial/Industrial (>50 annual MWh)Large Commercial/Industrial (>50 annual MWh)Large Commercial/Industrial (>50 annual MWh)Large Commercial/Industrial (>50 annual MWh)*	Municipal Services	*All other industriesAll other industriesAll other industriesAll other industries*	87,336	23	*60%*	*12 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
Garden Park Apartments	*Small Commercial/Industrial (<50 annual MWh)Small Commercial/Industrial (<50 annual MWh)Small Commercial/Industrial (<50 annual MWh)Small Commercial/Industrial (<50 annual MWh)*	Municipal Services	*All other industriesAll other industriesAll other industriesAll other industries*	30,000N/A	20N/A	*60%*	*12 hours*
Early Bird Nursery	Small Commercial/Industrial (<50 annual MWh)Small Commercial/Industrial (<50 annual MWh)Small Commercial/Industrial (<50 annual MWh)Small Commercial/Industrial (<50 annual MWh)	Municipal Services	*All other industriesAll other industriesAll other industriesAll other industries*	25,116	15	*60%*	*12 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
Rainbow's End Nursery	Small Commercial/Industrial (<50 annual MWh)Small Commercial/Industrial (<50 annual MWh)Small Commercial/Industrial (<50 annual MWh)Small Commercial/Industrial (<50 annual MWh)	Municipal Services	*All other industriesAll other industriesAll other industriesAll other industries*	27,864	15	*60%*	*12 hours*
Yorkshire Fire Department	Large Commercial/Industrial (>50 annual MWh)Large Commercial/Industrial (>50 annual MWh)Large Commercial/Industrial (>50 annual MWh)Large Commercial/Industrial (>50 annual MWh)	Municipal Services	*All other industriesAll other industriesAll other industriesAll other industries*	56,004	23	*60%*	*12 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
Town of Arcade Garage	Small Commercial/Industrial (<50 annual MWh)Small Commercial/Industrial (<50 annual MWh)Small Commercial/Industrial (<50 annual MWh)Small Commercial/Industrial (<50 annual MWh)	Municipal Services	*All other industriesAll other industriesAll other industriesAll other industries*	36,063	14	*60%*	*12 hours*
Arcade Comm. Tower	Small Commercial/Industrial (<50 annual MWh)Small Commercial/Industrial (<50 annual MWh)Small Commercial/Industrial (<50 annual MWh)Small Commercial/Industrial (<50 annual MWh)	Municipal Services	*All other industriesAll other industriesAll other industriesAll other industries*	20,772	8	*60%*	*12 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**
Wyoming County Comm. Tower	Small Commercial/Industrial (<50 annual MWh)Small Commercial/Industrial (<50 annual MWh)Small Commercial/Industrial (<50 annual MWh)Small Commercial/Industrial (<50 annual MWh)	Municipal Services	*All other industriesAll other industriesAll other industriesAll other industries*	14,172	8	*60%*	*12 hours*
Freedom Cell Tower	Small Commercial/Industrial (<50 annual MWh)Small Commercial/Industrial (<50 annual MWh)Small Commercial/Industrial (<50 annual MWh)Small Commercial/Industrial (<50 annual MWh)	Municipal Services	*All other industriesAll other industriesAll other industriesAll other industries*	49,800	8	*60%*	*12 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
Yorkshire Cell Tower	Small Commercial/Industrial (<50 annual MWh)Small Commercial/Industrial (<50 annual MWh)Small Commercial/Industrial (<50 annual MWh)Small Commercial/Industrial (<50 annual MWh)	Municipal Services	*All other industriesAll other industriesAll other industriesAll other industries*	31,428	7	*60%*	*12 hours*
Total				**12,116,221**	**3,020**	**60%**	

