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Notice

NY Prize Stage 1 – New Paltz Microgrid Project

Final Report

April 19, 2016
(Revised July 7, 2016)

Prepared For:

Prepared By:

New Paltz Microgrid Project Technical Team

In cooperation with Project Stakeholders including the Town and Village of New Paltz

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Executive Summary:

This report summarizes the work of the Project Team to assess the feasibility of a community microgrid for the Town and Village of New Paltz in Ulster County, New York, fulfilling the deliverable requirements for NY Prize Stage I, Task 5 – "Final Written Documentation." The report is divided into four sections (plus executive summary and conclusion), generally corresponding with Tasks 1 through 4 of the feasibility assessment process:[1]

Executive Summary
I. Capabilities and requirements
II. Technical feasibility
III. Business and legal feasibility
IV. Benefit-cost analysis
Conclusion

In consultation with the New Paltz Community,[2] the project team identified six strategic goals for the proposed microgrid:

1. Empower the community to implement its own energy strategy, as part of integrated community planning and development
2. Improve the resiliency of services that are critical to the health, safety, and vitality of the community
3. Increase the community's use of local resilient renewable energy assets, and facilitate ongoing local renewable energy investment
4. Reduce the community's fossil energy consumption and related environmental footprint, and facilitate ongoing reductions
5. Increase opportunities for local ownership of energy resources, keeping more energy dollars in the New Paltz economy
6. Support future economic development and growth by modernizing community energy infrastructure.

Based on these six community goals, as well as the objectives of the NY Prize program, the project team proposed a technical solution and a business structure that would meet these goals and objectives. Specifically, the project Task 2 report describes and analyzes technical designs for a multi-zone microgrid to serve multiple community critical assets. The design relies on technology systems and approaches that are either fully mature or are readily available and sufficiently demonstrated in the market today. The Task 3 report describes a business structure in which the microgrid would be developed, installed, owned, and operated by a public-private partnership (P3) special purpose entity (SPE). The P3 would generate revenue through energy service agreements for a 25-year period to support project cost

[1] Appendix A includes the Task 4 Benefit-Cost Analysis Summary provided by NYSERDA contractor Industrial Economics Inc. (IEc). Appended by reference are IEc's BCA data worksheets. Appendix B contains the Task 1 through 3 reports prepared during the course of the project.

[2] The term "New Paltz community" refers collectively to the Town of New Paltz, the Village of New Paltz, the New Paltz Central School District, and all energy customers and stakeholders in and around New Paltz, N.Y.

recovery, debt service, and investment returns. Such ownership and business structures are well understood and have been successfully applied at many analogous projects.

The project team analyzed project economics using a life-cycle cost analysis. This analysis shows that the project has a positive net-present value (NPV) and an estimated unlevered internal rate of return (IRR) of at least 6.4% – sufficient to support an investment in this project – given appropriate counterparty covenants and credit criteria.

The current weighted electric rate of the key critical facilities included in the proposed microgrid is approximately $0.166/kWh. Based on the estimated energy savings, assumed project financing costs, and the 25-year contract term, the study supports an ESA electric rate with an electric cost that represents an average discount of approximately 7% to 10% for the facilities in this project.

The project team's financial feasibility analysis generally agrees with IEc's benefit-cost analysis results, with some key differences detailed in Section IV. In sum, the IEc analysis indicates that the project achieves a positive benefit-cost ratio (1.1) if the area experiences one outage per year of a 2.4-hour duration. By comparison, the project team's analysis indicates that the project will produce economic benefits for the community in the absence of any outages.

The project team's analysis differs from the IEc analysis because IEc's standard framework for NY Prize projects included certain assumptions to allow all 83 projects to be evaluated on an equivalent basis. However, not all factors are equal across all 83 projects. For example, IEc assumed the same natural gas prices for all 83 NY Prize projects, and those prices are higher than retail natural gas prices provided by Central Hudson for distributed generation units in the project area. Additionally, IEc excluded the value of federal Investment Tax Credits, and it also assumed full replacement cost for all affected systems, versus the project team's expectations that existing equipment will be retained and incorporated into new systems.

These differences yield lower costs and more benefits in the project team's financial analysis, compared to the IEc analysis. These differences were anticipated, given the different purposes and assumptions of the two analyses. In either case, however, the proposed project presents a favorable economic case for the community, especially given the reasonable likelihood that the area will experience outages of at least 2.4 hours per year, on average.

In sum, the NY Prize Stage 1 feasibility analysis indicates that the proposed New Paltz Microgrid project would be a technically and economically feasible solution to address the six community goals outlined above. Moreover the proposed microgrid would establish a replicable and financeable structure for community microgrids that could be applied to other communities throughout the state of New York. Specifically, it would demonstrate a scalable and flexible public-private partnership (P3) ownership model; a multi-tiered service model that can be adapted for use in any community with similar strategic goals; a design and technology approach capable of providing resilience for critical facilities throughout a community; a financing approach that establishes standard covenants and structures capable of attracting both public and private commercial financing; and an integrated community planning approach that efficiently addresses both immediate and long-term community needs.

Background

Project Team:

The NY Prize Stage 1 feasibility assessment has been performed by a collaborative Project Team, comprised of the technical team and the New Paltz stakeholders team. Specifically, the technical team is led by Microgrid Institute, which managed collaborative efforts of its own principals as well as subcontractors Hitachi Microgrids, Green Energy Corp., and TeMix Inc. The technical team's efforts were guided by several New Paltz stakeholder organizations, including the Town and Village of New Paltz, the New Paltz Central School District, State University of New York (SUNY) at New Paltz, and the New York State Department of Environmental Conservation Region 3 Headquarters. The Project Team's utility partner is Central Hudson Gas & Electric. The NYSERDA Project Officer for this project is John Love.

Methodology and Tools:

The Project Team closely followed NYSERDA's instructions in performing its analysis. Specifically, to perform Tasks 1, 2, and 3, the Team performed outreach and engagement with community stakeholders to gather information about the baseline situation, resiliency needs, and several related community objectives – most notably involving reducing the community's environmental footprint, reducing reliance on fossil fuels and imported fuels, increasing use of local energy resources, modernizing local infrastructure, supporting opportunities for economic development, and retaining energy dollars in the local community.

The Team performed an iterative analysis process that included baseline research, microgrid design modeling, system modeling, analysis, and refinement. Vital steps in the research and analysis process included:

A) Visiting most of the facilities contemplated in the study, to gather as-built baseline data
B) Meeting with New Paltz stakeholders and the utility partner to discuss baseline and planned system configuration, usage, and requirements
C) Obtaining customers' historic energy usage, cost, and pricing records for substantially all facilities in the study
D) Convening weekly technical team conference calls to address Task issues, and collectively to analyze design issues and modeling outputs in support of additional research, modeling, and refinements
E) Convening bi-weekly Project Team conference calls to update project status, address outstanding action items, and collectively analyze design issues and modeling outputs
F) Conducting numerous additional phone calls and meetings to address questions and analyze design issues and modeling outputs

The team's efforts included two primary types of analysis:

A) Qualitative analysis, addressing general questions regarding objectives and potential solutions; and
B) Quantitative analysis, addressing the outputs of detailed modeling and simulation efforts to estimate system design and technical performance.

The outputs of such analysis informed iterative refinements of the proposed microgrid system design, business model and legal structure, and technical solutions specified to meet design objectives.

The Project Team performed qualitative analysis by applying to various project questions its experience and expertise with: microgrid systems, business, and regulatory models; utility distribution system technologies and practices; municipal integrated planning, development, and policy processes; and policy objectives of the State of New York generally and the Reforming the Energy Vision (REV) initiative in particular.

To allow empirical assessment of qualitative factors, the Team used Microgrid Institute's customer viability screening matrix to consider economic, technical, legal & market, and process factors, as well as other criteria. Based on the Team's research and engagement efforts, the customers to be served by the microgrid were assigned values for numerous viability factors, including:

- Needs and wants;
- Financial support options;
- Current energy supply arrangements;
- Credit strength;
- Thermal loads & load profiles;
- Existing infrastructure;
- Energy efficiency upgrade options;
- Siting & permitting factors;
- Local energy resources;
- Technology solution options;
- Regulation and policy context;
- Utility support for project objectives;
- Market costs for alternative services;
- Clarity of sponsor authority;
- Level of sponsor support; and
- Integration factors.

The results were unweighted for purposes of the Stage I analysis, to support baseline feasibility analysis within the NY Prize context. The outputs of this qualitative screening and analysis are described in the project Task 3 report.

The technical team based its quantitative analysis on two complementary modeling efforts – one technical and one economic. These efforts were intended to effectively model the feasibility of the proposed system within an accuracy tolerance of +/-30 percent.

The team modeled the technical approach using HOMER Pro (Hybrid Optimization Model for Multiple Energy Resources). 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. This modeling results in performance estimates for energy generation, system costs, lifecycle costs, and operational efficiencies. 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.

Where some or all customer energy data was unavailable, the project team estimated the energy intensity of those facilities. Where possible, the team used data from highly similar buildings in the state of New York, obtained through separate project efforts and the team members' proprietary data libraries. Where data on highly similar buildings were not available, the team used data from the Commercial Building Energy Consumption Survey provided by the U.S. Department of Energy.

In order to model the economic performance of this system, the project team used proprietary Hitachi analysis and analytics software called EconoSCOPE to model project costs and benefits. The tool incorporates engineering design considerations and allows for evaluation of financial sensitivities, projected financial impacts, goal-oriented scenario modeling, cash flow optimization, and cost-benefit analysis. EconoSCOPE is intended to provide insight into the financial viability of microgrid projects and as well as evaluate the benefits to multiple stakeholders. The software was designed and is supported by a development team at Hitachi's Matsudo Research Center in Japan, where Hitachi has developed and financed hundreds of energy projects including renewable energy, distributed generation, and microgrids.

With outputs from the proposed microgrid technical design and HOMER Pro models, EconoSCOPE analysis provided details of potential project costs and revenue streams (including PPA rates) with greater resolution than other available tools. The EconoSCOPE models used economic conditions the project team deemed likely given the anticipated use of a third-party energy services agreement to support project financing. The team then calculated the achievable internal rate of return with blended energy rates at or below current prices for the system off-takers.

The conclusions of the team's qualitative and quantitative analysis efforts are documented in the Task 2 and Task 3 reports.

Summary of Outcomes and Recommendations:

In addition to the outputs of its qualitative and quantitative analysis efforts, the Project Team's work yielded several top-level strategy outcomes that inform its feasibility assessment.

<table>
<tr><th>Assessment Outcomes</th><th>Recommendations</th></tr>
<tr><td>Critical community assets are widely dispersed in the New Paltz geography, making a single islanding system ineffective at meeting project objectives – e.g., to provide increased energy resilience for a full set of facilities that are critical to the health, safety, and vitality of the project community</td><td>A multi-zone system – combining several separately islanding systems in a collectively managed portfolio – can effectively meet community resiliency objectives.[3]</td></tr>
<tr><td>Community stakeholders strongly support the New Paltz Microgrid project, but the community also has a variety of interrelated goals for sustainability and resilience, and community objectives and plans are fluid as needs and opportunities change.</td><td rowspan="2">An integrated planning and design approach would best serve the community's interests in interdependent and complementary goals. A dynamic microgrid strategy will adapt to evolving community needs to the greatest practical degree. The NY Prize competition and the REV initiative support an innovative approach that allows the community to chart its own future path to implement its clean-energy strategy. The project team recommends an implementation approach that envisions more than a resilient multi-zone microgrid, but also a development platform that expands opportunities for community members to participate in ongoing local renewable energy deployments and energy efficiency improvements. Ideally the community would seek a platform to execute a communitywide, resilient clean-energy strategy through the mechanism of the proposed public-private partnership (P3).</td></tr>
<tr><td>The community strongly supports development of renewable and non-polluting energy resources including energy efficiency systems. The most readily available renewable energy resource in the area is solar energy, with some limited potential for geothermal heat pumping, and prospects for biomass energy production. The community is considering multiple opportunities, including shared solar gardens and community choice aggregation.</td></tr>
<tr><td>The proposed microgrid design and business model can produce net-positive benefit-cost values for the community, and a positive financial return for the public-private partnership (P3) that would own the system.</td><td rowspan="2">The project team recommends proceeding with NY Prize Stage 2 application, and continuing efforts to develop the proposed project.</td></tr>
<tr><td>The community lacks financial resources to continue with Stage 2 audit-grade engineering and economic study. Members of the Project Team are prepared to provide some cost-sharing capacity in Stage 2, but external financing support will be required for advanced development.</td></tr>
</table>

[3] In the proposed microgrid, each zone or "node" – which may be either a connected group of facilities or an individual facility – would be capable of operating independently in isolation from the utility grid. These zones would not be physically interconnected to each other, except insofar as they all are embedded in the Central Hudson distribution system.

In sum, the Project Team's assessment supports continued development of the New Paltz Microgrid. The assessment indicates the project is feasible, both technically and economically, and that it establishes design and development models that are both replicable and scalable for other New York communities. The New Paltz Microgrid project is an excellent candidate for NY Prize Stage 2 funding to enable advanced engineering and economic study and development in anticipation of project implementation.

I. Capabilities and requirements

The approach to microgrid architecture, design, and business operations described below incorporates lessons learned and best practices from other existing microgrid projects that the Technical Team has designed and developed (*e.g.,* Olney Town Center in Maryland). It also aims to support New York State initiatives to foster innovation and competition in energy services, including the Reforming the Energy Vision (REV) proceeding.

The New Paltz microgrid design is focused on the development of an overall energy strategy that incorporates both load management and new distributed generation and energy storage resources to support the microgrid's strategic and operational objectives. Microgrid operational objectives include improving resiliency, increasing energy efficiency, reducing environmental emissions, and reducing cost to energy users in the New Paltz community. Microgrid strategic objectives include establishing an engineering and economic platform for providing actionable energy resource information and supporting efficient deployment and operation of innovative clean energy systems.

Task 1.1 Minimum Required Capabilities

a. Serves Critical Facilities

The microgrid is expected to provide resilient energy services to a group of facilities with critical and vital loads in the project area, as listed below:

- New Paltz Municipal Center, Police Department, and public shelter
- New Paltz Community Center (public shelter)
- Fire Station #2, Rescue Squad
- New Paltz Water and Wastewater Systems
- SUNY at New Paltz Wellness Center, Elting Gymnasium (public shelters), Campus Health Center
- New Paltz High School and Duzine Elementary (public shelters)
- New Paltz Middle School (designated emergency shelter)
- Shop Rite, Stop & Shop, and MyMarket Grocery Stores

- Pharmacies and the Institute for Family Health (clinic)
- New York State Department of Environmental Conservation Region 3 Facilities (command center and State Police)
- Low-income and vulnerable population housing (including assisted living and subsidized apartments)
- Gas stations, hardware stores

During the Stage 1 feasibility assessment, some substantial factors were evolving in ways that affect the New Paltz Microgrid design. Final plans and designs will be reviewed and incorporated in Stage 2 study. Evolving factors include the following:

- The New Paltz Municipal Center facility was in preliminary design planning during the NY Prize Stage 1 feasibility assessment. The technical team based its Task 2 and Task 3 analysis on plans and architectural drawings provided by the Town and Village.
- During advanced study phases the school district established an agreement with Solar City Inc. to displace approximately 85 percent of the school district's annual energy consumption with output from a non-resilient, grid-tied PV system.
- SUNY New Paltz announced plans for a Solar PV & Battery Energy Storage project, financed by the New York Power Authority, including some assets that may be integrated into the New Paltz Microgrid.

The public shelter, command center, emergency response, water system, and retail facilities included in this microgrid assessment are important to the region for continued operations during extended grid outages and major storms. This mix includes State (SUNY and DEC) and local government (both Town and Village, as well as school district), public safety, private non-profit healthcare, and private for-profit business interests.

In addition to directly providing resilient energy services for several hundred housing units for low-income and vulnerable populations, the New Paltz Microgrid will directly or indirectly benefit all 14,000 residents of New Paltz, plus approximately 6,000 SUNY students, and by extension the 182,000 residents of Ulster County and additional residents served by the DEC Region 3 headquarters.

b. Primary Generation Resources

Generation sources in the community microgrid include the following:

- Building efficiency and load control
- Solar photovoltaics (PV)
- Battery energy storage systems (ESS)
- Natural gas-fired combined heat and power (CHP) units

The Task 2 report provides detailed information about sizing and siting of generation and storage systems.

c. Power in Grid-Connected and Island Modes

The basis of the microgrid is a portfolio of energy resources located within 10 separate zones or node groups. Because the microgrid project area is served almost exclusively with overhead distribution lines and service drops, the basis for resiliency would be improved by converting key segments to underground cables. The cost impact of underground cable installation is mitigated by limiting undergrounding to short distances only as required to connect major loads.

On loss of the grid, utility-controlled, remotely operated isolation switches would isolate each microgrid zone, leaving the microgrid to remain powered with its own distributed PV, ESS, CHP, and building load control systems.

