67 - Village of Lansing

Notice

Photo Credit: Kevin W. Hall

Tompkins County Community Microgrid

Final Report – NY Prize Stage 1: Feasibility Assessment

Submitted to:
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PROJECT TEAM

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GI Energy

- Peter Falcier

Green Energy Corp.

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KEY PROJECT STAKEHOLDERS

- Tompkins County Government
- Ithaca Tompkins Regional Airport
- Cayuga Medical Center and tenants of the Parkview Medical Campus
- TST BOCES
- Dewitt Middle School
- Tenants of the Cornell Business and Technology Park
- Courtyard Ithaca Hotel

TOMPKINS COUNTY COMMUNITY MICROGRID – KEY OVERVIEW METRICS

Team

Lead (Awardee):	Tompkins County
Technical Lead:	Green Energy Corp
Additional Consultants:	Hitachi Microgrids, Pace University, GI Energy

Utilities

Electric:	NYSEG
Gas:	NYSEG

Microgrid System Design

Size:	3,470	kW
Load Served:	16,688,040	kWh/yr

DER	Qty	Capacity
Combined Heat & Power:	18	420 kW
Anaerobic Digester:	1	800 kW
Photovoltaic:	15	2,250 kW
Existing Photovoltaic:	3	97 kW
Energy Storage Systems:	14	310 kWh
Existing Emergency Gen:	7	2,145 kW

Microgrid Financials*

Total Installed Cost:	$10,848,000
Net Installed Cost (after ITC):	$8,116,000
Resiliency Savings:	$ 98,219/yr
GHG Offset:	$ 249,000/yr
Avg. Current Electricity Cost:	$ 0.010/kWh

** Estimates based on financial modeling*

Supporting Organizations

Tompkins County Facilities Dept.	Ithaca Tompkins Regional Airport
Cornell University Sustainability	IAD Property Development
Cornell University Real Estate	Tompkins County Climate Protection
Village of Lansing	NYSEG
Cayuga Medical Center	Tompkins County Sheriff
Tompkins County Chamber of Commerce	Tompkins Dept. of Emergency Response
Tompkins County Health Dept.	

Customer Types

Gov't Administrative:	2
Emergency Services:	3
Municipal Services:	0
Education	2
Health Care:	2
Large Commercial:	6
Small Commercial:	0
Multi-Unit Residential:	0
Total:	**15**

Electric Demand & Consumption with Microgrid

	Max kW	Avg kW	kWh / yr
Node 1	1,800	1,631	14,289,684
Node 2	310	274	2,398,356
Total	**2,110**	**1,905**	**16,688,040**

Benefit Cost Analysis Outputs

	Scenario 1	Scenario 2
Days of Major Outage	0 days/yr	0.33 days/yr
Total Benefits**	$ 16,900,000	$ 23,700,000
Total Costs**	$ 23,700,000	$ 23,600,000
Net Benefits**	$ -6,700,000	$ 84,600
Benefit/Cost Ratio	0.7	1.0

*** Net Present Values*

EXECUTIVE SUMMARY

The New York State Energy Research and Development Program (NYSERDA) established the New York Prize program to stimulate adoption and deployment of community microgrids throughout the state to:

- Reduce energy costs
- Increase the reliability of the power supply and community resilience
- Promote cleaner sources of energy

This report describes the results of Stage 1 of the NY Prize Feasibility Assessment for the Tompkins County Community Microgrid. Hitachi Microgrids led the development of the microgrid design according to NYSERDA's requirements and the needs of and priorities of Tompkins County, using an iterative process that supports the optimization of cost, emissions and resilience goals. Tompkins County led the feasibility assessment, in collaboration with the Hitachi Microgrids, Green Energy Corp, Pace University, and GI Energy. Various community organizations and partners, including the future customers of the Tompkins County Community Microgrid, lent additional support.

Community Overview

Tompkins County is a rural county located in the Finger Lakes Region of New York, at the base of Cayuga Lake. The county is home to a wide range of socio-economic diversity, including areas of urban and rural poverty as well as relative affluence in and around the City of Ithaca, the county seat. The county is home to three institutions of higher learning: Cornell University, Ithaca College, and Tompkins Cortland Community College. These schools have a total enrollment of 34,000, a significant school-year addition for a county with 103,000 permanent residents.

The Tompkins County Community Microgrid is located just northeast of Ithaca, in the Village of Lansing. The microgrid is organized around the Ithaca Tompkins Regional Airport and includes several adjacent county public health and safety facilities, as well as a high-tech business park and a small healthcare campus. Directly to the south, a second microgrid node covers two primary schools.

The Tompkins County community is deeply committed to sustainability. The microgrid design reflects this focus, greatly reducing emissions associated with energy generation while simultaneously hardening several public services on which all county residents rely.

Community Requirements and Microgrid Capabilities

The Tompkins County Community Microgrid is designed to meet specific needs within the community. These include the need to improve sustainability, the need to harden infrastructure against damage, and the need to ensure continuity of emergency operations and services.

First, the microgrid is intended to advance Tompkins County's aggressive sustainability objectives. Based on these goals, the project team focused on maximizing the role of solar PV and energy storage, and minimizing the use of natural gas powered CHP systems. To meet the base load, an anaerobic digester was added to the design, coupled with an 800 kW gas engine. The anaerobic digester uses bacteria and chemical processes to rapidly break down biological wastes. The resulting biogas is used to fuel gas engines or turbines, and generate electricity. The anaerobic digester that is included in the Tompkins County Community Microgrid will likely take feedstock from nearby dairy farms and from municipal food waste. This will help to divert manure from local waterways, which will help prevent nitrification both in streams and in Cayuga Lake. The anaerobic digester will also help to offset greenhouse gas (GHG) emissions from the decomposition of manure in the field. Altogether, the Tompkins County Community Microgrid will reduce carbon emissions by 5,600 metric tons per year – equivalent to taking 1,556 cars off the road.

The Tompkins County Community Microgrid is also designed to harden infrastructure against storm damage. The airport that is at the center of the microgrid cannot function during an extended outage, since the air traffic control tower cannot take advantage of existing backup generation. The microgrid will allow the airport to continue operating uninterrupted during power outages, making use of the DER in Node 1. This added resiliency will help the airport to serve 2,000 passengers a week without delays or cancelled flights. As part of the microgrid project, the main feeds in the area will be converted from overhead lines to underground cables. This will dramatically improve the resilience of this equipment, making it virtually immune to storm damage of any kind, and helping to ensure constant supply of electricity to facilities included in the microgrid.

The microgrid is also specifically designed to ensure continuity in public services, especially those related to emergency operations. The microgrid covers many county facilities, including the public safety building (including the sheriff's office), the emergency response building, and the county health department. These facilities are vital to the health and safety of all of Tompkins County's 103,000 residents. The microgrid also covers the airport and associated facilities, including the crash, fire, and rescue facility. The airport is already critical in its day-to-day role transporting passengers from all over the region, but in an extended emergency, it may become even more important for the delivery of emergency supplies.

The microgrid is also designed to provide benefit to the utility. The proposed microgrid solution has the capability to provide important ancillary services to the NYSEG distribution grid, such as demand response, voltage support, and VAr support. Through aggregation of the nodes, the microgrid design supports the provision of ancillary services to the New York ISO. Existing programs include regulation and operating reserve, energy imbalance (using market-based pricing), and the cost-based services of scheduling, system control and dispatch, voltage control, and black start. In addition, the proposed microgrid may improve service reliability, helping NYSEG to meet regulatory requirements for service reliability improvements for years to come without additional capital expenditures.

Technical Design

Analysis of the Tompkins County Community Microgrid design indicates that the project is technically viable and meets the community's requirements with commercially available and proven technologies. The proposed design for the Tompkins County Community Microgrid is based on the strategic placement of microgrid resources among the included facilities. The resources in the microgrid design include solar photovoltaics (PV), natural gas powered combined heat and power (CHP), energy storage systems (ESS), and existing backup diesel generators. (No new backup generators will be installed). The microgrid resource selection is based on Hitachi's *Microgrid*

Portfolio Approach. This approach uses a careful analysis of energy requirements and the electric load profile of all covered facilities to determine optimal size and specification of equipment. The goal of this approach is to enable microgrid resources to serve the microgrid loads more efficiently, more cost effectively, and with lower emissions per unit of energy consumed.

Under this strategy, base-load CHP and the anaerobic digester will be designed to run at design output for a majority of the hours per year. All critical facility services can be provided by a set of continuously operating microgrid resources operating in conjunction with the grid for the majority of hours in a year. To meet the load that varies above the base load, PV and ESS will be integrated into the system. ESS are specified based on their capability to address PV intermittency support, PV load shifting, peak shaving (to manage utility imports), supporting CHP loading, and stabilize island mode operations. The design also incorporates active microgrid controls that enable optimal operation of energy storage, PV, and building management systems to manage load and reduce the afternoon peak load when needed.

The microgrid is designed to include critical facilities along a 1.5 mile stretch of Warren Rd. where it intersects with New York State Route 13. In order to include both north and south of the highway, the design is based on two separate nodes, one to the north and one to the south. Each of these nodes will have its own microgrid resources and will be able to island individually. In grid connected mode, the resources will be dispatched to minimize emissions. The table below, which also appears in the report that follows, summarizes the DER, new and existing, that will be included in the proposed microgrid design.

Executive Summary Table 1 - Microgrid Resources Comparison

Node	Operation Scenario	Grid	PV		Battery Energy Storage		CHP		Anaerobic Digester		Backup Generators	
		Peak kW	# of Inverters	kW	Qty	kW / kWh	Qty	kW	Qty	kW	Qty	kW
1	Business as Usual	2,540	3	97	-	-	-	-	-	-	5	1,745
	Microgrid	1,800	16	1,997	12	120/240	16	160	1	800	5	1,745
2	Business as Usual	660	-	-	-	-	-	-	-	-	2	400
	Microgrid	310	2	350	2	35 / 70	2	260	-	-	2	400

Executive Summary Table 2, which also appears in Section 2 of this report, gives an overview of the normal operation of the proposed microgrid design in terms of electricity demand and consumption, thermal load, and thermal heat recovery (through new CHP systems) by node.

Executive Summary Table 2 - Microgrid Energy Overview: Grid Connected Operation

	Electric Demand		Electric Consumption		Thermal Load		Thermal Recovery	
Node	Max (kW)	Avg (kW)	kWh/year	kWh/month	kBTU/year	kBTU/month	kBTU/year	kBTU/month
1	1,800	1,631	14,289,684	1,190,807	49,967,225	4,163,935	3,627,183	302,265
2	310	274	2,398,356	199,863	27,497,995	2,291,500	5,968,248	497,354
Total	**2,110**	**1,905**	**16,688,040**	**1,390,670**	**77,465,220**	**6,455,435**	**9,595,431**	**799,619**

The microgrid controller will operate the microgrid to maximize economic benefits, minimize emissions, and maximize reliability of service in the event of a fault on the grid. The microgrid controller will also track the hours of operation of each microgrid resource, and will employ a predictive maintenance strategy to schedule maintenance before any failure occurs and dispatch a technician in the event of an alarm. As the microgrid operates, a history of performance, trending, and signature analyses will develop, adding to the microgrid's ability to anticipate and avoid failures.

The ability of the Tompkins County Community Microgrid to provide critical facilities with an uninterrupted supply of electricity and heat during power outages depends on successful transitions into and out of "island mode." Island mode refers to the mode of operation in which the microgrid disconnects from the utility grid and powers critical facilities solely from on-site resources.

The microgrid controller will manage all microgrid resources for island mode operational and performance objectives. The microgrid design ensures a seamless transition into and out of island mode operation. The microgrid controller will have the capability to provide information to the electric utility.

One of the most important attributes of the Tompkins County Community Microgrid will be the ability to operate when the utility grid is not available. The methods of transitioning into an island mode are characterized as either a (1) planned transition or (2) unplanned transition.

- Planned Transition*:* In a planned transition, outside information is used to ramp up resources so there is zero grid import to the microgrid. A seamless transition occurs into island operations at the appropriate time. Outside information includes weather forecasts, grid frequency deviations, local voltage sags, or other information provided by the utility.
- Unplanned Transition*:* In an unplanned transition, an unanticipated outage takes place such as the loss of a transformer or a car hitting a distribution power pole. Depending on the microgrid resources operating at the time, an outage may take place that requires the microgrid to establish itself through a black start sequence of operation.

Financial Feasibility

The project team developed a general budget for the Tompkins County Community Microgrid project and incorporated it into the technical model to ensure that the design meets both the technical and economic requirements of the project. This budget includes costs for engineering, permitting, capital equipment, site preparation, construction, controls, start-up, commissioning, and training. The cost associated with "site preparation" includes the addition and modification of electrical infrastructure, point of common coupling (PCC) controls, monitoring, and protection equipment. Some of these infrastructure costs may be paid to the electric utility. The estimated installed cost for this project is $10,848,000 with an accuracy of +/- 25% (within the +/- 30% set by NYSERDA). The net cost with the federal investment tax credit (ITC) that was recently extended by the US Congress is $8,116,000. This cost does not include other incentives that may be applicable to the project that will be applied during the detailed analysis in Stage 2.

The outputs of the technical modeling process described above were used to evaluate the financial viability of the proposed microgrid from two perspectives. First, the project team analyzed the financial strength of the project when deployed using the proposed third-party ownership business model. Under this model, the project is funded through outside investment and debt which is recouped through a power purchase agreement (PPA) with each facility. In addition, NYSERDA contracted with Industrial Economics, Incorporated (IEc) to perform a benefit-cost analysis. The focus of this analysis is to evaluate the societal benefit of the microgrid, including benefits from emissions reductions, cost reductions, and resilience improvements.

Business Model Financial Results: Under the proposed business model, a third party would fund all development and construction of the microgrid, own and operate the assets, and sell the energy generated from the microgrid to community customers through PPAs. The community would incur no costs to build the project and would receive all of the benefits of energy resilience during a grid outage, and improved sustainability. Community stakeholders have indicated that third party ownership of the microgrid is currently the preferred ownership structure. The current weighted electric rate of the key critical facilities included in the proposed microgrid is approximately $0.10/kWh. Based on estimated project financing costs and the 25 year contract term, the study supports a PPA electric rate with an electric cost that is an average of 20% than the average cost of electricity currently paid by potential microgrid customers. This analysis does not include Stage 2 or Stage 3 NY Prize funding, which would have the potential to significantly lower the PPA rate.

Benefit-Cost Analysis Results: NYSERDA contracted with IEc to conduct a benefit-cost analysis. The project team provided detailed information to IEc to support this analysis. IEc ran two scenarios for this proposed microgrid. The first scenario modeled no power outages, and evaluated the grid connected mode of operation. The second scenario modeled the number of days (or partial days) outage at which the costs of the microgrid would be equal to its various benefits, thus yielding a cost benefit ratio of 1. For the Tompkins County Community Microgrid, the breakeven outage case is an average of .33 days of outage per year. The cost benefit results are presented in Table 3.

Executive Summary Table 3 – Cost Benefit Analysis Results

Economic Measure	Assumed average duration of major power outages	
	Scenario 1: 0 DAYS/YEAR	Scenario 2: 0.33 DAYS/YEAR
Net Benefits - Present Value	-$6,700,000	$84,600
Total Costs – Present Value	$23,700,000	$23,700,000
Benefit-Cost Ratio	0.7	1.0
Internal Rate of Return	-2.9%	6.3%

This benefit-cost analysis differs from the financial feasibility analysis performed by the project team in several ways. In addition to the differing objectives of these two analyses, the underlying assumptions used in each also differed. A few of these differences affected the results of these analyses in significant ways, including:

- Gas rates used in IEc'sbenefit-cost analysis were based on a state-wide average for commercial end-use customers, while those in the project team's financial feasibility analysis were based on the NYSEG's distributed generation rate. This resulted in year 1 gas rates of $6.34, for IEc's benefit-cost analysis and $5.61 for the project team's financial feasibility analysis. If NYSEG's distributed generation rate were applied to IEc's benefit-cost analysis, net benefits would be increased by $160,000.
- The project team's financial feasibility assessment incorporates the tax benefits of the Federal Investment Tax Credit, whereas the benefit-cost analysis does not. This benefit reduces the capital cost of the project by $2.7M.
- Capital replacement costs used in IEc's benefit-cost analysis were calculated as full replacement costs, whereas the project team assumed a 'rebuild' cost that is not equal to the full cost of replacement. The rebuild cost is $210,000 lower than the full cost of replacement.
- IEc included the cost of electricity purchased from the anaerobic digester as part of "fixed O&M," one of the line items under "Total Cost." The net present value of this electricity purchase is $5,340,000, or approximately $472,000 per year over a 25 year PPA term.
- IEc's benefit-cost analysis derives a price for electricity based on average wholesale energy costs, whereas the financial feasibility assessment evaluates the savings to the community based on actual costs paid by community participants.
- The period of analysis in IEc's benefit cost analysis is 20 years and the third party ownership model usted by Tompkins County is based on a period of analysis of 25 years.

The entirety of the IEc analysis can be found in Appendix D of this report.

Conclusions and Next Steps

The NY Prize feasibility assessment indicates that the Tompkins County Community Microgrid is technically viable, and may be economically viable if awarded further NY Prize grants. The microgrid will help the county to reach its ambitious sustainability goals while significantly improving the resilience of public safety and health services, and hardening critical infrastructure, including the regional airport. The project team believes that the proposed microgrid design will provide valuable lessons to other communities considering developing a microgrid around an airport, communities interested in maximizing the sustainability benefits associated with microgrid development, and those considering the use of an anaerobic digester as part of their microgrid resource portfolio. Key findings from the NY Prize feasibility assessment include:

1. **Engaged Stakeholders**: The larger loads in the Tompkins Community Microgrid are all at facilities and institutions that are well established and committed to the project, including many that are directly managed by county government.
2. **Clean Energy Profile**: The Tompkins County Community Microgrid is designed to advance the county's aggressive climate change abatement goals, including a target of 80% reduction in GHG emissions from 2008 levels by 2050, and an interim goal of 20% by 2020.   The microgrid's renewable energy resources (PV and anaerobic digester) will decrease the emissions associated with powering the facilities in the microgrid significantly. The GHG offset value of the microgrid will be equal to $249,000 per year.
3. **Natural Gas Availability:** The design of the Tompkins County Community Microgrid intentionally minimizes the use of natural gas fed CHP units to better support the county's climate and clean energy goals, and includes an anaerobic digester as an alternative means of meeting the base loads in Node 1. However, even if project stakeholders had wanted to use more natural gas generation, there would have been none available, as the supply from the gas utility is severely constrained at the microgrid location. The utility, NYSEG, is undecided about whether they will expand gas service to the area in the future. If no additional gas capacity is added, the project team will be constrained in the changes they can make to the design to try to lower costs, and the project will lose some scalability.
4. **Anaerobic Digester Costs**: The addition of the anaerobic digester to the Tompkins County Community Microgrid design has added significantly to projected energy costs for microgrid customers. Given the high capital cost of such a system, the project team decided that the special purpose entitiy (SPE) is likely to purchase the electricity from this system, rather than pay to develop and own it.   Should the Tompkins County Community Microgrid project reach Stage 2 of the NY Prize program, a detailed study will be conducted of the anaerobic digester system, and the details of its operation. In particular, the project team will need to determine the exact feedstock requirements of the system, and identify reliable and cost-effective sources for this feedstock. The economics of the system will need to be evaluated in detail to determine how the PPA price for the anaerobic digester electricity will contribute to the final PPA price paid by microgrid customers.

5. **Community Microgrid Financing Costs**: The cost of project financing is high for community microgrids. This is due to the fact that there are numerous stakeholders and potential customers, and that each stakeholder has its own procurement requirements. The project team will need to seek out a financier that is knowledgeable about these projects, and can help keep transaction costs to a minimum.
6. **Financial Prospects**: As it stands, the Tompkins Community Microgrid project is not likely to meet the financial requirements for third party financing and ownership. In order to meet these requirements, one or more of the following conditions would need to be met:
    a. The award of Stage 2 and Stage 3 NY Prize grants from NYSERDA
    b. Removal of smaller facilities within Node 1 to reduce transaction costs
    c. The use of PPA rates above the current average cost of energy for prospective microgrid customers.

The next steps that Tompkins County will need to undertake are to finalize the ownership structure to be proposed, and identify a team of partners to engage in the detailed design phase of the project. Once these decisions are made, the project team will draft a proposal to NYSERDA to compete in Stage 2 of NY Prize. This Stage 2 funding will help defray the additional cost and risk associated with a multi-stakeholder community microgrid. Stage 2 of the NY Prize program will require additional cost share, and a determination will need to be made about which parties will take this on.

Tompkins County Community Microgrid
Final Report – NY Prize Stage 1: Feasibility Assessment

TECHNICAL DESIGN

The proposed microgrid solution will focus on community resiliency based on distributed resources co-located at or near the critical facilities serving public safety, government, education and important research and commercial activity. The strategy is to develop a community microgrid that consists of multiple site-specific microgrids that may or may not be connected from an electrical perspective but are controlled as a single entity. One of the challenges of community microgrids is that the facilities and the microgrid resources are distributed. To maximize the economics, reliability, and emissions reduction potential of the community microgrid, the microgrid controller architecture must have the capability to coordinate and control different groups of resources as well as provide control for localized operations.

A screening process was developed and implemented to select the best sites for the microgrid based upon a set of screening criteria for the area immediately surrounding the Ithaca Tompkins Regional Airport and Cornell Business & Technology Park, and another for the BOCES campus and DeWitt Middle School. The BOCES/DeWitt node will be connected to the airport/technology park. Collectively, there are a total of 2 “nodes” that make up the Tompkins County Community Microgrid.

The two Tompkins nodes and included facilities and functions are listed in the table below.

Table 4 – Overview of Microgrid Nodes

Microgrid Node #	Facilities	Functions
1	• Tompkins County Public Safety • Tompkins County Emergency Response • Ithaca Tompkins Regional Airport • Crash, Fire and Rescue 1 & 2 • County Aviation • Aircraft Hangers (T1 & T2) • Taughannock Aviation • U.S. Geological Survey • County Health Dept. • NY Drug Testing • Ongweoweh Corp • Bin Optics • ATC-NY • Nielsen Claritas • Kionix • Cayuga Venture • Rheonix • Courtyard Ithaca Hotel • Bigwood Systems • Quintiles • CBORD Group • Advion • Langmuir Labs • USPS Facility • FedEx Facility • Cayuga Medical Associates • Cayuga Medical Convenient Care • Parkview Healthcare Campus	• Public Safety • Public Health • Emergency Response • Commercial Aviation • Private Aviation • Scientific Research • Economic Development • Commercial Business Operations • Emergency Medical Care • Specialized Health Care
2	• TST BOCES Campus • Dewitt Middle School	• Education • Shelter

The microgrid design employs underground cabling to support each microgrid node. While this greatly improves resiliency within a microgrid node, the cost of the underground cabling impacts the overall project costs. The main utility feeders are overhead lines, which cannot be relied upon in the event of a major storm. Some of the existing utility distribution lines are already underground. Strategic sections of existing overhead distribution lines will be under-grounded to improve resiliency within the node. The same general protection schemes are employed in each microgrid node as are used in utility distribution networks. Some pole-top transformers will be replaced with pad-mount distribution transformers, and additional isolating switches and breakers will be added at the point of common coupling (PCC). There is strategic underground cabling designed into the solution to create a large geographic area microgrid node (Node #1) as shown in Appendix A as the dotted white line.

The existing thermal infrastructure in all critical facilities consists of hot water (hydronic) systems. The CHP connections to the hot water systems are installed in parallel with the existing boiler, and fed into the supply and return headers.

In addition to the potential facilities identified above, the Tompkins County Community Microgrid will create benefits for other stakeholders. If selected for the next stage of NY Prize, the project team will continue to solicit their advice and participation. These stakeholders include:

Table 5 – Community Stakeholders to Benefit from the Microgrid

Organization	Benefits from Tompkins County Community Microgrid
New York State Electric and Gas (NYSEG)	By serving the local load and providing resilient energy, the system may allow the utility to delay potential investments in the existing substation equipment. This system will also help the utility meet its customer-sited renewable energy target under the New York's Renewable Portfolio Standard.
Cornell University	The microgrid will help the university to protect the operations of its facilities in the business park (including Langmuir Labs), and the business of its high technology tenants in the park. The renewable energy resources included in the microgrid would help Cornell to attain ambitious goals for greenhouse gas reduction outlined in the Cornell Climate Action Plan.
Local Farms	The anaerobic digester may provide a practical disposal option for local dairy farms that find animal waste disposal difficult or expensive.
Delta Airlines, American Airlines, and United Airlines	These airlines will be better able to serve the area, and may experience fewer cancelled flights, given the airport's increased resilience to power outages.

KEY FEATURES OF THE MICROGRID

Community Microgrid Controller

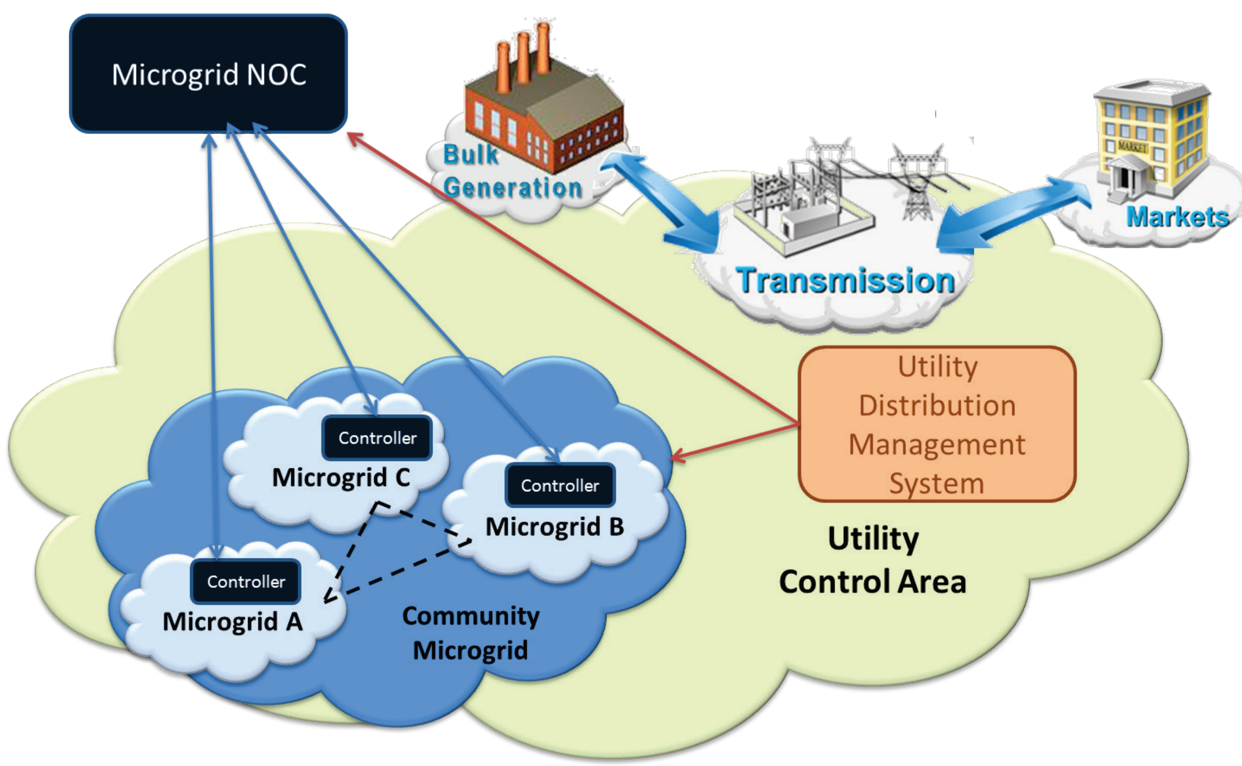
One of the challenges of community microgrids is that the facilities and the microgrid resources are distributed. To maximize the economics, reliability, and emissions reduction potential of the community microgrid, the microgrid controller architecture must have the capability to coordinate and control different groups of resources as well as provide control for localized operations.

Our team has developed a project concept for the community microgrid that allows for simultaneous control of multiple microgrids in the community as well as coordination with the local utility. Specifically, the solution includes local controllers in each microgrid part as well as a hosted controller in the Microgrid network operating center (NOC) that can operate each microgrid part separately or collectively.