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 (kWh) (12hr/day)	Fuel Consumption per Generator kW (60% efficiency or operation load)	
						Quantity	Unit
New Generator CHP 1250kW	Pioneer High School	Natural Gas CHP	1,250 kW	10,500 MWh	750kW x 12 hr = 9,000 kWh	1250/0.6*3.412 = 7,108	Mbtu/hr
New Generator CHP 600kW	Arcade Elementary School	Natural Gas CHP	600 kW	5040 MWh	350kW x 12hr = 4,200 kWh	600/0.6*3.412 = 3,412	Mbtu/hr
New Generator CHP 500kW	Arcade Sewage Plant	Natural Gas CHP	500 kW	4200 MWh	250kW x 12hr = 3,000 kWh	500/0.6*3.412 = 2,843	Mbtu/hr
Storage 250kW	Industrial Park	Battery	250 kW	22.5 MWh	250 kWh		

[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 (kW/year) (1.5hr x 12 months)	Does distributed energy resource currently provide peak load support?
Existing Generator	Arcade Village Office/Police	*1,620*	☐ Yes
Existing Generator	Arcade Sewage Plant	7,200	☐ Yes
Existing Generator	Arcade Fire Department	2,700	☐ Yes
Existing Generator	Arcade Sullivan Garage	900	☐ Yes
Existing Generator	Arcade Mill St. Garage	360	☐ Yes
Existing Generator	Arcade Sullivan Well	1,620	☐ Yes
Existing Generator	Arcade Sandusky Well	1,350	☐ Yes
Existing Generator	Substations/Other	4,680	☐ 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.

	Capacity Participating in Demand Response Program (kW/year)	
Facility Name	**Following Development of Microgrid**	**Currently**
Arcade Village Office/Police	*1,620*	*1500*
Arcade Sewage Plant	7,200	
Arcade Fire Department	2,700	
Arcade Sullivan Garage	900	
Arcade Mill St. Garage	360	
Arcade Sullivan Well	1,620	
Arcade Sandusky Well	1,350	
Substations/Other	4,680	
New Generator CHP 1250kW	22500	
New Generator CHP 600kW	10800	
New Generator CHP 500kW	9000	
Storage 250kW	4500	

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.

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

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
2,350 kW CHP	$6,000,000	25	Natural gas chp
250 kW Battery	$250,000	10	li-ion battery
Microgrid Master Controller	$1,250,000	20	Master controller and other infrastructure upgrades to accommodate microgrid on the distribution network

Capital Component	Installed Cost ($)	Component Lifespan (round to nearest year)	Description of Component

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?
$1,000,000	Planning and engineering design

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?
$529,694	Fuel O&M

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).

Variable O&M Costs ($/Unit of Energy Produced)	Unit	What cost components are included in this figure?
$5	$/MWh	Maintenance, tecsing, replacement, upkeep
	Choose an item.	
	Choose an item.	
	Choose an item.	
	Choose an item.	

Fuel Costs

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

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

Distributed Energy Resource Name	Facility Name	Duration of Design Event (Days)	Quantity of Fuel Needed to Operate in Islanded Mode for Duration of Design Event (12hr, 60% efficiency)	Unit
New Generator	Pioneer High School	*7*	750/0.6*3.412*12/1000 = 50	MMBtuMMBtuMMBtuMMBtu
New Generator	Arcade Elementary School	7	350/0.6*3.412*12/1000 = 23.88	MMBtu
New Generator	Arcade Sewage Plant	7	250/0.6*3.412*12/1000 = 17.06	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
Other - please specify ElectricOther - please specify ElectricOther - please specify ElectricOther - please specify Electric	1000	
Choose an item.		Choose an item.
Choose an item.		Choose an item.
Choose an item.		Choose an item.

Emissions Control Costs

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

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

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

☐ Yes

☒ No

D. *Environmental Impacts*

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

Emissions Type	Emissions per MWh	Unit (Ton/hr of operation of 3MW microgrid)
CO_2	3,787	Ton/hrTon/hrTon/hrTon/hr
SO_2	179	Ton/hrTon/hrTon/hrTon/hr
NO_x	5	Ton/hrTon/hrTon/hrTon/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.

Number of Power Quality Events Avoided Each Year	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]

[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 contro. 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.