The project Task 2 report describes grid-connected and island-mode operations and system parameters in detail.

d. Demonstrate Resilience to Forces of Nature

The feasibility assessment evaluated community-specific quality and reliability issues for both electric and gas distribution. The microgrid design is customer-facing resiliency, thus looking to uptime of the customer / critical facilities and their ability to achieve their mission. This analysis contrasts with the utility industry's standard metrics for reliability (system average interruption duration index (SAIDI), customer average interruption duration index (CAIDI), and system average interruption frequency index (SAIFI)), which measure transmission and distribution (T&D) network-level reliability and specifically ignore storm outages that cause the majority of outages affecting customers. (The project Task 1 report discusses this distinction in detail.)

The New Paltz Microgrid design aims to increase facility-specific uptime in the face of major storms, *i.e.,* to improve resiliency.

Task 1.2 Preferable Microgrid Capabilities

a. Advanced use-case functionality: Preferable microgrid capabilities include the ability to integrate and demonstrate operation of advanced, innovative technologies in design and operation. Notably, microgrid solutions are expected to address the microgrid EPRI/ORNL Use Cases (frequency control, voltage control, intentional islanding, unintentional islanding, island-to-grid connected transition, energy management, microgrid protection, ancillary services, black start, and user interface and data management), as well as an additional cybersecurity use case to prevent intrusion into sensitive community energy systems. The project Task 1 and Task 2 reports describe these use cases in detail, and describe active network control systems required to achieve operational objectives in these use cases.

b. Energy-efficiency designs and systems: The Team's philosophy is "lead with energy efficiency." To avoid over-sizing generation and storage systems, energy efficiency options are applied first to reduce the total energy load before sizing the microgrid's distributed energy resources. The Team's analysis of energy performance improvement opportunities followed a six-step process covering data collection, analysis, on-site evaluations, technology retrofit selection, installation, and operation. The project Task 1 report describes this process in detail. The results influenced load analysis that yielded the technical solutions described in the project Task 2 report.

d. Platform for innovative services (REV support): Key objectives of the proposed microgrid include modernizing local grid infrastructure and establishing a platform for development and operation of innovative and competitive energy assets and resources. These microgrid objectives are consistent with the objectives of New York's Reforming the Energy Vision (REV).

A successful community microgrid will establish an engineering and economic platform that supports efficient ongoing development and investments in local energy assets, and provides incentives for operation of assets to achieve optimal outcomes consistent with microgrid objectives – *e.g.,* improved local resilience, energy self-reliance, environmental performance, and financial economics. This includes both the physical infrastructure and transactional systems required to support innovation and competition in meeting community objectives. Platform capabilities, functions, and structures are described in Task reports 1, 2 and 3.

e. Public-private partnership (P3) structure: The microgrid is expected to be developed, owned, and operated by a public-private community development entity with shared ownership between public agencies and private entities, including individuals and companies, both for-profit and not-for-profit owners. Such a structure enables ongoing community control of the microgrid entity to ensure its investments and operational decisions support community objectives, and also supports access to low-cost capital. The proposed P3 ownership structure is described in detail in the project Task 3 report.

f. Accommodate resilient, clean energy development: Community goals include reducing environmental footprint and exploiting clean and renewable energy resources, and consequently the Project Team incorporated these objectives into its study efforts. The Task 3 report describes options to focus community clean energy investments toward assets that will support resiliency for critical facilities.

g. Strengthen New Paltz energy infrastructure: Preferred microgrid capabilities include the ability to strengthen the local electricity system by providing underground cable in key areas to reduce the community's vulnerability to storms and other physical assaults that cause outages and power quality issues. Additionally the energy resources installed throughout New Paltz will reduce local dependence on long-distance power transmission

h. Transactive energy micro-market systems: The Project Team designed microgrid technical solutions and financial structures that would support options for enabling economic dispatch of local energy and capacity resources, including customer loads. Specifically, the proposed microgrid would establish a physical platform for various entities to install, integrate, and operate DG, ESS, and demand-side management systems (DSM) – as well as an economic platform for dispatching resources and managing economic transactions among counterparties within the community. This micro-market platform would provide actionable information enabling customers to minimize their energy expenditures and maximize the value of their assets. Options and considerations for implementing a TE demonstration project within the New Paltz Microgrid are described in the project Task 3 report.

II. Technical design and configuration

2.1: Proposed Microgrid Infrastructure and Operations

Table 2-A – Overview of Microgrid Portfolio

Microgrid Node #	Facilities	Critical Functions
1	• Wastewater Treatment Plant	• Water treatment
2	• Woodland Pond Care Center	• Elder living and care
3	• Mt. Rest Rd. Pumping Station	• Water treatment
4	• SUNY New Paltz Elting Gym • SUNY New Paltz Wellness Center • SUNY New Paltz Student Health Center	• Public shelter • Healthcare
5	• New Paltz High School	• Public shelter
6	• New Paltz Rescue Squad	• Emergency response
7	• Stop & Shop Grocery • ShopRite Grocery • New York State Department of Environmental Conservation • Institute for Family Health • Sunoco Gas Station • True Value Hardware • Meadowbrook Farms II Apartments (affordable housing) • Additional Businesses	• Grocery • Pharmacy • State environmental police • Healthcare • Auto fuel • Low-income housing • Repair, rental, and other business
8	• New Paltz Middle School • Dedrick's Pharmacy	• Public shelter • Pharmacy
9	• Duzine Elementary School • Municipal Center • Community Center & Municipal Pool • My Market Grocery • Stewart's Convenience Store • ZNE Housing	• Public shelter • Emergency operations center • Police • Grocery • Housing • Other retail
10	• Fire Station #2	• Fire and rescue • Emergency response

The project Task 2 report provides detailed discussion of resources and systems for all 10 microgrid nodes, and a complete layout of the design and one-line diagrams showing all microgrid nodes are provided with the Task 4 deliverables.

Normal and Emergency Operations

The microgrid distributed energy resource (DER) selection described in the project Task 2 report is based on a 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, allowing critical facilities to be served by "always-on" microgrid resources for the majority of hours in a year without over-building. The goal is to serve microgrid loads more efficiently, more cost effectively, and with lower emissions per unit of energy consumed.

Under this strategy, base-load CHP is designed to run at design output for at least 8,000 hours per year. PV and energy storage systems are sized and integrated to serve additional and varying loads. Energy storage systems are specified based on their capability to change their output rapidly to support load following and buffering the differences between CHP, electrical load, and PV throughout the day. This approach minimizes maintenance and fuel costs, reducing the total cost of ownership.

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.

Among the most important attributes of the New Paltz community microgrid is the ability to operate when the utility grid is not available – through planned and unplanned transitions to island mode. The resources included in the New Paltz microgrid are sized and operated to support island operation for a minimum period of seven days, with multi-week operation likely.

2.2: Load Characterization

The project Task 2 report describes outputs of the technical team's effort to model and optimize each of the 10 microgrid nodes. The proposed system has a maximum demand of 6,498 kW and an average demand of 1,922 kW, and it will deliver approximately 16,800,000 kWh of electricity per year. The thermal loads in the microgrid total approximately 44,600,000 kBtu per year, of which approximately 26,000,000 kBTU will be recovered from the CHP systems and reused to support on-site thermal loads (*see Tables 2-B and 2-C*).

Table 2-B –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	129	37	321,769	26,814	656,315	54,693	476,830	39,736
2	1,355	419	3,669,426	305,786	18,023,168	1,501,931	8,180,847	681,737
3	171	25	218,254	18,188	232,746	19,396	87,218	7,268
4	510	177	1,549,655	129,138	1,383,616	115,301	1,210,550	100,879
5	496	111	974,992	81,249	1,235,417	102,951	668,957	55,746
6	52	15	134,408	11,201	256,548	21,379	119,333	9,944
7	2,815	924	8,091,466	674,289	18,498,912	1,541,576	13,511,386	1,125,949
8	413	77	675,681	56,307	886,711	73,893	509,016	42,418
9	544	136	1,190,548	99,212	3,267,873	272,323	1,238,709	103,226
10*	13	1	12,257	1,021	245,341	20,445	-	-
Total	**6,498**	**1,922**	**16,838,456**	**1,403,205**	**44,686,647**	**3,723,888**	**26,002,846**	**2,166,903**

***Node does not include CHP**

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 which represent an outage during the winter and an outage during the summer. Energy flows during the outages are presented as weekly averages in 2-C.

Table 2-C –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	94	42	7,044	32,587	19,966
	Summer	60	25	4,202	641	641
2	Winter	1,013	453	76,139	914,428	234,231
	Summer	979	369	61,922	131,234	129,338
3	Winter	145	34	5,785	11,958	2,665
	Summer	97	15	2,491	-	-
4	Winter	245	154	25,898	82,099	61,819
	Summer	281	170	28,487	613	613
5	Winter	322	96	16,054	70,487	28,329
	Summer	254	81	13,530	602	602
6	Winter	19	12	2,069	14,755	4,807
	Summer	23	15	2,450	-	-
7	Winter	1,748	859	144,298	890,154	511,165
	Summer	1,656	849	142,685	95,608	95,608
8	Winter	250	87	14,617	50,696	25,118
	Summer	267	74	12,400	350	350
9	Winter	446	150	25,163	173,363	37,982
	Summer	333	133	22,349	11,027	10,456
10*	Winter	11	1	188	12,627	-
	Summer	9	1	223	1,281	-
Total	**Winter**	**4,293**	**1,888**	**317,255**	**2,253,154**	**926,082**
	Summer	**3,958**	**1,731**	**290,739**	**241,357**	**237,609**

**** Node does not have CHP***

The project Task 2 report describes the team's efforts to model the electric and thermal load profiles for facilities in all 10 microgrid nodes. In sum, the technical team used actual and estimated 12-month customer energy usage data as inputs for EconoSCOPE to generate load profiles for modeling in HOMER Pro. Iterative modeling and simulation informed the technical team's efforts to specify onsite load management, generation, and energy storage systems sufficient to meet project objectives. The New Paltz microgrid is designed for 80% to 86% energy supply from on-site resources, with the remainder of the energy coming from the grid when the grid is operating.

2.3: Distributed Energy Resources Characterization

The project Task 2 report describes the DERs included in the proposed microgrid: PV, ESS, CHP, building load control, energy efficiency measures, the utility grid, and backup generators. The technical team sized DERs after first applying energy efficiency measures in the modeled microgrid, to ensure new resources are not oversized (*see Table 2-D*).

Table 2-D – Microgrid Generation and Storage Resources by Node

	NG CHP		PV		ESS		
Node	Units	Total kW	# of inverters	Total kW	Units	kW	kWh
1	1	30	1	50	1	5	10
2	1	248	3	650	1	95	190
3	1	15	1	40	1	5	10
4	1	130	2	150	1	20	40
5	1	60	1	270	1	5	10
6	1	10	1	15	1	5	10
7	2	710	2	940	2	70	140
8	1	50	2	170	2	20	40
9	2	80	3	300	3	30	60
10	-	-	1	8	1	5	10
Total	**11**	**1,333**	**17**	**2,593**	**14**	**260**	**520**

Microgrid DERs Resiliency

The project Task 1 and 2 reports describe specifications for DERs to withstand wind, tornado, hail, rain, flooding and hurricane forces, as well as earthquake, extreme heat, cold, and ice conditions. As a general matter, systems are either design rated to withstand expected conditions, or located inside enclosures that can effectively protect them.

Reliability of Fuel Sources

The operation of the microgrid will rely on solar energy and natural gas, which present substantially greater reliability and resilience to outage impacts than the integrated T&D system does. The design minimizes the use of existing emergency diesel generators, avoiding dependence on uncertain fuel resupply channels and extending the typical three-day onsite fuel load for the emergency diesel generators to one week.

2.4: Electrical and Thermal Infrastructure Characterization

The proposed microgrid nodes are supplied by two feeders off the same substation. The utility feeders are mainly overhead lines, which cannot be relied upon in the event of a major storm. The microgrid design avoids reliance on vulnerable overhead lines by isolating each node group separately, and employing new underground cable segments in key areas where it is required and cost effective for the overall project.

The electrical infrastructure currently consists of overhead distribution lines with pole-mounted transformers. Critical new electric distribution infrastructure will be located in Nodes #4, 7, 8, and 9 where the microgrid distribution resources are shared among multiple facilities. In these cases, new underground cables will be need for the common distribution segments. In the other nodes, the microgrid distributed energy resources will be behind the meter of a single customer, and the node design will support standalone island operation during a grid outage. Outdoor switches for the underground electric distribution network will be installed in enclosures in in-ground vaults.

The existing thermal infrastructure consists mainly of hot water systems. Microgrid DERs will not attach to steam systems because the output temperatures of the natural gas engines do not meet specifications for a steam system. The CHP connections to the hot water systems are expected to be installed in parallel with existing boilers, and fed into existing supply and return headers.

The project Task 2 report describes a point of common coupling (PCC) design and transition plan – compliant with IEEE 1547.4 and the EPRI/ORNL Use case 5 – to enable a utility-controlled breaker or switch to immediately open (frequency = 59.3 Hz) on loss of the grid. The microgrid controller will adjust all microgrid resources for island mode operational and performance objectives. The microgrid design ensures a seamless transition back to the grid when power is restored. The microgrid controller (and/or operator) will connect with the utility distribution management according to all appropriate protocols, safety mechanisms, and switching plans.

The Task 2 report also describes a microgrid protection scheme similar to a standard utility distribution level protection scheme, with additional features allowing two-way power flows across the PCC and power quality enhancements.

2.5: Microgrid and Building Controls Characterization

The project Task 2 report describes a community microgrid control system that allows for simultaneous control of multiple microgrid nodes 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 operations 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. 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.

In addition to performing functions to satisfy the EPRI/ORNL microgrid use cases, the microgrid controller will forecast variable aspects: load, wind, solar, storage; dispatch 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 the local utility; and meet rigid and proven cyber security protocols.

2.6: Information Technology (IT)/Telecommunications Infrastructure Characterization

To support the community node approach, the project Task 2 report describes a microgrid control scheme that provides for a secure external access to the NOC that can coordinate the various nodes within the community, as well as interoperation with the utility grid. 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 affect the local operations of any node.

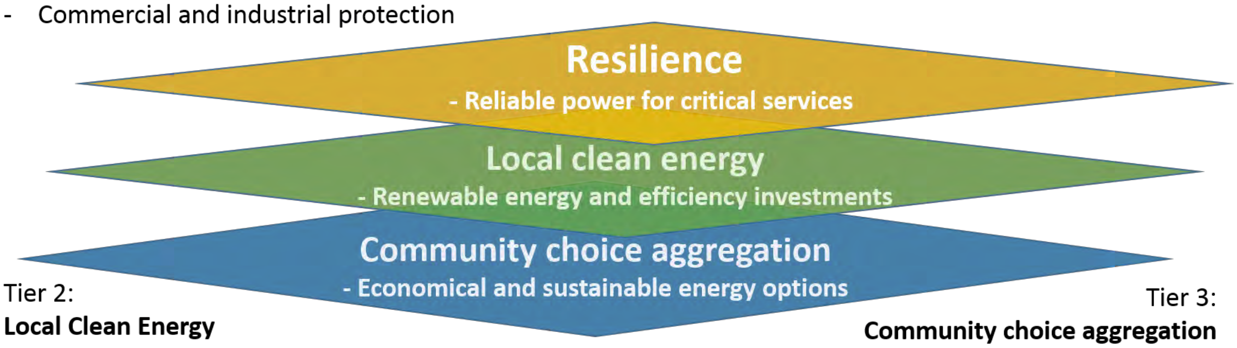
Each microgrid node will have a wireless LAN specific to the microgrid, powered by microgrid resources, and extended to every resource, device, sensor, and load interface (*e.g.,* building management system). This communications infrastructure will be designed with dual-redundant access points to assure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

III. Commercial and financial feasibility

Business model summary: The New Paltz Microgrid is designed to address the community's critical resiliency priorities while also serving its renewable energy and environmental priorities. The proposed business model uses a P3 ownership structure to support capital investments and operational capacities necessary to achieve the community's strategic goals. The microgrid entity will offer a menu of services to substantially all energy customers in the community, using a three-tiered service structure (*see Fig. 3-A*).

Fig. 3-A: New Paltz Microgrid Energy Services Model

Tier 1:
Resilient Power Solutions
- Critical and vital community facilities
- Commercial and industrial protection



Tier 2:
Local Clean Energy
- Distributed solar photovoltaics (PV)
- Resilient solar gardens
- Energy storage and EV charging
- Energy efficiency and conservation services

Tier 3:
Community choice aggregation
- Aggregated energy purchasing and trading
- Economical and sustainable energy options

Transactive energy study potential: The team's design and planning process included consideration of whether and how the proposed microgrid could serve as a demonstration platform for studying transactive energy (TE) micro-market dispatch of distributed energy resources (DER), and questions such study would address. Accordingly, where appropriate, the Task 3 report includes notes addressing TE study potential.

In general, the team determined that the proposed New Paltz Microgrid would serve as an effective platform for a pilot project to demonstrate TE micro-markets. Such a project would allow further study of prosumer participation and distributed controls for real-time micro-market dispatch of DERs, to achieve maximum economic and environmental objectives for the community. During Stage 2 study and development, the team will determine whether to propose a TE demonstration.

