82 - Village of Westfield

Notice

NY Prize Task 5 Milestone Deliverable:

Village of Westfield Final Report

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

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

WILLDAN
Celebrating 50 years of service

August 9, 2016

Steve Hoyt, Project Manager
NYSERDA
17 Columbia Circle
Albany, NY 12203-6399

Re: NY Prize Westfield Final Report

Dear Mr. Hoyt,

Willdan Energy Solutions (Willdan) presents the enclosed Analysis for Westfield, New York. Our report documents baseline site information, microgrid technical and financial analysis, and Cost Benefit Analysis, organized by NYSERDA defined tasks, for your review and discussion. Please refer to the Executive Summary for an overview of our analysis and findings.

To discuss any aspect of this report, or to arrange a personal meeting, please call me at 415-722-0132 or send an e-mail message to Mehdi.Ganji@Willdan.com. Again, we appreciate the opportunity to work with you and with the Westfield Community on this important project.

Respectfully submitted,

WILLDAN ENERGY SOLUTIONS

Dr. Mehdi Ganji
Vice President, Advanced Grid Technology

Engineering and Planning | Energy Efficiency and Sustainability | Financial and Economic Consulting | National Preparedness and Interoperability
212.785.4027 | fax: 212.785.2343 | Wall Street Plaza, 88 Pine Street, 18th Floor, New York, NY 10005 | www.willdan.com

Table of Contents

Tables

Figures

Executive Summary

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

Westfield incurs additional cost liability when the community exceeds its NYPA kW and kWh allocation (12,500kW and monthly 6,850,000 kWh respectively); most recently, Westfield incurred over $1,000,000 in 2014. This added cost exceeds Westfield Electric Department's annual revenue of $3,700,000 by 27%, a significant overrun requiring the community of Westfield to secure short-term financing to meet its unplanned energy obligations. The excess is largely due to residential electric heaters being operated in the cold winter months. In addition, Westfield's radial path distribution system is old, exposing the community to risk due to outages and equipment failures. Willdan proposes a community microgrid for the Village of Westfield, which will enhance the overall operational reliability of the electric distribution system, for all of the stakeholders, by providing a master controller which has the ability to perform, in real-time, reconfiguration of the microgrid functions, seamless islanding for economic, reliability, or resilience reasons, and optimization of storage and generation resources.

The Village of Westfield's eight critical loads, which include Westfield Electric Department, Wastewater Treatment Plant, Water Treatment Plant, Village Office, Police Department, Fire Department, Memorial Hospital, and Westfield Central School, will remain powered on while the microgrid is islanded. In addition to providing resiliency for critical loads, Willdan's proposed Westfield Community Microgrid could provide economic and reliability benefits for Westfield Electric Power's nearly 3,200 customers including critical facilities such as fire and police public safety services, medical services, water treatment and wastewater treatment plants, as well as maintaining power for public street lighting and security lighting all across the Westfield area while the microgrid is islanded during the prolonged period of losing bulk power.

The 3.25 MW microgrid is comprised of two 1.5 MW CHP systems, installed at the wastewater treatment plant and the high school respectively, along with a 250 kW battery storage system located at the high school and a master controller housed within the current Electric Department. A smaller microgrid would not support all critical services or reduce peak winter load to a significant extent, while a larger microgrid would quickly become cost prohibitive. Unfortunately, even in the optimized scenario, the results of the benefit cost analysis show a full microgrid is unlikely to pay itself off. However, this project has identified key vulnerabilities on which to focus, as well a potential project and partnerships to be explored in the future. For example, a partnership between the Village, High School, and Hospital to develop CHP could provide benefits to all parties. This partnership would only need to move forward with one of the 1.5 MW CHP systems, avoiding the cost of the wiring reconfiguration and communications upgrades required for a full microgrid deployment. The CHP could serve emergency heat and power to both the hospital and the school, as well as potentially lower their price of electricity.

Winter Peak Reduction of electrical load should be the primary concern of the Westfield community moving forward. The costs caused by exceeding NYPA allocations are a large burden on Westfield Electric Department's many customers, however, the most cost effective solution, switching to natural gas heat in homes and businesses, will serve only to reduce the revenue generated by Westfield Electric Department. Willdan recommends that Westfield Electric consider serving gas to their existing electric customers and the residents of Westfield. This would secure and even increase revenue and be a large benefit to the residents of Westfield. Westfield Electric can also consider an advanced metering infrastructure (AMI) expansion and subsequent implementation of time of use (TOU) pricing, which encourages customers to shift their electricity consumption to off peak hours by charging a premium during high use periods. This load shifting, if widely implemented, could alleviate some or all of the NYPA over-allocation charges.

Recommendations

Technical – If financial obstacles are overcome

Phased Design Approach:

1. Generation Assets: Two 1,500 kW Natural Gas Fed Generators, 250 kW Battery Energy Storage
2. Load Control and Energy Conservation Measures: Smart Building and Sub-Building Controllers and Energy Management System
3. Wiring Reconfiguration: High Reliability Distribution that Maximizes Existing Electrical Infrastructure
4. Communication Connectivity: Fiber Optic Backbone, Wireless Mesh Network Deployment
5. Microgrid Master Controller: Connect and Optimize Every Device in the System, Operator Friendly Interface

Operations and Maintenance

1. Utilize equipment vendor warranties
2. Setup automatic notifications, remote monitoring, automated reporting
3. Train Maintenance Personnel

Task 1 – Description of Microgrid Capabilities

Table 1. Westfield Community Microgrid Existing and Proposed Overview

Category	Existing Resources	Proposed/Suggested Improvement	Justification
Load	• Residential Electric Heat • 8 Critical facilities (1,936kW) • 12.5 MW and monthly 6,850MWh NYPA allocation • 18.5 MW Winter Peak	• Building Energy Efficiency • LED Street lighting • Load Curtailment • Winter Peak Shaving	• Resilience Reduced winter load • Reduce inefficiency
Distributed Energy Resources (DERs)	• 6 Backup Diesel Generators (2,010kW) • 2 Natural Gas fired backup generators (173kW)	• 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 34.5kV/4.8kV • 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 have been screened for their application to the Westfield 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 Westfield 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 Westfield, which will enhance the overall operational reliability of the electrical distribution system. By providing a master controller, the Westfield community microgrid would be capable of seamless islanding and resynchronization for economic, reliability, or resilience purposes. Seamless islanding and resynchronization is defined as automatic separation from the grid on loss of utility power and automatic restoration of grid power after an outage on the grid side is cleared.

Normal operating conditions would see reliability improvements through infrastructure reconfiguration, such as a High Reliability Distribution System (HRDS) which senses and clears faults with virtually no impact on building loads. Reliability is further improved to a self-healing and more fault tolerant grid by reducing the number of single points of failure, by adding redundancy to the electrical and communications networks, and by adding alternate sources of generation to serve critical and non-critical loads. In addition to increased reliability, the Westfield 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 Westfield 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 Westfield community microgrid with heat and power when it needs it most.

Load

Existing Resources

The total population of Westfield Electric's service territory is approximately 5,000. There are approximately 3,200 electric customers in Westfield in which 87.5% or 2,800 are residential customers (most with electric heating), and the remaining 400 are commercial, institutional and industrial customers. The Village of Westfield is allotted 12.5 megawatts (MW) power and 6,850MWh monthly 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, Westfield depends on electricity for heating and it needs to purchase additional power to meet the demand. The demand can reach as high as 18.5 MW in the winter season. Figure 1 shows the monthly load demand in Westfield for the recent years. Figure 2 illustrates monthly kWh consumption profile of the Westfield system. The shape of the monthly kWh usage matches the Heating-Degree-Days (HDD) of the locality. The locations of eight critical facilities are shown in figure 3.

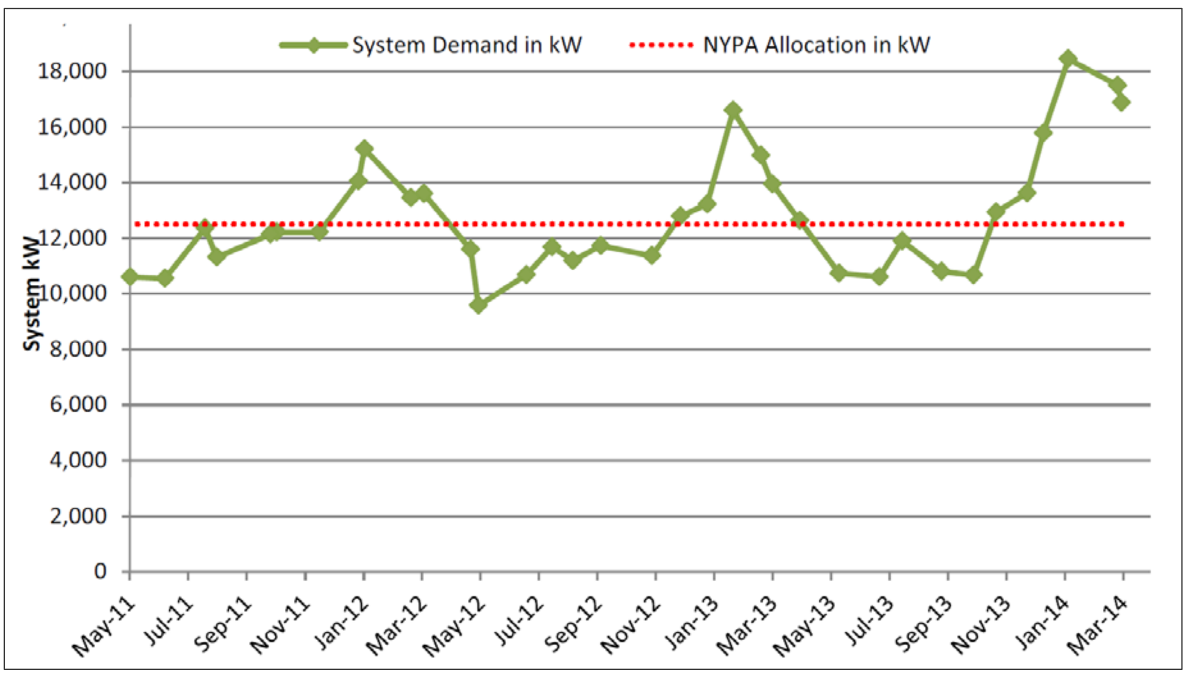


Figure 1. Load Demand Profile in Westfield

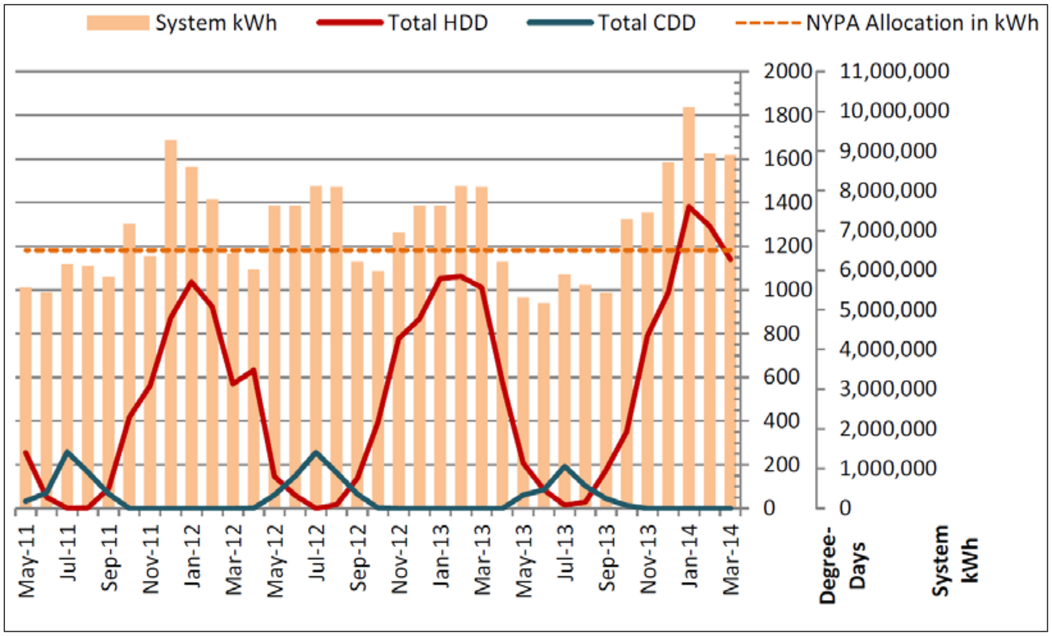


Figure 2. Westfield's Electric System kWh Profile (HDD: Heating-Degree-Days, CDD: Cooling-Degree Days)

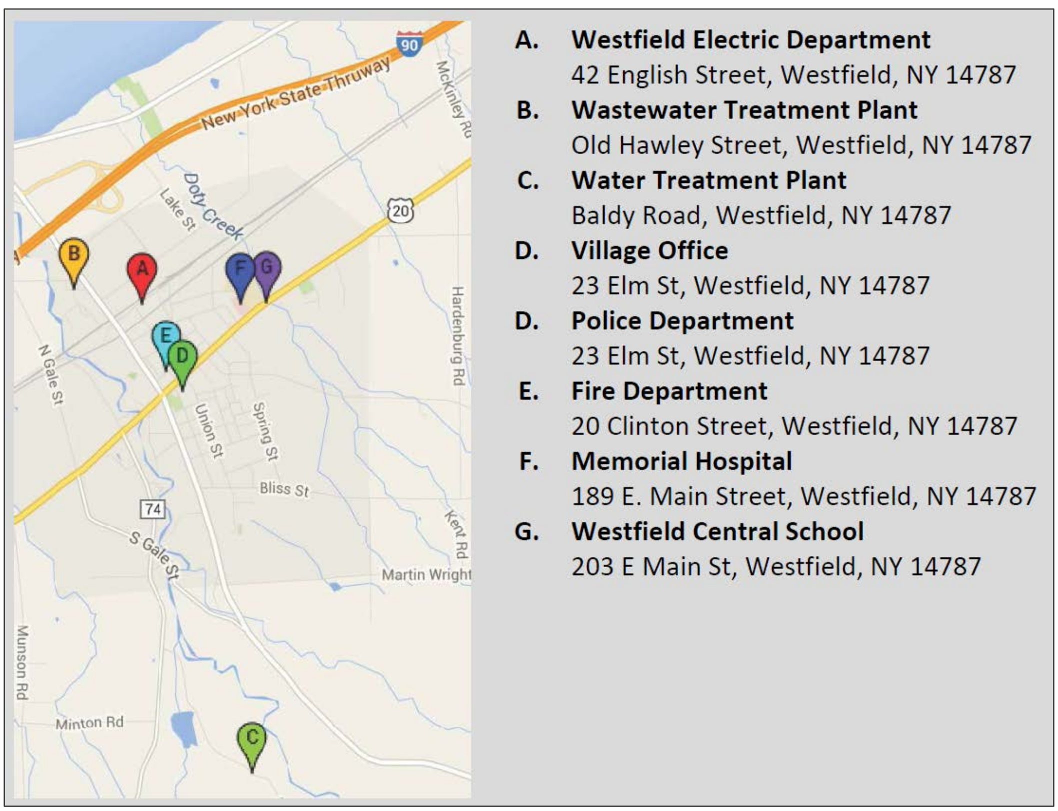


Figure 3. Critical Facilities for the Westfield Community Microgrid

The Village of Westfield's loads can be separated into the broad load categories, critical and non-critical, with critical facilities including the Westfield Electric Department, Wastewater Treatment Plant, Water Treatment Plant, Village Office, Police Department, Fire Department, Memorial Hospital, and Westfield Schools, and non-critical facilities including the many other businesses and residential customers served by Westfield Electric Department. The total electric critical load demand in year 2014 is about 1.936 MW. The detailed load information for all the critical loads is shown in table 3. The load demand in each facility can be further separated into the following load categories as shown in table 2 to describe the unique nature of, and opportunities available for, the different load types. The thermal loads that are not fed by electric heaters are also considered separately.

Westfield Electric Department has completed some energy efficiency projects which include: residential insulation replacement for the Village of Westfield; 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
Critical Facilities	N/A	N/A
Electric Department	744	3,912,000
Wastewater Treatment Plant	476	478,000
Water Treatment Plant	52	184080
Village Office	N/A	N/A
Police Department	72	162,000
Fire Department	216	1,090,400
Memorial Hospital	376	1,547,200
Total	**1936**	**7,373,680**

Consequences

Over 50% of Westfield's substation feeders for residential customers were operating near or at the medium voltage distribution feeders' rated amperage capacity of 350/450 amps when the system incurred its winter peak load. The substation transformers serving residential customers can overload during the system's winter peak loading. This is further exacerbated when multiple residential circuits fail and, during recovery, the resulting surge worsens the strain on the medium voltage substation transformers and ampere capacity constrained feeders. The residential winter peak also causes significant voltage sags in the distribution 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 Westfield community exceeds its NYPA kW and kWh allocation. Westfield purchases retail energy from the whole sale market to cover its extra consumption. Westfield Electric Department incurs additional cost liability of $7 per kW for each month the community exceeds its NYPA kW allocation and buys kWh on the retail market when consumption exceeds kWh allocations. In 2014, Westfield incurred additional per-kWh costs over $1,000,000 in total. This added cost exceeds Westfield Electric Department's annual revenue of $3,700,000 by 27%, a significant overrun requiring the community of Westfield to secure short-term financing to meet its unplanned energy obligations.

Opportunities

Westfield has explored placing the microgrid's CHP and distributed generation resources near the worst of the residential load pockets to reduce amperage on the substation feeders/transformers. Westfield will also explore power generation using the community's entirely gravity fed water distribution infrastructure. In addition, Westfield aims to reduce winter peaks supplied by the bulk power supply and broaden participation in demand-response programs. By applying Advanced Metering Infrastructure (AMI), Westfield Electric could 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 the constraints existing in Westfield's system by providing additional capacity and resiliency. Willdan proposes to replace all the existing diesel generators with natural gas fired CHP. Willdan has evaluated supporting critical facilities with distributed generation resources including CHP generators, locating at least 1,936 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 has considered additional generation capacity in steps of 250kW to eliminate extra winter consumption for the loads 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 the utility grid. Willdan proposes to replace all the existing lighting with high efficient LED (Light Emitting Diode) fixtures. By applying the latest building control technology in each building, Westfield 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, Westfield 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 Westfield 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, Westfield 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 will see 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.

DERs

Existing Resources

The existing DERs located in the proposed Westfield Community Microgrid are used primarily as backup generators in the event that utility power is interrupted. Most of the DERs located in Westfield are Diesel Generators, distributed among the critical facilities, and retain about a week of fuel. The detailed location and capacity information of the existing DERS are listed in table 4.

Table 4. Existing Backup Generators

Location	Capacity (kW)	Fuel Type
Electric Department	48	Natural Gas
Wastewater Treatment Plant	1200	Diesel
Primary Pump Station	300	Diesel
Village Office	60	Diesel
Police Department	125	Diesel
Fire Department	125	Diesel
Memorial Hospital	200	Diesel
Westfield Central School	125	Natural Gas
Total	**2,183**	173 kW Natural Gas | 2,010 kW Diesel

Consequences

While the critical loads have a maximum demand of about 1,936 kW and the DERs total just over 2,000kW of generation, the generation is not conveniently distributed to provide for all of this load. Comparing with table 3 and table 4, it can be seen that the backup generation is not enough for Westfield central school, memorial hospital, and water treatment in the event of emergency. This means that a number of vital critical facilities would be out of power in the event of an emergency, putting the entire Village of Westfield 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 Westfield, and must be stored or shipped into the village in the event of an outage.

Opportunities

Westfield 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 Westfield's substations also allows for the assessment of energy storage and CHP at each location. The additional heat capacity provided could be utilized to improve the year-round efficiency of the sludge treatment process, while supplementing local facilities. Westfield is interested in exploring an expansion of CHP for a number of their critical facilities as well as adding a generation source to their schools. This expansion would allow Westfield 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 Westfield.

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

Benefits

The addition of a range of DERs, including long term sources like CHP and Anaerobic Digestion, small hydro, and short term sources like Batteries and ICE DG, would allow Westfield to operate as a microgrid, take advantage of new revenue streams such as Demand Response and Fast Regulation Markets. 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 vital buildings will remain powered on in emergencies, providing the Village of Westfield with peace of mind.

Barriers

Additional modeling has been performed to determine the 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 Westfield Electric Department owns and operates the distribution system within the village to serve approximately 3,200 customers. Most of the distribution systems are old over-head systems. Westfield owns two substations, portage substation and English substation. Most of the distribution lines are 34.5kV or 4.8kV overhead lines; The Westfield Electric System is supplied by a single 115kV transmission line to provide bulk power which was last inspected in 1996. The distribution system in Westfield, which is connected with these two substations, is shown in Figure 4.

Consequences

Many of Westfield'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 distribution system. Westfield also experiences poor power factor at major industrial customers. It is common for the power factor at the affected customers to be less than 85% lagging during the day. Westfield Electric Department's distribution network has a limited NYPA connection to the surrounding grid. This single point of failure would remove electric service to all of Westfield's 3,200 customers, including critical facilities such as fire and police public safety services, medical services, water treatment, and wastewater treatment plants. The community of Westfield has long been concerned about the vulnerability to interruption of the single source of bulk supply.

Opportunities

Westfield Electric has explored placing the community microgrid's CHP distributed generation resources near the worst of the residential load pockets to reduce amperage on the substation feeders/transformers. Investment in a microgrid is a preferred path of the municipality to improve community's safety and resiliency. A community microgrid would solve any constraints by providing additional capacity and resiliency to the Westfield Electric system. Westfield is also looking forward to utilizing the heat produced from planned CHP for heating in buildings and in the wastewater treatment plant.

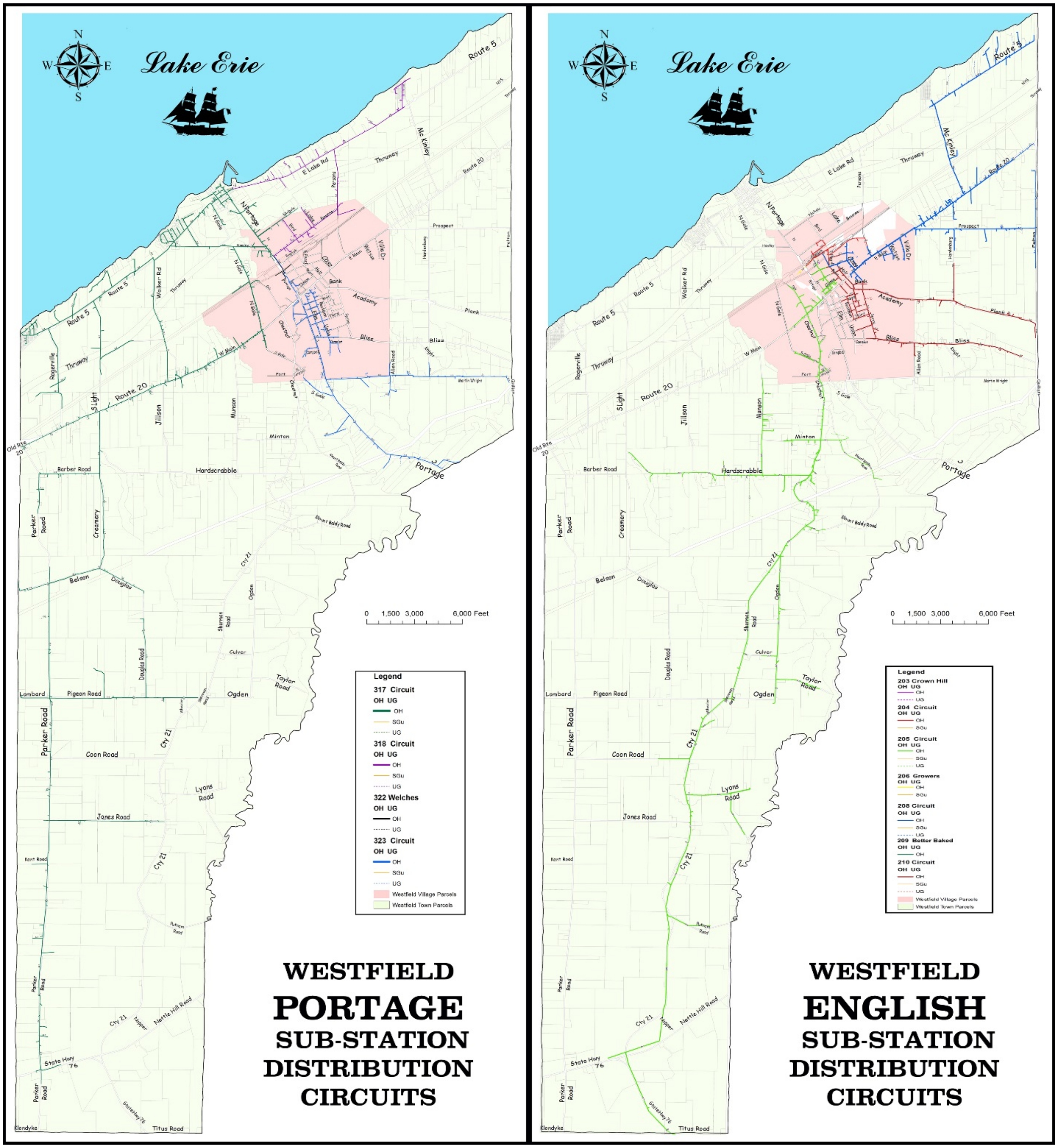


Figure 4. Distribution System in Westfield

Proposed/Suggested

Willdan proposes a Loop-based community microgrid for Westfield. 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 Westfield community microgrid can operate in either grid-connected mode or island mode. The distribution network can be easily reconfigured for reliability purposes and minimizing the system loss to 3 to 4 cycles (~40ms). The critical loads can also be served by multiple feeders. With the ATS, the community microgrid would be able to automatically isolate any 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. ATS require modern communications networks; a more complete review of existing infrastructure will have to be performed to determine any upgrades required.

Master Controller and Building Controls

Proposed/Suggested Improvements

A major element of the Westfield 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 Westfield community microgrid. It also coordinates the operation of on-site generation, storage, and individual building controllers. Intelligent switching and advanced coordination technologies of master controller through communication systems facilitates rapid fault assessments and isolations.

Figure 5 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 Westfield 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.

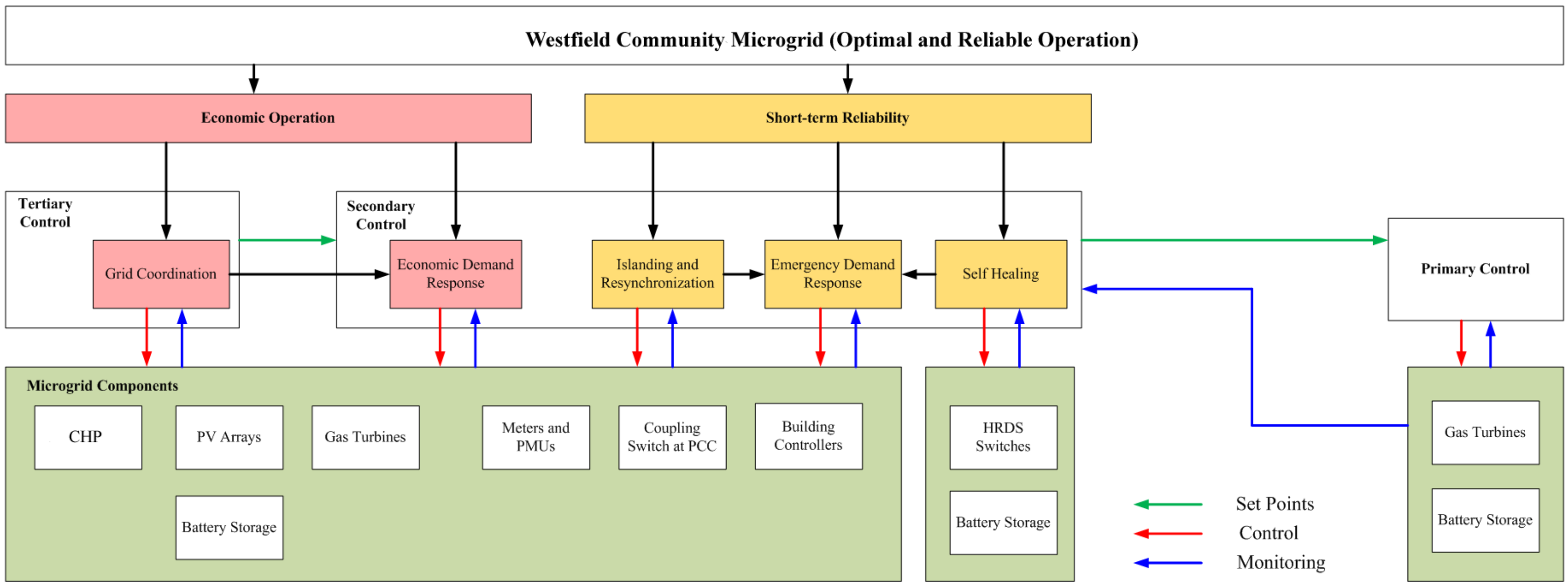
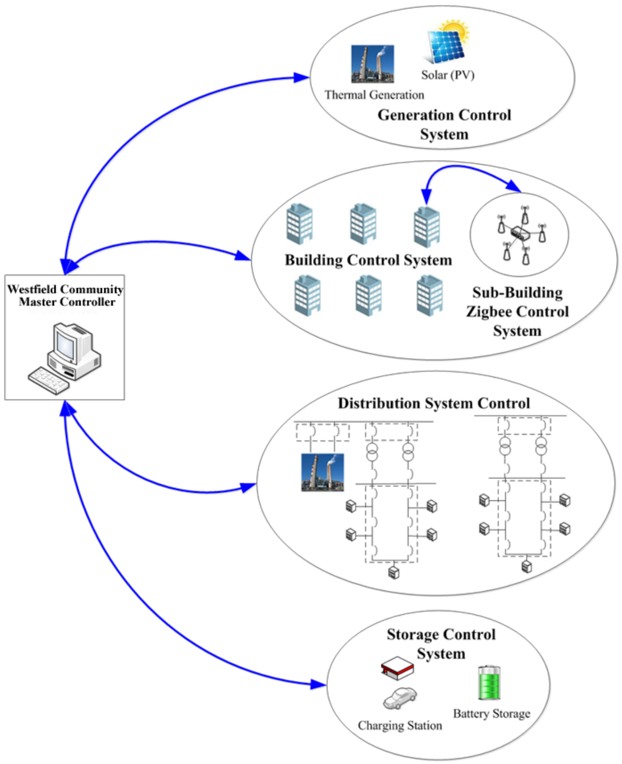
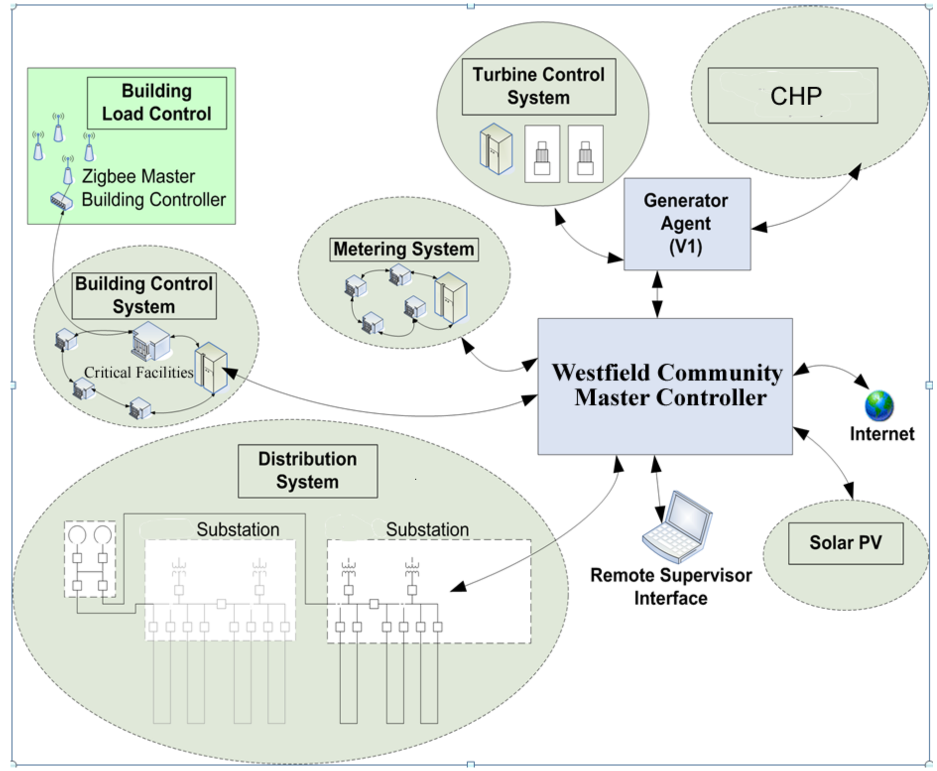


Figure 5. Objectives and Functions for the Control and Operation of the Westfield Community Microgrid





(a) (b)

Figure 6. Architecture of Master Controller for Westfield 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 5 shows the hierarchical framework of the Master Controller proposed for Westfield's community microgrid project. In Figure 6, 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 microgrids mainly contains four-level protection: load way, loop way, loop feeder way, and microgrid level.