Estimated SAIFI	Estimated CAIDI
1.17	2.87

SAIFI and CAIDI Values for 2014, as reported by DPS

Utility	SAIFI (events per year per customer)	CAIDI (hours per event per customer)
Central Hudson Gas & Electric	1.62	3.74
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.

Besides to the proposed microgrid. Arcade is interested in installing battery storage units for two of its industrial customers (API Heat Transfer Inc. and Prestolite of NY Inc.) in order to improve the power quality on these two sites. Along with the battery storage, 50kW solar panel is also planned for each of the facilities tery storage, 50kW solar panel is also planned for each of the facilities Besides to the proposed microgrid. Arcade is interested in installing battery storage units for two of its industrial customers (API Heat Transfer Inc. and Prestolite of NY Inc.) in order to improve the power quality on these two sites. Along with the battery storage, 50kW solar panel is also planned for each of the facilities tery storage, 50kW solar panel is also planned for each of the facilities Besides to the proposed microgrid. Arcade is interested in installing battery storage units for two of its industrial customers (API Heat Transfer Inc. and Prestolite of NY Inc.) in order to improve the power quality on these two sites. Along with the batBesides to the proposed microgrid. Arcade is interested in installing battery storage units for two of its industrial customers (API Heat Transfer Inc. and Prestolite of NY Inc.) in order to improve the power quality on these two sites. Along with the bat

Energy Cost and Environment benefit

It's assumed that the two facilities depend on electricity for heating during winter seasons. For API, the annual energy costs (including the annual capital cost) are $503,678 and $520,776 without/with battery storage and solar panel. For Prestolite, the annual energy costs (including the annual capital cost) are $578,468 and $590,021 without/with battery and solar. The detailed simulation results are summarized as in Table 14.

Table 14 – API and Prestolite With/Without Battery and Solar

Cases	Annual Cost ($)*	Electricity Purchase (kWh)	Electricity Cost ($)	Onsite Generation (kW)	Annual Capital Cost ($)	CO2 Emission (kg)
API without Battery and Solar	503,678	8,534,651	421,805	0	0	4,967,133
API With Battery and Solar	520,776	8,481,373	408,589	56,148	29,839	4,940,020
Prestolite without Battery and Solar	578,468	9,807,497	485,501	0	0	5,707,926
Prestolite With Battery and Solar	590,021	9,754,193	470,739	56,148	29,839	5,680,797

*Annual cost is estimated based on the available demand and price information which includes electricity cost, fuel cost and annual capital cost.

As shown in Table 14, the incremental total cost for both Industrial customers are due to the annualized capital cost of battery and solar. With the installation of the proposed battery and solar, the electricity cost (including energy cost and demand cost) would drop ($421,805 to $408,589 for API and $485,501 to $470,739 for Prestolite) and the proposed battery and solar would help in reducing the CO2 emission (27,113kg for API and 27,129kg for Prestolite) which would benefit the environment. In the estimation, the lifetime of battery and solar panel are assumed as 30 year and 15 year, respectively.

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: 78. Village of Arcade78. Village of Arcade78. Village of Arcade78. Village of Arcade

Point of contact for this questionnaire:

Name: Larry Kilburn, Superintendent of Public Works, Village of Arcade

Address: 17 Church Street Arcade, NY 14009

Telephone: (585) 492-1111 x 113

Email: larrykilburn@villageofarcade.org

Name: Larry Kilburn, Superintendent of Public Works, Village of Arcade

Address: 17 Church Street Arcade, NY 14009

Telephone: (585) 492-1111 x 113

Email: larrykilburn@villageofarcade.org
ade

Address: 17 Church Street Arcade, NY 14009

Telephone: (585) 492-1111 x 113

Email: larrykilburn@villageofarcade.org
Name: Larry Kilburn, Superintendent of Public Works, Village of Arcade

Address: 17 Church Street Arcade, NY 14009

Telephone: (585) 492-1111 x 113

Email: larrykilburn@villageofarcade.org
Name: Larry Kilburn, Superintendent of Public Works, Village of Arc