3.1 Commercial Viability – Customers

Through an iterative process of community outreach and planning, the Project Team identified customers in four categories of viability for Tier 1 resiliency services – High, Moderate, Weak, and Not Viable (*see Figure 3.1-A*). All major customer facilities included in the final microgrid modeled for the Task 2 report are initially categorized as either High or Moderate viability, supporting a strong likelihood of onboarding all identified customers. The project Task 3 report characterizes all customer groups in terms of economic, technical, legal and market, and process factors affecting their viability as part of the proposed microgrid.

3.1.1 Commercial terms and relationships

The New Paltz Microgrid is designed to address the community's critical resiliency priorities while also serving its renewable energy and environmental priorities. The Task 3 report describes a three-tiered energy services approach (*see Fig. 3-A*). Task 2 design and modeling efforts focused on systems required to fulfill Tier 1 customers' energy services requirements. Tier 2 and Tier 3 requirements are deemed out of scope for the current phase of study, except to establish business model context and describe the proposed project's strategic benefits and overall value proposition for the community.

3.1.2 Baseline situation

Central Hudson Gas & Electric provides retail electricity and gas distribution services to customers in New Paltz, using regulated retail rates. Additionally Central Hudson supplies electricity and natural gas using standard offer service rates. Tier 1 customers pay on average 16.6 cents/kWh for delivered electricity.

New Paltz customers may choose from among a variety of gas and electricity suppliers. Several customers to be served by the New Paltz Microgrid currently receive energy services from Direct Energy. Agreements with third-party energy suppliers generally are short in duration, and thus are not expected to prevent contracting with the P3.

3.1.3 Utility benefits and ancillary services

The Task 3 report describes several ways in which the proposed microgrid will support the electric utility, including providing congestion relief, accelerating service restoration, modernizing local distribution systems, reducing line losses, expanding service options, and supporting ancillary services at the distribution and regional grid level.

3.1.5 Microgrid stakeholders

The Supervisor of the Town of New Paltz initiated the NY Prize Stage 1 application response that led to the New Paltz Microgrid project proposal. The project team includes a broad group of major stakeholders in the New Paltz community. They include both local municipal entities – the Town and Village – along with other government units including the local school district, college campus, and the regional New York State environmental regulatory office serving seven counties. Together these entities provide local first response, law enforcement, and public water supplies for a large area of the mid-Hudson Valley region, centered on a vibrant community that totals up to 20,000 residents (including SUNY students). Commercial stakeholders include multiple grocery stores, pharmacies, gas stations, and a 500-bed senior living and healthcare facility.

3.1.6 Stakeholder/customer relationship

Several customer organizations (including units of local government) and their representatives are among stakeholders in the New Paltz Microgrid Project. Among the facilities included in the Task 2 model (approximately 30 facilities with a total 6.5 MW peak electricity load), about half are owned and operated by five administrative agencies: the Town and Village of New Paltz, the New Paltz Central School District, SUNY at New Paltz, and the New York State Department of Environmental Conservation. Other customers with stakeholder roles include Health Alliance of the Hudson Valley's Woodland Pond senior housing and healthcare complex, as well as the New Paltz Fire District and Rescue Squad. The modeled project includes subsidized housing complexes (Meadowbrook Farms II and New Paltz Housing).

The Village and Town of New Paltz assist in outreach and engagement with other groups of stakeholders and customers, including local businesses, nonprofit organizations, and residents eligible to receive microgrid service. Examples include grocery stores, pharmacies, gas stations, and a health clinic. Other commercial stakeholders include local developers, entrepreneurs, contractors, and employers whose capacity to provide services may benefit from improved local resilience.

Finally, energy business stakeholders include Central Hudson Gas & Electric, the distribution utility serving New Paltz. As a general matter, all microgrid customers are expected to remain Central Hudson customers while also receiving services from the New Paltz Microgrid.

3.1.8 Planned contractual agreements

Primary contractual agreements involve energy services agreements (ESA) and potentially a build-operate-transfer (BOT) agreement. Microgrid infrastructure and systems will be installed pursuant to contracts the P3 enters with vendors and service providers. Other forms of agreements, covenants, and policies may support financing resilience assets such as community shared-solar facilities, neighborhood energy storage, and other infrastructure. Finally, the microgrid P3 will be incorporated as the result of partnership agreements among public and private owners.

3.1.9 Customer recruitment and onboarding

The team estimates that with few exceptions, prospects are excellent for recruiting substantially all customers included in the Task 2 model. Noteworthy exceptions include two school facilities whose solutions may need to be omitted or reconfigured, pending school district execution of a remote net-metered solar contract with Solar City.

The New Paltz Microgrid P3 will be responsible for marketing and promoting service offerings at all phases of implementation.

3.2 Commercial Viability - Value Proposition

The New Paltz Microgrid value proposition is based on three key principles: 1) It will produce net economic benefits to customers and the community in excess of its life-cycle costs; 2) It will increase the community's energy resiliency, especially at critical facilities; and 3) It will serve the community's strategic goals, most notably providing a platform for ongoing reductions in fossil fuel consumption. The project Task 3 report describes these strategic goals as part of the project value proposition.

3.2.1 Community costs and benefits

The technical team's analysis indicates the proposed microgrid can produce direct economic benefits, providing enhanced services to customers for costs that are equal to or lower than current costs.

The proposed microgrid can cost-effectively provide energy for Tier 1 customers through 25-year ESAs at costs equal to or lower than current electricity rates. The proposed business model would support commercial financing for a substantial portion of the project's estimated $12 million initial capital cost.

Operating revenues for the modeled microgrid are projected to exceed operating costs – sufficiently to produce at least a 6.4% internal rate of return to the P3. Positive cash flow will ensure economic stability and creditworthiness to support continued access to low-cost operating and investment capital.

3.2.4 SWOT analysis

The project Task 3 report includes an abbreviated analysis of strengths, weaknesses, opportunities, and threats (SWOT). Key strengths include a diverse and committed stakeholder group, demonstrated needs for resilience, a positive benefit-cost analysis, and opportunities to support the REV process with an innovative set of services and technical options. Important weaknesses include economic challenges of serving small nodes and inconsistent load profiles, a potentially complex business structure, and innovative ownership structures. Key opportunities involve modernizing and strengthening critical facility energy systems, capturing local resource value, and supporting integrated community development and collaborative planning. Substantial threats involve the need to address customers' needs and concerns during onboarding phases, overcoming utility business or legal challenges, and competing against low-cost non-resilient energy alternatives.

3.2.5 Unique features

The proposed project envisions an innovative approach at the systems level that utilizes commercial, off-the-shelf technologies to create a community microgrid that serves multiple critical facilities and community partners at non-contiguous locations.

In New Paltz, this means serving a very diverse set of loads – from water and wastewater treatment systems, to community shelters, to gas stations and grocery stores. The New Paltz Microgrid design will provide true energy resilience for the community – not just emergency services.

The project also supports community zoning and planning efforts aimed at improving economic opportunities, while also strengthening and diversifying resilient microgrid systems. In future phases, the microgrid's underground extension may further serve community interests in support of area historic restoration and preservation priorities, in harmony with green development initiatives.

3.2.6 Project replicability and scalability

The project Task 3 describes a replicable and scalable approach to providing resilient energy and other energy services for New York communities. Ownership and management structures developed for the New Paltz Microgrid can be used in other situations, and the New Paltz Microgrid multi-tiered service model establishes an approach that is readily adaptable for application in any community that can benefit from integrated sustainable-planning and economic development. By specifying resilient infrastructure and resources in standard configurations, and by providing controls for managing clusters and portfolios of facilities that serve community resilience, the microgrid's design and technology approach establishes a roadmap for community resilience in other communities. The project's financing structures will help establish programmatic models for adaptation in other communities, and the project team's integrated planning and multi-phase development approach demonstrates methodologies for communities to meet immediate needs while planning and preparing for future growth and development.

3.2.7 Community need for resiliency

The New Paltz Microgrid will serve a group of facilities that are critical to the health, safety, and vitality of the community. This mix includes government facilities (Village, Town, State, and School District), public safety and infrastructure, private healthcare and assisted living, and private business interests. In addition to critical facilities, the microgrid footprint includes other essential services, including pharmacies, grocery stores, and gas stations. Benefits extend not only to local agencies and businesses, but also to residents in the greater New Paltz area, as well as Ulster County and the six other counties served by the NYS DEC Region 3 headquarters.

In addition to operational resilience, the microgrid system will contribute to the economic resilience of the community. By facilitating the deployment of DERs throughout the community, and providing service to customers under long-term agreements, the microgrid will help New Paltz customers to hedge against anticipated energy cost increases and volatility. Additionally the proposed microgrid will create a modernized energy infrastructure to attract new businesses and jobs to the community.

3.2.9 Prosumer opportunities

As a partnership that includes local public entities among its ownership group, the proposed microgrid would generate new energy services revenue for P3 owners who also are energy customers in New Paltz. In addition, the proposed microgrid would, in part, establish a platform for other energy consumers to become energy producers if they choose to invest in DERs. Examples include shared solar production, onsite green energy production, and thermal energy services.

Additionally, a TE micro-market demonstration could establish opportunities for prosumer investments and market competition. The prospective TE implementation would allow further study of opportunities for customers to engage fully in DER micro-markets, from acquiring shared solar assets to developing neighborhood storage systems.

3.2.10 State policy implementation

The New Paltz Microgrid directly promotes several New York State policy goals. The project Task 3 report describes ways in which the project supports the REV initiative, New York energy goals including renewable portfolio standards, community choice aggregation, and CHP, conservation, and demand-side management priorities.

3.2.11 Commercializing advanced technologies

The New Paltz Microgrid establishes a technology and business platform for deployment and operation of numerous technologies to exploit DER. The platform itself incorporates innovative technology – specifically, the microgrid controller and optimization software required to perform active energy management and system balancing among various DER systems. Microgrid systems also would enable utility integration of resources into its distribution management system, and would support continued deployment of resilient DERs – as opposed to non-resilient grid-tied systems incapable of serving customer loads during outages. Finally, the New Paltz microgrid would accommodate a TE micro-market project to demonstrate the use of distributed controls and customer participation for real-time micro-market dispatch of DERs, to achieve maximum economic and environmental objectives for the community, and to establish the real-time locational value of DERs.

3.3 Project team

The project technical team is comprised of the sponsoring community entities (the Town and Village of New Paltz, and the New Paltz Central School District), with a technical team comprised of Microgrid Institute, Hitachi Microgrids, Green Energy Corp., and TeMix Inc. Key members of the technical team are well positioned to continue project efforts in subsequent phases. The project Task 3 report describes team roles and qualifications in detail. The team anticipates expanding its capabilities in subsequent project phases to meet expanded project scope requirements – including, for example, project financial structuring and risk management, full-scope engineering-procurement-construction, operations, maintenance, and administration expertise.

New Paltz community stakeholders continue providing strong support for the project in close coordination with the technical team, and are prepared to consider participation as equity owners in a prospective P3 established to build, own, and operate the project.

Fig. 3-B: Project Team, Sponsors, and Roles

Team Member	Roles	Relationship
Town and Village of New Paltz; New Paltz Central School District	Sponsoring community entities, site hosts, and prospective P3 public partners	Sponsoring municipal entities
SUNY at New Paltz; New York State Department of Environmental Conservation Region 3	Local public stakeholders, site hosts, and prospective P3 public partners	Local public stakeholders
Microgrid Institute	Principal investigator, project manager, prospective P3 partner *- Microgrid design, development, outreach, economic and legal structuring and analysis, and financing*	Prime contractor
Hitachi Microgrids	Technical partner, prospective P3 partner *- Microgrid design, modeling, and technology and resource assessment for development, financing, and deployment*	Subcontractor
Green Energy Corp.	Technical consultant *- Microgrid control system analysis*	Subcontractor
TeMix Inc.	Technical consultant *- Transactive energy micro-market analysis*	Subcontractor
Central Hudson Gas & Electric	Utility partner, prospective P3 partner, and prospective BOT transferee	Utility partner

Fig. 3-C: New Paltz Microgrid P3 Structure

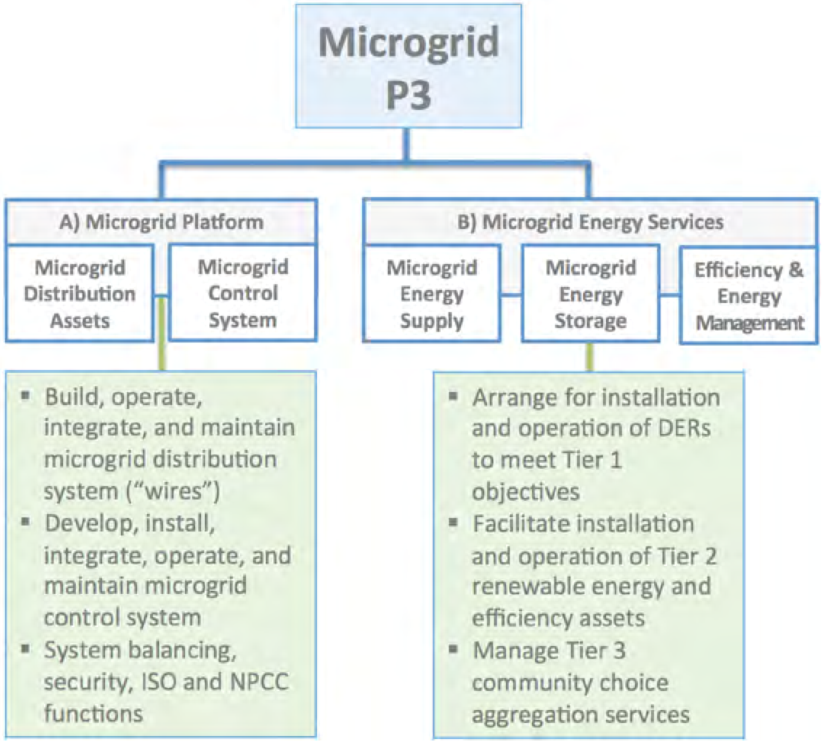


Fig. 3-D: New Paltz Microgrid P3 Prospective Equity Owners

Category	Prospective Owners
Public	Town of New Paltz, Village of New Paltz, SUNY at New Paltz, New Paltz Central School District, NYS DEC Region #3
Prosumer	Health Alliance of Hudson Valley (Woodland Pond), Stop and Shop Plaza, ShopRite, True Value Hardware, and individual businesses, institutions, and residential co-owners of microgrid resources
Private	Microgrid Institute, Hitachi, Central Hudson Gas & Electric, third-party investors

Fig. 3-D: Project capital sources

Capital component	Identified capital sources	Other potential sources
Equity (cash, cost-sharing, and capital assets)	Town of New Paltz Village of New Paltz SUNY at New Paltz	Private prosumers (consumer/producers) Vendor financing (construction) Commercial equity investors
Grants	NYSERDA (including NY Prize), NYPA	U.S. DOE, HUD
Construction financing	Commercial lenders, NY Green Bank	Vendors, EPC firms, commercial banks
Long-term debt financing	NY Green Bank, Energy Finance Solutions (on-bill recovery financing)	Institutional investors, commercial finance consortia
Tax-based financing (TIF, PACE, municipal bonds)	Energize NY	Municipal bond investors

3.3.4 Utility engagement and support

Central Hudson provided a letter of support for the New Paltz Microgrid NY Prize Stage 1 application, and has supported assessment efforts with utility system information, guidance, and engineering analysis. The team anticipates continued engagement with the utility as the project proceeds. The utility's inputs will be essential for implementation.

3.4 Creating and Delivering Value

The proposed project will create and deliver value for the community using a three-tiered energy services model. The microgrid P3 will serve as the New Paltz community's ESCO, arranging for full-scope energy supply, storage, efficiency, and load management necessary to provide Tier 1 resiliency services, Tier 2 green energy services, and Tier 3 community choice aggregation, throughout the term of customer contracts.

3.4.1 DER technology selection and challenges

As the DER portfolio is structured, the project team will determine during Stages 2 and 3 the size, manner of use, and specifications of each piece of DER equipment, and identify vendors to provide the equipment. The project team will give preference to the most mature technologies available for each purpose that meet or exceed the stakeholder and design objectives. Where the project must use emerging technology (namely microgrid controls and energy storage) the project team will take special measures to prove each product before including it in the microgrid, including detailed and thorough testing and commissioning, and securing strong vendor warranties.

New Paltz currently has one PV installation (SUNY Wellness Center, 50 kW) that will be incorporated into the proposed microgrid. Additional planned or existing customer-owned generation, including rooftop PV systems, may be leveraged if doing so is supported by Stage 2 project engineering analysis.

PCC and underground cabling

Where feasible, the proposed microgrid will use underground cabling to connect loads in multi-facility nodes. Overhead distribution lines do not provide the resiliency or reliability required to meet project objectives, and so the microgrid design is optimized to minimize reliance on vulnerable above-ground systems. Ownership of new purchased and installed underground cabling may be retained by the P3 or transferred to the utility pursuant to a BOT agreement, based on the objectives of community stakeholders.

The local utility will need to analyze and approve the final engineered design for system interconnection, switching, and protection systems that provide disconnect, islanding, and restoration functions in case of power disruption. The utility will also need to approve any plans to use of sections of utility distribution equipment while in island mode.

