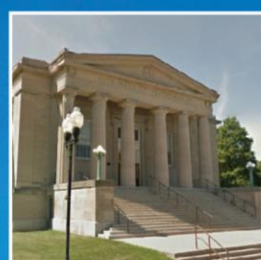
# 56 - City of Plattsburgh (SUNY)

# Notice

# NY Prize Task 5 Milestone Deliverable:

# City of Plattsburgh Final Report



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

Submit by:
Willdan Energy Solutions
on behalf of the City of Plattsburgh

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# Executive Summary

This study evaluated the feasibility of a microgrid for the Plattsburgh community that would serve the SUNY Plattsburgh campus, the Champlain Valley Physicians Hospital (CVPH), the Samuel F. Vilas home, the Meadowbrook Healthcare skilled nursing and rehabilitation facility, the Plattsburgh High School, and the Plattsburgh Housing Authority (PHA) apartment facilities on Oak Street and Cornelia Street. These facilities were chosen for their proximity to campus and for the critical nature of their functions and the vulnerable nature of the populations that many of them serve. In addition, many of them can serve as emergency shelters during storms and outages, and therefore would benefit from increased reliability. The Plattsburgh area has been affected both by winter storms and by hurricanes that have moved inland, and the community is considering how to increase reliability in the face of a potential increase in future severe weather events. The community is also concerned about sustainability and is looking for ways to decrease their carbon footprint.

The DER that were evaluated as part of this study are a 6.5 MW CHP installation at the campus's central heating plant and a 2 MW solar installation, likely either rooftop solar or covered-parking solar due to limited available land. These DER would be able to serve the average demand of the partners in an outage, and, in combination with the existing diesel backup generation, would be able to meet the peak demand as well. Another proposed DER was hydro generation installed in the water lines at the City of Plattsburgh water plant. We performed a rough calculation indicating there may be approximately 200 kW of generation potential there. It was decided not to include this in the microgrid due to the distance from campus, but the project may make sense as a self-contained DER. There has been discussion about the City of Plattsburgh supplying water to the surrounding Town of Plattsburgh, and in order to do this, water would need to be pumped uphill to the town. The hydro generation could help power these pumps.

The proposed DER would have a number of technical challenges. One of the biggest ones would be adequate space. There is limited space available at SUNY Plattsburgh's heating plant, so it is likely that an addition would need to be built to house a CHP plant. This addition would likely eliminate existing parking space, which could present a problem for SUNY Plattsburgh. Another challenge arises from the fact that SUNY Plattsburgh is served by two feeders that it owns, but the other partners are fed by various other feeders from different substations and at different voltages. These partners share these feeders with other residential and commercial load in the city. Therefore, in order to create a microgrid, express lines would need to be run to the various partners in order to create a loop and isolate the microgrid from PMLD. This would add to the complexity and cost of the project. In addition, the microgrid would not be able to export any power to the PMLD grid as PMLD is prohibited from purchasing DER power by it NYMPA contract. Therefore, all generation would have to serve as behind-the-meter load reduction.

In addition to technical challenges, the microgrid would also face economic challenges. Absent NY Prize Phase 2 funding, it is unlikely that the university would be able to obtain funding through its already limited capital budget. It is also unclear how much funding any of the other partners would be willing to contribute, particularly in light of the fact that CVPH and Vilas already have full backup capabilities. In particular, CVPH would receive limited benefits from the microgrid since they would be likely to maintain their full backup capabilities due to stringent hospital operating regulations. In addition to capital funding, operational funding would also be a challenge. The Task 4 cost-benefit analysis shows a positive return, but the analysis assumes that the price of electricity will increase following NYISO's projected trajectory, which may not be the case due to PMLD's NYPA allocation. In addition, the positive return relies heavily on the social cost of carbon and savings from avoided emissions allowances, which are costs not directly borne by the partners and are therefore costs which they may or may not be willing to consider when funding the microgrid. The extremely low-cost electricity in Plattsburgh ($0.03/kWh average) will make funding any DER project a challenge.

The environmental benefits of the microgrid could be attractive to the Plattsburgh community, particularly to the university, which is concerned with sustainability. The project leads from SUNY Plattsburgh for this project are two professors that work in sustainability and environmental policy. Even though the CHP generation would be powered by natural gas and would be competing economically against a NYPA allocation of clean hydro power, the power that it would actually be offsetting would be dirtier non-baseload fossil fuel power. Therefore, it would produce an environmental benefit. Obviously the solar power would as well.

The microgrid owner and operator would likely be a cooperative formed and governed by a board elected by these partners. The cooperative would purchase grid power from PMLD and resell it to the various partners. It would also generate electricity from the proposed CHP and solar installations within the microgrid and sell this power to the microgrid participants, and it would sell the heat from the CHP installation to SUNY Plattsburgh. The cooperative would be responsible for the maintenance of the microgrid infrastructure and would only keep enough revenue to cover its costs. Any profits would be returned to the microgrid participants as dividends. Cooperatives are often formed as 501(c)(12) not-for-profit corporations. The individual participant organizations would no longer be customers of PMLD but would instead be served by the cooperative as their utility.

The microgrid would also help PMLD stay within its NYPA allocation and avoid purchasing supplementary power on the open market through NYMP ($52/MWh and $7/kW of demand). PMLD only exceeds its allocation during the coldest winter months, but there would be some small benefit to the PMLD ratepayers.

If the Plattsburgh Community microgrid is able to overcome its technical and economic challenges, it could deliver both reliability and economic benefits to the microgrid partners and to the community as a whole.

# Task 1: Develop Microgrid Capabilities

*Table 1. Plattsburgh Community Microgrid – Existing and Proposed Overview*

| Category | Existing Resources | Proposed/Suggested Improvement | Justification |
|---|---|---|---|
| Load | • Residential electric heat<br>• 104 MW NYPA allocation<br>• 114 MW winter peak | • Building energy efficiency<br>• LED street lighting<br>• Load curtailment<br>• Winter peak shaving | • Resilience<br>• Reduced winter load<br>• Minimize size of generation |
| Distributed Energy Resources (DERs) | • Backup generators | • Combined Heat and Power (CHP)<br>• Energy storage<br>• Solar<br>• Hydro | • Demand Response<br>• Resilience<br>• Renewable sources<br>• Reduced winter load |
| Electrical and Thermal Infrastructure | • Radial path 4.16kV and loop at 12.47kV | • High Reliability Distribution System<br>• Self-healing | • Resilience<br>• Reliability |
| Master Controller and Building Controls | • Some building controls | • Connected master controller<br>• Upgraded building controls<br>• Smart charger/inverter for batteries/solar | • Resilience<br>• Optimal utilization of microgrid assets |
| IT/Communication Infrastructure | • Manual meters<br>• Some system-level load metering | • Advanced Metering Infrastructure (AMI)<br>• 900 MHz mesh network<br>• Fiber optic backbone<br>• Control interface for DER | • Resilience<br>• Reliable real time information<br>• Remote control |

# Introduction

SUNY Plattsburgh has completed a feasibility study for a microgrid that would be interconnected with the Plattsburgh Municipal Lighting Department (PMLD) distribution system. Included in the study are several partners who operate critical loads. These are the Champlain Valley Physicians Hospital (CVPH), Plattsburgh High School, Meadowbrook Nursing Home, Vilas Nursing Home, and the Plattsburgh Housing Authority.

A prolonged power outage can have significant consequences for all the partners involved. SUNY Plattsburgh has Memorandums of Understanding with the American Red Cross and other organizations to provide shelter during emergencies. In fact, they did so during an outage in 2003. There were costs incurred due to overtime labor, food spoilage, and other factors. The outage occurred when school was not in session, but if it had been in session, students would likely have had to be sent home and classes and tests rescheduled. The costs would have been significantly higher. The campus has backup generation to fully power four residential high rises (Wilson, Moffitt, deFredenburgh, and Hood Halls), but there are two high rises (Whiteface and Banks Halls) that are only partially powered. In these buildings, the students must be evacuated during an outage due to fire hazard from inoperable elevators. The nursing homes have complicated logistics and potentially serious consequences if residents must be evacuated. The hospital is often responsible for housing displaced seniors in an emergency, so they incur high costs as well.

2014's unusually cold winter resulted in high usage of electricity for the Plattsburgh community. Climate research suggests that winter and spring precipitation is projected to increase. The community is concerned with the extreme winter "polar vortex" conditions becoming more frequent and endangering many residents. The community's recent experience with flooding associated with Hurricane Irene is an indication of the level of damage extreme weather events can have. Lake Champlain's record-high levels during 2011 caused extensive damage as well. Climate science projections suggest similar events occurring in the future. According to 2014 National Climate Assessment (Ch. 16), "the Northeast has experienced a greater recent increase in extreme precipitation than any other region in the United States". The NYSERDA-sponsored report "Climate Change in New York State" also supports this finding for northern New York (Horton et al, 2014).

The existing technologies that support smart grid and microgrid capabilities were screened based on their financial and technical feasibility in their application to the Plattsburgh 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 available in the microgrid. Finally, the passing technologies were 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 City of Plattsburgh, which would enhance the overall operational reliability of the electrical distribution system. By providing a master controller, the Plattsburgh 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.

In addition to reliability goals, the microgrid would help SUNY Plattsburgh further its sustainability and carbon reduction efforts. This is important to the university as an organization that desires to play its part in the larger society and work for the common good. It also makes the university more attractive to both prospective and current students, thereby supporting the university's efforts in recruiting and retention. This has direct financial benefits as well as benefits to the university's reputation.

The microgrid could also be used as an educational tool in support of academic programs at the university. The 2013-2018 SUNY Plattsburgh Campus Strategic Plan has as one of its six goals "Increasing Opportunities for Experiential Learning." On April 13, 2015, the New York State Legislature established the requirement for an experiential learning component for every student graduating from SUNY and CUNY schools in the 2015-2016 budget. The project could be a central focus for learning activities focused on civic engagement and applied learning. Students would also have an exceptional context in which to study and understand the relevancy of global issues to local concerns. The infrastructure for this and other pedagogical initiatives is already in place at SUNY Plattsburgh through the Center for Teaching Excellence and the Center for Public Service.

Another soft benefit of the microgrid is that it could align with one of the missions of the hospital, which is to promote public health. If the microgrid increases the resiliency of the electric system and allows more people, particularly seniors, to stay in their homes during an emergency, then it is a benefit to public health.

Reliability would be improved through infrastructure upgrades, such as a High Reliability Distribution System (HRDS), which senses and clears faults with virtually no impact on building loads. This would create a self-healing and more fault-tolerant grid by adding redundancy to the electrical and communications networks in order to reduce the number of single points of failure. Reliability would be further enhanced by adding alternate sources of generation to serve critical and non-critical loads. 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 Plattsburgh 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 would be mitigated by a large natural gas-fed combined heat and power (CHP) plant, which would 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 Plattsburgh Community Microgrid with heat and power when it needs it most.

# Load

## Existing Resources

There are approximately 20,000 people living in Plattsburgh. The City of Plattsburgh is allotted 104.35 megawatts (MW) of hydroelectric power, with some natural gas and nuclear, from the New York Power Authority (NYPA) and 56 GWh/month, which is adequate to cover the peak loads except for the winter season (November through April). During the winter season, Plattsburgh depends on electricity for heating, and it occasionally needs to purchase additional power to meet the demand. PMLD incurs additional cost liability of $7/kW when the community exceeds the power allocation and $52/MWh when consumption exceeds the energy allocation. The demand can reach as high as 114 MW and the energy as high as 2.7 GWh in the winter season. Table 2 shows the summer and winter load in Plattsburgh for the recent years. Table 3 shows the critical facilities and their average and peak loads.

*Table 2. Load Demand in Summer and Winter*

| Year | Summer Demand (kW) | Winter Demand (kW) |
|---|---|---|
| 2015 | 51,332 | 103,955 |
| 2014 | 50,738 | 105,478 |
| 2013 | 54,464 | 96,055 |
| 2012 | 53,244 | 91,762 |
| 2011 | 51,376 | 101,688 |

The City of Plattsburgh's loads can be separated into the broad load categories, critical and non-critical, with participating critical facilities including SUNY Plattsburgh, Champlain Valley Physicians Hospital (CVPH), Plattsburgh High School, Meadowbrook Nursing Home, and Vilas Nursing Home, and non-critical facilities including the many other businesses and residential customers served by PMLD. The total critical load demand is about 10.7 MW. The load demand in each facility can be further separated into the load categories as shown in table. The thermal loads that are not fed by electric heaters are also considered separately.

*Table 3. Electrical Load Type*

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

### *Consequences*

Due to reliance of the community's customers on electricity as the fuel source for space heating, any bulk system disruption during winter conditions can create a safety issue. PMLD also incurs additional cost liability when the Plattsburgh community exceeds its NYPA kW and kWh allocation. In addition, Plattsburgh is vulnerable to bulk power outages as extreme weather conditions become more common.

#### *Opportunities*

A microgrid would allow the system to island and indefinitely energize the area, even on a rotating basis, and would dramatically improve resilience. In addition to resiliency benefits from islanding, the microgrid would provide financial benefits by enabling winter peak shaving, thereby buffering residents from rate increases due to the purchase of supplemental power on the open market. Further financial benefits could be realized by participation in demand-response programs.

### Proposed/Suggested Improvements

A community microgrid would be helpful for solving these constraints existing in Plattsburgh's system by providing additional capacity and resiliency. A new CHP plant and demand response would help in mitigating the reliance on power from the utility grid. Willdan proposes to upgrade any existing lighting, which has not already been upgraded or considered for upgrading, with high efficient LED (Light Emitting Diode) fixtures. Between this and other efficiency measures we expect to reduce the current load levels by 20%. By applying the latest building control technology in each building, the microgrid owner would have direct control of the curtailable and shift-able loads.

#### *Benefits*

With a community microgrid, Plattsburgh 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 Plattsburgh to reduce the extra cost incurred 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 could reduce maintenance cost and electricity bills. With the capability of direct control on the loads, PMLD 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. The electric customer would be able to get better quality electricity service even while cutting the electricity bill.

#### *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.

## DERs

### Existing Resources

Existing DERs located in the proposed Plattsburgh Community Microgrid are used primarily as backup generators in the event that utility power is interrupted. They consist of both diesel and natural gas (NG) generators. They are distributed among the critical facilities and retain about a week of fuel for or rely on NG pipelines for around 13.5 MW of generation. Existing DER related to critical loads are shown in figure 2 and in table 4.

*Table 4. Critical Facilities and their Respective Backup Generators*

| Facility | Average Demand (kW) | Peak Demand (kW) | Backup Capacity (kW) | Backup Type (kW) |
|---|---|---|---|---|
| SUNY Plattsburgh | 3,325 | 4,974 | 3,107 | #2 Fuel oil: 2,737<br>Natural gas: 200<br>Portable diesel: 170 |
| CVPH | 2,108 | 3,525 | 1,500 and 8,800 | Diesel |
| High School | 239 | 1,302 | None | N/A |
| Meadowbrook Nursing Home | 237 | 756 | None | N/A |
| Vilas Nursing Home | 55 | 154 | 175 | Diesel |
| Plattsburgh Housing Authority | 380 | 610 | None | N/A |
| **Total:** | **6,344** | **11,321** | **13,582** | **Diesel: 10,645**<br>**Natural Gas: 200**<br>**#2 Fuel oil: 2,737** |

### *Consequences*

While the critical loads have an average demand of about 11.2 MW and the DERs provide around 13.5 MW of generation, indicating that there is enough generation to provide critical loads with power in the event of an emergency, most of the generation, 10.6 MW of diesel generators, is concentrated in the CVPH. This means that a number of vital critical facilities, including the SUNY campus and high school as well as the Meadowbrook nursing home, would be partially or fully without power in the event of an emergency, putting the residents of Plattsburgh in a dangerous position. In addition, the community pays to maintain and test the backup generators, or runs risk of the generators not working when needed, and doesn't see any value added beyond emergency situations. Finally, it is worth noting that over two thirds of the generation runs off of diesel fuel, which is a relatively dirty fuel source that reduces the quality of the air, increases the carbon footprint of the City of Plattsburgh, and must be stored or shipped into the city in the event of an outage.

### *Opportunities*

The microgrid would replace some or all of the backup generation with 13 MW of natural gas-fed Combined Heat and Power (CHP) generation. The electricity provided from the CHP Plant could cover the electricity needs of the currently vulnerable critical facilities. The heat provided from the CHP plant could alleviate energy consumption from electric heaters in the Field House and Vilas Nursing home and potentially the CVPH during the winter and ensure that critical facilities have needed heat in the event of an emergency. This expansion would allow Plattsburgh 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 City of Plattsburgh.

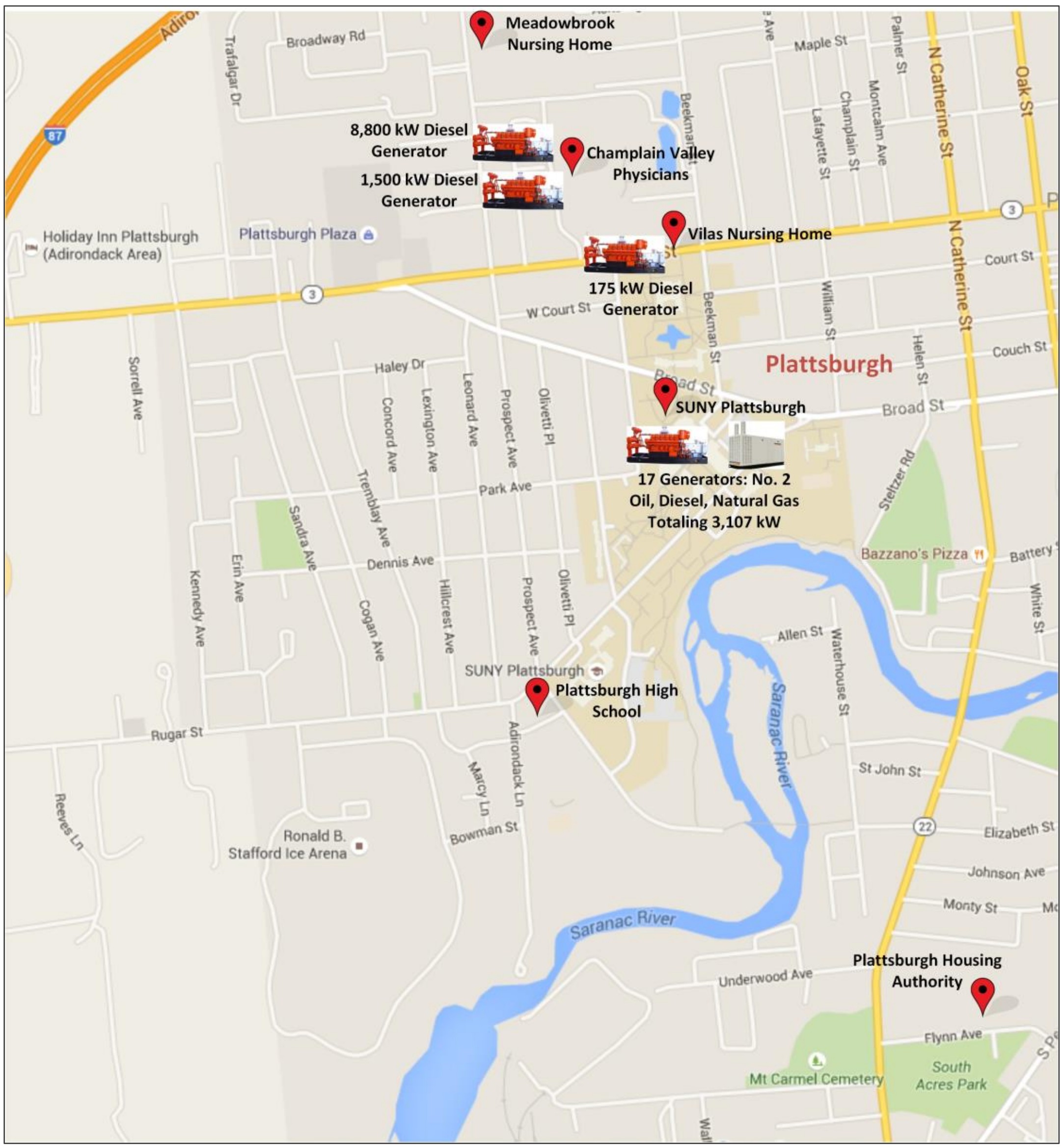



*Figure 1. Critical Load and Existing DER Map of Plattsburgh*

*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 Plattsburgh Community Microgrid favors CHP, batteries as energy storage, ICE DG as black start generators for CHP, and potentially some solar and hydro. Based on initial analyses of wind potential and its associated space and expertise requirements, wind is not justified economically or in terms of resiliency and does not merit further consideration.

### *Benefits*

The addition of a range of DERs, including long term sources like CHP, short term sources like batteries and ICE DG, and renewables like solar, would allow the City of Plattsburgh to operate as a microgrid, take advantage of new revenue streams such as Demand Response and Fast Regulation Markets, increase resiliency through on-site generation, and reduce charges associated with high winter heating loads by utilizing generation near residential load pockets. Distribution of these additional resources close to the school system, either at the campus central heating plant or at another campus location, and close to the nursing homes will ensure that critical facilities would remain powered on in emergencies, providing the City of Plattsburgh with peace of mind. In addition, the high temperature hot water produced by the combined cycle plant could be used for space heating, domestic hot water, laundry, pool heating, and absorption chilling.

# Electrical and Thermal Infrastructure

## Existing Resources


*Figure 2. Plattsburgh's Substation in Reference to the SUNY Plattsburgh Campus*

PMLD owns and operates the distribution system within the city to serve approximately 20,000 residents. SUNY Plattsburgh owns a 12.47 kV loop feeder, fed from breakers 7 and 8 of the Rugers Substation, which is shown in figure 2. The substation is grid-tied to NYPA and served on 46 kV transmission lines. The adjacent Adirondack Substation is being phased out and will be completely decommissioned within two years. The other proposed microgrid facilities are fed from various other substations on primarily 4.16 kV radial path feeders.

All of Plattsburgh is served using mechanical switches as its primary protection; there is no communication and no remote control using any type of Supervisory Control and Data Acquisition (SCADA) software. Reportedly, PMLD has spare capacity in all parts of their distribution system and does not suffer from power quality or voltage issues.

### *Consequences*

Ninety-six percent of Plattsburgh's customers use electric heating, which results in winter peaks that exceed NYPA allocations once or twice a year. The mechanical switches and protection that serve the Plattsburgh electrical distribution system are outdated and potential sources of reliability issues. The mechanical switches will operate reliably in the event of an emergency, but the utility has no visibility into the system outside of customer calls to complain and on-site system operators. This could extend the time of outages from minutes to hours and present dangerous situations for customers that rely on electricity for heating in the winter, which regularly sees temperatures below 0°F. Also, these switches do not reclose to clear potential transient faults, which are a majority of system faults during storms, causing the utility an undue amount of work and man hours to reset these switches and restore power that could have been restored in a fraction of a second by smarter switches.

### *Opportunities*

Plattsburgh has a relatively outdated electrical system with spare capacity but room for improvement as far as relays and protection as well as operational insight into the grid. As the primary system operators for around 20,000 customers and over 100 MW of load, phasing in reliability upgrades such as digital substations and automatic reclosers could see massive reliability improvements as well as economic benefits for Plattsburgh residents and especially PMLD.

## Proposed/Suggested

Willdan proposes a loop-based community microgrid for Plattsburgh. 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.  CHP could replace distributed and inefficient electric heaters with central steam or hot water heating for critical facilities and surrounding buildings, reducing the winter stress on the grid and providing reliable sources of heat during cold winters.

### *Benefits*

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

### *Barriers*

The existing or future distribution network will need further upgrades which may incur extra investment costs. Also, automatic smart switches are needed for fast automatic switching. Existing radial path feeders will have to be modified for closed loop configuration. PMLD, as a utility, might be concerned with the overall reduction in their revenue if load is served by DERs owned by customers or an external source.

## Master Controller and Building Controls

### Proposed/Suggested Improvements

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

Figure 3 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 Plattsburgh 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.

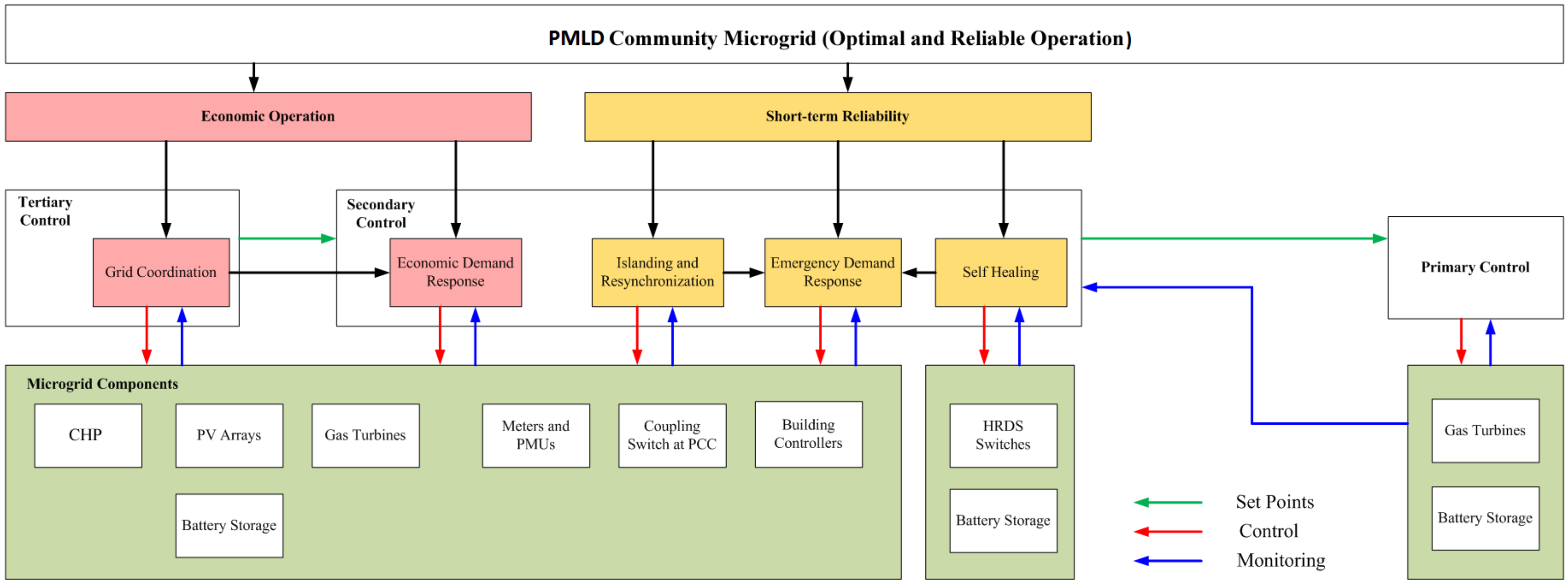
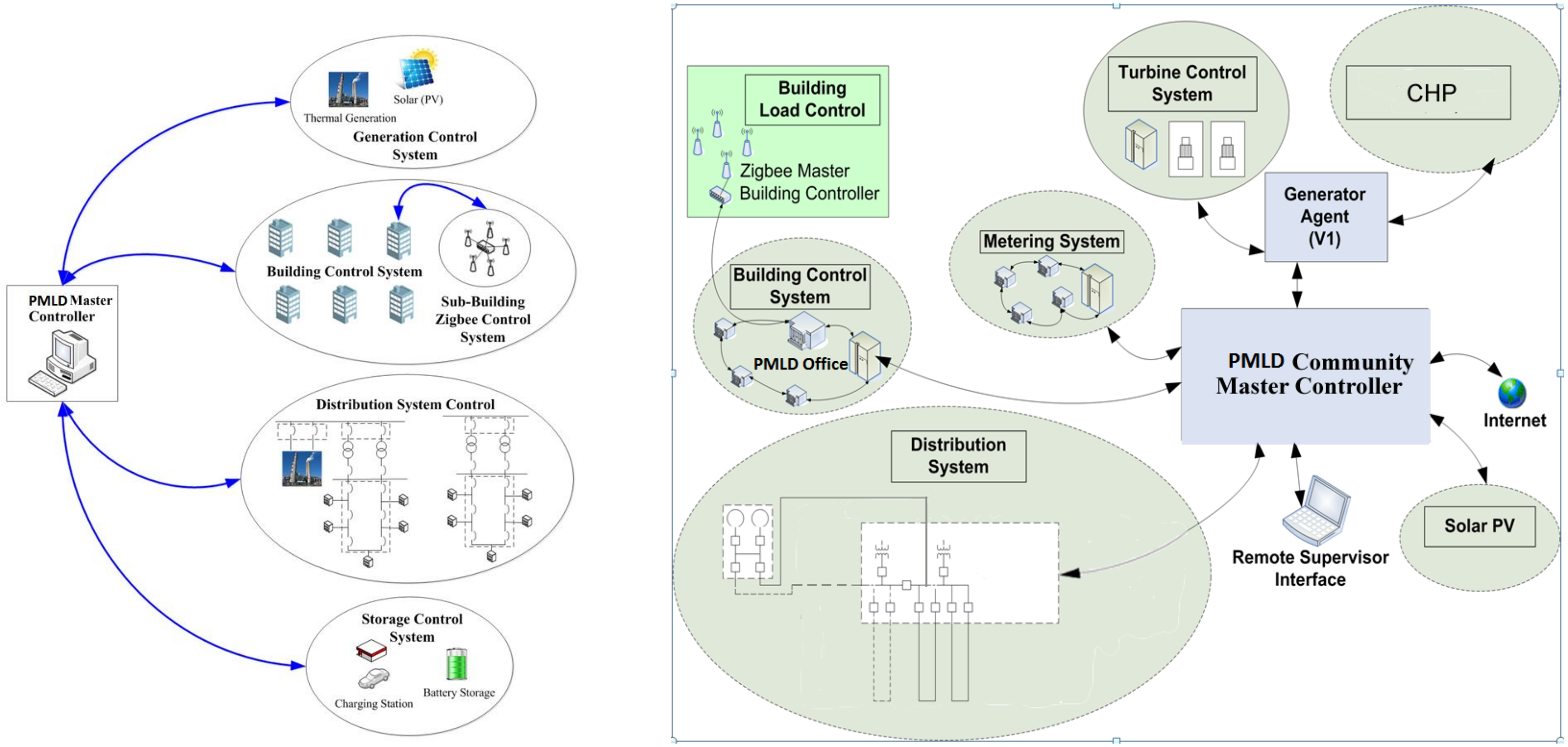



*Figure 3. Objectives and Functions for the Control and Operation of the Plattsburgh Community Microgrid*




(a) (b)

*Figure 4. Architecture of Master Controller for Plattsburgh 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 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 contingent modes. Figure 4 shows the hierarchical framework of the master controller proposed for Plattsburgh's community microgrid project. In figure 4, the monitoring signals provided to the master controller indicate the status of DER and distribution components, while the master controller signals provide set points for DER units and building controllers. Building controllers will communicate with sub-building controllers and monitoring systems to achieve a device-level rapid load management.