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 (kW)	Standard Operating Capacity (%)	Avg. Daily Production During Power Outage (kWh/Day) (6 hours)	Fuel Consumption per Day		One-Time Operating Costs ($)	Ongoing Operating Costs ($/Day)
						Quantity	Unit		
Arcade Village Office/Police	Unit 1	Diesel	90	60	648	108	Gallons	$400	$200
Arcade Sewage Plant	*Unit 2*	Diesel	400	*60*	2880	480	Gallons	$1000	$200
Arcade Fire Department	Unit 5	Diesel	150	60	1080	180	Gallons	$600	$200
Arcade Sullivan Garage	Unit 6	Diesel	50	60	360	60	Gallons	$400	$200
Arcade Mill St. Garage	Unit 7	Diesel	20	60	144	24	Gallons	$400	$200
Arcade Sullivan Well	Unit 8	Diesel	90	60	648	108	Gallons	$400	$200
Arcade Sandusky Well	Unit 9	Diesel	75	60	540	90	Gallons	$400	$200

Facility Name	Generator ID	Energy Source	Nameplate Capacity (kW)	Standard Operating Capacity (%)	Avg. Daily Production During Power Outage (kWh/Day) (6 hours)	Fuel Consumption per Day		One-Time Operating Costs ($)	Ongoing Operating Costs ($/Day)
						Quantity	Unit		
Substations/Other	Unit 10	Diesel	260	60	1872	312	Gallons	$1000	$200

"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?
Pioneer High School	*One-Time MeasuresOne-Time MeasuresOne-Time MeasuresOne-Time Measures*	*Evacuating and moving residents (approx. 1000 People)*	*1,500*	*$*	*Only necessary during winter months (October through March) because existing backup generator is not able to provide sufficient heating*
Pioneer High School	*Ongoing MeasuresOngoing MeasuresOngoing MeasuresOngoing Measures*	*Housing residents at alternative facilities*	*5,000*	*$/day*	*Only necessary during winter months (October through March) because existing backup generator is not able to provide sufficient heating*
Arcade Elementary School	*One-Time MeasuresOne-Time MeasuresOne-Time MeasuresOne-Time Measures*	*Evacuating and moving residents (about 500 people)*	*1,500*	*$*	*Only necessary during winter months (October through March) because existing backup generator is not able to provide sufficient heating*
Arcade Elementary School	*Ongoing MeasuresOngoing MeasuresOngoing MeasuresOngoing Measures*	*Housing residents at alternative facilities*	*5,000*	*$/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?
Arcade Village Office/Police	*One-Time MeasuresOne-Time MeasuresOne-Time MeasuresOne-Time Measures*	*Hooking up additional portable generator*	*200*	*$*	*Year-round*
Arcade Village Office/Police	*Ongoing MeasuresOngoing MeasuresOngoing MeasuresOngoing Measures*	*Renting additional portable generator*	*525*	*$/day*	*Year-round*
Arcade Sewage Plant	*One-Time MeasuresOne-Time MeasuresOne-Time MeasuresOne-Time Measures*	*Hooking up additional portable generator*	*300*	*$*	*Year-round*
Arcade Sewage Plant	*Ongoing MeasuresOngoing MeasuresOngoing MeasuresOngoing Measures*	*Renting additional portable generator*	*1560*	*$/day*	*Year-round*
Arcade Fire Department	*One-Time MeasuresOne-Time MeasuresOne-Time MeasuresOne-Time Measures*	*Hooking up additional portable generator*	*200*	*$*	*Year-round*