Benefits

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

Barriers

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

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 has been performed.

Existing Resources

Westfield Electric Department owns and operates two substations and distribution lines, serving over 3,200 local customers. A large majority of those customers are individually metered; at this stage, Westfield 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

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

Westfield-controlled AMI would also provide opportunity for community demand response aggregation, in which Westfield 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 Westfield 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 7.

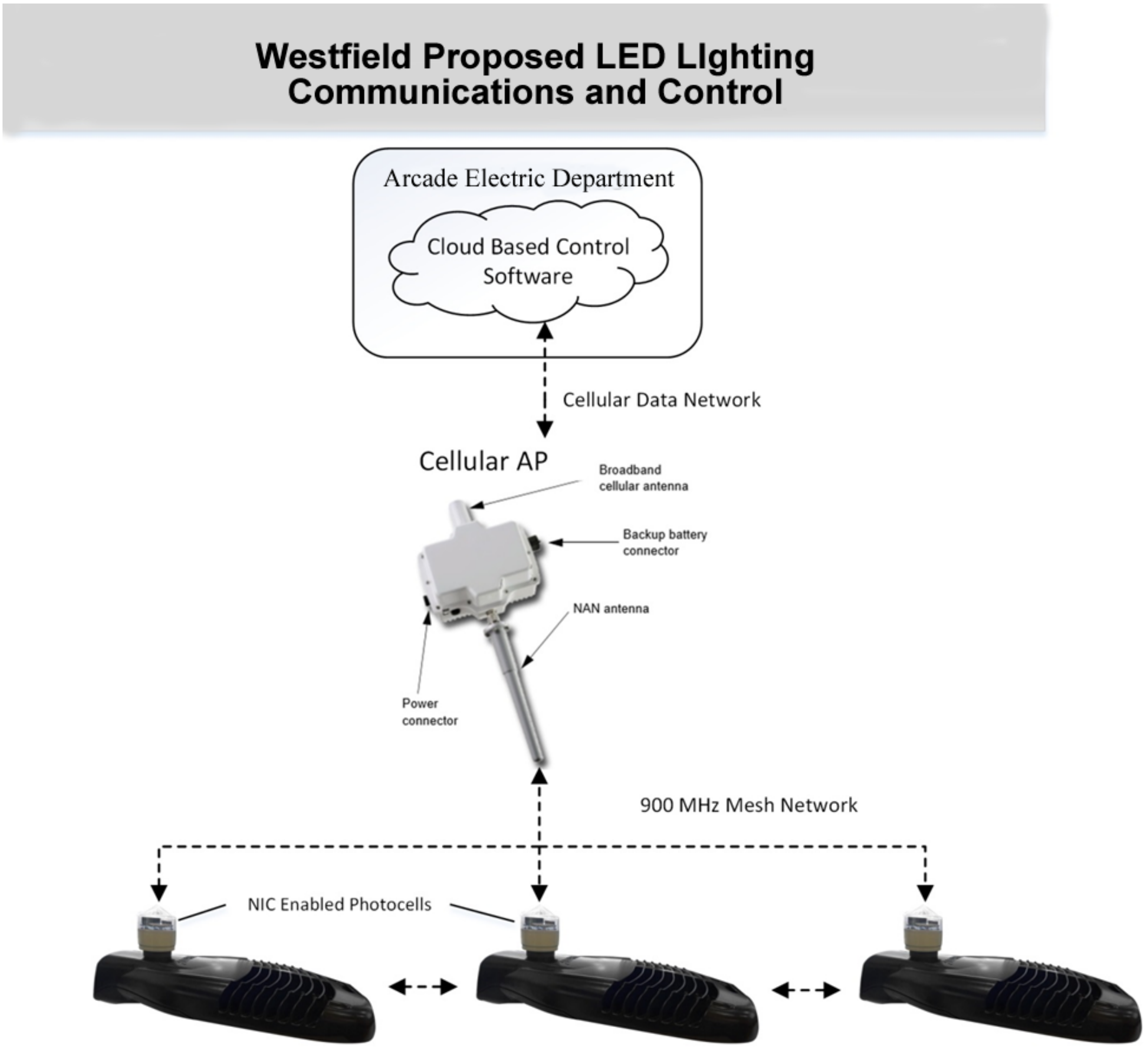


Figure 7. Westfield Proposed LED Lighting Communications and Control Diagram

In addition to meters and streetlights, circuit breakers, relays, re-closers and other switchgear are vital to the control of the Westfield 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 Westfield 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 – Preliminary Technical Design Costs and Configuration

Willdan has coordinated with Westfield Electric Department, National Fuel Gas, representatives from the Village of Westfield, and members of Westfield critical facilities to conduct a preliminary assessment of the technical design and system configuration for the proposed community microgrid. In accordance with NYSERDA guidelines, the study procedure and results have been included in the following pages under six sub tasks: Proposed Microgrid Infrastructure and Operations, Load, Distributed Energy Resources, Electrical and Thermal Infrastructure, Microgrid and Building Controls, and IT/Communications Infrastructure.

Study Approach

The existing technologies that support smart grid and microgrid capabilities have been screened for their application to the Westfield 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 Westfield 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.

DER-CAM

DER-CAM is a tool that was developed by Lawrence Berkeley National Laboratory (LBNL) to help optimize the selection and operation of distributed energy resources on a utility distribution system. The DER-CAM tool has application in the design of microgrids and Willdan has used the tool extensively as a key component of the qualitative microgrid analysis.

The main objective of DER-CAM is to minimize either the annual costs or the CO2 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 model are the customer's end-use energy loads, energy tariff structures and fuel prices, and a list of user-preferred equipment investment options, with extensive unit cost and operation parameters, as shown in Figure 8. Additional information is available on BNL's DER-CAM website[1].

[1] https://www.bnl.gov/SET/DER-CAM.php

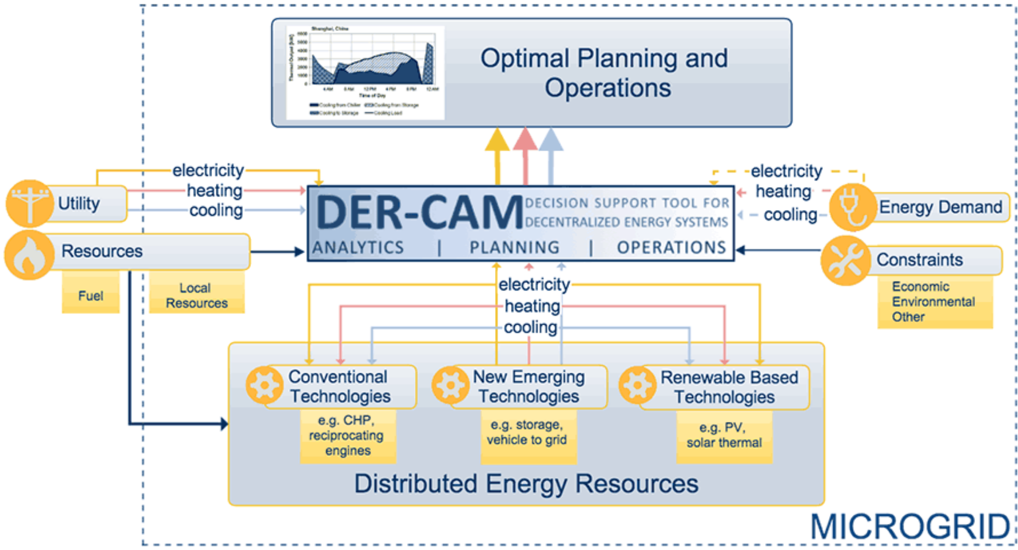


Figure 8. Schematic of Information Flow in DER-CAM

DER-CAM Input Data

Load profile

Accurate hourly load profiles are critical to DER-CAM simulations. The loads include electricity, space-heating, water-heating, cooling, refrigeration, natural gas only (e.g. for cooking). However, electricity and natural gas for space heating are the most important in terms of impact on the Westfield community. Since a year of hourly electric load data was not available for the Village of Westfield's critical loads, the data is scaled from a similar community, considering the entire Westfield community peak load. Because there was no natural gas demand profile, the natural gas demand profile of a similar community was normalized and again scaled based on the electricity load of the critical facilities to obtain the required profile.

Utility tariff

NREL lists the average commercial price of electricity in Westfield as 4.79 ¢/kWh[1]. The Natural Gas price is obtained from EIA[2] and the average commercial natural gas price for New York for 2015, based on available months, is used; 6.68 $/Mcf.

Technologies Investment

Both Electric Storage and PV were considered for the microgrid; their investment parameters are seen in table 6. CHP was considered in step sizes of 500 kW, 250 kW, and 100 kW, to obtain precise simulation results and due to the fact that DER-CAM considers a maximum of six of each of the suggested

[1] http://www.electricitylocal.com/states/new-york/westfield/
[2] https://www.eia.gov/dnav/ng/ng_pri_sum_dcu_SNY_m.htm

technologies, allowing for a maximum of 5,100 kW of CHP to be suggested. Costs were obtained from EIA[1] and from NREL[2 3].

Table 6. Continuous Investment Parameters

Technology	Fixed Cost ($)	Variable Cost ($/kW)	Lifetime (Years)	Fixed Maintenance ($/kW/Month)
Electric Storage	0	400	15	0.069167
PV	0	3250	30	0.25

Table 7. Discrete Investment Parameters

Technology	Max Power (kW)	Lifetime (Years)	Capital Cost ($/kW)	Om variable ($/kWh)	Fuel	Efficiency	Alpha (Heat to Power Ratio)
CHP Plant	500	20	1200	0.011	NG	0.32	1.4
CHP Plant	250	20	1200	0.011	NG	0.32	1.4
CHP Plant	100	20	1200	0.011	NG	0.32	1.4

Weather information

Hourly solar irradiance (Global Horizontal Irradiation (GHI)), hourly temperature, hourly wind speed were obtained from NREL's Solar Irradiance database[4]

Global setting

For this analysis, a 10 year maximum payback period was used. Minimizing energy cost was selected to maximize the economic benefit.

Simulations

First, a base case without any investment was simulated to obtain the reference cost. Then, an investment case was simulated to see the investment economic and CO2 emission benefits allowing DER-CAM to choose the best DER based on price. Then a series of simulations were run to determine both Grid Connected, and Island mode operations. In Grid Connected mode, the goal was to maximize

[1] http://www.eia.gov/forecasts/capitalcost/pdf/updated_capcost.pdf
[2] http://www.nrel.gov/docs/fy11osti/48595.pdf
[3] http://www.nrel.gov/docs/fy13osti/56776.pdf
[4] https://maps.nrel.gov/nsrdb-viewer

reliability and economics with at least 13 simulations being run for reliability to create a representative curve for Demand Response (DR) from 5 to 25%, Directly Controllable Load, from 5 to 25%, as well as a sensitivity analysis of existing and proposed backup generator to simulate downtime/outage of each generator unit, and at least 15 scenarios being run for economics, with sensitivity analysis to electricity price increase, from 0.03 $/kWh to 0.10 $/kWh, to natural gas price increase, from 0.0236 $/kWh to 0.12 $/kWh, and to load increase, from 5% to 25%, to account for possible changes over the 15-25 years of the microgrid. In Island mode the goal was to maximize resiliency with at least 12 simulations being run to simulate outages on the order of hours, to days, to a week, both during on and off peak electrical consumption hours and during summer and winter months to see the effect on the microgrid.

Results

The results of these simulations along with analysis of parameters outside of DER-CAM's array of options, such as Demand Response capacity credits, as well as qualitative additions to the microgrid, to be accepted or denied during the cost benefit analysis stage of the study, were analyzed and compiled in the following report based on technical and preliminary financial feasibility.

Sub Task 2.1 Proposed Microgrid Infrastructure and Operations

The Proposed Westfield Community Microgrid will leverage the existing Backup generators, shown in figure 9 and table 8 and new DERs installed at location of stakeholders as the critical loads, using DER-CAM[1] modeling software. Willdan proposed DERs location and capacity considering the output of the modeling and power flow simulation[2] software, shown in figure 10 and table 9, respectively. DERs' location was identified based on a consistent set of criteria including cost, benefits to grid and microgrid owner/operator, and availability of resources. Indeed, locating DERs in areas where reliability is an issue (high CAIDI[3] and SAIDI[4]) can provide a higher quality of service to those customers, including an increase in resiliency in response to some catastrophic event. Upon the availability of the distribution system one-line diagram and community network information, Power Flow simulation can be done in next phase of study, which will be used to identify the exact location of DERs[5]. Also, having the feeder level data including the critical loads and Non-critical loads would be helpful to identify the over loaded feeders (transformers), which won't be adequate points of interconnection.

[1] https://microgrids2.lbl.gov/
[2] Power Flow Simulation is out of this study's scope of work. Therefore DERs locations have been not specified with building level resolution.
[3] Customer Average Interruption Duration Index.
[4] System Average Interruption Duration Index.
[5] DERs location may be changed based on Community Microgrid asset ownership model.

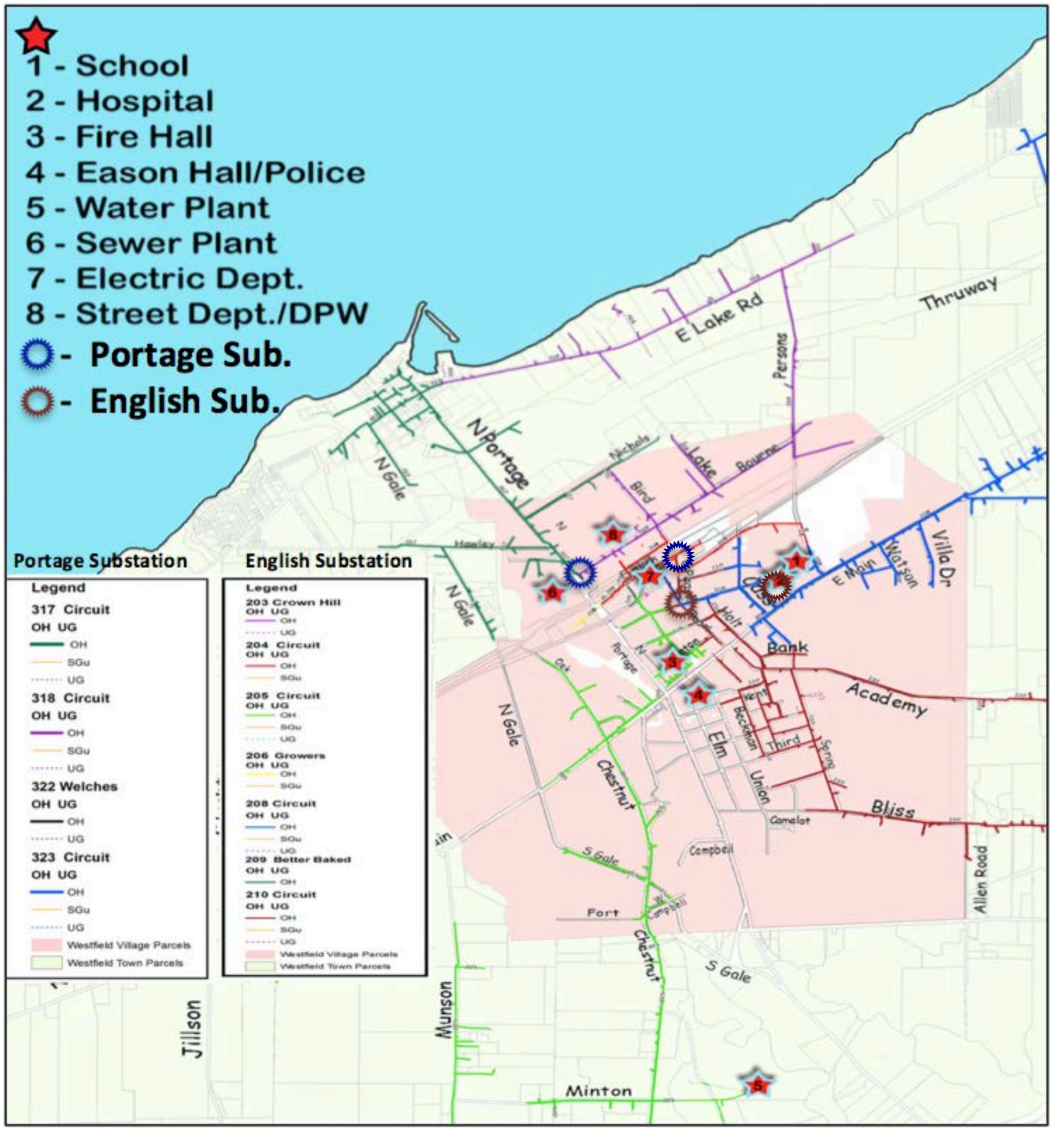


Figure 9. Existing Generation Simplified Equipment Layout Diagram

Table 8. Existing Backup Generators and Critical Facilities

Location	Capacity (kW)	Fuel Type	Average Demand (kW)
Electric Department	48	Natural Gas	N/A
Wastewater Treatment Plant	1,200	Diesel	744
Water Treatment Plant	300	Diesel	476
Village Office	60	Diesel	52
Police Department	125	Diesel	N/A
Fire Department	125	Diesel	72
Memorial Hospital	200	Diesel	216
Westfield Central School	125	Natural Gas	376
Total	**2,183**		**1,936**

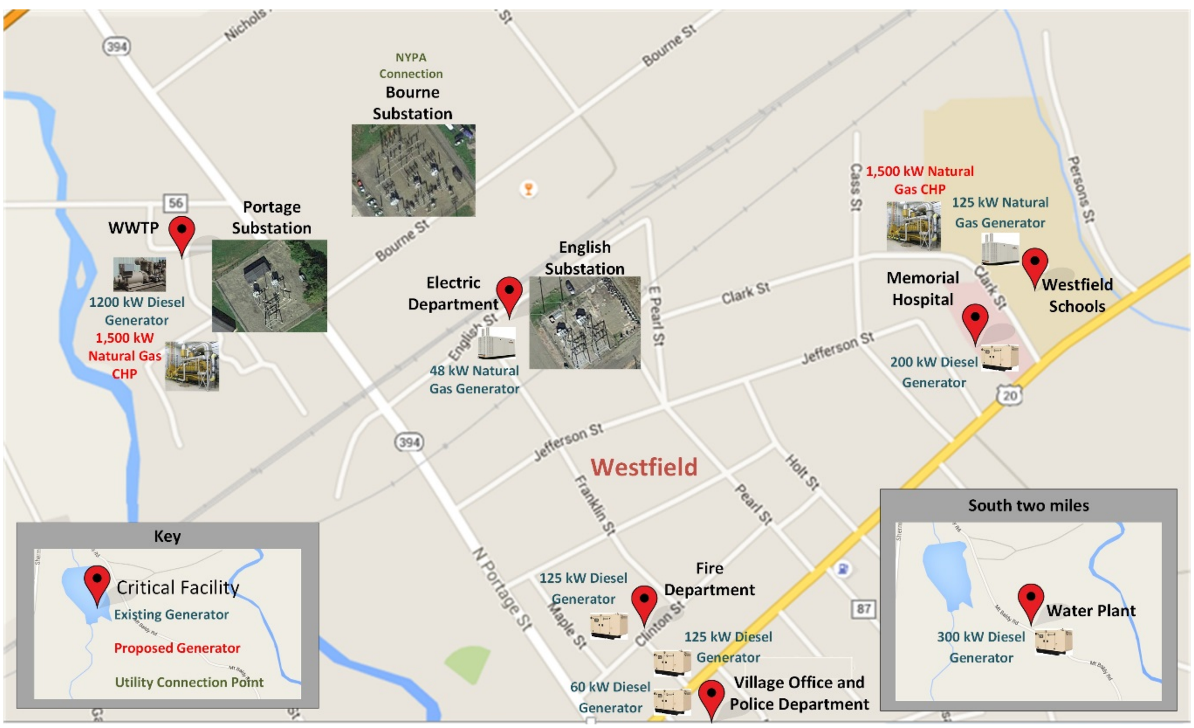


Figure 10. Existing and Proposed Generation Simplified Equipment Layout Diagram

Table 9. Proposed DERs and Backup Generation Units[1]

Location	DERs (kW)	Fuel Type	Backup (kW)	Fuel Type	Average Demand (kW)
Electric Department	-	-	48	Natural Gas	N/A
Wastewater Treatment Plant	1500	Natural Gas	1,200	Diesel	744
Water Treatment Plant	-	-	300	Diesel	476
Village Office	-	-	60	Diesel	52
Police Department	-	-	125	Diesel	N/A
Fire Department	-	-	125		72
Memorial Hospital	1500	Natural Gas	200	Diesel	216
Westfield Central School			125	Natural Gas	376
Total	**3,000**		**2,183**		**1,936**

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

Normal operating conditions would see reliability improvements through infrastructure reconfiguration, such as a High Reliability Distribution System (HRDS) which senses and clears faults with virtually no impact on building loads. Reliability is further improved to a self-healing and more fault tolerant grid by reducing the number of single points of failure, by adding redundancy to the electrical and communications networks, and by adding alternate sources of generation to serve critical and non-critical loads. In addition to increased reliability, the 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 most cost-effective, cleanest, and most reliable energy possible to the critical and non-critical microgrid facilities.

During emergency operating conditions, the Westfield 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 natural gas fed combined heat and power (CHP) plants and natural gas fired generators; which will maintain a black-start capability in the event

[1] Row's color represents the critical load groups in WCM.

the outage occurs when the CHP facility is not active. These plant or plants will rely on robust natural gas pipelines and produce adequate 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 Westfield community microgrid with heat and power when it needs it most.

Table 10. Microgrid Operational Modes

Conditions	Microgrid Operational Mode	Reasons	PCC Status	Non-Critical Load[1]
Normal	Grid Connected	-	Closed	ON
Emergency	Grid Connected	Grid Parallel Disturbance	Closed	ON/OFF
	Grid Connected	Internal Fault	Closed	ON/OFF
	Unplanned Island	Utility side outage	Open	ON/OFF
	Planned island	Approaching storm or threat	Open	ON/OFF

Willdan proposes a community microgrid for the Village of Westfield, which will enhance the overall operational reliability of the electrical distribution system. A community master controller will configure the system into different modes, shown in table 10 based on input from either the system or the operator. The modes of operation are:

- **Grid connected (Normal)** – System operates local generation on price signals, power quality needs, and projected electric loads for the day.
- **Unplanned Island mode** – System is able to match local generation with demand
  - Black start capability
  - Recover within few minutes with UPS/diesel to protect critical loads
- **Planned island mode** – In case of approaching storm or threat, system isolates and becomes islanded from the whole grid
- **Grid connected (Grid Parallel Disturbance/Emergency)** – In this case UPS/Inverters protect key facilities while generation starts in anticipation of more significant events. In this case Normal economic optimization features are disabled. Local system conditions are monitored and loads/generators/power quality devices are operated to maintain the system within set point conditions

[1] Critical Loads should be ON all the time. Non-Critical Load will be shed using the grid level circuit breakers or AMI during the time of on-site power outage.

- **Grid connected (Internal Fault)** - Include smart switches which sense and isolate the fault while rerouting power to ensure power to all loads

By providing a microgrid master controller, the 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.

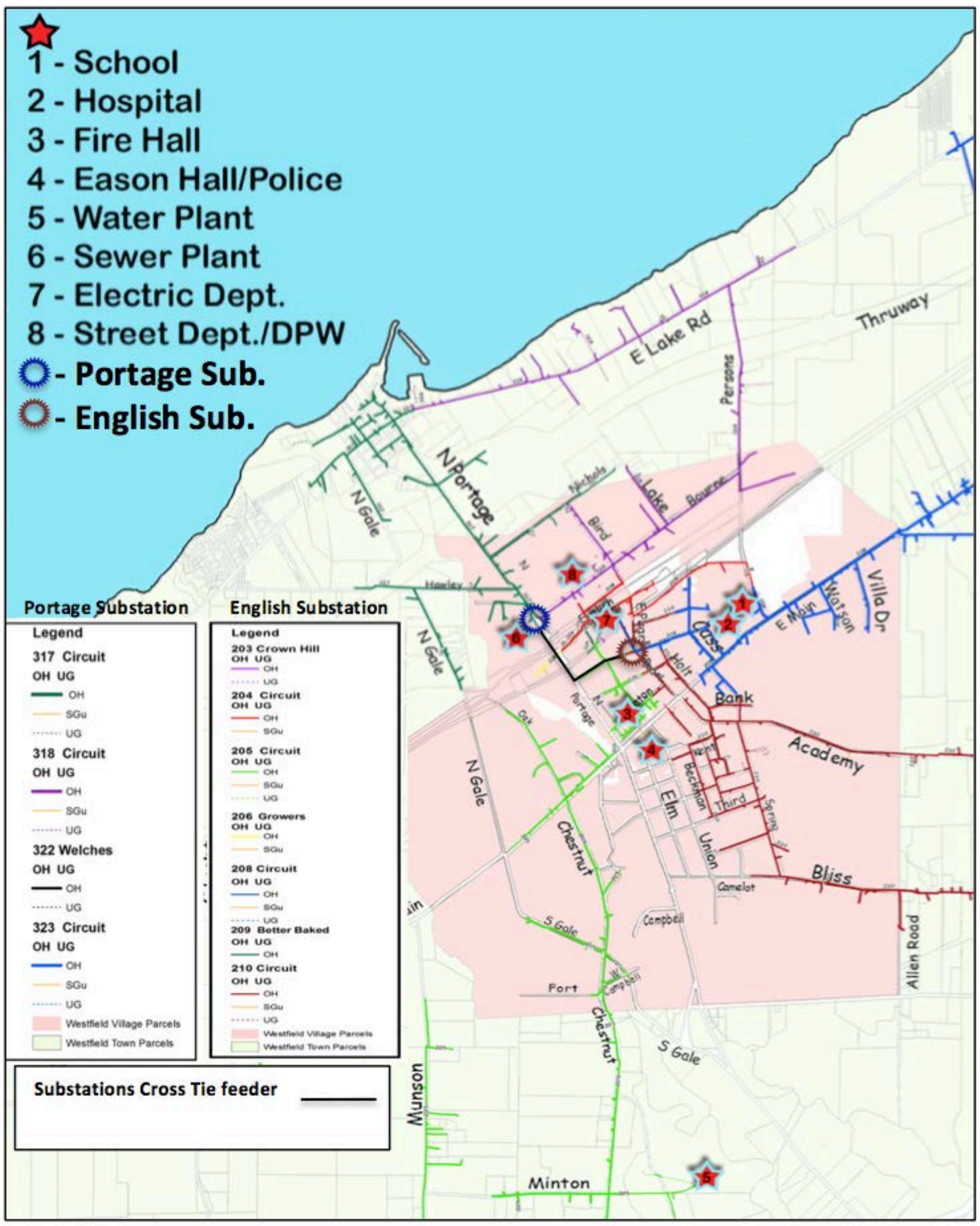


Figure 11. Generation Simplified Equipment Layout Diagram

Sub Task 2.2 Load Characterization

The proposed community microgrid would be able to address and mitigate the existing system constraints facing Westfield's current distribution system. Due to the peak demand during winter season, Westfield'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 Westfield community exceeds its NYPA kW and kWh allocation, shown in figure 12 (12,500kW and monthly 6,850,000 kWh respectively); most recently, Westfield purchased retail energy from the wholesale market to cover its extra consumption. In 2014, Westfield incurred additional per-kWh costs totaling over $1,000,000. This added cost exceeds Westfield Electric Department's annual revenue of $3,700,000 by 27%, a significant overrun requiring the community of Westfield to secure short-term financing to meet its unplanned energy obligations. The excess is largely due to residential electric heaters being operated in the cold winter months.