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

#### *Benefits*

The Plattsburgh 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 shutoff loads according to predetermined load priorities. Part of the load shedding will be accomplished by shutting off power to an entire building 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 Plattsburgh, 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 his communication infrastructure to monitor and control his grid assets. For a microgrid master controller and microgrid operators, this architecture enables real time control, rapid digestion of critical grid information, and historical data for analysis and reporting. As part of a feasible microgrid, assessment and upgrade of the equipment and protocols used in the microgrid area will be performed.

### Existing Resources

PMLD owns and operates two substations and many miles of distribution lines, serving around 20,000 residents. A large majority of those customers are individually metered; however, these meters are read manually every month by a meter reader. PMLD has no existing SCADA system and does not have smart switches or digital substations or any communications infrastructure associated with these resources.

### *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 the 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*

PMLD would benefit from an Advanced Metering Infrastructure (AMI) expansion, which would involve adding wireless communication infrastructure to each meter in the City of Plattsburgh 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.

PMLD-controlled AMI would also provide an opportunity for community demand response aggregation, in which PMLD 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 Plattsburgh 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 (figure 5).

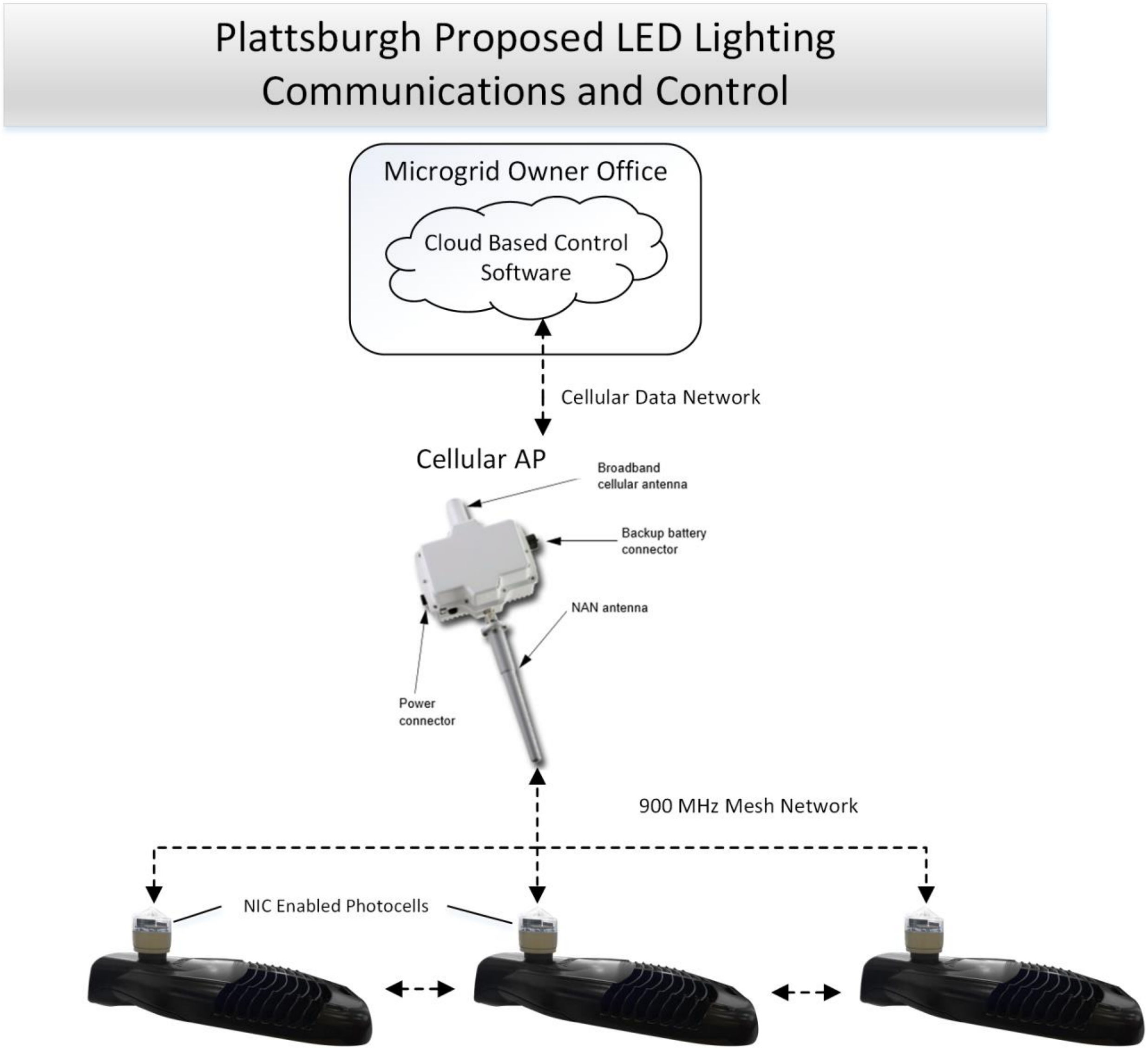



*Figure 5. Plattsburgh Proposed LED Lighting Communications and Control Diagram*

In addition to meters and streetlights, circuit breakers, relays, reclosers and other switchgear are vital to the control of the Plattsburgh 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 PMLD data center and the Fairview substation. The substation relays may have to be upgraded to communicate using the DNP3 protocol over TCP/IP, the de facto standard for modern utility communications, which will be used to monitor and control the proposed DER as well.

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

### *Benefits*

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

### *Barriers*

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

# Task 2: Develop Preliminary Technical Design Costs and Configuration

Note: Estimation of the costs and benefits at this stage of the NY Prize competition is likely to be accurate within +/- 30%. The emphasis at this stage of analysis is on establishing a reasonable basis for competing for funding for a detailed, audit-grade engineering and business case analysis at a subsequent stage of the NY Prize Community Microgrid Competition.

*Table 6. Plattsburgh Community Microgrid Existing and Proposed Overview[1]*

| Category | Existing Resources | Proposed/Suggested Improvement | Justification |
|---|---|---|---|
| Load | • Residential Electric Heat<br>• 11.3 MW Electrical Peak | • Building Energy Efficiency<br>• LED Street lighting<br>• Load Curtailment | • Resilience<br>• Reliability<br>• Cost Savings |
| Distributed Energy Resources (DERs) | • Backup Generators with capacity of 5.832 MW (4 in Diesel, 1 in Natural Gas and 1 in #2 Fuel oil) | • Combined Heat and Power (CHP) (6.5 MW)<br>• Energy Storage (1.4 MW)<br>• Solar (2.3 MW)<br>• Hydro (200 kW) | • Demand Response Revenue<br>• Resilience<br>• Renewable Sources<br>• Reduce Base load |
| Electrical and Thermal Infrastructure | • Radial Path 4.16kV and Loop at 12.47kV | • High Reliability Distribution System<br>• Self-Healing | • Resilience<br>• Reliability |
| Master Controller and Building Controls | • Some Building Controls | • Connected Master controller<br>• Upgraded building controls<br>• Smart Charger/Inverter for Batteries/Solar | • Resilience<br>• Optimal utilization of Microgrid Assets |
| IT/ Communication Infrastructure | • Manual Meters<br>• Some System Level Load metering | • Advanced Metering Infrastructure (AMI)<br>• 900 MHz mesh network<br>• Fiber optic backbone<br>• Control interface for DER | • Resilience<br>• Reliable real time information<br>• Remote Control |

[1] While the DERs are larger in capacity than the peak critical facility load, implying that there is enough DER capacity to meet the load in an emergency or islanding event, most of this generation capacity exists at the CVPH while most of the loads are distributed among the other critical facilities. This fact results in the proposal of new generation sources to meet this unserved load at SUNY Plattsburgh, High School, Meadowbrook Nursing Home and Plattsburgh Housing Authority, and also to replace the existing diesel backup generators.

## Sub Task 2.1 Proposed Microgrid Infrastructure and Operations


*Figure 6. Generation Simplified Equipment Layout Diagram*

The proposed microgrid for this study includes a CHP plant at the SUNY Plattsburgh central heating plant, a solar installation at a to-be-determined location, and a hydropower installation at the City's water plant. The Point of Common Coupling (PCC) would be at the Rugers substation, which serves the campus's feeder. The other facilities are served by other substations at different voltages and would be disconnected from these feeders and connected together with new lines to form a loop with the SUNY Campus.

Using two breakers at the PCC, the microgrid would be capable of operating in parallel with the grid or of disconnecting and forming an intentional island. While connected to the grid, the master controller would be capable of optimizing the operation of the microgrid for parameters such as cost or emissions.

It would control generation levels as well as loads enrolled in demand response programs. It could help PMLD reduce its winter peaks and stay under its NYPA allocation. Generation would be sized appropriately and reverse power flow protection would be put in place at the PCC so that no power would be exported to the grid as PMLD is prohibited from purchasing any DER power by their NYMPA contract. In the event of a utility outage, the microgrid would seamlessly form an island, thereby keeping more load online than is currently served by backup generators, and would then seamlessly resynchronize with the grid once the outage is over.

A hierarchical protection configuration strategy is proposed for the microgrid that contains four-level protection: load way, loop way, loop feeder way, and microgrid level. Each level is equipped with protection devices. Also, the four levels are coordinated. The protection devices and operational rules in each level are summarized in table 7. The load-shedding and other control schemes could also be implemented on the load-way protection level based on the under/over-voltage and the under/over-frequency functions of these relays. The hierarchical strategy aims to address the challenges in isolating various faults in time from loop-based microgrids. The microgrid protection functions are summarized below:

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

*Table 7. 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):<br>—Operates only in load-way faults (DOC and auto reclosing). |
| Loop protection | DOC digital relay with adaptive relay setting:<br>—Operates in loop faults [primary and backup permissive overreach transfer trip (POTT) Schemes<br>—Backup protection for load-way protection. |
| Loop-feeder protection | Non-direction Overcurrent (OC) relay:<br>—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:<br>*In grid-connected mode:*<br>—Unintentional islanding operation due to external fault or disturbance based on the signal from the MC<br>—OC relay (backup protection for the entire microgrid)<br>—Intentional islanding operation based on the islanding command from the MC.<br>*In island mode:*<br>—Resynchronization initiated by a command from the MC. |

## Sub Task 2.2 Load Characterization

There are approximately 20,000 people living in Plattsburgh. The City of Plattsburgh is allotted 104.35 MW (56 GWh) of hydroelectric power, with some natural gas and nuclear, from the New York Power Authority (NYPA), which is usually adequate to cover the peak loads except for during short periods of very cold winter weather. The average winter load is approximately 100 MW and peaks at 114 MW. The average summer load is approximately 50 MW and peaks at 54 MW. When the allocation is exceeded, PMLD must buy power at a significantly higher rate - $52/MWh plus $7/kW of demand. However, because the NYPA allocation is usually adequate, PMLD has not found the overage costs to be a major issue.

Figure 7 shows the monthly kWh profile for SUNY Plattsburgh for recent years. The shape of the monthly kWh usage matches the Heating-Degree-Days (HDD) of the locality. Table 8 lists the average and peak demand for all the facilities served by the microgrid. All the facilities, with the exception of the SUNY campus and CVPH have electric heat. The locations of eight critical facilities are shown in figure 9.

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

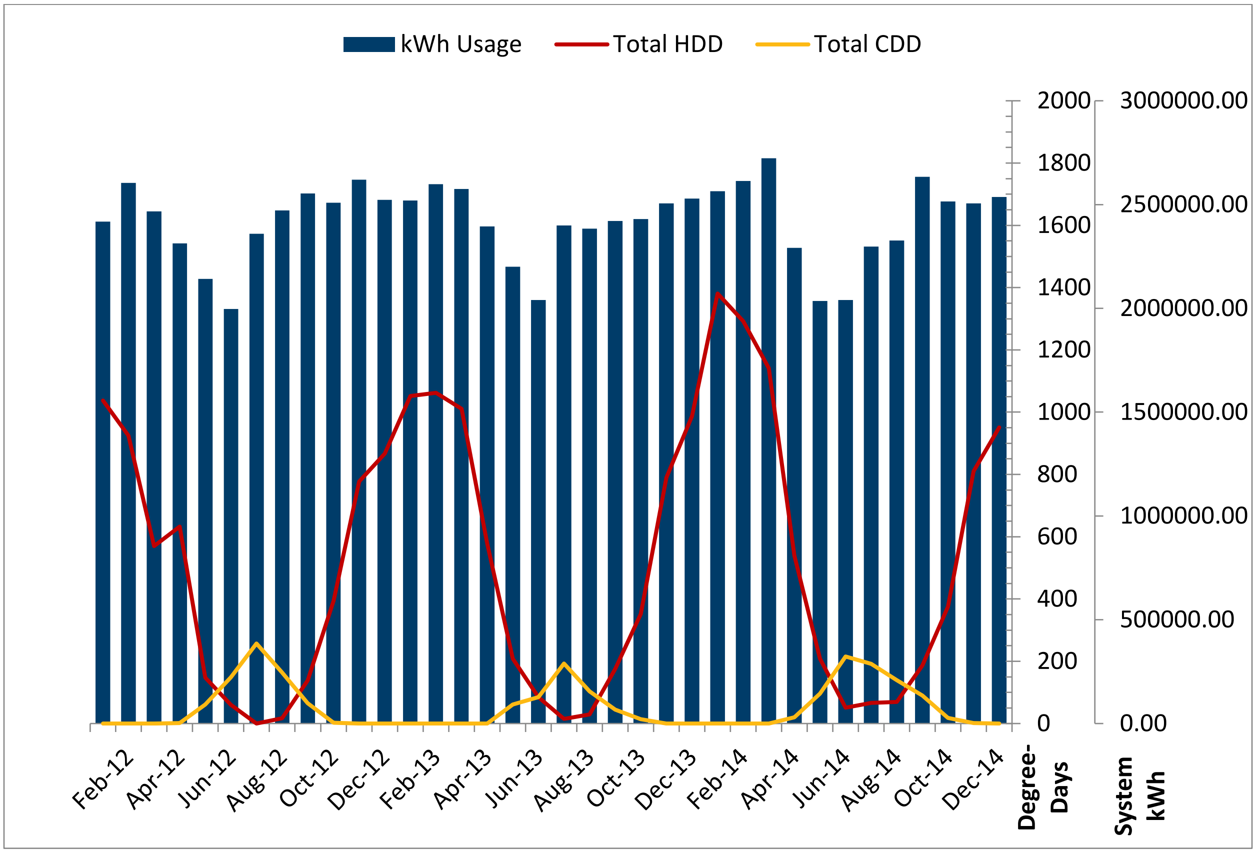


*Figure 7. SUNY Plattsburgh Monthly Energy Profile*

*Table 8. SUNY Electricity Usage*

| Month | Energy (kWh) |
|---|---|
| January, 2014 | 2,564,405 |
| February, 2014 | 2,614,029 |
| March, 2014 | 2,722,581 |
| April, 2014 | 2,291,167 |
| May, 2014 | 2,034,873 |
| June, 2014 | 2,040,196 |
| July, 2014 | 2,298,319 |
| August, 2014 | 2,327,543 |
| September, 2014 | 2,634,273 |
| October, 2014 | 2,515,557 |
| November, 2014 | 2,506,491 |
| December, 2014 | 2,535,934 |

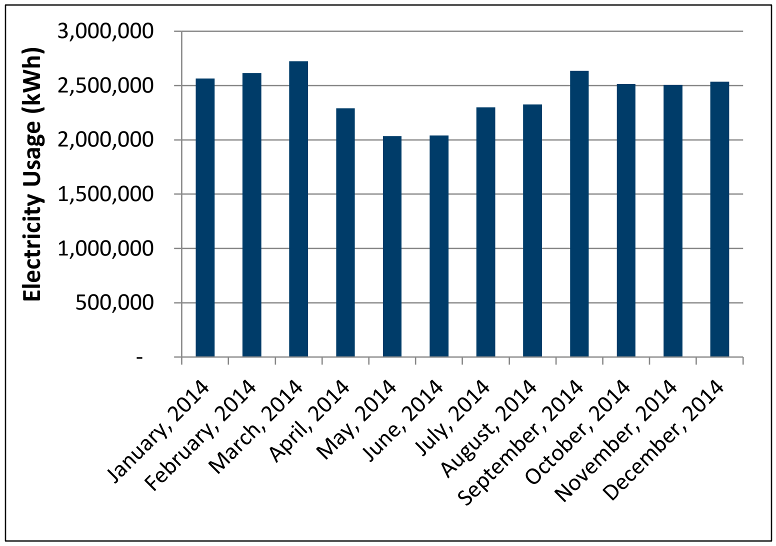


*Figure 8. SUNY Electricity Usage 2014*

*Table 9. Critical Loads*

| Critical Facility | Average Demand (kW) | Peak Demand (kW) |
|---|---|---|
| SUNY Plattsburgh | 3,325 | 4,974 |
| CVPH | 2,108 | 3,525 |
| High School | 239 | 1,302 |
| Meadowbrook Nursing Home | 237 | 756 |
| Vilas Nursing Home | 55 | 154 |
| Plattsburgh Housing Authority | 380 | 610 |
| **Total:** | **6,344** | **11,321** |

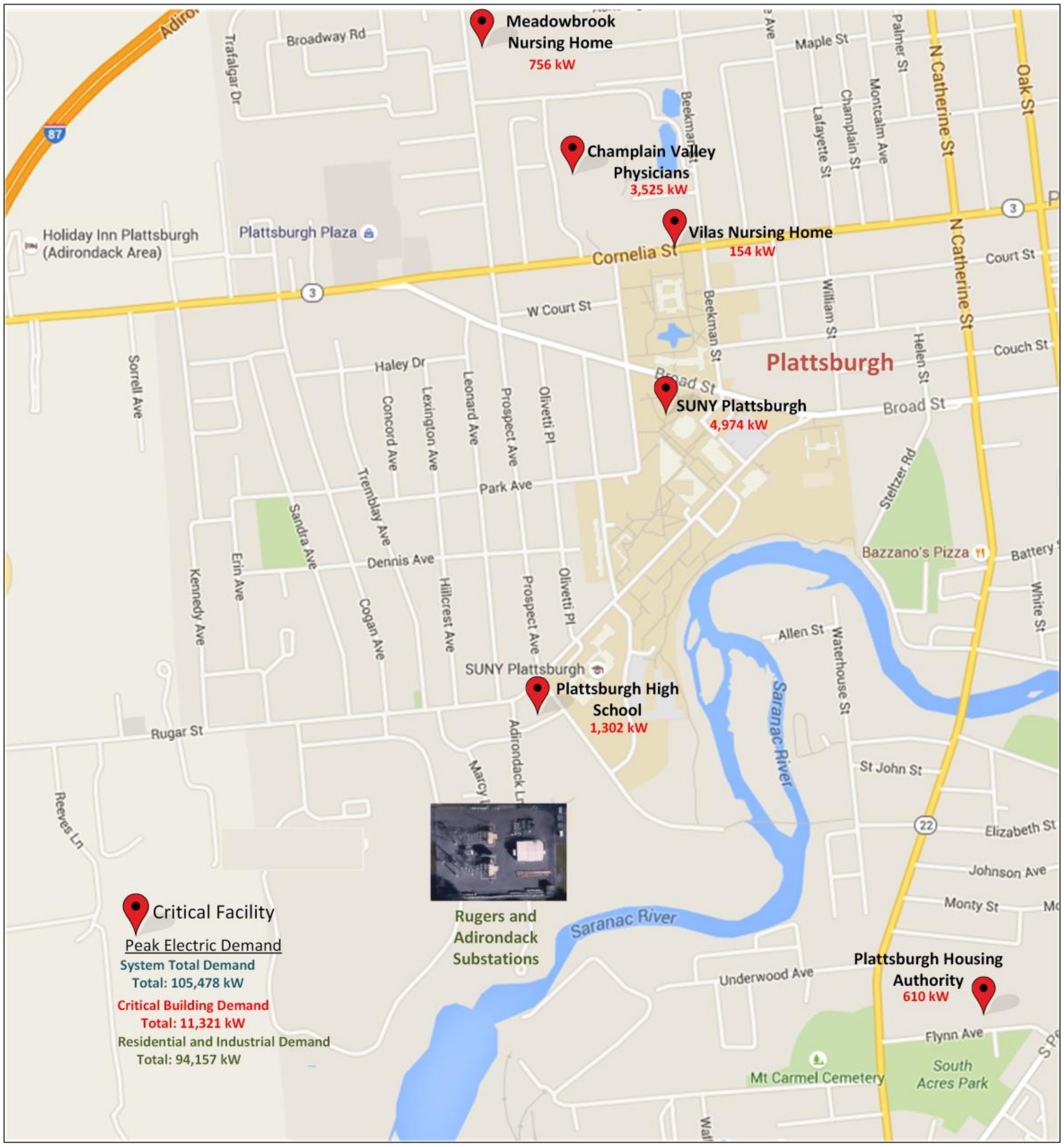


*Figure 9. Load Simplified Equipment Layout Diagram*

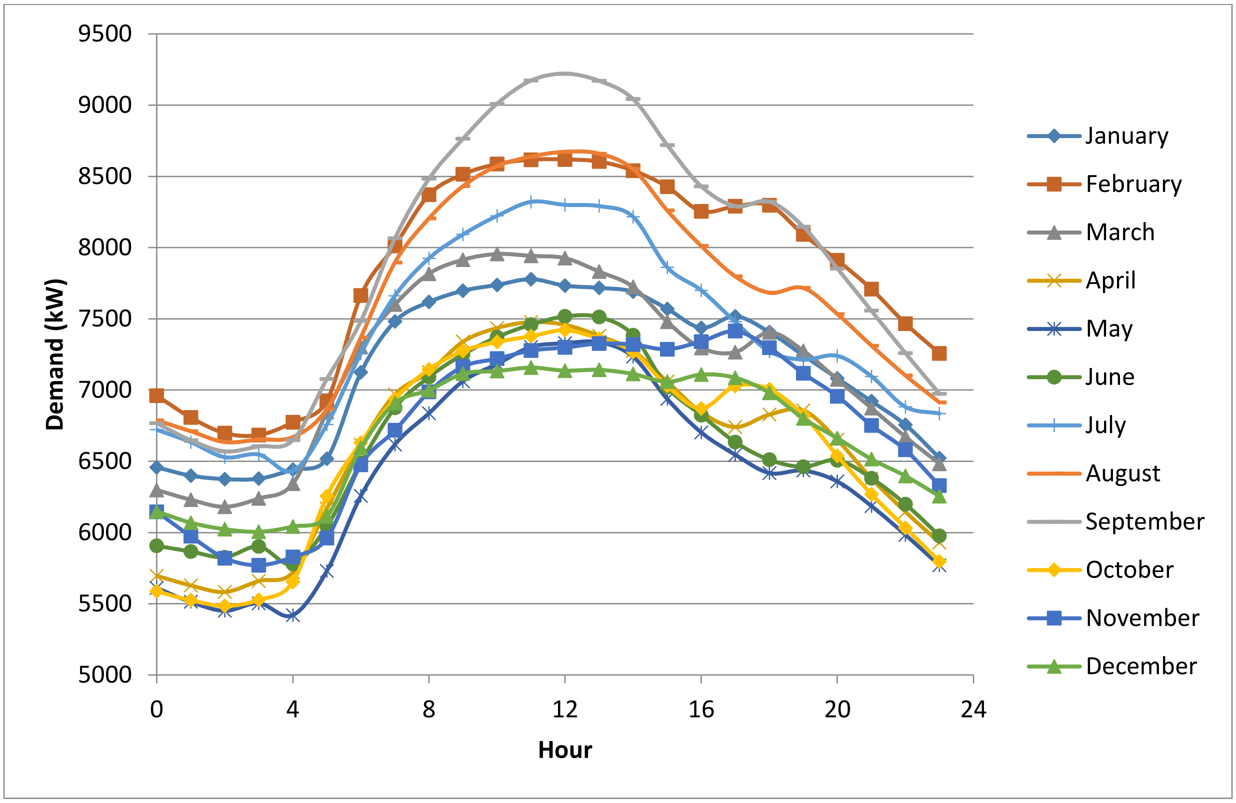


*Figure 10. Plattsburgh Average Daily Load by Month*

Figure 10 shows the hourly load profile of the total system load that is served by the microgrid.

## Energy Efficiency Projects

SUNY Plattsburgh is subject to the NY Governor's Executive Order 88 (EO 88) directing state agencies and authorities to improve the energy efficiency of state buildings. Under EO 88, SUNY Plattsburgh must, by April 1, 2020, reduce the average Energy Use Index (EUI) of the campus buildings by at least 20% from the same building's EUI for the state fiscal year 2010/2011. SUNY Plattsburgh has undergone a comprehensive energy audit as part of formulating an energy master plan, funded by NYPA. The final audit report, delivered in the fall of 2015, indicates that SUNY Plattsburgh has already completed energy efficiency projects resulting in an annual energy savings of 38,584 MMBtu and a cost savings of $151,418. This energy savings translates to a 6.85% reduction in EUI. This same report recommends a "cost-effective portfolio" of energy efficiency measures that would result in an additional 17.91% reduction in EUI, a 100,889 MMBtu annual energy savings, and a $638,863 annual cost savings. There is an additional 6.12% EUI reduction (34,478 MMBtu, $236,988) that is not recommended because the measures are not cost-effective. Some of the energy efficiency projects that SUNY Plattsburgh has already started or completed are:

- Installing ballasted new roof with 4" rigid insulation on 14 buildings (279,000+ $ft^2$ of roof surface for $5M+).

- Replacing all single pane windows in nine buildings with 1" Argon-filled insulated glazing units with Solarban60 low-e coating, costing $7.1M+ and increasing R values from 0.94 for the old windows to 3.5 for the new windows.
- Reducing ventilation energy in 21 Hudson Main building labs resulting in a forecasted annual energy cost savings of $11,200.
- Reducing computer energy consumption via software resulting in a forecasted annual energy cost savings of $28,500.

Plattsburgh High School recently completed two energy efficiency projects. The school replaced 500-watt canister auditorium lights with new energy-efficient 38-watt fixtures and replaced T12 gym light fixtures with energy efficient T-8 fixtures. One third of the new gym fixtures are provisioned with back-up emergency lights. Also, in 2015, the high school replaced its roof, improving the insulation from R5 to R35.

PMLD is a member of the Independent Energy Efficiency Program (IEEP), which manages a broad base of energy efficiency programs for municipal electric utilities across New York. With its support, PMLD has completed the following:

- 2011: $406,877 spent on lighting upgrades, upgrading motor efficiency/VFD drives, AMR meters, appliance upgrades and residential insulation improvements
- 2012: $417,000 spent on upgrading motor efficiency/VFD drivers, lighting upgrades, AMR meters, appliance upgrades and commercial insulation improvements
- 2013: $329,825 spent on commercial and residential insulation improvements, appliance upgrades, upgrading motor efficiency/VFD drives, installing motion sensor lighting control and lighting upgrades
- 2014: $330,372 spent on residential insulation improvements, appliance upgrade, upgrading motor efficiency/VFD drives and lighting upgrade
- 2015: $372,854 planned for residential insulation improvements, appliance upgrade, upgrading motor efficiency/VFD drives and lighting upgrade.