The utility will coordinate protection and switching schemes for the PCC and the distribution system. The microgrid P3 will address these needs in the interconnection agreement and the studies that support it. The proposed PCC solution simplifies the interconnection agreement and interconnection study by using a straightforward approach to isolate the microgrid from the distribution grid with control by the utility in accordance with the IEEE 1547 interconnection standard. This gives the utility control of the interconnected system and makes the interconnection agreement easier to execute.

3.4.2 Existing assets being leveraged

A general lack of suitable DERs and underground cable infrastructure in the New Paltz area limits the opportunity to leverage existing physical assets. Noteworthy existing assets to be leveraged include a 50 kW PV array at the SUNY Wellness Center, backup generation systems at several locations (for backup only, not baseload or peaking generation), and underground cabling at Woodland Pond and potentially at SUNY and in the Net-Zero Housing development.

3.4.3 Approach to generation and load balance

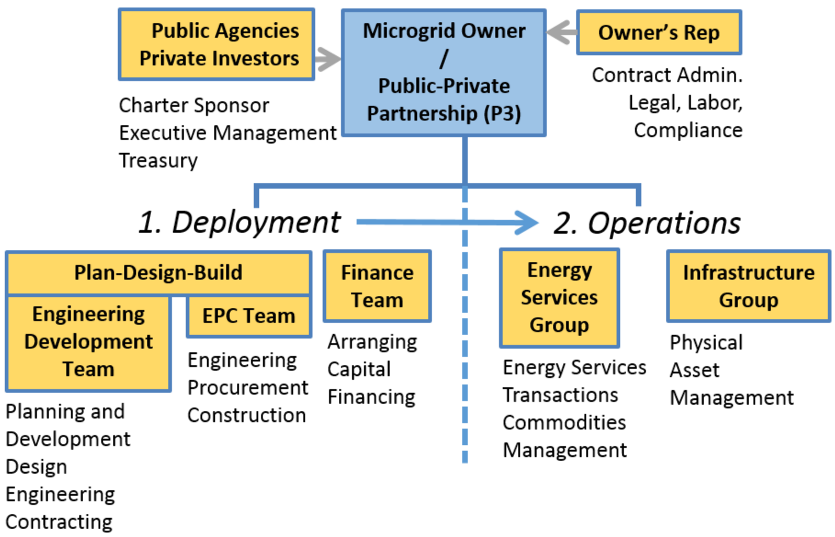
The project team will use a microgrid portfolio approach to select DERs for the microgrid. This approach focuses on analysis of the energy requirements of covered facilities, and is intended to achieve a close match between the DER portfolio and the electric load profile of those facilities.

Under this strategy, base-load CHP will be designed to run at design output for at least 8,000 hours per year. PV and energy storage will be integrated into the system to meet loads that vary above the base load. Energy storage systems will be specified based on their capability to change their output rapidly in response to dynamic transient conditions, perform load following, and provide an energy buffer among CHP, PV, and electric load throughout the day.

3.4.5 Development, construction and operating approach

The project team anticipates developing, building, and operating the proposed microgrid using a collaborative project management approach to ensure ongoing strategic focus on serving the community's goals. The P3 will oversee all development activities, delegating responsibility and entering contracts to plan, design, build, and commission the microgrid and related assets to serve Tier 1, Tier 2, and Tier 3 customers, and formalizing financial arrangements to provide capital funding for all phases of development. The P3 also will oversee all operational activities, including managing Tier 1, Tier 2, and Tier 3 customer service, energy transactions, and physical asset management. The microgrid P3 will retain, in accordance with its procurement and governance policies, additional contractors, vendors, suppliers, and consultants as needed to provide a variety of products, services, and support.

Fig. 3-E: Microgrid development model



3.4.6 Community benefits (summary)

The proposed microgrid produces a wide range of benefits, as described above and throughout the Task 2 and Task 3 reports. They can be summarized as: 1) Improved resilience for critical facilities; 2) opportunities to expand local investment in renewable energy and conservation; and 3) support for economic growth and development. Additionally the team's analysis indicates the proposed microgrid can produce direct economic benefits, providing enhanced services to customers for costs that are equal to or lower than current costs.

3.4.7 – Utility requirements

Utility participation is necessary to ensure the proposed project's feasibility and positive cost-benefit performance for the community. Key utility contributions include the following:

- Technical design input and guidance
- Interconnection requirements and procedural support
- Business model input and guidance
- Operating agreements
- Customer servicing arrangements

In principle the utility also may support the P3 as an equity partner, investing in distribution systems and platform assets necessary to serve microgrid customers.

3.4.8 DER maturity

The distributed energy systems specified for the New Paltz Microgrid all use thoroughly field-tested, off-the-shelf technologies. Photovoltaics, natural gas-fired CHP systems, and battery energy storage are all well-established technologies that have been proven to be effective and reliable both when installed singly and when deployed as part of a microgrid system.

Microgrid platform systems also will rely on thoroughly field-tested systems. Specified microgrid control systems will support seamless transition from grid-connected to island mode, and will use distributed controls and portfolio management methodologies with demonstrated capabilities to sustain balanced operation in support of project objectives. PCC, protection, and safety systems will support all required operational requirements in compliance with prevailing utility standards (*e.g.,* IEEE 1547).

3.4.9 Describe the operational scheme

Operation of the microgrid will include several key components:

A. **Metering:** The P3 will provide customer services via sub-metering arrangements. The project team will add new sub-metering as necessary to serve microgrid customers.
B. **Technical operations:** The microgrid controls, and microgrid design, are based on the 10 ORNL microgrid Use Cases (detailed in the project Task 1 and 2 reports). The most important use cases address transition to an island mode (planned and unplanned) and return to grid-connected operations. Other use cases also will optimize operations for economic and emissions-reduction objectives.
C. **Financial operations:** The microgrid P3 will bill system customers monthly for energy used by system resources. Depending on how the P3 and operating agreements are established, the customer may also still be billed by the utility. To simplify bill management, microgrid service may become a pass-through within utility billing, or vice-versa.
D. **Transaction management:** Any additional revenue to customers from shared program participation (community solar gardens, demand response, ancillary services) will be accounted for in the monthly bill that customers receive from the P3 or from the utility if bills are integrated.
E. **TE study notes:** In a TE deployment, market trading activity via long-term contracts and spot transactions would drive operational dispatch of various resources. The New Paltz Microgrid could serve as a test site to demonstrate micro-market dispatch of energy resources.

3.4.10 Replicability of the business model

The New Paltz Microgrid Project establishes a highly replicable and scalable approach to providing resilient energy and other energy services for New York communities. It applies several key elements that are consistent with commercial viability, technology and modernization objectives, and New York State energy policy goals.

A. **P3 ownership model:** Public-private ownership and management structures developed for the New Paltz Microgrid can be used in other community microgrid situations. Additionally these structures are highly scalable, being viable and supportive for projects of various sizes.
B. **Multi-tiered service model:** The New Paltz Microgrid service model is readily adaptable for application in any community that shares a similar level of local support for development of clean energy resources and resilient energy systems as part of an integrated sustainable-planning and economic development approach.

C. **Design and technology approach:** By specifying standardized DER and interconnection systems, and by providing controls for managing a networked portfolio of facilities, the New Paltz Microgrid's design and technology approach establishes a roadmap for building resilient community energy systems in locations with topology and market conditions similar to those in New Paltz.

D. **Financing:** The project's structured agreements and covenants will help to establish programmatic financing models readily adaptable for communities with similar needs and wants.

E. **Integrated Development Strategy:** The proposed energy services model and integrated community planning approach exemplify methodologies for communities to meet a variety of immediate needs while preparing for future growth and development.

3.4.11: Describe the barriers to market entry

-and-

3.4.12 Describe the plan to overcome the barriers

Several barriers require attention for NY Prize projects in general:

A. **Legacy business model:** Approaches to microgrid development that challenge traditional business models or alter customer relationships may prompt market incumbents to delay or prevent project progress. *Solution:* Define appropriate operating agreements, concessions, or exemptions, and facilitate their execution to enable project progress.

B. **Vulnerable resource lock-in:** Net metering policies provide incentives for non-resilient, grid-tied DER deployments that are vulnerable to outage risks can prevent investments in resilient assets to serve critical community facilities. *Solution:* Collaborate with stakeholders to define resiliency objectives, identify options, and develop appropriate solutions.

C. **Monetization gap:** Inadequate methodologies for attributing and monetizing the geotemporal value of DERs constrain cash flow and discourage investment in resilient assets. *Solutions:* 1) Provide service options to meet a wide range of customer profiles; 2) Demonstrate transactive energy micro-market clearing mechanisms to establish locational DER values with long-term contracts and spot transactions.

D. **Regulatory risk:** Regulatory risk associated with REV and other New York policy initiatives, and uncertainty about market access and regulatory models, deter commitments by market participants. *Solution:* Ensure sustained legal viability by establishing contingency options for implementation in the event of regulatory changes. Monitor regulatory developments and provide policy inputs as appropriate.

E. **Procurement hurdles:** Government procurement policies may compel state entities to apply competitive procurement requirements to microgrid participation, deterring early-stage commitment from qualified developers and vendors. *Solution:* Act as a procurement agent for the P3's public owners and customers. This role will be most effective if the State of New York provides public entities with confidence that they can participate without violating procurement regulations.

F. **Taxes and prevailing wages:** State and local taxes and prevailing-wage standards increase project costs compared to projects in some other U.S. jurisdictions. *Solution:* Develop structures to capture tax benefits. Seek grant and incentive funding to levelize project benefit-cost potential.

G. **Inadequate development funding support:** Limited available development capital, especially for early-stage support. *Solutions:* Seek NY Prize Stage 2 and Stage 3 funding. Leverage complementary programs. Seek financing wrap with funding for development.

3.4.13 Microgrid market for this approach

Critical facilities tend to be geographically dispersed throughout communities. The proposed model addresses this common situation with a standardized approach to designing and building multi-zonal networked microgrids. Moreover, with weather patterns becoming more extreme and contributing to more frequent and widespread electric outages, more communities will seek community microgrids. Further, community stakeholders increasingly recognize the value – and difficulty – of comprehensive integrated planning to optimize interrelated initiatives and investments. The proposed approach supports such integrated planning strategies to build more resilient communities.

3.5 Financial viability

As part of the Stage I feasibility assessment, a high-level project budget was developed to ensure that the design meets both technical and economic objectives. See IV. Cost-Benefit Analysis below for detailed discussion of financial feasibility assessment results.

The the estimated project budget for the project is $12 million with an accuracy of +/- 25%. *Note:* This cost includes an applicable deduction for the federal investment tax credit, which recently was extended by the U.S. Congress. The project cost excludes any other incentives that may be applicable to the project. Nevertheless, the team anticipates efforts to take advantage of all applicable incentives for the project, including NY Prize Stage 2 and Stage 3 awards. These potential incentives are addressed in the project Task 3 report.

The proposed microgrid creates savings to the community in the form of energy cost savings, resiliency savings, and carbon savings due to GHG reductions. Resiliency savings include likely business costs saved by avoiding anticipated outages. GHG savings are generated as the proposed system would produce fewer tons of greenhouse gases each year, due to an emissions profile that is much cleaner than that of the utility. The value of GHG reductions is based on the U.S. Environmental Protection Agency's CO_2 offset price of $40 per ton. A summary of the estimated microgrid savings for the first full year of operation of the proposed microgrid are presented in Fig. 3.5-A*:*

Fig. 3-F: Estimated Microgrid Year 1 Savings

Estimated Annual Energy Savings	**7% - 10% lower than current rates**
Estimated Annual Resilience Savings	$514,900
Estimated Annual GHG Savings	$146,600

This report proposes a business structure whereby the microgrid would be owned and operated by a P3 entity that would arrange funding for the project. The P3 would generate revenue through energy service agreements for a 25-year period. The economics of the project have been analyzed using a life-cycle cost analysis, which shows that the project has a positive net-present value (NPV) and an unlevered internal rate of return (IRR) of at least 6.4% – which experience demonstrates is sufficient to support an investment in this project.

The current weighted electric rate of the key critical facilities included in the proposed microgrid is approximately $0.166/kWh. Based on the estimated energy savings, assumed project financing costs, and the 25-year contract term, the study supports an ESA electric rate with an electric cost that represents an average discount of approximately 7% to 10% for the facilities in this project.

TE study notes: A TE approach would be expected to improve financial performance by providing customers with greater optionality. Long-term contracts would preserve the core financial proposition while spot-market transactions allow counterparties to pay or earn the geo-temporal value of resources.

3.5.1 Categories and magnitude of revenue streams to the owner

The proposed microgrid is expected to produce between $1.5 million and $2 million in annual revenues from Tier 1 energy services, all in the form of electricity sales to microgrid customers. Additional revenue streams to the microgrid P3 were not modeled for Stage 1 analysis. Such revenue streams may include electric energy, capacity, demand response, and ancillary services sales in the NY ISO wholesale market; revenues from related energy resource investments, including potential regional biomass production businesses; energy savings performance fees and bonuses; and consulting and service fees.

TE study notes: A TE micro-market would enable participants to be asset owners. As a result, the decisions of TE market participants may affect total microgrid revenues. A TE deployment would enable further study of how micro-market behavior might affect overall system economics.

3.5.2 Other incentives identified

In addition to NY Prize Stage 2 and Stage 3 incentives, the project would seek leverage various incentive programs and similar initiatives to support investments in resilient DERs and related systems and infrastructure. Examples may include: federal incentives, New York State program incentives, and utility energy efficiency programs. *Note:* The proposed microgrid does not rely on Central Hudson net-metering provisions for any new resources dedicated to serving Tier 1 critical facilities. The microgrid P3, however, may seek to structure qualifying project assets for inclusion in community net metering or community choice aggregation programs.

3.5.5 Describe the financing structure

The financing strategy for the project will be built on accessing private capital to supplement public capital sources for project financing. For example, tax credits and depreciation can provide access to equity and debt funds from private investors to carry qualifying tax benefits and liabilities. However, the P3's modest expected financial returns likely will limit access to some forms of commercial financing, necessitating a hybrid public-private financing structure. The public owners who support the P3 can access tax-exempt public capital sources, potentially including municipal bonds and federally insured public infrastructure development funding. Public entities with tax authority also can facilitate access to property assessed clean energy (PACE) funds for qualifying energy improvements. Grant funding (potentially including NY Prize Stage II and Stage III) will reduce project debt costs and further leverage P3 equity contributions. Each type of financing may contribute to a cost-effective capital financing strategy for the project, seeking to lower the capital costs of financing for the benefit of community taxpayers.

3.6 Legal Viability

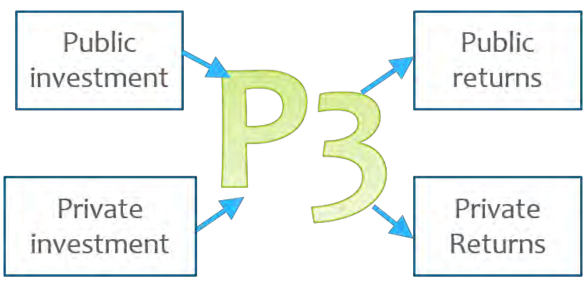
The project legal viability depends on factors that require resolution in Stage 2. The P3 ownership structure must be validated through Stage 2 collaboration with prospective P3 owners. The potential BOT arrangement must be validated through consultation with Central Hudson. Public Service Law and Central Hudson franchise issues must be addressed in Stage 2 through development of detailed operating agreements, concessions, and with administrative guidance from the New York Public Service Commission. Additionally, an operating methodology is required for the P3 to serve as a public-customer procurement agent for microgrid services.

3.6.1 Describe the ownership structure

A. Microgrid Public-Private Partnership (P3)

The project team anticipates that the proposed New Paltz Microgrid will be owned and operated by a public-private partnership (P3), combining private business and public organizational models to enable integrated planning, ensure strategic focus on community objectives, and provide access to a full range of funding and financing options. The P3 approach provides a comprehensive but flexible structure enabling the community to leverage investments that best support resiliency for critical services, while improving the community's energy and environmental infrastructure and supporting ongoing economic development. The team anticipates the P3 ownership structure will be formalized in Stage 2.

Fig. 3.6.1-A Public-private partnership structure

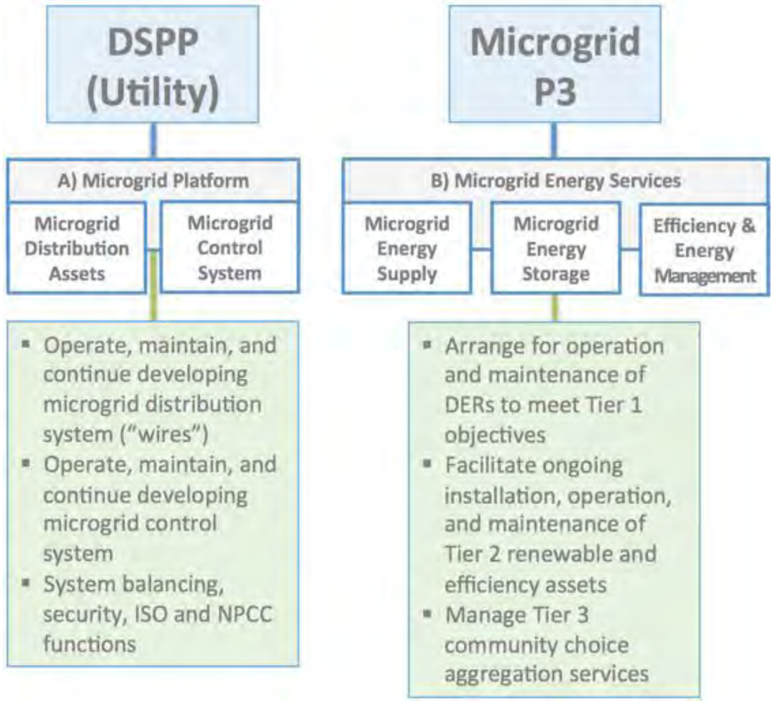


B. Build-Operate-Transfer Model

The project team proposes a potential build, own, operate and transfer structure. A BOT is a public-private partnership (P3) project model in which a private organization conducts a larger development project under contract with a public sector partner (such as the NY Prize communities).