The total population of Westfield Electric's service territory is approximately 5,000. There are approximately 3,200 electric customers in Westfield in which 87.5% or 2,800 are residential customers (most with electric heating), and the remaining 400 are commercial, institutional and industrial customers. The Village of Westfield is allotted 12.5 megawatts (MW) power and 6,850MWh monthly 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, Westfield depends on electricity for heating and it needs to purchase additional power to meet the demand. The demand can reach as high as 18.5 MW in the winter season. Figure 12 shows the monthly load demand in Westfield for the recent years.

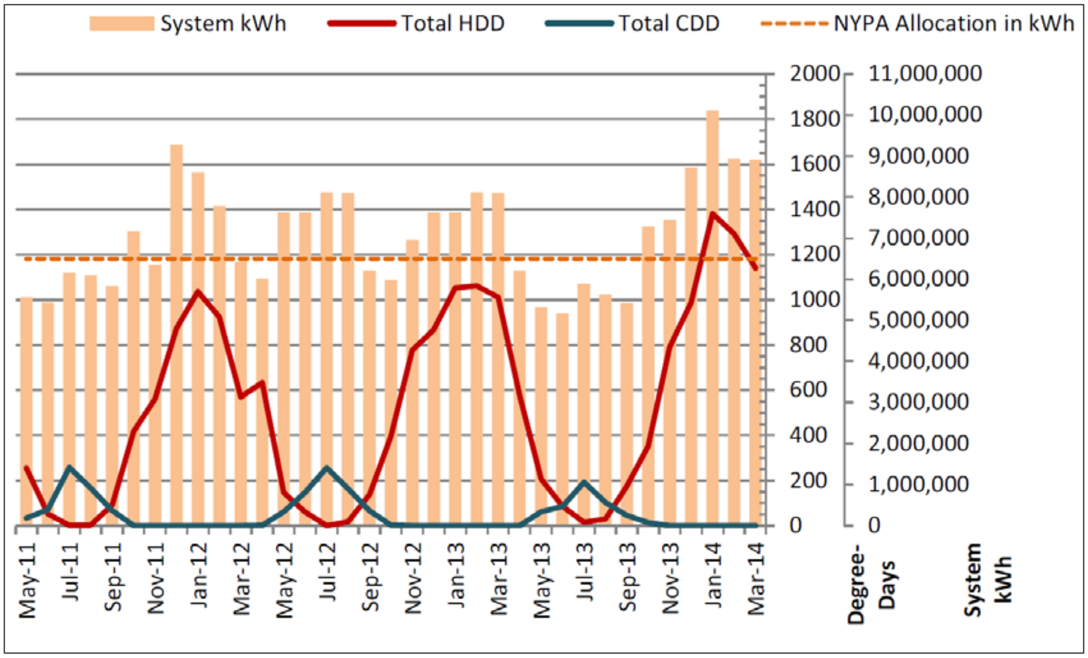


Figure 12. Westfield Monthly Energy Profile

Table 11 shows historical demand and energy for Westfield. Figure 15 shows the hourly average load profile of the total system load that is served by Westfield. The hourly load is broken down by month to reflect the drastically different usage and demand by month seen in figures 13, and 14 as well as in table 12. 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 15, summer months tend to produce a daily demand curve with one wide peak, starting at 6 a.m., ending at 9 p.m., 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 on 9 and 10 a.m. and one centered on 6 p.m. These correspond to the commercial industrial daytime peak and the residential evening peak electricity consumption times.

Table 11. Historical Demand and Energy for Westfield

Source	Summer Peak	Winter Peak	Annual Energy
Electricity	12 MW	18.5 MW	81,400 MWh

***Table** 12. **Electricity Usage** 2014*

Month	Energy (kWh)
January, 2014	7,800,000
February, 2014	8,100,000
March, 2014	8,200,000
April, 2014	6,300,000
May, 2014	5,300,000
June, 2014	5,200,000
July, 2014	6,000,000
August, 2014	5,800,000
September, 2014	5,500,000
October, 2014	7,200,000
November, 2014	7,300,000
December, 2014	8,700,000

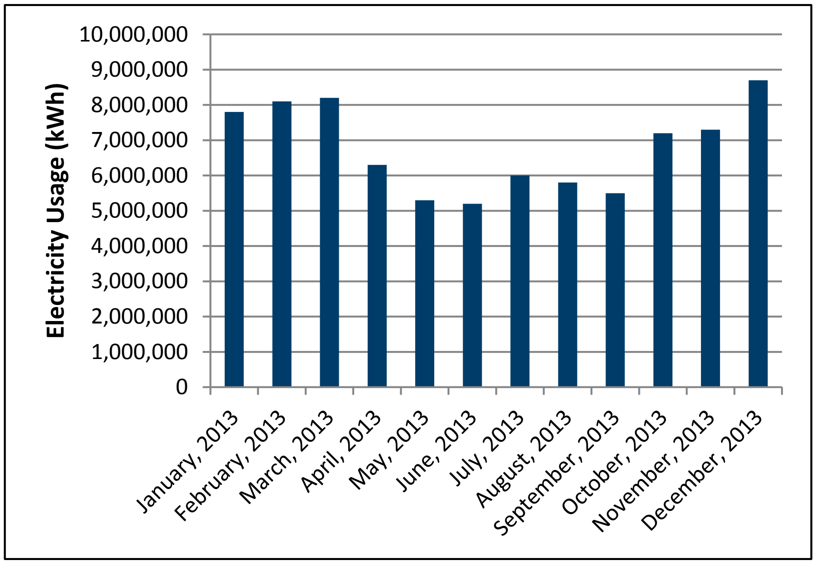


Figure 13. Electricity Usage 2013

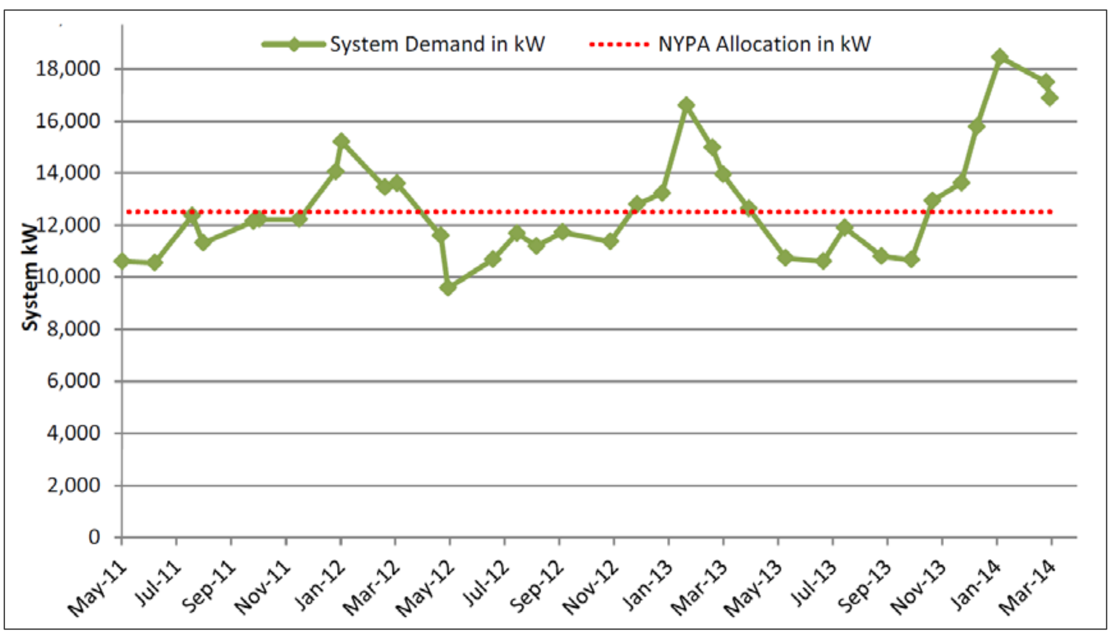


Figure 14. Westfield Monthly Demand Profile

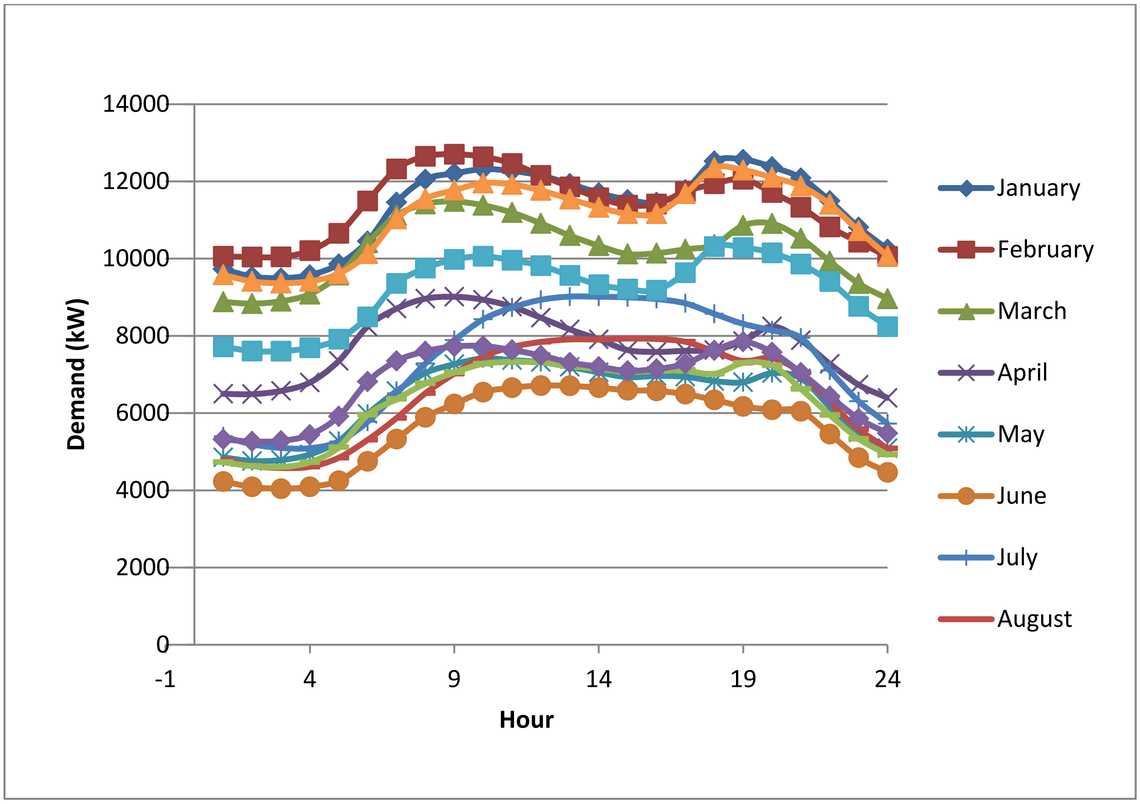


Figure 15. Westfield Average Daily Load by Month[1]

The Village of Westfield's loads can be separated into the broad load categories, critical and non-critical, with critical facilities including the Westfield Electric Department, Wastewater Treatment Plant, Water Treatment Plant, Village Office, Police Department, Fire Department, Memorial Hospital, and Westfield Central School, and non-critical facilities including the many other businesses and residential customers served by Westfield electric. The average critical load demand is about 2 MW.

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

A microgrid for the Village of Westfield will enhance the overall operational reliability of the electrical distribution system for all of the stakeholders, which include the Village of Westfield, National Fuel Gas, Wastewater Treatment Plant, Water Treatment Plant, Westfield Police Department, Westfield Fire Department, Westfield Memorial Hospital, and Westfield Central School. The thermal loads that are not fed by electric heaters are also considered separately.

[1] Westfield hourly load data is calculated based on the hourly load profile of Bath, NY due to the unavailability of hourly load data for Westfield at this time. Both Westfield and Bath depend on electricity for heating during winter seasons and are close to each other geographically, so it is assumed that both Westfield and Bath have a similar hourly load profile.

The detailed load information and locations for all the critical buildings are shown in table 13 and figure 16, respectively.

Table 13 Critical Buildings

Critical Facilities	Average kW (2014)	Total kWh (2014)
Electric Department	N/A	N/A
Wastewater Treatment Plant	744	3,912,000
Water Treatment Plant	476	478,000
Village Office	52	184,080
Police Department	N/A	N/A
Fire Department	72	162,000
Memorial Hospital	216	1,090,400
Westfield Central School	376	1,547,200
Total	**1,936**	**7,373,680**

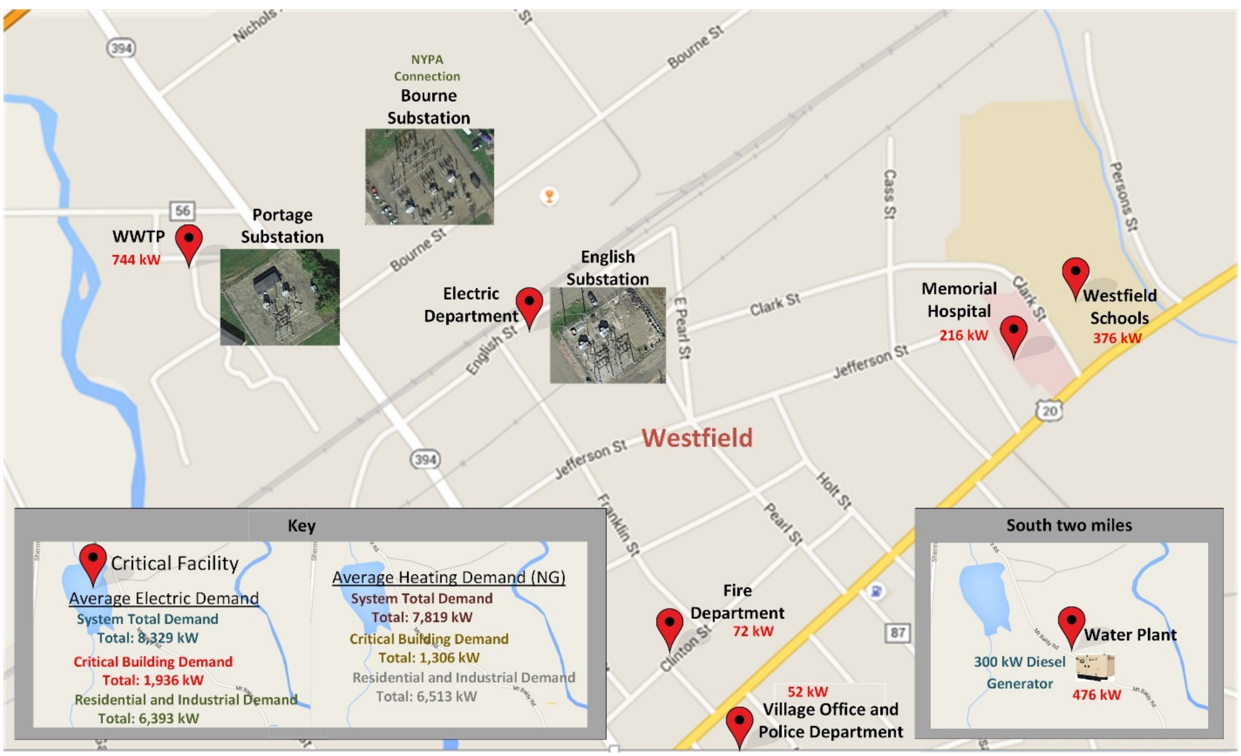


Figure 16. Load Simplified Equipment Layout Diagram

Figure 17 shows the hourly load profile of the total system load that is served by the microgrid. Figures 18 and 19 show DER-CAM simulation results for the critical buildings in the microgrid under normal base conditions with no added generation which represents the hourly load (kW) for critical building on typical day in January.

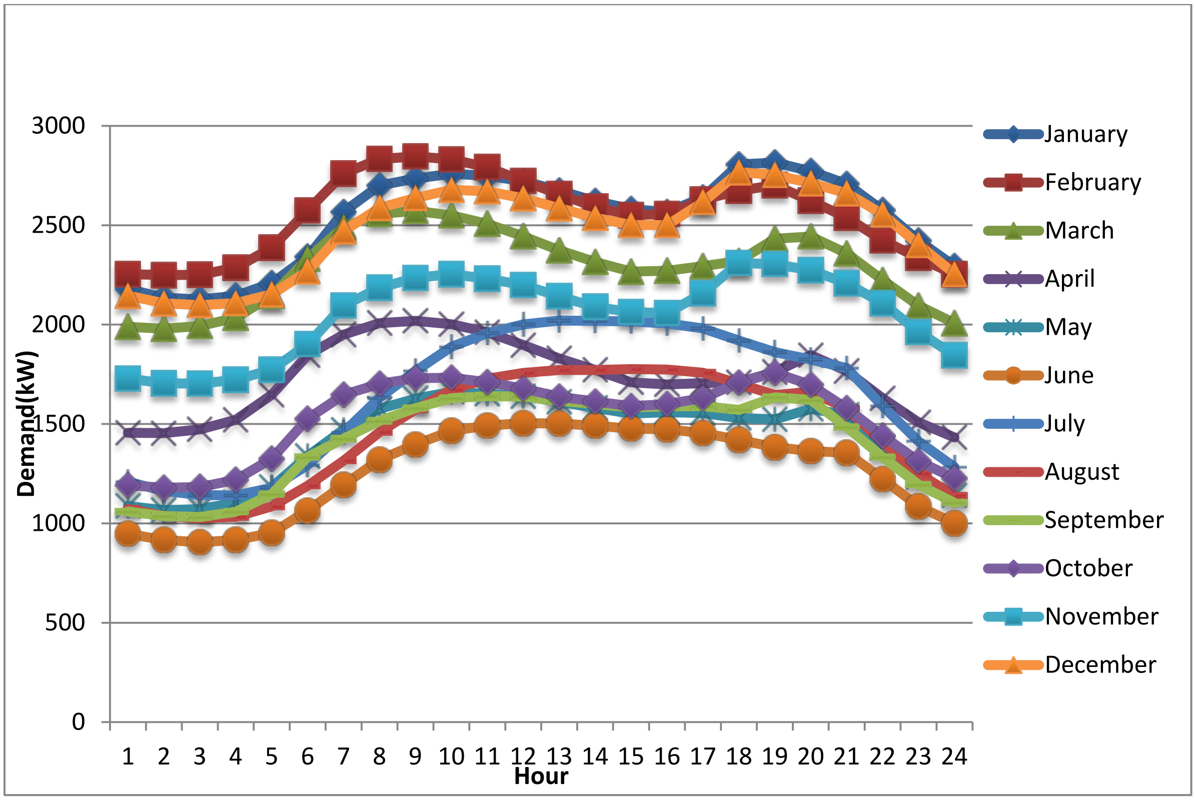


Figure 17. Westfield Average Daily Critical Load by Month[1]

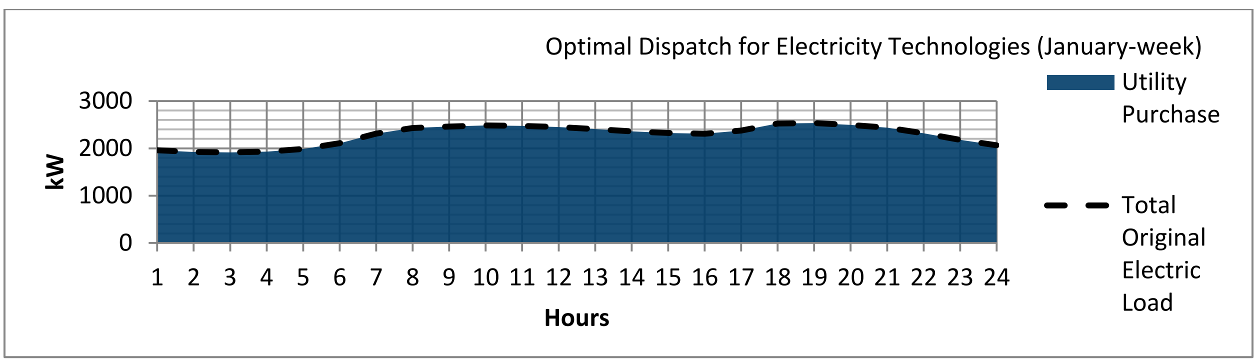


Figure 18. Pre Investment Average Electricity Dispatch for Critical Facilities[2]

[1] Hourly data for critical load is not available at this time. Data extrapolated based on hourly data provided for Bath project.
[2] DER-CAM simulation result.

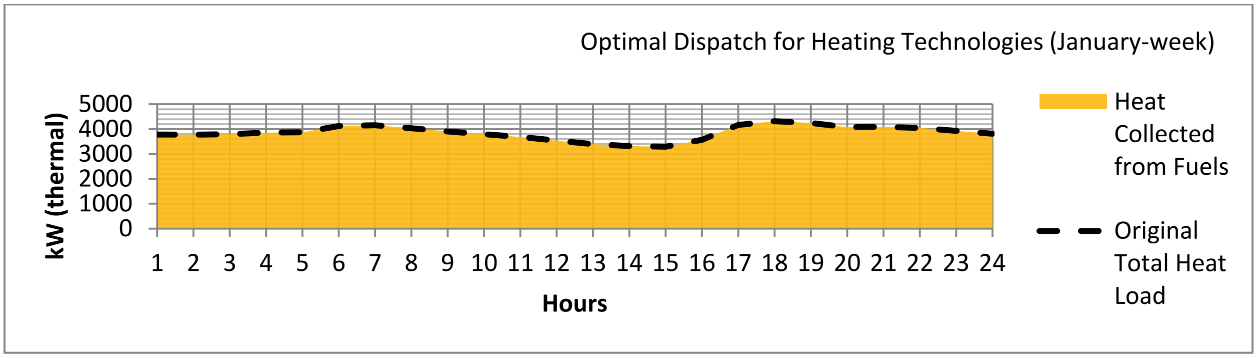


Figure 19. Pre Investment Average Heating Dispatch for Critical Facilities[1]

In addition to providing resiliency for critical loads, Willdan's proposed microgrid could provide economic and reliability benefits for Westfield Electric Power's nearly 3,200 customers including critical facilities such as fire and police public safety services, medical services, water treatment and wastewater treatment plants, as well as maintaining power for public street lighting and security lighting all across the Westfield area while the microgrid is islanded during the prolonged period of losing bulk power.

In addition to increased reliability, the 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

Capacity programs are a key component to keep electric power flowing in New York State, especially during periods of high electric demand. Capacity & Energy[2] is a partnership between NYPA and the participant. This option is appropriate for customers capable of providing load reductions for payment during the summer, the winter, or throughout the year. For the facilities, pledged capacity will be 85% of the average NYISO Monthly auction clearing price for each month enrolled. For verified performance by the facility during an event, the greater of $0.50/kWh or 100% of the market price during each hour of the event. The customer will also be paid 100% of the market price for participating in mandatory one-hour tests. The microgrid average load is 1,936kW. The community load in each critical facility can be further separated into the load categories shown in table 13 to describe the unique nature of, and opportunities available for, the different load types. The Westfield microgrid may participate in a Demand response program, either Capacity or Energy reduction through shifting the load to off-peak (midnight- 8:00 am) hours likes running appliances during the night or reducing the energy consumption of more efficient loads whose consumption can be adjusted, such as lighting and electric heaters.

[1] DER-CAM simulation result
[2] https://www.nypa.gov/PLM/PLMgovernment3.html

Sub Task 2.3 Distributed Energy Resources Characterization

Westfield 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 Westfield's substations also allows for the assessment of community energy storage and CHP at each location. The additional heat capacity provided could be utilized to improve the year-round efficiency of the sludge treatment process, while supplementing local facilities. Also Westfield is interested in exploring an expansion of CHP for a number of their critical facilities as well as adding a generation source to their schools. This expansion would allow Westfield to participate in Demand Response programs and reduce its dependency on its bulk electric power purchases.

The characteristics of the existing generation units and proposed DERs for DER-CAM simulation are assumed and listed in tables 14 and table 15, respectively.

Table 14. Main Parameters of Existing Backup Generators[1]

Location	Capacity (kW)	Cap Cost ($/kW)	OMvar ($/kWh)	Sprint Capacity (kW)	Efficiency	Backup Only	Year
Westfield Central School (NG)	48	1200	0.015	48	0.32	Yes	5
Wastewater Treatment Plant (Diesel)	125	1200	0.015	125	0.32	Yes	5
Water Treatment Plant (Diesel)	1200	865	0.013	1200	0.32	Yes	5
Village Office (Diesel)	300	865	0.013	300	0.32	Yes	5
Police Department (Diesel)	60	865	0.015	60	0.32	Yes	5
Fire Department (Diesel)	125	865	0.015	125	0.32	Yes	5
Memorial Hospital (Diesel)	125	865	0.015	125	0.32	Yes	5

[1] Default input parameters are included in DER-CAM.

Table 15. Main Parameters of Candidate CHP Units[1]

Location	Capacity (kW)	Cap Cost ($/kW)	OMvar ($/kWh)	Sprint Capacity (kW)	Efficiency /Alpha[1]	Backup Only	Year
CHP Unit 1	500	1200	0.011	500	0.32/1.4	No	0
CHP Unit 2	250	1200	0.011	250	0.32/1.4	No	0
CHP Unit 3	100	1200	0.011	100	0.32/1.4	No	0

CHP was considered in step sizes of 500 kW, 250 kW, and 100 kW, to obtain precise simulation results and due to the fact that DER-CAM only considers a maximum of six of each of the suggested technologies, allowing for a maximum of 5,100 kW of CHP to be suggested, which is more than enough to cover the entire demand of Westfield and therefore removes the black box constraint of DER-CAM. Costs were obtained from EIA[2] and from NREL[3,4].

Existing DERs located in the proposed microgrid are used primarily as backup generators in the event that utility power is interrupted. Six of the backup generators are diesel generators and two of them are natural gas (NG) fired backup generators, distributed among the critical facilities, and most retain about a week of fuel for 2,183 kW of capacity. Existing DER respective to critical load are shown in table 17 and the main backup generators are also shown in figure 20.

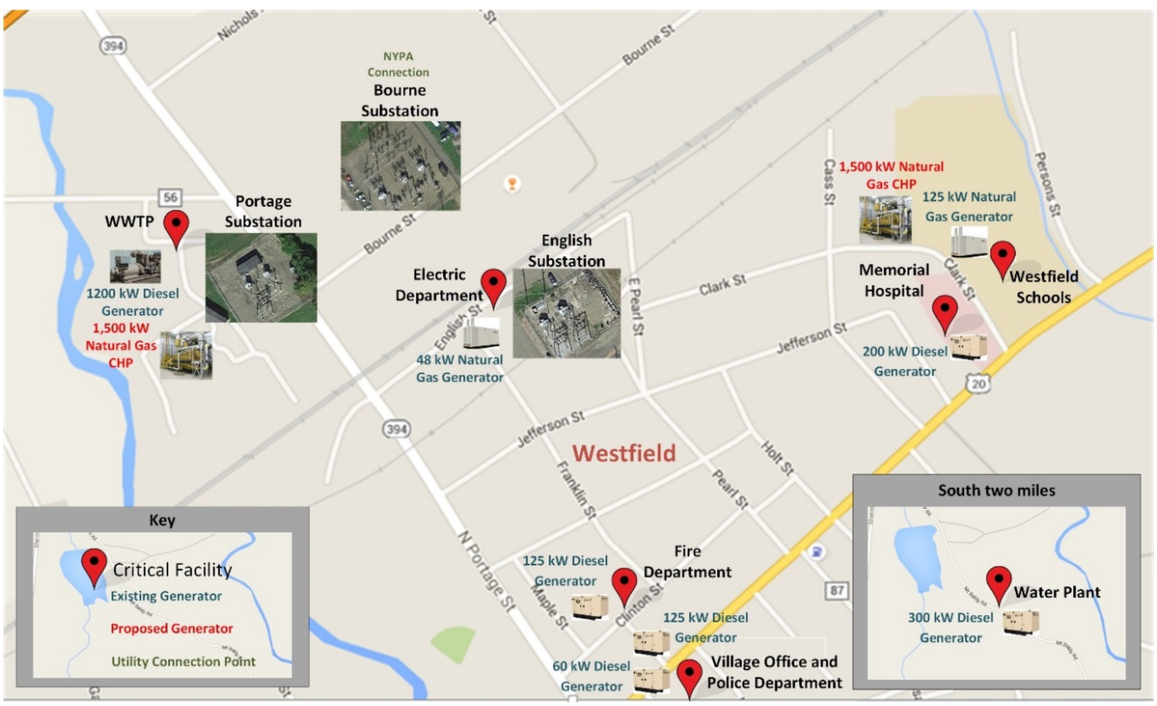


Figure 20. Existing and Proposed Generation Simplified Equipment Layout Diagram

[1] Alpha: Heat-to-power ratio for CHP.
[2] http://www.eia.gov/forecasts/capitalcost/pdf/updated_capcost.pdf
[3] http://www.nrel.gov/docs/fy11osti/48595.pdf
[4] http://www.nrel.gov/docs/fy13osti/56776.pdf

The proposed microgrid focuses on providing electricity for the critical buildings while relieving high winter peaks due to electric heating. Shown in figures 12 and 14 are the issues that the Westfield 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 16). The installation of 3,000-5,000 kW of CHP would be able to adequately serve the entire load, depending on the level of load shedding implemented.