Before any microgrid project is undertaken, Willdan recommends that all the partner facilities undertake energy efficiency measures in order to minimize the size of any required generation. Willdan estimates that a 15% load reduction across the microgrid could be achieved.

## Sub Task 2.3 Distributed Energy Resources Characterization

The existing DER among the proposed microgrid facilities is all backup generation fueled by natural gas, fuel oil, diesel, or propane. The facilities have a total average demand of about 6.3 MW and backup generation capabilities of about 5.8 MW. They retain fuel for between 48 and 96 hours of operation, and after that, they rely on fuel deliveries. See table 8 for a summary of the backup generation and figure 6 for the generator locations. The hospital can meet all its critical power needs with its existing backup generation, and of course is required to do so by laws and regulations. It does occasionally have to curtail some air conditioning load on hot summer days. The hospital is not interested in running this generation to provide power to the rest of the microgrid as they would worry about run hours and maintenance issues. The SUNY campus can meet some of its needs, but not all of its dorms are fully powered, and it cannot continue to operate fully as a university during an outage. The Vilas and Meadowbrook homes can meet their needs with exiting backup generation, although Meadowbrook does need to curtail some load in peak load situations. The PHA Oak Street building can only operate emergency lighting and elevators during an emergency. The high school has no backup generation and currently closes and sends students home in case of an outage.

The combination of CHP, Solar, and Energy Storage, Scenario 4 in table 14 in the results section, would meet the electrical and heating load needs of the microgrid, provide a robust and resilient alternate to grid power, and help the campus and the state of New York meet their energy efficiency goals. The additional generation provided by the microgrid, also seen in figure 6, would also allow the university to be more fully operational during an emergency, would provide the hospital with additional backup and resilience, would allow Vilas and Meadowbrook to have full backup without worrying about fuel supplies and maintenance issues, would allow PHA to be more functional and keep residents in place, and would allow the high school to serve as an emergency shelter for the community. The high school, as well as Memorial Hall and the field house on the SUNY campus, are designated as emergency shelters but currently have no backup generation. Additionally, the proposed natural gas-fired CHP generation would eliminate the costs of generator maintenance and testing, possibly even enabling facilities to sell their generators, and the natural gas generation would produce fewer emissions than existing diesel generation. Furthermore, the natural gas pipelines would provide added resiliency as fuel would not need to be shipped to the facilities in the event of a prolonged outage, and underground pipelines have a high level of resilience.

The proposed CHP plant would be powered by a natural gas-powered internal combustion engine. Heat from the plant would be added to the existing high temperature hot water (HTHW) loop on the SUNY campus. This loop is currently fed by four dual fuel (natural gas or fuel oil) boilers and is used for space heating and domestic hot water. During summer one of the boilers continues to operate, supplying domestic hot water. Waste heat would need to be utilized year round in order to qualify for NYSERDA incentives[1]. Additionally, the heat could be used to heat the field house, replacing the existing electric heat in this facility, or to heat the pool, but the additional thermal infrastructure that would be required and the distance of these facilities from the central heating plant would likely make this cost-prohibitive. The CHP plant could be located closer to one of these facilities, but colocation with the central heating plant would likely be easier from an operational and technical standpoint.

[1] http://www.nyserda.ny.gov/All-Programs/Programs/Combined-Heat-and-Power-Performance-Program


*Figure 11.Existing and Proposed Backup Generators in Plattsburgh*

*Table 10. Existing Backup Generators and Critical Facilities*

| Location | Total Capacity (kW) | Fuel Type and Capacity (kW) | Critical Facilities Avg. Demand (kW) | Critical Facilities Peak Demand (kW) |
|---|---|---|---|---|
| SUNY Plattsburgh | 3,107 | #2 Fuel oil: 2,737<br>Natural gas: 200<br>Portable diesel: 170 | 3,325 | 4,974 |
| CVPH | 1,500 and 800 | Diesel | 2108 | 3,525 |
| High School | None | N/A | 239 | 1,302 |
| Meadowbrook Nursing Home | 250 | Diesel | 237 | 756 |
| Vilas Nursing Home | 175 | Diesel | 55 | 154 |
| Plattsburgh Housing Authority | Minimal (emergency lighting and elevators only) | Propane | 380 | 610 |
| **Total** | **5,832** | | **6,344** | **11,321** |

Solar panels, with associated battery storage are also proposed for the microgrid. These would help meet one of SUNY Plattsburgh's goals, which is to reduce its carbon footprint by using renewable energy. Siting for the solar panels has not yet been determined.

The final piece of DER considered for the microgrid would be a hydropower installation in the gravity-fed intake pipes of the city's water plant. Upon further analysis, it's unlikely that this piece would be incorporated into the actual microgrid due to the plant's distance from the other facilities, but it could produce power for the plant itself. In particular, the City of Plattsburgh is exploring the idea of sharing water with the surrounding Town of Plattsburgh. Power from the hydro installation could be used to power the pumps that would be necessary to pump the water to the Town, which is at a higher elevation.

The water treatment plant runs about 2.5 million gallon per day (mgd) on average with not much variation between the daily minimum and the daily maximum. However, this flow is throttled, and the plant engineer estimated it could be at least 10 mgd. The head at the plant is about 300 feet. A rough estimate of the available power follows:

10 mgd = 10*1.548 = 15.48 CFS

Maximum power comes from flow of 15.48 / sqrt (3) = 8.92 CFS

Power = (flow x head)/11.8 = (8.92 x 300) / 11.8 = 226.8 kW

Assuming a turbine efficiency of 0.87 and a generator efficiency of 0.975 the available power = 226.8*0.87*0.975=192.4 kW.

## Sub Task 2.4 Electrical and Thermal Infrastructure Characterization

PMLD owns and operates the distribution system within the city to serve approximately 20,000 residents. The Rugers substation feeds the SUNY Plattsburgh campus from breakers 7 and 8 on a 12.47 kV loop. The substation location is shown in figure 12. The adjacent Adirondack substation is being phased out and will be decommissioned. The other proposed microgrid facilities are fed from other substations on 4.16 kV radial path feeders that are shared with by other non-microgrid load on the PMLD system. The PMLD substations are grid-tied to NYPA and served on 46 kV transmission lines.


*Figure 12. Substations in Plattsburgh*

The PMLD distribution system uses mechanical switches as its primary protection; there is no communication and no remote control using any type of Supervisory Control and Data Acquisition (SCADA) software. Power quality is good on the PMLD system. In particular, the power factor is very high due to the high level of resistance heating in the city.

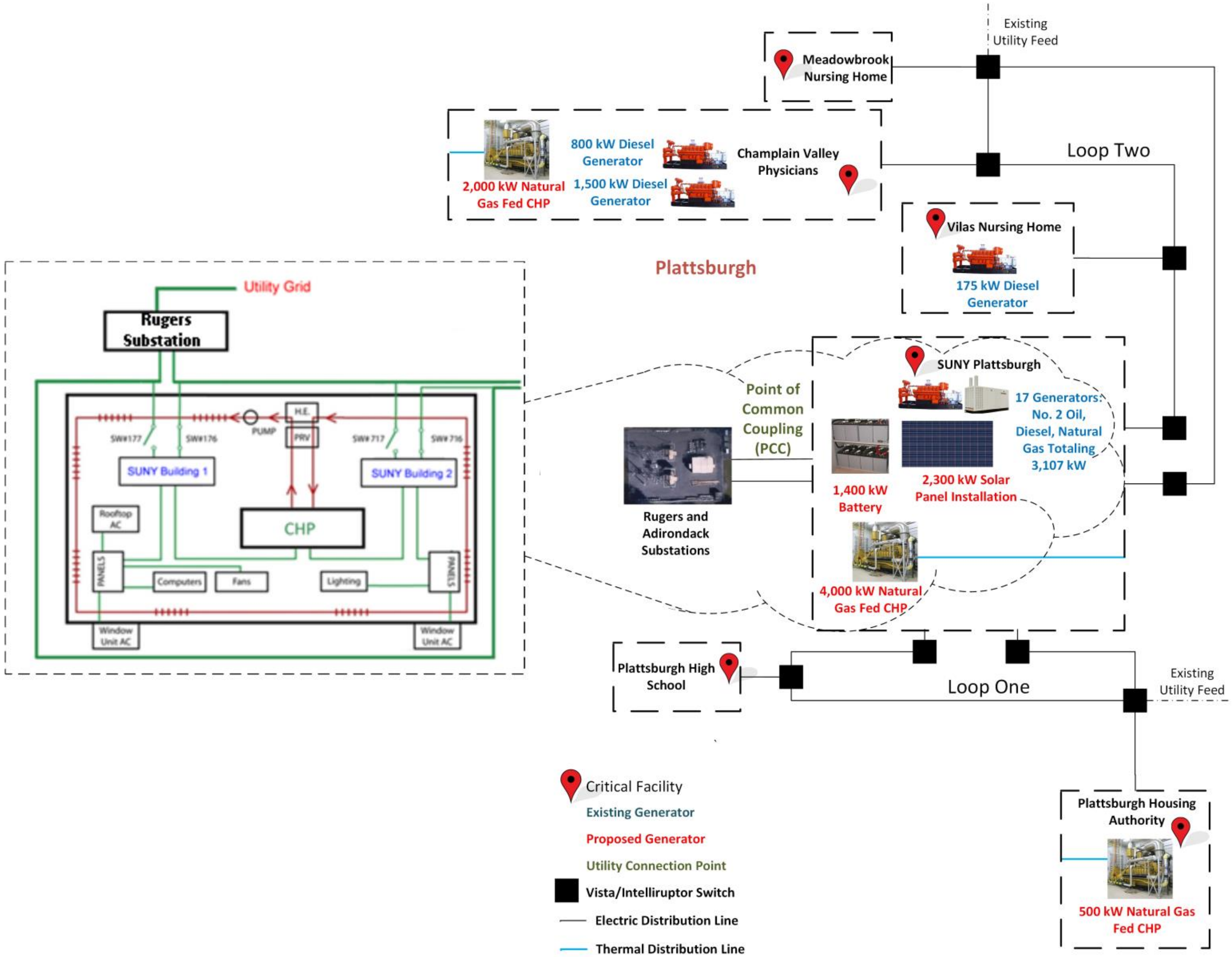


*Figure 13. Conceptual Loop Based Design of the Microgrid*

Willdan proposes a loop-based community microgrid for Plattsburgh which has the capability of supplying power to critical loads from two feeders in order to improve the energy resilience of critical facilities. The generation of local DERs would be shared between the critical facilities through new express lines connecting the critical buildings. Although the proposed loop-based structure would require more investment, it would improve the resiliency of the critical facilities significantly. In cases of extreme weather events, if one feeder fails, the building will still receive power from the other feeder. This new distribution network has a meshed structure which can operate either as a loop or as a radial path, though it would normally operate as a radial path (i.e., with no loop) so as to make the protection coordination easier (upstream to downstream) and to make the distribution design easier. Also, Automatic Transfer Switches (ATS) are proposed to be deployed within the community microgrid, which have the capability of network reconfiguration in case of emergency or an outage. The detailed configuration of the PMLD distribution system is not available at this time, so the conceptual design shown in figure 13 is a general layout. The squares represent the ATS which can operate in three ways to reconfigure the network or isolate the loads. Thermal distribution infrastructure would be added to the facilities with installed CHP plants as indicated in the conceptual design by the blue lines.

## Resilience of the Electrical and Thermal Infrastructure

Resilience refers to the ability of a system or its components to adapt to changing conditions and to withstand and rapidly recover from disruptions. The electrical and thermal infrastructure is vulnerable to many phenomena, such as hurricanes, earthquakes, drought, wildfire, flooding, and extreme temperatures. In the North Country, where Plattsburgh is located, snow storms and ice storms are a common threat. They can cause damage to overhead wires, make infrastructure repairs difficult, and pose a threat to residents who may be left without heat. The peak loads in winter due to the widespread electric heating in Plattsburgh exacerbate this situation. At SUNY Plattsburgh, an extended winter outage may force the university to send students home due to inadequate backup power in some of the dorms and the inability to fully function as a university. However, travel at this time would likely be limited, resulting in a difficult situation. Some extreme weather events have become more frequent and severe in recent years due to climate change. The community is concerned with “polar vortex” conditions, which occurred in 2014 and 2015, becoming more common and creating a condition where prolonged power outages would endanger residents. Hurricane Irene, which occurred in 2011, caused widespread flooding and damage as well as power outages in Plattsburgh. Also heat waves in summer could affect distribution lines and any equipment that needs to be cooled off, such as transformers and battery storage. A wind gust could cause tower/pole and conductor faults due to trees falling. Increased extreme weather makes upgrading distribution infrastructure and emergency planning and restoration more important. Natural gas disruptions are less likely than electricity disruptions; however, it is relatively more difficult to recover from the outages than it is in electric systems because of the difficulty in locating and repairing underground leakages. The damage from extreme weather events can impose large costs on the distribution system and severe impacts on the local economy.

## Sub Task 2.5 Microgrid and Building Controls Characterization

### Microgrid Control Architecture

Figure 14 shows the overall Plattsburgh community microgrid elements, functions, and control tasks associated with reliability and economics. In order to optimize the 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 (primary, secondary, and tertiary) are applied to the microgrid to support the proposed community microgrid in grid-connected and islanded operations:

- 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.

Primary and secondary controls are performed at the DER level using the local component controls. The centralized tertiary controls are performed by the master controller. The primary control utilizes the droop control in order to share the load among DER units with droop characteristics and avoid circulating currents among DER units because of different set points on real and reactive power dispatch. The secondary control restores the nominal frequency of power supply in islanded operation. Tertiary control is the upper level of the control system, which ensures the optimal operation of the microgrid by determining the set points of the generation and load to meet demands in grid-connected and islanded modes.

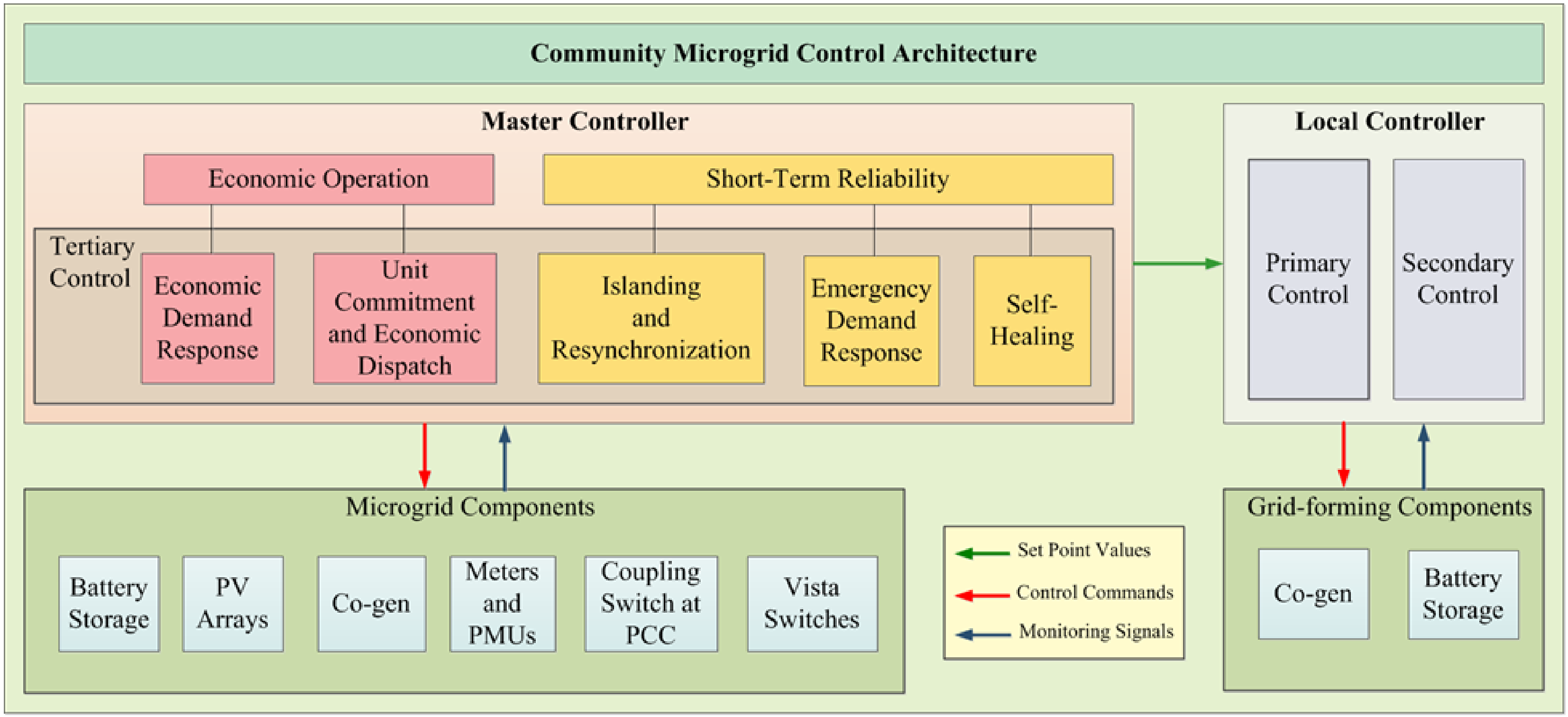


*Figure 14. Objectives and Functions for the Control and Operation of the Plattsburgh Community Microgrid*

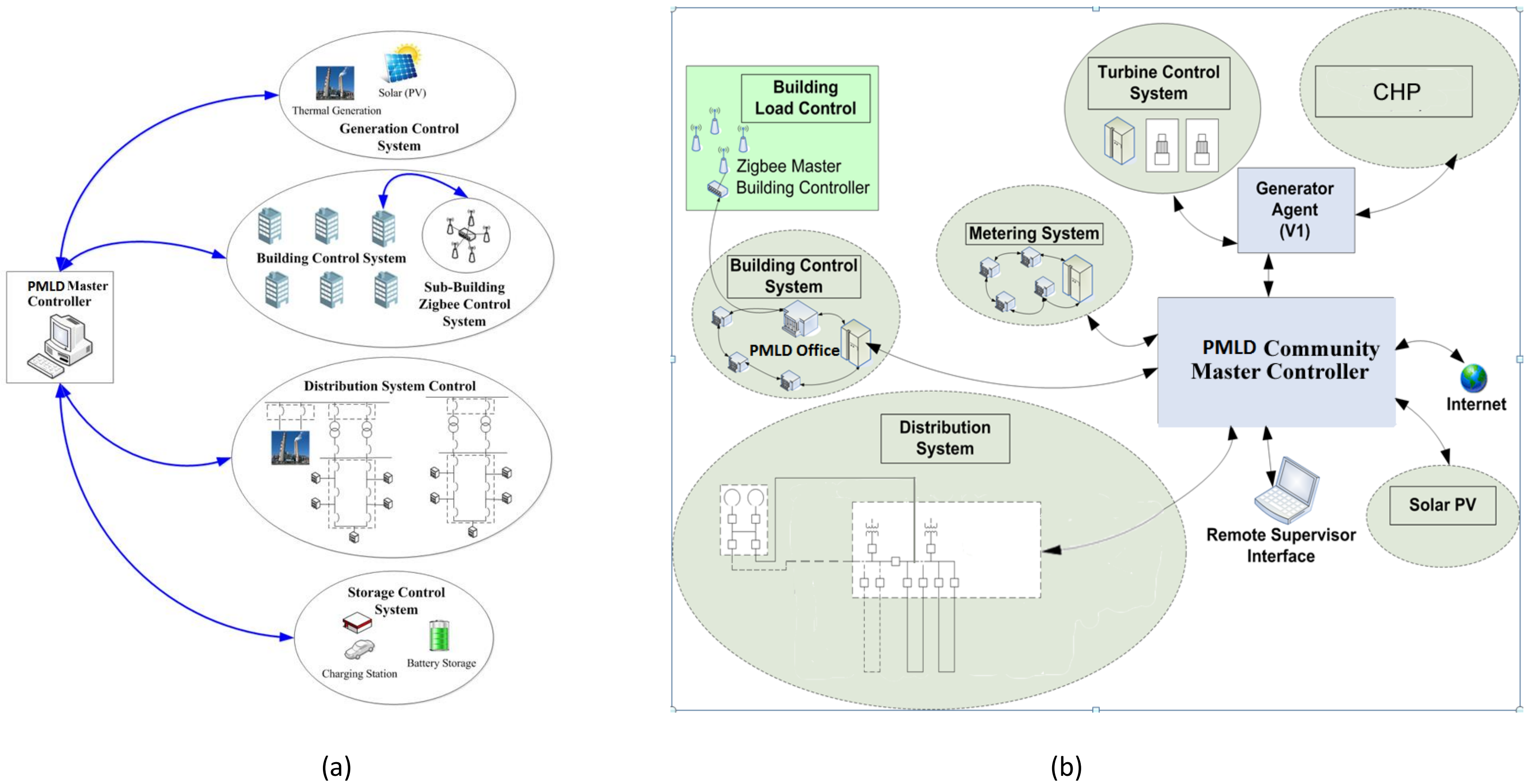


*Figure 15. Architecture of the Plattsburgh Community Microgrid Master Controller*

A major element of the Plattsburgh community microgrid is its master controller. The control signals from the master controller (MC) include the setpoints to adjust the proposed CHP or other dispatchable DERs within Plattsburgh (grid-forming elements for maintaining frequency and voltage if any), and the signals to open/close switches. 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. Intelligent switching and advanced coordination of the master controller technologies through the communication systems facilitates rapid fault assessments and isolations. In case of the failure of master controller, the primary control and secondary control would keep maintaining the stability of voltage and frequency within Plattsburgh community microgrid. The main functions of the Plattsburgh community microgrid master controller are as follows.

- Communications and errors management – detection and or safe shutdown
- P/Q control for generators
- Energy Storage System Management
- Point of Common Coupling (PCC) management - Power factor correction
- PCC management - Peak shaving/smoothing
- PCC management - Islanding and reconnection to grid
- Following active power command and voltage management
- Loss of communications safety
- Power limits, both kW and kVAR
- Loss of generation/storage asset management during grid-tied conditions
- Loss of generation/storage asset management during islanded conditions
- Unit commitment/availability
- Load shedding/Shifting
- Event logging

Plattsburgh community microgrid master controller (MC) provides the tertiary control functions for economic optimization and event-driven actions. Economic optimization is part of the unit commitment and economic dispatch functions (UC/ED).

*Economic Operations:*

- UC/ED (day-ahead):
  - Executed daily (islanded or grid-connected mode)
  - Initiated by MC for a 24-hour horizon and hourly time intervals
  - Objectives: cost minimization
  - Input: day-ahead forecasts for load, ancillary services requirements, solar PV, component status, fuel price, market price of electricity, load curtailment cost, maximum allowable load curtailment, utility grid power limit, and the ramping capability of co-gen and battery
  - Output: hourly commitment and dispatch of co-gen, battery, and demand response of adjustable loads (setpoints for controllable elements)

- UC/ED (real-time):
  - Executed every 1 minute (islanded mode, or for regulation of power exchange between utility grid and microgrid in grid-connected mode), every 10 minutes (grid-connected mode), or based on events (sudden step change of load, reconnection of load)
  - Initiated by MC for the next 1 minute or 10 minutes
  - Objective: cost minimization
  - Input: the current operating point, forecasted load and solar PV in the next 1 minute (islanded mode) or 10 minutes (grid-connected mode) , ancillary services requirements, component status, fuel price, market price of electricity, economic demand response flag, load curtailment cost (for economic demand response), maximum allowable load curtailment (for economic demand response), utility grid power limit, and the ramping capability of co-gen and battery
  - Output: set points for co-gen and battery, trip signals for load switches of load groups to be curtailed (for economic demand response)

The Plattsburgh community microgrid master controller will run a day-ahead scheduling optimization algorithm which will optimize the use of microgrid local generation and balance the hourly demand response (load curtailment and shifting of non-essential microgrid loads) for minimizing the cost of supplying the microgrid load. At times, the controller will consider demand response rather than power purchases from the grid. The generation dispatch signals are sent to distributed energy resource (DER) units, and the load signals are sent to building controllers across the SUNY Plattsburgh campus and the neighbor critical buildings. The master controller also receives the day-ahead price of electricity, weather data, cloud coverage and other data for utilizing the renewable sources within the community microgrid.

An interactive grid-forming control would be used either in island or grid-connected mode. In island mode, DERs apply this control scheme to share the load, while in the grid-connected mode DERs apply this control scheme to regulate the power exchange between the microgrid and the utility grid. In the grid-connected mode, the DER unit with grid-following control follows the microgrid voltage and frequency, which is set by the utility grid in grid-connected mode and by other DER units in island mode.

The hierarchical secondary control approach would receive information from loads and power supply entities as well as information on the status of the distribution network and implement the optimal solution via an hourly unit commitment and real-time economic dispatch. Figure 14 shows the hierarchical framework of the master controller proposed for the microgrid project. In figure 15, 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.

With the master controller, the Plattsburgh 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 SCADA. Normally the master controller would operate in autonomous mode based on predefined rules while optimizing the reliability and economics of the microgrid. In case of emergency, the master controller would isolate the microgrid from the utility grid and operate in island mode. Within the microgrid, the non-critical load could be curtailed or disconnected through smart meters or ATS, and the local distribution network would be reconfigured so that the local DERs could supply power to the critical loads.

## Plattsburgh Community Microgrid Controllable Resources

Master controller incorporates the following controllable resources:

- Grid-forming (controllable) resources: co-gen and battery; load adjustment (for economics/reliability management); load curtailment (for resilience purposes),
- Grid-following resources: solar PV and/or any other intermittent renewable resources which will be treated as negative load.
- Loads, loads are prioritized or grouped for curtailment;

### *Local Controls*

Generation and load management within Plattsburgh community microgrid is performed locally through local generator controls and customer load controllers, or building load management systems. In addition, protection, system re-configuration, and load restoration schemes of the microgrid is managed by distribution automation scheme, coordinated through event-driven commands from the master controller.

### *CHP Control*

CHP facility is equipped with a local generation control unit to manage operation of the natural gas turbines and unit cycling, if required. The local controller receives active and reactive power setpoints from the master controller during the grid connected mode for the CHP power dispatch. The fine tuning of the generation output is implemented through droop control scheme with adjustable setpoints. Once the system is islanded, CHP unit can be switched to Isochronous mode to operate at fixed speed (for the given frequency setpoint) and to regulate voltage within the island (based on the voltage setpoint). CHP unit control and operation is essential in ensuring the stability of the island. Each CHP manufacture utilizes vendor-specific control device for generator control and operation. The CHP control is in charge of engine start-up, synchronization and shut-down steps. The control utilizes “Power Control” for grid-parallel operation with user-adjustable active power setpoint, and speed control for island (isolated) operation. The multiple engine configurations have a master synch control panel, this assists with transitioning back and forth among multiple units and load balancing.

### *Battery Energy Storage System (BESS) Control*

As an example, PureWave Storage Management System[1] (SMS) package from S&C is considered in Plattsburgh community microgrid. The SMS with high energy density can provide power flow control (charge/discharge) and/or frequency control in the islanded mode. The power conversion system (PCS)

[1] http://www.sandc.com/products/energy-storage/sms.asp

of the SMS is comprised of four bidirectional inverters in parallel with 250 kW/268 kVA rating per inverter. The PCS is connected to the Plattsburgh community microgrid through a 1.5 MVA step-up transformer. The BESS control platform combines a robust control and communication protocols that ensure a flexible converter configuration and versatile applications that support stable, effective, and efficient solutions for energy management, power smoothing, grid stability, and power quality. The master controller defines the setpoints of the inverter controller; communicates with the SMS to manage the battery status; and provides dynamic islanding capability and remote SCADA control, using DNP3 TCP/IP protocol.

#### *Distribution Automation Control*

Vista smart switches are applied throughout the microgrid. The switches are equipped with distribution automation scheme (DAS) for fault detection, isolation and circuit reconfiguration. Each structure within the scheme can incorporate and control eight switches in the decision approach. Each distribution automation scheme is supervised by a “Coach”. The coaches from adjacent schemes have the responsibility to communicate and coordinate the operation of the switches within a scheme based on thermal load rating of each source feeding the schemes, and fault detection/location information. DAS monitors real time current and voltage throughout the Plattsburgh system and uses this information to make smart switching decisions within Plattsburgh community microgrid. DAS uses loss of voltage for automatic disconnection of the switches within a team.  DAS equipped controls utilize DNP 3.0 protocol and peer-to-peer communication via radio or fiber-optic transceivers.

#### *Load Control and Building Management Systems*

Critical building loads within the SUNY Plattsburgh campus and neighbor area are either controlled directly and/or through their building management system. Building controllers facilitate the building consumption management. The reduction in building consumption is accomplished by defining several operating modes representing different consumption levels in each building. Once the operation mode for each building is set by the master controller, the building controller will send signals to sub-building controllers to set the requested load level associated with the selected mode and feeds back the confirmation signal to the master controller to acknowledge the mode change. The building controllers are also able to monitor and control the energy flow within the buildings including hot and chilled water flow, heating and cooling loads, and can monitor the temperature of different spaces within the building.