The P3 can develop a larger public infrastructure project while accessing private funding in the capital stack for the project. A special purpose entity (SPE) would be formed to manage the construction, design, EPC, and operations of the project. To facilitate a BOT arrangement, the SPE would be structured with separation of generation ownership from project wires assets so that the two value streams from ownership are independent for accounting and regulation purposes. (*See Figs. 3.6.1-A and -B*)

Fig. 3.6.1-B: BOT microgrid - Post-Transfer Ownership Structure



3.6.2 Has the owner been identified? What is the approach?

The project team has discussed options for ownership participation in the microgrid P3, but formal agreements have not been entered. The project team anticipates continuing its involvement at the request of the charter members of the public-private partnership. In general:

Fig. 3.6.2-A New Paltz Microgrid P3 equity partners

Category	Prospective Owners
Public	Town of New Paltz, Village of New Paltz, SUNY at New Paltz, New Paltz Central School District, NYS DEC Region #3
Prosumer	Health Alliance of Hudson Valley (Woodland Pond), Stop and Shop Plaza, ShopRite, True Value Hardware, and individual businesses, institutions, and residential co-owners of microgrid resources
Private	Microgrid Institute, Hitachi Microgrids, Central Hudson Gas & Electric, third-party investors

3.6.4 Data security and privacy

Customer information is subject to best practices and industry standards for privacy and security, as well as data-retention policies. Systems for data entry, access, and storage will be designed to ensure cybersecurity and physical security against intrusion, unauthorized use, and data loss.

The proposed project customer service specifications include full-scope security, privacy, and data management policies.

IV. Benefit-Cost Analysis

The project team developed a general budget for the New Paltz 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, PCC controls, monitoring, and protection equipment. Some of these infrastructure costs may be paid to the electric utility. The estimated project budget for this project is $12 million with an accuracy of +/- 25% (within the +/- 30% range set by NYSERDA). This cost includes all applicable deductions associated with the federal investment tax credit (ITC) that was extended by the U.S. Congress in 2015. 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. *(See the project Task 3 report.)*

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 public-private partnership business model. Under this model, the project is funded with local and third-party investment and debt. Costs of invested capital are recovered through power purchase agreements (PPA) with each customer served by the microgrid.

In addition to the project team's financial feasibility analysis, NYSERDA contracted with Industrial Economics Inc. (IEc) to perform benefit-cost analyses for all 83 NY Prize Stage I projects. The focus of this analysis is to evaluate the societal benefits of the proposed microgrids, including benefits from emissions reductions, cost reductions, and resilience improvements. *(See "Appendix A – IEc Business-Cost Analysis.")*

Business Model Financial Results: Under the proposed business model, a P3 special-purpose entity 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 – except those that P3 participants wish to invest, including in-kind and real assets and cash – and would receive all of the benefits of cost savings, improved sustainability, and energy resilience against outage risks. Community stakeholders have indicated that P3 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 $0.166/kWh. Based on the estimated energy savings, assumed project financing costs, and the 25-year contract term, the study supports a PPA electric rate with an electric cost that represents an average discount of approximately 7 to 10% for the facilities in this project.

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 the various benefits produced, thus yielding a baseline cost-benefit ratio of 1.0. For the New Paltz Microgrid, the break-even outage case is less than one outage per year, for a duration of 2.4 hours (0.1 days/year). The IEc cost-benefit results are presented in Table 3.

Fig. 4-A: IEc Cost Benefit Analysis Summary

ECONOMIC MEASURE	EXPECTED DURATION OF MAJOR POWER OUTAGES	
	SCENARIO 1: 0 DAYS/YEAR	SCENARIO 2: 0.1 DAYS/YEAR
Net Benefits - Present Value	-$1,320,000	$4,850,000
Benefit-Cost Ratio	0.96	1.1
Internal Rate of Return	5.0%	10.4%

Figure 4-A summarizes the estimated net benefits, benefit-cost ratios, and internal rates of return for the scenarios described above. The results indicate that if there were no major power outages over the 20-year period analyzed (Scenario 1), the project’s costs would exceed its benefits. In order for the project’s benefits to outweigh its costs, the average duration of major outages would need to equal or exceed 0.1 days per year (Scenario 2). Appendix A provides additional detail on these findings.

The IEc 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 comparative results of these analyses in significant ways, including:

- Gas rates used in IEC’s benefit-cost analysis were based on a statewide average for commercial end-use customers. By comparison, the rates used in the New Paltz Microgrid financial feasibility analysis are based on Central Hudson’s distributed generation rate. This resulted in year-1 gas rates of $6.34 for the benefit-cost analysis, and $4.70 for the project team’s financial feasibility analysis. If Central Hudson’s distributed generation rate were applied to the benefit-cost analysis, net benefits would increase by $1.96 million.
- The financial feasibility assessment incorporates the tax benefits of the federal Investment Tax Credit, whereas the benefit-cost analysis does not. This benefit would reduce the capital cost of the project by approximately $3.6 million.

- Capital replacement costs used in the BCA were calculated as full-replacement costs, whereas the project team assumed a "rebuild" cost lower than the full cost of replacement (assuming continued use of existing assets where feasible). The rebuild cost for the New Paltz Microgrid is $1.83 million less than the full cost of replacement.
- 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, whereas the project's proposed P3 ownership model is based on a period of analysis of 25 years.

Lessons and Recommendations

Lessons Learned: The project team encountered several key challenges – some of them anticipated, some not anticipated.

Expected Challenges	Solutions	Lessons
Obtaining facility and load data	Standard template approach; persistent outreach; team site inspections; equivalent facility estimates for unavailable data	Budget substantial time and resources for stakeholder outreach and data gathering
Maintaining engagement among diverse stakeholder group	Regular project updates; follow-up outreach; thoughtful messaging; assistance from key stakeholders; site visits	Plan to provide project information for stakeholders in various forms and venues
Designing cost-effective solution meeting all customer requirements	Microgrid design and technology expertise; rigorous system modeling and financial analysis using state-of-the-art systems	Budget substantial time and resources for iterative modeling and analysis
Gaining utility support for alternative service models	Develop solutions that produce utility benefits	Engage utility as stakeholder; confirm utility support for community goals and project/program objectives; engage utility separately in design approach
Procurement requirements among public entity stakeholders	Determine requirements and develop processes to meet agency policies	Anticipate conflicting requirements and expectations among stakeholders

Unexpected Challenges	Solutions	Lessons
Vulnerable **resource lock-in** (e.g., *critical*	Develop alternative service models for locked-in loads	Expedite inquiries re: plans for remote net-metered systems

loads that are committed under long-term contract to purchase energy from non-resilient sources)		and other commitments to purchase energy from non-resilient sources; encourage integrated development of resources to maximize resilience; inform stakeholders that locked-in critical loads will limit resiliency options and impose cost premiums; restructure remote net-metered energy agreements if possible to support microgrid design
Parallel programs compete for stakeholders' attention and priorities	Stakeholder engagement; integrated planning	Learn ASAP about competing plans and seek complementary solutions
Ongoing changes in community critical facility plans	Adaptive design and technology approach; ongoing engagement; sustained focus on project objectives	Plan for dynamic planning basis and numerous midstream changes

New York State Policy Recommendations: Sections of this report dedicated to subtasks 3.4.11 and 3.4.12 describe seven specific barriers to development of community microgrids (*e.g.,* legacy business model, vulnerable resource lock-in, monetization gap, regulatory risk, procurement hurdles, taxes and prevailing wages, and inadequate development funding support) and offer prospective solutions, including policy recommendations where appropriate. The following comments highlight and expand on policy issues and recommendations that the team has identified as most important to facilitate future deployment of community microgrids.

1) **Inadequate development funding support:** Community microgrids tend to be complex projects serving multiple purposes and involving numerous stakeholders with competing strategic interests. Two serious consequences arise from this fact: first, projects require a sustained, long-term focus on serving disparate and evolving strategic objectives; and second, development and engineering costs represent a disproportionately large share of total system investment costs.

Communities generally lack the in-house technical expertise and long-term project management capacity necessary to execute such complex, integrated projects. Such expertise and capacity can readily be procured from third-party entities, but communities generally lack development capital to support such contracted services.

NY Prize funds notwithstanding, communities need greater access to grants and loan guarantees that can be applied to wide-ranging community clean energy and resiliency efforts. Existing programs are too narrowly focused, with short timelines and administrative restrictions, to support communities' needs for energy planning and project development requirements. Such lack of readily accessible and flexible funding deters many communities from integrated strategic energy planning and execution.

Solutions: Establish programs to support community energy planning and integrated community resiliency development, including annually renewed grants for early-stage assessment, development, design, and engineering, and loan guarantees and special development district financing (*e.g.,* property assessed clean energy (PACE) bonds).

2) **Legacy business model:** Approaches to microgrid development that challenge traditional business models or alter customer relationships may prompt market incumbents to delay or prevent project progress. The New York Reforming the Energy Vision (REV) initiative has established a market-leading framework for envisioning and implementing new approaches to providing energy services. To the degree the State of New York implements regulatory options that allow communities to pursue alternative service arrangements, the REV process will enable community microgrid development. Contrariwise, to the degree it limits options to those that reinforce legacy business models, the REV process will maintain key regulatory barriers that impede community microgrids. *Solution:* Define appropriate operating agreements, concessions, or exemptions, and facilitate their execution to enable project progress. Establish roles for franchised utilities that enable their beneficial involvement without impeding communities' access to innovative technologies and competitive service options.

3) **Vulnerable resource lock-in:** Net-metering policies that provide incentives for grid-tied DER deployments that effectively bind customers to purchasing utility power that is to be offset by net-metered renewable resources. Such a structure can diminish community resiliency when net-metered generation is deployed to offset the electricity purchases of critical-load customers, but isn't available to serve critical loads during an outage in the local distribution network. Noteworthy examples encountered by the project team include school districts entering remote net-metering contracts that offset substantially all of the school district's energy purchases, limiting the cost effective addition of resilient energy supplies on-site for school district facilities that can serve as public shelters. *Solutions:* For a given project, stakeholder collaboration is necessary to define resiliency objectives, identify options, and develop appropriate solutions to ensure that net-metered resources are designed and contracted in ways that support community resiliency and do not diminish it. Additionally, New York State policies could be revised to encourage investment in resilient DERs and discourage vulnerable resource lock-in. Specifically, New York could:

a. Define microgrids as a special class of asset that blends renewable and non-renewable DG with storage and demand resources;
b. Provide simplified and more flexible treatment of those resources, especially for purposes of net metering;
c. Establish higher net-metered facility caps for qualifying community microgrids;
d. Establish allowances for blended assets to explicitly allow full credit for the renewable output in the net-metering statute;
e. Change net-metering policies to allow re-marketing of non-resilient net-metered resources to non-critical customers on equivalent financial terms, freeing critical loads for service by resilient resources;
f. Establish bonus incentives to encourage deployment of resilient resources to serve loads deemed critical to communities. (Such incentives would reduce the economic penalty of

the interconnection, protection, and energy management systems necessary to enable safe and stable islanding – a key factor that deters net-metering customers from investing in resilient resources.); and

g. Structure net-metering policies to discourage, restrict, or prohibit long-term agreements that bind critical loads to non-resilient resources.

4) **Procurement hurdles:** Government procurement policies may compel state entities to apply competitive procurement requirements to microgrid participation. Differing requirements among various stakeholders create complexities and conflicts among participants, and some procurement requirements can deter early-stage contributions from qualified developers and vendors. For example, to the degree communities expect vendors and service providers to bear a portion of the risks and costs of early-stage development, communities' options will be limited to those few providers positioned to bear such costs and risks – and they may demand reimbursement for cost-shared contributions in the event they are not selected for a deployment contract. Such outcomes can yield project arrangements designed to prioritize the financial objectives of vendors and service providers, rather than the objectives of community stakeholders. *Solution:* Solutions to 1), above, can provide communities with greater flexibility to pursue alternatives optimized for their purposes. Also, a project consortium may be structured to perform as a procurement agent for the community microgrid's public owners and customers. Such a role will be most effective if the State of New York provides public entities with confidence that they can participate in joint procurement arrangements without violating regulations.

New Paltz Microgrid Project Recommendations: The results of the project team's feasibility assessment, as well as the IEc cost-benefit analysis, indicate that proposed New Paltz Microgrid project would be a technically and economically feasible solution. It would address the six community goals identified for the project, and it would satisfy the technical and economic criteria described by NYSERDA for the NY Prize program.

Additionally, the proposed microgrid would establish a replicable and financeable structure for community microgrids that could be applied to other communities throughout the state of New York. Specifically, it would demonstrate a scalable and flexible public-private partnership (P3) ownership model; a multi-tiered service model that can be adapted for use in any community with similar strategic goals; a design and technology approach capable of providing resilience for critical facilities throughout a community; a financing approach that establishes standard covenants and structures capable of attracting both public and private commercial financing; and an integrated community planning approach that efficiently addresses both immediate and long-term community needs.

As a result, the project team strongly supports continued development of the New Paltz Microgrid, and anticipates working with community stakeholders to prepare a NY Prize Stage 2 application for this project.

-END TASK 5 REPORT-

Appendix A: Benefit-Cost Analysis

Industrial Economics Inc. Business-Cost Analysis summary follows.

Benefit-Cost Analysis Summary Report

Site 46 – Town of New Paltz

PROJECT OVERVIEW

As part of NYSERDA's NY Prize community microgrid competition, the Town of New Paltz has proposed development of a microgrid that would serve the following facilities, grouped into ten nodes:

- Node 1 – New Paltz Wastewater Treatment Plant;
- Node 2 – Woodland Pond Care Center;
- Node 3 – Mt. Rest Road Pumping Station;
- Node 4 – SUNY Eliting Gym, SUNY Wellness Center, and SUNY Student Health Center;
- Node 5 – New Paltz High School;
- Node 6 – New Paltz Rescue Squad;
- Node 7 – NYS Department of Environmental Conservation (DEC), Institute for Family Health, Meadowbrook Farms II Apartments, ShopRite Grocery, Stop & Shop Grocery, Sunoco Gas Station, and True Value Hardware;
- Node 8 – Dedrick's Pharmacy, Convenient Deli, and New Paltz Middle School;
- Node 9 – New Paltz Municipal Center, My Market Grocery, ZNE Housing Development, New Paltz Community Center & Municipal Pool, Duzine Elementary School, and Stewarts Convenience Store; and
- Node 10 – Fire Station #2.

The microgrid would combine gas-fired generators, diesel-fired generators, combined heat and power (CHP) systems, and solar capabilities to provide base load power. The existing photovoltaic (PV) array, gas-fired generators, and diesel-fired generator have a total nameplate capacity of 600 kW. The new PV arrays would have a total nameplate capacity of 2.558 MW. The new gas-fired generators would have a total nameplate capacity of 1.328 MW, and the new diesel-fired generators would have a total nameplate capacity of 775 kW. The town anticipates that the new DERs would produce electricity for the grid during periods of normal operation; in contrast, the existing and new emergency generators would only operate in islanded mode. The system as designed would have sufficient generating capacity to meet average demand for electricity from the facilities on the microgrid during a major outage. Project consultants also indicate that the system would have the capability of providing ancillary services to the grid.

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

METHODOLOGY AND ASSUMPTIONS

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

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

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

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

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

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

The BCA considers costs and benefits for two scenarios:

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

RESULTS

Table 1 summarizes the estimated net benefits, benefit-cost ratios, and internal rates of return for the scenarios described above. The results indicate that if there were no major power outages over the 20-year period analyzed (Scenario 1), the project's costs would exceed its benefits. In order for the project's benefits to outweigh its costs, the average duration of major outages would need to equal or exceed 0.1 days per year (Scenario 2). The discussion that follows provides additional detail on these findings.

Table 1. BCA Results (Assuming 7 Percent Discount Rate)

ECONOMIC MEASURE	EXPECTED DURATION OF MAJOR POWER OUTAGES	
	SCENARIO 1: 0 DAYS/YEAR	SCENARIO 2: 0.1 DAYS/YEAR
Net Benefits - Present Value	-$1,320,000	$4,850,000
Benefit-Cost Ratio	0.96	1.1
Internal Rate of Return	5.0%	10.4%

Scenario 1

Figure 1 and Table 2 present the detailed results of the Scenario 1 analysis.