Table 16. Proposed DERs and Backup Generation Units[1]

<table>
<tr><th>Location</th><th>DERs (kW)</th><th>Fuel Type</th><th>Backup (kW)</th><th>Fuel Type</th><th>Average Demand (kW)</th></tr>
<tr><td>Electric Department</td><td>-</td><td>-</td><td>48</td><td>Natural Gas</td><td>N/A</td></tr>
<tr><td>Wastewater Treatment Plant</td><td>1,500</td><td>Natural Gas</td><td>1,200</td><td>Diesel</td><td>744</td></tr>
<tr><td>Water Treatment Plant</td><td>-</td><td>-</td><td>300</td><td>Diesel</td><td>476</td></tr>
<tr><td>Village Office</td><td>-</td><td>-</td><td>60</td><td>Diesel</td><td>52</td></tr>
<tr><td>Police Department</td><td>-</td><td>-</td><td>125</td><td>Diesel</td><td>N/A</td></tr>
<tr><td>Fire Department</td><td>-</td><td>-</td><td>125</td><td></td><td>72</td></tr>
<tr><td>Memorial Hospital</td><td rowspan="2">1,500</td><td rowspan="2">Natural Gas</td><td>200</td><td>Diesel</td><td>216</td></tr>
<tr><td>Westfield Central School</td><td>125</td><td>Natural Gas</td><td>376</td></tr>
<tr><td>Total</td><td>3,000</td><td></td><td>2,183</td><td></td><td>1,936</td></tr>
</table>

Figures 21 and 22 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.

Existing DERs located in the proposed microgrid are used primarily as backup generators in the event that utility power is interrupted. Six of the backup generators are diesel generators and two of them are natural gas (NG) fired backup generators, distributed among the critical facilities, and retain about a week of fuel for 2,183 kW of capacity. Diesel generators are not adequate to be used as constant sources of electricity generation throughout the year due to limited reserve of Diesel. Willdan proposes 3,000kW CHP in order to supply power to critical facilities in case of grid outage and improve the reliability and resiliency of the Westfield's distribution system. The total generation capacity would be enough to supply power for critical electrical loads in winter peak hours. At this phase the exact location of the DERs cannot be identified due to unavailability of the power system network data, however, Willdan recommends locating 1,500 kW at the WWTP and 1,500 kW at the memorial hospital and high

[1] Row's color represents the critical load groupings in WCM.

school. These locations will be able to provide critical facilities: water treatment, medical care, and emergency shelters, with heat and power in all situations.

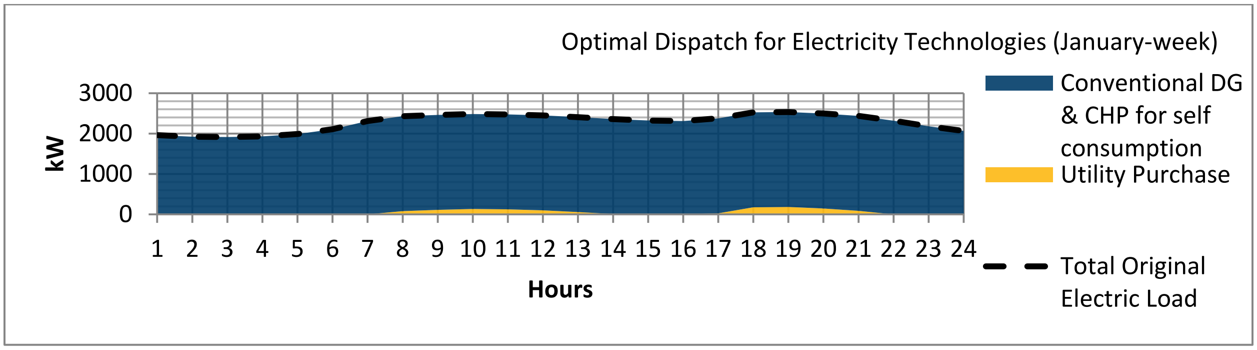


Figure 21. Post Investment Average Electricity Dispatch for Critical Facilities

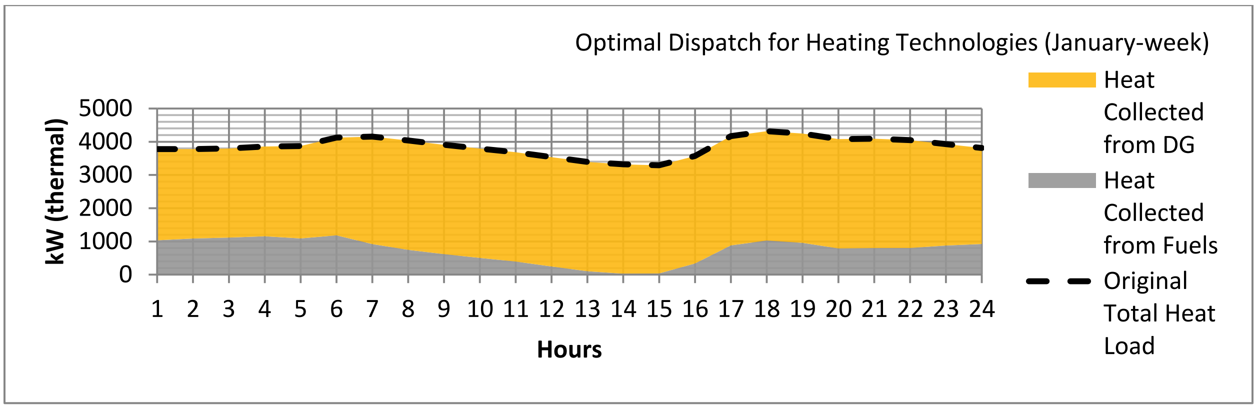


Figure 22. Post Investment Average Heating Dispatch for Critical Facilities

Furthermore, based on preliminary sensitivity analysis for the critical facilities, the microgrid is highly sensitive to the increases of Electricity price (figure 23). When Electricity price fluctuates, Westfield may need to consider further diversification of their DERs to include renewables or other forms of generation. As electricity increases, it would be more economical to install CHP for generating electricity instead of purchasing electricity from the grid. 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 Westfield shown in figure 23 is much cheaper than the Solar's LCOE, explaining why DER-CAM has not proposed any solar installation.

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

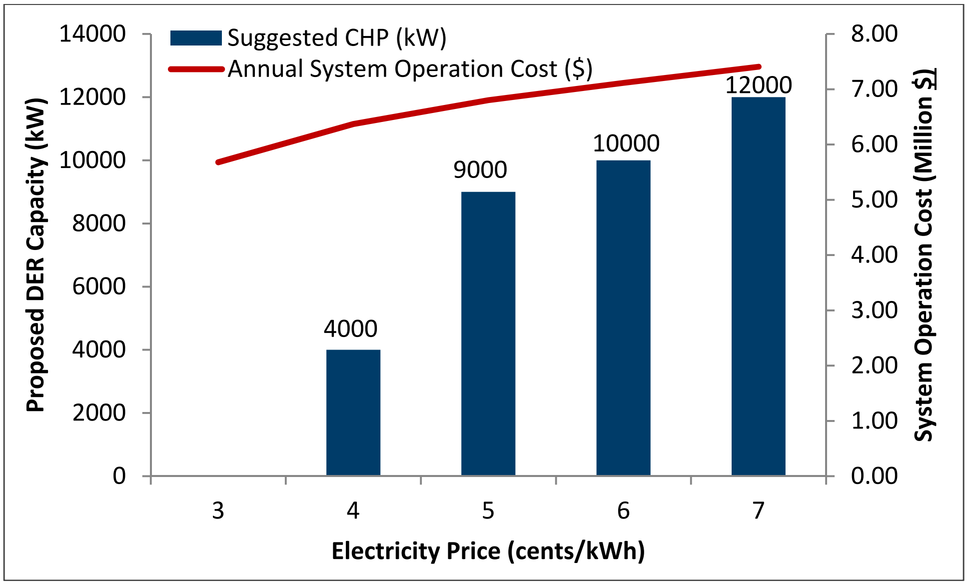


Figure 23. Full System Sensitivity Analysis Results for Electricity Price

While the critical loads have an average demand of about 1,936 kW and the total capacity of DERs are just over 2,000kW, shown in table 20, it can be seen that the backup generation is not enough for Westfield Central School, Memorial Hospital, and the water treatment plant in the event of an emergency. This means that a number of vital critical facilities would be out of power in the event of an emergency, putting the entire Village of Westfield in a risky 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 most of the generation runs off of diesel fuel, which is a fuel source that reduces the quality of the air, increases the carbon footprint of the Village of Westfield, and must be stored or shipped into the village in the event of an outage.

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 Westfield to operate as a microgrid, take advantage of new revenue streams such as Demand Response and Fast Regulation Markets. 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 local generation near residential load pockets. Distribution of these additional resources close to the school system, the fire department and other critical facilities, will ensure that critical facilities will remain powered on in emergencies, providing the Village of Westfield with peace of mind.

Table 17. 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 resource powered by the sun	$/kW of solar is greater than electricity price[1]	Clean, Reduce daytime peak load
Electric Storage	Converts electrical energy to chemical or mechanical for rapid dispatch when needed	Space, Capital Cost, Extra HVAC load requirement	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 resource 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

Two sets of simulation results are selected to be presented here to show the investment options for addressing the system resilience. The first case (Scenario 1) is the one hour islanding during peak load in January, while trying to keep the whole community powered on. The second case (Scenario 2) is maintaining the critical load's power with a one week disruption of power supply from the utility grid. Table 18 and figures 24-26 present the DER-CAM simulation results for the first scenario (Scenario 1) and table 19 and figures 28-30 demonstrate the simulation results for the second scenario (Scenario 2).

Table 18. The Annual Costs Savings by the Investment for Supplying the Loads in Westfield with Islanding in Peak Load Day (January)

Case	Base Case (no investment)	Investment Case (investment)	Increase
Total Annual Energy Costs (k$)	5,680	6,090.2	**410**

[1] 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), while the electricity price in Westfield is around 3 Cent/kWh.

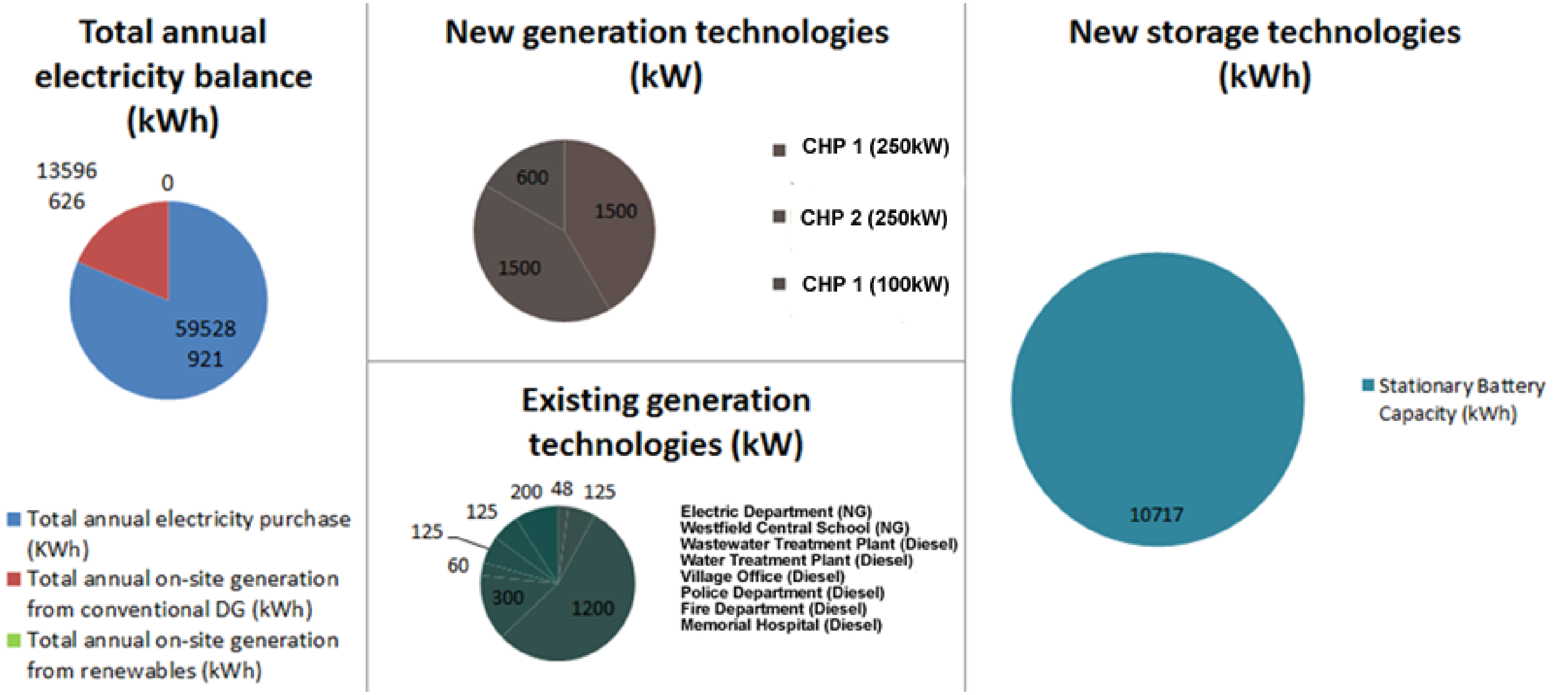


Figure 24. DER-CAM Investment Results – Serving Total Load with Island in Peak Load Hour

In Scenario 1, DER-CAM suggested 3,600kW CHP and 10,717kWh 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 economically beneficial. The major purpose of this case is just to get a total required generation resources figure.

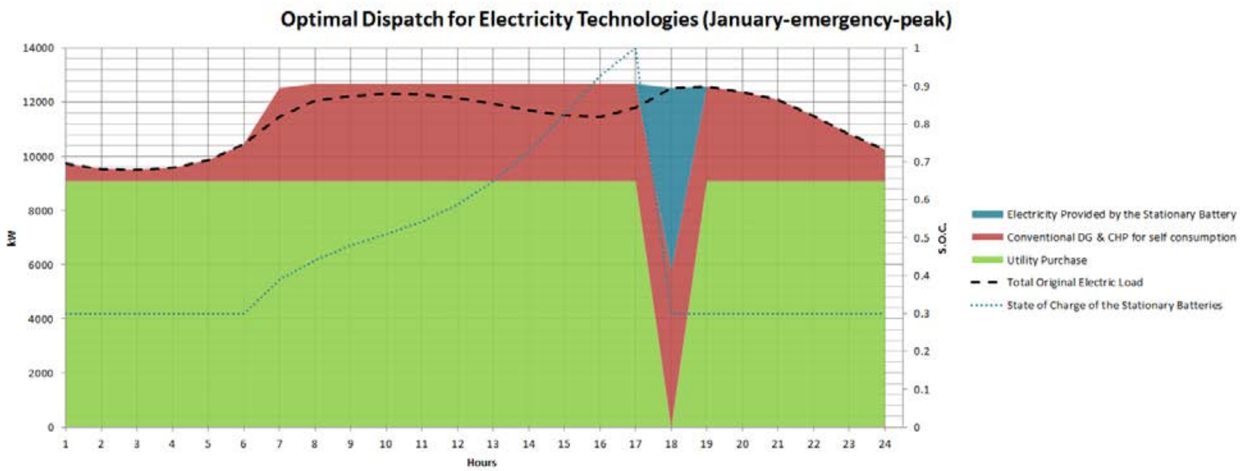


Figure 25. Optimal Dispatch with One Hour Islanding

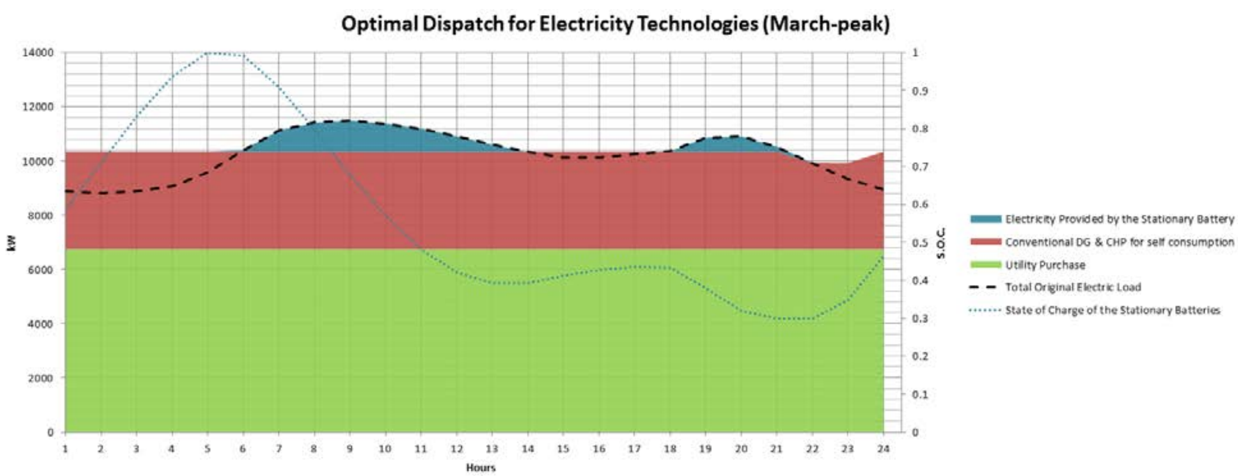


Figure 26. Optimal Dispatch in Grid-Connected Mode

In Scenario 2, it's assumed that only critical loads would be satisfied during disruption of utility grid. It can be seen from figure 28 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 29 which would improve the energy resilience of the critical facilities (Scenario 2: critical loads).

Table 19. The Annual Costs Savings by the Investment for Supplying Power for Critical Load with One Week Islanding in Peak Load Season (January)

Case	Base Case (no investment)	Investment Case (investment)	Increment
Total Annual Energy Costs (k$)	1,186.3	1,272.3	**86**

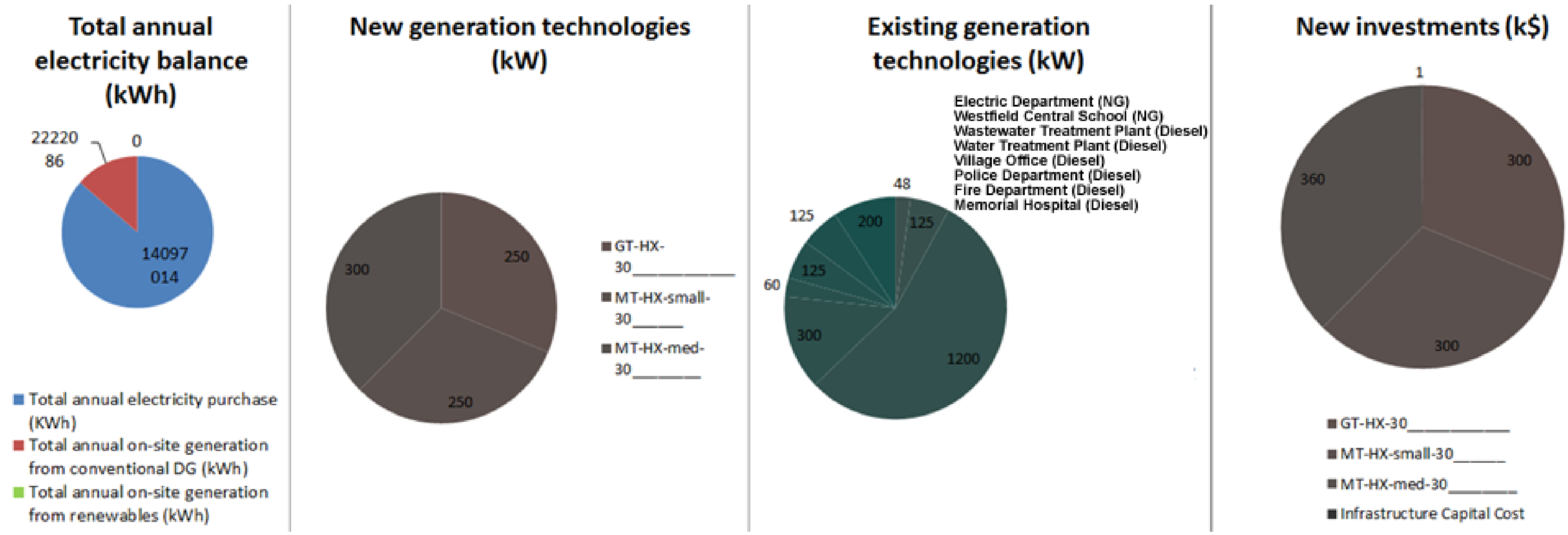


Figure 27. DER-CAM investment results – Serving Critical Load with one week island in January[1]

[1] The name of new generation technologies shown in the figure are set by DER-CAM whose parameters have been changed accordingly (250kW for GT-HX-30 and MT-HX-small-30 and 100kW forMT-HX-med-30, respectively).

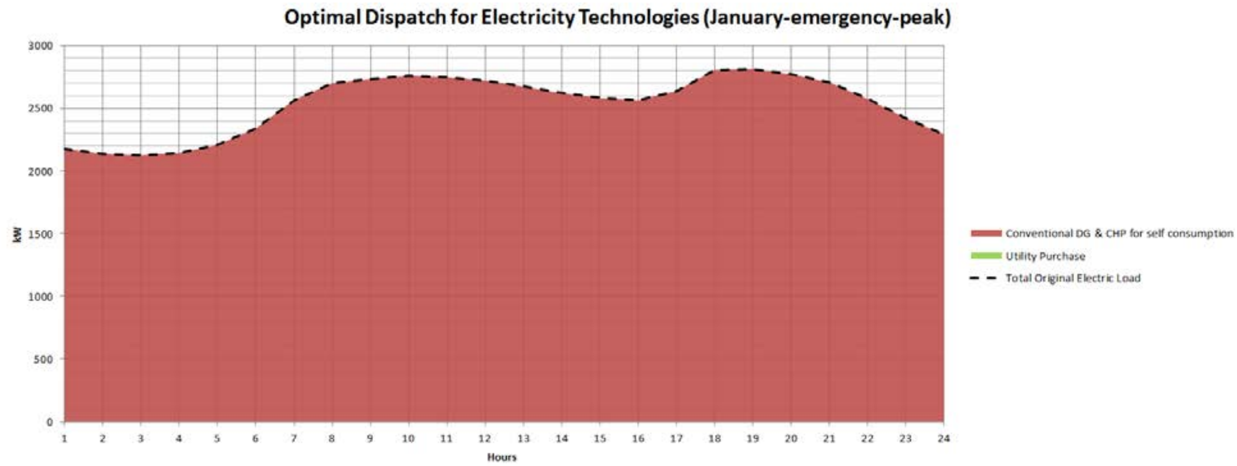


Figure 28. Optimal Dispatch in Islanding Mode

Figure 29 shows that CHP units are dispatched to generate heat in January and can cover a portion of electric load by its generated power as a secondary output.

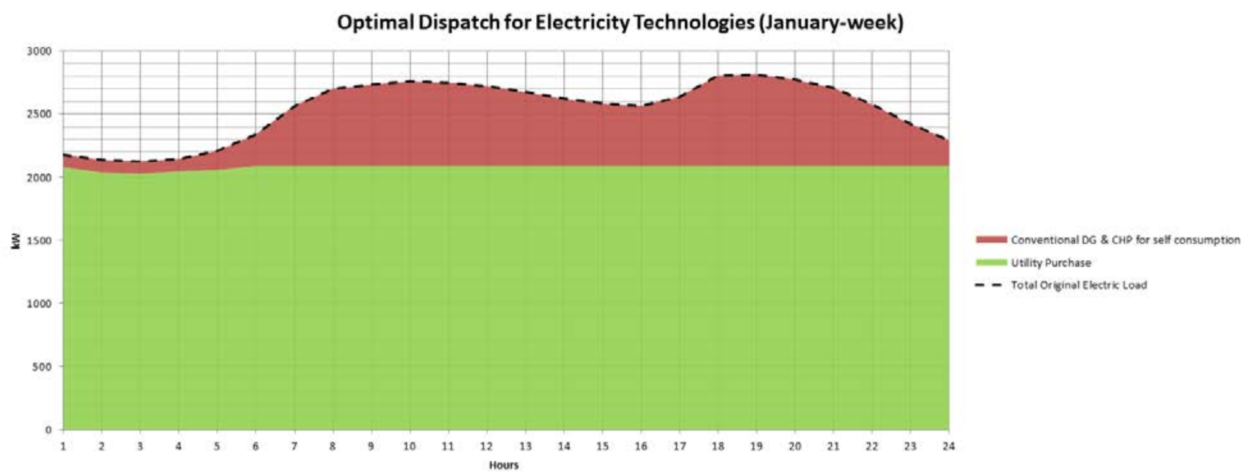


Figure 29. Optimal Dispatch in Grid-Connected Mode

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, thermal, and communication 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 used in winter seasons could cause damages or outages on the over-head system in the Village of Westfield. Also, heat waves in summer could affect distribution line

[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

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. It would also 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 of hours to a few weeks. Natural gas disruptions are less likely than electricity disruptions, however, it is relatively more difficult to recover from these outages than electric outages because of the difficulty to locate and repair the underground leaks. The extreme weather would affect both individual equipment failure and system operations. The damage from such events can impose large costs on the distribution system as well as severe impact on the local economy.

Many of Westfield'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 distribution system.

Willdan's proposed microgrid will help improve the Westfield community grid be resilient to:

- Energy resources for disrupting events (discussed in this section)
- Distribution Network disrupting events (discussed in subtask 2.4)
- Communication Network disruptive events (discussed in subtask 2.6)

This will help the community serve the critical loads at the time outage caused by the above events.

Energy resource disrupting events

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 (load curtailment levels). The proposed DER capacity and operational costs to serve all the critical loads (100% level/No curtailment) obtained from DER-CAM simulations are shown in Figure 31. 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 32 - 35 shows the simulation results for serving 90%-60% of critical loads (10%-40% load curtailment), 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, but the increase is not linear. This is due to the step-size of the suggested CHP installation by DER-CAM. The system operation cost would increase along with the islanding days when no extra DER is added since the loads would depend on the existing generation resources during the islanding time period. The longer outage the system experiences the higher the need is for new DER due to the fuel reserve being finished. In order to keep the critical load powered on new DER with consistent fuel supply is necessary, such as CHP. Once new DER is added, the cost of expensive diesel generation would drop. Combined with the investment cost of the new DER, the total system operational cost (including the averaged capital cost) would not increase linearly with the islanding days as shown in figures 31-35. The new added CHP would also help in reducing the operational cost. The DER-CAM simulation results are also shown in table 20 and table 21 based on the order of resilience in which we define that the capacity serving critical load without any disruption for seven days with no critical load curtailment as 100% resiliency and the capacity of serving 60% critical load for one day as 10% resiliency. As shown in table 20 and table 21 the prospective microgrid owner will invest in microgrid assets based on the available budget.