#### *Services and Benefits of the Plattsburgh Community Microgrid*

The proposed microgrid would be able to provide black start services, frequency and voltage support, and active and reactive power control. The functions provided by the master controller within Plattsburgh community microgrid are described as follows. The islanding would follow the procedure shown in figure 16, resynchronization follows the procedure shown in figure 17 and self-healing follows the procedure in figure 18, respectively.

- Plattsburgh community microgrid Islanding

  - Event driven which is initiated by relays at PCC (based on the loss of grid frequency and voltage)
  - Signals are sent by PCC relays to individual switches for a priority-based load shedding (emergency demand response in islanded mode) if the microgrid frequency cannot be restored at the secondary control level. Hierarchical control will then set the normal frequency and voltage at the islanded mode.
  - Mater Controller will perform load restoration (via tertiary control) by committing offline units and dispatching grid forming elements (objective: maximize load restoration based on the current operating point, estimated loads to be restored, and the ramping capability of co-gen and battery; output: setpoints for co-gen and battery, close signals for load switches)

- Plattsburgh community microgrid resynchronization
  - Event driven which is initiated by microgrid operator
  - Passive synchronization approach will be used.
  - Check frequency difference (<0.1 Hz) and voltage magnitude difference (<3%) for reconnecting the first feeder
  - Check frequency difference (<0.1 Hz), voltage magnitude difference (<3%), and voltage angle difference (<10o) for reconnecting the second feeder; MC sends resynchronization signal to the relay at PCC when conditions are satisfied.
  - Master controller will perform load restoration once the PCC switch is reclosed (objective: maximize load restoration based on the current operating point, estimated loads to be restored, and the ramping capability of co-gen and battery; output: setpoints for co-gen and battery, close signals for load switches)
  - Black start (executed by MC using pre-defined black start procedure)

- Plattsburgh community microgrid Self-Healing
  - Event driven by fault
  - Fault located and isolated by switches for self-healing
  - If fault leads to the permanent opening of the switch, signal will be sent to MC to perform UC/ED (real-time) for load balancing; Master controller will perform another UC/ED (real-time) once the switch is reclosed and fault is cleared.
  - Load transfer: event driven; losing one feeder -> load transferred to the other feeder; lose both feeders -> islanded mode); initiated by Vista switches based on pre-defined load transfer procedure

- Plattsburgh community microgrid Emergency Demand Response
  - Event driven by utility grid request (grid-connected mode), or trip of co-gen (grid-connected mode or islanded mode)
  - Master controller performing priority-based load shedding
  - Master controller performing priority-based load reconnection once the emergency demand response is completed
  - Master controller performing real-time UC/ED to balance the generation and load

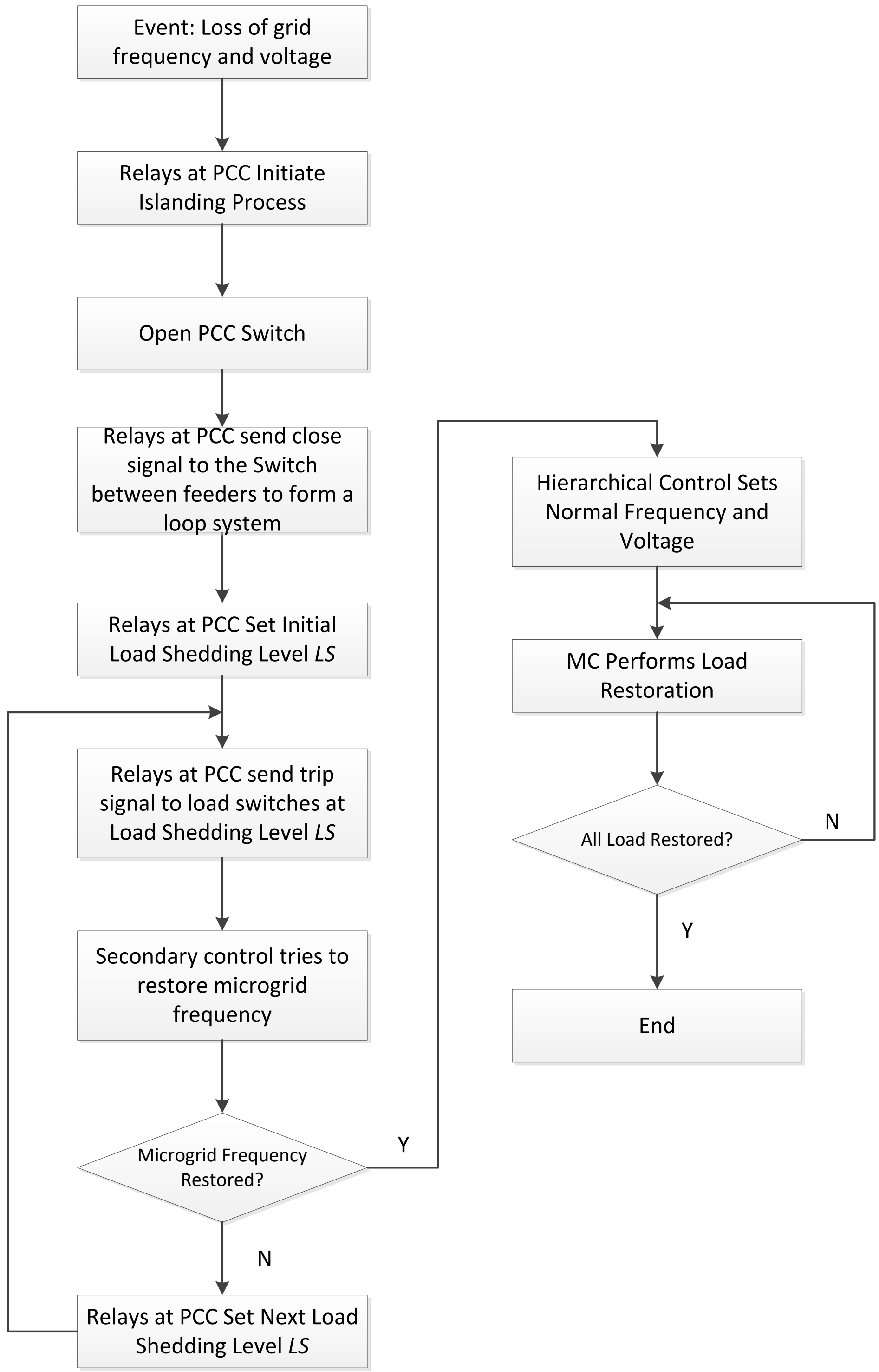


*Figure 16. Plattsburgh Community Microgrid Islanding Procedure*

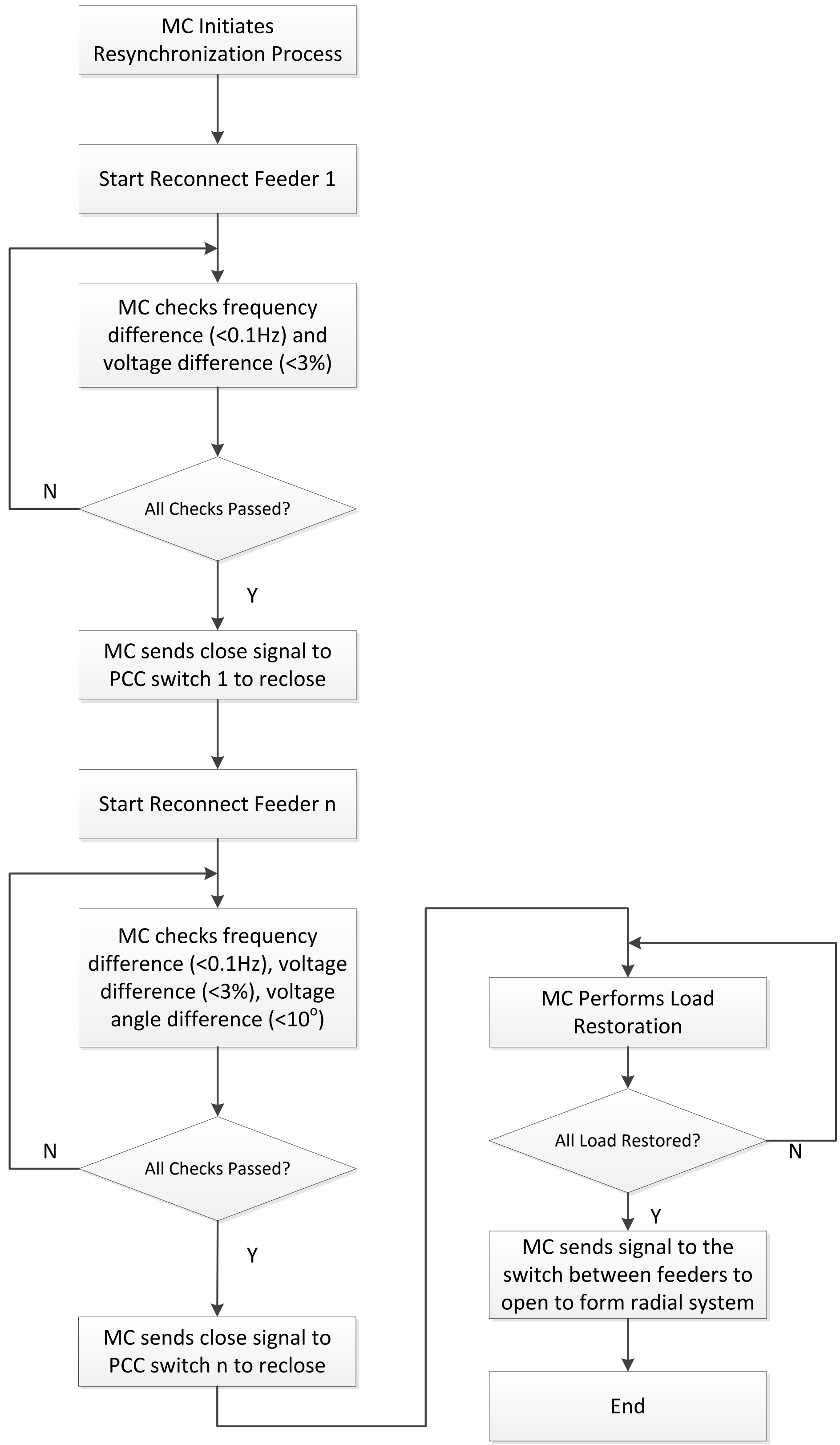


*Figure 17. Plattsburgh Community Microgrid Islanding Resynchronization Procedure*

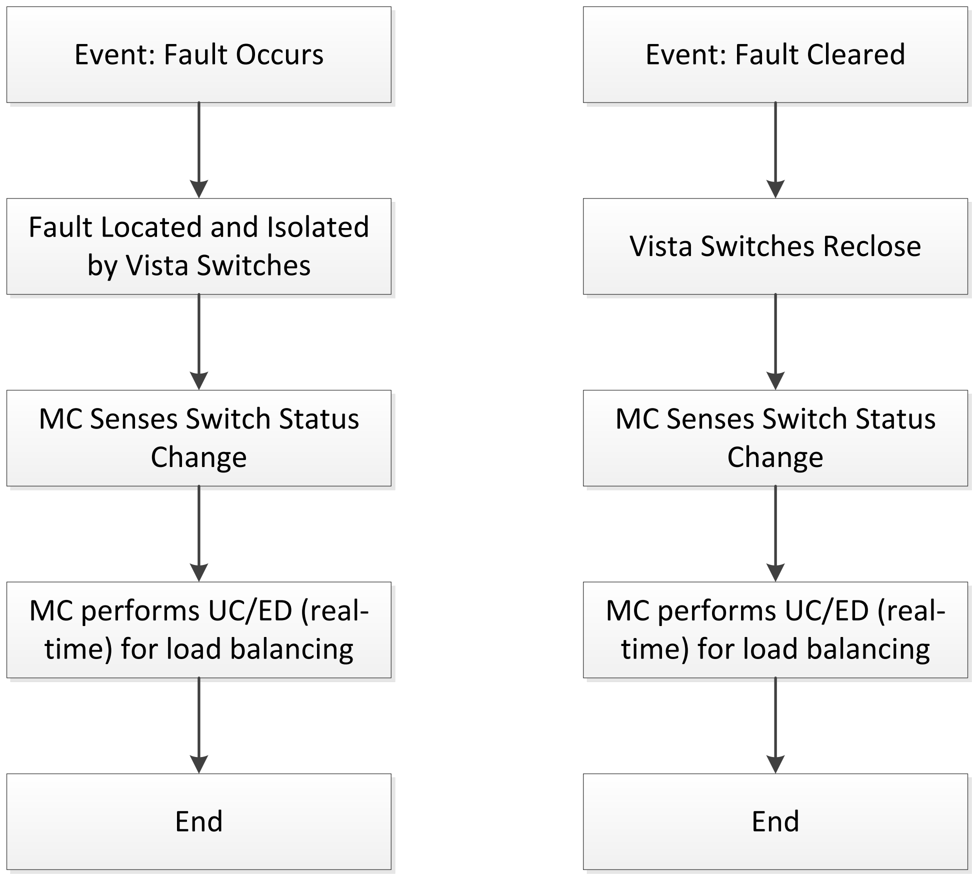


*Figure 18. Plattsburgh Community Microgrid Islanding Self-healing Procedure*

The PMLD distribution system has a very good power factor due to the prevalence of electric heat. The proximity of power generation to microgrid load could result in improved power quality, lower power losses, better voltage stability, and higher reliability (fewer customer outages) by engaging fewer components and by eliminating additional transmission services. With the added DERs, ATS, and other smart devices, the proposed Plattsburgh 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:

1. *Increase safety and resiliency*

   The reliability would be improved in normal operating conditions through infrastructure reconfiguration, using a high reliability distribution system which senses and clears faults with virtually no impact on building loads. The grid would be made more self-healing and fault-tolerant 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 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 would be mitigated by a natural gas-fed CHP plant, which would maintain a black-start capability in the event that the outage occurs when the CHP facility is not active. This plant would rely on robust natural gas pipelines and produce enough power to serve all of the critical facilities as well as public street lighting and security lighting.

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

   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 the availability of Distributed Energy Resources (DERs), the master controller would optimally dispatch the units to provide the cheapest, cleanest, and most reliable energy possible to the microgrid facilities.

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

Any modern utility or system operator relies heavily on communication infrastructure to monitor and control 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 building a microgrid, assessment and upgrade of the equipment and protocols used in the microgrid distribution network will be performed.

A large majority of PMLD customers are individually metered; however, these meters are read manually every month by a meter reader. PMLD has no existing SCADA system and does not have smart switches or digital substations or any communications infrastructure associated with these resources. 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 indicating the location and scope of the issue. Limited and delayed information leads to man hours wasted and longer outages, 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.

PMLD would benefit from an Advanced Metering Infrastructure (AMI) expansion, which would involve adding wireless communication infrastructure throughout the City of Plattsburgh 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. This allows signals to hop between installed meters to reach their ultimate destination, thereby increasing the propagation range of the signal. The integrated NICs are connected to a local access point that transmits data over a cellular wireless network back to the utility data center, see figure 19. For example, the metering and control signals for streetlights could be fed into a Supervisory Control and Data Acquisition (SCADA) platform for use in billing or monitoring the overall system.

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

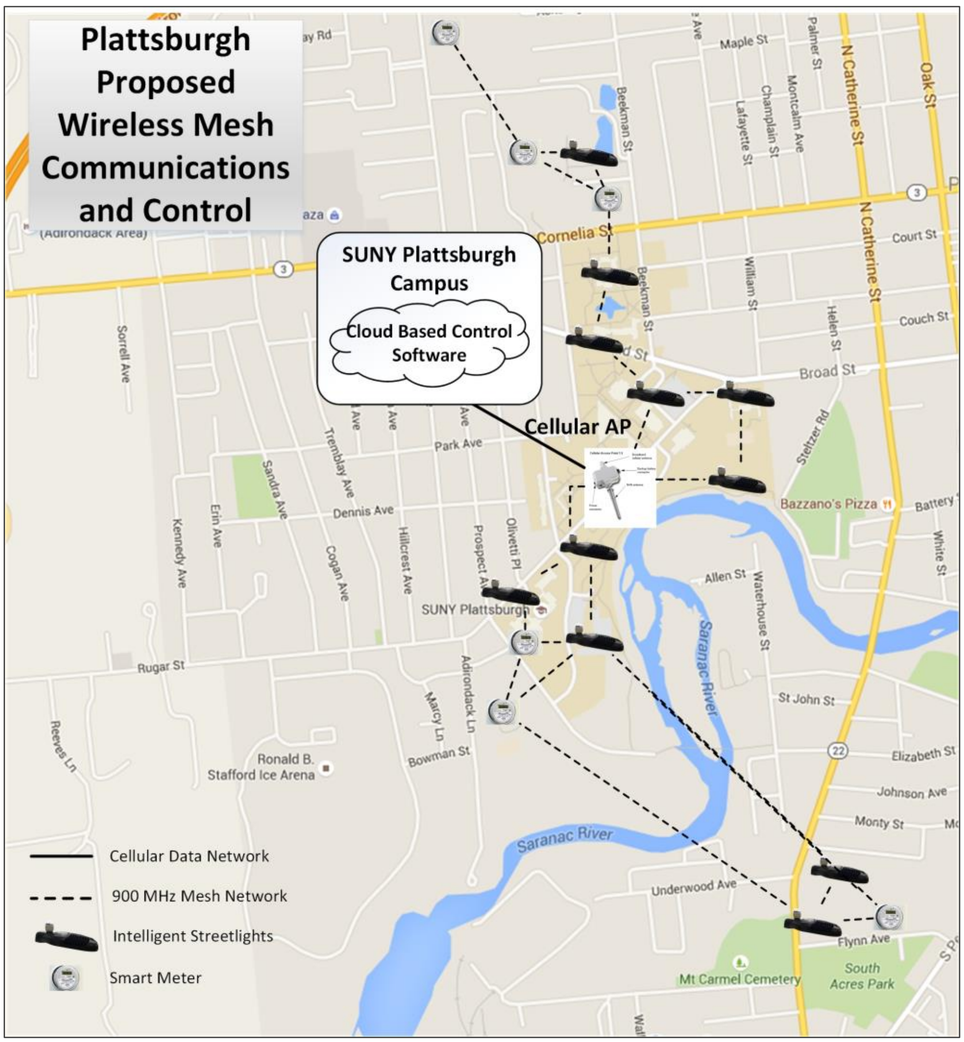


*Figure 19. Plattsburgh Proposed Wireless Mesh Network Communications and Control Diagram*

The communications 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.

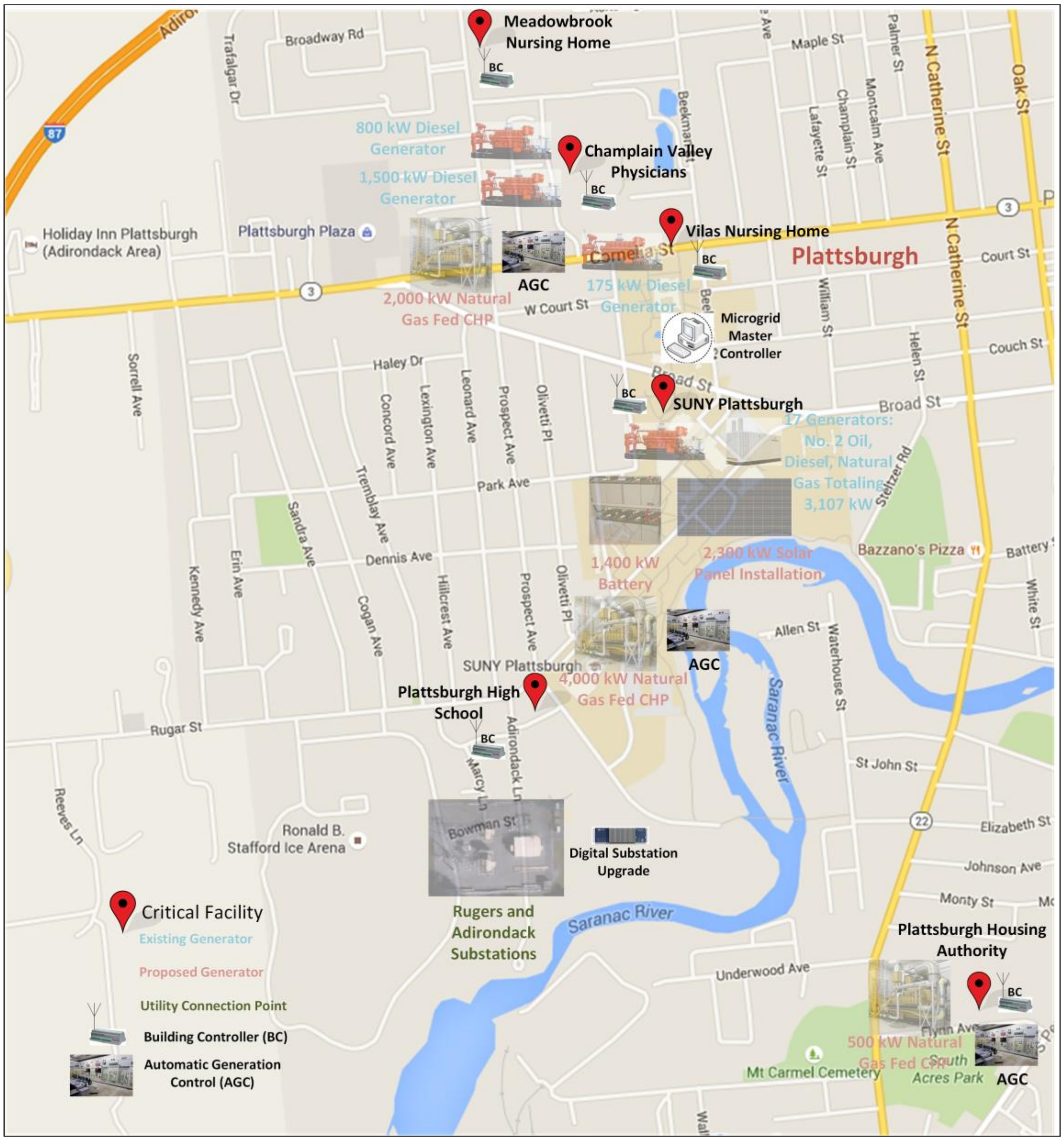


*Figure 20. Network Equipment Simplified Layout Diagram*

In addition to smart meters and intelligent control of loads like 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 microgrid control 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 a SCADA system to allow operators to access, visualize, and control all of the microgrid assets.

*Table 11. Existing and Proposed Controls*

| Critical Buildings | Existing | | Proposed | |
|---|---|---|---|---|
| | Controls | Systems Controlled | Controls | Systems Controlled |
| SUNY Plattsburgh | Honeywell EBI BMS | HVAC | Microgrid Master Controller, Upgraded Building Controls, Automatic Generation Control | HVAC, Load, Generation |
| CVPH | Limited | Limited | Upgraded Building Controls, Automatic Generation Control | HVAC, Load, Generation |
| Plattsburgh High School | Limited | Limited | Upgraded Building Controls | HVAC, Load |
| Meadowbrook Nursing Home | Limited | Limited | Upgraded Building Controls | HVAC, Load |
| Vilas Nursing Home | Limited | Limited | Upgraded Building Controls | HVAC, Load |
| Plattsburgh Housing Authority | Limited | Limited | Upgraded Building Controls, Automatic Generation Control | HVAC, Load, Generation |

In order to implement the communications network, a more extensive review of existing communications and control equipment would need to be performed to determine the exact quantity and specification of the required equipment, however, the current and proposed upgrades for basic microgrid controls are seen in table 9. The Microgrid Master Controller would be located on the SUNY Plattsburgh campus and configured to communicate with the microgrid facilities' individual building controllers.

Additionally, RF testing would need to be performed to determine the exact layout of the proposed wireless network. Training would have to be done on the SCADA system and the newly implemented relays, and personnel 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 would have to be obtained to determine exact cost savings of upgrading to the new system.

The proposed microgrid would rely heavily on the robust fiber optic backbone, see figure 21, and the 900 MHz mesh network for monitoring and control. This system remains extremely resilient in the face of inclement weather due to the fiber optic being underground and to the mesh network using heavily redundant mesh radios.

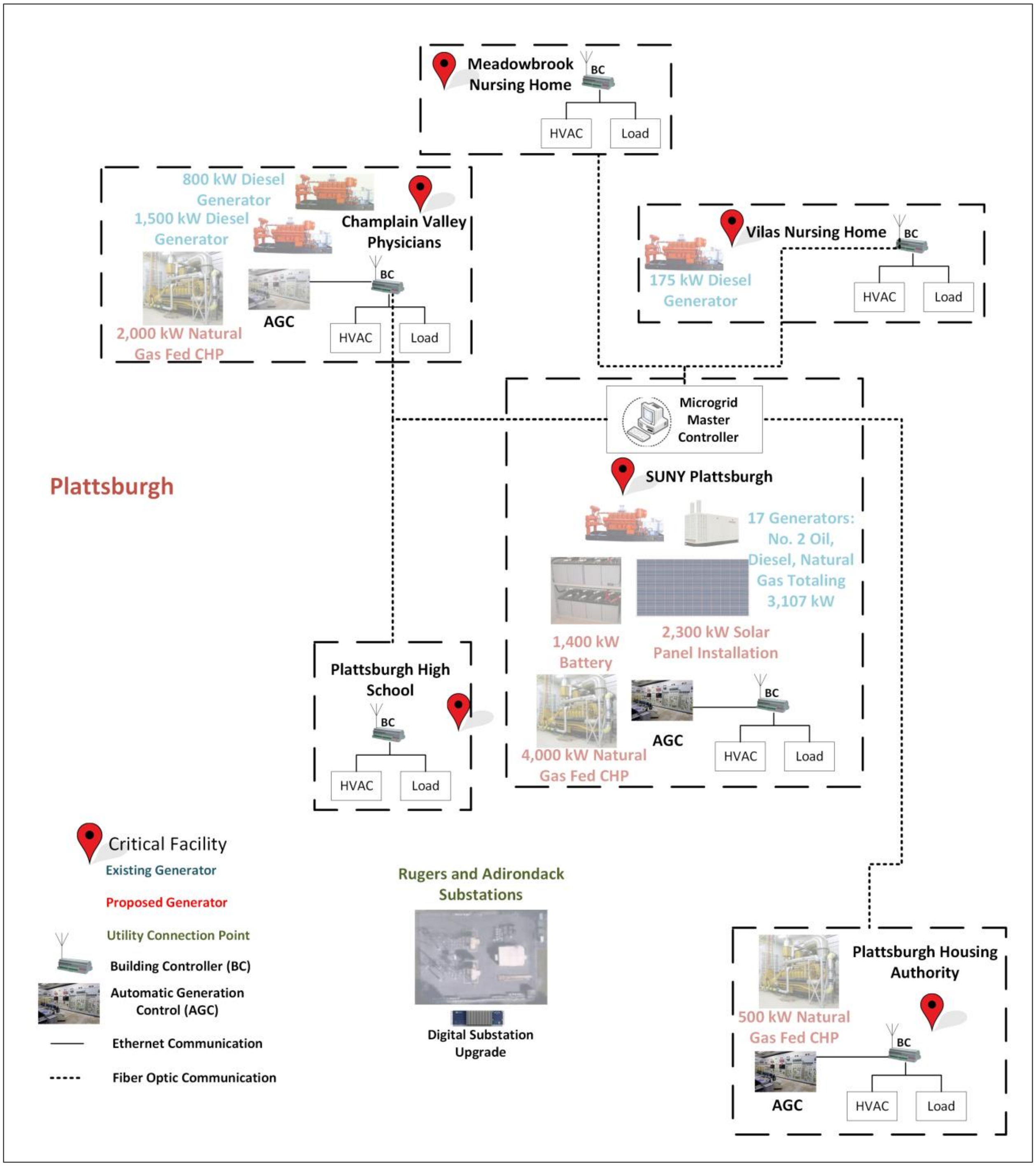


*Figure 21. Proposed Communications Layout*

## 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 quantitative microgrid analysis.

The main objective of DER-CAM is to minimize either the annual costs or the $CO_2$ emissions of providing energy services to the modeled site. It recommends a mix of purchased utility electricity and natural gas and distributed generation and takes into account both operational costs and amortized capital and maintenance costs. 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. Figure 1 shows the overall structure of DER-CAM, and additional information is available on BNL's DER-CAM website[1].