In the grid-connected mode, the primary operations will focus on maximizing economic benefits and minimizing emissions across all the microgrids within the community. In some cases, the aggregation of the microgrid resources can be leveraged to support utility firming request and/or RTO/ISO ancillary services such as demand response and frequency regulation. However, during a reliability event, the operation of each individual microgrid controller will focus on the load and generation assets only within its control. The local controller will transition to island mode while maintaining proper voltage and frequency.

Figure 1 presents our team's design approach for the community microgrid controller architecture.

Figure 1: Project Concept for Community Microgrid



The microgrid controller will have an active management and control architecture that supports the 10 EPRI/ORNL Use Cases:

1. **Frequency control**: In normal operations, the microgrid may not have enough resources to affect frequency on the grid. It could participate in the ancillary services markets by increasing output to support the frequency in the local grid, but total impact would be small. Nevertheless, the system will monitor frequency along several thresholds, providing a discrete high-low range; the system will detect if frequency is out of range and respond by taking resources off-line or dispatch other resources to manage frequency. Also, the system will analyze data to detect subtler trends that do not exceed thresholds but provide evidence of a possible problem.
2. **Voltage control**: In both grid-connected and islanded modes, the voltage control application will be used to provide stability to the microgrid and connected circuits. Voltage control leverages line sensing and metering to provide control actions when necessary. This application will take into account traditional volt/VAr instruments such as tap changers and cap banks along with inverter-based resources, which should provide a greater degree of optimization.
3. **Intentional islanding**: For each microgrid node, the islanding process will be semi-automatic so that a utility operator or local energy manager will be able to move through each step before opening the PCC. The utility operator will provide the appropriate permissives for opening the PCC. The local microgrid controller for each microgrid node will be responsible for setting the voltage source and load following resource.
4. **Unintentional islanding**: The designed PCC structure, coupled with additional analysis compliant with IEEE 1547.4, enables the utility-controlled breaker or switch to immediately open (frequency = 59.3 Hz) on loss of the grid. The microgrid managed synchronizing breaker will remain closed for a few more milliseconds until microgrid frequency reaches 57.0 Hz. Since the inverters and generator controls are keying off the synchronizing breaker, these few additional milliseconds enable the energy storage and power electronics to better manage the transient as the microgrid resources pick up the portion of the load served by the utility grid just before the grid was lost. When, or if, the frequency dips to 57.0 Hz and the synchronizing breaker opens, the microgrid will move into island mode. The microgrid controller will adjust all microgrid resources for the new state and island performance objectives.
5. **Islanding to grid-connected transition**: As with intentional islanding, the utility operator will provide the appropriate permission to close in the PCC. The local microgrid controller will support the reconfiguration of each dispatchable resource.
6. **Energy management**: The microgrid design incorporates a portfolio of resources. The EPRI Use Case takes a traditional energy management approach– economic dispatch, short-term dispatch, optimal power flow, and other processes typical in utility control room environments. The microgrid controller will have corresponding applications that manage a set of controllable generation and load assets. Within that portfolio, the system will also optimize the microgrid based on load forecast, ancillary services events, changes in configuration, outage of specific equipment, or any other kind of change to determine the optimal use of assets 48 hours ahead.

7. **Microgrid protection**: The microgrid controller will ensure two primary conditions. The first is that each protection device is properly configured for the current state of the microgrid, either islanded or grid-connected. The second condition is that after a transition, the microgrid controller will switch settings or test that the settings have changed appropriately. If the test is false in either condition, the controller will initiate a shutdown of each resource and give the appropriate alarm.
8. **Ancillary services**: The controller will provide fleet control of the nested microgrid parts. Specifically, the utility operation will have the ability to request and/or schedule balance up and balance down objectives for the fleet. The cloud-based controller will take the responsibility to parcel out the objectives for each microgrid part based on the available capacity.
9. **Black start**: The local microgrid controller will provide a workflow process for restarting the system. Each microgrid part will have a unique sequence of operations for predetermined use cases. One objective will be to provide this function both locally and remotely to meet the reliability requirements of the overall design.
10. **User interface and data management**: The solution provides local controllers in each microgrid part as well as a hosted controller that can operate each microgrid part separately or collectively. The primary actors are the utility operator, local energy managers, maintenance personnel, and analyst. The user experience for each actor will be guided by a rich dashboard for primary function in the system around Operations, Stability, Ancillary Services, and Administration.

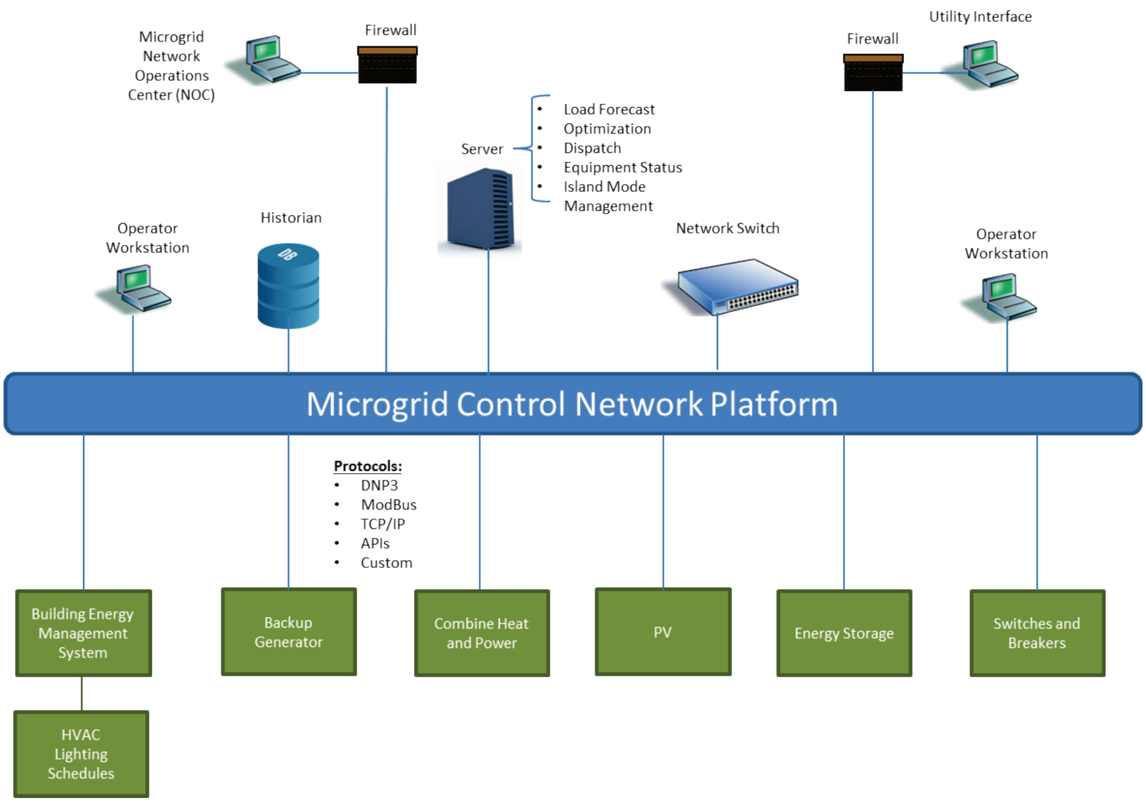
In addition, the microgrid controller will:

- Forecast variable aspects: load, wind, solar, storage
- Dispatch of DER to maximize economic benefit
- Continuously monitor and trend health of all system components
- Take into account utility tariffs, demand response programs, and ancillary service opportunities
- Understand operational constraints of various DER and vendor-specific equipment
- Interface to local utility
- Meet rigid and proven cyber security protocols

Ultimately, the control system will perform all of the functions above to continuously optimize the operation of the microgrid for economic, resiliency, and emissions performance.

A microgrid controller design needs to be reliable and have redundancy comparable to the other microgrid resources. A standard controller approach such as central controller or programmable logic controller (PLC) design will therefore not be sufficient. The architecture must support the capability to interface with field devices, provide a platform for communications and data management, provide for both local and remote operator access, have a data historian, and provide for applications to meet the microgrid Use Cases highlighted above. A conceptual controller topology is presented in Figure 2.

Figure 2 – Conceptual Microgrid Controller Topology



To support the community node approach, the microgrid control scheme will provide for a secure external access to the NOC that can coordinate the various nodes within the community. In addition, remote access to the utility will be provided to inform them and their distribution operators of the microgrid status and to communicate protection relay permissives for the island-mode transitions. The system will be designed so the core control functions are located within the microgrid and so that loss of communication with the NOC will not significantly impact the local operations of any node. The NOC monitors equipment performance and coordinates across nodes. In the event of an outage, all control will move to local controllers and focus on site specific optimization and operations.

The microgrid controller will leverage existing equipment to the greatest extent possible. This will include building energy management systems, backup generators, and local area networks. For the purposes of reliability and security, the microgrid control system will consist of new and independent infrastructure.

Telecommunications Infrastructure

Each microgrid node will have a wireless LAN specific to the microgrid, powered by microgrid resources, and extended to every resource, device, sensor, and load interface (e.g., building management system). This communications infrastructure will be designed with dual-redundant access points to ensure reliable onboard communications.

The architecture will conform to requirements established by the SGIP and generally accepted communications protocols, such as ModBus (TCP/IP), DNP3 (TCP/IP), and IEC61850, as well as field networks for buildings such as LonWorks and BACnet. ModBus will be used throughout the microgrid nodes for communications, as it is currently the most prominent communications protocol within the DER and inverter community. Communications with the utility distribution management systems will use DNP3, as that is the prominent protocol used by the utility industry.

In addition, the NIST IR 7628, "Guidelines for Smart Grid Cyber Security," will be followed in the architecture and design of the microgrid controls' IT and communications to ensure security and continuity of operations in all modes. Finally, the IT/telecommunications infrastructure will be new to secure the microgrid controls network separately from existing IT and communications systems at the facilities.

Communications – Microgrid and Utility

Communications between the microgrid and the utility will occur in two forms: (1) utility DMS will interface with the microgrid controls for monitoring and managing the PCC utility-controlled isolating switch and microgrid-controlled synchronizing breaker, and (2) a dashboard served by the microgrid controls to the utility via the internet will give the utility insight into the day to day operations of the microgrid.

In accordance with the EPRI/ORNL Microgrid Use Case 4, the microgrid will transition into island-mode operations upon loss of communications between the utility DMS and the microgrid, assuming loss of grid. No specific microgrid action will be taken on loss of the utility dashboard service via the Internet.

The microgrid control system will be local to the microgrid node in a secure, conditioned space, (e.g., electrical room) in one of the critical facilities within the microgrid node. This ensures that real-time control of the microgrid resources and loads will be maintained in the event of a loss of communications with the utility distribution management system (DMS) and Internet services. Although economic optimization will be reduced for a period of time, the reliability and resiliency optimization will be maintained because those algorithms are in the microgrid control system local to the microgrid node and do not require off-board communications to function.

The onboard communications within the microgrid LAN will be a dual-redundant architecture, where every LAN access point is backed up by another access point.

DISTRIBUTED ENERGY RESOURCE CHARACTERIZATION

A variety of generation sources are planned for the community microgrid. They include the following:

- Anaerobic Digester with generator
- CHP
- PV
- ESS
- Building Load Control
- Energy Efficiency Measures (EEMs)
- Utility Grid
- Backup Generators

The Tompkins microgrid design is focused on the development of an overall energy strategy that incorporates both demand-side management and new distributed generation resources to support the microgrid's operational objectives. During operation in the grid-connected mode, the resources will typically be dispatched in an economic optimization mode. This approach will ensure that the microgrid will operate in a manner that the energy delivered to the critical facilities is at or lower than the cost of electricity that could be purchased from the local utility. In this scenario, the CHP and anaerobic digester will operate in a constant output mode at its maximum efficiency and lowest emissions, the PV generation profile will be taken into account, the energy storage will operate in a manner to maximize microgrid benefits, and the grid will operate in a load following mode. The connection to the grid will also be used to manage the voltage and frequency of the microgrid.

The microgrid will take advantage of DER to remain in operation when the utility grid is not available. The microgrid controller will monitor island mode frequency and voltage and adjust equipment operation accordingly to maintain circuit stability. Existing backup generators will be leveraged to support island operations in conjunction with the new DER. New DER will minimize the need for the backup generator operation to minimize natural gas and diesel fuel usage. The microgrid will also support the transition back to the grid when the utility service is restored. The design ensures that the return to the grid is a seamless transition and is coordinated with the utility through appropriate protocols, safety mechanisms, and switching plans (to be communicated to the microgrid controller by the utility distribution management system).

To support steady-state frequency requirements, as well as the ANSI 84.1-2006 standard voltage requirements and to support the customer power quality requirements at PCC, the microgrid controller will actively manage the dispatch of generation resources; actively manage the charge and discharge of energy storage; provide observability of microgrid-wide telemetry including frequency, power factor, voltage, currents and harmonics; provide active load management; and provide advance volt-VAr variability algorithms and other stability algorithms based on steady state telemetry of the system.

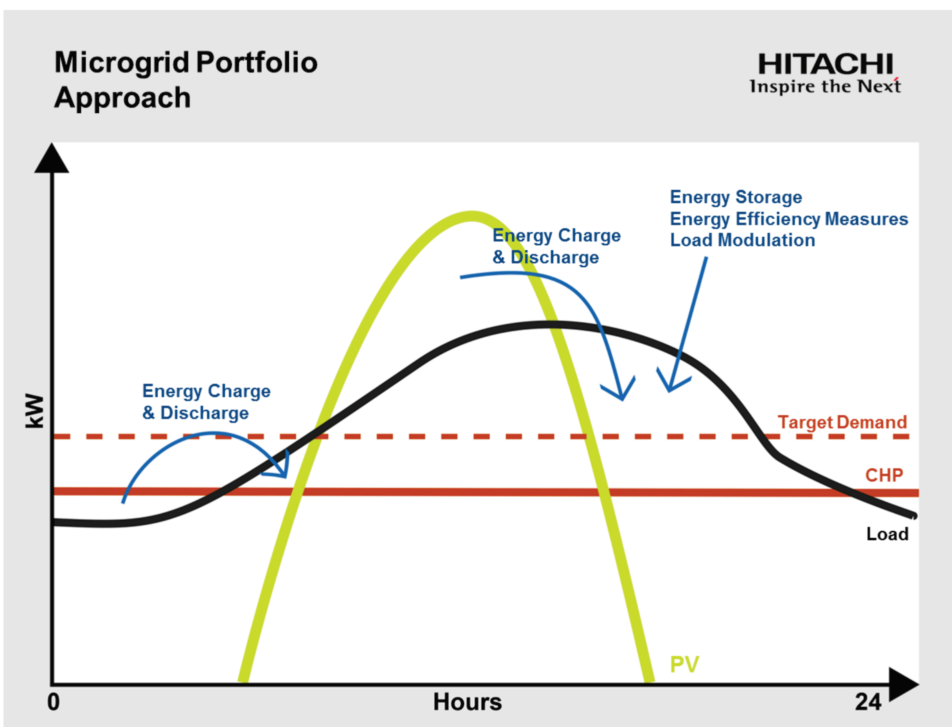
Normal and Emergency Operations

The microgrid DER selection is based on our *Microgrid Portfolio Approach* that focuses on energy requirements and a close match to the electric load profile of all covered facilities. The peak demand for critical facilities in the community occurs only a few hours per year. This means all critical facility services can be provided by continuously operating microgrid resources for the majority of hours in a year without over-building. The goal of this approach is to enable microgrid resources to serve the microgrid loads more efficiently, more cost effectively, and with lower emissions per unit of energy consumed.

Under this strategy, base-load CHP and the anaerobic digester will be designed to run at design output for a majority of the hours per year. All critical facility services can be provided by a set of "always-on" microgrid resources operating in conjunction with the grid for the majority of hours in a year. To meet the load that varies above the base load, PV and ESS will be integrated into the system. ESS are specified based on their capability to address PV intermittency support, PV load shifting, peak shaving (to manage utility imports), supporting CHP loading, and stabilize island mode operations. The design also incorporates active microgrid controls that enable optimal operation of energy storage, PV, and building management systems to manage load and reduce the afternoon peak load when needed.

This concept is presented in Figure 3.

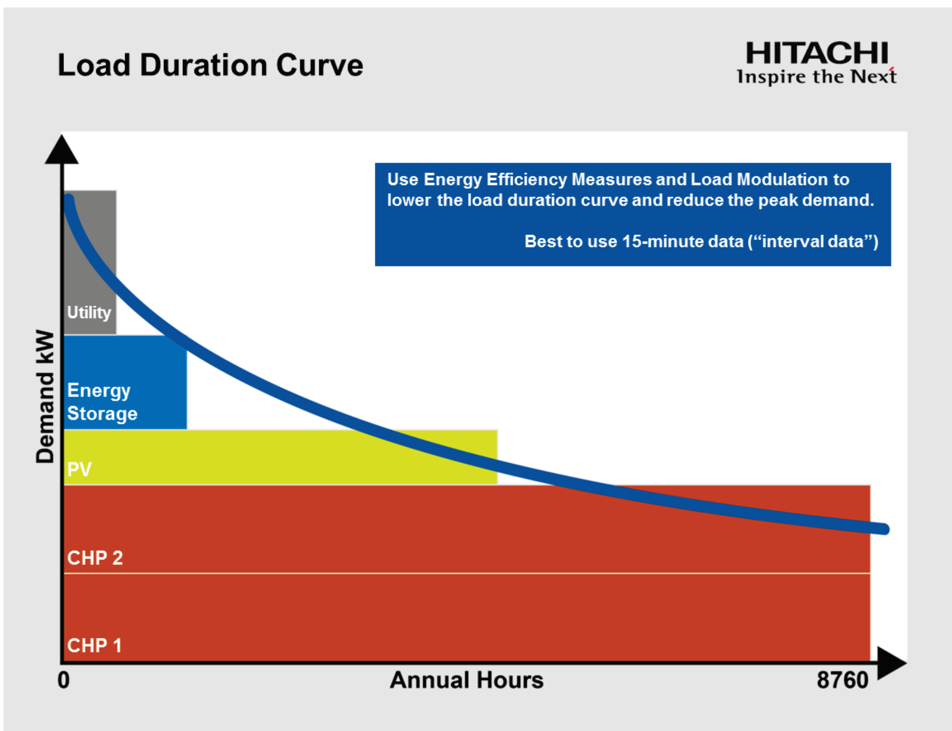
Figure 3 – Microgrid Portfolio Approach



From a long-term operations and maintenance standpoint, the Portfolio Approach enables the microgrid to operate energy resources within their design envelope. This keeps maintenance costs and fuel costs at a minimum, and helps to lower the total cost of ownership. The design also incorporates active microgrid controls that enable optimal operation of energy storage, PV, and building management systems to manage load and reduce the afternoon peak load when needed.

The load duration curve presented in Figure 4 illustrates another element of the resource selection and sizing strategy for the Tompkins microgrid. When operating in a grid-connected mode, the microgrid uses the grid as a resource to meet intermittent peak demand periods. When operating in island mode, the microgrid supply and demand will be managed through the dispatch of microgrid generation resources, load management, and to a minimum extent, the use of existing backup generation. This methodology allows the designers to evaluate the appropriate balance of grid service, generation resources, and load management capabilities, and provide both a technical and economic solution.

Figure 4 – Load Duration Curve

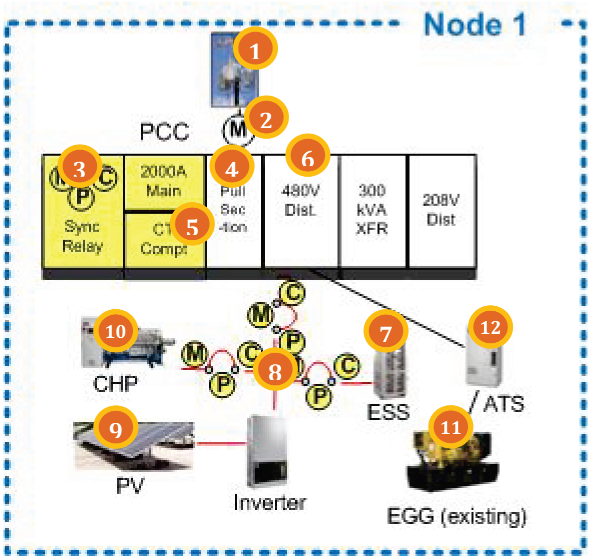


A complete layout of the design showing all microgrid nodes is presented in Appendix A. This geospatial image shows the facilities and location of electrical infrastructure and major new microgrid resources. More details about each individual node are presented on the following pages.

In addition, a microgrid one-line diagram is presented in Appendix B. The diagram includes the substation, major electrical equipment, and the rated capacity for each microgrid distributed energy resource. The PCCs are shown with associated monitoring (M), control (C), and protection (P) devices.

The figure below includes a brief explanation of the elements included in the one-line diagram.

Figure 5 – One-Line Diagram Explanation



1. Transformer to the critical facility
2. Utility meter
3. Synchronizing relay controls / main breaker with monitoring (M), protection relays (P), and controls ©
4. Main disconnect (pull section)
5. Instrument current transformer compartment
6. Main 480 Volt 3-phase distribution panel; step-down transformer and 208V 1-phase distribution panel
7. Energy storage system (ESS) with M, P, C
8. New 480 Volt 3-phase cable (red)
9. Solar PV array and associated inverter with M, P, C
10. Combined Heat & Power (CHP) with M, P, C
11. Emergency generators: Emergency Gas Generator (EGG) or Emergency Diesel Generator (EDG)
12. Automatic Transfer Switch (ATS)

The following pages highlight the layout design and one-line diagram subsection for the two nodes as well as a brief explanation of included energy resources.

Geospatial Diagrams and One-Line Subsections

Node 1 System Configuration: Overview

Geospatial Diagram

Description

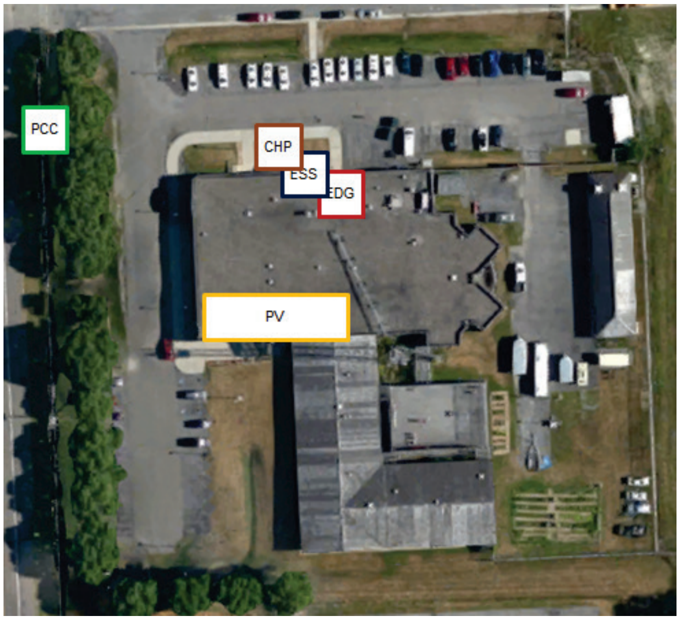
Node 1 includes the Ithaca Tompkins Regional Airport, the adjacent business park, and several facilities housing Tompkins County Agencies.

Node 1 covers a large area, and many new energy generation and storage resources are planned for inclusion in the microgrid.

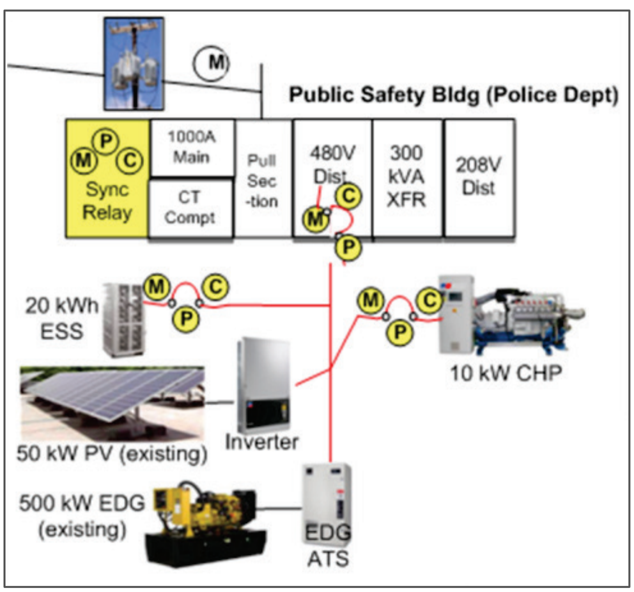
The placement and capacity of these resources at key facilities is described in the section-by-section breakdowns that follow.

Node 1 System Configuration: Public Safety Building

Geospatial Diagram



One-Line Diagram



Description

One of the Node 1 PCCs will be located to the west of the Tompkins County Public Safety Building, adjacent to Warren Rd.

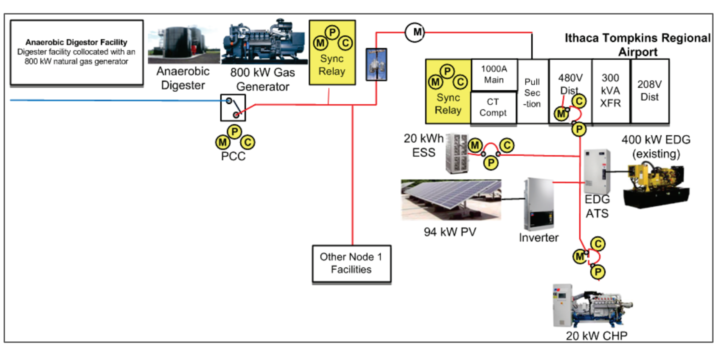
This building already features an existing 50 kW PV installation and a 500 kW EDG. As part of the microgrid, the following new resources will be installed:

- **CHP (10 kW):** A small CHP unit will be installed along the north wall of the building near the existing diesel generator.
- **ESS (20 kWh):** An ESS unit will be placed adjacent to the CHP system.

Node 1 System Configuration: Ithaca Tompkins Regional Airport

Geospatial Diagram

One-Line Diagram



Description

Node 1 includes the terminal building for Ithaca Tompkins Regional Airport. This facility features an existing 400 kW EDG.

As part of the microgrid, the following new systems will be installed:

- **PV (94 kW):** A ground mounted PV system will be installed on the grass area adjacent to the western border of the tarmac. An alternate location under consideration is the airport parking area in the form of a canopy PV system.

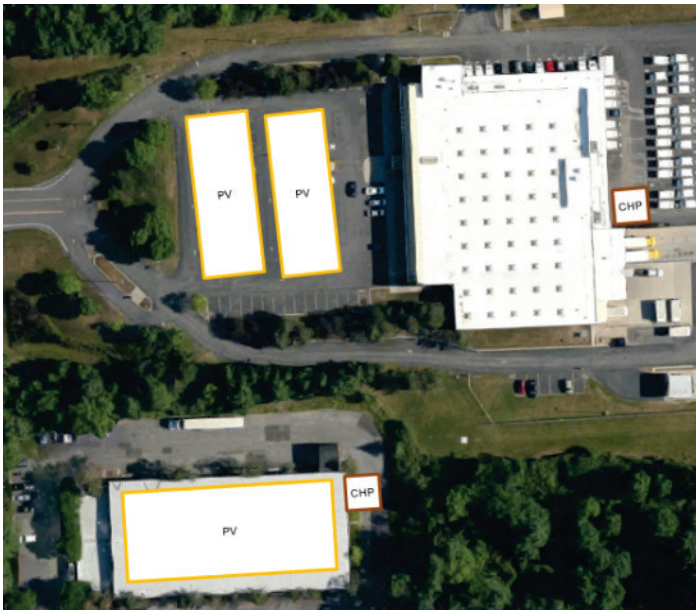
- **ESS (20 kWh):** An ESS unit will be placed next to the new PV system.

- **Anaerobic Digester (800 kW)**: An anaerobic digester system will be installed along the west side of the tarmac behind the airport terminal. The anaerobic digester system will be co-located with an 800 kW gas generator that will be fueled with the gas produced in the digester. The electricity generated from this system will be distributed to all the facilities in the Node.