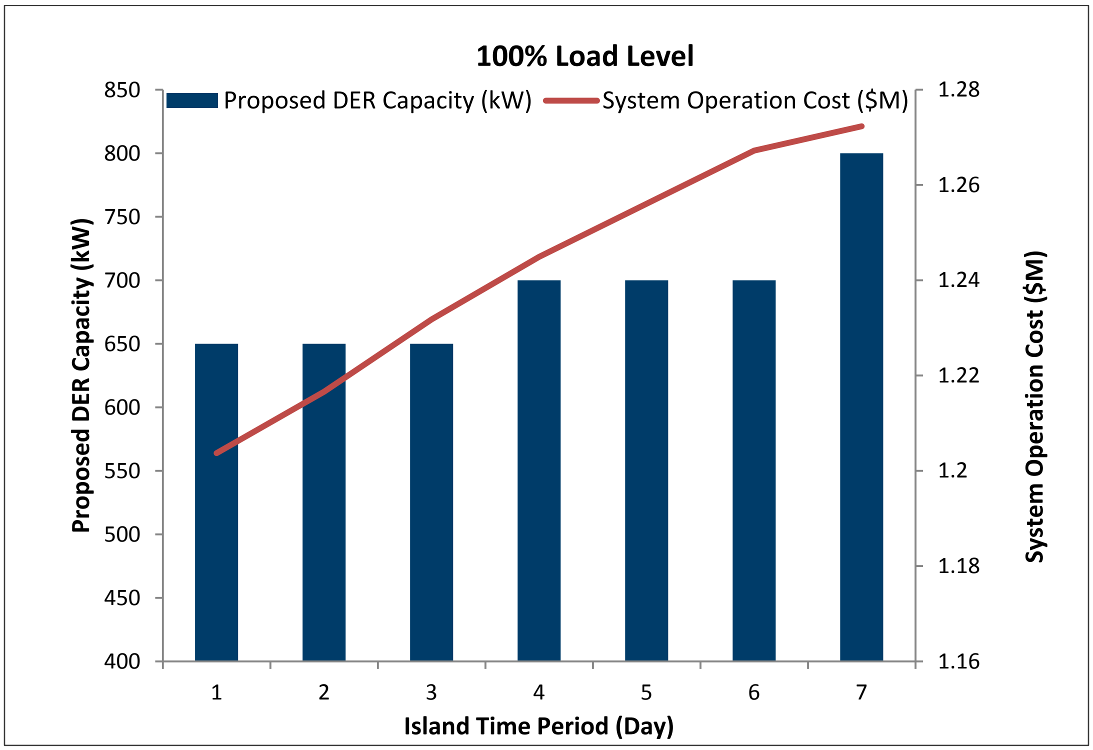


Figure 30. Proposed DER Capacity and Operation Cost for Serving 100% of Critical Loads

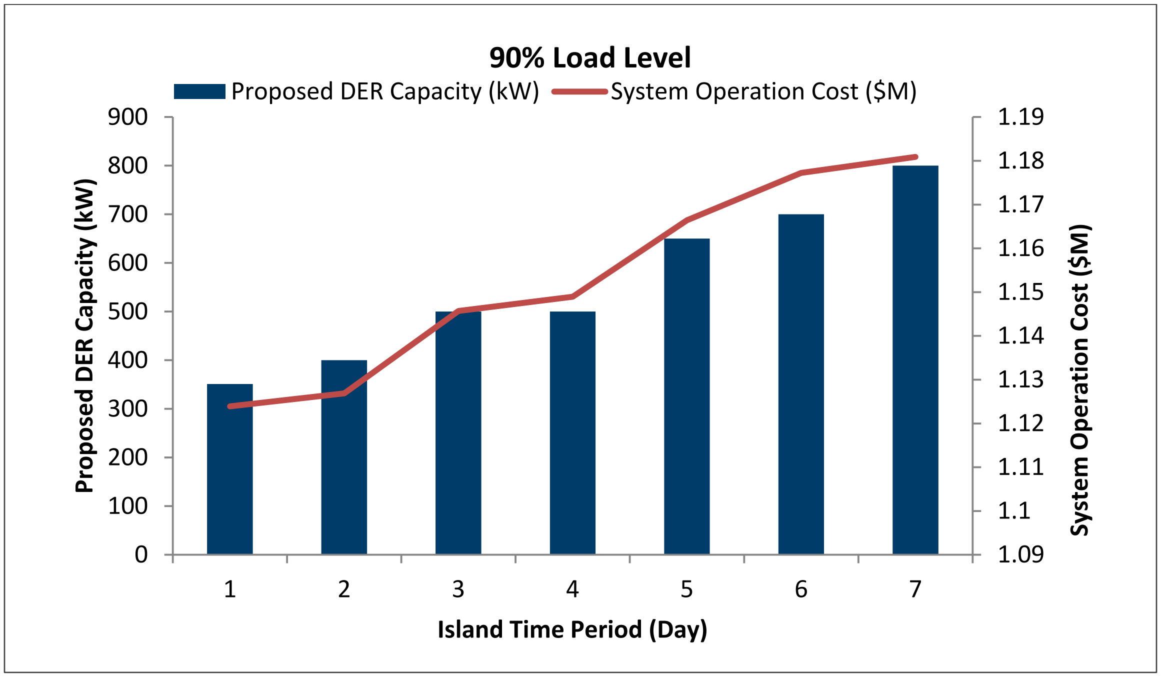


Figure 31. Proposed DER Capacity and Operation Cost for Serving 90% of Critical Loads

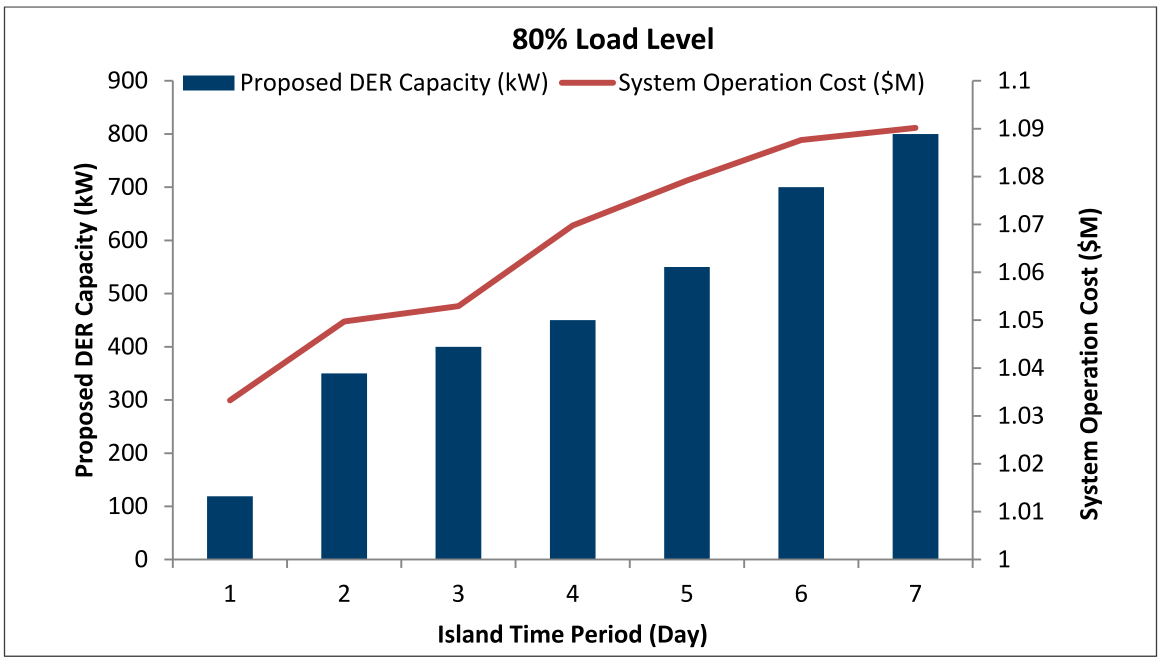


Figure 32. Proposed DER Capacity and Operation Cost for Serving 80% of Critical Loads

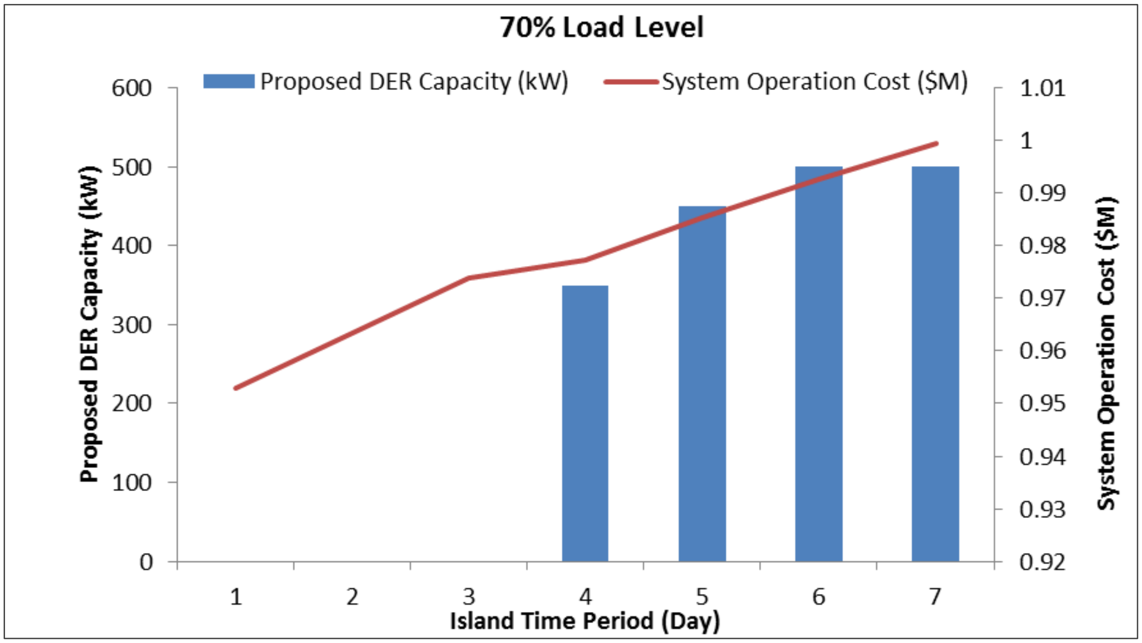


Figure 33. Proposed DER Capacity and Operation Cost for Serving 70% of Critical Loads

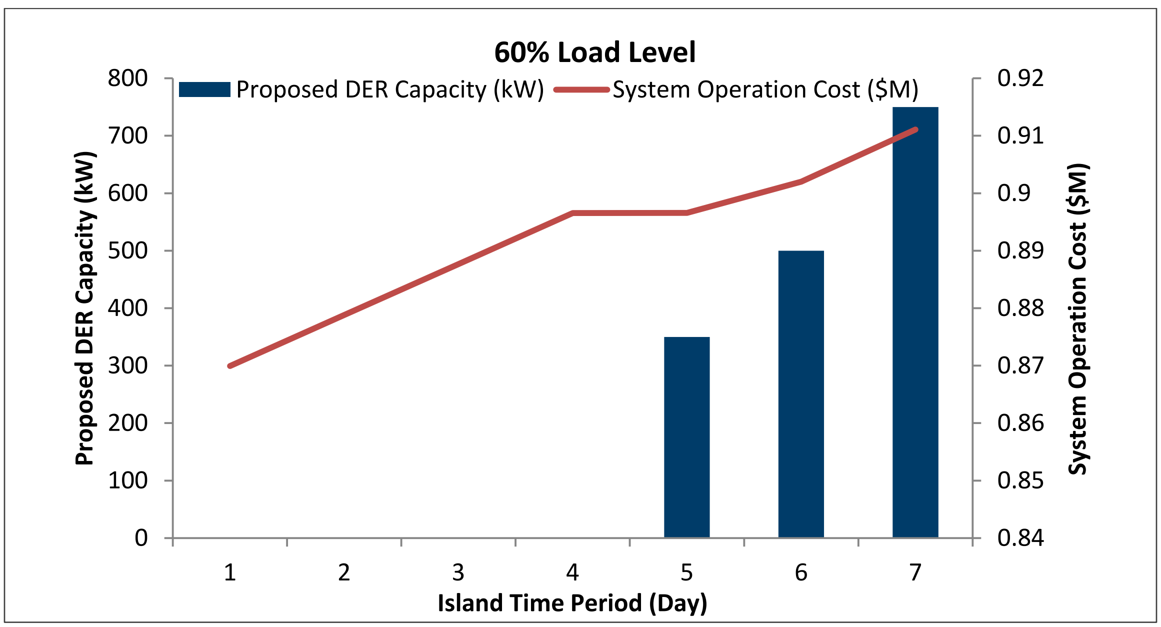


Figure 34. Proposed DER Capacity and Operation Cost for Serving 60% of Critical Loads

Table 20. 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%	800	1,272,318	961,000
	10%	97.35%	800	1,180,886	961,000
	20%	94.71%	800	1,090,158	961,000
	30%	92.06%	500	999,283	601,000
	40%	89.41%	750	911,097	901,000
6	0	86.76%	700	1,267,227	841,000
	10%	84.12%	700	1,177,256	841,000
	20%	81.47%	700	1,087,625	841,000
	30%	78.82%	500	992,551	601,000
	40%	76.18%	500	901,998	601,000
5	0	73.53%	700	1,257,270	841,000
	10%	70.88%	650	1,166,410	781,000
	20%	68.24%	550	1,079,190	661,000
	30%	65.59%	450	984,961	541,000
	40%	62.94%	350	896,430	421,000
4	0	60.29%	700	1,244,904	841,000
	10%	57.65%	500	1,148,943	601,000
	20%	55.00%	450	1,069,791	541,000
	30%	52.35%	350	977,144	421,000
	40%	49.71%	0	896,555	0
3	0	47.06%	650	1,231,774	781,000
	10%	44.41%	500	1,145,696	601,000
	20%	41.76%	400	1,052,924	481,000
	30%	39.12%	0	973,862	0
	40%	36.47%	0	887,683	0
2	0	33.82%	650	1,216,600	781,000
	10%	31.18%	400	1,126,858	481,000
	20%	28.53%	350	1,049,735	421,000
	30%	25.88%	0	963,366	0
	40%	23.24%	0	878,810	0
1	0	20.59%	650	1,203,702	781,000
	10%	17.94%	350	1,123,901	421,430
	20%	15.29%	100	1,033,253	128,650
	30%	12.65%	0	952,869	0
	40%	10.00%	0	869,936	0

Table 21. Serving Critical Loads with Islanding in Peak Load Season (January)

Islanding Days	Load Curtailment	Resilience Weight (%)[1]	Proposed DER	Operation Cost (K$)	Investment Cost (K$)
7	0-40%	100% - 89.41%	800- 500	1,272.3 –911.1	961 – 601
6	0-40%	86.76% -76.18%	700 -500	1,267.2 - 902.0	841 – 601
5	0-40%	73.53% - 62.94%	700 -350	1,257.3 - 896.4	841 – 421
4	0-40%	60.3% - 49.70%	700- 0	1,244.9 - 896.6	841 – 0
3	0-40%	47.06% - 36.47%	650- 0	1,231.8 - 887.7	781 – 0
2	0-40%	33.82% - 23.24%	650- 0	1,216.6 - 878.8	781 – 0
1	0-40%	20.59% - 10%	650- 0	1,203.7 - 869.9	781 – 0

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

During emergency operating conditions, the microgrid would be able to provide uninterrupted power to critical loads, through the use of DERs and load shedding schemes that ensure safe and reliable operation of the buildings that matter most in emergency situations. Long term outages will be mitigated by large natural gas fed combined heat and power (CHP) plants, which will maintain a black-start capability in the event the outage occurs when the CHP facility is not active. The computers that start the engines can be run with the use of a battery or backup diesel generator. Once up to speed, the microgrid controller must connect the system through a “generator breaker” to a load that allows it to supply power to the CHP parasitic loads (otherwise, the engines will overheat and shut down). The second step is to then engage the “tie breaker” that places the full load on the CHP system. To operate in this mode, the CHP system must be producing the electric power with a synchronous generator or inverter system.

Microgrid DERs with the capability of fast start-up time take about fifteen to thirty minutes from initial to start to full load. Multiple engines can be started in parallel in the microgrid. The short start-up time makes gas engine power plants an attractive solution for frequent start/stop operation and offers optimal load following capability. Reciprocating engines start quickly, follow load well, have good efficiencies even when operating at partial load, and generally have high reliability.

The 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

[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.

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. In 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. Reactive Power and Voltage Control service corrects for reactive power and voltage fluctuations caused by customers operations. This service helps maintain voltage within limits (interconnection standards) set by the National Electric Reliability Council (NERC) for the reliable operation of the system. Further details about these services and their implementation methodology are available in subtask 2.5.

Sub Task 2.4 Electrical and Thermal Infrastructure Characterization

The Westfield Electric Department owns and operates the distribution system within the village to serve approximately 3,200 customers. Most of the distribution system is an aging over-head system. Westfield owns two substations; portage substation and English substation. Most of the distribution lines are 34.5kV or 4.8kV overhead lines; The Westfield Electric System is supplied by a single 115kV transmission line to provide bulk power which was last inspected in 1996. The distribution system in Westfield, which connects the two substations, is shown in figure 35.

Willdan proposes moving the overhead supply underground and upgrading the distribution system by installing 34.5 kV rated components to lower system resistance losses and provide additional flexibility and capacity. This would also eliminate the need for the above ground transformers that currently step down the distribution voltage of 34.5 kV to the switchgear rating of 4.8 kV.

At this phase, no Power System grid information has been provided. As a result, a detailed study including power flow analysis is not possible. In phase 2, detailed analysis will be done upon the receipt of the distribution network information such as a detailed one-line diagram and network model.

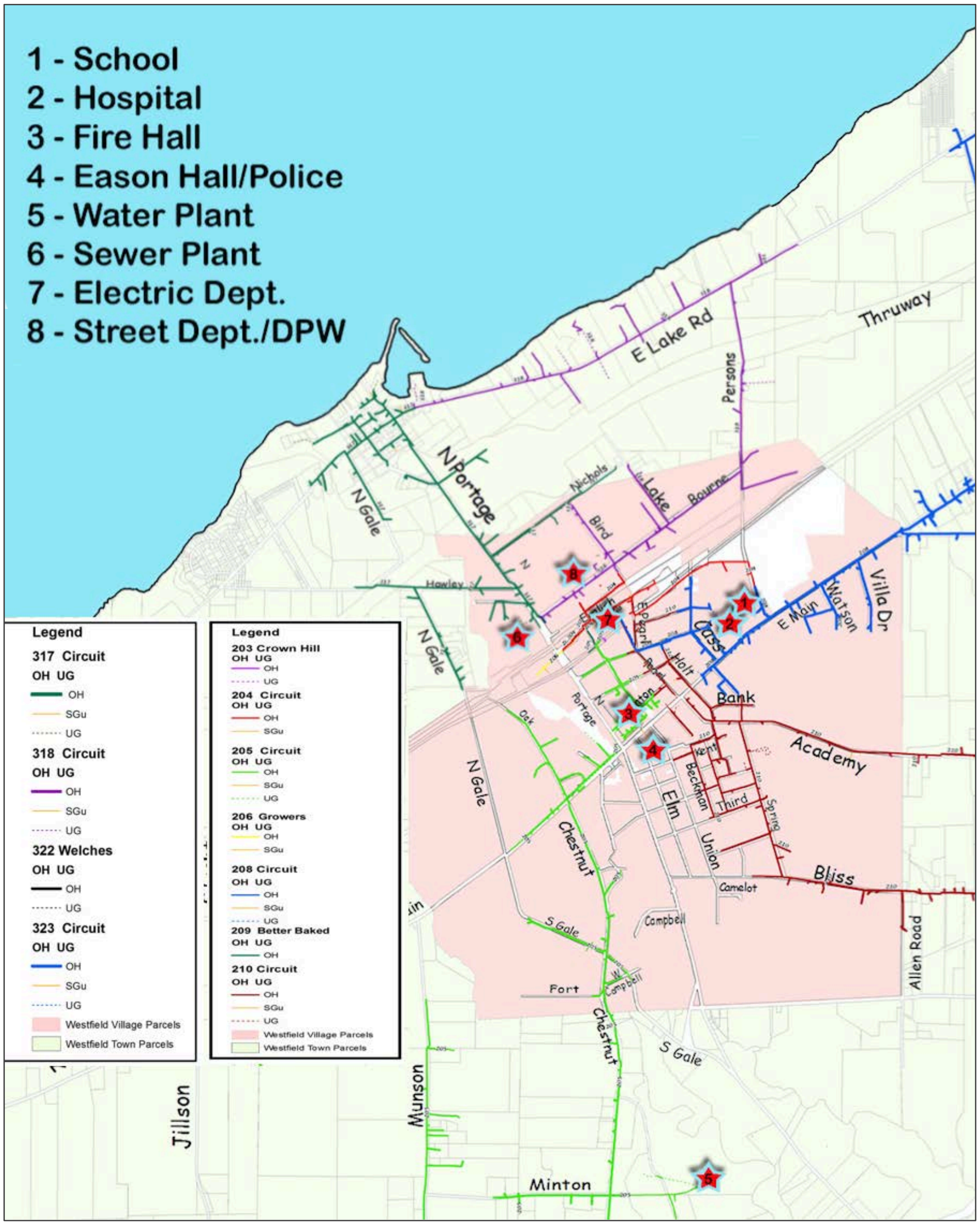


Figure 35. Simplified Electrical Infrastructure Layout

An intelligent distribution system consists of properly-sized cable and transformers capable of carrying the full expected load, feeder redundancy to offer an alternate power supply to buildings where power is interrupted, automated breakers and switches to execute the split second isolation of faults, automated restoration, and a communications system capable of orchestrating this split- second reconfiguration of the system.

Figure 36 provides a schematic diagram of a conceptual[1] energy system for two critical buildings, WWTP and Electric Department at microgrid. Power input to each building consists of two feeds from the Portage and English Substations. In WWTP Feeders B (primary) and A (secondary) from Portage substation provide feeder redundancy through manual switches 176 and 177, respectively. In Electric Department Feeders A (primary) and B (secondary) from Portage substation provide feeder redundancy through manual switches 716 and 717, respectively. A high pressure steam system supplies heating, as shown by the red lines. Portage and English substation feeds do not have an automatic crosstie. Willdan proposes to install an automatic cross tie switch between these two Substations, as shown at the top of figure 37.

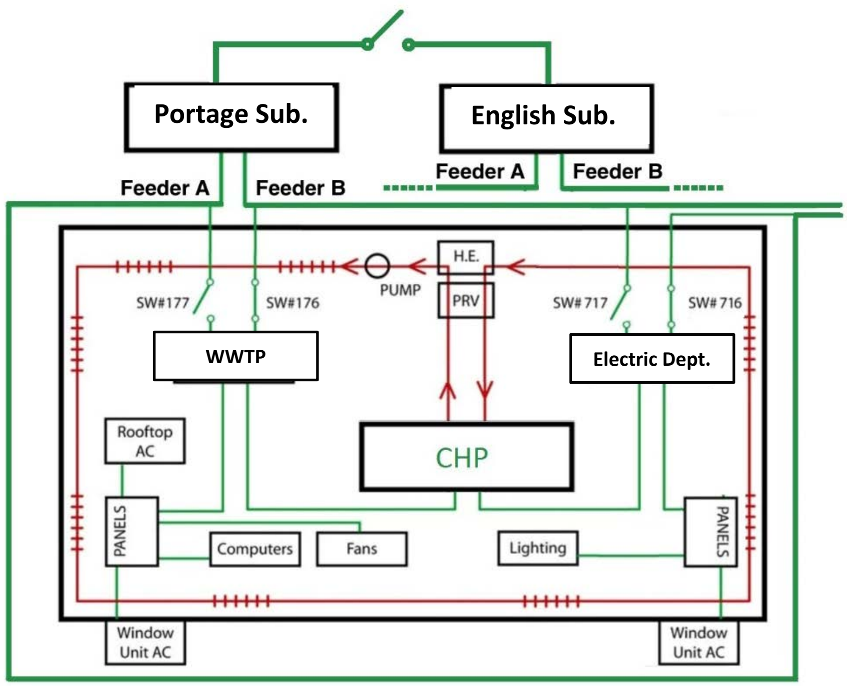


Figure 36. Schematic Diagram of Conceptual Energy System for WWTP and Electric Department Building[2]

Willdan's proposed microgrid will help improve the Westfield community grid be resilient to:

- Energy resources for disrupting events (discussed in subtask 2.3)
- Distribution Network disrupting events (discussed in this subtask)
- Communication Network disruptive events (discussed in subtask 2.6)

This will help the community serve the critical loads at the time outage caused by the above events.

[1] Network data was not available at this stage of the project and system design will be done in Phase 2.

[2] IIT Perfect Power Prototype, Final Report October 15, 2007 available at http://www.galvinpower.org/sites/default/files/documents/IIT_Perfect_Power_Prototype.pdf

Power System disrupting events

The proposed microgrid is equipped with Self-sustaining electric1 infrastructure which is crucial for the success of the microgrid. The many factors that can negatively affect power supply must be mitigated automatically by the system if outages are to be avoided. Many self-sustaining elements need to work in concert to achieve a true self-sustaining or self-healing electric infrastructure. Some of these elements are as follows.

Feeder redundancy

Feeder Redundancy will allow the re-routing of power to buildings in the event of a fault on a distribution feed. Used in concert with high-speed automated breakers and switches, redundant feeders allow for the instant reconfiguration of the system to keep power flowing to all buildings.

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

The HRDS leverages a continuously energized loop feeder concept, which provides a redundant electric supply to each campus building. Both feeds will be energized and supply electricity to the building, as well as be capable of carrying the entire building load. High-speed, intelligent, automated switches will detect and isolate a fault without loss of power to the building.

Willdan proposes a Loop-based community microgrid for Westfield. The HRDS 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. Vista Switches 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 Westfield's distribution network for supplying power to the critical loads is shown in figure 37. Each square represents one of the three ways located in Vista Switches, shown in figure 38. Each Vista switch has three or more ways: Way 1(inbound feeder), Way 2 (Outbound feeder) and Way 3 and beyond(Load)

These Vista switches 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 the microgrid.

[1] Perfect Power Prototype, at http://www.galvinpower.org/sites/default/files/documents/IIT_Perfect_Power_Prototype.pdf

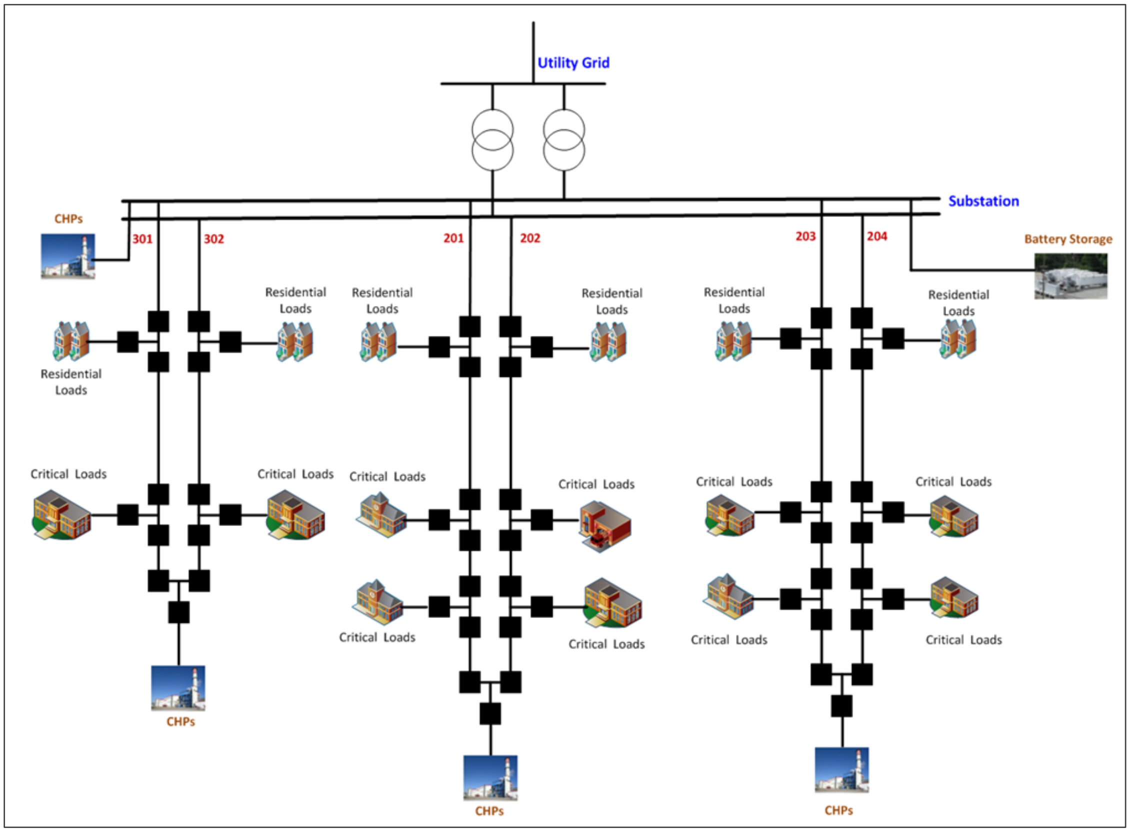


Figure 37. Conceptual Design of the Microgrid

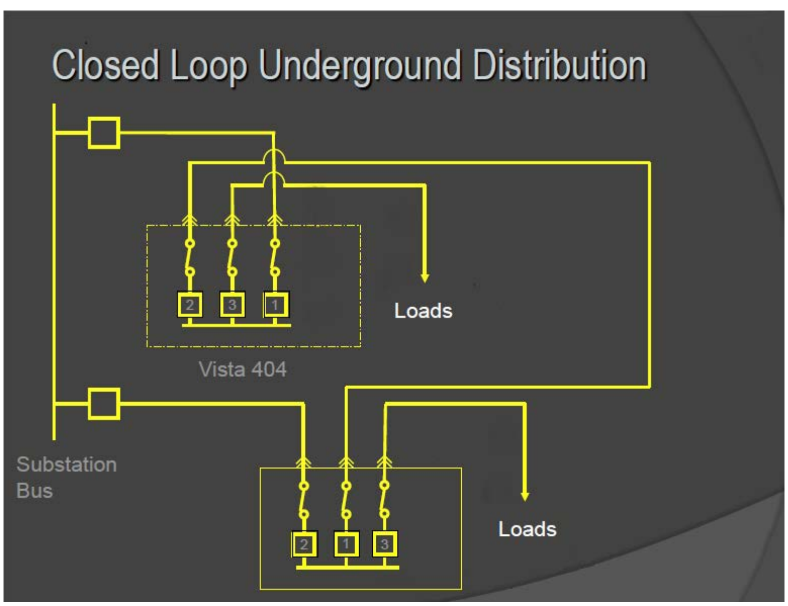


Figure 38. Conceptual Design of Close Loop System Using Two Vista Switches

The proposed HRDS design is reliable, versatile, upgradeable, and cost-efficient. The approach utilizes S&C Vista™ fault-clearing switchgear in a closed-loop system with SEL-351 or equivalent directional over current protection relays. In the microgrid, the following schemes will be implemented:

- A Permissive Over-reaching Transfer Trip (POTT) scheme will be used to protect the underground feeder cables. Using this scheme with the S&C Vista switch and SEL-351 relays results in clearing of primary faults in 3-6 cycles. In addition, a Directional Comparison Blocking scheme is used as a back-up to the POTT scheme.
- Branch line faults will be cleared by the integral Vista Over-current Control, which can operate the fault interrupter to clear the fault in as little as 3 cycles.
- The system will use two substations in two closed-loop configurations to support load requirements as well as load equalization if a fault occurs on a feeder.
- To support new load growth, additional Vista units can be added anywhere along the loop system and will adhere to the system design without any changes in relay settings.

Automated breakers and switches

Using an HRDS, the isolation of faults will be executed by automated breakers and switches that will sense fault conditions and open within 1/4 cycle, simultaneously isolating the fault and allowing power to flow along a secondary feeder route. This system of automated breakers and switches will employ:

- High speed, fault interrupting switchgear for the north and south main buses
- Automatic high speed transfer system – either at the individual building level, mid – distribution loop level, or substation level
- Multifunction directional over-current relays
- S&C Vista switches with vacuum fault interrupters

Finally, the Westfield distribution serving critical loads is old and does not provide for redundancy. To compensate for this, the microgrid provides local generation and UPS/backup generation at key facilities to ensure that the microgrid can operate when grid power is lost and to provide ancillary services to the grid.

The two substations located in Westfield community would be the point of common coupling (PCC) where the 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 microgrid protection which mainly contains four-level protection: load way, loop way, loop feeder way and microgrid level. Each level is equipped with protection devices and the four levels are coordinated. The protection devices and operational rules in each level are summarized in table 22. 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 faults both inside and outside of the microgrid
- Detect and isolate faults inside the microgrid in both grid-connected and island 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.

Table 22. 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.

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

Sub Task 2.5 Microgrid and Building Controls Characterization

Figure 39 shows the community microgrid elements, functions, and control tasks associated with each criterion. In particular, the tertiary control is the upper level of control system, which ensures the optimal operation of community microgrid by determining the set points of generation and load. 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 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.