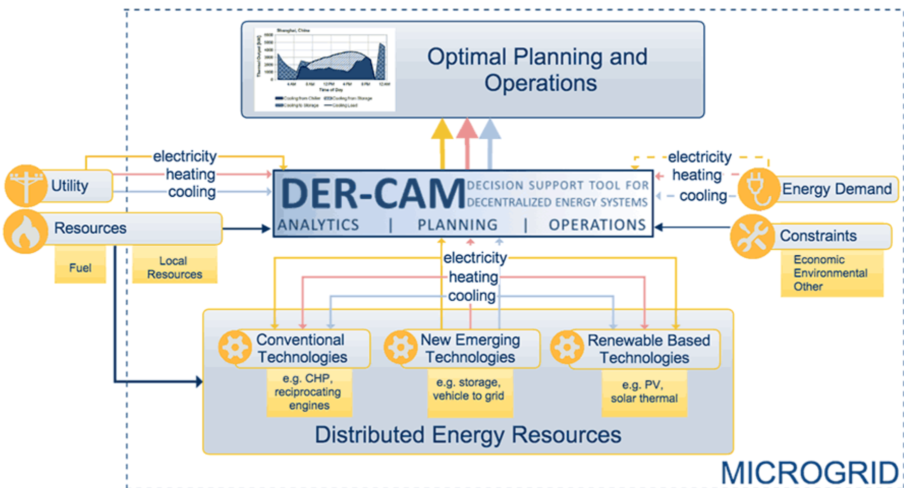


*Figure 22. Schematic of Information Flow in DER-CAM[2]*

### *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, and 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 microgrid facilities. Due to the nature of PMLD's manual metering, hourly load was not available for a number of the facilities. Therefore, the SUNY Plattsburgh campus and the CVPH hourly electric load profiles were scaled based on the peak load of the other facilities to obtain load estimates for all of the critical facilities. For heating load, usage was obtained from utility bills for the facilities that use natural gas for heat, CVPH and SUNY Plattsburgh. Then, the average demand was estimated based on this monthly

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

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

usage. Finally, the demand was applied to an hourly temperature curve to obtain a rough estimate of hourly heating load.

### Utility tariff

Based on PMLD billing data, the average energy price for the participating microgrid facilities was calculated to be $0.031/kWh, and the average natural gas price was $0.71/therm.

### Technologies investment

Both photovoltaic solar and electric Storage were considered for the microgrid; their investment parameters are seen in table 12. CHP units were considered in step sizes of 500 kW, 250 kW, and 100 kW (table 13). Costs were obtained from EIA[1] and from NREL[2,3].

*Table 12. Continuous Investment Parameters*

| Technology | Fixed Cost ($) | Variable Cost ($/kW) | Lifetime (Years) | Fixed Maintenance ($/kW/Month) |
|---|---|---|---|---|
| Electric Storage | 0 | 400 | 15 | 0.069 |
| PV | 0 | 3250 | 30 | 0.25 |

*Table 13. Discrete Investment Parameters*

| Technology | Max Power (kW) | Lifetime (Years) | Capital Cost ($/kW) | O&M ($/kWh) | Fuel | Efficiency | Alpha (Heat to Power Ratio) |
|---|---|---|---|---|---|---|---|
| **CHP** | 100, 250, or 500 | 20 | 1200 | 0.011 | NG | 0.32 | 1.4 |

### Weather information

Averages for hourly solar irradiance (Global Horizontal Irradiation), hourly temperature, and 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.  The weighting factor was set to minimize energy cost.

### *Simulations*

The following steps describe the process that was used to run the various simulations in DER-CAM:

[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

Step 1:

A base case without any investment was simulated to obtain the reference cost. In this case the annual cost, as well as optimal heat and electricity dispatch, were calculated using DER-CAM. The optimal dispatch chart is shown in tables 23 and 24. The calculated annual operational cost was used for the following steps as a reference cost. Costs are shown in table 12.

Step2:

An investment case was simulated to see the economic and $CO_2$ emissions benefits produced by incorporating DER into a microgrid. This case asked DER-CAM to recommend the optimal DERs based on their operational cost and amortized capital cost. The results showed that DER-CAM did not recommend any DER – the optimal financial strategy is to continue to purchase all electricity and natural gas from the local utilities. Additional simulations were run for a microgrid during normal operations in grid-connected mode. These simulations were run to determine if changing certain parameters would make DER financially worthwhile. According to the results, the only scenario in which DER does become financially viable is if the price of electricity increases to at least $0.06/kWh. The simulations that were run are as follows:

1. Implementing demand response at the point of common coupling (PCC) with levels of 5%, 10%, 15%, 20%, and 25% of the total load
2. Implementing direct load control with load reductions of 5%, 10%, 15%, 20%, and 25% of the total load
3. Sensitivity to electricity price increase, from $0.03/kWh to $0.11/kWh
4. Sensitivity to natural gas price increase, from $0.69/therm to $3.52/therm
5. Sensitivity to load increase, from 5% to 25%

Additionally, simulations were run to maximize load recovery when the microgrid is running in island mode due to either a planned or an unplanned outage. These simulations were as follows:

1. An outage lasting hours (summer and winter, off- and on-peak)
2. An outage lasting days (summer and winter off- and on-peak)
3. An outage lasting a week (summer and winter off- and on-peak)

Step 3:

Additional scenarios were created to account for all manner of resiliency situations the microgrid might encounter, such as main backup generators being out of commission or not shared by the microgrid or CHP being limited or being out of commission.

### *Simulation Results*

The proposed microgrid focuses on providing electricity for the critical buildings while relieving high winter peaks due to electric heating. The total average critical building demand is about 6,344 kW (table 9). The installation of 5,000-13,000 kW of CHP would be able to adequately serve the entire critical load, depending on the level of load shedding implemented.

The charts below show how the microgrid load is currently served and how it would be optimally served assuming that the microgrid was built for reliability or other non-financial reasons.

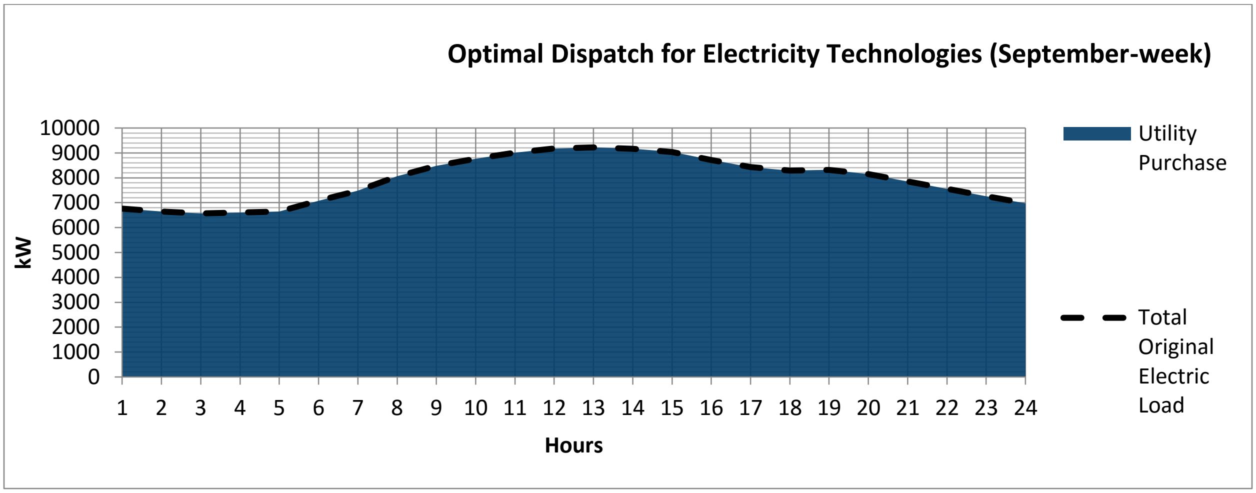


*Figure 23. Pre Investment Average Electricity Dispatch for Critical Facilities*

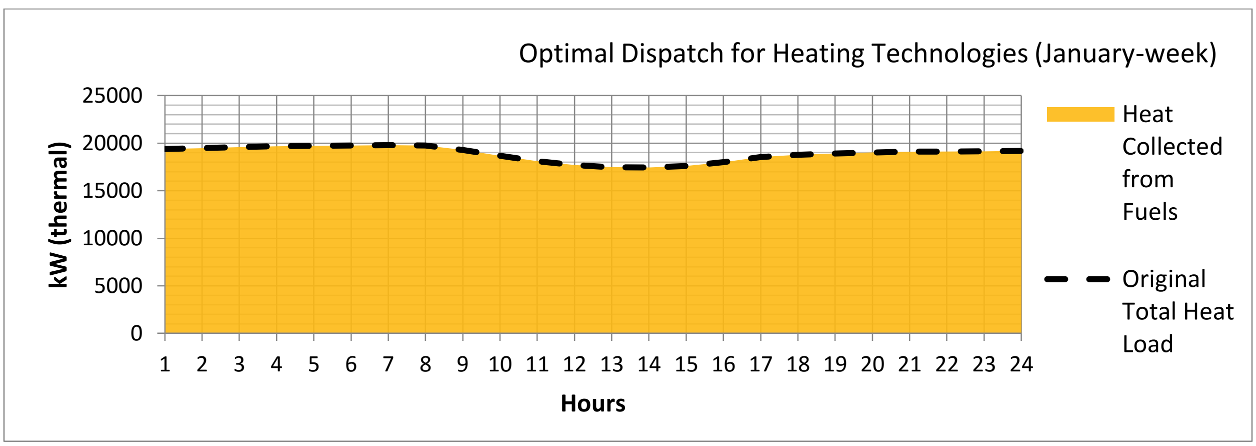


*Figure 24. Pre Investment Average Heating Dispatch for Critical Facilities*

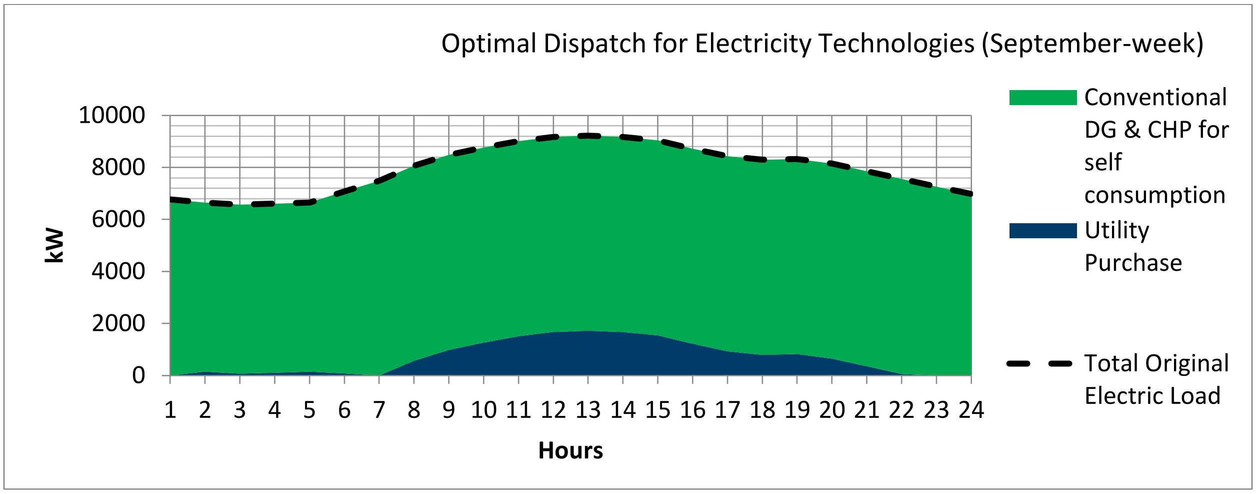


*Figure 25. Post Investment Average Electricity Dispatch for Critical Facilities*

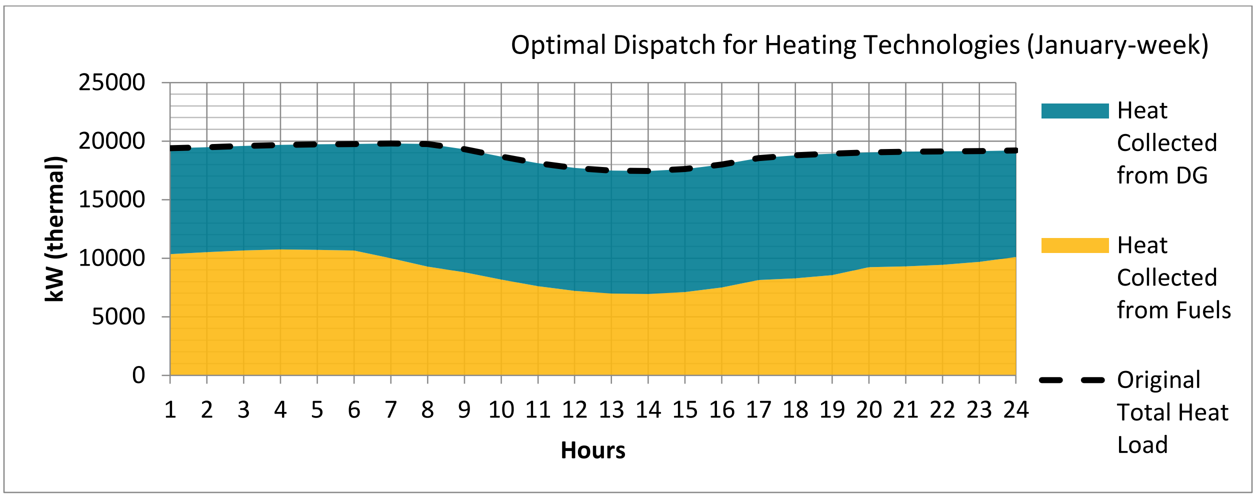


*Figure 26. Post Investment Average Heating Dispatch for Critical Facilities*

Figures 24 and 25 show DER-CAM simulation results for the critical buildings in the microgrid under normal base (interconnected mode) conditions with no added generation. Figures 26 and 27 show the same time period and load being served, but include 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). While heat is being generated, a CHP byproduct, electric power, will flatten the electricity curve throughout the day by the dispatch of the CHP units for electricity for self-consumption.

Figure 25 and 27 assume that the microgrid is built. However, based on the sensitivity analysis run in DER-CAM, the price of electricity would have to increase significantly before distributed generation makes economic sense (see figure 27). The current electric price in Plattsburgh is about $0.03/kWh, which is much lower than the national average. Were this price to rise, it would eventually become economical to install CHP for generating electricity and heat instead purchasing energy from the grid. This happens at a price of $0.06/kWh. Were the price to increase further, the annual system operation cost would start to become insulated from the price of electricity. This would be an economic benefit of the microgrid but would only occur at much higher electricity prices. Since such a large price increase is unlikely to occur in the near future, distributed generation will likely fail to be able to deliver a financial payback for some time to come.

The levelized cost of energy (LCOE), which the LCOE is calculated as Total life Cycle Cost/Total Lifetime Energy Production[1], for solar is around $0.125/kWh. Since the electricity price in Plattsburgh is much cheaper than the solar's LCOE, DER-CAM does not propose any solar installation if no another preference constraints are taken into account.

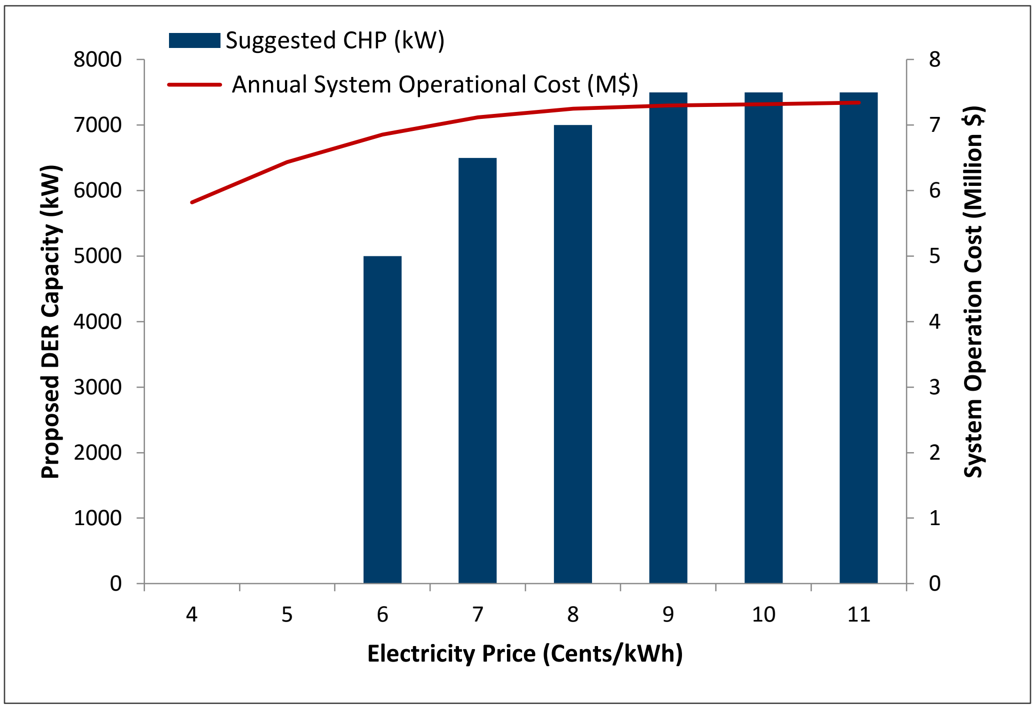


*Figure 27. Full System Sensitivity Analysis Results for Electricity Price*

DER-CAM was used to simulate a number of scenarios utilizing varying amounts of different types of distributed generation assuming this generation were installed for non-financial reasons. The simulation results for all the scenarios are summarized in table 14. In the case when the amount of CHP is limited, DER-CAM chose to serve the load with the more expensive option of solar and battery. Based on contingency analysis methodology[2], the largest backup generator in the proposed microgrid is considered out of service in scenarios 2-7.

[1] http://solarcellcentral.com/cost_page.html
[2] Vadari, Subramanian, and Mani Vadari. Electric System Operations: Evolving to the Modern Grid. Artech House, 2013.

**Scenario 1:** One week islanding

**Scenario 2:** One week islanding, 2.7 MW of diesel backup generation is in outage or in maintenance, maximum 5.5MW CHP is installed.

**Scenario 3:** One week islanding, 2.7 MW of diesel backup generation is in outage or in maintenance, maximum 6 MW CHP is installed.

**Scenario 4:** One week islanding, 2.7 MW of diesel backup generation is in outage or in maintenance, maximum 6.5MW CHP is installed.

**Scenario 5:** One week islanding, 2.7MW of diesel backup generation is in outage or in maintenance, maximum 7MW CHP is installed.

**Scenario 6:** One week islanding, 2.7MW diesel backup generation is in outage or in maintenance, maximum 7.5MW CHP is installed.

**Scenario 7:** One week islanding and 2.7 MW of diesel backup generation is in outage or in maintenance.

In the more environmentally friendly scenario (Scenario 4) in which solar and battery are considered, Willdan limited CHP to 6,500 kW; consequently 2,277 kW solar and 1.4 MW battery were suggested in order to supply power to critical facilities in case of a power outage. In addition, the total generation capacity would be enough to supply power for critical electrical loads in peak hours.

**Scenario 1**: Plattsburgh would need 5,250 kW of new DER in order to serve all the critical facilities in case of a utility grid outage. With the proposed 5,250kW DER along with the existing backup generation, all the loads can be served during the islanding time period. As shown in figure 28, all the critical loads can be picked up by the existing backup generation and the proposed DERs.

*Table 14. Serving Critical Facilities with Islanding in Peak Load Season*

| Scenario | Proposed CHP Capacity (kW) | Proposed Solar Capacity (kW) | Proposed Battery Capacity (kW) | Operation Cost, Including Amortized Investment Cost (K$) | Investment Cost (K$) | Averaged Investment Cost (K$/kW) |
|---|---|---|---|---|---|---|
| **1** | 5,250 | 0 | 0 | 5892.5 | 6,301 | 1.2 |
| **2** | 5,500 | 5,987 | 9,591 | 7,004.8 | 29,896.5 | 1.76 |
| **3** | 6,000 | 3,277 | 5,446 | 6,452.2 | 20,028.1 | 1.36 |
| **4** | 6,500 | 2,277 | 1,443 | 6,176.1 | 15,778.9 | 1.54 |
| **5** | 7,000 | 1,139 | 1,394 | 6,037 | 12,659.8 | 1.328 |
| **6** | 7,500 | 801 | 0 | 5,991.1 | 11,602.8 | 1.4 |
| **7** | 8,100 | 0 | 0 | 5,895.4 | 9,721 | 1.2 |

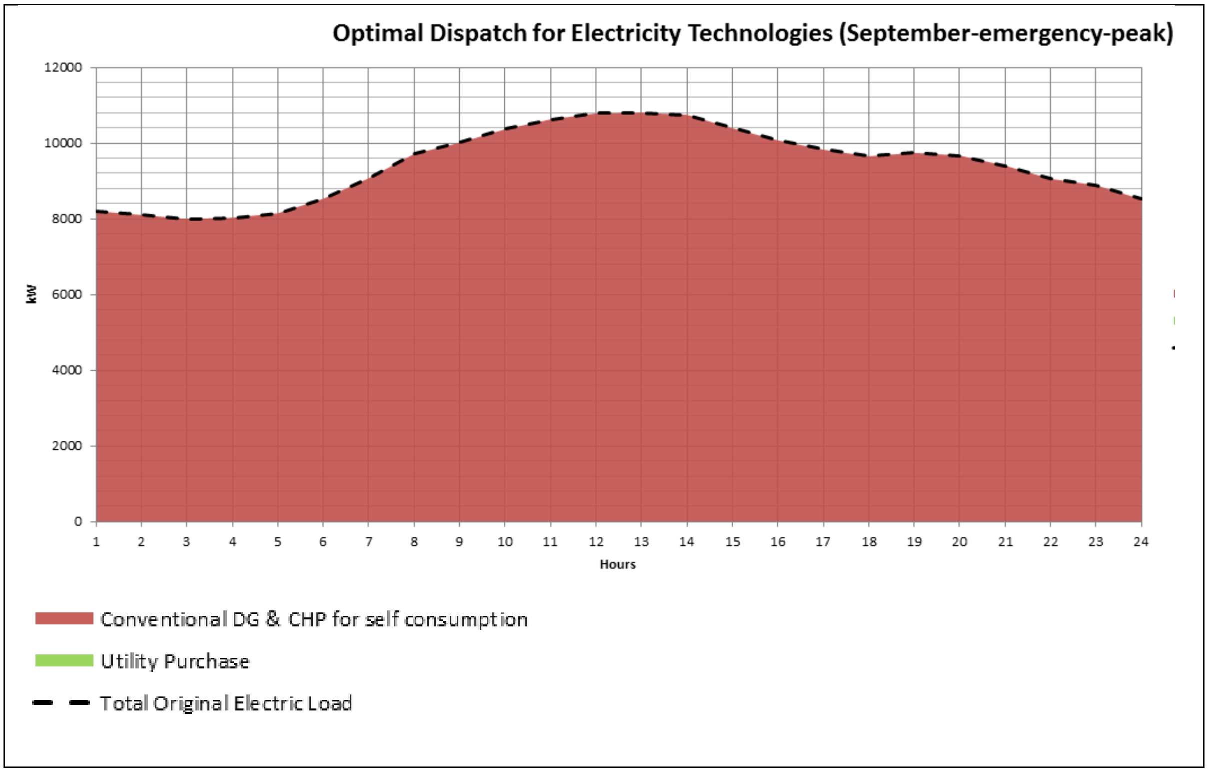


*Figure 28. Electricity Dispatch During Islanding Time Period in Scenario 1*

**Scenarios 2-6:** These scenarios demonstrate the simulation results under different preference conditions. Scenario 2 would integrate more renewable energy while Scenario 6 utilizes CHP for economic reasons. All the simulation results are also shown in figure 30. As the graph shows, the amount of suggested solar and battery would decline as more CHP is added. If SUNY Plattsburgh prefers to install solar and battery on campus for environmental and educational purposes, Scenario 4 may be the best option with around 2 MW solar and a corresponding 1.5 MW battery. Figure 30 shows the DER-CAM simulated investment results in which solar PV and battery are suggested by DER-CAM due to the forced cap of the CHP. The electricity dispatch for both the grid-connected mode and islanding mode are shown in figure 31 and figure 32 respectively. As seen in figure 32, all the loads would be satisfied by the combination of CHP, solar, and battery. With the proposed CHP in Scenario 4, the space heating load would partly be supplied by the CHP during winter time as shown in figure 33.

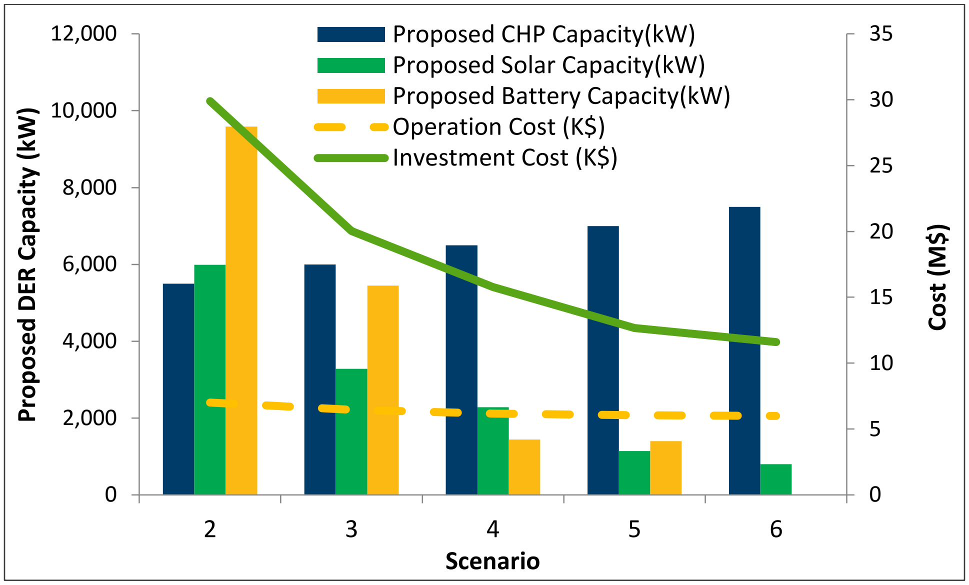


*Figure 29. DER-CAM investment results – Serving Total Load with island in Peak Load Hour in Scenarios 2-6*

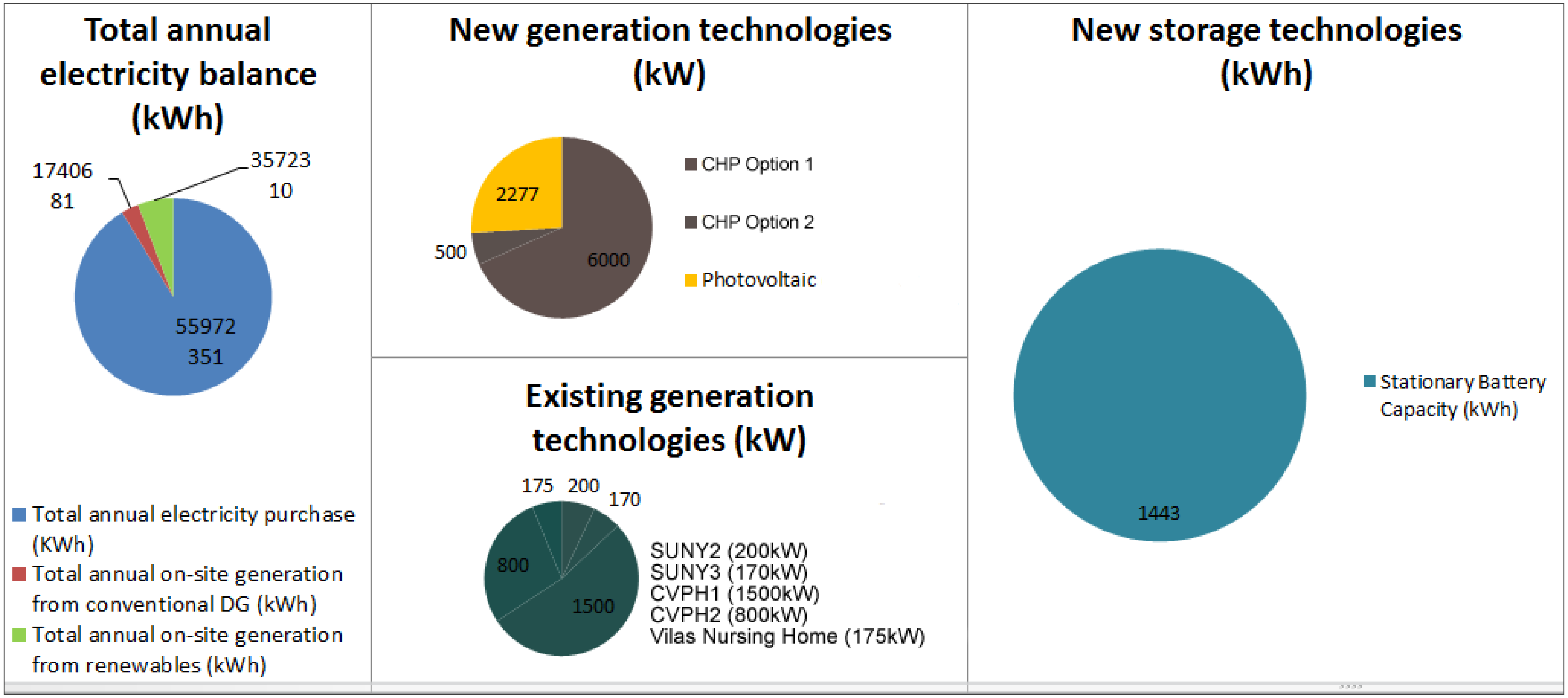


*Figure 30. DER-CAM investment results – Serving Total Load with island in Peak Load Hour in Scenario 4*