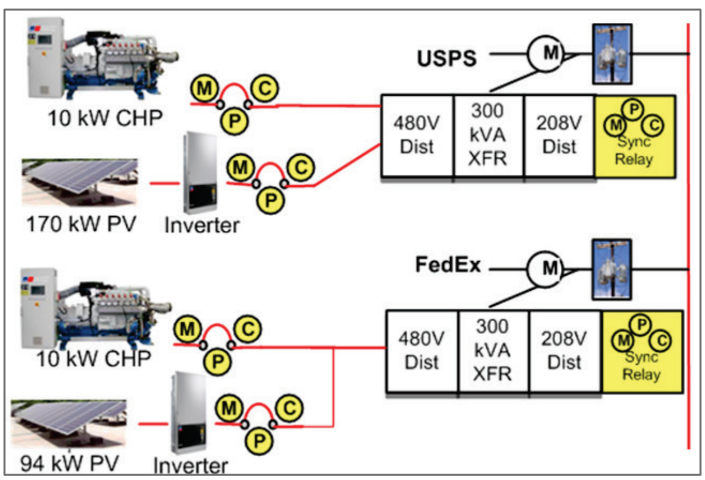
- **CHP (20 kWh):** A 20 kW CHP system will be installed next to the existing EDG behind the terminal.

Node 1 System Configuration: USPS & FedEx

Geospatial Diagram



One-Line Diagram



Description

A FedEx shipment center is located next to a U.S. post office along Warren Rd on the western edge of the Node 1.

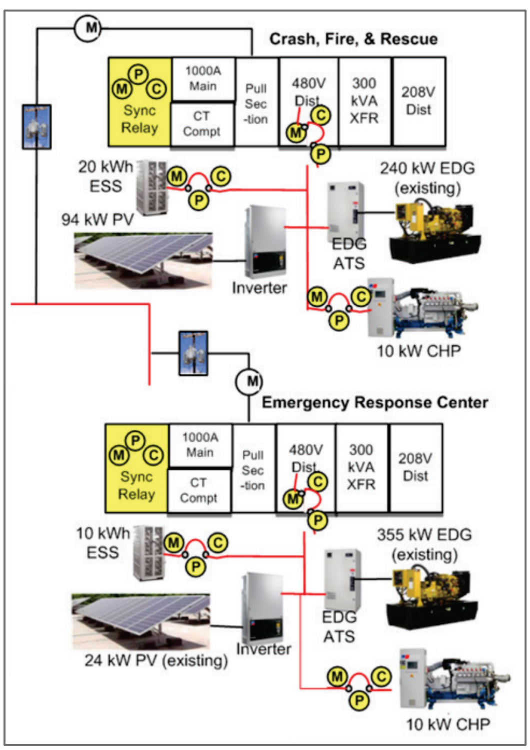
As part of the microgrid, the following new resources will be installed:

- **PV (170 kW):** A covered-parking system will be installed over the large parking area for the post office.
- **PV (94 kW):** A roof mounted system will be installed on the FedEx warehouse.
- **CHP (10 kW):** A small CHP system will be located to the east of the FedEx building.
- **CHP (10 kW):** Another small CHP system will be placed behind the post office.

Node 1 System Configuration: Emergency Response Center & Crash, Fire, and Rescue

Geospatial Diagram

One-Line Diagram



Description

The airport's Crash, Fire, and Rescue building features an existing 240 kW emergency natural gas generator. In addition to a 355 kW emergency duel fuel emergency generator, the adjacent Tompkins County Emergency Response Center also has 24 kW of PV installed on the roof.

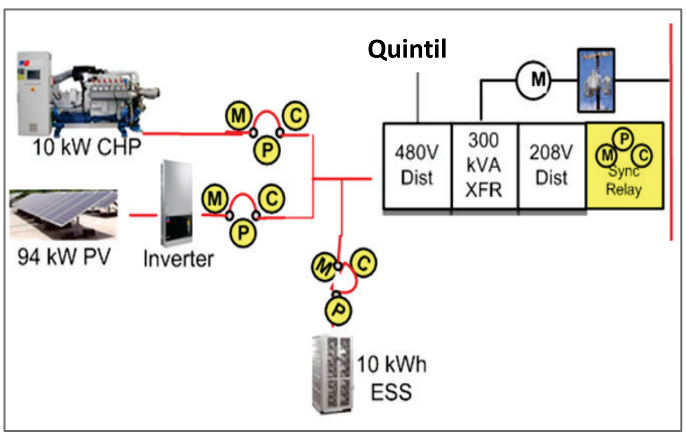
As part of the microgrid, the following new systems will be installed on these facilities:

- **PV (50 kW):** A rooftop PV system will be installed on the Crash, Fire, and Rescue building.
- **CHP (10 kW):** A CHP unit will be placed on the east side of the Crash, Fire, and Rescue building near the existing backup generator.
- **ESS (20 kWh):** An ESS unit will be placed next to the CHP system in the Crash, Fire, and Rescue Building
- **ESS (10 kWh):** An ESS unit will be placed in the Emergency Response Center to complement the existing PV system.
- **CHP (10 kW):** A small CHP system will be installed behind the Emergency Response Center.

Node 1 System Configuration: Large Commercial Customer Example

Geospatial Diagram

One-Line Diagram



Description

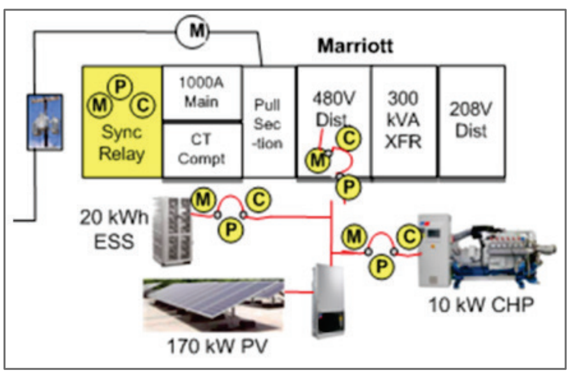
This representative commercial customer (BinOptics) is a tenant on Brown Road in the business park in Node 1. These facilities do not have any existing PV or backup generators. The strategy for these larger commercial facilities is to add PV and a small energy storage system as represented for this example:

- **PV (94 kW):** A rooftop PV system will cover the north side of the roof of the building.
- **ESS (10 kWh):** An ESS unit will be placed in the facility to complement the existing PV system.
- **CHP (10 kW):** A small CHP system will be installed behind the building.

Node 1 System Configuration: Marriott Courtyard Ithaca Airport/University

Geospatial Diagram

One-Line Diagram



Description

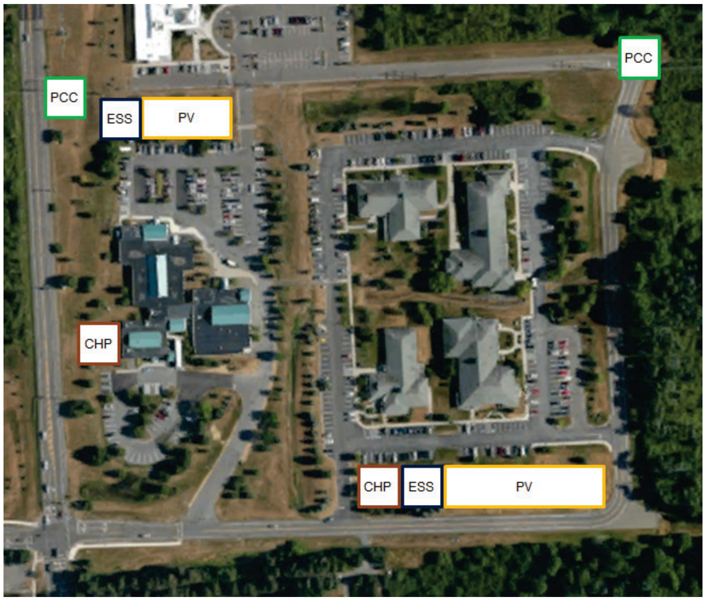
The Courtyard Ithaca Airport/University does not have any existing backup generation.

As part of the microgrid, the following microgrid resources will be installed on this facility:

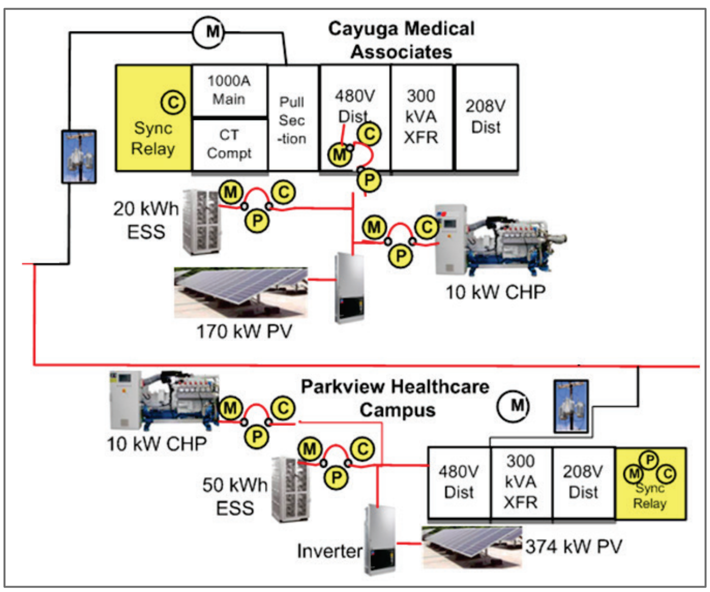
- **PV (170 kW):** Covered parking PV systems will be installed in the parking lot of the hotel.
- **CHP (10 kW):** A CHP unit will be installed just east of the hotel patio.
- **ESS (20 kWh):** An ESS unit will be placed next to the CHP unit on the southeast corner of the property.

Node 1 System Configuration: Cayuga Medical & Parkview Healthcare Campus

Geospatial Diagram



One-Line Diagram



Description

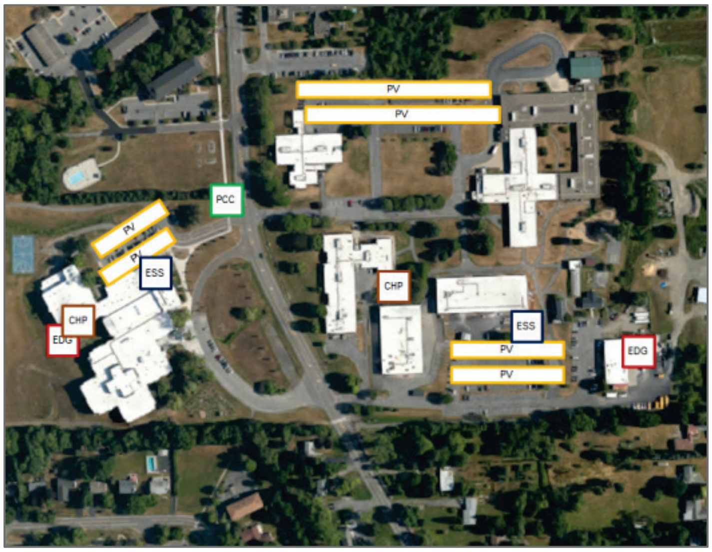
Node 1 also includes the small medical campus that lies to the south of Route 13. It includes the facilities at 8 Brentwood Dr., 16 Brentwood Dr., and the Cayuga Medical Center Convenient Care at Ithaca facility.

As part of the microgrid, the following will be installed on these facilities:

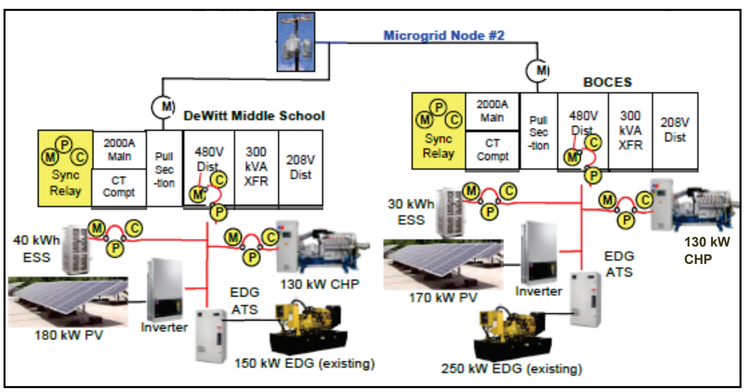
- **PV (90 kW):** A ground mounted PV system will be installed on the lawn south of the complex near 8 Brentwood Dr.
- **PV (200 kW):** A ground mounted PV unit will be located across from the building at the Parkview Healthcare Campus, 16 Brentwood Dr.
- **ESS (20kWh):** An ESS unit will be placed next to the PV array near 8 Brentwood Dr.
- **ESS (50 kWh):** An ESS unit will be placed next to the PV array near the Parkview Healthcare Campus, 16 Brentwood Dr.
- **CHP (10 kWh):** A small CHP system will be installed behind the Convenient Care near Warren Rd.
- **CHP (10 kWh):** Another small CHP system will be installed next to the PV system on the lawn south of the 8 Brentwood Dr. complex.

Node 2 System Configuration

Geospatial Diagram



One-Line Diagram



Description

A second microgrid node will be located just south of the medical campus along Warren Road. Node 2 will include the campuses of TST BOCES and DeWitt Middle School. The PCC will be located at the intersection of Warren Rd and the driveway to Dewitt Middle School. There is an existing 150 kW dual fuel emergency generator installed at the middle school, and a 250 kW dual fuel emergency generator installed at BOCES.

As part of the microgrid, the following will be installed:

- **PV (180 kW):** Rooftop systems will be installed on the roof of the northern building of Dewitt's campus.
- **PV (170 kW):** Covered parking systems will be installed over the parking lots in the north and south ends of the BOCES campus.
- **CHP (130 kWh):** A CHP system will be installed in the rear of the middle school, near the existing backup generator.
- **CHP (130 kWh):** A CHP system will be installed in the southeast corner of the BOCES campus, near the existing backup generator.
- **ESS (40 kWh):** An ESS unit will be installed alongside the CHP system at the middle school.
- **ESS (30 kWh):** An ESS unit will be installed alongside the CHP system at BOCES as well.

Modeling Methodology

The microgrid was modeled with HOMER Pro software. HOMER Pro is a microgrid software tool originally developed at the National Renewable Energy Laboratory (NREL) and enhanced and distributed by HOMER Energy. HOMER nests three integrated tools in one software product, allowing microgrid design and economics to be evaluated concurrently. The key features of HOMER Pro are:

- **Simulation:**
  HOMER simulates the operation of a hybrid microgrid for an entire year, in time steps from one minute to one hour.
- **Optimization:**
  HOMER examines all possible combinations of system types in a single run, and then sorts the systems according to the optimization variable of choice.
- **Sensitivity Analysis:**
  HOMER allows the user to run models using hypothetical scenarios. The user cannot control all aspects of a system and cannot know the importance of a particular variable or option without running hundreds or thousands of simulations and comparing the results. HOMER makes it easy to compare thousands of possibilities in a single run.

Load Description

The microgrid design team modeled and optimized the two nodes separately. Table 6 presents an overview of the annual energy operations of the microgrid by node. The microgrid will have a maximum demand of 2,110 kW and an average demand of 1,905 kW. The average and peak demand are close in grid-connected mode because microgrid resources will be managed to meet peak loads, and lower the peak demand from the grid. The microgrid will deliver approximately 16,700,000 kWh per year. The thermal loads in the microgrid will be approximately 77,500,000 kBTU per year, of which approximately 9,600,000 kBTU will be recovered from the CHP systems and reused to support on-site thermal loads.

Table 6 –Microgrid Energy Overview: Grid Connected Operation

	Electric Demand		Electric Consumption		Thermal Load		Thermal Recovery	
Node	Max (kW)	Avg (kW)	kWh/year	kWh/month	kBTU/year	kBTU/month	kBTU/year	kBTU/month
1	1,800	1,631	14,289,684	1,190,807	49,967,225	4,163,935	3,627,183	302,265
2	310	274	2,398,356	199,863	27,497,995	2,291,500	5,968,248	497,354
Total	**2,110**	**1,905**	**16,688,040**	**1,390,670**	**77,465,220**	**6,455,435**	**9,595,431**	**799,619**

Table 7 – Electricity Purchased/Produced Currently and With Microgrid (kWh)

Currently

	Grid Purchases	PV	CHP	Anaerobic Digester
Node 1	14,228,138	118,860	-	-
Node 2	2,407,103	-	-	-
Total	**16,635,241**	**118,860**	-	-

Under Microgrid

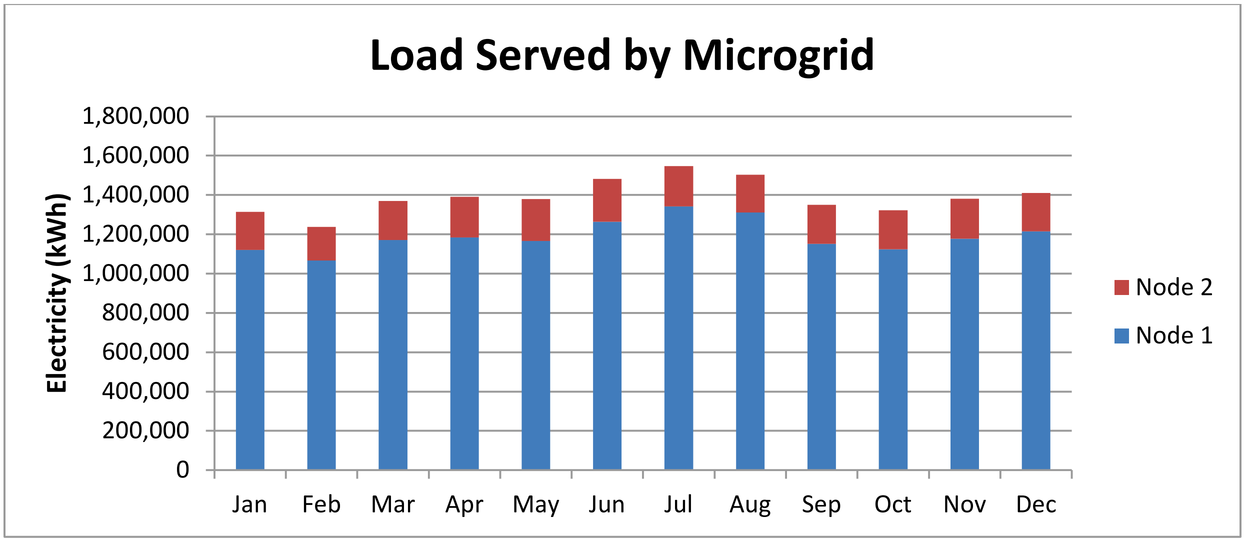
	Grid Purchases	PV	CHP	Anaerobic Digester
Node 1	5,823,548	2,328,180	1,021,412	5,240,686
Node 2	456,990	467,203	1,483,438	-
Total	**6,280,538**	**2,795,383**	**2,504,850**	**5,240,686**

The monthly energy delivery by microgrid node is presented in Table 8 and presented graphically in Figure 6.

Table 8 –Monthly Grid Connected Operation by Node

Month	Node 1	Node 2	Total
	(kWh)		
Jan	1,119,788	194,818	1,314,606
Feb	1,066,114	172,288	1,238,402
Mar	1,171,016	197,884	1,368,900
Apr	1,183,305	206,759	1,390,064
May	1,166,358	213,344	1,379,702
Jun	1,264,181	217,405	1,481,586
Jul	1,341,799	205,159	1,546,958
Aug	1,310,220	193,505	1,503,725
Sep	1,150,710	199,336	1,350,046
Oct	1,123,255	199,559	1,322,814
Nov	1,177,222	203,429	1,380,651
Dec	1,215,715	194,870	1,410,585
Total	**14,289,684**	**2,398,356**	**16,688,040**

Figure 6 - Monthly Grid Connected Operation by Node



The Tompkins microgrid is designed for the majority of the energy supply from on-site resources, with the remainder of the energy coming from the grid when the grid is operating. The microgrid treats the utility grid as an additional resource and incorporates reliability history of the grid into reliability optimization.

The reliability of the Tompkins County Community Microgrid will be ensured with the following measures:

- The use of multiple, distributed, smaller unit sizes to help minimize generation loss and ensure that the microgrid can gracefully accommodate the failure
- The use of distributed energy storage systems that can accommodate short periods of high loading if the resource loss reason is known and quickly recoverable (15 minutes)
- Increasing the energy dispatch from the grid (in grid-connected mode - 99% of the time), to accommodate the loss of a resource until recovered
- The use of a combination of ESS and load modulation (up to 20% without curtailment) in island mode to accommodate the loss of a resource for a few hours. Beyond a few hours, non-critical loads will be shut down until the resource is recovered
- Much greater use of underground cabling and indoor infrastructure than is seen in the traditional utility grid

These techniques are employed in the Tompkins County Community Microgrid design so that equipment loss is mitigated or accommodated in the specific microgrid nodes for this community, under grid-connected and islanded modes of operation. Table 9 summarizes the microgrid resources in each node in terms of number of devices and the total installed capacity by technology.

Table 9 - Microgrid Node Resources Comparison

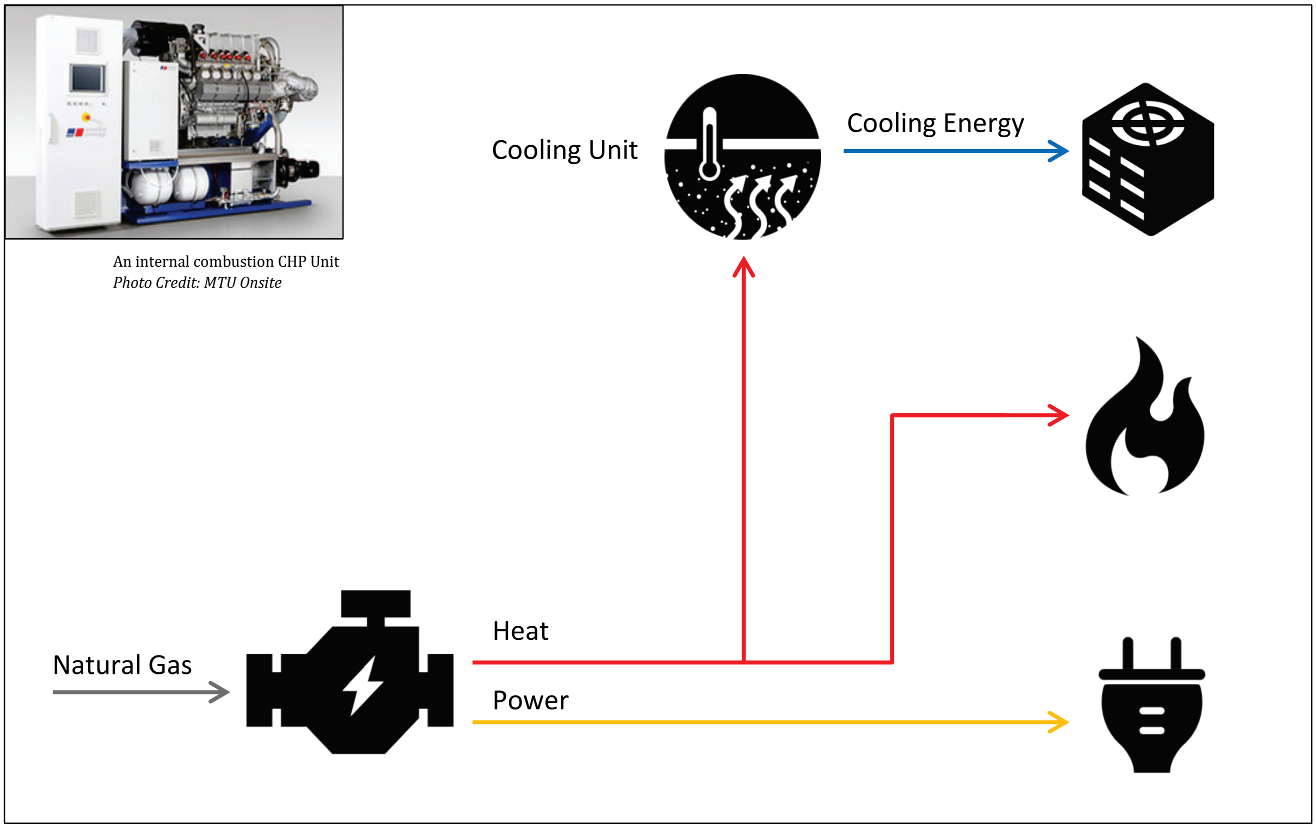
Node	Operation Scenario	Grid	PV		Battery Energy Storage		CHP		Anaerobic Digester		Backup Generators	
		Peak kW	# of Inverters	kW	Qty	kW / kWh	Qty	kW	Qty	kW	Qty	kW
1	Business as Usual	2,540	3	97	-	-	-	-	-	-	5	1,745
	Microgrid	1,800	16	1,997	12	120/240	16	160	1	800	5	1,745
2	Business as Usual	660	-	-	-	-	-	-	-	-	2	400
	Microgrid	310	2	350	2	35 / 70	2	260	-	-	2	400

An overview of each technology, installation, operating strategy, and modeled operation are presented in this section.

Combined Heat and Power

CHP generators provide electrical and thermal energy from a single source. The use of fuel to generate both heat and power makes CHP systems more cost effective than traditional power generation. Most power generation produces heat as a byproduct, but because power is generated far from the end user, the heat is lost. CHP units take advantage of the fact that they are colocated with the end user and make use of thermal energy for heating and sometimes even cooling nearby buildings. For this microgrid application, internal combustion engine based CHP systems have been modeled. Internal combustion engines, also called reciprocating engines, use a reciprocating motion to move pistons inside cylinders that turn a shaft and produce power. Internal combustion engines typically range between 5 kW-7 MW and are best suited for load-following applications. An image of an internal combustion engine generator is presented in Figure 7.

Figure 7 – CHP System Overview



An internal combustion CHP Unit
Photo Credit: MTU Onsite

Benefits of CHP

- Reduces utility costs and improves economic competitiveness
- Increases power reliability and self-sufficiency
- Reduces GHG emissions and other pollutants
- Reduces demand for imported energy supplies
- Capable of operating on renewable or nonrenewable resources
- Suite of proven, commercially available technologies for various applications
- Additional financial incentives through the NYSERDA available for eligible customers

CHP Approach

- Co-locate generators near thermal loads on the customer-side of the meter
- Design for base load operation, and to maximize heat recovery when grid connected
- Support microgrid operations when the electric grid is not available along with PV, energy storage, and building load control
- Design to serve specific winter Heat Recovery Loads, such as a boiler plant, space heating, DHW, and pool heating

- Design to serve specific summer Heat Recovery Loads, including space cooling, DHW, and pool heating

CHP in the Microgrid

The size and location of the planned CHP units is presented in the layout diagram and single-line diagram presented in the Appendix. Table 10 summarizes the CHP components by node of the microgrid.

Table 10 - Microgrid CHP Resources by Node

Node	Natural Gas Engine or CHP	
	Qty	**Total kW**
1	16*	160
2	2	260
Total	**18**	**420**
*Note**:** This table includes only stand-alone CHP systems, not the anaerobic digester system**.**		

The following tables and figures summarize the annual operation of the CHP fleet in the Tompkins microgrid on a monthly basis for each node.