Facility Name	Type of Measure (One-Time or Ongoing)	Description	Costs	Units	When would these measures be required?
Arcade Fire Department	*Ongoing MeasuresOngoing MeasuresOngoing MeasuresOngoing Measures*	*Renting additional portable generator*	*640*	*$/day*	*Year-round*
Arcade Sullivan Garage	*One-Time MeasuresOne-Time MeasuresOne-Time MeasuresOne-Time Measures*	*Hooking up additional portable generator*	*200*	*$*	*Year-round, but only necessary five days per week*
Arcade Sullivan Garage	*Ongoing MeasuresOngoing MeasuresOngoing MeasuresOngoing Measures*	*Renting additional portable generator*	*390*	*$/day*	*Year-round, but only necessary five days per week*
Arcade Mill St. Garage	*One-Time MeasuresOne-Time MeasuresOne-Time MeasuresOne-Time Measures*	*Hooking up additional portable generator*	*200*	*$*	*Year-round, but only necessary five days per week*
Arcade Mill St. Garage	*Ongoing MeasuresOngoing MeasuresOngoing MeasuresOngoing Measures*	*Renting additional portable generator*	*240*	*$/day*	*Year-round, but only necessary five days per week*
Arcade Sullivan Well	*One-Time MeasuresOne-Time MeasuresOne-Time MeasuresOne-Time Measures*	*Hooking up additional portable generator*	*200*	*$*	*Year-round, but only necessary five days per week*
Arcade Sullivan Well	*Ongoing MeasuresOngoing MeasuresOngoing MeasuresOngoing Measures*	*Renting additional portable generator*	*390*	*$/day*	*Year-round, but only necessary five days per week*
Arcade Sandusky Well	*One-Time MeasuresOne-Time MeasuresOne-Time MeasuresOne-Time Measures*	*Hooking up additional portable generator*	*200*	*$*	*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?
Arcade Sandusky Well	*Ongoing MeasuresOngoing MeasuresOngoing MeasuresOngoing Measures*	*Renting additional portable generator*	*525*	*$/day*	*Year-round, but only necessary five days per week*

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.
Arcade Village Office/Police	*0%*
Arcade Sewage Plant	*0%*
Pioneer High School	*100%*
Arcade Elementary School	*100%*
Fire Department	*0%*
Arcade Sullivan Garage	*0%*
Arcade Mill St. Garage	*0%*
Arcade Sullivan Well	*0%*
Arcade Sandusky Well	*0%*
Arcade North Lift Station	*100%*
Arcade West Lift Station	*100%*
Arcade Manor	*100%*
Garden Park Apartments	*100%*
Early Bird Nursery	*50%*
Rainbow's End Nursery	*50%*
Yorkshire Fire Department	*100%*
Town of Arcade Garage	*50%*
Arcade Comm. Tower	*50%*

Facility Name	Percent Loss in Services When Using Backup Gen.
Wyoming County Comm. Tower	*50%*
Freedom Cell Tower	*50%*
Yorkshire Cell Tower	*50%*

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

Facility Name	Percent Loss in Services When Backup Gen. is Not Available
Arcade Village Office/Police	*50%*
Arcade Sewage Plant	100%
Pioneer High School	100%
Arcade Elementary School	100%
Fire Department	50%
Arcade Sullivan Garage	100%
Arcade Mill St. Garage	100%
Arcade Sullivan Well	100%
Arcade Sandusky Well	100%
Arcade North Lift Station	100%
Arcade West Lift Station	100%
Arcade Manor	100%
Garden Park Apartments	100%
Early Bird Nursery	50%
Rainbow's End Nursery	50%
Yorkshire Fire Department	100%
Town of Arcade Garage	100%
Arcade Comm. Tower	100%
Wyoming County Comm. Tower	100%
Freedom Cell Tower	100%
Yorkshire Cell Tower	100%

B. Questions for facilities that provide: Fire Services

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

10,000

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

50%

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

Yorkshire Fire Department:3 miles, Chaffee Sardinia Fire Company: 5.3 miles

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

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

7500

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:

50%

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

Wyoming Medical Services 27 miles

D. Questions for facilities that provide: Hospital Services

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

No Hospital in Village

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

Wyoming County Community Health System (27 miles) Bertrand Chaffee Hospital (13.7 miles)

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

5,000

E. Questions for facilities that provide: Police Services

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

2200

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.

11

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

6

c. The percent reduction 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?

7500

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?

7500

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.)?

Apartments, nursing homes, group housing

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).

10000