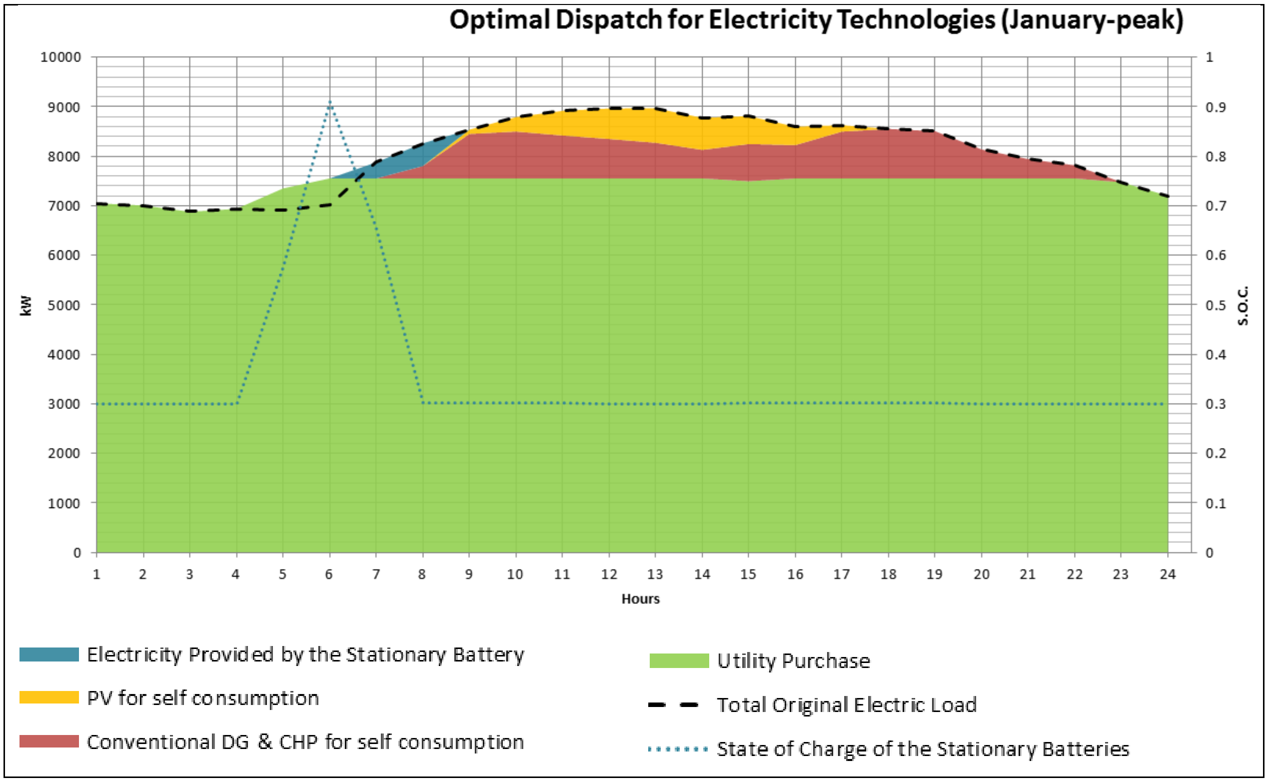


*Figure 31. DER-CAM investment results – Electricity Dispatch in Grid-Connected Mode in Scenario 4*

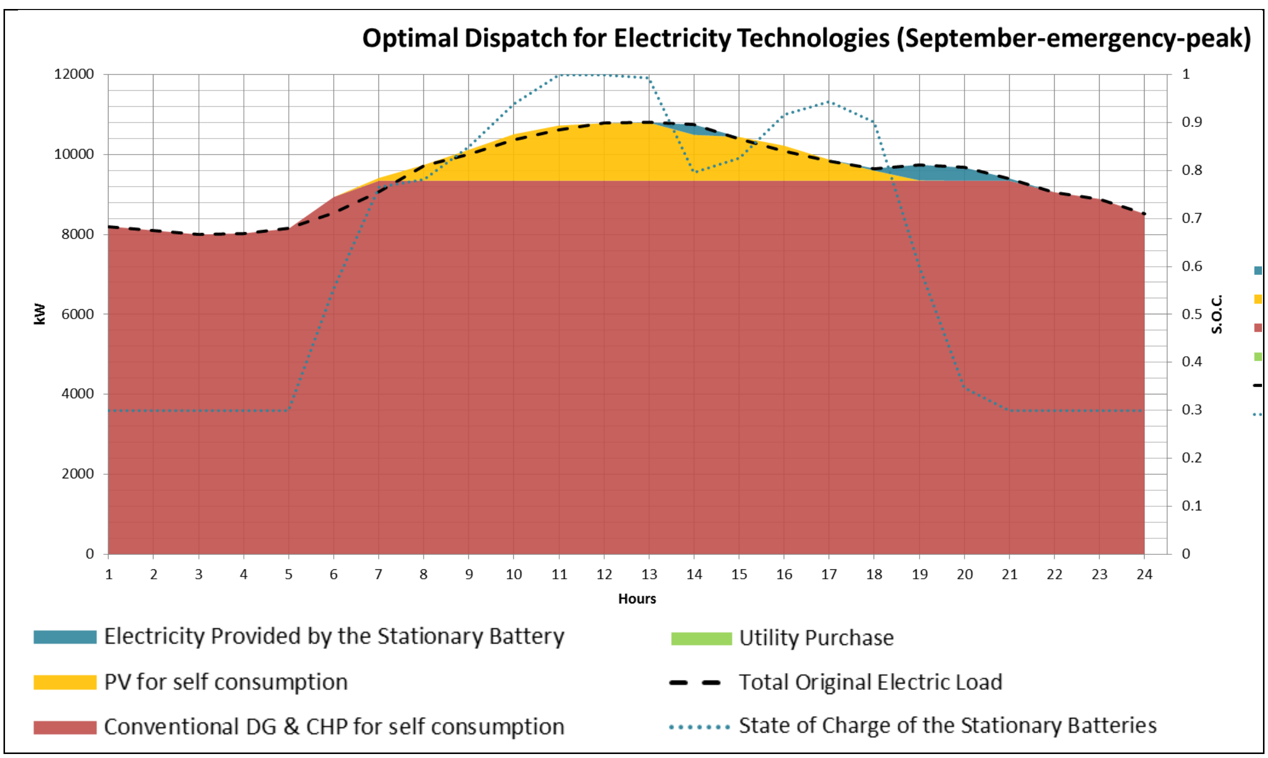


*Figure 32. DER-CAM investment results – Electricity Dispatch in Islanding Mode in Scenario 4*

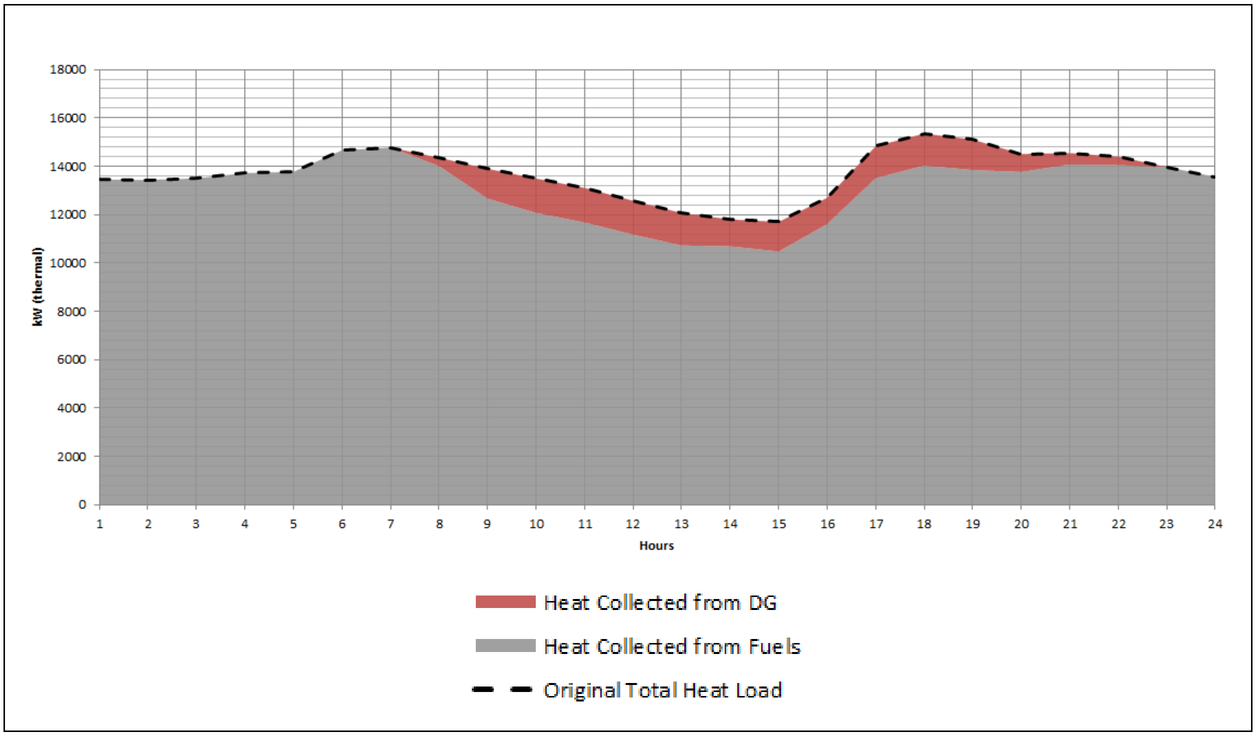


*Figure 33. DER-CAM investment results – Heating Dispatch in Islanding Mode in Scenario 4*

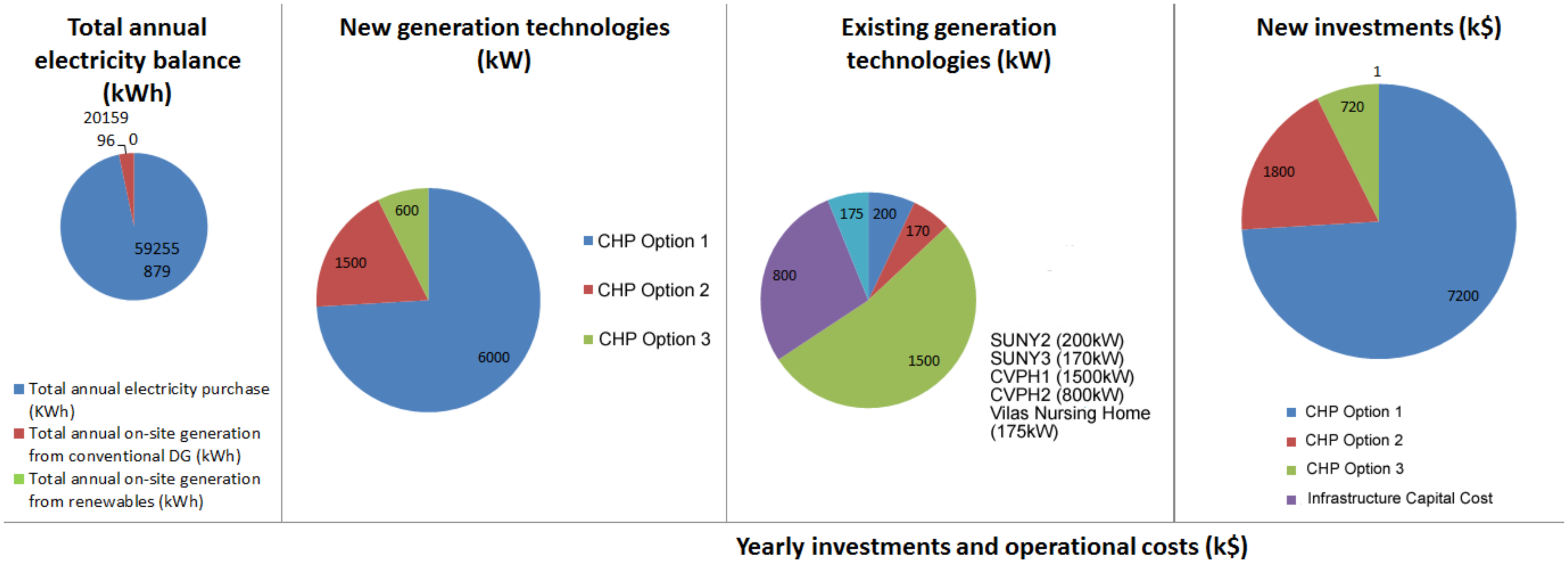


*Figure 34. DER-CAM investment results – Serving Total Load during Islanding in Peak Load Hour in Scenario 7*

**Scenario 7**: When the 2.7 MW diesel backup generator is in outage or undergoing maintenance, CHP would be promoted first. 8,100kW of new CHP along with the other existing backup generators would be able to satisfy all the electricity demand in both peak and off-peak time periods. Figure 34 shows the simulated investment results. The left pie charts in figure 34 show the annual energy portfolio of the community with a chance of islanding. They show a small portion of the total electricity would be generated by local DER due to the low electricity rate in Plattsburgh. The left middle pie chart in figure 34 shows total of 8,100kW CHP are proposed by DER-CAM, which would be enough to serve the critical facilities' electricity and heating demand during islanding time periods and help in improving the community's overall resiliency as result. The right pie chart in figure 34 shows the relevant investment cost information.

# Task 3: Assessment of Plattsburgh Community Microgrid's Commercial and Financial Feasibility

## Subtask 3.1 Commercial Viability – Customers

The proposed Plattsburgh Community microgrid would serve the SUNY Plattsburgh campus, the Champlain Valley Physicians Hospital (CVPH), the Samuel F. Vilas home, the Meadowbrook Healthcare skilled nursing and rehabilitation facility, the Plattsburgh High School, and the Plattsburgh Housing Authority (PHA) apartment facilities on Oak Street and Cornelia Street. The microgrid owner and operator would likely be a cooperative formed and governed by a board elected by these partners. The cooperative would purchase grid power from the Plattsburgh Municipal Lighting Department (PMLD) and resell it to the various partners. It would also generate electricity from the proposed Combined Heat and Power (CHP) and solar installations within the microgrid and sell this power to the microgrid participants, and it would sell the heat from the CHP installation to SUNY Plattsburgh. The cooperative would be responsible for the maintenance of the microgrid infrastructure and would only keep enough revenue to cover its costs. Any profits would be returned to the microgrid participants as dividends. Cooperatives are often formed as 501(c)(12) not-for-profit corporations. The individual participant organizations would no longer be customers of PMLD but would instead be served by the cooperative as their utility.

The combined facilities that would be part of the microgrid serve a large and often vulnerable population. SUNY Plattsburgh serves over 6,000 students, faculty, and staff; CVPH has 341 beds, with over 50,000 emergency room visits and 9,800 admissions annually, and contains a 96-resident nursing home; the Samuel F. Vilas home is a 44-bed assisted living facility; Meadowbrook Healthcare is a 200-bed skilled nursing and rehabilitation facility; Plattsburgh high school has over 600 students, faculty, and staff; and the two PHA facilities contain 106 apartment units serving low income residents, many of them elderly. The ability to keep the medical and residential facilities powered during a storm event has direct safety benefits to the patients and residents who would not need to be moved to another facility as well as financial benefits to the facility operators who would not need to incur this cost. The ability to keep the schools operating has cost benefits in being able to continue educational operations as well as safety benefits if Plattsburgh students were able to remain at the university rather than being sent home in hazardous travel conditions or if the schools were able to be used as shelters for the public when needed. Only CVPH and the Vilas home have enough existing backup generation to meet most or all of their needs in an outage. The high school has no backup, and the other facilities only have partial backup. In addition, the existing backup relies on diesel, fuel oil, and propane supplies, which could run out during an extended outage.

The microgrid will benefit PMLD and its rate payers by reducing the number of times that PMLD's allocation of inexpensive NYPA power is exceeded, forcing PMLD to purchase power on the open market through its power agency, the New York Municipal Power Agency (NYMPA). Currently the cost is

$52/MWh and $7/kW of demand. PMLD does not exceed their allocation frequently – only during the coldest winter weather – so the magnitude of this savings would not be large.

The Plattsburgh community microgrid may also produce economic benefits in the form of potential revenue streams from participating in demand response programs and ancillary service markets such as regulation and operating reserve. This is discussed further in Section 3.5.

## Subtask 3.2 Commercial Viability – Value Proposition

The primary benefit to the microgrid stakeholders will be in the form of added reliability and resiliency. This is particularly important to these stakeholders. The hospital and nursing homes serve vulnerable populations that are both expensive, and in some cases dangerous, to move to other locations in the event of an outage, particularly in inclement weather. The SUNY campus serves a large number of students, and in the event of a prolonged winter outage, the university may find it necessary to cancel classes and send students home due to inadequate backup power to fully maintain operations and to keep all the dorms habitable. This would be both expensive and disruptive to university operations and would present a hazard to students attempting to travel in inclement weather. Although cancelling classes at the high school would not be as significant an event, it would nonetheless result in expense and academic disruption. The inability to power the university and the high school in an emergency also limits their use as a community shelter, presenting a safety risk to the larger community. Finally, the PHA facilities serve low-income residents, many of whom are elderly. The elderly residents would be difficult to move, and the other residents may not have many other shelter options in a storm event.

The most common causes for prolonged grid outages in Plattsburgh are snow and ice storms. The two distribution feeders that serve the SUNY Plattsburgh campus are both underground and therefore very resilient to these types of storms. If the larger grid were to lose power in a storm, SUNY's feeders would be isolated in a microgrid and could be served indefinitely by the CHP plant, which would be fed by NYSEG's gas lines. In order to have the same level of resilience, the express lines to the other facilities creating the microgrid loop would also need to be installed underground, although this can increase the cost of installing the lines by an order of magnitude. Some load curtailment may be necessary if the outage was to outlast the diesel supplies for the backup generators and if diesel delivery was not possible, but this scenario is unlikely. The proposed 2.3 MW solar array would also provide some added resiliency, although it could not be depended on to provide power throughout an entire outage, particularly in a snow storm. The added resiliency in the electric distribution system is particularly important for the Plattsburgh community as all the facilities proposed for the microgrid, with the exception of the SUNY campus and CVPH, rely on electric heat. Even the SUNY campus has the field house, a designated emergency shelter, which relies on electric heat.

As mentioned in Section 3.1, the microgrid may produce some rate benefit to the PMLD ratepayers, but it is also expected to increase PMLD's costs somewhat, particularly during the construction phase when the non-SUNY facilities would need to be removed from their current feeders so that they can be tied together with express lines. PMLD states that they have adequate capacity in the section of the city where the microgrid would be, so the microgrid is not expected to provide significant capacity relief. SUNY Plattsburgh currently cooperates with NYISO to occasionally curtail some summer load, but they are not compensated for this. The microgrid, with its generation capabilities and a control system that could be used for automatic load curtailment, may enable formal participation in demand response programs and capacity programs. This would be both a benefit to the New York State grid as well as a potential revenue stream for the microgrid. The microgrid may also be able to provide other ancillary services, but at this time, the potential for this is unclear.

The number of facilities included in the proposed microgrid make this a true community microgrid. Community microgrids are currently very rare – almost all existing microgrids are campus-style microgrids serving a single entity. The proposed generation for the microgrid – CHP and solar – is not new technology, but, in the case of solar, the price continues to drop as the industry and the technology develop. The control and communications technology associated with the microgrid is relatively new and emerging as microgrids are still relatively rare. This project will help to further the development pf both the generation and control technologies and support NY REV's goals of increasing local, clean, and renewable generation. In addition, it can serve as a model for microgrids throughout the 64-campus SUNY system.

Table 13 summarizes the value proposition for the various stakeholders, and table 13 presents a SWOT analysis.

*Table 15. SWOT Analysis*

| Parameter | Strengths | Weaknesses | Threats | Opportunities |
|---|---|---|---|---|
| **Technology** | State of the Art | Unproven-- Lack of performance history, in particular in emergency conditions | Disruptive next generation versions or replacements (rapid obsolescence) | Maximize operational efficiency |
| | Resilient | Expensive | Failure (potentially catastrophic) | Reduce environmental impacts |
| | Smart | Complicated | Potentially steep price reductions over near-term (6 months) | Leverage revenue and mitigate cost exposure to power purchases |
| | Efficient | Difficult to obtain private financing absent performance guarantee | Deployment challenges & supporting infrastructure requirements | Enhance security & resiliency |
| | New | Limited vendors, lack of standardization (married to technology choice) | Vendor attrition | Economic benefits (enhanced revenue, rapid recovery, security, load shaping, etc.), support new technology development |
| **Regulatory** | Complies with REV | May not comply with market restructuring rules | Permitting hurdles, obstacles, and timing | Advance next-generation energy resources |
| | Environmental benefits | May not comply with permitting requirements | Ability to acquire land for solar installation | Increase efficiency, optimize loads, enhance resilience |
| | Enhances grid/energy security and ability to provide emergency services | Must go through aggregator to reach NYISO markets | Utility interconnection requirements | Enhanced compliance with civic obligations for safety and emergency services |

*Table 15. 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 small and neither guaranteed nor predictable | Increased deployment may limit market opportunities and/or revenue stream values | Benefit grid and environment |
| | Fuel supply price (natural gas) gives CHP attractive payback | Fuel supply availability during winter peak can be constrained | Fuel supply price and availability subject to supply/demand competition | Enhancing alternative fuel penetration/markets |
| | True community microgrid provides benefits to wide range of participants | Relatively high price for reliability benefits | Variations in available incentives | Replacement of obsolete/ aging infrastructure |
| | No capital investment required for PPA | Limited capital funds available | Annual variations in SUNY capital budget | Serve as model for SUNY |
| **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 operation date | Enhancing/upgrading distribution infrastructure |
| | Enhanced services during emergencies | Technology training and additional infrastructure | Fuel supply interruption | Enhanced load control |

## Subtask 3.3 Commercial Viability – Project Team

SUNY Plattsburgh is the project applicant and lead partner on the project. They have engaged Willdan Energy Solutions to complete the feasibility study work and have gained community support through outreach and forums. All the other microgrid participants have played a supporting role in providing information and outlining their needs with regards to a microgrid. Several of them have also participated in project workshops and community forums on the microgrid. SUNY Plattsburgh has also engaged students in the project in order to provide educational opportunities for the students and assistance to the projects.

SUNY Plattsburgh currently owns and operates its own electrical distribution feeders and switchgear in addition to the central high temperature hot water heating plant and other HVAC equipment throughout its 50-plus buildings. Willdan is a 51-year-old company that provides energy and engineering expertise and professional services to thousands of municipalities across the country. They are working on eight NY Prize awards.

PMLD would not be directly involved in the proposed project beyond what would be necessary to reconfigure the distribution infrastructure and establish microgrid operations. To date they have played a supporting role by providing infrastructure and cost information.

Both Willdan and SUNY Plattsburgh have a network of legal and regulatory advisors. Additional support may be sought for Phase 2 when additional detail around permitting and financing is required.

## Subtask 3.4 Commercial Viability – Creating and Delivering Value

Smart grid and microgrid technologies were screened to determine which ones would best support the requirements of a microgrid in Plattsburgh. CHP was chosen because it integrates well with the existing central heating plant and is able to provide continuous power in outage situations as well as having a strong resilience to weather events. It may also have environmental benefits, depending on the emissions mix of the utility power that it is offsetting. Solar was chosen for its sustainability benefits and for the protection it provides from fuel cost increases. Communications and control technologies were chosen based on the team’s experience with microgrids and its judgment of what would work best with the Plattsburgh infrastructure and proposed generation.

The addition of CHP and solar generation to the Plattsburgh campus will allow it to operate as a microgrid and to take advantage of new revenue streams such as demand response and capacity markets and increase resiliency through on-site generation. The installation of CHP may require the construction of an addition to the central heating plant, or of an entirely separate building, and it would require training and possibly the hiring of additional personnel to operate it. The proposed financing mechanism for the solar installation is a Power Purchase Agreement (PPA), so this would need to be negotiated, and suitable land may need to be purchased. As free land is scarce near the SUNY campus, solar panels installed on covered parking lots or rooftop solar would also be options. Both CHP and solar systems will require ongoing maintenance.

SUNY Plattsburgh owns its own feeder loop, operating at 12.47 kV, which connects to PMLD's Rugers substation. Since the university owns its own feeder that does not carry any other load, the feeder can be isolated from the PMLD grid to form an islanded microgrid. However, the other facilities are fed from other substations on 4.16 kV radial path feeders, so these facilities would need to be separated from these feeders and joined to the SUNY Plattsburgh feeder via express lines. SUNY Plattsburgh's existing high temperature hot water loop will be used to absorb the thermal load from the proposed CHP. The existing 5.8 MW of existing diesel and natural gas backup generation will continue to play a role in the microgrid. Many of the campus buildings are now controlled by a Carrier Comfort Network building automation system, which will be useful to the control of the microgrid, and CVPH has an extensive automation system as well.

The microgrid master controller would optimize the operation of the microgrid through generation dispatch and load schedule signals. The generation dispatch signals are sent to dispatchable distributed energy resource (DER) units, and the load schedule signals are sent to building controllers. An interactive grid-forming control would be used both in island and in grid-connected mode. In island mode, DERs apply this control scheme to share the load, while in the grid-connected mode, DERs apply this control scheme to regulate the power exchange between the microgrid and the utility grid. In 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 by other DER units in island mode.

The general process for project development will proceed from feasibility assessment to design and construction in phases beginning with DER installation, and concluding with the master controller installation and commissioning.

The general community will benefit from the added resiliency provided by the microgrid in that it will help ensure that emergency shelters are available during outages and provide added assurance that the hospital can remain fully functional. They may also see some rate relief from PMLD since the microgrid would help ensure that PMLD does not exceed its NYPA allocation, thereby saving the cost of purchasing power on the open market through NYMPA.

## Subtask 3.5 Financial Viability

### Potential Revenue Streams

The proposed microgrid may provide demand response revenue and some cost savings from reduced winter peaks. It may also potentially provide some revenue from ancillary services. However, the overall cost savings are likely to be negative as the cost of operating the CHP plant would be higher than the cost of purchasing electricity from the grid at the current price of $0.03/kWh. The primary financial benefit of the microgrid would be cost savings resulting from the ability to maintain operations during a prolonged outage.

Potential revenue streams and/or savings will be highly dependent upon the final configuration of the microgrid, factors affecting power prices in the New York Independent System Operator's (NYISO's) markets, and natural gas markets, among other items. Should the Plattsburgh 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 Plattsburgh 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 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 14 illustrates potential Option 3 capacity revenues assuming 2 MW of generation under the NYPA Option 3 tariff, pursuant to which capacity payments are based on 85% of the average monthly NYISO auction clearing price. Customers can enroll based on summer (May-Oct) or winter (Nov-Apr) participation. Based on these estimates, revenues of approximately $93,000 would result from capacity payments for 12-months of participation. If the full proposed 6.5 MW of CHP was enrolled in the program, projected revenues would increase to $301,866.

*Table 16. Illustrative Example of NYPA Option 3 Capacity Revenues*

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

Energy payments under NYPA's Option 3 tariff are based on the greater of $500/MWh or 100% of the NYISO market price. Over the past five years, upstate or statewide curtailment occurred an average of 10 hours,[2] participants are also paid for 1 hour of monthly testing.[3] Assuming 22 hours of revenues, the microgrid would earn $22,000 in energy over 12 months. Increasing the capacity to 5MW would increase projected revenues to $71,500.

[1] http://www.nypa.gov/PLM/PLMgovernment3.html.
[2] Demand Response, New York Market Orientation Course, November 5, 2015, NYISO.
[3] NYISO guarantees a minimum payment of 4 hours.

## Ancillary Services

Microgrid generation may potentially participate in other NYISO Ancillary Services Markets, however the extent to which resources can take advantage of these potential revenue streams is not clear as NYPA does not currently have tariffs in place. For example, NYPA lacks a tariff for regulation service. To participate in the regulation market, Plattsburgh 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 $56,370 to $79,000 (25% to 35%)[1] *but could be significantly lower or higher*. This range would increase to between $183,000 and $257,000 for 6.5 MW of capacity.

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

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

## Purchased Power Savings

PMLD receives an allocation of low-cost hydroelectric power from NYPA. PMLD is a partial requirements customer; winter heating loads occasionally cause PMLD to exceed its monthly allocation during the coldest winter months. When that happens, PMLD must purchase power on the open market through the New York Municipal Power Agency (NYMPA). Table 15 illustrates the amount by which PMLD exceeded its allocation and the resulting cost, from 2011 to 2016. Although the average cost to PMLD is not large (approximately 1% of their revenue), the installation of the microgrid DER would mitigate a portion or all of this cost exposure.

[1] http://www.nyiso.com/public/webdocs/markets_operations/documents/Studies_and_Reports/Reports/Market_Monitoring_Unit_Reports/2014/NYISO2014SOMReport__5-13-2015_Final.pdf, Page 12. The calculation is based on Regulation payments of $12.87/MWh.