Table 11 - Microgrid CHP Electric Production by Node

Month	Node 1	Node 2	Total
	Electric Production (kWh)		
Jan	80,697	121,248	201,945
Feb	77,244	106,293	183,537
Mar	80,456	118,243	198,699
Apr	85,653	123,297	208,950
May	80,644	127,098	207,742
Jun	93,855	124,909	218,764
Jul	93,609	130,289	223,898
Aug	87,571	125,400	212,971
Sep	81,930	124,694	206,624
Oct	79,845	130,873	210,718
Nov	87,677	127,972	215,649
Dec	92,231	123,123	215,354
Total	**1,021,412**	**1,483,439**	**2,504,851**

Figure 8 – Microgrid CHP Electric Production

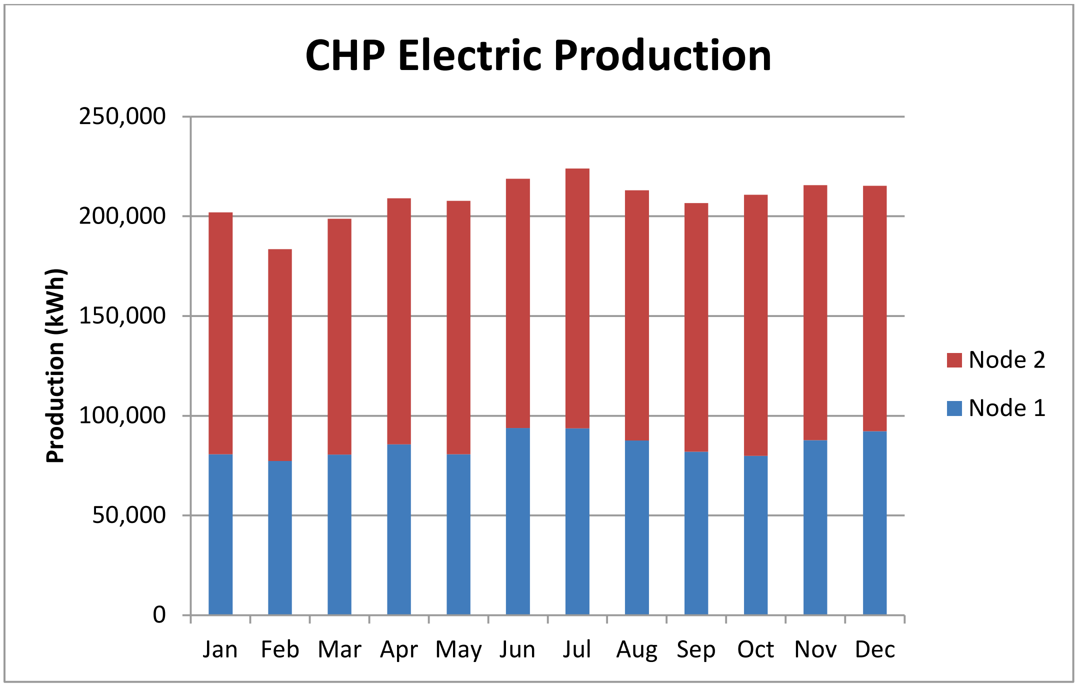


Table 12 - Microgrid CHP Heat Recovery by Node

Month	Node 1	Node 2	Total
	Heat Recovery (kBTU)		
Jan	287,052	648,709	935,761
Feb	274,769	572,398	847,167
Mar	286,193	632,713	918,906
Apr	304,682	652,778	957,460
May	286,343	578,916	865,259
Jun	332,777	192,784	525,561
Jul	331,697	99,124	430,821
Aug	310,688	97,179	407,867
Sep	289,001	482,176	771,177
Oct	284,022	686,215	970,237
Nov	311,879	672,048	983,927
Dec	328,080	653,209	981,289
Total	**3,627,183**	**5,968,249**	**9,595,432**

Figure 9 – Microgrid CHP Heat Recovery

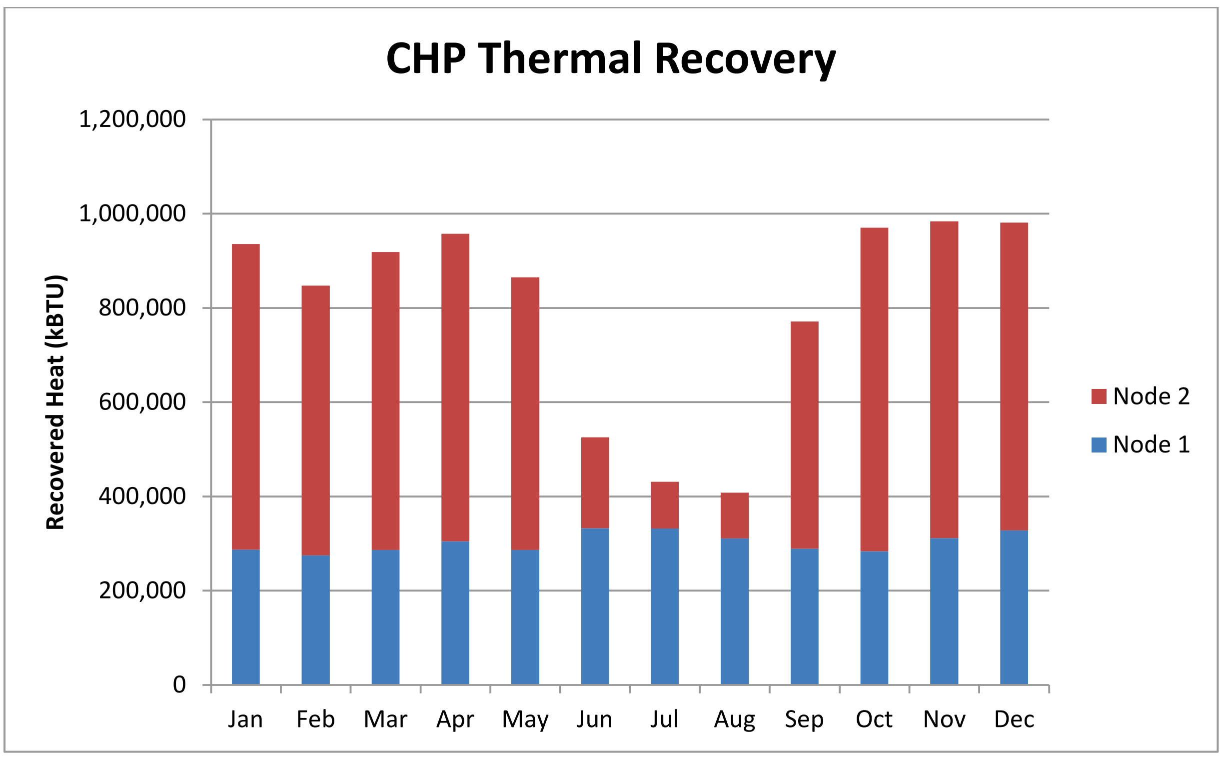
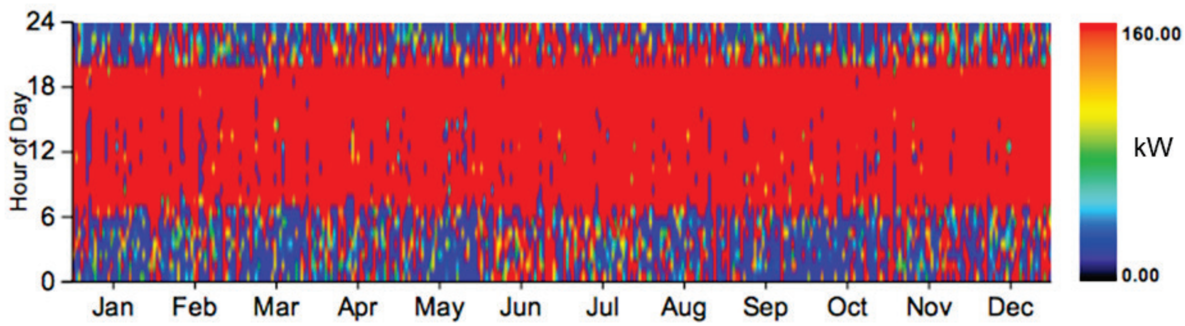


Figure 10 presents the hourly operation of the CHP fleet in Node #1 in the form of a heat map. For maximum efficiency, CHP systems operate near full capacity during normal business hours (red). During non-occupied time periods, the CHP units will operate at partial load or be shut off completely as indicted in the blue areas on the heat map.

Figure 10 – Example Node CHP Operational Summary

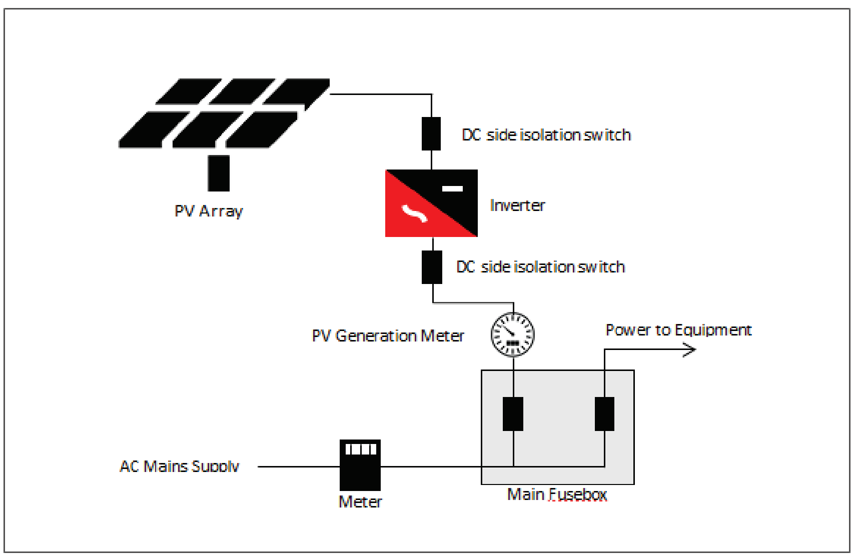
CHP Output



Solar Photovoltaics

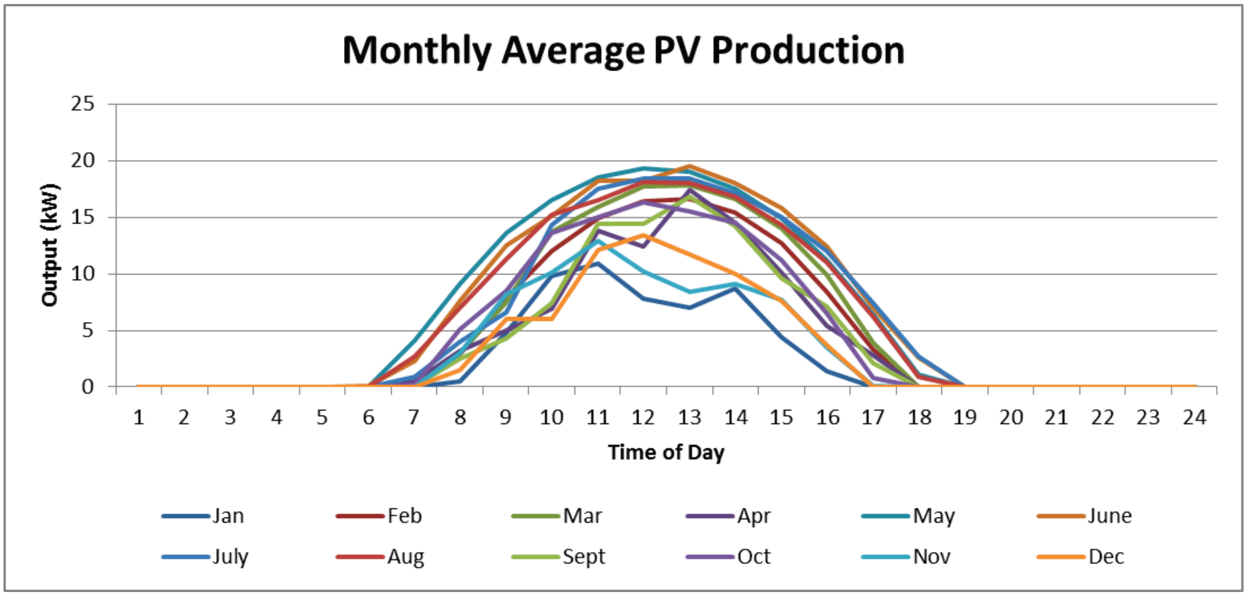
The solar PV will be rooftop, parking lot, or ground mounted using hail-rated solar panels. PV devices generate electricity directly from sunlight via an electronic process that occurs naturally in certain types of material, called semiconductors. Electrons in these materials are freed by photons and can be induced to travel through an electrical circuit, resulting in the flow of electrons to create energy in the form of direct current. The direct current is transformed into usable alternating current through the use of an inverter. A typical customer-side of the meter PV installation is presented in Figure 11.

Figure 11 – PV Installation Diagram (Customer Side of Meter)



Since the PV systems are driven by sunlight, the electric production profile varies with the position of the sun and is impacted by the level of cloud cover. Figure 12 presents the typical average daily PV generation profiles by month and demonstrates the seasonal variation of PV as a generation resource. The HOMER model takes this variability into account when simulating and optimizing the sizing of PV as a microgrid resource.

Figure 12 – Typical PV Daily Generation Profiles



PV systems are planned for rooftops, parking spaces, and ground-mount configurations. Figure 13 presents examples of each these types of installations

Figure 13 – PV Installation Options.

Benefits of PV

- Reduces utility costs and improves economic competitiveness
- Increases power reliability and self-sufficiency
- Reduces GHG emissions and other pollutants
- Reduces demand for imported energy supplies
- Fueled by a renewable resource
- Based on a suite of proven, commercially available technologies for a variety of applications
- Competitive market for hardware and installation services

PV Approach

- Co-locate PV systems on the customer-side of the meter to support resiliency
- Install on roofs, ground mount and covered parking
- Provide renewable energy resource (reduce site emissions and no fuel cost)
- Support day-time load requirements and annual energy loads (grid connected operation)
- Support microgrid operations when the electric grid is not available along with CHP, energy storage, and building load control

PV in the Microgrid

The size and locations of the planned PV systems is presented in the layout diagram and single-line diagram in the Appendix. Table 13 summarizes the PV components by node of the microgrid.

Table 13 - Microgrid PV Resources by Node

Node	PV	
	# of Inverters	Total kW
1	16	1,997
2	2	350
Total	**18**	**2,347**

The table and figures below present the monthly operation of the PV fleet by node.

Table 14 – Microgrid PV Fleet Electric Production

Month	Node 1	Node 2	Total
Electric Production (kWh)			
Jan	165,099	29,462	194,561
Feb	184,820	34,858	219,678
Mar	219,492	45,445	264,937
Apr	207,837	43,668	251,505
May	223,443	46,460	269,903
Jun	222,884	45,005	267,889
Jul	227,431	46,590	274,021
Aug	221,242	44,851	266,093
Sep	208,733	42,070	250,803
Oct	179,768	35,806	215,574
Nov	132,748	26,385	159,133
Dec	134,684	26,603	161,287
Total	**2,328,180**	**467,203**	**2,795,383**

Figure 14 – Microgrid PV Fleet Electric Production

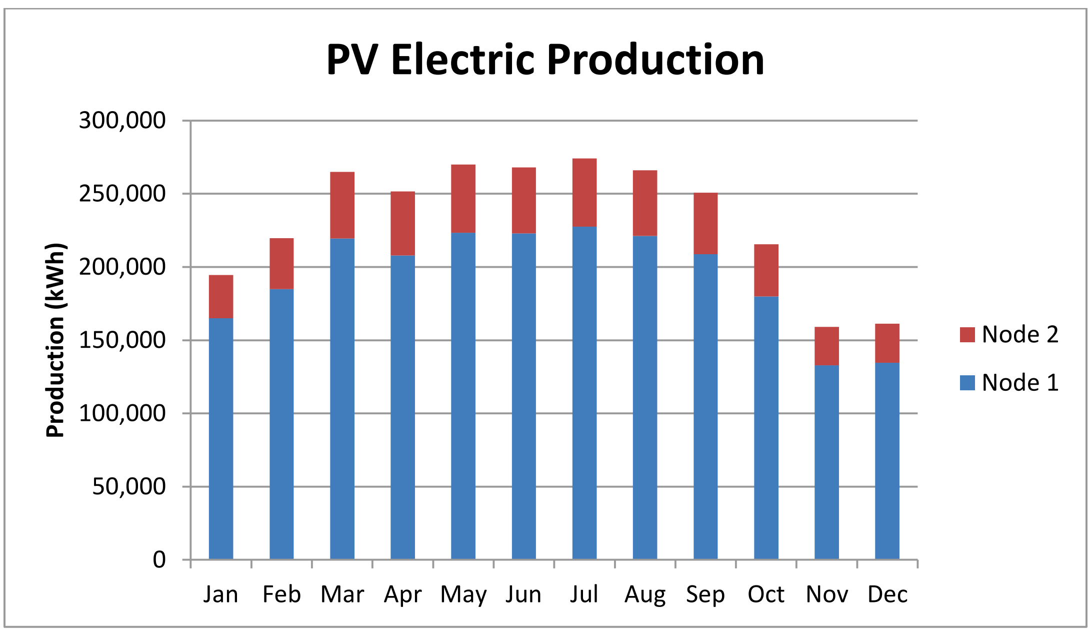
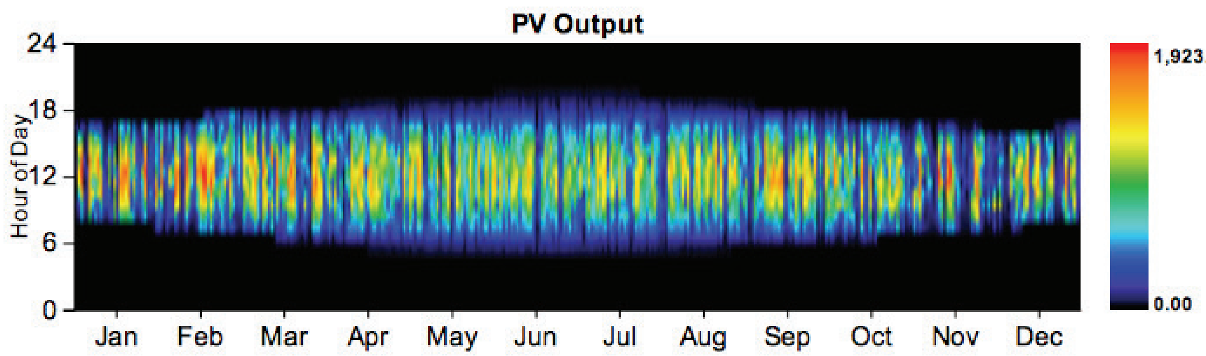


Figure 15 presents the hourly operation of the PV in an example node in the form of a heat map. This representation demonstrates how the PV units operate during hours of sunshine with maximum production in the middle of the day, ramping up in the mornings and ramping down in the afternoon hours. This also illustrates the trend of narrower daily bands of production in the winter and then expansion to maximum production in the summer.

Figure 15 – Example Node PV Operational Summary



Energy Storage Systems

Energy storage in a microgrid can improve the payback period for the whole system by enabling an increase in the penetration of renewable energy sources, shifting the energy produced by PV, enabling peak load management, managing PV intermittency, providing volt/VAr support, and supporting island mode transitions. The technology specified for the Tompkins microgrid is Li-ion batteries, which have a fast reaction response to changes in load, a fairly small footprint, and a relatively high round trip efficiency. Li-ion batteries have some unique operational characteristics:

- The usable energy capacity is between a 15% and 95% state of charge (SOC)
- The life of the batteries are impacted by temperature and charge rate
- Most systems are capable of approximately 3,000 deep discharge cycles (+/- 80% SOC cycles)
- Most systems are capable of more than 100,000 shallow discharge cycles (+/- 15% SOC cycles)
- The batteries are at a high risk of failure if the system is discharged to a zero percent sate of charge
- The systems typically have different rates (kW) for charge and discharge
- Most Li-ion systems have accurate methods of determining the system SOC
- Typical power electronic systems provide multiple modes of operation
- Systems are typically capable of four quadrant operation

Benefits of Energy Storage

- Reduces utility costs and improves economic competitiveness
- Increases power reliability and self-sufficiency

- Reduces GHG emissions and other pollutants
- Reduces demand for imported energy supplies
- Supports system with a high level of renewable energy penetration
- Based on a suite of proven, commercially available technologies for a variety of applications
- Competitive market for hardware and installation services
- Provides multiple functions and benefits to the microgrid:
    - Peak Load Management
    - Load Shifting
    - Frequency Regulation
    - Reactive Power Support
    - PV Support
    - Demand Response
    - Energy Arbitrage
    - Backup Power

Figure 16 presents examples of energy storage installations for the technologies addressed for this microgrid design.

Figure 16 – Example ESS Installations

25 kW / 75 kWh pad mount system

25 kW / 50 kWh pad mount system with storage in underground vault

Multiple 5 kW / 12 kWh systems

Energy Storage Approach

- Co-locate with PV systems on the customer-side of the meter to support resiliency
- Install indoors or outdoors (indoor installation better for resiliency)
- Maximize functional benefits for the microgrid
- Support microgrid operations when the electric grid is not available along with CHP, PV, and building load control

ESS in the Microgrid

The size and location of the planned ESS systems is presented in the layout diagram and single-line diagram presented in the Appendix. Table 15 summarizes the ESS components by node of the microgrid.

Table 15 - Microgrid ESS Resources by Node

Node	Battery Energy Storage		
	Qty	kW	kWh
1	12	120	240
2	2	35	70
Total	**14**	**155**	**310**

Unlike the other microgrid resources, the ESS both consumes and produces energy. When properly used, the net energy consumed is very small. The annual operation of the ESS in Node 2 is presented in Table 16, which presents both the charge and discharge modes of operation. The net value is positive which takes into account the operational losses for the systems.

Table 16 presents the montlhy operation of the ESS. Photovoltaic production is high in March and April, due in part to more moderate spring temperatures. During these times, the extra energy generated by the PV keep the ESS charged to maximum SOC. Also during this time, the CHP thermal recovery is high, which also results in a lower level of exercising of the ESS.

Table 16 – Microgrid ESS Operation Sample Node

Month	Charge	Discharge	Net
	(kWh)		
Jan	739	402	336
Feb	0	0	0
Mar	0	0	0
Apr	0	0	0
May	344	316	28
Jun	3,595	3,308	288
Jul	5,541	5,098	443
Aug	6,953	6,397	556
Sep	1,102	1,013	88
Oct	1,498	1,379	120
Nov	3,533	3,251	283
Dec	3,558	3,273	285
Total	**26,864**	**24,437**	**2,426**

Island Mode Modeling Results

The resources included in the Tompkins County Community Microgrid have been sized and operated to support island operation for a minimum period of seven days, with multi-week operation likely. During island mode operation, the microgrid control system will maintain system stability and ensure a balance of generation and load. The controller will forecast critical load and PV generation and then dispatch resources to match the load. We anticipate that the resources available to be controlled during island operations will include CHP, fossil fuel generators, PV systems, energy storage, and building load. We also expect that the utility will be able to provide an estimated time to restoration. This estimate will be used to help determine the remaining duration of island operation required, and will influence the dispatch of microgrid resources.

The design strategy for the Tompkins County Community Microgrid is to supply the critical load at a level that enables the critical services that keep the community functioning at a sufficient level throughout the entire event duration. This provides full functionality for police, fire, and emergency services while also providing some level of heat and power to other facilities and residents. Each node was modeled for operation during an extended outage (one week) to evaluate and optimize microgrid resources operating in island mode. Two outage events were modeled to represent an outage during the winter and an outage during the summer. Energy flows during the outages are presented as weekly averages in Table 17. In order to manage peak loads while in island mode, certain loads may be reduced for periods of time with minimal customer impact to ensure that the loads associated with the most critical missions are served. The exact strategy for load modulation will be worked out in Stage 2.

Table 17 –Microgrid Energy Overview: Island Mode Operation

Node	Season	Electric Demand		Electric Consumption	Thermal Load	Thermal Recovery
		Max (kW)	Avg (kW)	kWh/week	kBTU/week	kBTU/week
1	Winter	4,426	1,734	291,321	2,370,303	73,437
	Summer	2,826	1,323	222,237	311,926	89,007
2	Winter	939	289	48,542	1,501,572	165,961
	Summer	725	274	46,048	25,114	23,105
Total	**Winter**	**5,365**	**2,023**	**339,863**	**3,871,875**	**239,398**
	Summer	**3,551**	**1,597**	**268,285**	**337,040**	**112,112**

FINANCIAL FEASIBILITY

The outputs of the technical modeling process described above were used to evaluate the financial viability of the proposed microgrid from two perspectives. First, the project team analyzed the financial strength of the project when deployed using the proposed third-party ownership business model. Under this model, the project is funded through outside investment and debt which is recouped through a power purchase agreement (PPA) with each facility. In addition, NYSERDA contracted with Industrial Economics, Incorporated (IEc) to perform a benefit-cost analysis. The focus of this analysis is to evaluate the societal benefit of the microgrid, including benefits from emissions reductions, cost reductions, and resilience improvements.

Installed Cost

At this feasibility stage of the project, a high-level project budget was developed and incorporated into the technical model to ensure that the design meets both the technical and economic elements of the project. This budget includes costs for engineering, permitting, capital equipment, site preparation, construction, controls, start-up, commissioning, and training. The cost associated with "site preparation" includes the addition and modification of electrical infrastructure, PCC controls, monitoring, and protection equipment. Some of these infrastructure costs may be paid to the electric utility. The estimated installed cost for this project is $10,848,000 with an accuracy of +/- 25% (within the +/- 30% set by NYSERDA). The net cost with the federal investment tax credit (ITC) that was recently extended by the US Congress is $8,116,000. This cost does not include other incentives that may be applicable to the project that will be applied during the detailed analysis in Stage 2.

The project team evaluated several available financial incentives when performing the financial analysis for the Tompkins County Community Microgrid. The following programs[1] were evaluated:

- **Demand Response**: NYSEG's demand response programs pay customers who are able to temporarily reduce electric usage when requested. This capability will be improved by the existence of the microgrid.
- **Sales Tax Exemption**: Solar photovoltaic systems are 100% free from state and local taxes.
- **Business Energy Investment Tax Credit (ITC):** The ITC includes a 30% tax credit for solar or fuel cell systems on residential and commercial properties and 10% tax credit for CHP systems. In December, several ITC credits were extended for three years, with a ramp-down through 2022. The credits for PV systems (including associated software control systesms) were among those extended, and are part of this analysis. The credits for CHP have not been extended past 2016, so CHP credits were not included in this analysis.
- **NYSERDA PON 2568 CHP Acceleration Program**: This program provides financial incentives for the installation of CHP systems at customer sites that pay the SBC surcharge on their electric bill, and will be fueled by natural gas that is subject to the SBC surcharge on the gas bill.
- **NY SUN initiative:** This program provides rebates and performance incentives for new residential and commercial solar PV installations. The program provides up to $0.34 per watt for new installed PV that displaces existing usage. An additional incentive of $50,000 applies if the project includes energy storage. An additional incentive of $50,000 applies if the project includes integrated energy efficiency. The program will provide up to 50% of the total installed system cost.
- **New York Power Authority – Energy Services Program for Public Utilities**: This program provides various rebates on energy efficient equipment.
- **NYSERDA Sub Metering Program**: This program will provide $250 incentive for each advanced sub meter and $1,500 for each master meter.
- **Federal Energy-Efficient Commercial Buildings Tax Deduction**: This deduction provides $0.30-$1.80 per square foot, depending on technology and amount of energy reduction for buildings that become certified as meeting specific energy reduction targets as a result of improvements in interior lighting; building envelope; or heating, cooling, ventilation, or hot water systems.

Third Party Ownership

Under the proposed business model, a third party would fund all development and construction of the microgrid, own and operate the assets, and sell the energy generated from the microgrid to community customers through PPAs.