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

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

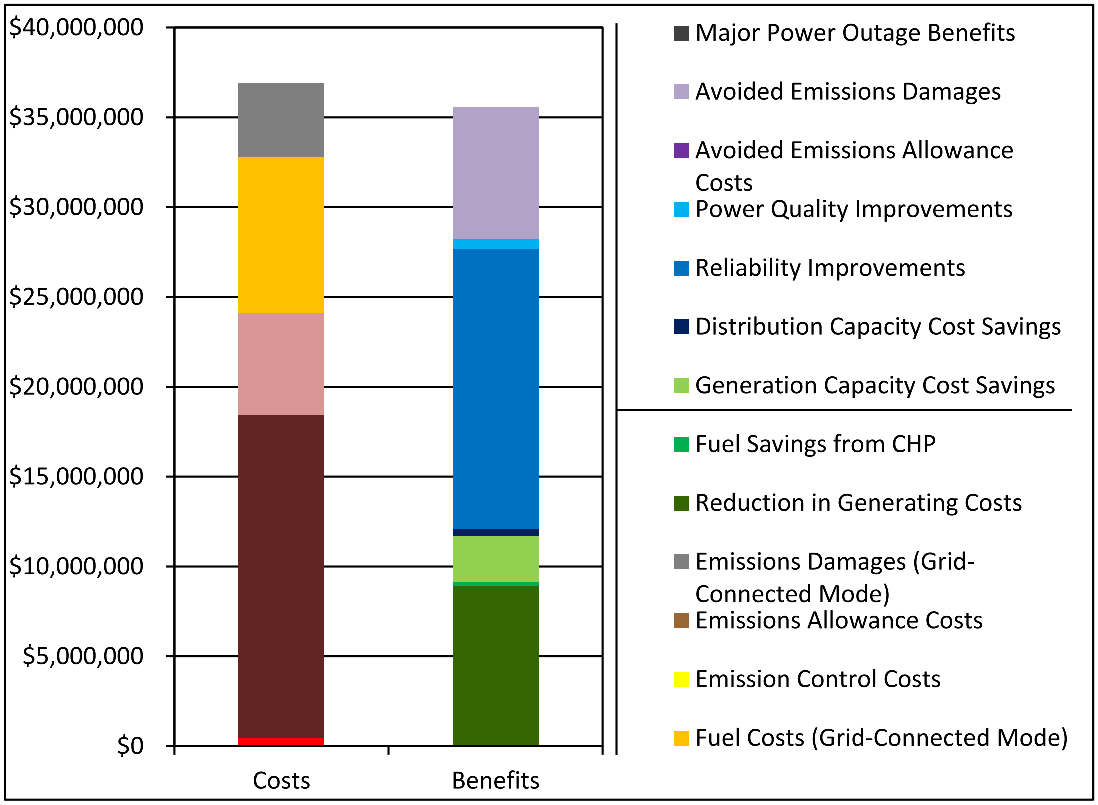

Table 2. Detailed BCA Results, Scenario 1 (No Major Power Outages; 7 Percent Discount Rate)

COST OR BENEFIT CATEGORY	PRESENT VALUE OVER 20 YEARS (2014$)	ANNUALIZED VALUE (2014$)
Costs		
Initial Design and Planning	$475,000	$41,900
Capital Investments	$18,000,000	$1,450,000
Fixed O&M	$5,640,000	$498,000
Variable O&M (Grid-Connected Mode)	$0	$0
Fuel (Grid-Connected Mode)	$8,700,000	$767,000
Emission Control	$0	$0
Emissions Allowances	$0	$0
Emissions Damages (Grid-Connected Mode)	$4,090,000	$267,000
Total Costs	**$36,900,000**	
Benefits		
Reduction in Generating Costs	$8,940,000	$788,000
Fuel Savings from CHP	$220,000	$19,400
Generation Capacity Cost Savings	$2,570,000	$226,000
Distribution Capacity Cost Savings	$387,000	$34,200
Reliability Improvements	$15,600,000	$1,380,000
Power Quality Improvements	$536,000	$47,300
Avoided Emissions Allowance Costs	$4,800	$424
Avoided Emissions Damages	$7,320,000	$478,000
Major Power Outage Benefits	$0	$0
Total Benefits	**$35,600,000**	
Net Benefits	**-$1,320,000**	
Benefit/Cost Ratio	**0.96**	
Internal Rate of Return	**5.0%**	

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. The present value of the project's capital costs is estimated at approximately $18 million, including costs associated with installing a microgrid control system; equipment for the substations that will be used to manage the microgrid; the IT infrastructure (communication cabling) for the microgrid; the new gas-fired generators; the new diesel-fired generators; the new photovoltaic arrays; and the power lines needed to distribute the electricity the microgrid would generate. Operation and maintenance (O&M) of the entire system would be provided under fixed price service contracts, at an estimated annual cost of $498,000. The present value of these O&M costs over a 20-year operating period is approximately $5.6 million.

Variable Costs

The most significant variable cost associated with the proposed project is the cost of natural gas to fuel operation of the system's primary 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.[3] The present value of the project's fuel costs over a 20-year operating period is estimated to be approximately $8.7 million.

The analysis of variable costs also 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 natural gas generators are estimated at approximately $267,000 annually. The majority of these damages are attributable to the emission of CO_2. Over a 20-year operating period, the present value of emissions damages is estimated at approximately $4.1 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 $8.9 million. This estimate assumes the microgrid provides base load power – consistent with the operating profile upon which the analysis is based – and takes into account not only the electricity that the microgrid's distributed energy resources would produce, but also an anticipated reduction in annual electricity use at the facilities the microgrid would serve.[4] Cost savings would also result from reductions in fuel consumption for space heating purposes. The BCA estimates the present value of these savings over a 20-year operating period to be approximately $220,000; The reduction in demand for electricity from bulk energy suppliers and the fuel efficiency of the new CHP systems would also reduce emissions of CO_2 and NO_x from these sources, yielding emissions allowance cost savings with a present value of approximately $4,800 and avoided emissions damages with a present value of approximately $7.3 million.[5]

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.[6] The analysis estimates the impact on available generating capacity to be approximately 1.7 MW per year, based primarily on estimates of output from the new CHP units. In addition, the project team expects development of the microgrid to reduce the conventional grid's demand for generating capacity by an additional 0.52 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 $2.6 million over a 20-year operating period. The present value of the project's potential distribution capacity benefits is estimated to be approximately $387,000.

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[3] 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.

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

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

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

The project team has indicated that the proposed microgrid would be designed to provide ancillary services to the New York Independent System Operator (NYISO). Whether NYISO would select the project to provide these services depends on NYISO's requirements and the ability of the project to provide support at a cost lower than that of alternative sources. Based on discussions with NYISO, it is our understanding that the market for ancillary services is 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 $1.4 million per year, with a present value of approximately $15.6 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:[7]

- System Average Interruption Frequency Index (SAIFI) – 1.24 events per year.
- Customer Average Interruption Duration Index (CAIDI) – 136.2 minutes.[8]

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.[9] It assumes that establishment of a microgrid would reduce the rate of failure to near zero.

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

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 New Paltz project team estimates that the microgrid would help the facilities it serves avoid an average of approximately 2.3 power quality events per year. The model estimates the present value of this benefit to be approximately $536,000 over a 20-year operating period.

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[7] www.icecalculator.com.

[8] The analysis is based on DPS's reported 2014 SAIFI and CAIDI values for Central Hudson Gas & Electric.

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

Summary

The analysis of Scenario 1 yields a benefit/cost ratio of 0.96; i.e., the estimate of project benefits is approximately 96 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.[10,11]

As noted above, the Town of New Paltz's microgrid project would serve 25 facilities. The project's consultants indicate that at present, only Woodland Pond Care Center, Mt. Rest Road Pumping Station, SUNY Wellness Center, SUNY Student Health Center, ShopRite Grocery, Stop & Shop Grocery, and My Market Grocery are equipped with backup generators; the level of service these units can support ranges from 0 to 100 percent (see Table 3). Operation of these units costs approximately $2,000 per day.

Table 3. Percent Loss in Service While on Backup Power, Scenario 2

FACILITY NAME	PERCENT LOSS IN SERVICE WHILE ON BACKUP POWER
Woodland Pond Care Center	56%
Mt. Rest Road Pumping Station	25%
SUNY Wellness Center	90%
SUNY Student Health Center	0%
ShopRite	100%
Stop &Shop	25%
My Market Grocery	100%

Project consultants indicate that the following facilities would rent backup generators in the event of an outage: the New Paltz Wastewater Treatment Plant; New Paltz High School; New Paltz Rescue Squad; NYS DEC; Sunoco Gas Station; Meadowbrook Farms II Apartments; New Paltz Middle School; Dedrick's Pharmacy; Duzine Elementary School; and the New Paltz Municipal Center. The operation of these units would cost approximately $8,200 per day. In the absence of backup power – i.e., if the backup generators failed and no replacements were available – these facilities, as well as those currently

[10] 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.

[11] 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.

equipped with their own backup generators – would experience losses in service capabilities ranging from 0 to 100 percent (see Table 4).

Table 4. Percent Loss in Services in the Absence of Backup Power, Scenario 2

FACILITY NAME	PERCENT LOSS IN SERVICES WHEN BACKUP IS NOT AVAILABLE
New Paltz Wastewater Treatment Plant	100%
Woodland Pond Care Center	100%
Mt. Rest Road Pumping Station	100%
SUNY Eliting Gym	95%
SUNY Wellness Center	95%
SUNY Student Health Center	95%
New Paltz High School	100%
New Paltz Rescue Squad	75%
NYS Dept. of Environmental Conservation	90%
Institute for Family Health	100%
Meadowbrook Farms II Apartments	100%
ShopRite	100%
Stop &Shop	100%
Sunoco	100%
True Value Hardware	100%
Dedrick's Pharmacy/Convenient Deli	100%
New Paltz Middle School	100%
New Paltz Municipal Center	95%
My Market Grocery	100%
ZNE Housing Development	100%
New Paltz Community Ctr. & Municipal Pool	100%
Duzine Elementary School	100%
Stewarts Convenience Store	100%
Fire Station #2	0%

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

- SUNY Eliting Gym, SUNY Wellness Center, New Paltz High School, New Paltz Middle School, New Paltz Municipal Center, and Duzine Elementary School would be used for emergency shelter, and the New Paltz Community Center would be used as an emergency operations center and police station.
- The fire station would remain fully in service (its garage doors can be operated manually, and dispatch is handled elsewhere). A loss in lighting and phones would not materially affect the serviceability of the facility.

- In the event of an outage during the winter, additional costs would be incurred at New Paltz High School, New Paltz Middle School, and Duzine Elementary School to prevent pipes from freezing.[12]
- In all cases, the supply of fuel necessary to operate the backup generators would be maintained indefinitely.
- At each facility or cluster of facilities, there is a 15 percent chance that the backup generator would fail.

The economic consequences of a major power outage also depend on the value of the services the facilities of interest provide. The impact of a loss in service at these facilities is based on the following value of service estimates:

- For the New Paltz Wastewater Treatment Facility, a value of approximately $939,000/day.[13]
- For Woodland Pond Care Center, a value of approximately $113,000 per day. This figure is based on the approximate number of residents at this facility (300) and state data on the average rate for nursing home care in the area ($377/patient/day).[14]
- For Mount Rest Rd. Pumping Station, a value of approximately $772,000/day.[15]
- For the Police Department, a value of approximately $2,900 per day.[16]
- For Meadowbrook II Farms Apartments and ZNE Housing Development, a value of approximately $11,300 per day.[17]
- For the emergency shelters (SUNY Eliting Gym, SUNY Wellness Center, New Paltz High School, New Paltz Middle School, New Paltz Municipal Center, and Duzine Elementary School), a value of approximately $382,000 per day.[18]
- For Node 7 (ShopRite Grocery, Stop & Shop Grocery, Sunoco Gas Station, Institute for Family Health, NYS DEC, True Value Hardware), a value of approximately $597,000 per day.[19]
- For Group A (SUNY Student Health Center and Dedrick's Pharmacy), a value of approximately $130,000 per day.[20]

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[12] Because these costs would only be incurred during the winter, the probability that an outage would trigger them is set at 25 percent..

[13] This figure is based on FEMA's standard methodology for facilities of this type.

[14] https://www.health.ny.gov/facilities/nursing/estimated_average_rates.htm. Note that this value is at best a rough approximation of the social welfare loss attributable to a loss of power at a facility of this type, as it does not account for potential impacts on the health and well-being of residents or for changes in the cost of caring for residents during an extended outage.

[15] This figure is based on FEMA's standard methodology for facilities of this type..

[16] This figure is based on FEMA's standard methodology for facilities of this type. In this case it represents the value of service for the New Paltz Community Center, which would become an emergency operations center and serve as a base of operations for the police department in the event of an outage.

[17] This figure is based on FEMA's standard methodology for facilities of this type..

[18] This figure is based on FEMA guidelines on space requirements for emergency shelters (40 ft^2/person) and Red Cross guidelines on the cost of providing a shelter ($50 per person per day).

[19] www.icecalculator.com; The service value for these facilities was developed for the group as a whole, based on the common number of hours of electricity they would require during an outage (24 hours per day) and similar average annual electricity usage per customer.

- For Group B (My Market Grocery and Stewarts Convenience), a value of approximately $94,000 per day.[21]

Based on these values, the analysis estimates that in the absence of a microgrid, the average cost of an outage for the facilities of interest is approximately $2.9 million per day.

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 0.1 days per year without power. If the average annual duration of the outages the microgrid prevents is below this figure, its costs are projected to exceed its benefits.

[20] *ibid*

[21] *ibid*.

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

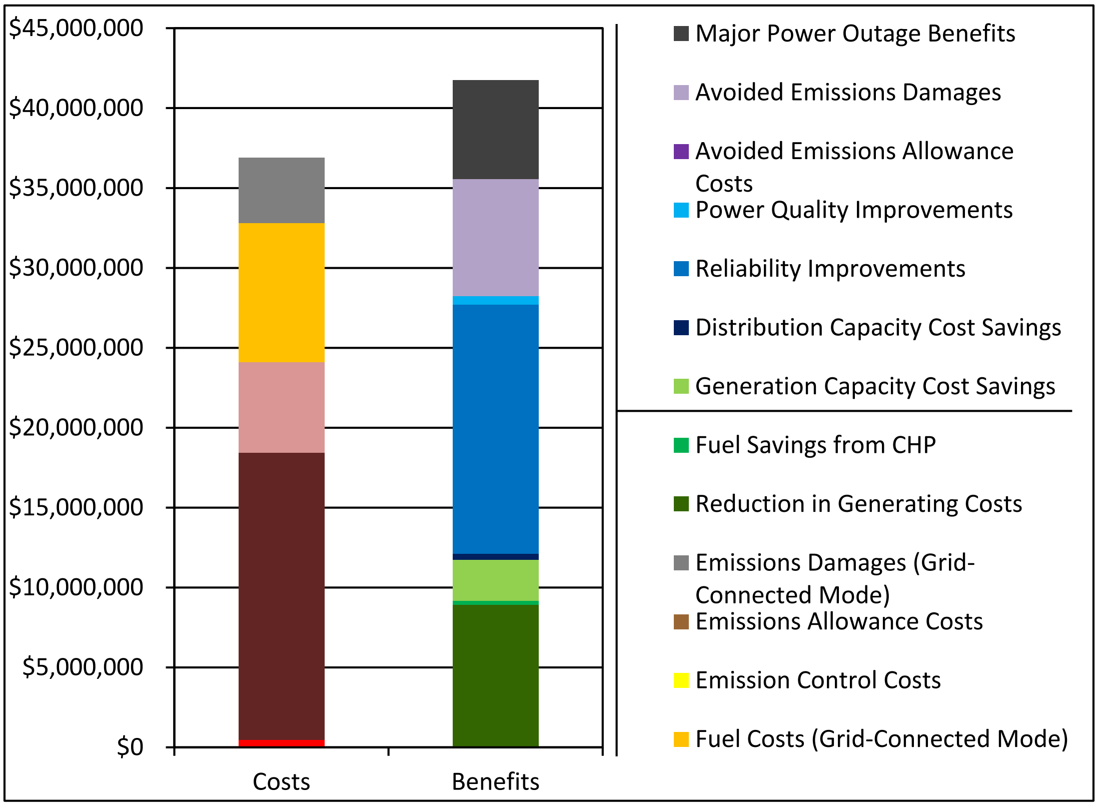


Table 5. Detailed BCA Results, Scenario 2 (Major Power Outages Averaging 0.1 Days/Year; 7 Percent Discount Rate)

COST OR BENEFIT CATEGORY	PRESENT VALUE OVER 20 YEARS (2014$)	ANNUALIZED VALUE (2014$)
Costs		
Initial Design and Planning	$475,000	$41,900
Capital Investments	$18,000,000	$1,450,000
Fixed O&M	$5,640,000	$498,000
Variable O&M (Grid-Connected Mode)	$0	$0
Fuel (Grid-Connected Mode)	$8,700,000	$767,000
Emission Control	$0	$0
Emissions Allowances	$0	$0
Emissions Damages (Grid-Connected Mode)	$4,090,000	$267,000
Total Costs	**$36,900,000**	
Benefits		
Reduction in Generating Costs	$8,940,000	$788,000
Fuel Savings from CHP	$220,000	$19,400
Generation Capacity Cost Savings	$2,570,000	$226,000
Transmission & Distribution Capacity Cost Savings	$387,000	$34,200
Reliability Improvements	$15,600,000	$1,380,000
Power Quality Improvements	$536,000	$47,300
Avoided Emissions Allowance Costs	$4,800	$424
Avoided Emissions Damages	$7,320,000	$478,000
Major Power Outage Benefits	$6,170,000	$544,000
Total Benefits	**$41,700,000**	
Net Benefits	**$4,850,000**	
Benefit/Cost Ratio	**1.1**	
Internal Rate of Return	**10.4%**	

Appendix B: Task 1, Task 2, and Task 3 Reports

Final Task 1, Task 2, and Task 3 Project Reports follow.