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

*Table 17. PMLD Costs Due to Exceeding NYPA Allocation (2011-2016)*

| Time Period | Excess Demand (kW) | Excess Demand Cost | Excess Consumption (kWh) | Excess Consumption Cost | Total Cost |
|---|---|---|---|---|---|
| **Jan-16** | 0 | $0 | 0 | $0 | $0 |
| **Jan-15** | 6329 | $44,303 | 6,004,000 | $312,208 | $356,511 |
| **Feb-15** | 8057 | $56,399 | 10,207,000 | $530,764 | $587,163 |
| **Jan-14** | 9713 | $67,991 | 8,523,000 | $774,916 | $842,907 |
| **Feb-14** | 717 | $5,019 | 0 | $0 | $5019 |
| **Mar-14** | 0 | $0 | 264,000 | $17,600 | $17,600 |
| **Jan-13** | 8116 | $56,812 | 1,620,000 | $84,240 | $141,052 |
| **2012** | 0 | $0 | 0 | $0 | $0 |
| **Jan-11** | 8591 | $60,137 | 2,345,000 | $121,940 | $182,077 |
| **2010** | 0 | $0 | 0 | $0 | $0 |
| **Jan-09** | 8743 | $61,201 | 3,549,000 | $180,999 | $242,200 |
| **Jan-08** | 0 | 0 | 1,098,000 | $47,214 | $47,214 |
| **Feb-08** | 614 | $4,298 | 0 | $0 | $4,298 |
| **Mar-08** | 0 | $0 | 2,330,000 | $100,190 | $100,190 |
| **Annual average cost of exceeding NYPA allocation (excluding 2016):** | | | | | **$194,325** |

## Additional Infrastructure

The microgrid will require upgrades to the existing distribution system. The non-SUNY facilities would need to be isolated from their existing feeder and connected together with express lines to form a microgrid loop. There may be upgrades necessary to the gas infrastructure as well. The timing of these resources will impact the microgrid, in particular potential permitting requirements.

## 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.

As with all SUNY campuses, funding new capital projects is difficult for SUNY Plattsburgh, and the capital budget is largely controlled at the state level. SUNY Plattsburgh has a $135 million capital plan over 10 years but has only received $15-30 million of this. The heating plant is currently undergoing an $8 million renovation, so installing CHP would be a second project on top of this. Grant funding, through NYSERDA or possibly through the Regional Economic Development Council or other sources, would need to be pursued.

## 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. 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. Additional research is warranted in the next phase.

The anticipated cost categories and relative cost magnitudes for the microgrid's construction and operation are as follows, although depending on the ultimate configuration of the microgrid, additional costs may exist:

- CHP installation: $10-20 million
- Solar installation: $7-8 million
- Distribution system modifications/upgrades: $5 million
- Communication and control system installation: $1-2 million
- Ongoing operations and maintenance: $400,000 - $600,000/year
- CHP fuel: $1.5 - $2 million/year

Microgrid development will be funded through feasibility by NYSERDA grants. Development and construction will be funded through available grants, private equity (where possible), and the SUNY capital budget. The solar installation would likely be funded through a Power Purchase Agreement (PPA). For other parts of the microgrid, an Engineering, Procurement, and Construction (EPC) contract will be used as a vehicle for performance through the commercial operation date (COD). Appropriate warranties will be obtained from technology providers and cover each key component of the microgrid. Additional team members would be added as needed to support the construction and financing of the project. Potential project team members in the design and build phase of the project may include an engineering and construction firm, technology vendors, a permitting consultant, and financing partners.

## Subtask 3.6 Legal Viability

The proposed microgrid would have to be configured and operated so that it does not export any power to the PMLD grid as PMLD is prohibited by its NYMPA contract from purchasing power from distributed generation. All microgrid DER would have to be "behind the meter."

There are several other legal issues that would need to be investigated further in future phases. It may be necessary to acquire rights-of-way in order to run express lines to connect the microgrid partners together. Land for a solar installation may potentially have to be acquired, but the most likely scenario is to install PV on covered parking or rooftops. The specific land areas in question would need to be identified more precisely in future phases. There would be legal work involved in setting up a cooperative to own and operate the microgrid. Finally, the established cooperative would need to make sure it could support the hospital in meeting its power reliability requirements due to the sensitive nature of its work. Building permits would be required for all phases of microgrid construction, but these are not expected to differ significantly from any other project.

# Task 4: Develop Information for Benefit Cost Analysis for Plattsburgh Community Microgrid

The Task 4 questionnaires, along with the BCA results provided by Industrial Economics and this descriptive document, serve as the Task 4 Milestone Deliverable. Each bullet in this scope of work has been answered at least once, with the exact location provided within this document. To avoid redundancy, only short explanations will be made within this document, as the required answers and descriptions are provided within the questionnaire documents. This guidance document is followed by the Microgrid Questionnaire, then the Facility Questionnaire, and finally the BCA results.

## Sub Task 4.1 Facility and Customer Description

- Indicate the rate class to which the facility belongs (i.e., residential, small commercial/industrial, large commercial/industrial).
- Indicate the economic sector to which the facility belongs (e.g., manufacturing, wholesale and retail trade, etc.).
- Indicate whether multiple ratepayers are present at the facility (e.g., multi-family apartment buildings).
- Indicate the facility's average annual electricity demand (MWh) and peak electricity demand (MW). For facilities with multiple ratepayers, indicate average annual and peak demand per customer, rather than for the facility as a whole.
- Indicate the percentage of the facility's average demand the microgrid would be designed to support during a major power outage.
- In the event of a multi-day outage, indicate the number of hours per day, on average, the facility would require electricity from the microgrid.

The list and description of these facilities is provided in Section A, Table 1 of the Microgrid Questionnaire. These facilities were chosen for their proximity to campus and the critical nature of their function. The Plattsburgh Housing Authority (PHA) facilities were added after the project kicked off when the PHA expressed interest in joining the project.

## Sub Task 4.2 Characterization of Distributed Energy Resources

- Energy/fuel source.
- Nameplate capacity.
- Estimated average annual production (MWh) under normal operating conditions.
- Average daily production (MWh/day) in the event of a major power outage.
- For fuel-based DER, fuel consumption per MWh generated (MMBtu/MWh).

Section A, Question 2 of the Microgrid Questionnaire characterizes the DER of the proposed microgrid. The proposed DER would serve the average demand of the partner facilities in an outage, and, in combination with the existing diesel backup generation, it would be able to meet the peak demand. It should be noted that there is a significant degree of uncertainty surrounding the capital costs for CHP, particularly with regards to the costs for facility expansion or land acquisition. Space in the existing heating plant is limited, so an addition may be necessary, which may in turn require reconfiguration of parking space. An investment-grade analysis should be done before any CHP is implemented. This same issue exists for the solar installation as available land is very limited. Solar would likely have to be rooftop solar or installed on covered-parking facilities. It should also be noted that the BCA assumes that the cost of electricity will rise in accordance with the NYISO forecasted trajectory. Due to PMLD's NYPA allocation, this may not be the case. Finally, the BCA also relies heavily on the social cost of carbon and avoided emissions benefits in order to make the case for CHP. If the project is self-funded by the partners, they may or may not be willing to take these benefits into account.

Another proposed DER was hydro generation installed in the water lines at the City of Plattsburgh water plant. We performed a rough calculation indicating there may be approximately 200 kW of generation potential there. It was decided not to include this in the microgrid due to the distance from campus, but this may make sense as a self-contained DER. There has been discussion about the City of Plattsburgh supplying water to the surrounding Town of Plattsburgh, and in order to do this, water would need to be pumped uphill to the town. The hydro generation could help power these pumps.

## Sub Task 4.3 Capacity Impacts and Ancillary Services

- The impact of the expected provision of peak load support on generating capacity requirements (MW/year).
- Capacity (MW/year) of demand response that would be available by each facility the microgrid would serve.
- Associated impact (deferral or avoidance) on transmission capacity requirements (MW/year).
- Associated impact (deferral or avoidance) on distribution capacity requirements (MW/year).
- Ancillary services to the local utility (e.g., frequency or real power support, voltage or reactive power support, black start or system restoration support)
- Estimates of the projected annual energy savings from development of a new combined heat and power (CHP) system relative to the current heating system and current type of fuel being used by such system
- Environmental regulations mandating the purchase of emissions allowances for the microgrid (e.g., due to system size thresholds)
- Emission rates of the microgrid for CO2, SO2, NOx, and Particulate Matter (emissions/MWh).

Section B, Questions 3-8 estimate the impact that the proposed microgrid will have on the capacity and ancillary services. The microgrid is not expected to have a significant impact on the capacity of the PMLD distribution system as they claim to have adequate capacity, and ancillary services are also not expected to play a significant role in the microgrid, although there would likely be some demand response participation.

## Sub Task 4.4 Project Costs

- Fully installed costs and engineering life span of all capital equipment.
- Initial planning and design costs.
- Fixed operations and maintenance (O&M) costs ($/year).
- Variable O&M costs, excluding fuel costs ($/MWh).
- What is the maximum amount of time each DER would be able to operate in islanded mode without replenishing its fuel supply? How much fuel would the DER consume during this period?

Section C of the Microgrid Questionnaires provides information about the costs of the proposed generators and other microgrid assets. The estimates came from the DER-CAM library and information from the DOE Technical Assistance Partnership program. The costs are rough estimates, and an investment-grade analysis should be done before any implementation work.

## Sub Task 4.5 Costs to Maintain Service during a Power Outage

- Fuel/energy source of each existing backup generator.
- Nameplate capacity of each existing backup generator.
- The percentage of nameplate capacity at which each backup generator is likely to operate during an extended power outage.
- Average daily electricity production (MWh/day) for each generator in the event of a major power outage, and the associated amount of fuel (MMBtu/day) required to generate that electricity.
- Any one-time costs (e.g., labor or contract service costs) associated with connecting and starting each backup generator.
- Any daily costs ($/day) (e.g., maintenance costs) associated with operating each backup generator, excluding fuel costs.
- Given a widespread power outage (i.e., a total loss of power in the surrounding area), describe and estimate the costs of any emergency measures that would be necessary for each facility to maintain operations, preserve property, and/or protect the health and safety of workers, residents, or the general public. Please include costs for one-time measures (e.g., total costs for connecting backup power) and any ongoing measures (expressed in terms of average costs per day). Specify these costs for two scenarios: (1) when the facility is operating on backup power, if applicable, and (2) when backup power is not available.

The first six bullets are answered in Section I, Table 1 of the Facility Questionnaire. Most of this information came from the first two deliverables under the NY Prize scope of work, and has been refined into the data found within Table 1. Input from the microgrid partners was included. The final bullet is answered in the two tables of Section II of the Facility Questionnaire.

## Sub Task 4.6 Services Supported by the Microgrid

- Estimate the population served by each facility.
- Describe how a power outage would impact each facility's ability to provide services. If possible, estimate a percentage loss in the facility's ability to serve its population during a power outage, relative to normal operations (e.g., 20% service loss during a power outage), both when the facility is operating on backup power and when backup power is not available.
- Describe the type of housing the facility provides (e.g., group housing, apartments, dormitory, nursing home, assisted living, etc.).
- Estimate the number of residents that would be left without power during a power outage.

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 various microgrid partners.

# 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 Michael Razanousky, NYSERDA Project Manager, for making this work possible. Willdan would also like to thank Curt Gervich and Lauren Eastwood, SUNY Plattsburgh professors and project sponsors; the many other members of the SUNY Plattsburgh staff and students who contributed to the project; and the representatives of CVPH, Meadowbrook Healthcare, the Samuel F. Vilas Home, and Plattsburgh Housing Authority who supported the project. The cost benefit analysis portion of the project was completed by Industrial Economics Inc.

# NY Prize Benefit-Cost Analysis: Microgrid Questionnaire

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



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

Microgrid site: Choose an item.

Point of contact for this questionnaire:


Name: Steve Heinzelman

Address: 807 Ridge Road, Suite 210B | Webster, NY 14580

Telephone: 585-750-7728

Email: sheinzelman@willdan.com


## *A. Project Overview, Energy Production, and Fuel Use*

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

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

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

| Facility Name | Rate Class | Facility/Customer Description (Specify Number of Customers if More Than One) | Economic Sector Code | Average Annual Electricity Usage Per Customer (MWh) | Peak Electricity Demand Per Customer (MW) | Percent of Average Usage Microgrid Could Support During Major Power Outage | Hours of Electricity Supply Required Per Day During Major Power Outage |
|---|---|---|---|---|---|---|---|
| SUNY Plattsburgh Campus | Large Commercial/Industrial (>50 annual MWh) | University campus consisting of over 50 buildings | All other industries | 29,127.888 | 4.97376 | 100% | 24 |
| CVPH | Large Commercial/Industrial (>50 annual MWh) | Hospital | All other industries | 18,463.707 | 3.52512 | 100% | 24 |
| Meadowbrook Skilled Nursing and Rehabilitation | Large Commercial/Industrial (>50 annual MWh) | Nursing home | All other industries | 2,073.600 | 0.75600 | 100% | 24 |
| Samuel F. Vilas Home | Large Commercial/Industrial (>50 annual MWh) | Nursing home | All other industries | 481.760 | 0.1536 | 100% | 24 |
| Plattsburgh High School | Large Commercial/Industrial (>50 annual MWh) | High school | All other industries | 2,091.600 | 1.30200 | 100% | 24 |
| Plattsburgh Housing Authority Oak St. (Robert S. Long apartments) | Large Commercial/Industrial (>50 annual MWh) | 6 floor low-income senior apartment building | Residential | 708.800 | 0.11 | 100% | 24 |
| Plattsburgh Housing Authority Cornelia St. (Hortense B. Sterns apartments) | Large Commercial/Industrial (>50 annual MWh) | 2 floor low income apartment buildings | *Residential* | 555.4 | 0.09 | 100% | 24 |
| | Choose an item. | | Choose an item. | | | | |
| | Choose an item. | | Choose an item. | | | | |
| | Choose an item. | | Choose an item. | | | | |
| | Choose an item. | | Choose an item. | | | | |
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| | Choose an item. | | Choose an item. | | | | |
| | Choose an item. | | Choose an item. | | | | |
| | Choose an item. | | Choose an item. | | | | |

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

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

| Distributed Energy Resource Name | Facility Name | Energy Source | Nameplate Capacity (MW) | Average Annual Production Under Normal Conditions (MWh) | Average Daily Production During Major Power Outage (MWh) | Fuel Consumption per MWh | |
|---|---|---|---|---|---|---|---|
| | | | | | | Quantity | Unit |
| CHP Generator | SUNY Central heating plant | Natural Gas | 6.5 | 54,093 | 156 | 9.5 | MMBtu/MWh |
| Solar | Land adjacent to SUNY campus | Solar | 2.3 | 3,358 | 2.3 | N/A | Choose an item. |
| | | Choose an item. | | | | | Choose an item. |
| | | Choose an item. | | | | | Choose an item. |
| | | Choose an item. | | | | | Choose an item. |
| | | Choose an item. | | | | | Choose an item. |
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| | | Choose an item. | | | | | Choose an item. |
| | | Choose an item. | | | | | Choose an item. |
| | | Choose an item. | | | | | Choose an item. |

***B.*** *Capacity Impacts*

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

☐ No – proceed to Question 6

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

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

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

**Provision of Peak Load Support**

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

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

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

| Distributed Energy Resource Name | Facility Name | Available Capacity (MW/year) | Does distributed energy resource currently provide peak load support? |
|---|---|---|---|
| | | | ☐ Yes |
| | | | ☐ Yes |
| | | | ☐ Yes |
| | | | ☐ Yes |
| | | | ☐ Yes |
| | | | ☐ Yes |
| | | | ☐ Yes |
| | | | ☐ Yes |
| | | | ☐ Yes |
| | | | ☐ Yes |
| | | | ☐ Yes |
| | | | ☐ Yes |
| | | | ☐ Yes |

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

**Participation in a Demand Response Program**

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

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

| Facility Name | Capacity Participating in Demand Response Program (MW/year) | |
|---|---|---|
| | Following Development of Microgrid | Currently |
| SUNY Plattsburgh | 3.5 MW | 2 MW |
| | | |
| | | |
| | | |
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6. Is development of the microgrid expected to enable utilities to avoid or defer expansion of their transmission or distribution networks?

☐ Yes – proceed to Question 7

☒ No – proceed to Section C

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

| Impact of Microgrid on Utility Transmission Capacity | Unit |
|---|---|
| | MW/year |

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

| Impact of Microgrid on Utility Distribution Capacity | Unit |
|---|---|
| | MW/year |

## ***C.*** *Project Costs*

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

### Capital Costs

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

| Capital Component | Installed Cost ($) | Component Lifespan (round to nearest year) | Description of Component |
|---|---|---|---|
| CHP | 9,750,000 | 20 | |
| Solar | 7,400,250 | 30 | |
| Distribution lines - Underground | 5,000,000 | 40 | |
| Transformer | 53,000 | 20 | |
| S&C PME Switch | 18,500 | 20 | |
| Smart Switch | 18,000 | 20 | |
| Automatic Transfer Switch | 685 | 20 | |
| 35kV breaker | 40,000 | 20 | |
| 12.47kV breaker | 15,000 | 20 | |
| 1500A PANELBOARD (208V) | 18,000 | 20 | |
| Manhole | 3,750 | 40 | |
| Building Controller | 700 | 15 | |
| Wired Communication in Buildings | 80,000 | 15 | |
| Master Controller | 100,000 | 25 | |
| Smart Meters | 1,000 | 15 | |
| E Bridge/Repeater | 350 | 15 | |
| Access Point | 1,500 | 15 | |
| Fiber Optic | 100,000 | 15 | |
| Relay | 3,000 | 20 | |
| Automatic Generation Controller | 2,508 | 20 | |
| SCADA Software | 100,000 | 25 | |
| OSIsoft Data Historian (PI) Full (50,000 tags) | 537,500 | 25 | |
| OSIsoft Data Historian (PI) Full (50,000 tags) + training | 690,625 | 25 | |

## 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? |
|---|---|
| $3,590,155 | 15% of investment 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? |
|---|---|
| 412,877 | Routine inspections, scheduled maintenance |

Please proceed to Question 14.

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

| Year | Fixed O&M Cost ($) | What cost components are included in this figure? |
|---|---|---|
| 1 | | |
| 2 | | |
| 3 | | |
| 4 | | |
| 5 | | |
| 6 | | |
| 7 | | |
| 8 | | |

| Year | Fixed O&M Cost ($) | What cost components are included in this figure? |
|---|---|---|
| 9 | | |
| 10 | | |
| 11 | | |
| 12 | | |
| 13 | | |
| 14 | | |
| 15 | | |
| 16 | | |
| 17 | | |
| 18 | | |
| 19 | | |
| 20 | | |

## Variable O&M Costs (Excluding Fuel Costs)

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

| Variable O&M Costs ($/Unit of Energy Produced) | Unit | What cost components are included in this figure? |
|---|---|---|
| $3.72 | $/MWh | Overhauls, operating labor |
| | Choose an item. | |
| | Choose an item. | |
| | Choose an item. | |
| | Choose an item. | |

## Fuel Costs

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

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

- **Fuel consumption:** For each distributed energy resource that requires fuel, please specify the quantity of fuel the resource would consume if operated in islanded mode for the assumed duration of the design event.

| Distributed Energy Resource Name | Facility Name | Duration of Design Event (Days) | Quantity of Fuel Needed to Operate in Islanded Mode for Duration of Design Event | Unit |
|---|---|---|---|---|
| CHP Generator | SUNY Plattsburgh central heating plant | Indefinite | N/A | Choose an item. |
| Solar | SUNY Plattsburgh | Indefinite | | Choose an item. |
| | | | | Choose an item. |
| | | | | Choose an item. |
| | | | | Choose an item. |

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

☒ Yes – proceed to Question 17

☐ No – proceed to Question 18

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

| Type of Fuel Offset by New CHP System | Annual Energy Savings Relative to Current Heating System | Unit |
|---|---|---|
| Natural gas | 180,000 | MMBtu |
| Choose an item. | | Choose an item. |
| Choose an item. | | Choose an item. |
| Choose an item. | | Choose an item. |

## Emissions Control Costs

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

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

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

☐ Yes

☒ No

## D. Environmental Impacts

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

| Emissions Type | Emissions per MWh | Unit |
|---|---|---|
| $CO_2$ | 0.199609885 | Short tons/MWh |
| $SO_2$ | 1.70607E-06 | Short tons/MWh |
| $NO_x$ | 1.27955E-05 | Short tons/MWh |
| PM | 1.27119E-05 | Short tons/MWh |

## E. Ancillary Services

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

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

## F. Power Quality and Reliability

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

☐ Yes – proceed to Question 23

☒ No – proceed to Question 24

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

| Number of Power Quality Events Avoided Each Year | Which facilities will experience these improvements? |
|---|---|
| | |

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

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

| Estimated SAIFI | Estimated CAIDI |
|---|---|
| 1.34 | 2.97 |

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

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.
Click here to enter text.

# 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: 56. City of Plattsburgh (SUNY)

Point of contact for this questionnaire:

Name: Kim Bailey

Address: 19 Grace Ave, Plattsburgh, NY 12901

Telephone: 518-569-8599

Email: kbail008@plattsburgh.edu

# I. Backup Generation Capabilities

1. Do any of the facilities that would be served by the microgrid currently have backup generation capabilities?
   a. ☐ No - proceed to Question 4
   b. ☒ Yes - proceed to Question 2

2. For each facility that is equipped with a backup generator, please complete the table below, following the example provided. Please include the following information:
   a. **Facility name:** For example, “Main Street Apartments.”
   b. **Identity of backup generator:** For example, “Unit 1.”
   c. **Energy source:** Select the fuel/energy source used by each backup generator from the dropdown list. If you select “other,” please type in the energy source used.
   d. **Nameplate capacity:** Specify the nameplate capacity (in MW) of each backup generator.
   e. **Standard operating capacity:** Specify the percentage of nameplate capacity at which the backup generator is likely to operate during an extended power outage.
   f. **Average electricity production per day in the event of a major power outage**: Estimate the average daily electricity production (MWh per day) for the generator in the event of a major power outage. In developing the estimate, please consider the unit’s capacity, the daily demand at the facility it serves, and the hours of service the facility requires.
   g. **Fuel consumption per day:** Estimate the amount of fuel required per day (e.g., MMBtu per day) to generate the amount of electricity specified above. This question does not apply to renewable energy resources, such as wind and solar.
   h. **One-time operating costs:** Please identify any one-time costs (e.g., labor or contract service costs) associated with connecting and starting the backup generator.
   i. **Ongoing operating costs:** Estimate the costs ($/day) (e.g., maintenance costs) associated with operating the backup generator, excluding fuel costs.

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

| Facility Name | Generator ID | Energy Source | Nameplate Capacity (MW) | Standard Operating Capacity (%) | Avg. Daily Production During Power Outage (MWh/Day) | Fuel Consumption per Day | | One-Time Operating Costs ($) | Ongoing Operating Costs ($/Day) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Quantity | Unit | | |
| Meadowbrook Healthcare Skilled Nursing and Rehab Facility | Unit 1 | Diesel | .250 | 80 | 4.8 | 250 (worst case - winter) 150 (best case) | gal | 0 | 0 |
| Meadowbrook Healthcare Skilled Nursing and Rehab Facility | Unit 2 (Aug 2016) | Diesel | ~.250 | 80 | 4.8 | 250 (worst case-winter) 150 (best case) | gal | 0 | 0 |
| Vilas Home | Unit 1 | Diesel | .175 | 75 max in winter | 3 | 190 | gal | 0 | 0 |
| Champlain Valley Physicians Hospital (CVPH) | Unit 1 | Diesel | 1.5 | 80 | 28.8 | 500 | gal | 0 | 1000 |
| CVPH | Unit2 | Diesel | .8 | 80 | 15.4 | Combined with unit 1 | gal | 0 | Combined with unit 1 |
| Suny Plattsburgh | 14 Units | #2 Fuel Oil | 2.737 combined | 100 | 66 | 5000 | gal | 0 | 44 combined See notes |
| Suny Plattsburgh | Usable Unit | Natural Gas | .200 | 100 | 4.8 | 62000 | $ft^3/d$ | 0 | See notes |
| Suny Plattsburgh | Portable Units (2ea) | Diesel | .025, .045 | 100 | .6, 1.1 | 280 | gal | In house labor to hook up and disconnect | See notes |
| Plattsburgh High school | ***Rental*** | Diesel | .25 | 80 | 4.8 | 250 (worst case-winter) 150 (best case) | gal | 6750 | 230 |
| Plattsburgh Housing Authority | Long | Propane | .130 | 100 | 3.1 | 360 (worst case-winter) 250 (best case) | gal | 0 | Unk addl staffing and OT costs |

| Facility Name | Generator ID | Energy Source | Nameplate Capacity (MW) | Standard Operating Capacity (%) | Avg. Daily Production During Power Outage (MWh/Day) | Fuel Consumption per Day | | One-Time Operating Costs ($) | Ongoing Operating Costs ($/Day) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Quantity | Unit | | |
| Plattsburgh Housing Authority | ***Rental 1 - Long*** | Diesel | .25 | 80 | 4.8 | 250 (worst case-winter) 150 (best case) | gal | 6750 | 230 + Unk addl staffing and OT costs |
| Plattsburgh Housing Authority | ***Rental 2 - Stearns*** | Diesel | .25 | 80 | 4.8 | 250 (worst case-winter) 150 (best case) | gal | 6750 | 230 + Unk addl staffing and OT costs |

*Meadowbrook notes: Fuel usage is based on facility manager's estimate. Additional cost to maintain **each** generator is $1100/year for preventative maintenance servicing.

**Vilas Home notes: Fuel usage is based on facility manager's estimate. Additional cost to maintain generator is estimated at $1100/year for preventative maintenance servicing.

***CVPH notes: Fuel usage and ongoing costs for labor to staff generators are combined totals for both generators and were based on facility manager's estimate.

****SUNY Plattsburgh notes: Fuel usage estimated based upon charts obtained from http://www.dieselserviceandsupply.com/Diesel_Fuel_Consumption.aspx and http://www.dieselserviceandsupply.com/Natural_Gas_Fuel_Consumption.aspx and do not take into account any variations in load due to time of day or season.

Ongoing costs associated with generator operation include monthly in-house service and inspections, fuel tank registrations, and annual service inspections and are estimated at $1350/month combined for the 17 units and does not include call in labor to monitor.

*****Plattsburgh High School notes: In the event of a power outage or weather emergency, the high school would send students and faculty/staff home. The purpose of including it in the proposed microgrid is that it is a designated Red Cross emergency shelter and its proximity to SUNY made it a good candidate.

The info in the chart is an estimate based upon a rental unit, which would be required for use as a shelter if municipal power fails.

The one time and ongoing costs are the same as those reported in question 4, and do not include additional fuel storage requirements (no diesel storage on site) or electrical contracting costs above and beyond those required for a replacement generator (no existing generator).

******Plattsburgh Housing Authority notes: Fuel usage based upon facility manager's estimate and would be very temperature dependent.

The Long generator only powers elevators and emergency lights. The Stearns complex has no backup generation.

Rental estimate is based upon a generator large enough to provide heat and electricity, but may be underestimated as each unit has a full kitchen. The estimate does not account for additional fuel storage requirements (no diesel storage on site) or for electrical contracting costs above and beyond those required for a replacement generator (existing generators are a different fuel source and not intended to provide full load).

# 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? |
|---|---|---|---|---|---|
| Meadowbrook Healthcare Skilled Nursing and Rehab Facility Main Street Nursing Home | Ongoing Measures | Laundry service | 143 | $/day | Year-round. Existing generator does not support 100% of services |
| Meadowbrook Healthcare Skilled Nursing and Rehab Facility | Ongoing Measures | Paper product use | 150 | $/day | Year-round. Existing generator does not support 100% of services |
| Vilas Home | Ongoing Measures | | 0 | | Year-round. Existing generator supports 100% of services |
| CVPH | Ongoing Measures | OT to staff emergency power system | 1000 | $/day | Year-round |
| CVPH | Ongoing Measures | OT and increased operational costs | Unk | $/day | Year-round, dependent upon duration and geographic reach of outage |
| SUNY | Ongoing measures | See notes | | | |
| Plattsburgh High School | NA | NA | NA | NA | No existing backup |
| Plattsburgh Housing Authority | Ongoing Measures | Wages and OT to staff emergency power system | unk | $/day | Year-round |
| Plattsburgh Housing Authority | One time | Wages and OT necessary to help evacuate residents | unk | $/day | Cold weather and prolonged outage in warm weather |
| Plattsburgh Housing Authority | Ongoing measures | Provide food to residents | unk | $/day | Warm weather only, dependent on duration of outage |

*Meadowbrook notes: Laundry estimate based on towels, sheets, and gowns for 207 beds contracted to Century Linen. Paper products include meals plus lack of computer services for documentation.

***CVPH notes: OT to staff emergency power system is the same as indicated in question 2i.

****SUNY notes: Ongoing costs associated with generator operation include monthly in-house service and inspections, fuel tank registrations, and annual service inspections.