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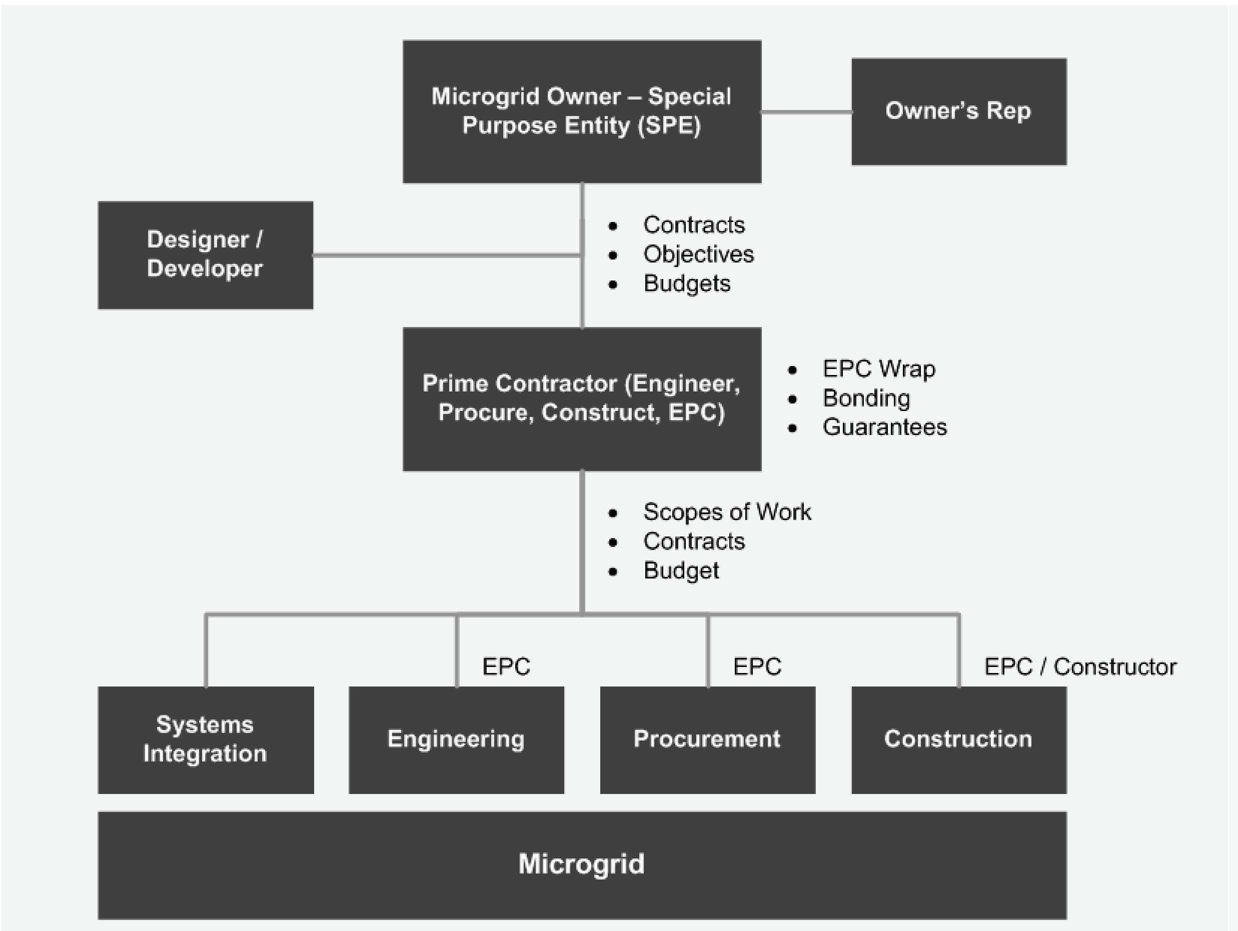
[1] Identified from the DSIRE database as of December 2015.
http://programs.dsireusa.org/system/program?state=NY

The Special Purpose Entity (SPE) will engage the design team to finalize the construction drawings and utility interconnection agreements. The SPE will engage an engineering, procurement, and construction firm to build the microgrid, and will be financially responsible for all engineering, procurement, and construction for the system. The SPE will also be financially responsible for integrating the controls and communications systems. This process is presented in the Figure 17 below.

Figure 17: Microgrid Development Relationships



To ensure proper operation of individual microgrid resources, an Energy Performance Contractor (EPC)(selected through a partnership or solicitation, and hired by the SPE) will conduct site acceptance tests that validate the operation and performance of the new equipment. Once the system construction and integration are complete, the SPE will engage a third party commissioning agent that will test the microgrid as a system to ensure that the controls, communication and sequence of operation function to meet the requirements as defined in the specified use cases and the final design. After the fully commissioned system is accepted and transferred to the SPE, the SPE will own and operate the microgrid for a period of 25 years. If selected for Stage 2, the team would evaluate how shorter PPA periods would affect the energy price and discuss those options with potential system participants.

The operation of the microgrid will leverage the autonomous functionality of the microgrid controller, and minimize the need for on site operators. The controller will operate the microgrid to maximize economic benefits, minimize emissions, and maximize reliability of service in the event of a fault on the grid. In addition, the microgrid controller will monitor the performance, operation and alarms of the distributed resources. In the event of an alarm, the SPE will be notified through the network operations center, and dispatch a service technician who will be engaged through a service contract. The microgrid controller will also track the hours of operation of each microgrid resource, and will employ a predictive maintenance strategy to schedule maintenance before any failure occurs, and at a time that will have the least impact on the overall operation of the microgrid. As the microgrid operates, a history of performance, trending and signature analyses will develop, adding to the microgrid's ability to anticipate failures.

It is not anticipated that the development of the microgrid system will create any additional revenue streams or costs. The SPE model will prevent the community from incurring any costs to buy or operate the system outside of the PPA (contract). Benefits from state incentives and any participation in the utility ancillary services market would be retained by the SPE.

Microgrid customers will benefit from increased resilience and a cleaner energy profile. The Tompkins County Community Microgrid is designed to maximize the use of clean, renewable energy sources, and is a part of the county's plan to reduce GHG emissions by 80% by 2050. The microgrid will decrease the amount of GHG associated with powering the included facilities by 35%. As such, the rates paid by microgrid customers will not be as low as they would be if the generation portfolio leaned more heavily on natural gas. Still, given the load management and demand response capabilities of the microgrid, customers may pay energy costs comparable to, or only slightly above their current cost of energy. During the lifetime of the project, electric and natural gas rates from the local utility are expected to increase at a faster rate than the PPA rate, so annual cost savings may be achieved for all facilities served by the microgrid sometime around the mid-point of the contract term. Note that some facilities may realize small energy cost savings right away. All facilities will realize resiliency and carbon savings starting in the first year of the project.

The project team conducted a thorough econometric analysis of the proposed Tompkins County Community Microgrid to determine the financial viability of the project. Hitachi has developed proprietary economic modelling software, known as EconoSCOPE™, that is specifically designed to support financial analysis for public infrastructure projects. The project team used this software to support the analysis of the financial viability of the Tompkins County Community Microgrid project. Financial institutions do not yet allow for recognition of incentives in their evaluations of project attractiveness. Therefore, the project team did not include them in the underlying economic analysis at this time. During the detailed design phase, financial incentives will be evaluated as part of the entire system costs.

The current weighted electric rate of the key critical facilities included in the proposed microgrid is approximately $0.10/kWh. Based on estimated project financing costs and the 25 year contract term, the study supports a PPA electric rate with an electric cost that is an average of 20% than the average cost of electricity currently paid by potential microgrid customers. This analysis does not include Stage 2 or Stage 3 NY Prize funding, which would have the potential to significantly lower the PPA rate.

Benefit-Cost Analysis

NYSERDA contracted with IEc to conduct a benefit-cost analysis. The project team provided detailed information to IEc to support this analysis. IEc ran two scenarios for this proposed microgrid. The first scenario modeled no power outages, and evaluated the grid connected mode of operation. The second scenario modeled the number of days (or partial days) of outage at which the costs of the microgrid would be equal to its various benefits, thus yielding a cost benefit ratio of 1. For the Tompkins County Community Microgrid, the breakeven outage case is an average of .33 days of outage per year. The cost benefit results are presented in Table 18. The analyses indicate that if there were no major power outages over the 20-year period analyzed (Scenario 1), the project's costs would exceed its benefits. In order for the project's benefits to outweigh its costs, the average duration of major outages would need to equal or exceed 0.33 days per year (Scenario 2).

Table 18 – Cost Benefit Analysis Summary Results

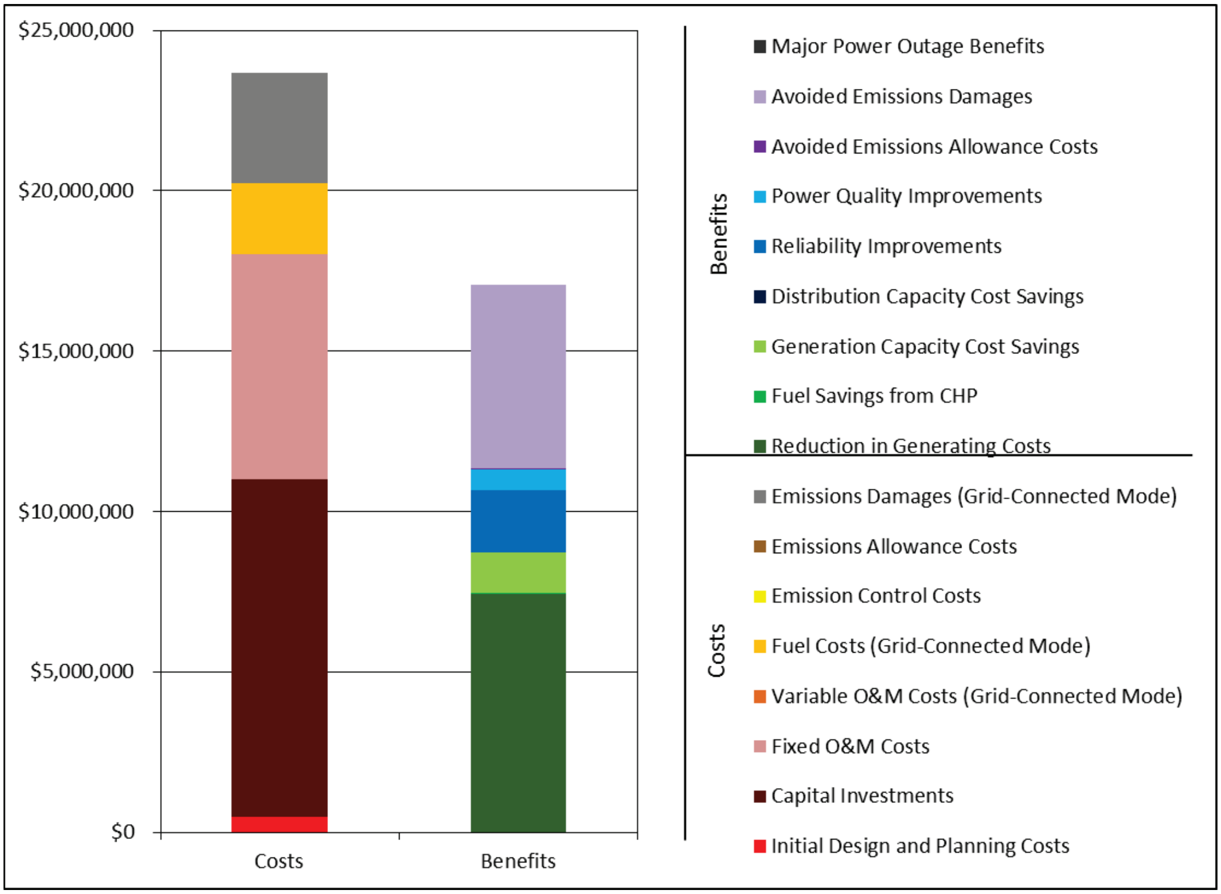
Economic Measure	Assumed average duration of major power outages	
	Scenario 1: 0 DAYS/YEAR	Scenario 2: 0.33 DAYS/YEAR
Net Benefits - Present Value	-$6,700,000	$84,600
Total Costs – Present Value	$23,700,000	$23,700,000
Benefit-Cost Ratio	0.7	1.0
Internal Rate of Return	-2.9%	6.3%

The cost benefit analysis results for scenario 1 are presented in Table 19.

Table 19– Cost Benefit Analysis 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	$475,000	$41,900
Capital Investments	$10,500,000	$848,000
Fixed O&M	$7,030,000	$621,000
Variable O&M (Grid-Connected Mode)	$0	$0
Fuel (Grid-Connected Mode)	$2,200,000	$194,000
Emission Control	$0	$0
Emissions Allowances	$0	$0
Emissions Damages (Grid-Connected Mode)	$3,380,000	$221,000
Total Costs	**$23,700,000**	
Benefits		
Reduction in Generating Costs	$7,360,000	$650,000
Fuel Savings from CHP	$36,300	$3,200
Generation Capacity Cost Savings	$1,260,000	$111,000
Distribution Capacity Cost Savings	$0	$0
Reliability Improvements	$1,930,000	$170,000
Power Quality Improvements	$662,000	$58,400
Avoided Emissions Allowance Costs	$3,800	$335
Avoided Emissions Damages	$5,670,000	$370,000
Major Power Outage Benefits	$0	$0
Total Benefits	**$16,900,000**	
Net Benefits	**-$6,700,000**	
Benefit/Cost Ratio	**0.7**	
Internal Rate of Return	**-2.9%**	

Figure 18 – Cost Benefit Analysis Scenario 1
(No Major Power Outages; 7 Percent Discount Rate)



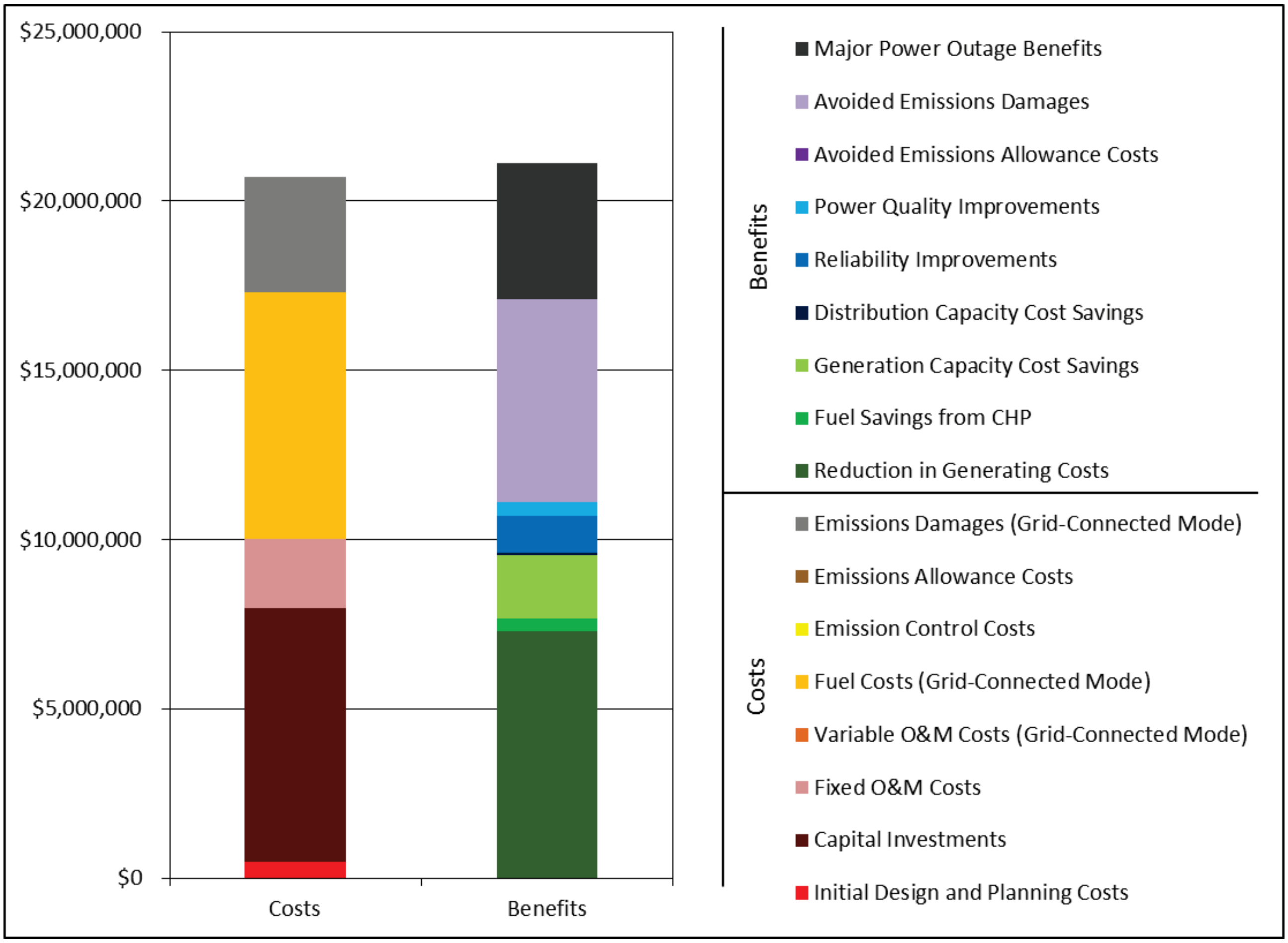
The major drivers of costs are the capital investments and fixed O&M, where the major benefits are reduction in generation costs and avoided emissions damages. Note that for the purposes of their analysis, IEc included the cost of electricity purchased from the anaerobic digester as part of fixed O&M cost.

Under the current design, the microgrid owner would purchase energy from the anaerobic digester technology provider, and would not bear any capital costs. As such, the anaerobic digester company did not disclose the capital cost to develop the digester. However, the project team estimates that given a reasonable return on investment of the anaerobic digester company, the expected profile of feedstock costs, and the PPA rate that the company disclosed, capital costs are likely to fall in the area of $5,000/kw to $7,000/kW installed. Thus we estimate the total capital cost between $4 million and $5.6 million.

Table 20 – Cost Benefit Analysis Scenario 2
(Major Power Outages Averaging 0.33 Days/Year; 7 Percent Discount Rate)

COST OR BENEFIT CATEGORY	PRESENT VALUE OVER 20 YEARS (2014$)	ANNUALIZED VALUE (2014$)
Costs		
Initial Design and Planning	$475,000	$41,900
Capital Investments	$10,500,000	$848,000
Fixed O&M	$7,030,000	$621,000
Variable O&M (Grid-Connected Mode)	$0	$0
Fuel (Grid-Connected Mode)	$2,200,000	$194,000
Emission Control	$0	$0
Emissions Allowances	$0	$0
Emissions Damages (Grid-Connected Mode)	$3,380,000	$221,000
Total Costs	**$23,600,000**	
Benefits		
Reduction in Generating Costs	$7,360,000	$650,000
Fuel Savings from CHP	$36,300	$3,200
Generation Capacity Cost Savings	$1,260,000	$111,000
Distribution Capacity Cost Savings	$0	$0
Reliability Improvements	$1,930,000	$170,000
Power Quality Improvements	$662,000	$58,400
Avoided Emissions Allowance Costs	$3,800	$335
Avoided Emissions Damages	$5,670,000	$370,000
Major Power Outage Benefits	$6,790,000	$599,000
Total Benefits	**$23,700,000**	
Net Benefits	**$84,600**	
Benefit/Cost Ratio	**1.0**	
Internal Rate of Return	**6.3%**	

Figure 19 – Cost Benefit Analysis Scenario 2
(Major Power Outages Averaging 0.5 Days/Year; 7 Percent Discount Rate)



The benefits from the half day outages result in $4,040,000 during the life of the microgrid. The entirety of the IEc analysis can be found in Appendix D of this report.

Model Comparisons

This benefit-cost analysis differs from the third party ownership financial feasibility analysis performed by the project team in several ways. As described above, the benefit-cost analysis is intended to account for all of the societal costs and benefits associated with the system. The financial analysis conducted by the project team is intended to evaluate the financial strength of the project from the perspective of third party ownership. In addition to the differing objectives of these two analyses, the underlying assumptions used in each also differed. A few of these differences affected the results of these analyses in significant ways, including:

- Gas rates used in IEc's benefit-cost analysis were based on a state-wide average for commercial end-use customers, while those in Tompkins financial feasibility analysis were based on the NYSEG's distributed generation rate. This resulted in year 1 gas rates of $6.34 and $5.61, for the benefit-cost analysis and the financial feasibility analysis, respectively. If NYSEG's distributed generation rate were applied to the benefit-cost analysis, net benefits would be increased by $160,000.

- The financial feasibility assessment incorporates the tax benefits of the Federal Investment Tax Credit, whereas the benefit-cost analysis does not. This benefit reduces the capital cost of the project by $2.7M.
- Capital replacement costs used in the BCA were calculated as a full replacement costs, whereas the project team assumed a 'rebuild' cost that is not equal to the full cost of replacement. The rebuild cost is $210,000 lower than the full cost of replacement.
- IEc included the cost of electricity purchased from the anaerobic digester as part of "fixed O&M," one of the line items under "Total Cost." The net present value of this electricity purchase is $5,340,000, or approximately $472,000 per year over a 25 year PPA term.
- The benefit-cost analysis derives a price for electricity based on average wholesale energy costs, whereas the financial feasibility assessment evaluates the savings to the community based on actual costs paid by community participants.
- The period of analysis in the benefit cost analysis is 20 years and the third party ownership model is based on a period of analysis of 25 years.

Development, Construction, and Operating Approach

Once the design phase of a microgrid project is complete, the project must be brought to life by a well-designed and effectively supported development approach.

Prior to construction, it is important to clearly define the manner in which operations and maintenance (O&M) will be managed once the microgrid is operational. There are multiple options for handling microgrid O&M:

- System owner O&M – The system owner, or SPE, hires staff to operate and maintain the microgrid.
- O&M Contractor – The SPE hires an O&M contractor under a long term service-level agreement.
- Separate Operations and Maintenance Contractors – The SPE hires separate operations and maintenance contractors under long term service-level agreements because each has its own skills advantages and cost savings advantages.

For the long term benefit of all stakeholders, it is important to structure a deal in which all parties benefit from optimal operations of the microgrid. Therefore, the SPE revenue and profitability must be in balance with savings to the community off-takers. The appropriate O&M approach for the Tompkins County Community Microgrid has not yet been determined.

System development will involve a complex permitting process. In Stage 2, the team will conduct an environmental assessment that includes CHP air emissions, PV and ESS recycle potential, inverter recycle potential, and visual obtrusion. The CHP systems will require air quality operating permits, but all proposed systems will qualify for permitting.

The local utility will need to approve of the design of the switching that provides disconnect, islanding, and restoration functions in case of power disruption. The utility will also need to approve plans to use sections of utility distribution equipment while in island mode.

The utility will coordinate protection and switching schemes for the points of common coupling and the distribution system.The development team will address these needs in the interconnection agreement and the studies that support it.

We anticipate that the microgrid will use only underground cabling to connect loads in the Tompkins County Community Microgrid. Overhead distribution lines do not provide the resiliency or reliability required to meet the specified uptime requirements. Ownership of new purchased and installed underground cabling could be retained by the SPE or gifted to the utility, based on the objectives of community stakeholders. The REV proceedings include a consideration of such arrangements.

If the utility owns the underground cable, then the utility may charge full delivery charges, or “freight,” to the customers. This will likely not be the case if the microgrid project paid for the underground cable. A full freight policy, based on past practice and not true value, eliminates nearly all the community’s financial benefit associated with the microgrid. This may become an issue for consideration under REV.

Operation of the microgrid will include several key components:

Metering: The SPE will require the state of New York to allow sub-metering that can be applied to the microgrid.

Technical Operations: The microgrid controls and microgrid design are based on the ten Oak Ridge National Laboratory Microgrid Use Cases. The most important use cases address transition to an island mode (planned and unplanned) and return to grid-connected operations.

Under normal conditions, the microgrid will operate under one of two regimes to accommodate its nodal structure. The first regime is local (within each node) where optimization is primarily focused on assurance of reliable and resilient operations. The second regime is global – across the entire microgrid – where optimization includes economic and emissions reduction objectives. At the global microgrid level, operations are focused on savings to the community and reduction of emissions. Under normal condition, the microgrid will operate under the global regime.

Financial Operations: The SPE will bill system off-takers monthly for energy from system resources. Depending on how the SPE is established with the community, the customer may still be billed by the utility. To simplify bill management for the customers of the microgrid, the utility bill may become a pass-through within the microgrid billing.

Transactional: Any additional revenue to customers from shared utility program participation (demand response, ancillary services) will be accounted for in the monthly bill that the customer receives from the SPE.

PROJECT TEAM

The success of this project relies on a strong team to take it from a feasibility study to an operational system. This Tompkins County Community Microgrid team has engaged with a majority of the community stakeholders. Local government representatives from Tompkins have led this project from the beginning, and have signaled Tompkins's clear interest in participating in a microgrid that can deliver resilient, cost effective energy. The community has not stated interest in any kind of public-private partnership at this time, but the project team will continue to consider the potential benefits of such an approach as the project is designed. This could take the form of partial ownership of the SPE by one or more local government agencies.

Other stakeholders have been kept informed throughout the process and have assisted the study by supporting site audits, providing facility information, and participation in regular status calls. As this project enters the next phase, the project team will hold face-to-face meetings with participants to review the results of the feasibility study and touch base on their interest in participating in the microgrid project.

NYSEG is aware of this project, provided a letter of support for the initial feasibility study and participated in the project kick-off meeting. Throughout the process, the project team has engaged NYSEG in design discussions through the RFI process. As of this date, NYSEG has not yet weighed in on the value of this project based on the results of the feasibility study. The final report for this feasibility study will be shared with NYSEG for their reference and evaluation. Tompkins County will determine whether to pursue the development of the microgrid. The County has the experience executing complex projects through various construction and energy projects over the years. Key team members will include:

- Engineering
- Procurement
- EPC Contractor
- CHP Design Firm
- PV Design Firm
- Microgrid Controller Vendor
- Project Financiers
- Legal and Regulatory Advisors
- Operations and Maintenance Firms

LEGAL VIABILITY

The project team has developed a model for the legal organization of the Tompkins County Community Microgrid based on ownership by a dedicated SPE. The project team has proven the legal viability of this model through numerous existing microgrid projects. This ownership structure maximizes opportunity for low-cost financing, and helps to ensure that final customer rates are kept as low as possible. Other team members or community stakeholders may decide to take an ownership stake in the system. However, at this time, no community customers or stakeholders have been solicited or expressed interest in an ownership role.

The SPE will not own the real estate or facilities in which microgrid systems and equipment will be installed. In each case these sites are owned by customers included in the microgrid. These customers have been included in the planning process throughout the feasibility study.

Representatives for each accompanied the project team as they walked through the sites following the kick-off meeting, they have worked with the project team to gather data necessary to construct the model, and they have been included in the project close-out meeting. In each step of the process the project team has discussed plans for locating microgrid equipment at each site with the customers who own that site.

Market Barriers

There are a number of variables which could impact the viability of the project, even if the technical and economic fundamentals look strong. They include:

Financing: There may be aspects of the current market that make securing financing at a competitive cost of capital more difficult. The primary barrier is the education level and familiarity with microgrids within the finance sector. While solar PPAs are now a well-established financing opportunity, only ten years ago, they were little understood by financiers. Today, microgrids are not as well understood in the financial sector. The financial industry has not yet created standardized financing products for microgrids, and each new project has required a custom deal. This tends to drive up the cost of capital.

Stage 2 NY Prize Funding: Stage 1 funding was not sufficient to cover the costs of a comprehensive feasibility study. This was anticipated, and many organizations involved in the delivery engaged in cost sharing and were prepared to make significant investments to deliver a high quality and reliable study for the Tompkins feasibility study. However, given the levels of investment required of vendors in Stage 1, there will be little appetite or ability to incur additional cost share or risk in Stage 2. This is exacerbated by the inherent risks and known and unknown costs associated with the next phase of development, many of which are specific to community microgrids. Stage 2 funding is critical to moving forward to the next stage of project development.

Customer Commitments: The project economics are highly sensitive to the microgrid design. The design is dependent on customer sites and loads, and the distributed energy resources planned for those locations. A major risk is posed by the possibility of customers withdrawing before final contracts are signed. This would affect the overall microgrid design and fundamental project economics.

Utility Cooperation: The negotiation of interconnection agreements with local utilities can cause significant delays and lead to new costs when the proposed microgrid concepts are unfamiliar to the utility's staff and engineering contractors. To date, NYSEG has demonstrated general support for the approach and has not identified any deal killers so far. They will provide more detailed input to the design and interface requirements in the detailed engineering stage following this study. Through continued collaboration and sharing of design details, Tompkins can expect this risk to be fairly small in the next phase.

Regulatory Issues

The ownership model of the Tompkins County Community Microgrid will influence the type of regulatory status it has under Public Service Law. This report assumes that the system will be owned by a third-party SPE. Privately-owned microgrids are legal in New York.

The system will not be considered an electric distribution company by the public services commission because it utilizes qualifying forms of generation,[1] is under 80 MW,[2] serves a qualifying number of users, and its related facilities (including any private distribution infrastructure) are located "at or near" its generating facilities. This saves the system from a raft of burdensome regulatory requirements.

Placing distribution wires or leveraging the existing utility distribution system for energy sharing between facilities will be subject to state-wide electric utility regulations, local franchise and rights of way statutes, and the willingness of the local utility.