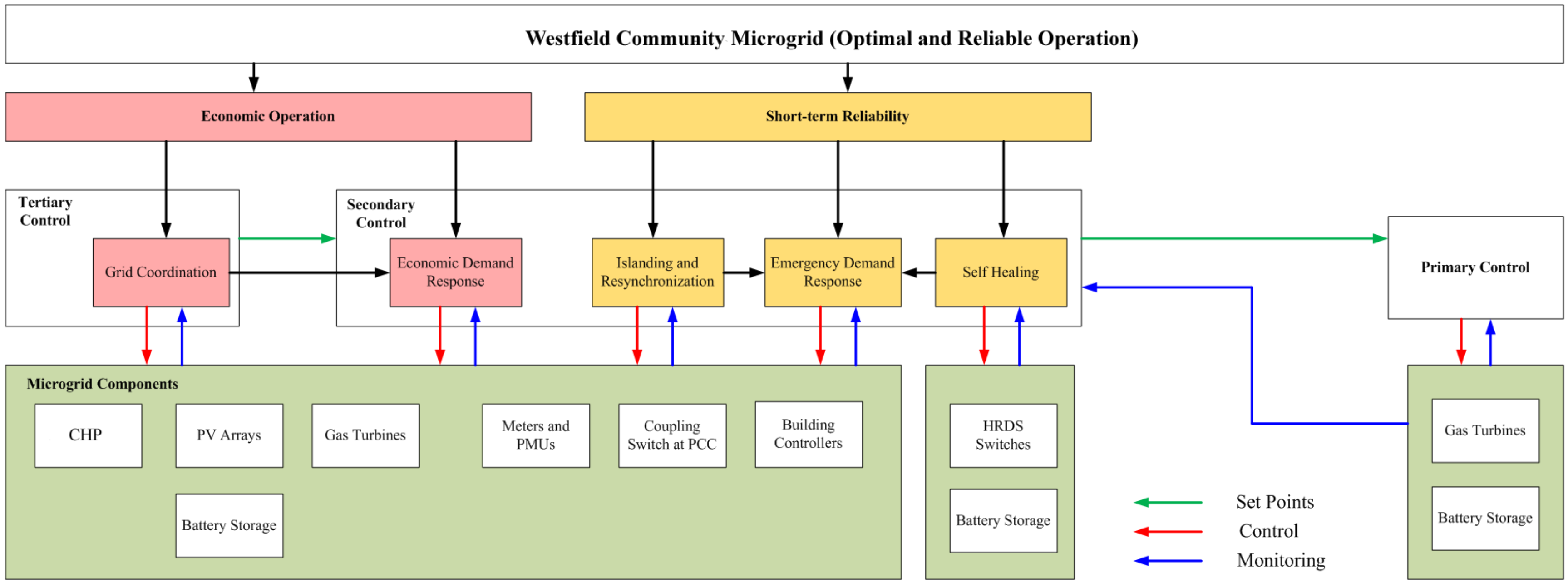


Figure 39. Objectives and Functions for the Control and Operation of the Microgrid

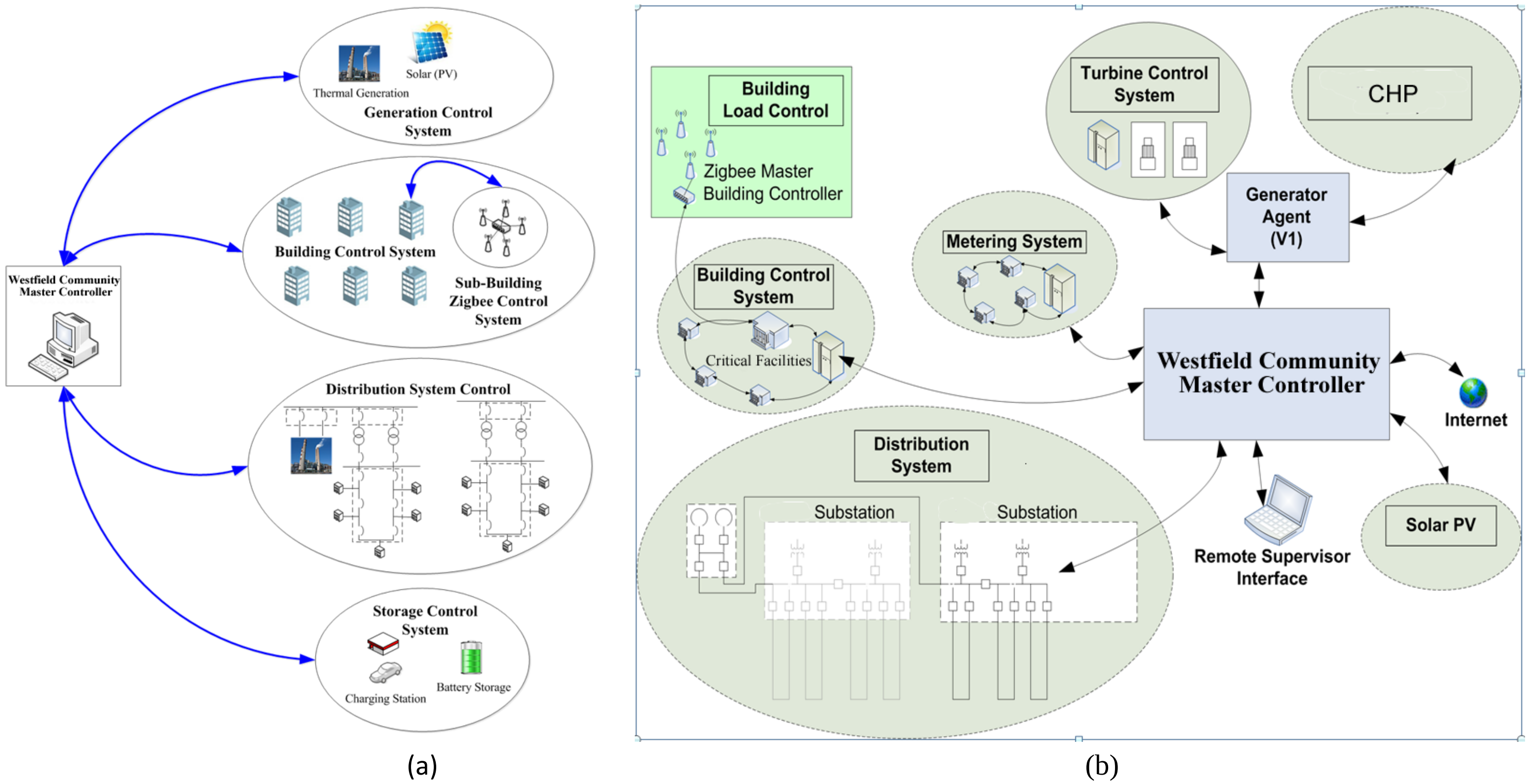


Figure 40. Architecture of Master Controller for the Microgrid

A major element of the 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 microgrid. It also coordinates the operation of on-site generation, storage, and individual building controllers, shown in figure 41. Intelligent switching and advanced coordination technologies of the master controller through communication systems facilitates rapid fault assessments and isolations.

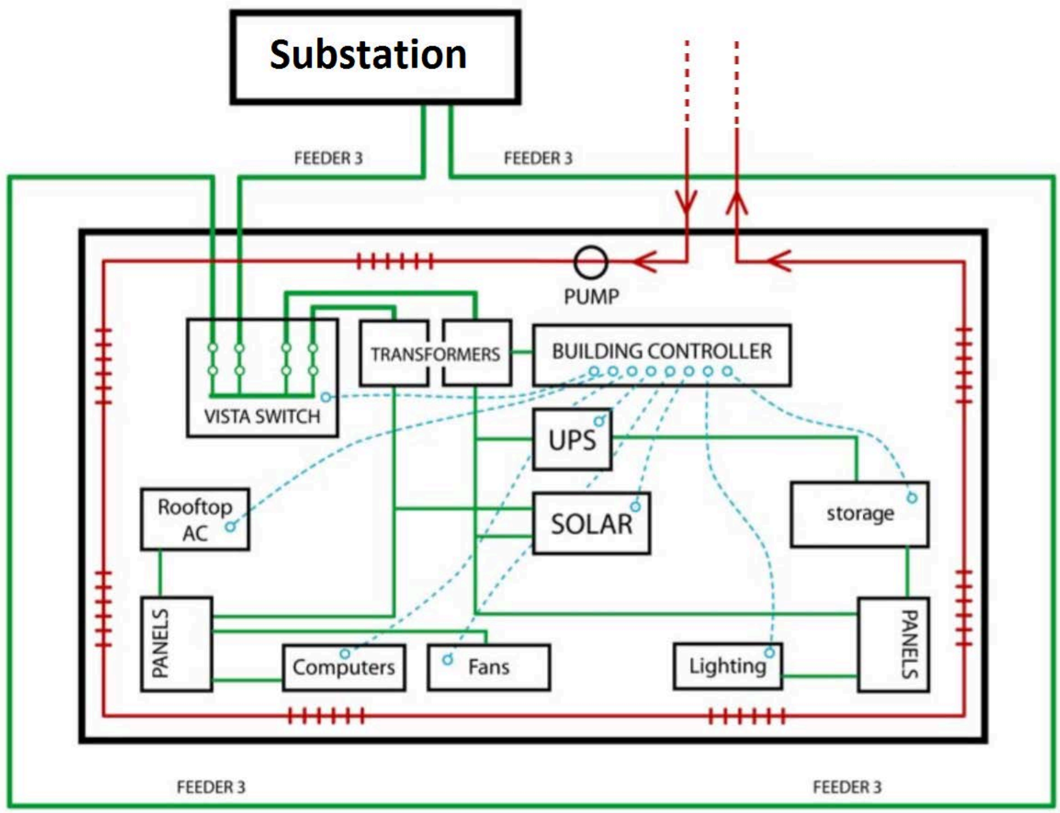


Figure 41. Conceptual Architecture of Building Controller System[1]

The hierarchical secondary control approach would receive the information from loads and power supply entities as well as the information on the status of the distribution network and procure the optimal solution via an hourly unit commitment and real-time economic dispatch for serving the load in the normal operation mode and contingencies. Figure 41 shows the hierarchical framework of the Master Controller proposed for Westfield's community microgrid project. In figure 41, the monitoring signals provided to the master controller indicate the status of DER and distribution components, while

[1] IIT Perfect Power Prototype, Final Report October 15, 2007 available at http://www.galvinpower.org/sites/default/files/documents/IIT_Perfect_Power_Prototype.pdf

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 Westfield's electric department office. With the master controller, the community microgrid would be able to provide ancillary services to the grid including voltage support, frequency regulation, and distribution system restoration. The master controller would collect the real-time data and send out set-point information through the SCADA software. Most of the time, the master controller would operate in autonomy mode based on predefined rules while keeping the reliability and economics of the whole community microgrid. In case of an emergency, the operator would utilize the master controller to isolate the community from the utility grid and operate in island mode, or this could happen automatically. Within the community microgrid, the non-critical load could be curtailed or disconnected through smart meters or Vista Switches, local distribution network sare reconfigured so that the local DERs can supply power to the critical loads.

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

6. *Increase safety and resiliency*

   The Westfield 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 Westfield 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. Reliability is further improved to a self-healing and more fault tolerant grid by reducing the number of single points of failure, by adding redundancy to the electrical and communications networks, and by adding alternate sources of generation to serve critical and non-critical loads.

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

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

Additional heat generation electricity from a centrally located CHP plant would allow Westfield 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 Westfield'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 as well as smart home appliances in with the proposed community microgrid, load shedding and load shifting will be enabled in addition to reductions in community and residential customers' maintenance costs and electricity bills.

The Westfield 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.

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

Westfield 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 Westfield's existing piping and distribution infrastructure to deliver thermal loads.

9. *Resolve existing system constraints*

The proposed community microgrid would be able to address and mitigate the existing system constraints facing the Westfield's current distribution system. Due to the peak demand during winter season, Westfield'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. The electric department would also incur additional cost liability when the Westfield community exceeds its NYPA kW and kWh allocation. With the electricity and heat produced by local CHP, the power import from the grid could be curtailed which is helpful in mitigating demand and dependency on the grid; resulting in reliability, resilience, and economic benefits.

10. *Job creation*

The operational requirement of a new CHP plant, battery storage and microgrid system in the Village of Westfield is expected to require the creation of new professional-level jobs. Current evaluations estimate that eight 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

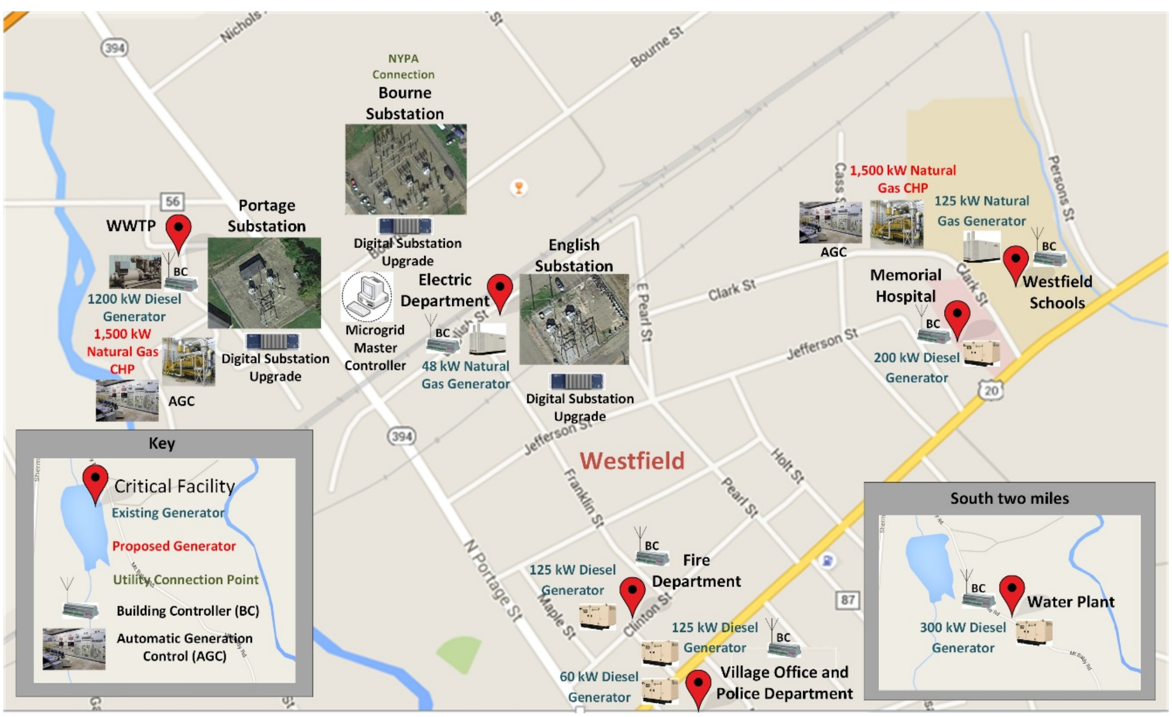


Figure 42. Network Equipment Simplified Layout Diagram

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 has been performed.

Westfield Electric Department owns and operates four substations and over 30 miles of distribution lines, serving nearly 3,200 electric customers. A large majority of those customers are individually metered; however, these meters are read manually every month by a meter reader. Westfield 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 Westfield fiber optic network. However, a few devices utilize a cellular backhaul. The equipment in Westfield 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 Westfield 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.

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.

Willdan's proposed microgrid will help improve the Westfield community grid be resilient to:

- Energy resources for disrupting events (discussed in subtask 2.3)
- Distribution Network disrupting events (discussed subtask 2.4)
- Communication Network disruptive events (discussed in this subtask)

This will help the community serve the critical loads at the time outage caused by the above events.

Communication System disrupting events

Westfield Electric Department would benefit from an Advanced Metering Infrastructure (AMI) expansion, which would involve adding wireless communication infrastructure throughout the Village of Westfield 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.

The 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 43.

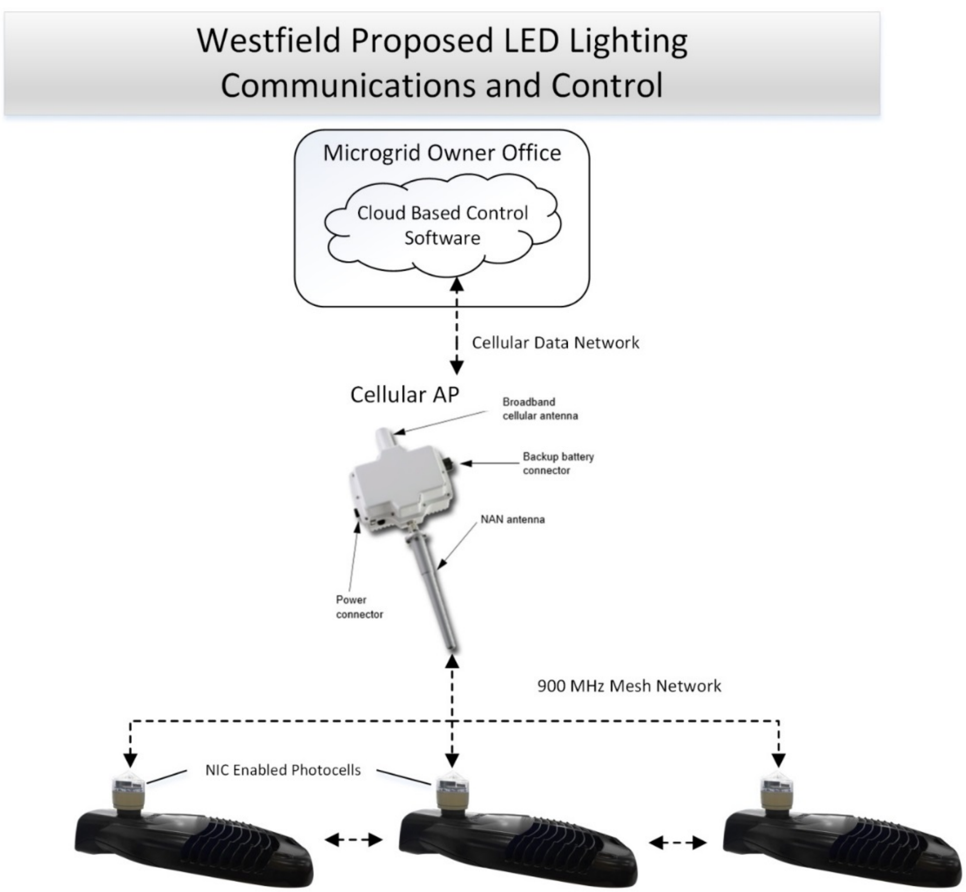


Figure 43. Westfield Proposed LED Lighting Communications and Control Diagram

In addition to meters and streetlights, circuit breakers, relays, reclosers and other switchgear are vital to the control of the 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 Westfield 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.

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.

Further communications and control equipment study, upon the provision of more detailed data about existing communication 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.

As Westfield Electric Department is the proposed owner/operator for the microgrid, the Master controller would be located in the Westfield Electric Department office data center that houses Westfield’s existing SCADA system. While the master controller would automatically communicate with the Westfield SCADA system as well as with the field devices such as the building controllers (BCs) and automatic generation controllers (AGCs), Westfield 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 microgrid would rely heavily on a robust fiber optic backbone and a 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 Westfield, approximately 5,000 residents would be without power and face a greater risk of being without police, fire, health services, water, or shelter. Westfield currently has a single point of connection with the greater transmission grid and if that fails then the entire Westfield Electric System could be off line. Critical loads include Wastewater treatment and Clean Water plants, Village offices, police and fire departments and a hospital. Every resident of Westfield would be affected in the event of a major outage. The proposed microgrid would not serve all of the customers with power, but could support the police, fire, hospital, electric utility, water, and potential emergency shelter locations with heat and power as needed.

Microgrid generation may potentially participate in other NYISO Ancillary Services Markets, however the extent to which resources can take advantage of these potential revenue streams is not clear as NYPA does not currently have tariffs in place. For example, NYPA lacks a tariff for regulation service. To participate in the regulation market, Westfield 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 $91,600 to $128,200 (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 hospital is the only critical facility served by the microgrid that is not owned by the Village, meaning it will be the only customer purchasing additional services from the microgrid in outage situations.

[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.

Three major grape juice processors are located within the Village of Westfield and represent a significant load. These customers could see greater reliability and better power quality with the installation of a microgrid, depending on where the microgrid operators decide to install generation resources and how they plan to dispatch them. Importantly, the grid operators will be given the tools they need to make improvements or provide premium service to customers. The microgrid will also cut the peak load of the Westfield system, especially during winter months where Westfield Electric Department greatly exceeds its NYPA allocation and is forced to charged customers higher per kWh charges. This generation benefit reduces the energy the utility needs to purchase from NYPA, reducing the overage charge, which was over $1,000,000 in 2014, and reducing or removing the charge passed on to the customers. For example, if the utility normally charges 4 cents/kWh, during over allocation periods, they may have to charge the customer 11 cents/kWh to cover the utility's additional cost of 6 c/kWh charged by NYPA.

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

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

Only one additional facility contract may be necessary and that is with Westfield Memorial Hospital. The hospital is the only critical facility not owned by the Village, but it is an excellent location for combined heat and power. The Westfield Electric Department would likely own and operate the system; necessitating some arrangement for use of space at the Hospital facility.

The Westfield Electric Department will continue to serve all of its normal customers in blue sky mode, and will control which critical facilities receive power in island mode.

No additional commodities are expected to be provided to customers outside of the critical facilities at this time. Critical facilities will have to work out agreements with the microgrid owner if they are expecting to be provided heat from installed CHP.

Sub Task 3.2 Commercial Viability - Value Proposition

The microgrid owner, expected to be Westfield Electric Department, would be faced with the initial investment costs of upgrading their electrical infrastructure to a High Reliability Distribution System (HRDS) including Automatic Transfer Switches (ATS), Upgraded Circuit Breakers and Relays, improved communication infrastructure including, fiber optic and wireless RF, as well as the cost to build CHP plants and to train CHP plant operators or maintenance supervisors and network and controls engineers to configure and manage the newly upgraded system. Overall the utility cost would be lowered by the benefits from upgrading and improving the system from a reduction in the cost of electricity, maintenance costs, and the NYPA over allocation charges. These improvements could also help the utility avoid upgrade and capacity improvement costs.

The project will be structured to ensure that any financial obligations are met and the Village of Westfield receives its regulated rate of return (ROR) through incorporation of microgrid assets into its ratebase. The Westfield 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 23 presents the SWOT analysis.

Table 23. 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	Individual Component or System Failure (potentially catastrophic)	Reduce environmental impacts
	Smart	Complicated	Potentially steep price reductions over near-term (6 months) of emerging technology could lead Westfield to miss opportunities or to be stuck overpaying	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 23. 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 Westfield 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 as the utility sells less power	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 Westfield 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.

Table 24. Stakeholder Value Proposition

Stakeholder	Value Proposition
Electricity Purchaser	The community microgrid will ensure a constant reliable source of heat and electricity to the communities critical facilities, ensuring that emergency shelters and police and fire stations remain fully operational in the event of an emergency while, at the same time, lowering the overall cost of electricity purchases by passing along savings from new sources of revenue and cost savings gained by the electric utility
Critical Facilities	In the event of an emergency the critical facilities would see uninterrupted flow of heat and electricity and maintenance of the full extent of the facility's operation. During normal operation, the financial benefits to the critical facilities would increase the money available for other community improvements while lowering costs for the critical facilities
Utility	The Utility would have deferred upgrades due to the installation of the microgrid assets by the microgrid owner as well as additional capacity due to the microgrid load being served by DER. In addition, there would be some maintenance cost reduction due the microgrid owner being responsible for a small portion of their service area
Suppliers and Partners	The microgrid owner would purchase more Natural Gas from their NG Supplier that they would use for CHP for Heat and Power, reduce the strain on NYPA caused by exceeding its allocation, provide safety and reliability to the residents of Westfield, and build a stronger and more resilient community in New York
NY State	NYISO could benefit from having another Demand Response participant that it could call on in times of need with grid balancing, and finally the state of New York would prosper as a technically advanced and resilient community grows and develops under its guidance

Westfield is a small NY Community, like many other NY Communities. Also, Westfield is approximately average, when compared to other municipal electric departments, in terms of the number of its customers and quantity and value of its assets. 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 Westfield system and the system is of a finite size. However, aggregation of multiple microgrids generation resources across the state for demand response/economic purposes could be an option for scalability.

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, thermal, and communication 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 used in winter seasons could cause damages or outages on the over-head system in the Village of Westfield. 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. It would also 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 of hours to a few weeks. Natural gas disruptions are less likely than electricity disruptions, however, it is relatively more difficult to recover from these outages than electric outages because of the difficulty to locate and repair the underground leaks. The extreme weather would affect both individual equipment failure and system operations. The damage from such events can impose large costs on the distribution system as well as severe impact on the local economy.

Many of Westfield'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 distribution system.

The fact that Westfield has a single point of entry to the macrogrid makes this area unique in terms of NY State Communities. However, many small municipal electric utilities have this same issue. If the larger grid outside Westfield loses power, all 5,000 residents lose power. This is a distinct possibility, particularly in the dead of winter when Westfield experiences extreme snow events for days at a time. This is further exacerbated by the potential for overhead lines to be damaged by winter storms or heavy snow and ice. The microgrid, using underground gas lines for on-site CHP and ideally using underground electric distribution lines, is expected to be resilient to most typical extreme weather events in the area.

Steam produced by the CHP plants installed throughout the microgrid will be transported and sold to critical facilities and potentially to surrounding commercial or residential customers by way of newly installed thermal transport infrastructure.

Based on the owner/operators chosen business model, the power purchasers, commercial, residential, and Industrial customers, will have the unique opportunity to participate in a potential real-time pricing program, encouraging electricity use off of peak hours and savings for willing participants.

[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

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

Financially feasible, commercially viable, and more established or mature technology services or components were primarily considered to allow more financing opportunities for the overall project investments and to mitigate risk of emerging or early stage technologies being incorporated into the community microgrid. With the exception of natural gas-fired CHP technology, each major component proposed, including smart switches, AMI, wireless smart grid infrastructure, and the master controller, is a new (i.e., emerging or young) technology.

Sub Task 3.3 Commercial Viability - Project Team

The Village of Westfield and the Westfield Electric Department are championing this project. The Village has drawn the support of organizations within the state. 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 Westfield Electric Department is the owner, operator and applicant on this project. Westfield Electric owns and operates the electrical distribution system to serve approximately 5,000 customers including two substations and both 34.5kV and 4.8kV distribution lines. For decades, Westfield Electric has successfully expanded and operated the electric distribution system as well as backup generators and is prepared to add the combined heat and power plants and upgrade to intelligent distribution. 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 Westfield 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 Westfield is a rating of A2 from Moody's in June of 2010 with a Stable Outlook.[1]

Willdan Energy Solutions is a nationwide engineering consulting firm that serves investor and municipal owned utilities, private sector and government clients through its regional and local offices and has so for over 50 years. Willdan's service offerings span a broad set of complementary disciplines that include energy efficiency and sustainability, engineering and planning, financial and economic consulting, and national preparedness. To date, Willdan has served more than 125,000 customers with 75,000+ projects. Willdan provides expert analysis of energy baseline and consumption, installs energy efficiency

[1] The Village of Westfield's issuance of $1.355M of Serial Bonds was rated -Aaa by Moody's according to the 2003 Official Statement.

conservation measures identified through an Investment Grade Audit, performs complete measurement and verification analysis for installed measures used to verify Guaranteed Savings, and provides project management by highly experienced and credentialed technical staff to handle project from conceptual design all the way through full project implementation. Willdan has established partnerships with academic institutions such as the Illinois Institute of Technology (IIT) and thought leaders nationwide developing and demonstrating microgrid technologies, including eight community microgrid feasibility studies through NY Prize.

There has been interest from numerous financiers and investors, though none have been chosen to this point. There is the potential for the municipal utility to own the microgrid and for it to bond the project and use ratebase recovery to pay back the bonds. The major issues with this include the threat of regulatory ratebase recovery disallowance, i.e. proving the benefits to the customers, as well as cost competition from low-cost Niagara hydro allocations. Willdan and Westfield are collaborating to determine the best path forward for the Electric Department and expect to choose a financing plan or partner for this project within the next year. For the 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 Westfield 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 Westfield 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 Westfield 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. The following sections describe in detail the main technologies chosen, Combined Heat and Power (CHP), building controllers for load control, high reliability distribution for reliability, and a wireless mesh IT infrastructure supporting a Master Controller for system optimization. While all of these technologies have been market tested for some time, connecting and optimizing them with the addition of a master controller and allowing the grid to be separated from the surrounding grid is a novel idea that can provide major benefits in terms of economics, reliability, and resilience.

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 Westfield 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 Westfield with greater resiliency to natural and macro-grid events.

Challenges

Additional modeling has been 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. Combined Heat and Power plants allow for extremely efficient heat and power output with relatively clean and resilient natural gas pipelines as inputs. This means that the community will see maximum benefits while spending relatively little to maintain and operate these generators and will be able to utilize the units year round for power and for domestic hot water, while providing space heat in the winter. 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 CHP Plants.

As Natural Gas fed CHP is the most feasible option for the Westfield 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 Westfield to prevent any small issues from leading to major problems if there is an interruption in natural gas supply. However, since Westfield currently owns and operates the gas distribution system with a high grade of reliability, there is not expected to be any additional burden with regard to gas system maintenance.

The Westfield community microgrid master controller would determine the optimal and reliable operation of the microgrid through optimal generation dispatch and load schedule signals. This dispatch is what balances generation and load. 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 grid-connected mode; DERs apply this control scheme to regulate the power exchange between the microgrid and the utility grid. In 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. Westfield Electric Department already operates the distribution grid and has assured the project team of their capability to operate the microgrid. The proposed generation will be located at Village-owned buildings, on Westfield’s existing network, with the master controller at the Westfield Electric Department headquarters where the system is already operated, ensuring smooth operation of the microgrid.

Willdan recommends a phased design approach, seen below, as well the operations recommendations.

Phased Design Approach

1. Generation Assets: Natural Gas Fed Combined Heat and Power Generators
2. Load Control and Energy Conservation Measures: Smart Building and Sub-Building Controllers and Energy Management System
3. Wiring Reconfiguration: Maximize Existing Electrical Infrastructure and Improve Resilience
4. Communication Connectivity: Fiber Optic Backbone, Wireless Mesh Network Deployment
5. Microgrid Master Controller: Connect and Optimize Every Device in the System, Operator Friendly Interface

Operations and Maintenance

1. Utilize equipment vendor warranties
2. Setup automatic notifications, remote monitoring, automated reporting
3. Train Maintenance Personnel

Additional permitting for on-site generation and emissions may be required, though a more detailed analysis of the specific type and cost will have to be performed during the next phase of this project.