NY Prize Stage 1 – New Paltz Microgrid Project

Capabilities Report

Sept. 15, 2015

Prepared For:

<u>NYSERDA</u>

Prepared By:

New Paltz Microgrid Project Technical Team

In cooperation with Project Stakeholders including the Town and Village of New Paltz

New Paltz Microgrid Project – NY Prize Stage I
Task 1 Deliverable: Microgrid Capabilities Report

Summary: This report outlines the minimum required capabilities of a community microgrid for the Town and Village of New Paltz in Ulster County, New York. The Project Team believes this microgrid design will serve as a leading example for New York, and will be beneficial and replicable for hundreds of other communities across the state and beyond. The approach to microgrid architecture, design, and business operations described below incorporates lessons learned and best practices from other existing microgrid projects that the Technical Team has designed and developed (*e.g.,* Olney Town Center in Maryland). It also aims to support New York State initiatives to foster innovation and competition in energy services, including the Reforming the Energy Vision (REV) proceeding.

The New Paltz microgrid design is focused on the development of an overall energy strategy that incorporates both load management and new distributed generation and energy storage resources to support the microgrid's strategic and operational objectives. Microgrid operational objectives include improving resiliency, increasing energy efficiency, reducing environmental emissions, and reducing cost to energy users in the New Paltz community. Microgrid strategic objectives include establishing an engineering and economic platform for providing actionable energy resource information and supporting efficient deployment and operation of innovative clean energy systems.

Task 1.1 Minimum Required Capabilities

a. Serves Critical Facilities

The microgrid is expected to provide resilient energy services to a group of facilities with critical and vital loads in the project area, as listed below:

- New Paltz Village Hall
- Fire Stations #1 & #2, Rescue Squad
- New Paltz Police Department
- New Paltz Water and Wastewater Systems
- SUNY at New Paltz Wellness Center, Elting Gymnasium, Health Center, and Campus Police Department
- New Paltz High School
- New Paltz Middle School
- Shop Rite and Stop&Shop Grocery Stores and Pharmacies
- New York State Department of Environmental Conservation Region 3 Facilities
- Low-income and vulnerable population housing facilities
- Gas stations, mechanic shops, hardware stores

These public shelter, command center, emergency response, water system, and retail facilities are important to the region for continued operations during extended grid outages and major storms. This mix includes state and local government (both Town and Village of New Paltz), public safety, private non-profit healthcare, and private for-profit business interests.

In addition to directly providing resilient energy services for several hundred housing units for low-income and vulnerable populations, the New Paltz Microgrid will directly or indirectly benefit all 14,000 residents of New Paltz, plus 8,000 SUNY students, and by extension the 182,000 residents of Ulster County.

b. Primary Generation Resources

Generation sources in the community microgrid include the following:

- Natural Gas and Biofuel-fired Generators and Combined Heat and Power (CHP) Units
- Solar Photovoltaics (PV)
- Energy Storage
- Building Efficiency and Load Control

The mid-Hudson Valley region has substantial bio resources and prospects for regional bio-resource projects, so to the degree feasible CHP will be biogas/biomass fueled, depending on maturity, resource availability, economic, and reliability drivers.

Solar PV capacity will be rooftop, parking lot, or ground-mounted systems using hail-rated solar panels. The energy storage systems are anticipated to be proven fast-responding Lithium-ion and flow battery technologies, although other options will be considered.

Due to community desires to exploit local renewable energy resources and reduce reliance on natural gas and other fossil fuels, the Team will assess alternate methods for renewable and alternate fuels for the gas-fired generators and CHP units, as much as possible.

Existing generation assets will also be included in the microgrid. They include rooftop solar PV at Village and SUNY facilities (totaling 65 kW); and gas-fired backup generators at several Town and Village facilities (approximately 300 kW). (The design basis omits consideration of diesel-fired systems that depend on regular refueling and produce undesirable environmental consequences.)

The Team's preliminary analysis of minimum energy needs for critical and vital facilities in New Paltz suggests targeting between 1,000 kW and 1,500 kW of natural gas and/or biomass-fired generators and CHP systems, 900 kW to 1,200 kW of solar PV systems, and 350 kW to 450 kW of energy storage systems, distributed throughout the resilient community microgrid.

c. Power in Grid-Connected and Island Modes

The basis of the microgrid is a portfolio of energy resources on a new underground cable network (converted from overhead lines) on existing rights of way within the two primary node groups (East and West). Because the microgrid project area is served almost exclusively with overhead distribution lines and service drops, the basis for resiliency would be improved by converting key segments to underground cables. On loss of the grid, utility-controlled, remotely operated isolation switches would isolate these underground portions of the utility's circuits, leaving the microgrid to remain powered with its own distributed generators and CHP units, PV, energy storage systems, and building load control.

To maximize overall efficiencies, CHP units will be sited optimally to serve the thermal loads of larger buildings in the microgrid area. Solar PV arrays will be sited in optimal locations throughout the network, most notably on suitable rooftops, parking areas, and open land where available. Energy storage units, which are relatively small, will be sited near the solar PV resources, with a preference for indoor locations.

The layout of critical facilities in U.S. communities is typically dispersed, often served by multiple separate circuits in the power network. The New Paltz project area includes two contiguous community microgrid areas with a mixture of critical and non-critical loads, served on two 13.2 kV circuits from a single substation. As stated before, the New Paltz Microgrid is conceive as mixed-resource portfolio. The reasoning for this approach is shown below in the Team's Microgrid Portfolio Concept for financially viable microgrids (*see Fig. 2*):

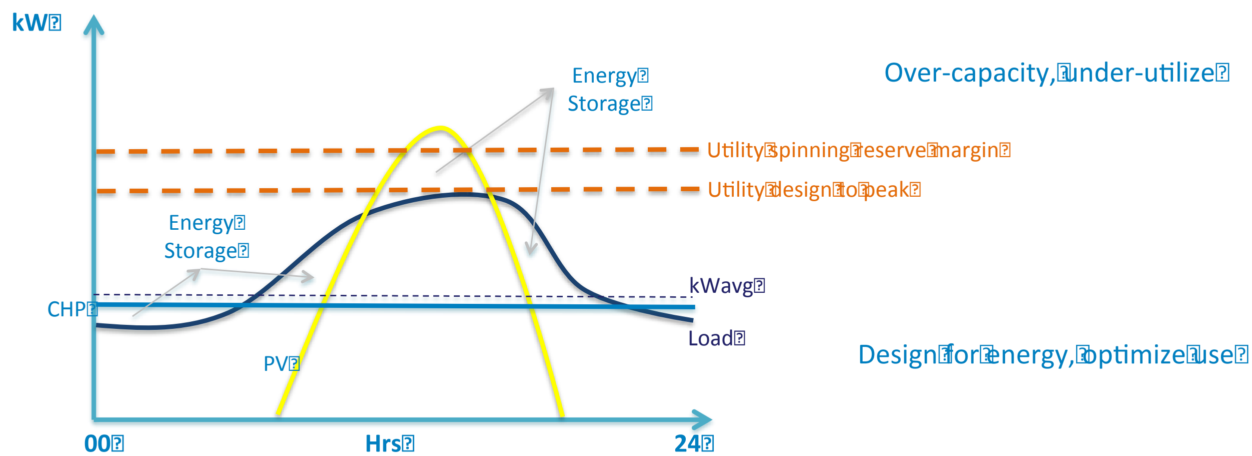


Figure 2: The Microgrid Portfolio Concept

Natural gas (NG) fuel cells, microturbines, and CHP units generally are not designed to follow load. With de-rating of units, they can be used as variable resources. Using such generators in this way, however, can impair their operating efficiency and reduce their reliability and service life. In addition, emissions per unit of energy output often are increased, and maintenance costs are much higher – double or more – with sub-optimal use. Finally, some vendors will void warranties when base-load units are used as load-following units.

To better match the load profile, our approach is to reduce the size of the base-load generation units (CHP systems, for example) so that they run at design output for at least 8,000 hours per year.

This means that for a majority of the day, the load and CHP generation are closely coordinated. Daytime peak customer loads are better served with generation resources that have an output profile similar to the load, such as PV. Since energy storage can be designed to change its output rapidly and address ramp-rate issues, ESS can be used to follow load and to buffer the differences between CHP, electrical load, and PV throughout the day. Also, it is very important to consider the thermal load, including thermal energy storage and existing boiler operations, to ensure the resource portfolio is designed and operated to meet thermal ramping requirements as well.

From the long-term operations and maintenance standpoint, the Portfolio Concept enables the microgrid to use its resources within their design envelope. This helps keep maintenance costs and fuel costs at their minimum, making the total cost of ownership as low as possible.

Further, active microgrid controls enable optimal incorporation of energy efficiency measures, energy storage, PV, and building management systems to control load in such a way to reduce the afternoon peak load when needed (see Figure 3).

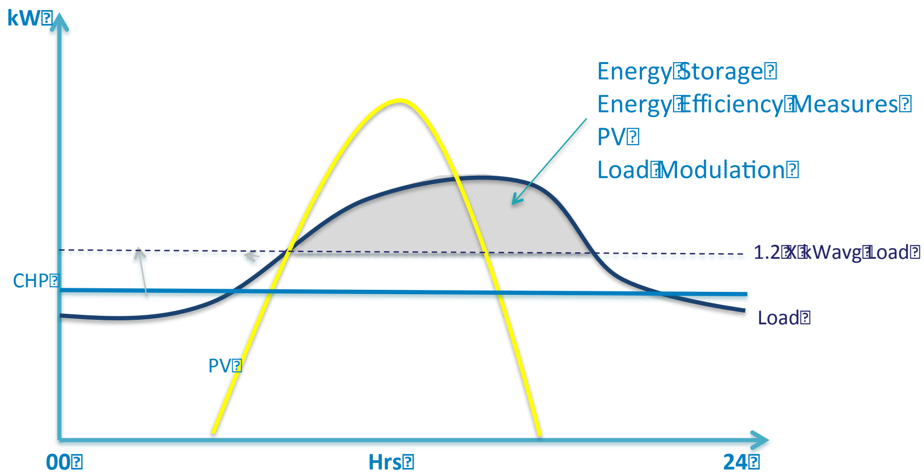


Figure 3: Area of Interest for Active Management of Load

The benefit of this approach is to enable the microgrid's resources to serve connected loads more efficiently, more cost effectively, and with lower emissions per unit of energy consumed.

As Figure 4 illustrates, critical facilities in the community reach their peak demand for only a few hours each year. This means all critical facility services can be served by the "always-on" microgrid resources for the vast majority of hours in a year without over-sizing generation capacity. In essence, the resiliency provided by the microgrid is consistent with favorable economic and emissions performance, as compared to traditional approaches where generation systems are oversized to accommodate peak loads, and where thermal and electrical needs are satisfied independently of each other. And even utility electric service is lost, the impact on critical facility services is minimized because utility power supplies represent a small portion of the energy supply to the critical facility in grid-connected mode.

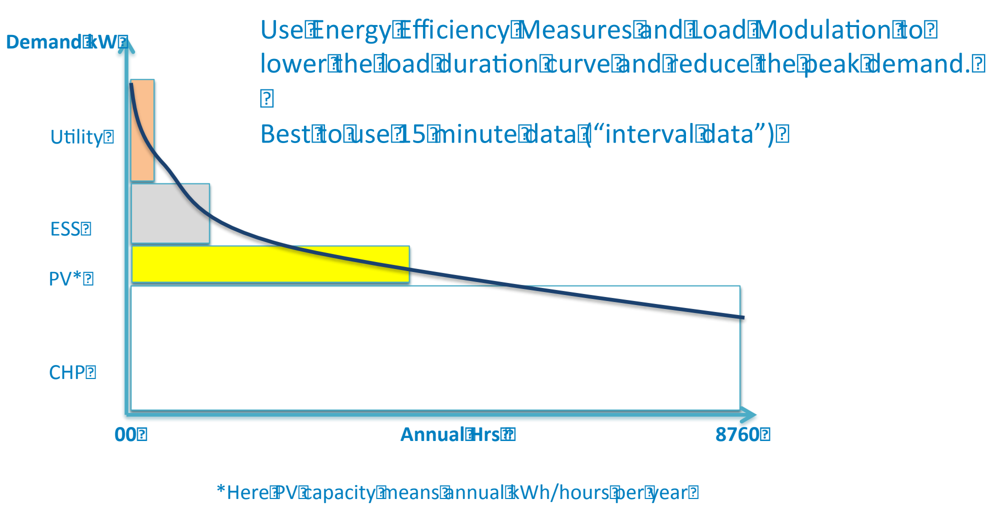


Figure 4: Load Duration Curve

The microgrid will use a proven microgrid controller. This sophisticated active microgrid control system ensures that the microgrid's operation is being optimized for resiliency. The same software is used to manage the microgrid resources as a fleet for optimizing economics and minimizing emissions over all. The production and consumption balance of energy will be managed across the utility distribution system. The additional resiliency needed to protect the community will be available during island-mode operation of the microgrid controller. The result is improved resiliency for critical facilities and improved economics and environmental performance for the community as a whole.

In addition to this critical-facility microgrid design, the Team planned for a distributed energy overlay to serve the entire community's non-critical loads co-located with the critical loads. The plan includes sufficient distributed generation to serve the community's non-critical loads. If grid outages occur outside the community, but the community's distribution grid is unaffected, the total microgrid resources portfolio will continue to supply the needs of the non-critical loads as well as the critical facilities. If the community's distribution grid is affected, the microgrid will maintain service for facilities within the microgrid footprint, with resources prioritized for critical and vital loads.

d. Form Intentional Island

The Electric Power Research Institute (EPRI) and Oak Ridge National Laboratory collaborated on a set of ten (10) Microgrid Use Cases.[1] Use Case #3 – Intentional Islanding – describes the process by which a microgrid transitions from grid-connected operation to island-mode operation in a planned manner.

The islanding process for the New Paltz Microgrid will be semi-automatic so that a utility operator or local energy manager will be able to apply each operating step and resiliency-preserving option before opening the point of common coupling (PCC), which is the point where the microgrid connects to the utility grid. The utility operator will provide the appropriate permissions for opening the PCC. The local controller for the microgrid will be responsible for determining the voltage source and load-following resource for transitioning to island mode.

Island-mode operation, in general, is the key to community resiliency in the face of power system disturbances, such as outages due to major storms. During extended events and outages, resilient energy supplies become more critical for a variety of community services, beyond police, fire, and emergency response facilities. Island operation is necessary for community resiliency in any significant outage, and especially for multi-day outages like those experienced in New York in recent years.

Through the duration of an extended power system disturbance, different services become critical to the community's health, safety, and vitality. Police, fire, and emergency medical services are critical from the beginning of a major storm or extended outage, and other services become increasingly important with time. For the first few hours of an outage, for example, a community can manage without access to fresh water, groceries, or public shelters. Within 24 hours, however, such services become necessary, and in subsequent hours and days the community develops increasingly critical needs for access to pharmacies, gas stations, banks, and places to charge mobile phones and obtain Internet service.

One microgrid design approach involves using the smallest possible amount of distributed generation and storage to meet the bare minimum of critical loads. Such an approach requires curtailing critical loads at the beginning of an outage event, and restoring critical services when and if temporary generation resources can be acquired. However, this inverted approach can complicate relief and recovery efforts, because it constrains essential services from the beginning of the event. Also, this approach leaves the community dependent upon the inventory of temporary generation, which can be

[1] The EPRI Microgrid Use Cases repository is available at http://smartgrid.epri.com/Repository/Repository.aspx

unreliable and inadequate; in a major event, New Paltz will not be the only community seeking mobile generators, and units will be in short supply. Moreover, mobile generators burning liquid fuels can operate only until fuel supplies can be replenished, which can be challenging in the aftermath of a major weather event.

Another microgrid design approach is the Project Team's strategy, which involves installing local generation resources sufficient to supply the critical load at its typical level at the beginning of an outage event, and then operating those resources to maintain critical services at 80 percent of normal capacity through the entire event duration. This ensures continuous energy supplies for the most critical services – police, fire, and emergency responders – and maintains basic services enabling more community residents to shelter in place rather than evacuate the area. Such an approach provides the community with a more robust and sustainable system that can sustain critical and vital functions indefinitely, and right from the beginning of an outage event.

The process of islanding a microgrid can create problematic transient power conditions and add risk to operations. To minimize this, the Project Team employs a specific design approach to interconnecting with the utility grid at the point of common coupling. Refer to Figure 5 for a description of the PCC structure.