Privacy

Ensuring the privacy of the microgrid clients will be of paramount importance for both customer satisfaction and project replicability. The Project Team has taken steps to improve the privacy of all stakeholder data, including all utility data, plans, diagrams and site specific and sensitive information. The project team has done this by setting up a secure data site which allows our team to minimize access of this data to only those directly involved in the modeling and design process. This tightened data control will ensure the project stakeholder's data meets all privacy requirements.

CONCLUSIONS AND NEXT STEPS

The NY Prize feasibility assessment indicates that the Tompkins County Community Microgrid is technically viable, and may be economically viable if awarded further NY Prize grants. The microgrid will help the county to reach its ambitious sustainability goals while significantly improving the resilience of public safety and health services, and hardening critical infrastructure, including the regional airport. The project team believes that the proposed microgrid design will provide valuable lessons to other communities considering developing microgrids around airports, communities interested in maximizing the sustainability benefits associated with microgrid

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[1] Qualifying generation facilities are defined in PSL § 2 as those falling under the definitions of "Co-generation facilities," "Small hydro facilities," or "Alternate energy production facilities." A qualifying co-generation [1]
[2]Qualifying generation facilities are defined in PSL § 2 as those falling under the definitions of "Co-generation facilities," "Small hydro facilities," or "Alternate energy production facilities." A qualifying co-generation facility is defined as "Any facility with an electric generating capacity of up to eighty megawatts…. together with any related facilities located at the same project site, which is fueled by coal, gas, wood, alcohol, solid waste refuse-derived fuel, water or oil, …. and which simultaneously or sequentially produces either electricity or shaft horsepower and useful thermal energy that is used solely for industrial and/or commercial purposes." NY PSL § 2-a. A qualifying small hydro facility is defined as "Any hydroelectric facility, together with any related facilities located at the same project site, with an electric generating capacity of up to eighty megawatts." NY PSL § 2-c. A qualifying "alternate energy production facility is defined as "Any solar, wind turbine, fuel cell, tidal, wave energy, waste management resource recovery, refuse-derived fuel or wood burning facility, together with any related facilities located at the same project site, with an electric generating capacity of up to eighty megawatts, which produces electricity, gas or useful thermal energy." NY PSL Ser § 2-b.

[2] Id.

development, and those considering the use of an anaerobic digester as part of their DER portfolio. Key findings from the NY Prize feasibility assessment include:

1. **Engaged Stakeholders**: The larger loads in the Tompkins Community Microgrid are all at facilities and institutions that are well established, and are engaged in the project, including many that are directly managed by county government.
2. **Clean Energy Profile**: The Tompkins County Community Microgrid is designed to advance the county's aggressive climate change abatement goals, including a target of 80% reduction in GHG emissions from 2008 levels by 2050, and an interim goal of 20% by 2020. The microgrid's renewable energy resources (PV and anaerobic digester) will decrease the emissions associated with powering the facilities in the microgrid significantly. The GHG offset value of the microgrid will be equal to $249,000 per year, according to the analysis conducted by IEc. This is equal to a roughly 35% decrease in GHG emissions under current levels.
3. **Natural Gas Availability:** The design of the Tompkins County Community Microgrid intentionally minimizes the use of natural gas fed CHP units to better support the county's climate and clean energy goals, and includes an anaerobic digester as an alternative means of meeting the base loads in Node 1. However, even if project stakeholders had wanted to use more natural gas generation, there would have been none available, as the supply from the gas utility is severely constrained at the microgrid location. The utility, NYSEG, is planning to resolve restrictions on natural gas availability in the area. If no additional gas capacity is added, the project team will be constrained in the tweaks they can make to the design to try to lower costs, and the project will lose some scalability.
4. **Anaerobic Digester Costs**: The addition of the anaerobic digester to the Tompkins County Community Microgrid design has added significantly to projected energy costs for microgrid customers. Given the high capital cost of such a system, the project team decided that the SPE is likely to purchase the electricity from this system, rather than pay to develop and own it. Should the Tompkins County Community Microgrid project reach Stage 2 of the NY Prize program, a detailed study will be conducted of the anaerobic digester system, and the details of its operation. In particular, the project team will need to determine the exact feedstock requirements of the system, and identify reliable and cost-effective sources for this feedstock. The economics of the system will need to be evaluated in detail to determine how the PPA price for the anaerobic digester electricity will contribute to the final PPA price paid by microgrid customers.
5. **Community Microgrid Financing Costs**: The cost of project financing is high for community microgrids. This is due to the fact that there are numerous stakeholders and potential customers, and that each stakeholder has its own procurement requirements. The project team will need to seek out a financier that is knowledgeable about these projects, and can help keep transaction costs to a minimum.

6. **Financial Prospects**: As it stands, the Tompkins Community Microgrid project is not likely to meet the financial requirements for third party financing and ownership. In order to meet these requirements, one or more of the following conditions would need to be met:
    a. The award of Stage 2 and Stage 3 NY Prize grants from NYSERDA
    b. The use of PPA rates above the current average cost of energy for prospective microgrid customers.

The next steps that Tompkins County will need to undertake are to finalize the ownership structure to be proposed, and identify a team of partners to engage in the detailed design phase of the project. Once these decisions are made, the project team will be able to draft a proposal to NYSERDA to compete in Stage 2 of NY Prize. This Stage 2 funding will help defray the additional cost and risk associated with a multi-stakeholder community microgrid. Stage 2 of the NY Prize program will require additional cost share, and a determination will need to be made about which parties will contribute.

[End of Report]

APPENDIX A: TOMPKINS MICROGRID LAYOUT DIAGRAM

SHEET TITLE Microgrid Concept Overview				PROJECT Community Microgrid - Tompkins
PROJECT NO:	MARK	DATE	DESCRIPTION	
CAD DWG FILE:				
DRAWN BY:				
CHK'D BY:				

SHEET OF

SHEET NUMBER

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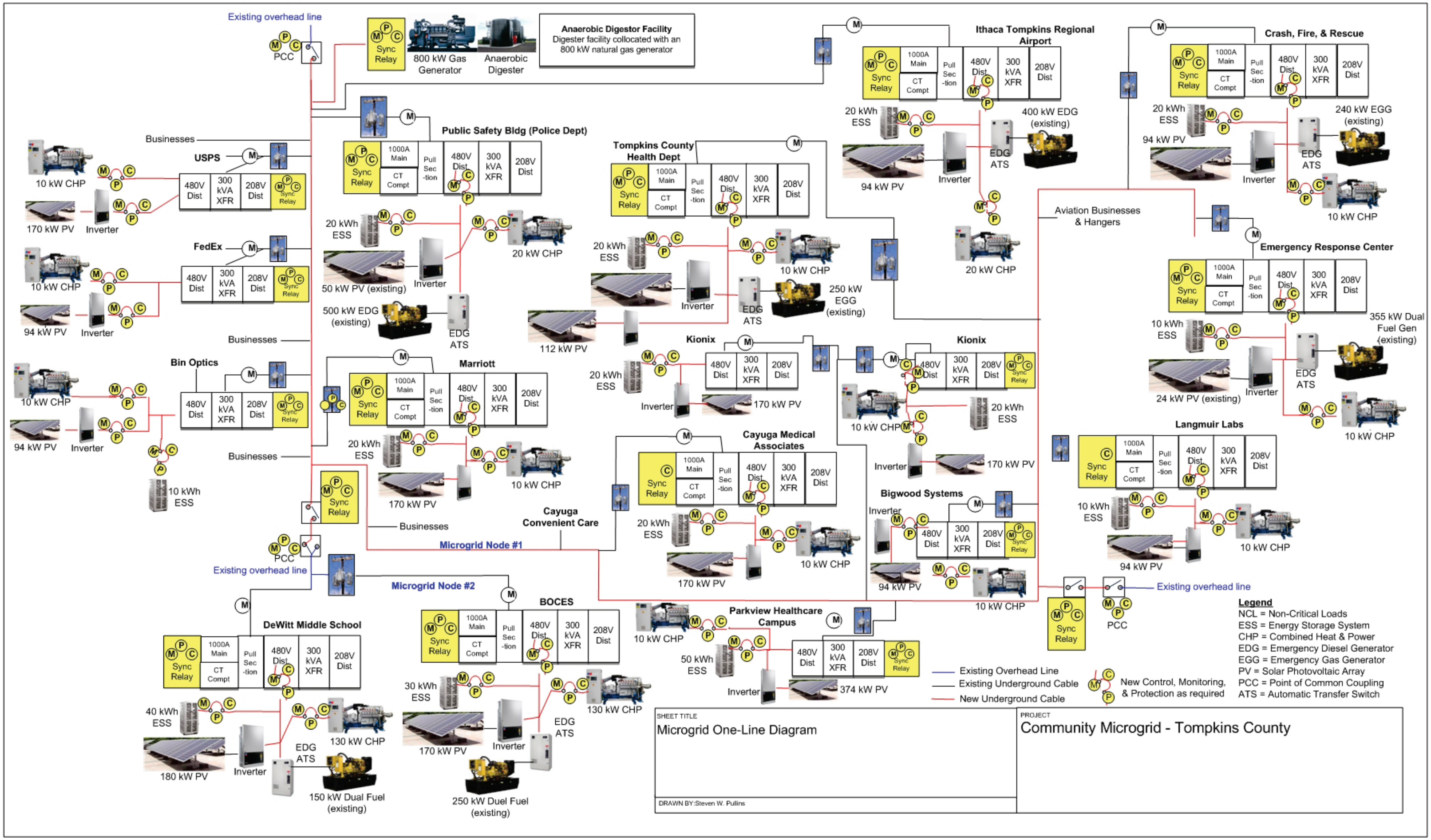
APPENDIX B: TOMPKINS MICROGRID ONE-LINE DIAGRAM



APPENDIX C: LEGAL AND REGULATORY REVIEW

Legal Issues Related to Ownership Structure

I. Ownership and Public Service Law (PSL) Regulatory Treatment

The ownership model that the Tompkins County microgrid undertakes will influence the type of regulatory status it has under PSL. Three basic potential ownership models are identified below, with relevant regulatory implications noted.

1. Utility Ownership of Microgrid Assets, Inclusive

Utility ownership of microgrid assets can have the potential benefits of lowering the technical and administrative burdens on project participants, easing the interconnection process, and providing a ready source of capital, among others. If NYSEG ownership of various DER assets within the microgrid is proposed, it will be necessary to address how generation assets will be treated, considering ongoing discussions in REV proceedings and potential demonstration project status.

The Public Service Commission (Commission) has considered utility ownership of DER, which would include *inter alia* microgrid generation and storage assets. The Commission's stated policy from its February 26th "Order Adopting Regulatory Policy Framework and Implementation Plan" can be summarized as follows:

> "A basic tenet underlying REV is to use competitive markets and risk based capital as opposed to ratepayer funding as the source of asset development. On an ex ante basis, utility ownership of DER conflicts with this objective and for that reason alone is problematic….As a general rule, utility ownership of DER will not be allowed unless markets have had an opportunity to provide a service and have failed to do so in a cost-effective manner…. [U]tility ownership of DER will only be allowed under the following circumstances: 1) procurement of DER has been solicited to meet a system need, and a utility has demonstrated that competitive alternatives proposed by nonutility parties are clearly inadequate or more costly than a traditional utility infrastructure alternative; 2) a project consists of energy storage integrated into distribution system architecture; 3) a project will enable low or moderate income residential customers to benefit from DER where markets are not likely to satisfy the need; or 4) a project is being sponsored for demonstration purposes."[3]

Of these four qualifying scenarios, most likely only the fourth would apply here.

Speaking to the first scenario, the utility may always appeal to the Commission to own DERs if it first conducts an open solicitation process for private owners. In the context of this feasibility study, such a solicitation process will not be undertaken, so for now we ignore this condition. If other ownership models proposed by this study prove untenable following the appropriate solicitations, this condition may become relevant.

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[3] Case 14-M-0101, Order Adopting Regulatory Policy Framework and Implementation Plan, Feb. 26, 2015, at 67-70.

Speaking to the second scenario, while a microgrid may incidentally incorporate storage devices into utility infrastructure, it is clear from the context surrounding these comments that the Commission intends for projects qualifying under this condition to be primarily geared towards expanding the utility's understanding of how storage assets can provide benefit to the distribution grid, and specifically noted that "[w]ith respect to resources at the customer location, utility ownership should not be necessary."[4] Storage integrated into a microgrid would not seem to qualify under this condition.

Speaking to the third scenario, the proposed project does not target low/moderate income customers who may not otherwise be likely to receive microgrid service from the market. As such it may not target utility ownership as a potential DER ownership structure under this condition.

Speaking to the fourth scenario, there remains substantial uncertainty regarding what will be determined a satisfactory "demonstration project" by the Commission. The only criterion for demonstration projects promulgated by the Commission to date is its December 12, 2014 "Memorandum and Resolution on Demonstration Projects," which states that:

> 1. REV demonstrations should include partnership between utility and third party service providers.
>
> 2. The utility should identify questions it hopes to answer or problems or situations on the grid and the market should respond with solutions. Hence, third party participation through a traditional RFP/RFI method where the utility has pre-diagnosed the solution(s) does not meet this requirement.
>
> …
>
> 4. The market for grid services should be competitive. *The regulated utility should only own distributed energy resources if market participants are unwilling to address the need and the utility is acting as the service provider of last resort (in this instance, "provider of last resort" and "needed" means that no one in the market is providing the solution and the distributed solution is less costly than alternatives for the problem)* (emphasis added).[5]

The fourth principle for demonstration projects articulated by the Commission leaves some uncertainty regarding what conditions utility ownership will be permitted under in the context of a demonstration project. The Commission elsewhere notes that "proponents of demonstration projects should strive for third party ownership of DER, keeping in mind that any regime of third party ownership must be done in a manner that ensures safety, reliability and consumer protection."[6]

In practice, the Commission has approved demonstration projects that involve utility ownership of DERs. Consolidated Edison's Virtual Power Plant demonstration project, for example, allows

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[4] Id. at 69.

[5] Case 14-M-0101, "Memorandum and Resolution on Demonstration Projects," Dec. 12, 2014, at Appendix A.

[6] Id. at 9.

Consolidated Edison to own storage assets that are marketed as a package with PV provided by a third party to customers as, when taken together, a resilient power system.[7]

The Commission has noted that "[d]emonstration projects will be a continuing effort as the implementation of REV develops….The need for demonstrations will continue, and we will examine methods for utilities to develop a common platform for sharing of information regarding needs and potential offerings by third parties."[8] The Commission has not yet issued a formal deadline for the proposal of new demonstration projects at this time.

In the Tompkins County microgrid, it is plausible that NYSEG would be allowed to act as the owner/operator of a substantial set of DERs if such an arrangement were pursued: (a) as a demonstration project; (b) for the purpose of testing a hypothesis of how to provide REV-related benefits to customers, perhaps through a novel tariff or third party partnership; and (c) where there is not a ready market provider for the same service. This model may be pursued further through a demonstration project filing if there is an appetite among project stakeholders for utility ownership of microgrid assets.

2. Utility Ownership of Non-Generation Microgrid Assets Only

Even if NYSEG does not own any of the DER assets within the Tompkins County microgrid, it may still be beneficial for the project to rely on existing distribution service to carry power between microgrid customers and avoid the investment and regulatory burden associated with private distribution. If NYSEG ownership of only distribution microgrid assets is proposed, it will be necessary to address the method under which the microgrid will export to the utility grid. There are several potential regimes under which individual customers within the microgrid may export power onto the utility grid.

A) Net metering

New York's net metering rules allow customers with eligible distributed generation sources to export power onto the utility grid. This mechanism may be relevant for facilities exporting power onto utility-owned wires for distribution to other microgrid customers. Net metering allows onsite generators to offset grid electricity purchases (when onsite demand exceeds onsite generation) with power exported to the grid (when onsite generation exceeds onsite demand). Under this mechanism, qualifying generators can effectively receive retail rates for their excess generation. Net metering is available in New York to residential and nonresidential solar, wind, fuel cells, micro-hydroelectric, agricultural biogas, and residential micro-CHP.

The size of the eligible generator is capped depending on the kind of generation (e.g., solar, wind, etc.) and customer type (e.g., residential, nonresidential, farm). The cap for residential solar, wind, and micro-hydroelectric is 25 kW. The cap for nonresidential solar, wind and micro-hydroelectric is 2 MW. The cap for farm-based wind is 500 kW, and the cap for farm-based biogas is 1 MW. The cap

[7] See Case 14-M-0101, "REV Demonstration Project Outline: Clean Virtual Power Plant," Consolidated Edison, July 1, 2015, and Case 14-M-0101, Letter from Scott Weiner, Deputy for Markets and Innovation, NYS Public Service Commission, to Consolidated Edison, August 3, 2015.

[8] Case 14-M-0101, Order Adopting Regulatory Policy Framework and Implementation Plan, Feb. 26, 2015, at 117.

for residential fuel cells and micro-CHP is 10 kW, while the cap for nonresidential fuel cells is 1.5 MW.[9]

New York's net metering policies may be revisited through the REV proceeding, and the Microgrid Working Group has particularly flagged for resolution the issue of how eligible and non-eligible net metering resources at a given site will be accounted for.

In the Tompkins microgrid project, proposed PV generation assets may be eligible to receive net metering credit.

B) Buyback Tariffs

For generation that is not eligible for net metering, microgrid owners may also sell energy services through applicable "buy back" tariffs that require utilities to purchase excess generation from qualifying facilities. NYSEG's buyback tariff can be found at Service Classification No. 10, Buy Back Service Energy only rate, as described in 4.D Application of Credits at Avoided Cost.

The buyback tariff will typically provide highly variable rates to the microgrid owner for energy services. The utility typically buys generation from the participating customer at the Locational Based Marginal Price (LBMP), which reflects the wholesale price of energy through NYISO's bulk power markets at the transmission level. From the standpoint of the nonutility microgrid owner, selling relatively large amounts of energy produced via a buy back tariff would likely not be a preferred arrangement due to the uncertainty of the revenue stream resulting from the fluctuating wholesale price of energy.

Selling energy back to the utility via a buy back tariff may be a viable option for Tompkins County if used as a secondary means of receiving compensation for energy services. This may be particularly salient if the system is designed to provide thermal energy through CHP operated to follow thermal demand. In these instances, there will be times where electric generation exceeds electric demand. When this occurs, the grid can serve as a destination for the surplus power produced.

The ability to sell surplus energy via the buyback tariff also provides the option for microgrids to export intentionally to the grid when the LBMP is at favorable rates. For example, while the Burrstone Microgrid has established a PPA with each microgrid user that covers most of the energy produced, the microgrid sells surplus power to National Grid at the LBMP. To operationalize the microgrid's interaction with the wholesale power market, Burrstone developed an algorithm that governs the microgrid control system. Using market prices fed into the algorithm, the microgrid control system provides signals to the units indicating when to run and when not to run. Burrstone's algorithm makes hourly operational decisions that are automatically implemented by the Energy Management System.

C) Creation of New Tariff for Microgrid Service

Specially designed tariffs or service agreements may be adopted to support microgrids that rely on the utility distribution system to wheel power between microgrid users. Such a "wheeling charge," specialized tariff or other form of service agreement may be agreed to by the parties, and may

[9] NY PSL § 66-j.

potentially be approved by the Commission as a REV demonstration project. As articulated by the Commission:

> "Demonstrations should inform pricing and rate design modifications….Demonstrations should include opportunities for third parties to demonstrate how various rate designs, information sharing, adjusted standby tariffs, and other technologies can be used to benefit consumers, encourage customer participation, and achieve REV's efficiency and bill management objectives."[10]

These criteria may open the door for NYSEG to propose novel methods of billing microgrid customers for their use of the distribution system. In other settings, utilities have already considered or proposed REV-related projects that include reaching unique service agreements with microgrid customers.[11]

3. Privately-Owned Microgrid Distribution

Tompkins County may pursue a privately-owned microgrid in a variety of flavors: a third-party energy services company, a special purpose entity or LLC owned and controlled by microgrid customers, or some combination of the two as relates to different assets. The important legal question across all varieties of this model will be whether the microgrid is an electric distribution company under PSL, and if so, what level of regulation it will fall under at the Public Service Commission. Discussion of the State-level regulatory landscape, Section 2 of the PSL, and various cases applying its standards will inform this discussion. New models of regulatory treatment, currently under discussion in the REV proceeding, may also apply if adopted in the future.

A) Currently Existing Regimes of Regulating Privately-Owned Microgrid Distribution Under PSL.

Under existing law and Commission guidance, the Tompkins County microgrid will be treated as an electric corporation under PSL unless it is deemed a qualifying facility under the terms of PSL §§ 2(2-d) or otherwise qualifies for lightened regulation.

If subject to the full spectrum of regulation that the Commission may exercise over an electric corporation, the microgrid may be regulated for general supervision[12] (investigating the manufacture, distribution, and transmission of electricity; ordering improvements; and performing audits), rates,[13] safe and adequate service,[14] all aspects of the billing process, financial, record-keeping, and accounting requirements,[15] corporate finance and structure,[16] and more. This expansive purview of regulation may prove too administratively onerous for a small project like the Tompkins County microgrid to comply with. It is therefore important that, if the microgrid utilizes

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[10] Case 14-M-0101, "Memorandum and Resolution on Demonstration Projects," Dec. 12, 2014, at Appendix A.
[11] See, e.g., Case 14-E-0318, "Testimony of the Reforming the Energy Vision Panel," July 15, 2014, at 14.
[12] PSL § 66.
[13] PSL § 65.
[14] PSL § 66.
[15] PSL § 66, 68(a).
[16] PSL § 69.

private distribution infrastructure, it be designated a qualifying facility, be subject to lightened regulation, or be granted some alternate regulatory status, as discussed in part (B) of this section.

i. Qualifying Facility

Tompkins County's microgrid may be exempted from much of the PSL regulation applying to electric distribution companies if it is deemed a qualifying facility under the terms of PSL §2. A microgrid will be deemed a qualifying facility if it utilizes qualifying forms of generation,[17] is under 80 MW,[18] serves a qualifying number of users, and its related facilities (including any private distribution infrastructure) are located "at or near" its generating facilities.

Type of generation facilities: In the Tompkins county project, PV generation facilities have been proposed that will qualify. CHP facilities have also been proposed that will likely qualify if its electricity, shaft horsepower, or useful thermal energy is used solely for industrial and/or commercial purposes.

Size of generation facilities: In the Tompkins County project, generation facilities will fall well under the statutorily imposed 80 MW limit.

Qualifying number of users: It is difficult to apply the requirement that a microgrid serve a qualifying number of users in the abstract. This requirement has not been explicitly spoken to by the Commission, but has been contested in Case 07-E-0802, regarding the Burrstone Energy Center.[19] There, petitioners raised the question of whether a qualifying facility may distribute power to three different institutional users – a hospital, college, and nursing home. The Commission found that "furnishing electric service to multiple users" is specifically contemplated in PSL §2(2-d) "by providing that electricity may be distributed to 'users,' in the plural."[20] The Burrstone Energy Project was held to qualify for regulatory exemption.

The *Burrstone* case is the only existing precedent of the Commission applying the "qualifying facility" standard to more than one user. One interpretation of this precedent might conclude that no upper bound exists on the number of users that may be served by a qualifying facility. This

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[17] Qualifying generation facilities are defined in PSL § 2 as those falling under the definitions of "Co-generation facilities," "Small hydro facilities," or "Alternate energy production facilities." A qualifying co-generation facility is defined as "Any facility with an electric generating capacity of up to eighty megawatts…. together with any related facilities located at the same project site, which is fueled by coal, gas, wood, alcohol, solid waste refuse-derived fuel, water or oil, …. and which simultaneously or sequentially produces either electricity or shaft horsepower and useful thermal energy that is used solely for industrial and/or commercial purposes." NY PSL § 2-a. A qualifying small hydro facility is defined as "Any hydroelectric facility, together with any related facilities located at the same project site, with an electric generating capacity of up to eighty megawatts." NY PSL § 2-c. A qualifying "alternate energy production facility is defined as "Any solar, wind turbine, fuel cell, tidal, wave energy, waste management resource recovery, refuse-derived fuel or wood burning facility, together with any related facilities located at the same project site, with an electric generating capacity of up to eighty megawatts, which produces electricity, gas or useful thermal energy." NY PSL Ser § 2-b.

[18] Id.

[19] Case 07-E-0802 - Burrstone Energy Center LLC – Petition For a Declaratory Ruling That the Owner and Operator of a Proposed Cogeneration Facility Will Not Be Subject to Commission Jurisdiction (August 28, 2007).

[20] Id.

interpretation, however, may prove unwisely speculative. In the case of the Tompkins County microgrid, it would be wise, as the petitioners in *Burrstone* did, to petition the Commission for a declaratory ruling that the multiple users anticipated in this microgrid do not run counter to the Commission's interpretation of PSL §2.

Distribution facilities at or near generation: The physical distance that distribution facilities may extend from generation facilities has been questioned in several Commission decisions applying the qualifying facility standard.[21] A limited review of prior cases interpreting the "at or near" requirement could suggest that a project will be deemed a qualifying facility if its distribution network is under two miles. However, this range might expand (or contract) depending on several types of variables, which the Commission has cited in previous precedent, including: whether the project site is in a densely or sparsely developed location; what type of technologies it uses (e.g., a wind farm will naturally require a broader distribution network due to the acreage it takes up); and whether those facilities stay on private property or cross public rights of way.[22]

In the Tompkins County microgrid, the geographic footprint of private distribution facilities will likely satisfy the "at or near" test developed by the Commission. Declaratory rulings addressing facilities in comparable environments have met or exceeded the distance between customers in the proposed project, such as *Burrstone* (approximately half a mile),[23] *Nissoquogue Cogen Partners* (1.5 miles),[24] and *Nassau District Energy Corporation* (1.7 miles).[25] Of these, the closest precedent may be the Burrstone case, because the Commission in Burrstone considered whether crossing multiple property lines complicated the "at or near" analysis (while Nissoquogue and NDEC involved distribution passing almost entirely over a single property).

In light of the above factors, the Tompkins County microgrid project may satisfy the "at or near" requirement to achieve qualifying facility status. If the project wishes to secure its qualifying status, it must petition the Commission for a declaratory ruling to this effect.

ii. Lightened Regulation

If the Tompkins County project does not otherwise qualify for regulatory exemption, it may petition the Commission for a lightened regulatory burden. The Commission may consider a "realistic appraisal" of the need to regulate the microgrid based on a three-prong analysis: 1) whether a particular section of the PSL is inapplicable on its face; 2) if a provision is facially applicable, whether it is possible for an entity to comply with its requirements; and 3) whether imposing the requirements on an entity is necessary to protect the public interest, or whether doing so would adversely affect the public interest.[26] A realistic appraisal yields different results depending upon the microgrid's characteristics. The PSC recently applied the "realistic appraisal" test to the

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[21] See NYSERDA, "Microgrids for Critical Infrastructure Resiliency in New York," (Dec. 2014), at 31.
[22] Id.
[23] Case 07-E-0802 - Burrstone Energy Center LLC – Petition For a Declaratory Ruling That the Owner and Operator of a Proposed Cogeneration Facility Will Not Be Subject to Commission Jurisdiction (August 28, 2007).
[24] Case 93-M-0564, In re Nissoquogue Cogen Partners, Declaratory Ruling (1993)
[25] Case 89-E-148, Nassau District Energy Association, Petition for a Declaratory Ruling (Sept. 27, 1989).
[26] Case 98-E-1670, In re Carr St. generating Station, Order Providing for Lightened Regulation, at 4–5 (Apr. 23, 1999).

Eastman Park facility, which resembles a microgrid.[27] The precedent of microgrids receiving lightened regulatory burden under this standard is very thin, however, and it is difficult to prognosticate how this standard would be applied to the Tompkins County project.

B) Future Regimes of Regulating Privately-Owned Microgrid Distribution Under PSL

In its February 26th "Order Adopting Regulatory Framework and Implementation Plan,"[28] the Commission considered that a third model for regulating "community microgrids" with respect to the PSL might be appropriate. The Commission did not fully articulate how this model would function or make specific proposals. Parties were invited to comment on this matter on May 1st, 2015. The Tompkins County microgrid project may be impacted by any future regulatory developments issued by the Commission pursuant to these comments or otherwise in REV.