The Village of Westfield 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 Westfield Community Microgrid project, barriers to entry are significant due to regional power market characteristics and the availability of low cost hydropower. The Village of Westfield's retail power rates appear in table 27. These prices 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 projects meet 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, determined during the design phase, 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 Westfield Electric's customers, Demand Response related revenues, 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 Westfield (Westfield) exceeds its monthly allocation of hydropower, and potentially displace energy purchases during NYISO peak summer months. General estimates of these costs follow. Should the Westfield 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 Westfield Community Microgrid could potentially participate in the NYISO market through NYPA, a Market Participant. Such participation would therefore be compensated under NYPA's tariffs. Currently, NYPA offers demand response rates for Government Customers under three options: Option 1 is for energy reductions, Option 2 is for peak reduction within NY City, and Option 3 is for capacity (fixed) and energy (variable).[1]

Table 25 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 25. 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://icap.nyiso.com/ucap/public.
[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 Westfield currently receives approximately $104,000 in electric revenues from sales to other public authorities.[3] The Westfield 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 Westfield receives allocations of low-cost hydroelectric power from NYPA. The Village of Westfield is a full requirements customer and winter heating loads cause it to exceed its monthly allocation from November to April. Table 26 illustrates monthly peak demands versus Niagara allocations for 2013-2015. As can be seen from these data, 3.25 MW of generation and storage should eliminate these overages. The cost of such excesses can be significant. In 2014, for example, such overages cost the Village of Westfield nearly $1M.

Table 26. Village of Westfield Actual Peak Demands vs. NYPA Allocations by Month (2013-2015)

	NYPA Allocation [4] (kW)	Actual Peak Monthly Demand (kW)[5]				Excess/ (Margin) (kW)
		2013	2014	2015	Average	
January	12,510	11,185	18,441	16,720	15,449	**2,939**
February	12,510	11,725	17,489	17,921	15,712	**3,202**
March	12,510	11,367	16,868	15,309	14,515	**2,005**
April	12,510	12,785	12,353	12,434	12,524	**14**
May	12,510	13,223	10,733	10,004	11,320	(1,190)
June	12,510	16,592	10,604	11,023	12,740	**230**
July	12,510	14,972	11,900	10,557	12,476	(34)
August	12,510	13,939	10,800	9,761	11,500	(1,010)
September	12,510	12,629	10,665	10,827	11,374	(1,136)
October	12,510	9,578	12,933	11,954	11,488	(1,022)
November	12,510	10,679	13,622	15,579	13,293	**783**
December	12,510	11,684	15,775	14,391	13,950	**1,440**

[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 Westfield for the Year Ended May 31, 2015 to the State of New York Public Service Commission, page 300. http://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId=%7B4FC65D78-24C3-4839-8046-F172F648E6DE%7D
[4] Preference power sales are limited to 74,508,109 kWh. Source: *Niagara Power Project Power Allocations, Rates, And Opportunities, Prepared for: New York Power Authority,* The Brattle Group, August 2005, Table A-1. Copyright © 2005 New York Power Authority.
[5] Source: Municipal Electric Utilities Annual Report of the Village of Westfield for the Years Ended May 31, 2013-2015 to the State of New York Public Service Commission, page 400.

In addition to peak shaving, the Village of Westfield would earn retail sales revenues when system power purchases are displaced by behind-the-meter generation or injections from storage. Table 27 illustrates its current rates by customer class. Production modeling would be required to determine the load that would be replaced and resultant retail revenues received. Depending on capacity and configuration, the Village of Westfield may enter into bilateral Power Purchase Agreements (PPA) for portions of the generation output, so long as such contracts do not conflict with other obligations. The potential revenues realized from such PPAs cannot be quantified at this time and may include both fixed and variable components.

Table 27. Village of Westfield Electric Rates by Customer Class

Village of Westfield Current Rates by Customer Class (excludes Purchase Power Adjustment)	
Service Classification – Residential	
Customer Service Charge ($/Month)	3.00000
Energy Charge ($ per kWh)	0.03700
Service Classification – Small Commercial (Under 3,500 kWH/Month)	
Customer Service Charge ($/Month)	2.50000
Energy Charge ($ per kWh)	0.03617
Service Classification – Large Commercial (Over 3,500 kWH/Month)	
Energy Charge ($ per kWh)	0.02952
Peak Demand Charge ($/kW-Month)	3.75000
Over 20 kW ($ per kW-Month)	5.61
Service Classification – Industrial (Over 75 kW demand) Distribution Demand and Energy Charges apply	
Energy Charge ($ per kWh)	0.02039
Peak Demand Charge ($/kW-Month)	4.00000
Service Classification – Outdoor Lighting (Security Lighting) Mercury Vapor Lights	
175W Luminaire ($ per month per light)	6.12000
400W Luminaire ($ per month per light)	10.55000
400W Flood ($ per month per light)	11.33000

Additional Infrastructure

Certain components of the microgrid will require upgrades to existing, and installation of new, infrastructure (e.g., distribution system, natural gas pipelines, storage). The timing of these resources will impact the microgrid, in particular potential permitting requirements. For example, the microgrid requires deployment of Advanced Metering Infrastructure (AMI). Natural gas infrastructure would likely require upgrades and installation of new assets.

Funding

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

Project Guarantees/Financing Backstops

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

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

Depending on the ultimate configuration of the microgrid, additional capital and operating costs may exist, though primary components are outlined 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 Westfield Electric Department receives its regulated rate of return (ROR) through incorporation of microgrid assets into its ratebase. The Village of Westfield's ratebase was $4.6 M as of May 31, 2015 and its ROR was 4.00%.[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 Westfield 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 Westfield will be the owner of the Westfield Community Microgrid and the applicant. The Village of Westfield is the municipal utility for the Village of Westfield.

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 Westfield to ensure compliance with such requirements, though since The Village of Westfield is the existing power provider with an existing privacy protocol, continuing the protocol is expected to be straightforward.

The amount of generation on Westfield's system allowed by NYPA may be a hurdle to this project, although recent discussions with NYPA indicate their full support of the current 3 MW microgrid proposal.

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

Task 4 – Develop Information for Cost Benefit Analysis

Sub Task 4.1 Facility and Customer Description

Table 28. Facility and Customer Detail

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
Westfield Electric Department	Small Commercial/Industrial (<50 annual MWh)	Municipal Services	All Other Industries	NA	NA	*60%*	*12 hours*
Wastewater Treatment Plant	Small Commercial/Industrial (<50 annual MWh)	Municipal services	All Other Industries	3,192,000	744	*60%*	*12 hours*
Water Treatment Plant	Small Commercial/Industrial (<50 annual MWh)	Municipal services	*All other industries*	478,000	476	*60%*	*12 hours*
Village Office	*Small Commercial/Industrial (<50 annual MWh)*	*Government Building*	*All other industries*	184,080	52	*60%*	*12 hours*
Police Department	Small Commercial/Industrial (<50 annual MWh)	Municipal services	*All other industries*	162,000	72	*60%*	*12 hours*
Fire Department	Small Commercial/Industrial (<50 annual MWh)	Emergency	*All other industries*			*60%*	*12 hours*
Memorial Hospital	Small Commercial/Industrial (<50 annual MWh)	Healthcare	*All other industries*	1,090,400	216	*60%*	*12 hours*
Westfield Central School	*Small Commercial/Industrial (<50 annual MWh)*	*School*	*All other industries*	1,547,200	376	*60%*	*12 hours*
Total				**6,653,680**	**1,936**	**60%**	

The list and description of these facilities is provided in Section A, table 1, above, of the Microgrid Questionnaire. Seven of the eight potential microgrid facilities are owned and operated by local municipalities, though the third largest, Memorial Hospital, is not. The largest energy users on the Westfield system also happen to be those facilities that provide emergency services, such as the Hospital, the High School, and the Village Offices.

Due to the low cost of power in the Village of Westfield, the proposed microgrid designs are not intended to cover more than the load of the critical facilities. This is because Westfield is not incentivized to generate its own power most of the year. Of the 12 months in a year, Westfield is able to stay below its NYPA allocation for 7-8 months, meaning that during those months, every unit of energy purchased will be at the NYPA rate, about $0.035 per kWh. This constraint makes it very difficult for any investments in energy generation to pay themselves off.

However, to increase resiliency for the Village, which is dependent on a single transmission line into a single substation, and reduce peak purchases in the 4-5 months Westfield exceeds its allocation, the microgrid designed herein is meant to be flexible and to maximize economic benefit in all conditions.

Sub Task 4.2 Characterization of Distributed Energy Resources

Table 29. Distributed Energy Resources

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	*Wastewater Treatment Plant*	Natural Gas CHP	1,500 kW	13,000 MWh	250kW x 12 hr = 3,000 kWh	1500/0.6 *3.412 = 8,530	Mbtu/hr
New Generator	Memorial Hospital and Westfield Central School	Natural Gas CHP	1,500 kW	13,000 MWh	250kw x 12hr = 3000 kWh	1500/0.6 *3.412 = 8,530	Mbtu/hr
Storage	Westfield Central School	Battery	250 kW	45 MWh	250 kWh		

Section A, Question 2, above, 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 3 MW of Natural Gas CHP split between the High School (1.5 MW), and Wastewater Plant (1.5 MW), along with a 250 kW battery storage system at the High School. The battery storage system would be located at the school and hospital's CHP plant and would be implemented instead of diesel backup generators for black start generation as it allows immediate response and doesn't have the same 15-30 minute start up time as a diesel backup, this would allow the CHP plant to operate more quickly in a black start situation. In addition, the battery could be used for carryover of absolutely critical hospital facilities if a power outage occurs when the CHP is not running.

As previously stated, the microgrid is not designed to support the entire Westfield system; to do so would not be economical. The microgrid proposed in this document is small enough to minimize financial burden on Westfield, while maximizing the benefits to the Village in blue-sky and major outage conditions. The 3+ MW of generation on the microgrid is enough to support the Hospital, emergency services (fire and police), water systems, and to provide a shelter for every resident of the Village if needed. In major outages, the natural gas supply from National Fuel is expected to be operational, allowing the CHP systems to run continuously, providing heat and power to the critical facilities. In blue-sky conditions, the CHP systems can operate as dispatchable load for the Electric Department, a particularly useful resource in the winter peak months. The battery system located near the High School will be able to provide additional revenue to the Village in the form of ancillary services, and also sets the stage for future solar development at the High School.

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, Westfield 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. Westfield is also open to enroll assets in demand response in the event that doing so makes economic sense. To this point, Westfield currently has two assets enrolled in demand response: a large generator at the wastewater plant and a small generator at the Village Office. In addition to enrolling existing generators in peak support or demand response, any new generator will be examined for participation as well.

The operational schemes for the CHP systems at the High School and wastewater plant are intended to be flexible to the needs of the Westfield Electric Departments. In the summer, Westfield typically stays below the NYPA allocation, and is therefore not incentivized to generate any of its own power. However, there is a possibility of forming an agreement with the grape juice processors in the Village that could potentially use the heat from the CHP system year round. A public-private partnership such as this would have a large economic benefit to the Village and could save cost for the grape juice plant managers. The grape juice plant is located nearby the fire department, village office, and police department, In the winter, the heat could be used to offset the aging electric heat infrastructure at the critical facilities located nearby, such as the hospital and Westfield schools. This could drastically reduce the winter peak load on the Westfield system, which benefits the aging distribution infrastructure and reduces cost for the Electric Department and its ratepayers.

Sub Task 4.4 Project Costs

Table 30. Project Costs

Capital Component	Installed Cost ($)	Component Lifespan (round to nearest year)	Description of Component
3000 kW CHP	$9,000,000	25	CHP at wastewater plant and hospital
250 kW Battery	$1,000,000	10	Li-ion battery storage
Infrastructure (controls, IT, communication)	$2,000,000	30+	Controller, IT, Communication upgrade

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

Each 1.5 MW CHP system is expected to cost around $4.5 million, with estimates provided by experienced firms ranging from $2,750 -$3,250 per installed kW. These installations will be located at the wastewater plant and the high school, and are expected to last 25 years. At $4,000 per kW, the 250 kW battery is expected to cost $1 million. The lifespan of the battery is dependent on the usage, though typical expectations are for a 10-year lifespan.

Other costs to construct the system include planning and design costs, and the cost of the master control system. The master control system for a microgrid this size is estimated to be around $2 million with a lifespan much greater than the rest of the physical infrastructure, as the master controller is software based and can be updated as new versions come out, as changes happen in market conditions, or as upgrades occur across the microgrid. Planning and design costs are estimated at around 10-15% of the total microgrid cost, coming in around $1.5 million.

Sub Task 4.5 Costs to Maintain Service during a Power Outage

Table 31. Service Maintenance Costs during a Power Outage

Facility Name	Generator ID	Energy Source	Nameplate Capacity (MW)	Standard Operating Capacity (%)	Production During Power Outage (kWh/Day) (6	Fuel Consumption per Day		One-Time Operating Costs ($)	Ongoing Operating Costs ($/Day)
						Quantity	Unit		
Electric Department	Unit 1	Natural gas	48 kW	60	346	3.5	MCF	$300	$100
Wasterwater treatment plant	*Unit 2*	Diesel	*1200 kW*	*60*	*8,650*	*605*	*Gl*	$300	$100
Water Treatment Plant	*Unit 3*	Diesel	300 kW	60	2,160	151	Gl	$300	$100
Village Office	Unit 4	Diesel	60 kW	60	432	30	Gl	$300	$100
Police & Fire Department	Unit 5	Diesel	125 kW	60	900	63	Gl	$300	$100
Memorial Hospital	Unit 6	Diesel	200 kW	60	1,440	101	Gl	$300	$100
Westfield Central School	Unit 7	Natural Gas	125 kW	60	900	9.1	MCF	$300	$100

The first six bullets are answered in Section I, table 1, above, 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 majority of the backup generators on the Westfield system are old diesel generators. The Electric Department, as well as some of the building managers of the critical facilities have expressed an interest in doing away with the diesel generators altogether. The development of 3MW of CHP to support the critical facilities would more than make up for the 1.8 MW of diesel generators located across the critical facilities currently. This decision has the potential to lower costs for each facility that currently owns a diesel generator by negating the necessary diesel purchases and eliminating the costly and time-consuming testing required to maintain such generators.

In the event of a major outage, with no microgrid each individual facility would turn on their diesel generators and run for as long as they can on the fuel supply. Interestingly, most facilities still have electric heat, so in the winter a majority of the generators power would go to running electric heaters. With a microgrid, the CHP systems would solve both issues by providing a clean power source that also provides heat to the local facilities.

Sub Task 4.6 Services Supported by the Microgrid

Table 32. Services Supported by the Microgrid

Facility Name	Percent Loss in Services When Using Backup Generator	Percent Loss in Services When Backup Generator is Not Available
Electric Department	50%	100%
Wastewater treatment plant	50%	100%
Water treatment plant	50%	100%
Village Office	0%	100%
Police and Fire Department	0%	100%
Memorial Hospital	50%	100%
Westfield Central School	50%	100%

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 Westfield (a municipal utility) goes down, all residents will lose power. This has not happened in recent memory, although Westfield is a village with many low-income residents and a large percentage of homes heated with electric heaters. Outages, particularly in the winter, pose a serious hazard to the residents in Westfield.

- **Fire Services**, serves 5,000, 50% average increase in response time during power outage
- **EMS**, serves 5,000, 25% average increase in response time during power outage
- **Hospital**, Serves 10,000, 17.7 miles to nearest alternative hospital
- **Police**, serves 10,000, 50% average reduction in service effectiveness during outage
- **Wastewater and Water Services**, serves 7,500

Since all 5,000 residents of Westfield are currently supported by one substation fed by one transmission line, a major outage would affect every single resident. Also, since Westfield is a small community, most services are not duplicated as they are in a larger city. If the transmission line into Westfield should be affected, the outage could last days, which would put the Village in a very difficult position. The microgrid is designed to allow the generation resources to provide all of the critical services without fail, even in the event of a major outage.

Benefit-Cost Analysis Summary Report - Village of Westfield

Project Overview

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

The offices of the Westfield Electric Department;

- The village's Wastewater Treatment Plant, which processes both domestic sewage and wastewater from commercial and industrial sources, including substantial flows from the area's grape processing plants;
- The village's Water Treatment Plant, which supplies drinking water to residents of both the Village and Town of Westfield;
- The Village Office and the Westfield Police Department, both of which are located in the village's primary municipal building, Eason Hall;
- The Westfield Fire Department;
- Westfield Memorial Hospital; and
- Westfield Academy and Central School, the local public elementary and junior/senior high school, which is designated as a community shelter in the event of an emergency.

The microgrid would be powered by two new 1.5 MW natural gas combined heat and power (CHP) units. One of these units would be located at the wastewater treatment plant; the other would serve both the hospital and the neighboring school. In addition, the microgrid would incorporate a 250 kW battery storage system.[1] The operating scenario submitted by the project's consultants indicates that the CHP systems together would produce approximately 26,000 MWh of electricity per year, roughly 3.8 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.[2] They also indicate that the system would be capable of providing reactive power support to the grid.

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

---

[1] In addition to these resources, the microgrid may incorporate one or more of the emergency generators that currently serve the facilities listed above. These units, however, would only be relied upon in extreme circumstances, would not operate on a regular basis, and are not considered integral to the design of Westfield's microgrid.

[2] As noted previously, the capacity of the generators appears sufficient to supply 100 percent of average daily electricity use at facilities within the microgrid's island.

Methodology and Assumptions

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

- *Costs* represent the value of resources consumed (or benefits forgone) in the production of a good or service.
- *Benefits* are impacts that have value to a firm, a household, or society in general.
- *Net benefits* are the difference between a project's benefits and costs.

Both costs and benefits must be measured relative to a common baseline - for a microgrid, the "without project" scenario - that describes the conditions that would prevail absent a project's development. The BCA considers only those costs and benefits that are incremental to the baseline.

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

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

With respect to public expenditures, the model's purpose is to ensure that decisions to invest resources in a particular project are cost-effective; i.e., that the benefits of the investment to society will exceed its costs. Accordingly, the model examines impacts from the perspective of society as a whole and does not identify the distribution of costs and benefits among individual stakeholders (e.g., customers,

[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.]

utilities). When facing a choice among investments in multiple projects, the "societal cost test" guides the decision toward the investment that produces the greatest net benefit.

The BCA considers costs and benefits for two scenarios:

Scenario 1: No major power outages over the assumed 20-year operating period (i.e., normal operating conditions only).

Scenario 2: The average annual duration of major power outages required for project benefits to equal costs, if benefits do not exceed costs under Scenario 1.[1]

Results

Table 33 summarizes the estimated net benefits, benefit-cost ratios, and internal rates of return for the scenarios described above. The results indicate that if there were no major power outages over the 20-year period analyzed (Scenario 1); the project's costs would exceed its benefits. In order for the project's benefits to outweigh its costs, the average duration of major outages would need to equal or exceed 0.8 days per year (Scenario 2). The discussion that follows provides additional detail on these findings.

Table 33. BCA Results (Assuming 7 Percent Discount Rate)

Economic Measure	Assumed Average Duration of Major Power Outages	
	Scenario 1: 0 Days/Year	Scenario 2: 0.8 Days/Year
Net Benefits - Present Value	-$6,810,000	$125,000
Benefit-Cost Ratio	0.8	1.0
Internal Rate of Return	-0.7%	6.0%

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

Scenario 1

Figure 44 and table 34 present the detailed results of the Scenario 1 analysis.

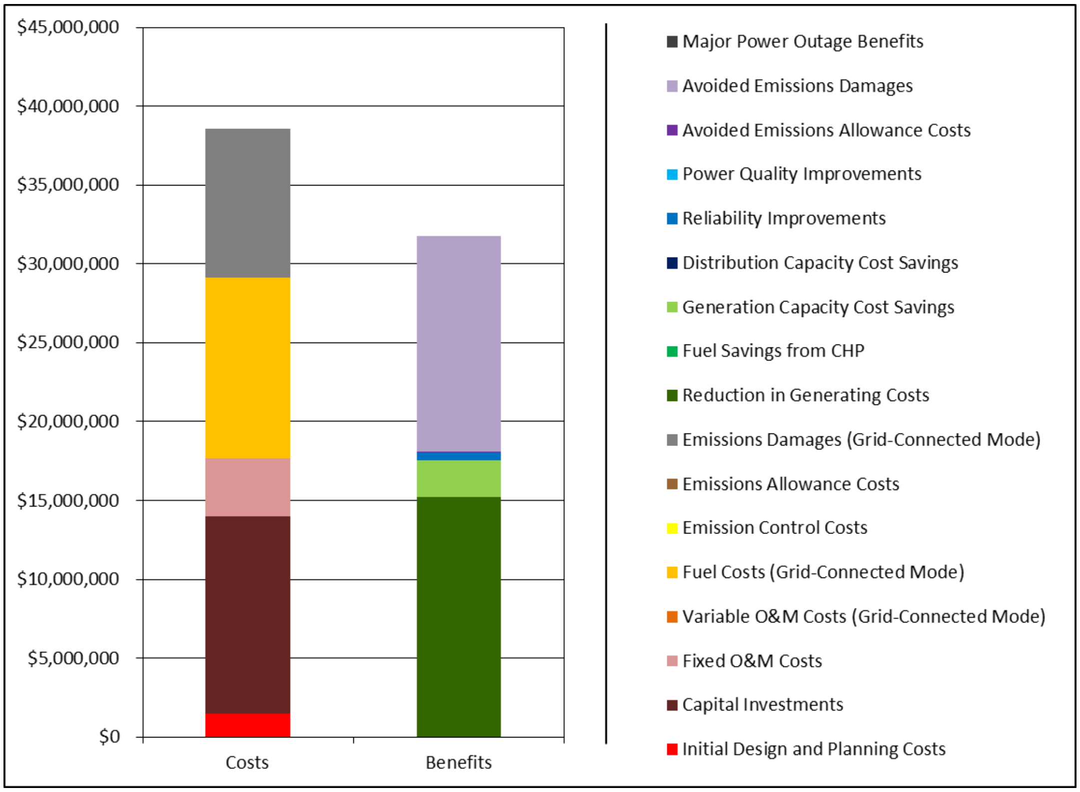


Figure 44. Present Value Results, Scenario 1 (No Major Power Outages; 7 Percent Discount Rate)

Table 34. 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	$1,500,000	$132,000
Capital Investments	$12,500,000	$1,010,000
Fixed O&M	$3,680,000	$325,000
Variable O&M (Grid-Connected Mode)	$0	$0
Fuel (Grid-Connected Mode)	$11,500,000	$1,010,000
Emission Control	$0	$0
Emissions Allowances	$0	$0
Emissions Damages (Grid-Connected Mode)	$9,450,000	$616,000
Total Costs	**$38,600,000**	
Benefits		
Reduction in Generating Costs	$15,200,000	$1,340,000
Fuel Savings from CHP	$0	$0
Generation Capacity Cost Savings	$2,380,000	$210,000
Distribution Capacity Cost Savings	$0	$0
Reliability Improvements	$496,000	$43,800
Power Quality Improvements	$0	$0
Avoided Emissions Allowance Costs	$9,230	$814
Avoided Emissions Damages	$13,700,000	$895,000
Major Power Outage Benefits	$0	$0
Total Benefits	**$31,800,000**	
Net Benefits	**-$6,810,000**	
Benefit/Cost Ratio	**0.8**	
Internal Rate of Return	**-0.7%**	

Fixed Costs

The BCA relies on information provided by the project team to estimate the fixed costs of developing the microgrid. The project team's best estimate of initial design and planning costs is approximately $1.5 million. The present value of the project's capital costs is estimated at approximately $12.5 million, including costs associated with installing the two new CHP units, the battery storage system, and associated microgrid infrastructure (controls, communication systems, information technology, etc.). 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 $3.7 million, based on an annual cost of $325,000.

Variable Costs

A significant variable cost associated with the proposed project is the cost of natural gas to fuel operation of the system's two CHP units. 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 $11.5 million.[2]

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 $616,000 annually. The majority of these damages are attributable to the emission of CO_2. Over a 20-year operating period, the present value of emissions damages is estimated at approximately $9.4 million.

Avoided Costs

The development and operation of a microgrid may avoid or reduce a number of costs that otherwise would be incurred. These include generating cost savings resulting from a reduction in demand for electricity from bulk energy suppliers. The BCA estimates the present value of these savings over a 20-year operating period to be approximately $15.2 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] These reductions 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 $9,000 and avoided emissions damages with a present value of approximately $13.7 million.[4]

In addition to the savings noted above, development of a microgrid could yield cost savings by avoiding or deferring the need to invest in expansion of the conventional grid's energy generation or distribution capacity.[5] Based on application of standard capacity factors for the CHP units, as well as the capacity of the battery storage system, the analysis estimates the present value of the project's generating capacity benefits to be approximately $2.4 million over a 20-year operating period. The analysis anticipates no impact on distribution capacity requirements.

---

[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 1,200 MWh.

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

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

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

Reliability Benefits

An additional benefit of the proposed microgrid would be to reduce customers' susceptibility to power outages by enabling a seamless transition from grid-connected mode to island mode. The analysis estimates that development of a microgrid would yield reliability benefits of approximately $43,800 per year, with a present value of $496,000 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:[1]

System Average Interruption Frequency Index (SAIFI) – 0.96 events per year.

Customer Average Interruption Duration Index (CAIDI) – 116.4 minutes.[2]

The estimate takes into account the number of small and large commercial or industrial customers the project would serve; the distribution of these customers by economic sector; average annual electricity usage per customer, as provided by the project team; and the prevalence of backup generation among these customers. It also takes into account the variable costs of operating existing backup generators, both in the baseline and as an integrated component of a microgrid. Under baseline conditions, the analysis assumes a 15 percent failure rate for backup generators.[3] It assumes that establishment of a microgrid would reduce the rate of failure to near zero.

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

Summary

The analysis of Scenario 1 yields a benefit/cost ratio of 0.8; i.e., the estimate of project benefits is approximately 80 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] www.icecalculator.com
[2] The analysis is based on DPS's reported 2014 SAIFI and CAIDI values for National Grid.
[3] http://www.businessweek.com/articles/2012-12-04/how-to-keep-a-generator-running-when-you-lose-power#p1.

Scenario 2

Benefits in the Event of a Major Power Outage

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

The Village of Westfield's proposed microgrid project would serve a number of critical facilities during an extended outage. The project's consultants indicate that at present, all of these facilities are served by backup generators. Table 35 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 30 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.[3]

Table 35. 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
Westfield Electric Department	$300	$122	50%	100%
Wastewater Treatment Plant	$300	$984	50%	100%
Water Treatment Plant	$300	$321	50%	100%
Village Office	$300	$122	0%	100%
Police & Fire Department	$300	$192	0%	100%
Westfield Memorial Hospital	$300	$248	50%	100%
Westfield Academy & Central School	$300	$157	50%	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.

[3] Based on the anticipated operation of the backup generators at these facilities and the facilities' average daily use of electricity, the loss of service capabilities while relying on backup power may be greater than 50 percent at the school and less than 50 percent at the wastewater treatment plant or water treatment plant.

As table 30 indicates, the backup generator at Westfield Academy and Central School lacks sufficient capacity to keep the facility fully operational. In particular, the generator is incapable of providing sufficient power to heat the building adequately. As a result, the school is unable to serve as an emergency shelter during heating season (October through March). Any residents who require shelter during this period would need to be evacuated to a shelter in another community. The village's consultants estimate the cost of such an evacuation at $1,500.

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 at the Electric Department to $500 at the Wastewater Treatment Plant. Once connected, the cost of operating these generators would range from $200 to $9,000 per day. The availability of rental units, however, is uncertain, particularly in the event of a prolonged outage.

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 and Fire Departments 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.

The remaining facilities would rely on their existing backup generators, experiencing a 50 percent loss in service capabilities while these generators operate. If their backup generators fail, these facilities would experience a total loss of service.

The school would be capable of sheltering residents only while its backup generator operates, and even then only during outages that occur from April through September. If an outage occurs during heating season – or if the backup generator fails at any time – any residents who require shelter would be evacuated, at a one-time cost of $1,500.

In all cases, the supply of fuel necessary to operate the backup generators would be maintained indefinitely.

In all cases, there is a 15 percent chance that the backup generator would fail.

The consequences of a major power outage also depend on the economic costs of a sustained interruption of service at the facilities of interest. The analysis calculates the impact of a loss in the village's police, fire, wastewater treatment, water supply, hospital, and emergency medical services using standard FEMA methodologies.[1] The impact of a loss in service at other facilities is based on the following value of service estimates:

---

[1] The Westfield Fire Department provides emergency medical services to the Westfield area, transporting patients to Westfield Memorial Hospital.

For the Village Office and the offices of the Westfield Electric Department, values of approximately $23,000 per day. These figures are estimated using the ICE Calculator, assuming 12 hours of microgrid demand per day during an outage.[1]

For Westfield Academy and Central School, a value of approximately $25,000 per day. This figure is based on an estimate of the facility's shelter capacity (500 people) and American Red Cross data on the cost of providing overnight shelter ($50/person/day).[2]

Based on these values, the analysis estimates that in the absence of a microgrid, the average cost of an outage for the facilities of interest is approximately $765,000 per day.

Summary

Figure 45 and table 36 present the results of the BCA for Scenario 2. The results indicate that the benefits of the proposed project would equal or exceed its costs if the project enabled the facilities it would serve to avoid an average of 0.8 days per year without power. If the average annual duration of the outages the microgrid prevents is less than this figure, its costs are projected to exceed its benefits.