*****Plattsburgh High School notes: see note above question 2.

******Plattsburgh Housing Authority notes: During winter, residents would be without heat. They could probably stay 2 days before the Long building cooled too much. The Stearns complex would cool much faster, as it is not a high-rise. During warmer temps, residents could probably stay, with support by the Housing Authority for food.

The Housing Authority would assist its residents in evacuating, but it is not responsible for providing alternatives or paying for them. The residents are renters in the buildings. Individuals units are not able to be powered by portable generators, the entire facility would have to be addressed.

***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? |
|---|---|---|---|---|---|
| Meadowbrook Healthcare Skilled Nursing and Rehab Facility (Meadowbrook) | Ongoing Measures | 300kW Generator rental | 230 | $/day | Year-round |
| Meadowbrook | One time Measures | Cable costs and transportation | 1750 | $/unit | Year-round |
| Meadowbrook | One time Measures | Hook up and disconnect by certified electrician | 5000 | $/unit | Year-round |
| Meadowbrook | Ongoing Measures | Laundry service | 143 | $/day | Year-round. |
| Meadowbrook | Ongoing Measures | Paper product use | 150 | $/day | Year-round |
| Meadowbrook | Ongoing Measures | Refrigeration truck | 400 | $/day | Year-round – may be reduced in winter |
| Meadowbrook | One-Time Measures | Small generator for ice production | 500 | $ | During summer when decision is made to NOT evacuate |
| Meadowbrook | Ongoing Measures | Overtime to cover increased operational costs and employee coverage | unk | $ | Dependent on duration and geographic extent of outage |
| Meadowbrook | One-time Measures | Patient evacuation | unk | $ | Year round if extended outage ONLY if no backup generator rental is available |
| Vilas Home | Ongoing Measures | 200kW Generator rental | 180 | $/day | Year-round |
| Vilas Home | One time Measures | Cable costs and transportation | 1750 | $/unit | Year-round |
| Vilas Home | One time Measures | Hook up and disconnect by certified electrician | 5000 | $/unit | Year-round |

| Facility Name | Type of Measure (One-Time or Ongoing) | Description | Costs | Units | When would these measures be required? |
|---|---|---|---|---|---|
| Vilas Home | Ongoing Measures | Laundry service | 30 | $/day | Year-round when appropriately sized generator is not available – see notes |
| Vilas Home | Ongoing Measures | Paper product use | 100 | $/day | Year-round when appropriately sized generator is not available – see notes |
| Vilas Home | Ongoing Measures | Refrigeration truck | 400 | $/day | Year-round when appropriately sized generator is not available – see notes (may be reduced in winter) |
| Vilas Home | Ongoing Measures | Overtime to cover increased operational costs and employee coverage | unk | $ | Dependent on duration and geographic extent of outage |
| Vilas Home | One time measure | Patient evacuation | unk | $ | Year round if extended outage ONLY if no backup generator rental is available |
| CVPH | Ongoing Measures | 1500 kW Generator Rental<br>800kW Generator Rental | 285<br>115 | $/day | Year round |
| CVPH | One-Time Measures | Patient evacuation | unk | $ | Year round |
| SUNY | See notes | | | | |
| SUNY | Ongoing Measures | 600kW Generator Rental | 0 | $/day | Year round |
| SUNY | One time Measures | Cable costs and transportation | 1750 | $/unit | Year-round |
| SUNY | One time Measures | Hook up and disconnect by certified electrician | 5000 | $/unit | Year-round |
| Plattsburgh High School | Ongoing Measures | 300kW Generator Rental | 230 | $/day | Year round |
| Plattsburgh High School | One time Measures | Cable costs and transportation | 1750 | $/unit | Year-round |
| Plattsburgh High School | One time Measures | Hook up and disconnect by certified electrician | 5000 | $/unit | Year-round |
| Plattsburgh Housing Authority | Ongoing Measures | 300kW Generator Rental | 460 | $/day (two unis)t | Year round |
| Plattsburgh Housing Authority | One time Measures | Cable costs and transportation | 3500 | $ (two units) | Year-round |
| Plattsburgh Housing Authority | One time Measures | Hook up and disconnect by certified electrician | 10000 | $ (two units) | Year-round |
| Plattsburgh Housing Authority | Ongoing Measures | Wages and OT to staff emergency power system | unk | $/day | Year-round |
| Plattsburgh Housing Authority | One time | Wages and OT necessary to help evacuate residents | unk | $/day | Cold weather only |
| Plattsburgh Housing Authority | Ongoing measures | Provide food to residents | unk | $/day | Warm weather only, dependent on duration of outage |

General notes:

1. Generator rental costs were obtained from Milton CAT and would likely come from Clifton Park NY. Available generator sizes were limited and estimates are made based upon a conservative estimate of required generator size. Costs/day are based upon a 7 day period but estimate was given for a week long rental which may be a minimum.
2. Costs for hook up and disconnect were obtained from Wm. J. Murray Inc., a local electrical contractor, in reference to the Vilas home. Similar costs are assumed for all locations.
3. *Meadowbrook notes: Patients would not be evacuated if a rental generator was located in a reasonable amount of time. Costs to move patients is difficult to quantify and would depend on family capabilities, ambulance needs/costs, fuel costs and bed costs at a new facility as well as overtime costs incurred.
4. With addition of new wing and new generator, it is possible that redundancy within the system could preclude the rental of a generator, and modifications to patient care could be made, as it would be unlikely that both generators would fail.
5. **Vilas Home notes: Laundry estimate based on towels, sheets, and gowns for 44 beds contracted to Century Linen.
6. Residents would not be evacuated if a rental generator was located in a reasonable amount of time. Costs to move patients is difficult to quantify and would depend on family capabilities, ambulance needs/costs, fuel costs, and bed costs at a new facility as well as overtime costs incurred
7. The largest generator available locally is 70kW and would cost $300/day. Transport costs would be minimal, but it would not serve all building needs and laundry service, paper product and refrigeration costs would be incurred
8. ***CVPH notes: Hospital would not be evacuated if a rental generator was located Costs to move patients is difficult to quantify and would depend on ambulance costs, fuel costs, and bed costs at a new facility as well as overtime costs incurred
9. An MOU exists with CAT Diesel for a backup rental. It is unlikely that both generators would fail, and some level of service could be maintained.
10. 
11. ****SUNY Plattsburgh notes: Backup generation is spread throughout the campus and one failure does not impact another, except for the Central Heating Plant. Costs provided only refer to a replacement for the Central Heating Plant. Rental of equipment to replace all other backup power would depend on decisions made relative to the extent of the outage, the duration, concerns regarding infrastructure damage (due to extreme temps) and the necessity of the buildings for shelters.
12. It should be noted that Memorial Hall and the Fieldhouse are designated emergency shelters, yet neither has back up power generation.
13. SUNY does not pay rental of generators, as they are owned by NYS. They do have to pay transport and hookup costs.
14. 
15. *****Plattsburgh High School notes: The one time and ongoing costs are the same as those reported in question 4, and do not include additional fuel storage requirements (no diesel storage

on site) or electrical contracting costs above and beyond those required for a replacement generator (no existing generator).

16.

17. ******Plattsburgh Housing Authority notes: Rental estimate is based upon a generator large enough to provide heat and electricity and does not account for additional fuel storage requirements (no diesel storage on site) or for electrical contracting costs above and beyond those required for a replacement generator (existing generators are a different fuel source and not intended to provide full load). During winter, residents would be without heat. They could probably stay 2 days before the Long building cooled too much. The Stearns complex would cool much faster, as it is not a high-rise. During warmer temps, residents could probably stay, with support by the Housing Authority for food.

18. The Housing Authority would assist its residents in evacuating, but it is not responsible for providing alternatives or paying for them. The residents are renters in the buildings.

19. 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. |
|---|---|
| Meadowbrook Healthcare Skilled Nursing and Rehab Facility | 20% |
| Vilas Home | 0% |
| CVPH | 10% |
| SUNY | 80-85% |
| Plattsburgh High School | 0% if rental unit obtained, and hooked up - otherwise 100% |
| Plattsburgh Housing Authority | 90%Long, 100% Stearns |

*Meadowbrook notes:  Max use of onsite fuel is 4 days in good weather.  Prevention of fuel delivery due to weather will impact loss of services.

**Vilas Home notes:  Max use of onsite fuel is 44 hours in good weather.  Prevention of fuel delivery due to weather will impact loss of services.

***CVPH notes:  Max use of onsite fuel is 96 hrs.  Prevention of fuel delivery due to weather will impact loss of services. Loss of services may include outpatient services.

6. During a power outage, <u>if backup generation is not available</u>, 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 |
|---|---|
| Meadowbrook Healthcare Skilled Nursing and Rehab Facility | 100% in winter; 80% in summer |
| Vilas Home | 100% in winter; 80% in summer |
| CVPH | 100% if no backup generator is available |
| SUNY | 100% for each building that loses backup generator - See notes |
| Plattsburgh High School | 100% |
| Plattsburgh Housing Authority | 100% |

*Meadowbrook notes:  207 bed facility (+80 Aug 2106). Evacuation would be season and outage duration dependent.  Worst case is winter.  It is a high-rise building, but has windows, so summer temps can be managed (potentially – depending on temp).   Loss of elevator usage would make evacuation very difficult.

**Vilas Home notes:  42 bed facility.  Evacuation would be season and outage duration dependent.  Worst case is winter.  Summer temps would be manageable.  Elevator loss would greatly hinder patient movement.

***CVPH notes:  Hospital would evacuate.

****SUNY notes:  Students would be sent home.  Backup generation is spread throughout the campus and one failure does not impact another, except for the Central Heating Plant.  Rental of equipment to replace all other backup power would depend on decisions made relative to the extent of the outage, the duration, concerns regarding infrastructure damage (due to extreme temps) and the necessity of the buildings for shelters.

It should be noted that Memorial Hall and the Fieldhouse are designated emergency shelters, yet neither has back up power generation.

***<u>B. Questions for facilities that provide: **Fire Services**</u>***

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

| |
|---|
| |

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

| |
|---|
| |

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

| |
|---|
| |

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

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

| |
|---|
| CVPH EMS: 20000 (City of Plattsburgh). Neighboring paid and volunteer EMS would serve outlying areas |

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:

| |
|---|
| 0 |

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

| |
|---|
| 3 miles |

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

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

| |
|---|
| CVPH: 80000-120000 people. Clinton County has a population of 80000, 2 neighboring counties have populations of 38000 and 50000. There are small hospitals in each, but there would be usage from neighboring counties due to proximity and services provided |

15.

| |
|---|
| 34 miles |

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

| |
|---|
| 40000-200000. Burlington VT population is 38000, Chittenden County VT population is 159000, and this hospital would also serve neighboring counties in VT |

***E. Questions for facilities that provide: Police Services***

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

| |
|---|
| SUNY: 7000 |

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

☐ Metropolitan Statistical Area

☒ Non-Metropolitan City (**university campus)**

☐ Non-Metropolitan County

19. Please estimate:

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

| |
|---|
| 7 |

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

| |
|---|
| Click here to enter text. |

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

| |
|---|
| 0 |

SUNY Plattsburgh University Police and the City of Plattsburgh have a reciprocal MOU to provide support upon request.

***F. Questions for facilities that provide: Wastewater Services***

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

| |
|---|
| Click here to enter text. |

21. Does the facility support (check one):

☐ Residential customers

☐ Businesses

☐ Both

***G. Questions for facilities that provide: Water Services***

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

| |
|---|
| |

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.)?

| |
|---|
| Meadowbrook Healthcare Skilled Nursing and Rehab Facility: 207 beds + 80 beds 8/2016 |

Vilas Home: 42 bed NYS Certified Adult Home (assisted living)

CVPH: 60-bed skilled nursing facility is a part of the hospital

SUNY: Dormitories and student housing

Plattsburgh Housing Authority: 160 units low-income senior housing

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

| |
|---|
| Meadowbrook Healthcare Skilled Nursing and Rehab Facility: 100% 287 as of 8/2016 |

Vials Home: 100% 42-44 residents

CVPH: 100% 60 beds (depending on occupancy) This refers to residents in skilled nursing only – not hospital in-patient beds

SUNY: 2900 during school session, <100 international or infirmed students following a planned evacuation (sending most students home)

Plattsburgh Housing Authority: 150 (estimate based on 60 efficiency units Long, 28 efficiency and 18 1bedroom units Stearns)

## Benefit-Cost Analysis Summary Report - Site 56 – City of Plattsburgh (SUNY)

### Project Overview

As part of NYSERDA's NY Prize community microgrid competition, the City of Plattsburgh has proposed development of a microgrid that would enhance system resiliency in an area increasingly vulnerable to severe winter storms and flooding. The microgrid would primarily serve the State University of New York (SUNY) Plattsburgh campus, which encompasses more than 50 individual buildings. It would also serve the following six commercial customers:

- Champlain Valley Physicians hospital;
- Two nursing homes--the Meadowbrook Skilled Nursing and Rehabilitation Facility and the Samuel F. Vilas Home;
- Plattsburgh High School, which would serve as a Red Cross emergency shelter in the event of a prolonged power outage; and
- Two large apartment buildings managed by the Plattsburgh Housing Authority.

The microgrid would be powered by a new 6.5 MW natural gas-fired combined heat and power (CHP) generator, which would be located at the SUNY Central Heating Plant, and a new 2.3 MW solar photovoltaic array, located adjacent to the SUNY campus. Both of these resources would produce electricity for the grid during periods of normal operation, as well as in islanded mode during power outages. The system as designed would have sufficient generating capacity to meet average demand for electricity from all included facilities during a major outage. Project consultants also indicate that the system would have the capability of providing frequency regulation and 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.

### Methodology and Assumptions

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

- *Costs* represent the value of resources consumed (or benefits forgone) in the production of a good or service.
- *Benefits* are impacts that have value to a firm, a household, or society in general.
- *Net benefits* are the difference between a project's benefits and costs.
- Both costs and benefits must be measured relative to a common *baseline* - for a microgrid, the "without project" scenario - that describes the conditions that would prevail absent a project's development. The BCA considers only those costs and benefits that are *incremental* to the baseline.

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

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

With respect to public expenditures, the model's purpose is to ensure that decisions to invest resources in a particular project are cost-effective; i.e., that the benefits of the investment to society will exceed its costs. Accordingly, the model examines impacts from the perspective of society as a whole and does not identify the distribution of costs and benefits among individual stakeholders (e.g., customers, utilities). When facing a choice among investments in multiple projects, the "societal cost test" guides the decision toward the investment that produces the greatest net benefit.

The BCA considers costs and benefits for two scenarios:

- Scenario 1: No major power outages over the assumed 20-year operating period (i.e., normal operating conditions only).
- 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.[2]

[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 CO2 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 SO2, NOx, and PM2.5, and therefore also applies a three percent discount rate to the calculation of damages associated with each of those pollutants. [See: State of New York Public Service Commission. Case 14-M-0101, Proceeding on Motion of the Commission in Regard to Reforming the Energy Vision. Order Establishing the Benefit Cost Analysis Framework. January 21, 2016.]

[2] 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.

## Results

Table 1 summarizes the estimated net benefits, benefit-cost ratios, and internal rates of return for the scenarios described above. The results indicate that even if there were no major power outages over the 20-year period analyzed (Scenario 1), the project's benefits would exceed its costs by approximately ten percent. As a result, the analysis does not evaluate Scenario 2. Consideration of Scenario 2 would further increase the project's already positive benefit-cost ratio.

The discussion that follows provides additional detail on these findings.

*Table 18. BCA Results (Assuming 7 Percent Discount Rate)*

| Economic Measure | | |
|---|---|---|
| Net Benefits - Present Value | $5,960,000 | Not Evaluated |
| Benefit-Cost Ratio | 1.1 | Not Evaluated |
| Internal Rate of Return | 6.2% | Not Evaluated |

## Scenario 1

Figure 34 and table 19 present the detailed results of the Scenario 1 analysis.

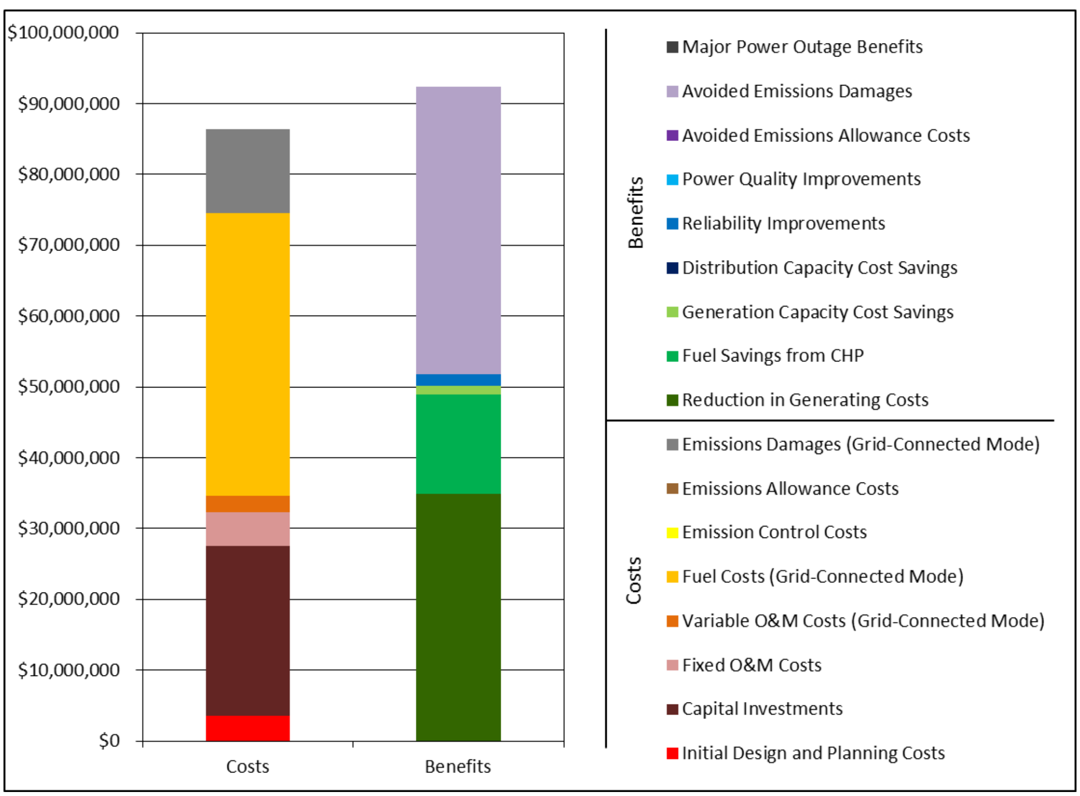

*Figure 35. Present Value Results, Scenario 1 (No Major Power Outages; 7 Percent Discount Rate)*

*Table 19. 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 | $3,590,000 | $317,000 |
| Capital Investments | $24,000,000 | $1,920,000 |
| Fixed O&M | $4,680,000 | $413,000 |
| Variable O&M (Grid-Connected Mode) | $2,420,000 | $214,000 |
| Fuel (Grid-Connected Mode) | $39,800,000 | $3,510,000 |
| Emission Control | $0 | $0 |
| Emissions Allowances | $0 | $0 |
| Emissions Damages (Grid-Connected Mode) | $12,000,000 | $781,000 |
| Total Costs | $86,500,000 | $317,000 |
| Benefits | | |
| Reduction in Generating Costs | $35,000,000 | $3,080,000 |
| Fuel Savings from CHP | $13,900,000 | $1,230,000 |
| Generation Capacity Cost Savings | $1,280,000 | $113,000 |
| Distribution Capacity Cost Savings | $0 | $0 |
| Reliability Improvements | $1,570,000 | $138,000 |
| Power Quality Improvements | $0 | $0 |
| Avoided Emissions Allowance Costs | $19,500 | $1,720 |
| Avoided Emissions Damages | $40,600,000 | $2,650,000 |
| Major Power Outage Benefits | $0 | $0 |
| **Total Benefits** | **$92,400,000** | |
| **Net Benefits** | **$5,960,000** | |
| **Benefit/Cost Ratio** | **1.1** | |
| **Internal Rate of Return** | **6.2%** | |

### *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 $3.6 million, based on a standard estimate of 15 percent of the total investment cost. The present value of the project's capital costs is estimated at approximately $24.0 million, including costs associated with the new 6.5 MW combined heat and power (CHP) system; new 2.3 MW photovoltaic array; underground distribution lines; smart meters; and other system controls. The present value of the microgrid's fixed operations and maintenance (O&M) costs (i.e., O&M costs that do not vary with the amount of energy produced) is estimated at approximately $4.7 million, or $413,000 annually.

### *Variable Costs*

The most significant variable cost associated with the proposed project is the cost of natural gas to fuel operation of the system's CHP generator. 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] The present value of the project's fuel costs over a 20-year operating period is estimated to be approximately $39.8 million.

The BCA also considers the project team's best estimate of the microgrid's variable O&M costs (i.e., O&M costs that vary with the amount of energy produced). The present value of these costs is estimated at approximately $2.4 million, or $3.72 per MWh.

In addition, the analysis of variable costs considers the environmental damages associated with pollutant emissions from the distributed energy resources that serve the microgrid, based on the operating scenario and emissions rates provided by the project team and the understanding that none of the system's generators would be subject to emissions allowance requirements. In this case, the damages attributable to emissions from the microgrid's natural gas generator are estimated at approximately $781,000 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 $12.0 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 $35.0 million; this estimate assumes the microgrid provides base load power, consistent with the operating profile upon which the analysis is based. Cost savings would also result from fuel savings due to the CHP system powered by the new natural gas generator; the BCA estimates the present value of fuel savings over the 20-year operating period to be approximately $13.9 million. The reduction in demand for electricity from bulk energy suppliers and for heating fuel would also avoid emissions of $CO_2$, $SO_2$, $NO_x$, and particulate matter, yielding emissions allowance cost savings with a present value of approximately $19,500 and avoided emissions damages with a present value of approximately $40.6 million.[2]

In addition to the savings noted above, development of a microgrid could yield cost savings by avoiding or deferring the need to invest in expansion of the conventional grid's energy generation or distribution

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

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

capacity.[1] The project team expects development of the microgrid to reduce the conventional grid's demand for generating capacity by an additional 1.5 MW each month as a result of new demand response capabilities. The new CHP generator and photovoltaic array may also provide peak load support to the grid. According to the project team, however, the local utility has no plans to expand generating capacity in the foreseeable future; development of the microgrid is therefore not expected to avoid or defer investments as a result of peak load support capabilities. The BCA therefore estimates the present value of the project's generating capacity benefits to be approximately $1.28 million over a 20-year operating period, based on the project team's estimate of demand response capabilities. Similarly, the project team took a conservative approach with respect to distribution capacity benefits, projecting no impact on local distribution capacity requirements. We note, however, that the project would entail a substantial investment in new distribution infrastructure (e.g., underground distribution lines, smart meters); these investments may yield benefits not accounted for in this analysis.

The project team has indicated that the proposed microgrid would be designed to provide ancillary services, in the form of frequency regulation and 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 these services.

### *Reliability Benefits*

An additional benefit of the proposed microgrid would be to reduce customers' susceptibility to power outages by enabling a seamless transition from grid-connected mode to islanded mode. The analysis estimates that development of a microgrid would yield reliability benefits of approximately $138,000 per year, with a present value of $1.6 million over a 20-year operating period. This estimate is developed using the U.S. Department of Energy's Interruption Cost Estimate (ICE) Calculator, and is based on the following indicators of the likelihood and average duration of outages in the service area:[2]

- System Average Interruption Frequency Index (SAIFI) – 1.03 events per year.
- Customer Average Interruption Duration Index (CAIDI) – 118.2 minutes.[3]

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

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

[2] www.icecalculator.com.

[3] The analysis is based on DPS's reported 2014 SAIFI and CAIDI values for New York State Electric & Gas (NYSEG).

analysis assumes a 15 percent failure rate for backup generators.[1] It assumes that establishment of a microgrid would reduce the rate of failure to near zero.

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

### *Summary*

The analysis of Scenario 1 yields a benefit/cost ratio of 1.1; i.e., the estimate of project benefits is approximately 10 percent greater than that of project costs. Accordingly, the analysis does not consider the potential of the microgrid to mitigate the impact of major power outages in Scenario 2. Consideration of such benefits would further increase the net benefits of the project's development.

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

# Task 5: Conclusions and Recommendations

The Willdan team concluded that a Plattsburgh Community microgrid would be technically feasible but financially infeasible. The cluster of facilities in Plattsburgh that could benefit from increased reliability – educational facilities, nursing homes, a hospital, and low-income residential facilities – is one factor that would make a microgrid attractive. In addition, there was strong support from the personnel at these facilities, from students, and from the community at large for a microgrid project that would have both reliability and environmental benefits. This support is important for a community microgrid project as it makes it much easier to coordinate the various stakeholders, gather the necessary information, formulate a design, and generally move the project along. One key participant, PMLD, while willing to support the NY Prize feasibility study, was not a direct participant in the project and does not see a need for a community microgrid. This made it more difficult to gather detailed information on the existing distribution system. Should a microgrid be built in Plattsburgh, it would be important that the utility see a benefit to the project and that it be fully incorporated into the project planning.

There are technical hurdles that would significantly drive up the cost of a microgrid project, making it economically infeasible. One such factor is that the proposed facilities are on different feeders at different voltages, and other than SUNY Plattsburgh, the facilities all share their feeders with significant non-microgrid load. This would necessitate isolating the facilities from their feeders and tying them together with express lines to form a loop configuration. At least some of these lines would need to cross roadways and would likely need to be buried. The cost of distribution lines was estimated at $5,000,000. Another hurdle is the lack of space for DER in the area of the proposed microgrid. The Plattsburgh central heating plant is the proposed location for a CHP installation, but there is little available space inside the plant. An addition to the building could be constructed, but parking space would likely need to be removed to make way for the addition, driving up cost and reducing available parking. CHP could also be installed at the hospital, but the plant there does not have available space, so land would likely need to be acquired from neighboring properties in order to construct an addition. The proposed solar installation would also face some of the same hurdles. There is little nearby open land for a solar installation, so rooftops or covered parking would need to be utilized, likely limiting the size of the installation and increasing costs.

The biggest impediment to justifying any DER economically is that the average cost of electricity in Plattsburgh is $0.03/kWh due to its NYPA allocation of inexpensive hydropower. Any power produced through a solar Power Purchase Agreement (PPA) would likely be more expensive than this, and CHP would likely operate at a net loss, unable to recover capital costs. In order to make CHP economically viable, the Department of Energy recommends a “spark spread” (the difference in energy unit cost between electricity and natural gas) of $20/MMBtu. In Plattsburgh, the spark spread is $1.69/MMBtu. Exacerbating the poor economics of CHP in Plattsburgh is the fact that there would not be a significant summer heat load in order to justify year-round operation.

Another barrier to building a microgrid that creates value for the partners is that several of the partners already have diesel generator backup capabilities. CVPH and the Vilas home have full or nearly full backup capabilities, so while a microgrid could deliver some enhanced reliability benefits in an extended outage by eliminating reliance on diesel deliveries, the reliability case for these facilities is not as strong. It is also unclear how fully the hospital would be willing to have its DER and load subject to a microgrid controller due to the critical nature of its mission and the resulting regulations under which it operates.

The microgrid would have environmental benefits. While the hydropower received from Niagara Falls is essentially emissions-free, the EPA recommends that this generation be considered baseload generation, so any DER on the microgrid could be assumed to be offsetting fossil-fuel generation with an emissions profile equivalent to the average fossil fuel generation profile for upstate New York. Viewed this way, a CHP installation would result in a decrease in emissions. In addition, a solar installation would obviously have emissions-free operation. There could be further environmental benefits if the microgrid and its control system were to enable increased participation in demand response programs. However, the study found that demand response participation would likely be minimal unless policy changes are made to increase the availability and attractiveness of these programs.

Financing any type of large capital project will be a challenge for SUNY Plattsburgh. As a state university, its budget is controlled at the state level, and the process is somewhat political. Both SUNY Plattsburgh and another SUNY school that Willdan worked with as part of NY Prize, have a prioritized list of capital requests which is significantly underfunded. Therefore, it’s likely that even being able to fund the cost-sharing portion of a NY Prize Phase 3 award would be a challenge.

The project team recommends that SUNY Plattsburgh and any of the other project partners pursue a solar installation should they be able to obtain an attractive PPA. However, the cost of electricity would likely need to rise in order for this to happen. While a solar installation alone would not be a microgrid, it would have environmental benefits and may also have some reliability benefits. The project team also recommends that SUNY Plattsburgh implement the energy efficiency recommendations in the audit report created as part of their work to comply with the NY Governor’s Executive Order 88. This report contains a portfolio of cost-effective measures that would result in an estimated 17.91% reduction in EUI and a $638,863 annual cost savings. The other facilities that have not had energy audits done should also consider doing so and implementing the recommendations. Finally, the project team recommends that the Plattsburgh water plant further investigate the feasibility of installing hydro generation in the plant lines. This location was eliminated from consideration for the microgrid because of geographic distance and the likely limited generation potential. However, there may be enough power potential there to power pumps at the plant. Further investigation into the costs and generation potential would need to be done.