II. Contractual Considerations for Various Ownership Models

The regulatory implications addressed in Section I make some distinction regarding who owns various types of microgrid infrastructure. As previously discussed, whether the utility or private parties own different types of microgrid assets may impact how they are treated by the Commission and under PSL. However, setting aside State regulatory issues, there remain various contractual considerations that may impact how rights and responsibilities are aligned between microgrid parties. This section will consider those contractual questions.

Tompkins County's microgrid proposal has not yet addressed which parties may have the appetite for ownership, the access to capital, expertise, or what the preferred ownership structure would be for other participants. This section therefore addresses the potential ownership models introduced in Section I in the abstract and notes the areas of contractual tension that may arise for these parties.

1. Contracting between Utility and Customer/Project Developer in a Utility-Owned DER/Generation Model

Wholly utility-owned microgrids may have several advantages over privately-owned microgrids, including ease of the interconnection process, the utility's superior access to capital, and ease of customer solicitation, given the utility's existing relationship with its customers. Examples of microgrids where the utility owns at least some of the generation assets are the Consortium for Electric Reliability Technology Solutions (CERTS) demonstration project in Ohio, owned by American Electric Power,[29] and the Borrego Springs microgrid owned by San Diego Gas & Electric.[30] These projects, which take place in jurisdictions where rules regarding utility ownership of generation are more permissive, face lower regulatory burdens than utility-owned microgrids in

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[27] Case 13-M-0028, RED-Rochester LLC and Eastman Kodak Company, Order Approving Transfer Subject to Conditions, Providing For Lightened Ratemaking Regulation, and Making Other Findings (issued May 30, 2013).

[28] Case 14-M-0101, Order Adopting Regulatory Framework and Implementation Plan, Feb. 26, 2015, at 110.

[29] See "CERTS Microgrid Test Bed with American Electric Power," CERTS, available at. http://energy.lbl.gov/ea/certs/certs-derkey-mgtb.html.

[30] See "Microgrids: Benefits, Models, Barriers and Suggested Policy Initiatives for the Commonwealth of Massachusetts," DNV KEMA, at 6-3; and "Microgrids: An Assessment of Values, Opportunities, and Barriers to Deployment in New York State," NYSERDA, at A-2.

New York may face. However, at least one New York project has proceeded under a utility-owned model, and others have been proposed in rate case settings.

In the Town of Denning, NY, Central Hudson Gas & Electric (Central Hudson) developed a microgrid system to serve an electric load center located more than 14 miles from the distribution substation after an evaluation of the electric service reliability of the area found service to be unacceptable. The microgrid's internal DER consists of a 1,000-kVA diesel engine—owned and operated by Central Hudson—which is capable of serving the total peak load of the feeder. After the utility evaluated electric service reliability in the area of concern and determined it was below acceptable standards, Central Hudson developed a comprehensive corrective action plan to improve reliability that evaluated four different options with their respective costs. One option evaluated was the microgrid proposal and the other three options involved more traditional measures that included rebuilding miles of electric distribution lines. Due to its rugged and remote terrain, additional transmission and distribution investments were not comparably cost effective, as well as being an environmentally inferior option.[31]

In other settings, utilities have proposed microgrid ownership as part of pilot projects. Consolidated Edison, for example, agreed as part of its 2013 rate case to convene a collaborative geared towards developing a microgrid pilot. Central Hudson, in its 2014 rate filing, proposed a utility-owned microgrid pilot that has not moved forward yet.

Given the general prohibition on utility-owned generation, NYSEG would have to show that a microgrid is the cheapest alternative to distribution upgrades required to maintain adequate service, as in Denning, or propose a utility-owned microgrid as a demonstration or pilot, possibly in the REV proceeding. In the present case, Tompkins County does not appear to suffer service adequacy issues that would invoke the need to build a utility-owned microgrid purely for reliability purposes. It is likely that, if this project were to proceed as a utility-owned microgrid, it would need to seek a PSC approval as a demonstration project or pilot.

From a contracting perspective, utilities may have broad latitude to develop unique contracting arrangements directly with customers in a pilot or demonstration project. Model contract templates for microgrid service do not exist. In Central Hudson's microgrid proposal, for example, it proposed developing "a service agreement for a specified term under which the cost for [microgrid] facilities would be recovered,"[32] but left open for collaborative discussions how this agreement would be structured. Customers will want to be concerned with the following aspects of contracting for microgrid service:

- Price of power
    - Potentially variable depending on customer class, demand level, and time of use
    - Potentially variable as linked to fluctuating operating costs, such as fuel prices
    - Value of tax credits, incentives, accelerated depreciation incorporated into rates or otherwise passed onto customers

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[31] Central Hudson Gas & Electric EPTD 1208 Program Proposal. See also NYSERDA, Microgrids for Critical Infrastructure Resiliency in New York (2015) at 122.

[32] Case 114-E-0318, Testimony of Reforming the Energy Vision Panel (July 25, 2014) at 14.

- Customer obligation to take specific quantities of power or total system output over a given period
- Utility's obligation to produce certain quantities of project power over a given period
- Load shedding protocols
    - Price for varying levels of continued service in outage situation
- Penalties for non-performance or lateness in developing the project
- Ownership of renewable energy certificates generated
- Any applicable terms relating to leasing customer land or facilities to microgrid owner
    - Insurance to cover damages to property
- Level of exit fees
- Allocation of interconnection costs
- Transferring service obligation to future property owners / encumbering property
- Potential joint-financing schemes (i.e., a municipal customer with a higher credit rating than utility may take lead on securing financing for some portion of project)

Regulatory Issues and Tariffs

I. Franchises and Rights-Of-Way

All entities that require the use of public ways (i.e., for transmission or distribution facilities) must be granted permission by the presiding municipal authority in the form of a franchise or some lesser consent, depending on the scope of the usage. The proposed project includes customers on either side of public rights of way in both the Village of Lansing and the Town of Ithaca.

The cities, towns, and villages of New York have specific statutory authority to grant franchises: as provided by N.Y. Twn. Law § 64 and N.Y. Vil. Law § 4-412, every town and village is empowered to grant franchises or rights to use the streets, waters, waterfront, public ways, and public places of the city. "Use" encompasses occupying public rights-of-way and operation of the provider's built infrastructure to provide the public service.[33]

As noted in section 3.6 of the preceding report, neither the Town of Ithaca nor the Village of Lansing has specified the process for granting a franchise for electric distribution wires, nor is any other franchising procedure provided for guidance. Under N.Y. Town and Village Law, the Town and Village Boards will have discretion in determining the application process to obtain a franchise or lesser consent, subject to a public hearing preceded by proper notice.[34] Comparable jurisdictions have adopted specific franchise requirements that Ithaca and Lansing may look to.[35]

II. Application of Other Local Codes

1. Zoning

The candidates to receive microgrid service in Tompkins County are zoned as follows:

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[33] See, e.g., "Contract of April 7, 1887 between Hess et al. Commissioners & Consolidated Telegraph & Electrical Subway Co." (Con Tel and Electrical Subway Company Agreements 1886-1891.pdf)
[34] N.Y. Twn. Law § 64.
[35] See, e.g., Chapter 292 of New Rochelle Code, available at http://ecode360.com/6737770.

- Tompkins County Public Safety, 779 Warren Rd., Village of Lansing, NY 14850: Business and Technology District
- Tompkins County Emergency Response, 92 Brown Rd, Village of Lansing, NY 14850: Business and Technology District
- Ithaca Tompkins Regional Airport, 1 Culligan Dr, Village of Lansing, NY 14850: Business and Technology District. Including:
    - Crash, Fire and Rescue Buildings 1 and 2
    - County Aviation
    - Aircraft Hangars (T1 and T2)
- Taughannock Aviation, 66 Brown Rd, Village of Lansing, NY 14850: Business and Technology District
- US Geological Survey, 30 Brown Rd, Village of Lansing, NY 14850: Business and Technology District
- County Health Department, 55 Brown Rd, Village of Lansing, NY 14850: Business and Technology District
- Ongweoweh Corporation, 767 Warren Rd, Village of Lansing, NY 14850: Business and Technology District
- Binoptics, 9 Brown Rd, Village of Lansing, NY 14850: Business and Technology District
- Nielsen Claritas, 53 Brown Rd, Village of Lansing, NY 14850: Business and Technology District
- Kionix, 36 Thornwood Dr, Village of Lansing, NY 14850: Business and Technology District
- Cayuga Venture Fund, 15 Thornwood Dr, Village of Lansing, NY 14850: Business and Technology District
- Rheonix Inc.: 22 Thornwood Dr # 4, Village of Lansing, NY 14850: Business and Technology District
- Courtyard Ithaca Hotel, 29 Thornwood Dr, Village of Lansing, NY 14850: Business and Technology District
- Bigwood Systems Inc, 35 Thornwood Dr # 400, Village of Lansing, NY 14850: Business and Technology District
- Quintiles, 19 Brown Rd, Village of Lansing, NY 14850: Business and Technology District
- CBORD Group, 61 Brown Rd, Village of Lansing, NY 14850: Business and Technology District
- Advion Bioservices 10 Brown Rd, Village of Lansing, NY 14850: Business and Technology District
- Langmuir Labs, 283 Langmuir Lab, Box 1001, Village of Lansing, NY 14850: Business and Technology District
- USPS, 757 Warren Rd, Village of Lansing, NY 104850: Business and Technology District
- FedEx Ship Center, 747 Warren Rd, Village of Lansing, NY 14850: Business and Technology District
- Cayuga Medical Associates, 16 Brentwood Dr, Village of Lansing, NY 14850: Human Health Services District
- Cayuga Medical Convenient Care, 10 Arrowwood Dr, Village of Lansing, NY 14850: Human Health Services District
- Parkview Healthcare Campus, 15 Thornwood Drive Ithaca, NY 14850: Business and Technology District
- TST BOCES, 555 Warren Rd, Town of Ithaca, NY 14850: Medium Density Residential

- De Witt Middle School, 560 Warren Rd, Town of Ithaca, NY 14850: MDR Medium Density Residential

Additional microgrid customers may be identified in the Cornell Business Park in Stage 2, and are likely to also fall into the Business and Technology District.

Generation as Permitted Use

All microgrid customers except BOCES and De Witt Middle School are located in the Village of Lansing. For purposes of analyzing permitted uses in the village of Lansing, analysis of customers in Business/Technology zones and Human Health Services Zones will be identical. Therefore, these Lansing customers will all be considered under one heading below. Both BOCES and De Witt Middle School are located in the Town of Ithaca, in the same Medium Density Residential Zone. They will be considered separately.

Lansing Customers

Electric generation is not expressly listed as a permitted or special permit use in any district in the Village of Lansing, and the Lansing Code is clear that "All uses not specifically set forth in this section or in the Chart of Uses … or described as typical uses in categories in § 145-82 are expressly prohibited."[36] Generation must be sited pursuant to some other permitted or special permit use, or as a variance.

Permitted Uses: "Utility service underground" is expressly permitted in the relevant Lansing zones. §145-82 illustrates the type of uses qualifying under this category as "Electric; communications; and gas, sewer and water lines providing essential services to normal land use activities."[37] While this permitted use is unlikely to stretch to encompass generation, it will permit the undergrounding of wire anticipated throughout node 1 of the project. "Utility" is not defined anywhere in the Lansing Code, so it may be open to interpretation whether such underground wire must be installed by NYSEG, or whether it may be installed by a private entity providing the same service.

Accessory Use: Unlike in most jurisdictions, "accessory uses" are not defined or included anywhere in the Lansing Code, and §145-38, quoted above, makes clear that accessory uses are not meant to be inferred into the Code. They will not apply to this discussion.

Special Permit Uses: "Utility transmission/storage/plants" is a specially permitted use in the relevant Lansing zones. §145-82 illustrates the type of uses qualifying under this category as "Electric; communications; gas, sewer and water transmission lines; and service including stations, substations, treatment plants, pumping stations and storage tanks."[38] "Stations" are not defined in the Code, and an argument could be made to interpret generating stations under this definition. Again, the Code is unclear whether any facilities installed under this use owned by NYSEG, or whether it may be owned by a private entity providing the same service.

If NYSEG or a private party wished to secure a special permit, it may file an application with the Village Clerk, whereupon a public hearing will be held within 62 days. The Planning Board will issue

[36] Village of Lansing Zoning Code §145-38.

[37] Village of Lansing Zoning Code §145-82.

[38] Village of Lansing Zoning Code §145-82.

a recommendation within another 32 days from the date of the hearing. The Village Board of Trustees will review the application against its stated requirements.[39] The Village Board of Trustees must issue a decision on the permit within 62 days of the hearing, complete with any permit conditions it deems fit.[40]

Variances: The Zoning Board of Appeals is empowered to hear applications for variances from the use restrictions of the Zoning Code.

Code specifies that each variance applicant should meet four criteria:

(a) The applicant cannot realize a reasonable return, provided that lack of return is substantial as demonstrated by competent financial evidence;
(b) That the alleged hardship relating to the property in question is unique and does not apply to a substantial portion of the district or neighborhood;
(c) That the requested variance, if granted, will not alter the essential character of the neighborhood; and
(d) That the alleged hardship has not been self-created.[41]

These provisions are consistent with New York State precedent,[42] as well as State law incorporating that precedent. These requirements are unlikely to be satisfied for microgrid facilities, which may add value to the properties in question, but are not indispensable to the value of the properties in general.

Town of Ithaca Customers

Electric generation, generally, is not expressly listed as a permitted or special permit use in Medium Density Residential zones in the Town of Ithaca, and the Ithaca Code is clear that "All uses not

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[39] The Village Board must determine of the specially permitted use that "(1) It will not be detrimental to or endanger the public health, safety or general welfare. (2) It will not be injurious to the use and enjoyment of other property in the vicinity or neighborhood. (3) It will not impede the orderly development of the vicinity or neighborhood and is appropriate in appearance and in harmony with the existing or intended character of the vicinity or neighborhood. (4) The street system and off-street parking facilities can handle the expected traffic in a safe and efficient manner. (5) Natural surface water drainageways are not adversely affected. (6) Water and sewerage or waste disposal facilities are adequate. (7) The general environmental quality of the proposal, in terms of site planning, architectural design and landscaping, is compatible with the character of the neighborhood. (8) Lot area, access, parking and loading facilities are sufficient for the proposed use. (9) The requested use or facility conforms in all other respects to the applicable regulations of the district in which it is located. (10) The applicant has shown that steps will be taken where necessary to meet all performance standards and all other applicable general regulations." Village of Lansing Zoning Code §145-59.

[40] Village of Lansing Zoning Code §145-59.

[41] Village of Lansing Zoning Code §145-74.

[42] *See* Otto v. Steinhilber, 282 N.Y. 71 (1939). In that case, the owner of a parcel of property which was located in both a residential and commercial zone applied for a variance enabling him to use the entire parcel for a skating rink, which was a permitted commercial use. The lower court upheld the granting of the use variance, which ruling was affirmed by the Appellate Division. The Court of Appeals, the highest court in the State, reversed these holdings and in doing so, set forth the definitive rules that are still followed today.

specifically set forth as permitted uses in a zone are expressly prohibited as uses in that zone."[43] Solar generation, however, is expressly permitted in all zones,[44] and small wind generation is similarly permitted subject to certain siting restrictions (although small wind generation is not currently proposed here).[45] Non-solar or wind generation must be sited pursuant to some other permitted use, or as a variance.

Permitted Uses: Medium Density Residential zones permit "Any municipal or public utility purpose necessary to the maintenance of utility services except that substations and similar structures shall be subject to the same setback requirements as apply to residences in the district in which the substations or similar structures are constructed."[46] This permission may be interpreted widely enough to incorporate generation. This permission would appear to permit uses by the Town of Ithaca or NYSEG exclusively, including the electrical generation and distribution. While it does not expressly prohibit a private entity from operating the same facilities, the qualifier "public" would seem to limit those intended to apply to utility companies serving the general public, like NYSEG.

Accessory Use: "Accessory uses" are not defined in the Lansing Code, and while some specific zones make express mention of specific permitted accessory uses, none are included in Medium Density Residential Zones. §270-9, quoted above, makes clear that accessory uses are not meant to be inferred into sections of the Code they are not mentioned in. They will not apply to this discussion.

Special Permit Uses: No relevant special permit uses apply to Medium Density Residential Districts.

Variances: Following formal application, public hearing and review processes, the Zoning Board of Appeals is authorized to grant use variances for projects that do not violate any of the following conditions:

(a) Whether an undesirable change will be produced in the character of the neighborhood or a detriment to nearby properties will be created by the granting of the variance;
(b) Whether the benefit sought by the applicant can be achieved by some method, feasible for the applicant to pursue, other than a variance;
(c) Whether the requested variance is substantial;
(d) Whether the proposed variance will have an adverse effect or impact on the physical or environmental conditions in the neighborhood or district; and
(e) Whether the alleged difficulty was self-created, which consideration shall be relevant to the decision of the Board of Appeals but shall not necessarily preclude the granting of the variance.[47]

This comparatively relaxed standard for granting use variances may be more permissive than that adopted in the Village of Lansing. Notably, it does not require the applicant show that it cannot make economic use of its property without the variance. If the permitted uses available in the Town of Ithaca do not suffice for the purposes of the project team, seeking a variance may be a viable option to site DERs.

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[43] Town of Ithaca Zoning Code §270-9.
[44] Town of Ithaca Code §270-219.1.
[45] Town of Ithaca Code §270-219.4
[46] Town of Ithaca Code §270-66.
[47] Town of Ithaca Code §173-18.

Zoning Solutions in both Lansing and Ithaca: For zones in which electric generation is not permitted, or is not permitted under conditions amenable to the project's needs, some simple zoning reform may help. If electric generation for were added as a specially permitted use in the relevant districts, it would create a regulatory path forward while allowing the Zoning Board of Appeals to maintain some essential controls over the character and uses of affected neighborhoods. Some relevant considerations for policymakers and model language have been attached in Appendix C.

2. Fire Code

Ithaca has adopted the New York State Uniform Fire Prevention and Building Code, with no substantive additions that would pertain to distributed generation or distribution.[48] The same can be said of the Village of Lansing.[49]

3. Building Code

The Town of Ithaca has adopted the New York State Uniform Fire Prevention and Building Code, with no substantive additions that would pertain to distributed generation or distribution.[50] The same can be said of the Village of Lansing.[51]

4. Electric Code

The Village of Lansing has adopted the National Electric Code and "any applicable New York State law or code" without any substantive additions that would affect distributed generation or distribution.[52] The Town of Ithaca has not adopted an electric code.

III. Applicable Tariffs

Distributed generation may be eligible for new tariffs for each of the customers at which DG is sited. This section outlines the various tariff structures one or several customers within the microgrid may fall under. This section builds on the discussion in Section I(2), which discussed tariffs under which power could be exported onto the utility grid, including net metering, buyback, offset, and potential future microgrid regimes.

1. Standby Tariff

Customers operating private generating facilities to cover part of their load while receiving backup or supplementary power from the utility will be subject to NYSEG's standby tariff[53] unless they are otherwise exempt.[54] Under current standby rate design, NYSEG recovers the cost of supplying

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[48] Town of Ithaca Code §125-1.
[49] Village of Lansing Code §75-2.
[50] Town of Ithaca Code §125-1.
[51] Village of Lansing Code §75-2.
[52] Village of Lansing Code §62.
[53] Located at http://www.nyseg.com/MediaLibrary/2/5/Content%20Management/NYSEG/SuppliersPartners/PDFs%20and%20Docs/PSC120ServiceClassification_11.pdf.
[54] In April 2015, the Commission expanded exemptions to standby rates, notably by permitting exemption for CHP system up to 15 MW. Exemptions also apply to fuel cells, wind, solar thermal, photovoltaic, biomass, tidal,

supplemental power through three distinct charges: customer charges, contract demand charges, and daily as used demand charges. The customer charge is designed to recover certain fixed costs, such as metering expenses and administrative costs that do not vary with energy use. The customer charge shows up on the customer's bill as a fixed monthly charge.

The standby contract demand charge is intended to recover variable costs associated with distribution infrastructure dedicated to the customer (e.g. nearby infrastructure that only serves the single customer). The contract demand charge is based on the customer's maximum metered demand during some previous 12 month period of time. The charge is levied regardless of whether the customer's actual maximum peak demand approaches the level at which the charge is set.

The actual level at which the contract demand charge is set can be established by the customer or NYSEG. If the customer opts to set their own contract demand charge, penalties can be levied if the charge is exceeded, while a charge set by the utility is not subject to penalties. Exceedance penalties will result in a surcharge equal to between 12 to 24 times (depending on the level of exceedance) the sum of the monthly demand charges for the demand in excess of the contract demand.

The daily as-used demand charge is designed to recover the costs of distribution infrastructure needed to meet the entire system's demand peaks. Therefore, the charge is assessed based upon the customer's daily maximum metered demand during peak-hour periods on the macrosystem.

Standby rates are under reexamination as part of the REV proceeding. Staff has noted that "the methodology for allocating costs that determine the contract demand and as-used demand components of standby rates should be reviewed in this new [REV] context."[55] The manner in which these rates change cannot be forecast at this time.

2. Community Net Metering

In July 2015, the Public Service Commission established a community net metering regime[56] that is currently pending implementation through tariff revisions in NYSEG's territory. Qualifying generation assets include those that would be eligible under net metering (See Section I(2)(A) above). Under community net metering, a project sponsor could size eligible generators far beyond the demand of a host utility account and distribute retail-value net metering credit to a set of "subscribing" customers in the same utility service territory. This may be a substantial value-added to the rate paid on qualifying generation assets for power exported to the utility.

Note that the Commission's Order required at least 10 subscribing customers in a qualifying community net metering project, which threshold is currently met by the project's proposed microgrid customers.

3. Residential/Non-Residential DG Gas Rate

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geothermal, and methane waste-powered generation. See Case 14-E-0488, "Order continuing and Expanding the Standby Rate Exemption," (Apr. 20, 215).

[55] Case 14-M-0101, "Staff Whitepaper on Ratemaking and Utility Business Models," (July 28, 2015).

[56] Case 15-E-0082, "Order Establishing a Community Distributed Generation Program and Making Other Findings," (July 17, 2015).

A distributed generation rate is established in NYSEG's territory, applying to DG "designed to provide electricity to a single customer or specific customers within a defined geographical location with generating capacity of less than 50 Megawatts (MW) that maintains a load factor of 50% or more."[57] This rate may be economically advantageous for CHP components of the microgrid, although customers should compare costs against a Transportation Rate or the price offered by a third-party gas marketer, as these may also propose a cost-effective solution.

1.1 Cost of Gas Service Upgrades

Microgrids that incorporate new natural gas-fired generators or CHP systems may require the delivery of substantially more natural gas to the site than was previously provided by the utility. If the additional natural gas demand exceeds the current infrastructure's capacity, the relevant natural gas mains, service piping and related facilities will need to be upgraded for the project to succeed. The requirements of utilities and gas upgrade applicants regarding gas service upgrades are governed by 16 NYCRR §230. Prior to any upgrades, the applicant must sign an agreement to assure the NYSEG that he/she will be a reasonably permanent customer, pay the utility for any installation and materials costs beyond the costs the utility is required to bear, and pay a rate for future gas delivery charged to similarly situated customers.[58] Section §230.2 outlines the "100 foot rule," which requires gas utilities to install up to 100 feet of main and service line extensions and related facilities at no cost to the applicants.[59] Utilities can bear the cost of extensions and additional facilities beyond 100 feet if the utility deems the expansion to be cost justified.[60] This situation, however, is relatively rare, and utilities will often require the applicant to pay for any installation and material costs beyond 100 feet.

Distributed generation that is designed to receive gas at high inlet pressures may be more economical in cases where it can receive gas service directly from the utility company's high pressure transmission lines, rather than the comparatively lower pressure distribution lines that service most customers.[61] This might save a customer-generator the cost of buying and maintaining gas compressors that raise the gas pressure to appropriate inlet levels. In such a case, the customer must typically apply to the utility company for a dedicated service line at high pressure connecting to the transmission line, which would be built and paid for under the same set of rules the govern gas service upgrades, described above.

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[57] *See* NYSEG Gas Tariff Service Classification 10.

[58] 16 NYCRR § 230.2(b).

[59] 16 NYCRR § 230.2 (c), (d), and (e).

[60] 16 NYCRR § 230.2 (f). Methods for determining cost-justified upgrades are set forth in each utility's tariff. For example, Con Edison analyzes whether the projected net revenue derived from the potential customer will cover the cost to install the service line beyond the 100 ft. maximum. If so, Con Edison will provide line upgrades beyond 100 feet at no cost to the customer.

[61] Different types of natural-gas powered DG may or may not require higher pressure gas service. E.g., small scale reciprocating engines do not require high pressure gas lines to operate. A sub 500kwe unit may require 0.3(min)-0.8(max) PSIG input pressure. Small scale microturbines may require higher gas input pressure of about 75-80PSIG.

IV. Relevant Considerations for Revising Zoning Codes to Establish a Special Permit for Microgrid Distributed Generation

A common barrier for microgrid development are zoning codes which are silent on siting distributed generation as either a permitted use, an accessory use, or a special permit use. While in many jurisdictions, on-site generation has been deemed an accessory use where it is used for back-up, particularly for critical infrastructure such as hospitals and municipal services, there is typically greater regulatory uncertainty where distributed generation is planned at a scale to provide significant export to other customers, as in a microgrid. Clarifying the type, size, and review process to site distributed generation through the zoning code may greatly expand opportunities for microgrid development.

Policymakers will be concerned to adjust zoning codes broadly enough to permit microgrids of appropriate technical configurations, and narrowly enough to preserve the essential character of the districts in question. To balance these concerns, we recommend:

1. The definition of a microgrid be incorporated into the definitions section of the zoning code. This will allow the code to later limit the circumstances in which an applicant can site distributed generation substantially larger than their on-site load to circumstances where that power will support other local customers.
2. Permitted microgrid generation technologies should be incorporated into the definitions section of the zoning code, and fashioned broadly enough to support appropriate technical configurations. For example, the code should explicitly permit natural gas fired combined heat and power systems, but may wish to restrict diesel generation.
3. The siting of qualified microgrid generation should be added as a specially permitted use to each of the districts in question, subject to a comparable review by the Zoning Board of Appeals as other specially permitted uses. The standard for permitting microgrid generation by the Zoning Board of Appeals should be more lenient than granting a variance. For example, the granting of a special permit for microgrid generation may be contingent on a showing that the generation will:
    a. Be sited on a lot of a certain size and not occupy over a certain percentage of the square footage of that lot. For certain technologies, such as solar, the code may place other appropriate restrictions on siting, explored further below.
    b. Be designed, enclosed, painted or colored and screened so that it is harmonious with the area in which it is located.
    c. Be landscaped and maintained in conformity with the standards of property maintenance of the area.
    d. Be surrounded by protective fencing and gates.
    e. Comply with appropriate limitations on capacity, noise, or emissions for the district in which sited.

    The special permit process should not, however, require a showing of economic hardship in the absence of the permit, as is typically required for a variance.

It is beyond the scope of this feasibility study to prescribe exactly how policymakers may wish to restrict the siting of microgrid generation in their zoning codes in each district. We offer model language addressing several of the points identified above from other jurisdictions for consideration.

Defining Microgrids

New York State has adopted the US Department of Energy's definition of microgrids, which is "A group of interconnected loads and distributed energy resources within clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid and that connects and disconnects from such grid to enable it to operate in both grid-connected or island mode."

We recommend this definition be applied in the zoning context.

Defining Permitted Microgrid Generation Technologies

Zoning codes should at least permit the breadth of technologies identified, e.g., in the definition of "Renewable Energy Systems" from the Portland, Oregon zoning code,[62] although we recommend a broader scope of permitted generation, including all CHP systems, and diesel generation designed to run solely in back-up scenarios. While Portland's code specifies maximum sizes of certain types of generation, we recommend that such restrictions be determined on a district-by-district basis. A hospital with a 5 MW load, e.g., may be a more appropriate site for a large CHP generator than a residential area, where smaller renewables may play a role.