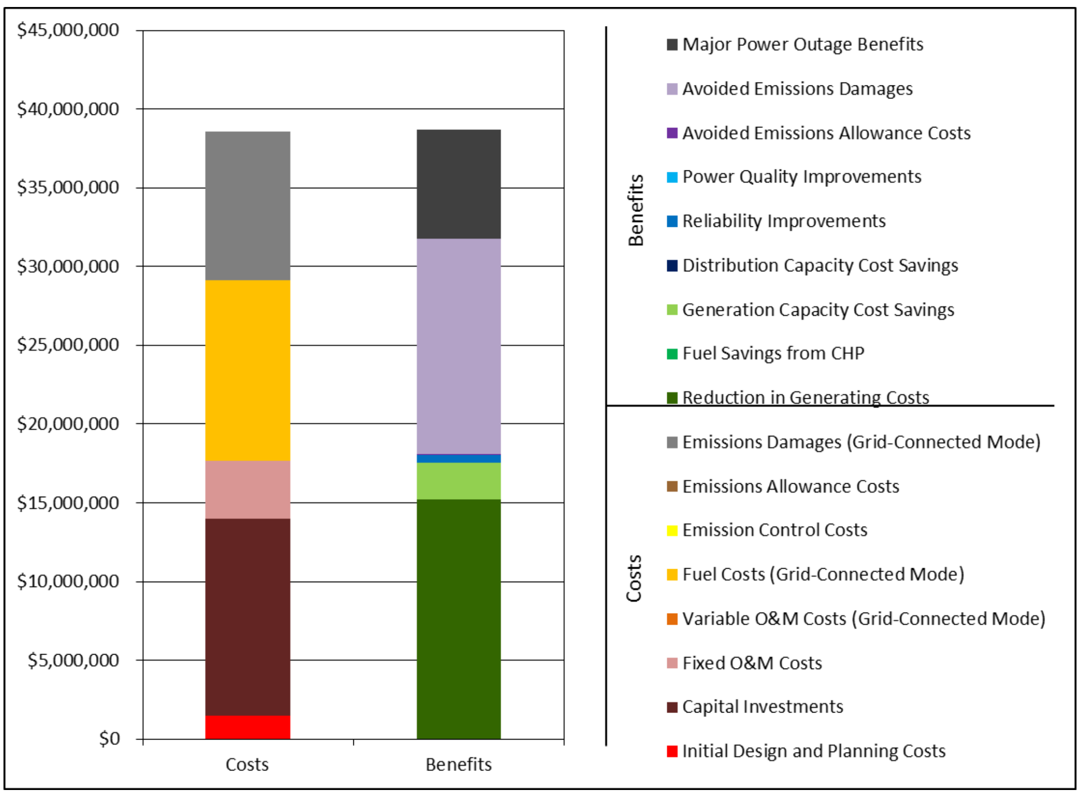


Figure 45. Present Value Results, Scenario 2 (Major Power Outages Averaging 0.8 Days/Year; 7 Percent Discount Rate)

[1] http://icecalculator.com/

[2] American Red Cross, Fundraising Dollar Handles for Disaster Relief Operations, Revised March 2014 – based on FY14 Figures.

Table 36. Detailed BCA Results, Scenario 2 (Major Power Outages Averaging 0.8 Days/Year; 7 Percent Discount Rate)

Cost or Benefit Category	Present Value Over 20 Years (2014$)	Annualized Value (2014$)
Costs		
Initial Design and Planning	$1,500,000	$132,000
Capital Investments	$12,500,000	$1,010,000
Fixed O&M	$3,680,000	$325,000
Variable O&M (Grid-Connected Mode)	$0	$0
Fuel (Grid-Connected Mode)	$11,500,000	$1,010,000
Emission Control	$0	$0
Emissions Allowances	$0	$0
Emissions Damages (Grid-Connected Mode)	$9,450,000	$616,000
Total Costs	**$38,600,000**	
Benefits		
Reduction in Generating Costs	$15,200,000	$1,340,000
Fuel Savings from CHP	$0	$0
Generation Capacity Cost Savings	$2,380,000	$210,000
Distribution Capacity Cost Savings	$0	$0
Reliability Improvements	$496,000	$43,800
Power Quality Improvements	$0	$0
Avoided Emissions Allowance Costs	$9,230	$814
Avoided Emissions Damages	$13,700,000	$895,000
Major Power Outage Benefits	$6,940,000	$612,000
Total Benefits	**$38,700,000**	
Net Benefits	**$125,000**	
Benefit/Cost Ratio	**1.0**	
Internal Rate of Return	**6.0%**	

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 Steve Hoyt, NYSERDA Project Manager, for making this work possible. Willdan would also like to thank the Westfield Electric Department project sponsors and staff that supported this project as well as the Village of Westfield. The cost benefit analysis portion of the project was completed by Industrial Economics Inc. The many tasks of this work could not have been completed without the dedicated effort of Schuyler Matteson, Project Manager, Mehdi Ganji, Technical Lead, Patrick Burgess, Technical Project Manager, Dr. Wei Tian, Lead Engineer, Lisa Vedder, Financial and Regulatory Lead.

Appendix

Microgrid Questionnaire

NY Prize Benefit-Cost Analysis: Microgrid Questionnaire

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

- **A.** Project Overview, Energy Production, and Fuel Use
- **B.** Capacity Impacts
- **C.** Project Costs
- **D.** Environmental Impacts
- **E.** Ancillary Services
- **F.** Power Quality and Reliability
- **G.** Other Information

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

Microgrid site: 82. Village of Westfield

Point of contact for this questionnaire:

Name: Andrew Thompson, Director of Public Works and Chief Operator WPCF

Address: Village of Westfield, 42 English Street, Westfield, NY 14787

Telephone: (716) 326-2145

Email: wpcfmain@villageofwestfield.org
Name: Andrew Thompson, Director of Public Works and Chief Operator WPCF

Address: Village of Westfield, 42 English Street, Westfield, NY 14787

Telephone: (716) 326-2145

Email: wpcfmain@villageofwestfield.org
s and Chief Operator WPCF

Address: Village of Westfield, 42 English Street, Westfield, NY 14787

Telephone: (716) 326-2145

Email: wpcfmain@villageofwestfield.org
Name: Andrew Thompson, Director of Public Works and Chief Operator WPCF

Address: Village of Westfield, 42 English Street, Westfield, NY 14787

Telephone: (716) 326-2145

Email: wpcfmain@villageofwestfield.org
Name: Andrew Thompson, Director of Public Works and Chief Operator WPCF

Address: Village of Westfield, 42 English Street, Westfield, NY 14787

Telephone: (716) 326-2145

Email: wpcfmain@villageofwestfield.org
Name: Andrew Thompson, Director of Public Works and Chief Operator WPCF

Address: Village of Westfield, 42 English Street, Westfield, NY 14787

Telephone: (716) 326-2145

Email: wpcfmain@villageofwestfield.org
Name: Andrew Thompson, Director of Public Works and Chief Operator WPCF

Address: Village of Westfield, 42 English Street, Westfield, NY 14787

Telephone: (716) 326-2145

Email: wpcfmain@villageofwestfield.org
Name: Andrew Thompson, Director of Public Works and Chief Operator WPCF

Address: Village of Westfield, 42 English Street, Westfield, NY 14787

Telephone: (716) 326-2145

Email: wpcfmain@villageofwestfield.org
Name: Andrew Thompson, Director of Public Works and Chief Operator WPCF

Address: Village of Westfield, 42 English Street, Westfield, NY 14787

Telephone: (716) 326-2145

Email: wpcfmain@villageofwestfield.org
s and Chief Operator WPCF

Address: Village of Westfield, 42 English Street, Westfield, NY 14787

Telephone: (716) 326-2145

Email: wpcfmain@villageofwestfield.org
Name: Andrew Thompson, Director of Public Works and Chief Operator WPCF

Address: Village of Westfield, 42 English Street, Westfield, NY 14787

Telephone: (716) 326-2145

Email: wpcfmain@villageofwestfield.org
Name: Andrew Thompson, Director of Public Works and Chief Operator WPCF

Address: Village of Westfield, 42 English Street, Westfield, NY 14787

Telephone: (716) 326-2145

Email: wpcfmain@villageofwestfield.org
Name: Andrew Thompson, Director of Public Works and Chief Operator WPCF

Address: Village of Westfield, 42 English Street, Westfield, NY 14787

Telephone: (716) 326-2145

Email: wpcfmain@villageofwestfield.org
Name: Andrew Thompson, Director of Public Works and Chief Operator WPCF

Address: Village of Westfield, 42 English Street, Westfield, NY 14787

Telephone: (716) 326-2145

Email: wpcfmain@villageofwestfield.org
Name: Andrew Thompson, Director of Public Works and Chief Operator WPCF

Address: Village of Westfield, 42 English Street, Westfield, NY 14787

Telephone: (716) 326-2145

Email: wpcfmain@villageofwestfield.org

Name: Andrew Thompson, Director of Public WorkName: Andrew Thompson, Director of Public Works and Chief Operator WPCF

Address: Village of Westfield, 42 English Street, Westfield, NY 14787

Telephone: (716) 326-2145

Email: wpcfmain@villageofwestfield.org
Name: Andrew Thompson, Director of Public Works and Chief Operator WPCF

Address: Village of Westfield, 42 English Street, Westfield, NY 14787

Telephone: (716) 326-2145

Email: wpcfmain@villageofwestfield.org
s and Chief Operator WPCF

Address: Village of Westfield, 42 English Street, Westfield, NY 14787

Telephone: (716) 326-2145

Email: wpcfmain@villageofwestfield.org
Name: Andrew Thompson, Director of Public Works and Chief Operator WPCF

Address: Village of Westfield, 42 English Street, Westfield, NY 14787

Telephone: (716) 326-2145

Email: wpcfmain@villageofwestfield.org
Name: Andrew Thompson, Director of Public Works and Chief Operator WPCF

Address: Village of Westfield, 42 English Street, Westfield, NY 14787

Telephone: (716) 326-2145

Email: wpcfmain@villageofwestfield.org
Name: Andrew Thompson, Director of Public Works and Chief Operator WPCF

Address: Village of Westfield, 42 English Street, Westfield, NY 14787

Telephone: (716) 326-2145

Email: wpcfmain@villageofwestfield.org
Name: Andrew Thompson, Director of Public Works and Chief Operator WPCF

Address: Village of Westfield, 42 English Street, Westfield, NY 14787

Telephone: (716) 326-2145

Email: wpcfmain@villageofwestfield.org
Name: Andrew Thompson, Director of Public Works and Chief Operator WPCF

Address: Village of Westfield, 42 English Street, Westfield, NY 14787

Telephone: (716) 326-2145

Email: wpcfmain@villageofwestfield.org
Name: Andrew Thompson, Director of Public WorkName: Andrew Thompson, Director of Public Works and Chief Operator WPCF

Address: Village of Westfield, 42 English Street, Westfield, NY 14787

Telephone: (716) 326-2145

Email: wpcfmain@villageofwestfield.org
Name: Andrew Thompson, Director of Public Works and Chief Operator WPCF

Address: Village of Westfield, 42 English Street, Westfield, NY 14787

Telephone: (716) 326-2145

Email: wpcfmain@villageofwestfield.org
s and Chief Operator WPCF

Address: Village of Westfield, 42 English Street, Westfield, NY 14787

Telephone: (716) 326-2145

Email: wpcfmain@villageofwestfield.org
Name: Andrew Thompson, Director of Public Works and Chief Operator WPCF

Address: Village of Westfield, 42 English Street, Westfield, NY 14787

Telephone: (716) 326-2145

Email: wpcfmain@villageofwestfield.org
Name: Andrew Thompson, Director of Public Works and Chief Operator WPCF

Address: Village of Westfield, 42 English Street, Westfield, NY 14787

Telephone: (716) 326-2145

Email: wpcfmain@villageofwestfield.org
Name: Andrew Thompson, Director of Public Works and Chief Operator WPCF

Address: Village of Westfield, 42 English Street, Westfield, NY 14787

Telephone: (716) 326-2145

Email: wpcfmain@villageofwestfield.org
Name: Andrew Thompson, Director of Public Works and Chief Operator WPCF

Address: Village of Westfield, 42 English Street, Westfield, NY 14787

Telephone: (716) 326-2145

Email: wpcfmain@villageofwestfield.org
Name: Andrew Thompson, Director of Public Works and Chief Operator WPCF

Address: Village of Westfield, 42 English Street, Westfield, NY 14787

Telephone: (716) 326-2145

Email: wpcfmain@villageofwestfield.org
Name: Andrew Thompson, Director of Public WorkName: Andrew Thompson, Director of Public Works and Chief Operator WPCF

Address: Village of Westfield, 42 English Street, Westfield, NY 14787

Telephone: (716) 326-2145

Email: wpcfmain@villageofwestfield.org
Name: Andrew Thompson, Director of Public Work

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 island 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
Westfield Electric Department	Small Commercial/Industrial (<50 annual MWh)	Municipal Services	*All other industries*	NA	NA	*60%*	*12 hours*
Wastewater Treatment Plant	Small Commercial/Industrial (<50 annual MWh)	Municipal services	*All other industries*	3,192,000	744	*60%*	*12 hours*
Water Treatment Plant	Small Commercial/Industrial (<50 annual MWh)	Municipal services	*All other industries*	478,000	476	*60%*	*12 hours*
Village Office	*Small Commercial/Industrial (<50 annual MWh)*	*Government Building*	*All other industries*	184,080	52	*60%*	*12 hours*
Police Department	Small Commercial/Industrial (<50 annual MWh)	Municipal services	*All other industries*	162,000	72	*60%*	*12 hours*
Fire Department	Small Commercial/Industrial (<50 annual MWh)	Emergency	*All other industries*			*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
Memorial Hospital	Small Commercial/Industrial (<50 annual MWh)	Healthcare	*All other industries*	1,090,400	216	*60%*	*12 hours*
Westfield Central School	*Small Commercial/Industrial (<50 annual MWh)*	*School*	*All other industries*	1,547,200	376	*60%*	*12 hours*
Total				**6,653,680**	**1,936**	**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 island 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	*Wastewater Treatment Plant*	Natural Gas CHP	1,500 kW	13,000 MWh	250kW x 12 hr = 3,000 kWh	1500/0.6*3.412 = 8,530	Mbtu/hr
New Generator	Memorial Hospital and Westfield Central School	Natural Gas CHP	1,500 kW	13,000 MWh	250kw x 12hr = 3000 kWh	1500/0.6*3.412 = 8,530	Mbtu/hr
Storage	Westfield Central School	Battery	250 kW	45 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	*Wastewater treatment plant*	*21,600*	☐ Yes
Existing Generator	*Water Treatment Plant*	5,400	☐ Yes
Existing Generator	*Village Office*	*1,080*	☐ Yes
Existing Generator	*Police Department*	2,250	☐ Yes
Existing Generator	*Fire Department*	2,250	☐ Yes
Existing Generator	*Memorial Hospital*	3,600	☐ Yes
Existing Generator	*Westfield Central School*	125	☐ Yes
New Generator	*Wastewater Treatment Plant*	27,000	☐ Yes
New Generator	Memorial Hospital and Westfield Central School	27,000	☐ Yes

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

Participation in a Demand Response Program

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

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

Facility Name	Capacity Participating in Demand Response Program (kW/year)	
	Following Development of Microgrid	Currently
Wastewater treatment plant	*21,600*	*21,600*
Water Treatment Plant	5,400	
Village Office	*1,080*	*1,080*
Police Department	2,250	
Fire Department	2,250	
Memorial Hospital	3,600	
Westfield Central School	125	
Wastewater Treatment Plant	27,000	
Memorial Hospital and Westfield Central School	27,000	

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
1,500 kW CHP	4,500,000	25	CHP at wastewater plant
1,500 kW CHP	4,500,000	25	CHP at Hospital
250 kW Battery	1,000,000	10	Li-ion battery storage
Automatic Generation Controllers	22,572	20	7,524 each System Automatic Generation Controllers
S&C Switch	148,000	20	18,500 each, S&C PMH-9 Pad Mounted Gear
Cable and Conduit	500,000	40	Cable and Conduit
Historical Data Software	690,625	25	OSIsoft Data Historian (PI) Full (50,000 tags) + training
Pole (+Riser)	88,000	20	11,000 each
Smart Meters	12,000	15	1,000 each, all buildings
Master Controller	250,000	25	Connects and optimizes all system components
Automatic Transfer Switch	90,000	20	18,000 each

Capital Component	Installed Cost ($)	Component Lifespan (round to nearest year)	Description of Component
Relay	36,000	20	SEL – 451, 3,000 each
Ethernet	21,303	15	In building wiring for building control

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?
$1,500,000	Planning, engineering design, Audit, Permit, Project management and Financing (5% design, 0.5% audit, 1% permit, 6% PM and financing) 12.50% of project cost

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?
$455,000	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).

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 island 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 island 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 Island mode for Duration of Design Event (12hr, 60% efficiency)	Unit
New Generator	*Wastewater Treatment Plant*	*7*	300/0.6*3.412*12/1000 = 20.5	MMBtu
New Generator	Memorial Hospital and Westfield Central School	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
Electricity	3 MW x 24 hr x 4.5 month x 30 days = 9,720	MWh
Choose an item.		Choose an item.
Choose an item.		Choose an item.
Choose an item.		Choose an item.

Emissions Control Costs

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

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

☐ Yes

☒ No

D. Environmental Impacts

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

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

E. Ancillary Services

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

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

F. Power Quality and Reliability

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

☐ Yes – proceed to Question 23

☒ No – proceed to Question 24

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

24. The benefit-cost analysis model will characterize the potential reliability benefits of a microgrid based, in part, on standard estimates of the frequency and duration of power outages for the local utility. In the table below, please estimate your local utility's average **outage frequency per customer** (system average interruption frequency index, or SAIFI, in events per customer per year) and average **outage duration per customer** (customer average interruption duration index, or CAIDI, in hours per event per customer).

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

Estimated SAIFI	Estimated CAIDI
1.17	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.

[1] The DPS service interruption reporting system specifies 10 cause categories: major storms; tree contacts; overloads; operating errors; equipment failures; accidents; prearranged interruptions; customers equipment; lightning; and unknown (there are an additional seven cause codes used exclusively for Con Edison's underground network system). SAIFI and CAIDI can be calculated in two ways: including all outages, which indicates the actual experience of a utility's customers; and excluding outages caused by major storms, which is more indicative of the frequency and duration of outages within the utility's control. The BCA model treats the benefits of averting lengthy outages caused by major storms as a separate category; therefore, the analysis of reliability benefits focuses on the effect of a microgrid on SAIFI and CAIDI values that exclude outages caused by major storms.

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: 82. Village of Westfield

Point of contact for this questionnaire:

Name: Andrew Thompson, Director of Public Works and Chief Operator WPCF

Address: Village of Westfield, 42 English Street, Westfield, NY 14787

Telephone: (716) 326-2145

Email: wpcfmain@villageofwestfield.org
Name: Andrew Thompson, Director of Public Works and Chief Operator WPCF

Address: Village of Westfield, 42 English Street, Westfield, NY 14787

Telephone: (716) 326-2145

Email: wpcfmain@villageofwestfield.org
s and Chief Operator WPCF

Address: Village of Westfield, 42 English Street, Westfield, NY 14787

Telephone: (716) 326-2145

Email: wpcfmain@villageofwestfield.org
Name: Andrew Thompson, Director of Public Works and Chief Operator WPCF

Address: Village of Westfield, 42 English Street, Westfield, NY 14787

Telephone: (716) 326-2145

Email: wpcfmain@villageofwestfield.org
Name: Andrew Thompson, Director of Public Works and Chief Operator WPCF

Address: Village of Westfield, 42 English Street, Westfield, NY 14787

Telephone: (716) 326-2145

Email: wpcfmain@villageofwestfield.org
Name: Andrew Thompson, Director of Public Works and Chief Operator WPCF

Address: Village of Westfield, 42 English Street, Westfield, NY 14787

Telephone: (716) 326-2145

Email: wpcfmain@villageofwestfield.org
Name: Andrew Thompson, Director of Public Works and Chief Operator WPCF

Address: Village of Westfield, 42 English Street, Westfield, NY 14787

Telephone: (716) 326-2145

Email: wpcfmain@villageofwestfield.org
Name: Andrew Thompson, Director of Public Works and Chief Operator WPCF

Address: Village of Westfield, 42 English Street, Westfield, NY 14787

Telephone: (716) 326-2145

Email: wpcfmain@villageofwestfield.org
Name: Andrew Thompson, Director of Public Works and Chief Operator WPCF

Address: Village of Westfield, 42 English Street, Westfield, NY 14787

Telephone: (716) 326-2145

Email: wpcfmain@villageofwestfield.org
s and Chief Operator WPCF

Address: Village of Westfield, 42 English Street, Westfield, NY 14787

Telephone: (716) 326-2145

Email: wpcfmain@villageofwestfield.org
Name: Andrew Thompson, Director of Public Works and Chief Operator WPCF

Address: Village of Westfield, 42 English Street, Westfield, NY 14787

Telephone: (716) 326-2145

Email: wpcfmain@villageofwestfield.org
Name: Andrew Thompson, Director of Public Works and Chief Operator WPCF

Address: Village of Westfield, 42 English Street, Westfield, NY 14787

Telephone: (716) 326-2145

Email: wpcfmain@villageofwestfield.org
Name: Andrew Thompson, Director of Public Works and Chief Operator WPCF

Address: Village of Westfield, 42 English Street, Westfield, NY 14787

Telephone: (716) 326-2145

Email: wpcfmain@villageofwestfield.org
Name: Andrew Thompson, Director of Public Works and Chief Operator WPCF

Address: Village of Westfield, 42 English Street, Westfield, NY 14787

Telephone: (716) 326-2145

Email: wpcfmain@villageofwestfield.org
Name: Andrew Thompson, Director of Public Works and Chief Operator WPCF

Address: Village of Westfield, 42 English Street, Westfield, NY 14787

Telephone: (716) 326-2145

Email: wpcfmain@villageofwestfield.org
Name: Andrew Thompson, Director of Public WorkName: Andrew Thompson, Director of

Public Works and Chief Operator WPCF

Address: Village of Westfield, 42 English Street, Westfield, NY 14787

Telephone: (716) 326-2145

Email: wpcfmain@villageofwestfield.org
Name: Andrew Thompson, Director of Public Works and Chief Operator WPCF

Address: Village of Westfield, 42 English Street, Westfield, NY 14787

Telephone: (716) 326-2145

Email: wpcfmain@villageofwestfield.org
s and Chief Operator WPCF

Address: Village of Westfield, 42 English Street, Westfield, NY 14787

Telephone: (716) 326-2145

Email: wpcfmain@villageofwestfield.org
Name: Andrew Thompson, Director of Public Works and Chief Operator WPCF

Address: Village of Westfield, 42 English Street, Westfield, NY 14787

Telephone: (716) 326-2145

Email: wpcfmain@villageofwestfield.org
Name: Andrew Thompson, Director of Public Works and Chief Operator WPCF

Address: Village of Westfield, 42 English Street, Westfield, NY 14787

Telephone: (716) 326-2145

Email: wpcfmain@villageofwestfield.org
Name: Andrew Thompson, Director of Public Works and Chief Operator WPCF

Address: Village of Westfield, 42 English Street, Westfield, NY 14787

Telephone: (716) 326-2145

Email: wpcfmain@villageofwestfield.org
Name: Andrew Thompson, Director of Public Works and Chief Operator WPCF

Address: Village of Westfield, 42 English Street, Westfield, NY 14787

Telephone: (716) 326-2145

Email: wpcfmain@villageofwestfield.org
Name: Andrew Thompson, Director of Public Works and Chief Operator WPCF

Address: Village of Westfield, 42 English Street, Westfield, NY 14787

Telephone: (716) 326-2145

Email: wpcfmain@villageofwestfield.org
Name: Andrew Thompson, Director of Public WorkName: Andrew Thompson, Director of Public Works and Chief Operator WPCF

Address: Village of Westfield, 42 English Street, Westfield, NY 14787

Telephone: (716) 326-2145

Email: wpcfmain@villageofwestfield.org
Name: Andrew Thompson, Director of Public Works and Chief Operator WPCF

Address: Village of Westfield, 42 English Street, Westfield, NY 14787

Telephone: (716) 326-2145

Email: wpcfmain@villageofwestfield.org
s and Chief Operator WPCF

Address: Village of Westfield, 42 English Street, Westfield, NY 14787

Telephone: (716) 326-2145

Email: wpcfmain@villageofwestfield.org
Name: Andrew Thompson, Director of Public Works and Chief Operator WPCF

Address: Village of Westfield, 42 English Street, Westfield, NY 14787

Telephone: (716) 326-2145

Email: wpcfmain@villageofwestfield.org
Name: Andrew Thompson, Director of Public Works and Chief Operator WPCF

Address: Village of Westfield, 42 English Street, Westfield, NY 14787

Telephone: (716) 326-2145

Email: wpcfmain@villageofwestfield.org
Name: Andrew Thompson, Director of Public Works and Chief Operator WPCF

Address: Village of Westfield, 42 English Street, Westfield, NY 14787

Telephone: (716) 326-2145

Email: wpcfmain@villageofwestfield.org
Name: Andrew Thompson, Director of Public Works and Chief Operator WPCF

Address: Village of Westfield, 42 English Street, Westfield, NY 14787

Telephone: (716) 326-2145

Email: wpcfmain@villageofwestfield.org
Name: Andrew Thompson, Director of Public Works and Chief Operator WPCF

Address: Village of Westfield, 42 English Street, Westfield, NY 14787

Telephone: (716) 326-2145

Email: wpcfmain@villageofwestfield.org
Name: Andrew Thompson, Director of Public WorkName: Andrew Thompson, Director of Public Works and Chief Operator WPCF

Address: Village of Westfield, 42 English Street, Westfield, NY 14787

Telephone: (716) 326-2145

Email: wpcfmain@villageofwestfield.org
Name: Andrew Thompson, Director of Public Work

I. Backup Generation Capabilities

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

   a. ☐ No - proceed to Question 4

   b. ☒ Yes - proceed to Question 2

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

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

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

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

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

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

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

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

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

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

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

Facility Name	Generator ID	Energy Source	Nameplate Capacity (MW)	Standard Operating Capacity (%)	Avg. Daily Production During Power Outage (kWh / Day) (6 hours)	Fuel Consumption per Day		One-Time Operating Costs ($)	Ongoing Operating Costs ($ / Day)
						Quantity	Unit		
Electric Department	Unit 1	Natural gas	48 kW	60	346	3.5	MCF	$300	$100
Wasterwater treatment plant	*Unit 2*	Diesel	*1200 kW*	*60*	*8,650*	*605*	*Gl*	$300	$100
Water Treatment Plant	*Unit 3*	Diesel	300 kW	60	2,160	151	Gl	$300	$100
Village Office	Unit 4	Diesel	60 kW	60	432	30	Gl	$300	$100
Police & Fire Department	Unit 5	Diesel	125 kW	60	900	63	Gl	$300	$100
Memorial Hospital	Unit 6	Diesel	200 kW	60	1,440	101	Gl	$300	$100
Westfield Central School	Unit 7	Natural Gas	125 kW	60	900	9.1	MCF	$300	$100

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

II. Costs of Emergency Measures Necessary to Maintain Service

We understand that facilities may have to take emergency measures during a power outage in order to maintain operations, preserve property, and/or protect the health and safety of workers, residents, or the general public. These measures may impose extraordinary costs, including both one-time expenditures (e.g., the cost of evacuating and relocating residents) and ongoing costs (e.g., the daily expense of renting a portable generator). The questions below address these costs. We begin by requesting information on the costs facilities would be likely to incur when operating on backup power. We then request information on the costs facilities would be likely to incur when backup power is not available.

A. Cost of Maintaining Service while Operating on Backup Power

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

   a. One-time emergency measures (total costs)

   b. Ongoing emergency measures (costs per day)

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

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

   As a guide, see the examples the table provides.

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

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?
Electric Department	*One-Time Measures*	*Hooking up additional portable generator*	*200*	*$*	*Year-round, but only necessary five days per week*
Electric Department	*Ongoing Measures*	*Renting additional portable generator*	*400*	*$/day*	*Year-round, but only necessary five days per week*
Wastewater treatment plant	*One-Time Measures*	*Hooking up additional portable generator*	*500*	*$*	*Year-round, but only necessary five days per week*
Wastewater treatment plant	*Ongoing Measures*	*Renting additional portable generator*	*9,000*	*$/day*	*Year-round, but only necessary five days per week*
Water treatment plant	*One-Time Measures*	*Hooking up additional portable generator*	*300*	*$*	*Year-round, but only necessary five days per week*
Water treatment plant	*Ongoing Measures*	*Renting additional portable generator*	*900*	*$/day*	*Year-round, but only necessary five days per week*
Village Office	*One-Time Measures*	*Hooking up additional portable generator*	*200*	*$*	*Year-round, but only necessary five days per week*
Village Office	*Ongoing Measures*	*Renting additional portable generator*	*600*	*$/day*	*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?
Police Department + Fire Department	*One-Time Measures*	*Hooking up additional portable generator*	*300*	*$*	*Year-round, but only necessary five days per week*
Police Department + Fire Department	*Ongoing Measures*	*Renting additional portable generator*	*700*	*$/day*	*Year-round, but only necessary five days per week*
Memorial Hospital	*One-Time Measures*	*Hooking up additional portable generator*	*300*	*$*	*Year-round, but only necessary five days per week*
Memorial Hospital	*Ongoing Measures*	*Renting additional portable generator*	*700*	*$/day*	*Year-round, but only necessary five days per week*
Westfield Central School	*One-Time Measures*	*Hooking up additional portable generator*	*300*	*$*	*Year-round, but only necessary five days per week*
Westfield Central School	*Ongoing Measures*	*Renting additional portable generator*	*700*	*$/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.
Electric Department	*50%*
Wastewater treatment plant	*50%*
Water treatment plant	*50%*
Village Office	*0%*
Police + Fire Department	*0%*
Memorial Hospital	*50%*
Westfield Central School	*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
Electric Department	*100%*
Wastewater treatment plant	100%
Water treatment plant	100%
Village Office	100%
Police + Fire Department	100%
Memorial Hospital	100%
Westfield Central School	100%

B. Questions for facilities that provide: Fire Services

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

5,000

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?

Chautauqua Fire Department:6.8 miles, Brocton Fire Hall: 13.1 miles

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

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

5,000

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:

No EMS on the area, just Memorial Hospital ambulance response. Response time increase would be 25%.

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

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

D. Questions for facilities that provide: Hospital Services

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

10,000

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

Brooks Memorial Hospital (aprox 17.7 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?

10,000

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

☐ Metropolitan Statistical Area

☐ Non-Metropolitan City

☒ Non-Metropolitan County

19. Please estimate:

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

17

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

10

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?

7,500

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?

7,500

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.)?

There are residential homes, apartments, and healthcare facilities

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).

5,000

Westfield Electric has approximately 3,200 electric accounts, 87.5% or 2,800 are residential customers (most with electric heating), and the remaining 400 are commercial, institutional and industrial customers. The total population of Westfield Electric's service territory is approximately 5,000.