Portland's definition of "Renewable Energy System" follows:

> **Renewable Energy System**. Energy production where the energy is derived from the following:
>
> 1. Solar;
> 2. Small wind energy turbines;
> 3. Geothermal;
> 4. Hydroelectric systems that produce up to 100 kW;
> 5. Waste heat capture, heat exchange or co-generation of energy as a byproduct of another manufacturing process;
> 6. The following systems that use only biological material or byproducts produced, harvested or collected on-site. Up to 10 tons a week of biological material or byproducts from other sites may be used where the base zone regulations specifically allow it:
>
> - Biogas. Generation of energy by breaking down biological material in anaerobic conditions to produce gas that can be used to generate electricity or heat. The process generally occurs inside a closed system such as a tank or container.
> - Biomass. Generation of energy through the combustion of biological material to produce heat, steam, or electricity.

[62] Portland Oregon Code section 33.910, available at https://www.portlandoregon.gov/bps/article/53500.

7. Any of the methods listed here or natural gas used to produce steam, heat or cooling, with an output up to 1 megawatt.

Special Permitting Restrictions on Siting

Different sizes and types of microgrid generation may be subject to different restrictions on where and how they can be sited. Butte County, California, for example, has developed a tiered set of siting restrictions for solar installations of different sizes and types. A similar exercise may be helpful for other types of generation.[63]

Developing sophisticated restrictions tailored to each type of generation and each district in which it may be sited may be time-intensive and unnecessarily delay projects, however. We recommend it as a long-term regulatory goal. In the short term, many microgrids may benefit from simply being permitted to site generation within existing facilities in such a way that they will not be noticeable to the public. As an immediate measure, we recommend the zoning code permit generation that can be entirely contained within existing buildings and structures on the property.

Butte County's Solar Zoning Ordinance follows:

> **Tier 1.** A roof-mounted Solar Electric System used to power on-site primary or accessory uses located on structures or placed over parking lots or a ground mounted Solar Electric System up to one-half acre in size. Tier 1 includes building-integrated photovoltaic systems where the Solar Electric System is part of the building materials used in the construction of on-site primary or accessory structures.
>
> **Tier 2.** A ground-mounted Solar Electric System used to power on-site primary or accessory uses, limited to less than 15 percent of the parcel's size up to 5-acres, whichever is less, with less than 50 percent of the power generated being used off-site.
>
> **Tier 3.** A ground-mounted Solar Energy System, limited in Agriculture zones to "Grazing Land" and "Other Land" as defined under the latest mapping under the California Department of Conservation Division of Land Resource Protection Farmland Mapping and Monitoring Program, not subject to a Williamson Act Contract, and limited to less than 30 percent of a parcel's size up to 20 acres maximum with 50 percent or more of the power generated for on-site primary and accessory uses, with the remainder of the power delivered off-site.

[63] Butte County Zoning Code, Chapter 24-157, available at https://www.buttecounty.net/Portals/10/Docs/Zoning/ButteZoningOrdinance2015-06.pdf.

Tier 4. A ground-mounted Solar Energy System limited in Agriculture zones to "Grazing Land" and "Other Land" as defined under the latest mapping under the California Department of Conservation Division of Land Resource Protection Farmland Mapping and Monitoring Program, and not subject to a Williamson Act Contract, where most or all power generated is delivered off-site with little or no on-site use.

APPENDIX D: IEC BENEFIT-COST ANALYSIS

Site 67 – Village of Lansing (Tompkins County)

PROJECT OVERVIEW

As part of NYSERDA's NY Prize community microgrid competition, Tompkins County has proposed development of a microgrid serving numerous facilities in and around the Village of Lansing. The microgrid would focus on maintaining service at Ithaca-Tompkins Regional Airport. The airport is served by three airlines and provides a national and international connection for travelers accessing Cornell University, Ithaca College, and private companies in the Ithaca region.[64] Table 1 summarizes specific commercial and industrial facilities that the proposed microgrid would serve. As shown, the facilities include a variety of airport operations (terminal, hangars, etc.); public health and safety facilities; educational facilities; government offices; college and private research laboratories; shipping and delivery services; financial service firms; semiconductor and pharmaceutical manufacturing facilities; a software developer; a medical campus that includes outpatient services and emergency treatment facilities; and a hotel.

The microgrid would combine gas-fired generators, combined heat and power (CHP) systems, and solar capabilities to provide base load power. The system would be centered around a 0.8 MW generator fueled by an anaerobic digester that recovers gas from dairy cattle manure and food waste decomposition. This distributed energy resource (DER) would supply roughly half of the microgrid's power under normal operating conditions. Three photovoltaic (PV) arrays with a total nameplate capacity of 2.35 MW would contribute substantially to the system's output. Two natural gas-fired CHP units with a combined capacity of 0.41 MW would supply additional base load power. A set of seven existing diesel generators would complement the microgrid. Two of these generators would be used under normal operating conditions, while the remaining five would supplement production only during major power outages. In addition, a battery storage system and energy efficiency measures would be incorporated into the microgrid.

METHODOLOGY AND ASSUMPTIONS

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

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

Table 1. Facilities Served by Proposed Microgrid

[64] http://flyithaca.com/about/, accessed on March 27, 2016.

Facility Name	Facility Description
Public Safety Building	Public safety services, including police
Cornell University – Langmuir Labs	University laboratory
Health Department	Public health services
Marriott (Courtyard) - Ithaca	Hotel
United States Geological Survey	Federal agency office
Advion	Private pharmaceutical laboratory
Ongweoweh Corp.	Pallet management and secondary packaging services
NY Drug Testing	Public correctional drug testing facility
US Postal Service	Federal Postal Service office
FedEx	Private shipping office
Taughannock Aviation	Private business aviation services
ATC-NY	Computer systems architecture and security
Nielsen Claritas	Marketing strategy and analytics services
Bigwood Systems	Utility software engineering
Quintiles	Pharmaceutical developer
Cayuga Venture/Integrated Property Systems	Venture capital fund
Rheonix	Pharmaceutical laboratory
Kionix	Inertial sensor manufacturer
Cayuga Medical Campus	Medical services (outpatient and emergency care)
Bin Optics	Photonic semiconductor manufacturer
Crash Fire & Rescue	Emergency services at airport
Emergency Response Center	Emergency services (Tompkins County)
Airport Terminal	Public airport service building
Old IHA Hangar	Aviation hangar
Sand Storage Building	Airport facilities
T Hangar I	Aviation hangar
T Hangar II	Aviation hangar
TST BOCES	Cooperative education services
DeWitt Middle School	Public middle school

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.[65] 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.[66]

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

[66] 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

RESULTS

Table 2 summarizes the estimated net benefits, benefit-cost ratios, and internal rates of return for the scenarios described above. The results suggest that if no major power outages occur over the microgrid's assumed 20-year operating life, the project's costs would exceed its benefits. In order for the project's benefits to outweigh its costs, the average duration of major outages would need to exceed approximately 0.33 days per year (Scenario 2). The discussion that follows provides additional detail on the findings for these two scenarios.

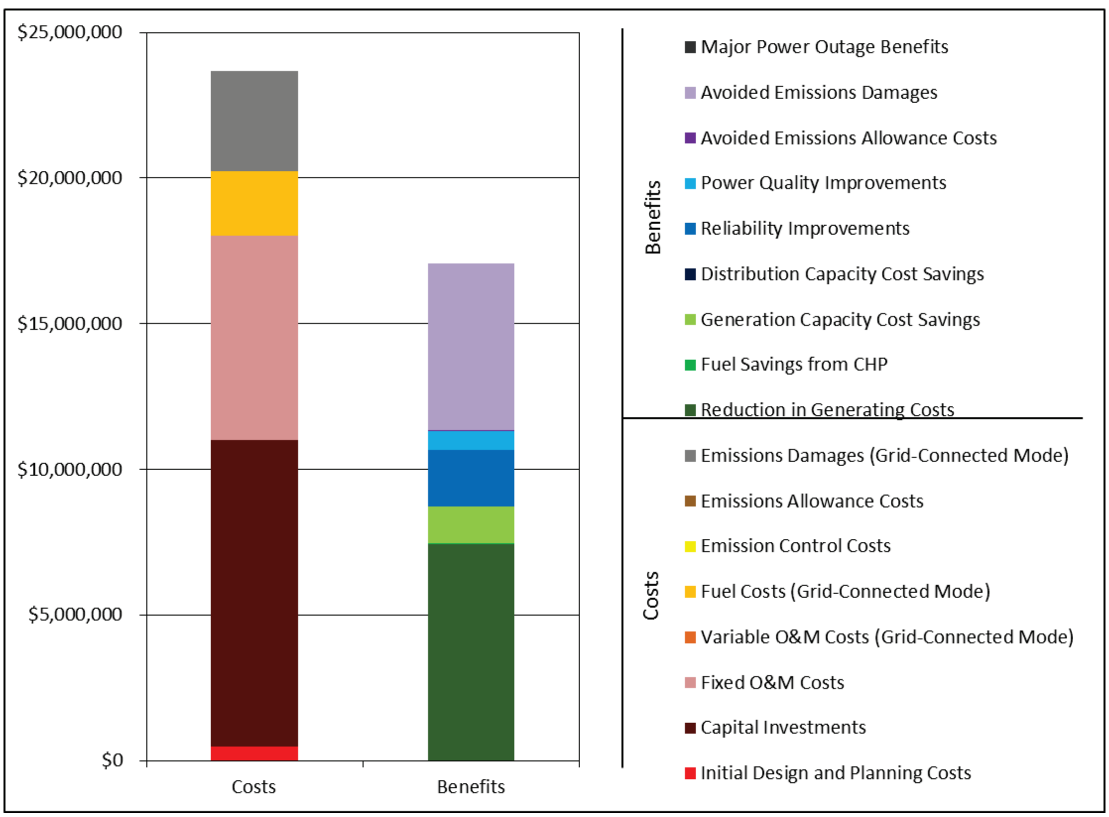
Table 2. BCA Results (Assuming 7 Percent Discount Rate)

ECONOMIC MEASURE	ASSUMED AVERAGE DURATION OF MAJOR POWER OUTAGES	
	SCENARIO 1: 0 DAYS/YEAR	SCENARIO 2: 0.33 DAYS/YEAR
Net Benefits - Present Value	-$6,700,000	$84,600
Benefit-Cost Ratio	0.7	1.0
Internal Rate of Return	-2.9%	6.3%

Scenario 1

Figure 1 and Table 3 present the detailed results of the Scenario 1 analysis.

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



beyond a utility's control as "major power outages," and evaluates the benefits of avoiding such outages separately.

Table 3. 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	$475,000	$41,900
Capital Investments	$10,500,000	$848,000
Fixed O&M	$7,030,000	$621,000
Variable O&M (Grid-Connected Mode)	$0	$0
Fuel (Grid-Connected Mode)	$2,200,000	$194,000
Emission Control	$0	$0
Emissions Allowances	$0	$0
Emissions Damages (Grid-Connected Mode)	$3,380,000	$221,000
Total Costs	**$23,700,000**	
Benefits		
Reduction in Generating Costs	$7,360,000	$650,000
Fuel Savings from CHP	$36,300	$3,200
Generation Capacity Cost Savings	$1,260,000	$111,000
Distribution Capacity Cost Savings	$0	$0
Reliability Improvements	$1,930,000	$170,000
Power Quality Improvements	$662,000	$58,400
Avoided Emissions Allowance Costs	$3,800	$335
Avoided Emissions Damages	$5,670,000	$370,000
Major Power Outage Benefits	$0	$0
Total Benefits	**$16,900,000**	
Net Benefits	**-$6,700,000**	
Benefit/Cost Ratio	**0.7**	
Internal Rate of Return	**-2.9%**	

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 $475,000.[67] The present value of the project's capital costs is estimated at approximately $10.5 million. Significant investments include the cost of the PV arrays (about $5.6 million) and grid improvements (about $2.2 million). Other significant capital expenditures are required for the CHP units, as well as for the controllers and software needed to manage the microgrid.

[67] The project's consultants note that this estimate is based on the costs of developing the power purchase agreement (PPA), negotiating other contracts, and arranging financing and insurance. It represents an average cost estimate; the actual costs ultimately incurred may be higher or lower, depending on the complexity of the site.

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 $7.0 million, or about $621,000 annually. About three-quarters of these costs relate to the anaerobic digester and the associated generator unit. The team's consultants plan to establish a power purchase agreement (PPA) with a third party supplying the AD system. Under the agreement, the microgrid operators would pay the third party $0.09 per kWh produced from the system. The consultants indicate that these payments are tailored to cover the capital cost of the AD system over the anticipated 25-year project life; hence, the payments provide a rough proxy for the capital cost of the system.

Variable Costs

One variable cost associated with the proposed project is the cost of fuel, primarily natural gas, for the CHP units and other conventional power generators. 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.[68] The present value of the project's fuel costs over a 20-year operating period is estimated to be approximately $2.2 million.

In addition, the analysis of variable costs considers the environmental damages associated with pollutant emissions from the distributed energy resources that serve the microgrid, based on the operating scenario and emissions rates provided by the project team and the understanding that none of the system's generators would be subject to emissions allowance requirements. In this case, the damages attributable to emissions from the microgrid's fuel-based generators are estimated at approximately $221,000 annually. These damages are primarily attributable to the emission of CO_2. Over a 20-year operating period, the present value of emissions damages is estimated at approximately $3.4 million.

Avoided Costs

The development and operation of a microgrid may avoid or reduce a number of costs that otherwise would be incurred. These include generating cost savings resulting from a reduction in demand for electricity from bulk energy suppliers. The BCA estimates the present value of these savings over a 20-year operating period to be approximately $7.4 million. This estimate takes into account the electricity that the microgrid's CHP units and PV arrays would produce, as well as an anticipated reduction in annual electricity use at the facilities the microgrid would serve.[69] The new CHP units would also conserve fuel, providing additional savings relative to current heating systems. The BCA estimates the present value of fuel savings over the 20-year operating period to be approximately $36,000. These reductions in demand for electricity from bulk energy suppliers and heating fuel would also cut emissions of CO_2, SO_2, NO_x, and particulate matter, yielding avoided emission allowance costs with a present value of $3,800 and avoided emissions damages with a present value of approximately $5.7 million.[70]

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[68] 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.

[69] The project's consultants anticipate an annual reduction in electricity consumption of approximately four percent due to energy efficiency upgrades included with the microgrid.

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

In addition to the savings noted above, development of a microgrid could yield cost savings by avoiding or deferring the need to invest in expansion of the conventional grid's energy generation or distribution capacity.[71] The analysis estimates the impact on available generating capacity to be approximately 1.3 MW per year. In addition, the project team expects development of the microgrid to reduce the conventional grid's demand for generating capacity by an additional 0.155 MW as a result of new demand response capabilities. Based on these figures, the BCA estimates the present value of the project's generating capacity benefits to be approximately $1.3 million over a 20-year operating period.

The project team has indicated that the proposed microgrid would be designed to provide ancillary services to the New York Independent System Operator (NYISO) in the form of reactive power support, black start capability, and frequency or real power support. 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 such 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 $170,000 per year, with a present value of $1.9 million over a 20-year operating period. This estimate is calculated 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:[72]

- System Average Interruption Frequency Index (SAIFI) – 1.03 events per year.
- Customer Average Interruption Duration Index (CAIDI) – 118.2 minutes.[73]

The estimate takes into account the number of small and large commercial or industrial customers the project would serve; the distribution of these customers by economic sector; average annual electricity usage per customer, as provided by the project team; and the prevalence of backup generation among these customers. It also takes into account the variable costs of operating existing backup generators, both in the baseline and as an integrated component of a microgrid. Under baseline conditions, the analysis assumes a 15 percent failure rate for backup generators.[74] It assumes that establishment of a microgrid would reduce the rate of failure to near zero.

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.

[71] 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.

[72] www.icecalculator.com.

[73] SAIFI and CAIDI values were provided by the project team for New York State Electric & Gas.

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

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

Power Quality Benefits

The power quality benefits of a microgrid may include reductions in the frequency of voltage sags and swells or reductions in the frequency of momentary outages (i.e., outages of less than five minutes, which are not captured in the reliability indices described above). The analysis of power quality benefits relies on the project team's best estimate of the number of power quality events that development of the microgrid would avoid each year. The Tompkins County team estimates that the microgrid would help the facilities it serves avoid an average of 1.9 power quality events per year. The model estimates the present value of this benefit to be approximately $662,000 over a 20-year operating period.

Summary

The analysis of Scenario 1 yields a benefit/cost ratio of 0.7; i.e., the estimate of project benefits is about 70 percent of project costs. Accordingly, the analysis moves to Scenario 2, taking into account the potential benefits of a microgrid in mitigating the impact of major power outages.

Scenario 2

Benefits in the Event of a Major Power Outage

The estimate of reliability benefits presented in Scenario 1 does not include the benefits of maintaining service during outages caused by major storm events or other factors generally considered beyond the control of the local utility. These types of outages can affect a broad area and may require an extended period of time to rectify. To estimate the benefits of a microgrid in the event of such outages, the BCA methodology is designed to assess the impact of a total loss of power – including plausible assumptions about the failure of backup generation – on the facilities the microgrid would serve. It calculates the economic damages that development of a microgrid would avoid based on (1) the incremental cost of potential emergency measures that would be required in the event of a prolonged outage, and (2) the value of the services that would be lost.[75,76]

The proposed microgrid project would serve 31 facilities during an extended outage. In the BCA model, several factors influence the costs that facilities would incur during an outage, including the following:

- Whether or not backup generation currently exists at the facility;
- Whether the facility would rent a backup generator to supply power during an outage;
- The ability of the facility to operate when using backup power;

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

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

- The ability of the facility to operate during a complete loss of power;
- The cost of operating existing or rental generators;
- The extent to which the facility incurs costs for emergency measures (e.g., evacuation of patients or staff); and
- The economic value of the services that the facility would cease to provide during an outage.

Table 4 summarizes these parameters for six sets of facilities:

- **Emergency Shelters**: The project consultants indicate that the educational facilities would be used as places of refuge in the event of a major outage. Considered together, the facilities are capable of providing shelter for 3,568 individuals. The total value of services per day is based on the capacity of the shelter facilities multiplied by the American Red Cross estimate of the cost of providing overnight shelter ($50/person/day). Both schools are equipped with backup generators.
- **Airport Facilities**: This facility group includes several buildings at Ithaca-Tompkins Regional Airport. The project consultants suggest that daily revenue losses would total roughly $10,000 per day.[77] These costs would be incurred even with backup generation, since air traffic control systems cannot be operated on backup power.
- **Other Commercial Facilities with Backup Power**: The Tompkins County Health Department is equipped with a backup generator and is capable of operating at full capacity while on backup power.
- **Commercial Facilities with High Service Losses**: This subset of commercial facilities has no existing backup capabilities and, because of the nature of their operations (primarily medical and manufacturing), would have difficulty maintaining service during a power outage. The collective value of service, as estimated by the ICE Calculator, is high (about $1.0 million per day), reflecting extensive power usage and the fact that four of the six facilities engage in manufacturing. Most of the facilities would rent backup generators to maintain a portion of their operations. Additional costs that would occur as a result of a complete loss of power include transporting patients from the medical facility to local hospitals and the cost of canceling and rescheduling appointments.
- **Commercial Facilities with Moderate Service Losses**: Another subset of commercial facilities has no backup generation capability, but would rent generators and be somewhat more capable of continuing operations while on backup power. Specifically, these facilities would maintain roughly half of their services while on backup power. The cost to deliver, set up, and run rental generators is relatively high, and additional costs in the event of a complete power loss include closing the hotel. The overall value of service for these facilities is based on ICE Calculator estimates.
- **Emergency Response Services**: A final set of facilities includes the Emergency Response Center (EMS service); the Crash, Fire and Rescue facility (which provides fire and rescue service at the airport and in the surrounding community); and the Public Safety Building (which houses

[77] Revenue losses likely overstate the economic value of airport services; therefore, the analysis may overstate major power outage benefits.

the police department). All have backup generators and would maintain full service in the event of an outage. The analysis calculates the impact of an outage on these facilities using standard FEMA methodologies.[78]

In all cases, backup generators are assumed to run 24 hours per day, and each has a 15 percent chance of failing.

Based on the estimated value of service as well as the backup power capabilities and operational features of the facilities, the analysis estimates that in the absence of a microgrid, the average cost of an outage is approximately $1.7 million per day.

[78] The Cayuga Medical Center also provides emergency medical care services, separate from its outpatient services. The analysis values the emergency care function by treating the Medical Center as a hospital and applying standard FEMA valuation estimates. The analysis assumes that emergency room care is available to all the residents of Tompkins County (as with fire and police).

Table 4. Summary of Major Power Outage Parameters, Scenario 2

CATEGORY	FACILITIES INCLUDED	VALUE OF SERVICE		PERCENT LOSS IN SERVICE CAPABILITIES DURING AN OUTAGE		GENERATOR COSTS		OTHER EMERGENCY COSTS	
		VALUE PER DAY	BASIS	WITH BACKUP POWER	WITHOUT BACKUP POWER	ONE-TIME	DAILY	ONE-TIME	DAILY
Emergency Shelters	TST BOCES; DeWitt Middle School	$178,400	Red Cross	2%	100%	$0	$376	$0	$0
Airport Facilities	Old IHA Hangar, Sand Storage Bldg., Airport Terminal, and T Hangars I & II	$10,000	Revenue loss (from applicant)	50%	100%	$0	$390	$0	$0
Commercial Facilities with Existing Backup Generators	Health Department	$53,880	ICE	0%	100%	$0	$63	$0	$0
Commercial Facilities without Existing Backup and High Service Loss	Cayuga Medical Center, Rheonix, Advion, Bin Optics, Kionix, Quintiles	$1,013,577	ICE	86%	93%	$8,300	$26,743	$87,450	$12,000
Commercial Facilities without Existing Backup and Medium Service Loss	ATC-NY, Bigwood Systems, Cornell Langmuir Labs, FedEx, Marriott Courtyard, Nielsen Claritas, NY Drug Testing, Ongweoweh Corp. Taughannock Aviation, USPS, USGS, Cayuga Venture	$736,385	ICE	50%	98%	$39,300	$11,609	$500	$10,000
Emergency Services	Emergency Response Center, Crash Fire & Rescue, Public Safety	FEMA methodologies		0%	Various	$0	$402	$0	$0

Summary

Figure 2 and Table 5 present the results of the BCA for Scenario 2. The results indicate that the benefits of the proposed project would equal or exceed its costs if the project enabled the facilities it would serve to avoid an average of 0.33 days per year without power. If the average annual duration of the outages the microgrid prevents is less than this figure, its costs are projected to exceed its benefits.

Figure 2. Present Value Results, Scenario 2 (Major Power Outages Averaging 0.33 Days/Year; 7 Percent Discount Rate)

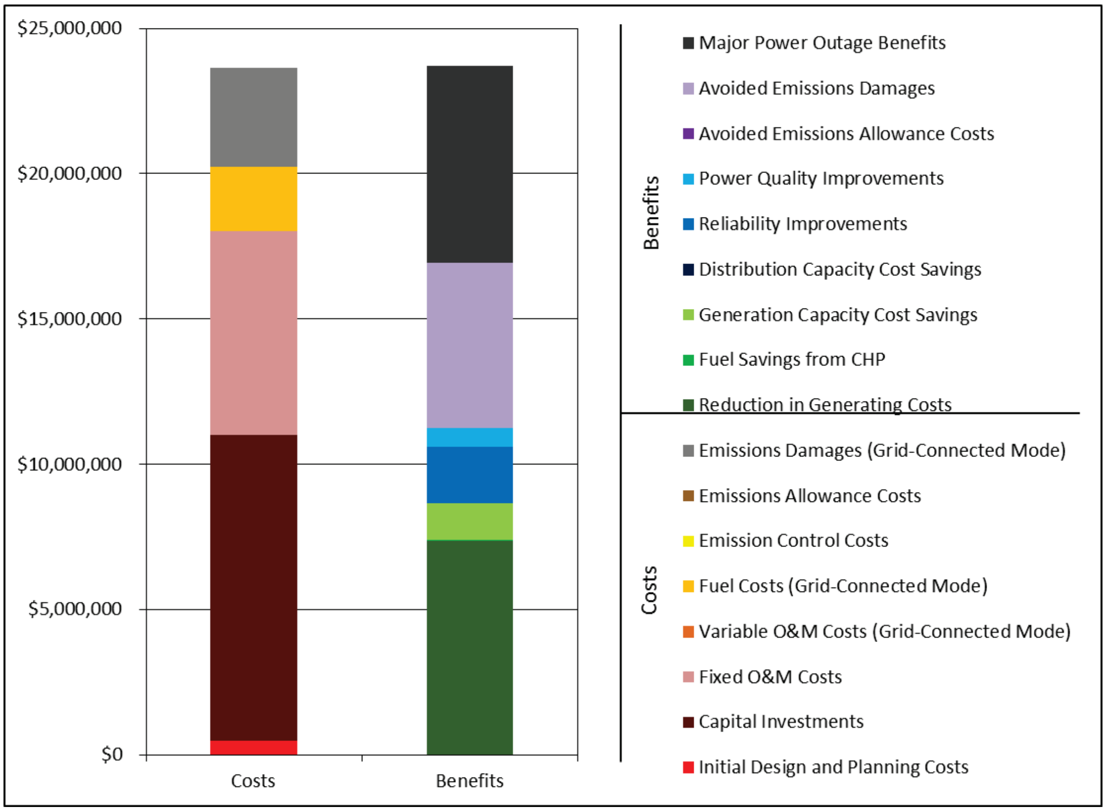

Table 5. Detailed BCA Results, Scenario 2 (Major Power Outages Averaging 0.33 Days/Year; 7 Percent Discount Rate)

COST OR BENEFIT CATEGORY	PRESENT VALUE OVER 20 YEARS (2014$)	ANNUALIZED VALUE (2014$)
Costs		
Initial Design and Planning	$475,000	$41,900
Capital Investments	$10,500,000	$848,000
Fixed O&M	$7,030,000	$621,000
Variable O&M (Grid-Connected Mode)	$0	$0
Fuel (Grid-Connected Mode)	$2,200,000	$194,000
Emission Control	$0	$0
Emissions Allowances	$0	$0
Emissions Damages (Grid-Connected Mode)	$3,380,000	$221,000
Total Costs	**$23,600,000**	
Benefits		
Reduction in Generating Costs	$7,360,000	$650,000
Fuel Savings from CHP	$36,300	$3,200
Generation Capacity Cost Savings	$1,260,000	$111,000
Distribution Capacity Cost Savings	$0	$0
Reliability Improvements	$1,930,000	$170,000
Power Quality Improvements	$662,000	$58,400
Avoided Emissions Allowance Costs	$3,800	$335
Avoided Emissions Damages	$5,670,000	$370,000
Major Power Outage Benefits	$6,790,000	$599,000
Total Benefits	**$23,700,000**	
Net Benefits	**$84,600**	
Benefit/Cost Ratio	**1.0**	
Internal Rate of Return	**6.3%**	

APPENDIX E: ACRONYM GLOSSARY

- ATS- automatic transfer switch
- BCA – benefit-cost analysis
- BTU – british thermal unit
- CCA- community choice aggregation
- CHP- combined heat and power plants
- DER- distributed energy resources
- DHW- domestic hot water
- DMS- distribution management system
- EDG- emergency diesel generator
- EEM- energy efficiency measures
- EGG- emergency gas generator
- EPC- engineering procurement contractor
- EPRI- Electric Power Research Institute
- ESS- energy storage systems
- GHG- greenhouse gases
- Hr - hour
- IEEE- Institute of Electrical and Electronics Engineers
- ISO- independent system operators
- IT – information technology
- ITC- Investment Tax Credit
- kBTU – 1,000 BTU
- kV - kilovolt
- kW – kilowatt
- kWh – kilowatt-hour
- LAN- local area network
- Li-ion- lithium ion
- MW - megawatt
- NOC - Network Operations Center
- NREL- National Renewable Energy Laboratory
- NYSERDA- New York State Energy Research and Development Authority
- O&M- operations and maintenance
- ORNL- Oak Ridge National Laboratory
- PCC - point of common coupling
- PLC- programmable logic controller
- PPA- power purchase agreement

- PV- solar photovoltaics
- REV- Reforming the Energy Vision
- RFI- request for information
- RFP- request for proposals
- RTO- Regional Transmission Organizations
- SGIP- Smart Grid Interoperability Panel
- SOC- state of charge
- SPE- special purpose entity