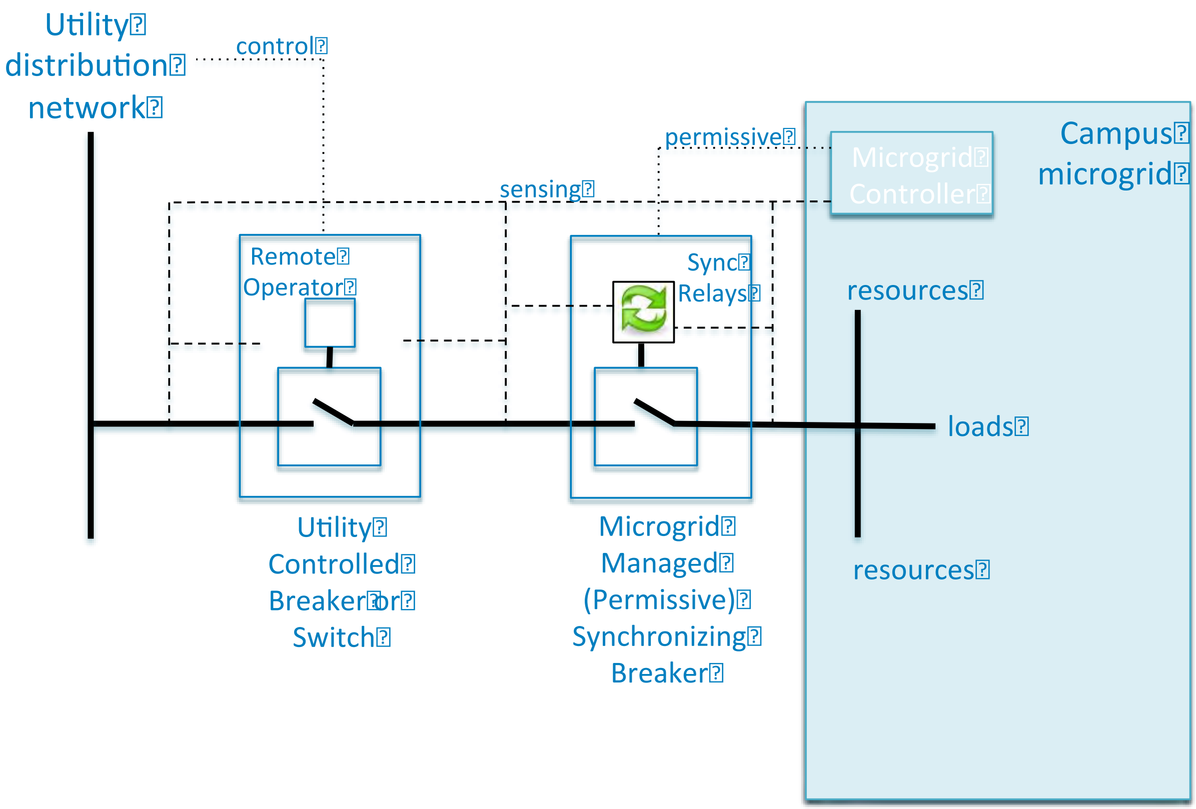


Figure 5: Point of Common Coupling (PCC) Structure

This 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 microgrid resources are dispatched to supply the portion of the load served by the utility grid just before the grid was lost. If and when the frequency dips to 57.0 Hz and the synchronizing breaker opens, the microgrid begins operating in an island mode. The microgrid controller will adjust all microgrid resources for the new state, to meet island performance objectives.

In a case where the island transition is too small to generate a transient (such as an intentional island operation), the microgrid controller will open the synchronizing breaker when voltage, frequency, and phase angle are matched and stable across the breaker.

e. Island from the Grid and Reconnect to the Grid

When islanding from the utility grid, several Use Cases are in action:

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 dispatching 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. The 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 step 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**: For each microgrid node, the islanding process will be automatic as described above.
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 most complex Use Case. 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 at a set of controllable generation and load assets. Within that portfolio, the system will 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**: This 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 setting or verify that the setting has changed appropriately. In either

condition if the test is false then the controller will issue a shutdown of each resource and initiate the appropriate alarm.

More discussion on the microgrid controls can be found below in section 1.2.

The sequence of events for transitioning to an island mode is discussed above.

The sequence of events for transitioning from an island mode to grid-connected mode is formed in accordance with the EPRI/ORNL Use Case 5. The summary of the transition is as follows:

- Utility determines it is acceptable for the microgrid to reconnect to the grid and closes the utility controlled breaker (see Figure 4).
- Microgrid controller senses voltage, frequency, and phase angle on the bus between the utility controlled breaker and the microgrid synchronizing breaker. The controller also senses voltage, frequency, and phase angle within the microgrid.
- Microgrid controller (and/or operator) decides to reconnect the microgrid to the utility grid.
- Microgrid controller adjusts controllable resources and loads to match voltage, frequency, and phase angle across the microgrid synchronizing breaker. This minimizes differences and power flows.
- When matched, the microgrid controller give a "permissive to close" signal to the microgrid synchronizing breaker.
- The synchronizing breaker does its own checking of voltage, frequency, and phase angle matching, and closes when matched.
- The microgrid controller places some microgrid load on the utility grid, and re-optimizes for economics and emissions reduction.

f. Scheduled Maintenance Intervals and Utilization of Power

The scheduled maintenance for the high-efficiency natural gas engine-based CHP typically requires a quarterly routine maintenance session (< 6 hours) plus an annual routine maintenance session (< 1 week). These CHP units typically demonstrate full power operations above 8,500 hours per year.

The scheduled maintenance for the PV is an annual cleaning. The Project Team's experience in California with PV is that solar panel surfaces foul to a 97% production level within 3 weeks of surface cleaning. Therefore, cleaning does not provide a significant difference in annual production. The annual cleaning is more about observing anything unusual in or around the installation.

The scheduled maintenance for the energy storage systems is a quarterly routine inspection of the units. The condition of the units is monitored and trended continuously during operations, which drives all maintenance based on trends in conditions. The scheduled maintenance is basically an external inspection for environmental conditions that may impact the lifetime of the energy storage systems.

The utilization of power available from the distributed energy resources (DER) in the microgrid is the primary driver for optimization. This is why the microgrid concept of operations is energy first, capacity second as described in section 1.1.c above. Energy storage becomes the most important tool in maximizing the utilization of these generating assets from addressing the inherent intermittency of solar PV to managing total microgrid power factor to 0.98.

Distributed energy storage systems (ESS) have the ability to serve many roles in a microgrid. This is why ESS is referred to as the "utility infielder" of the microgrid. Properly selected ESS can support many modes of operation:

- Constant Charge

- Constant Discharge
- Peak Shaving
- Load Smoothing
- PV Intermittency
- Load Shifting
- VAr Control
- Voltage Support
- Frequency Support
- Demand Response
- Arbitrage
- Island (voltage source)

The fundamental principle behind the technology is its capability to provide real or reactive power whether it is charging or discharging. Figure 6 shows how a community energy storage (CES) unit operates effectively in all four quadrants when commanded to do so.

kW	kVAr	kVA
0	25	25
7	24	25
15	20	25
25	0	25
15	-20	25
7	-24	25
0	-25	25
-7	-24	25
-15	-20	25
-25	0	25
-15	20	25
-7	24	25

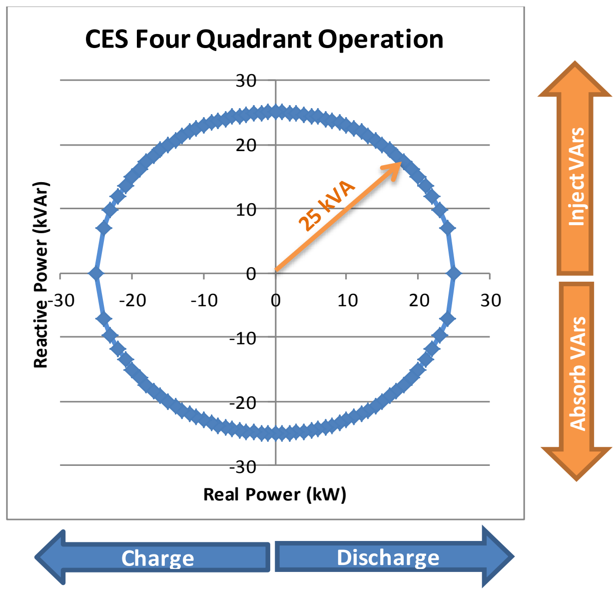


Figure 6: ESS Four Quadrant Operations

This data is from Green Energy Corp actual testing of a CES unit operating in a community in San Diego.

g. Follow Load and Maintain the Voltage and Frequency

The microgrid design focused on the development of an overall energy strategy that incorporates both demand-side management and new distributed generation resources to support the microgrid 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 that the cost of electricity that could be purchased from the local utility. In this scenario, the CHP 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.

One of the key elements of the microgrid is the ability to operate when the utility grid is not available. The methods of transitioning into an island mode are characterized as either a planned transition or an unplanned transition. In the planned transition, outside information is used to ramp up resources so that there is zero import at the point of common coupling to the microgrid and then to seamlessly transition into island operations at the appropriate time. For the microgrid project, the design requirement will be to size and operate the microgrid resources in island operation for a minimum period of 7 days with a multi-week operation likely. During island mode operation, the microgrid control system must ensure that there is a balance of generation and load in order to maintain system stability including voltage and frequency. To accomplish this, the microgrid controller must be able to provide a load forecast of the critical load, forecast PV generation, and then dispatch resources to match the load. It is anticipated that the resources available to be controlled during the island operations include CHP, fossil fuel generators, PV systems, energy storage, and building load. The microgrid controller will monitor island mode frequency and voltage and adjust equipment operation accordingly to maintain circuit stability. The other key element is the transition back to the grid when the utility service is restored. The design will ensure that the return to the grid is a seamless transition and is coordinated with the utility through appropriate protocols, safety mechanisms, and switching plans that will 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.

h. Two-Way Communication and Control

Communication within the microgrid and external hosted systems requires the use of wired and wireless solutions. Communication types can be classified as both data and control paths. The microgrid controller is agnostic of the communication media and provide a level of data-in-motion security between field devices and external systems. At minimum, two way communication to support control functions is used. A more flexible communication method is the use of a publish / subscribe middleware to support one to many communications. The communication bandwidth supports dozens of devices communicating every 1 to 10 seconds. In special cases, high frequency measurements, as many as 60 samples per second, can be used for stability applications. In this case the network is tuned to support this requirement.

Controls are essential in this type of system requiring analog outputs (AO), direct operate (DO), and select-before-operate (SBO) over a reliable messaging layer. Resource levels controls occur as fast as every second for certain periods of time.

An advanced control concept is employed as distributed control logic, also referred to as machine-to-machine communication. This is dependent on the microgrid controller, middleware, and the configuration of the network.

i. Power a Diverse Group of Customers with Critical Facilities

As discussed above, the New Paltz Microgrid will be designed to serve a group of critical facilities, plus additional non-critical facilities. This mix includes government facilities (Village, Town, and State), public safety and infrastructure, private healthcare and assisted living, and private business interests. In addition to critical facilities, the microgrid footprint includes other essential services, including pharmacies, grocery stores, and gas stations.

The benefits of the New Paltz Microgrid extend not only to local agencies and businesses, but also to residents in the greater New Paltz area. During times of extended grid outages and major storms, when public safety and health services are needed throughout such events, continuously powering those facilities is essential. As the grid outage extends into the second day and beyond, additional services become critical, such as shelter, food, prescription medicines, and fuel.

j. Uninterruptable Fuel Supply

By converting the 13.2 kV class distribution circuits, the basis for resiliency would be improved for the microgrid. This microgrid underground cable is further made resilient by installing utility-controlled remotely-operated isolation switches that can isolate this portion of the circuit on loss of the grid, leaving the microgrid to remain powered with its own distributed CHP, PV, energy storage systems, and building load control.

The microgrid resource portfolio will have natural gas and biofuel-based generators and CHP units, solar PV, energy storage, and building load control. The ability to use biofuels will depend on fuel-supply maturity, resource availability, and economic and reliability drivers.

The feasibility assessment also will consider the potential use of ground-source heat pumps for heating and cooling. This would reduce the natural gas load in the community, which could enable use of natural gas for the CHP or further reduce the risk of loss of natural gas supply during a major storm.

Also, the use of existing emergency diesel generators will be minimized by the microgrid's operation. Therefore, the typical three-day onsite fuel load for emergency diesel generators will be extended to one week.

k. Demonstrate Resilience to Forces of Nature

The industry tends to talk about reliability and resiliency in terms of system average interruption duration index (SAIDI), customer average interruption duration index (CAIDI), and system average interruption frequency index (SAIFI). The IEEE 1366 reliability index of SAIDI (system average interruption duration index) is a transmission and distribution (T&D) network-level index that <u>specifically precludes storm outages</u>. The IEEE 1366 consensus standard considers outages due to storms to be outside the utility's responsibility to prevent. The range of utility distribution network SAIDI and CAIDI in the US is between 60 and 200 minutes (national average ~ 120) per customer per non-storm outage. The outage numbers with storms included is much higher.

Therefore, the SAIDI measure is not really consistent with the concept of community resiliency, since SAIDI does not measure resiliency to storms. The IEEE 1366 measures are network focused.

In contrast, the reliability measures used in the data center industry are much more centered on the end-user reliability. The data center industry's Uptime Institute provides much information about designing highly resilient customer (data center) systems. Uptime is defined as serving the mission, and downtime is defined as not serving the mission.

The point is that resiliency is a customer-facing objective and the metrics to demonstrate resiliency should be customer-facing as well.

According to the New York State 2012 Electric Reliability Performance Report, the NYSEG SAIFI = 0.98 interruptions/customer/year and CAIDI = 2.00 hours each outage/customer/year. These metrics exclude storm-related outages in accordance with the IEEE 1366 standard. This is roughly equivalent to the national average for non-storm related grid outages. From separate studies, the national average storm-related CAIDI is 6.67 hours each outage/customer/year; a first approximation for the storm-related resiliency in Ulster County.

The feasibility assessment evaluated community-specific quality and reliability issues for both electric and gas distribution. The microgrid design is customer-facing resiliency, thus looking to uptime of the customer / critical facilities and their ability to achieve their mission.

The New Paltz Microgrid design is a direct attempt to address facility-specific uptime in the face of major storms, i.e., resiliency.

l. Provide Black Start

The Project Team employs the Black Start use case from EPRI/ORNL:

> **Black start**: The local microgrid controller will provide a workflow process for restarting the system. Each microgrid node 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.

Our microgrid solution has multiple black-start sources. The existing emergency generators at several locations have black-start capabilities, and automatically start on loss of the distribution grid.

In addition, each of the distributed energy storage systems within the microgrid is voltage source (normal mode) or current source (selectable). These units act as black-start capable units within 50 milliseconds of loss of voltage at the distribution grid.

In addition, the natural gas engine-based CHP units can be purchased as black-start capable.

Our scheme leads with the energy storage units in the case where a black-start would normally be required. As such, the energy storage units will serve as the first voltage source for all other equipment. For defense in depth, the emergency diesels and the CHP have the ability to serve as voltage sources for all equipment.

Task 1.2 Preferable Microgrid Capabilities

1. Integrate and Demonstrate Operation of Advanced, Innovative Technologies in Design and Operation

The Project Team employs the microgrid EPRI/ORNL Use Cases. These generic use cases provide the Team with a starting point for tailoring the use cases to the community's microgrid controls situation. The uses cases are described below, plus another use case on Security was added because a community resiliency microgrid represents a high-value target requiring a secure system of operations.

- **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.
- **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. The 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.

- **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 step through each step before opening the PCC. The utility operator will provide the appropriate permissions for opening the PCC. The local microgrid controller for each microgrid node will be responsible for setting the voltage source and load following resource.
- **Unintentional islanding**: For each microgrid node, the islanding process will be automatic as described in section 1.1.d above.
- **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.
- **Energy management**: The most complex Use Case. 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 at a set of controllable generation and load assets. Within that portfolio, the system will 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.
- **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 setting or verify that the setting has changed appropriately. In either condition if the test is false then the controller will initiate a shutdown of each resource and give the appropriate alarm.
- **Ancillary services**: The primary point of this use case is to 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.
- **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.
- **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.
- **Security**: – The solution will demonstrate a trustful design and integration. This will include the following:

  a. show how human and machine actors are authenticated and authorized,

  b. show how data in motion is protected,

c. show how data at rest is managed, and

d. show how system monitoring is accomplished

Domain data will be used to provide simple event processing for anomaly detection and a threat model of the system will be in place to help analyze suspect operations.

From a customer perspective, an emergency generator serves 4 or 5 of these Use Cases, the utility grid serves 5 or 6 of these Use Cases, but the microgrid serves all 11 Use Cases.

The fundamental drivers for the microgrid are creating a resilient energy supply for critical facilities, while at the same time creating better economics and reducing the emissions footprint. With active control, new distributed energy technologies, and the coordinated signals to drive decisions, solving the multi-objective function is doable.

a. Active Network Control System

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 groups of resources as well as provide control for localized operations. Figure 7 below presents the project concept for the community microgrid controller.

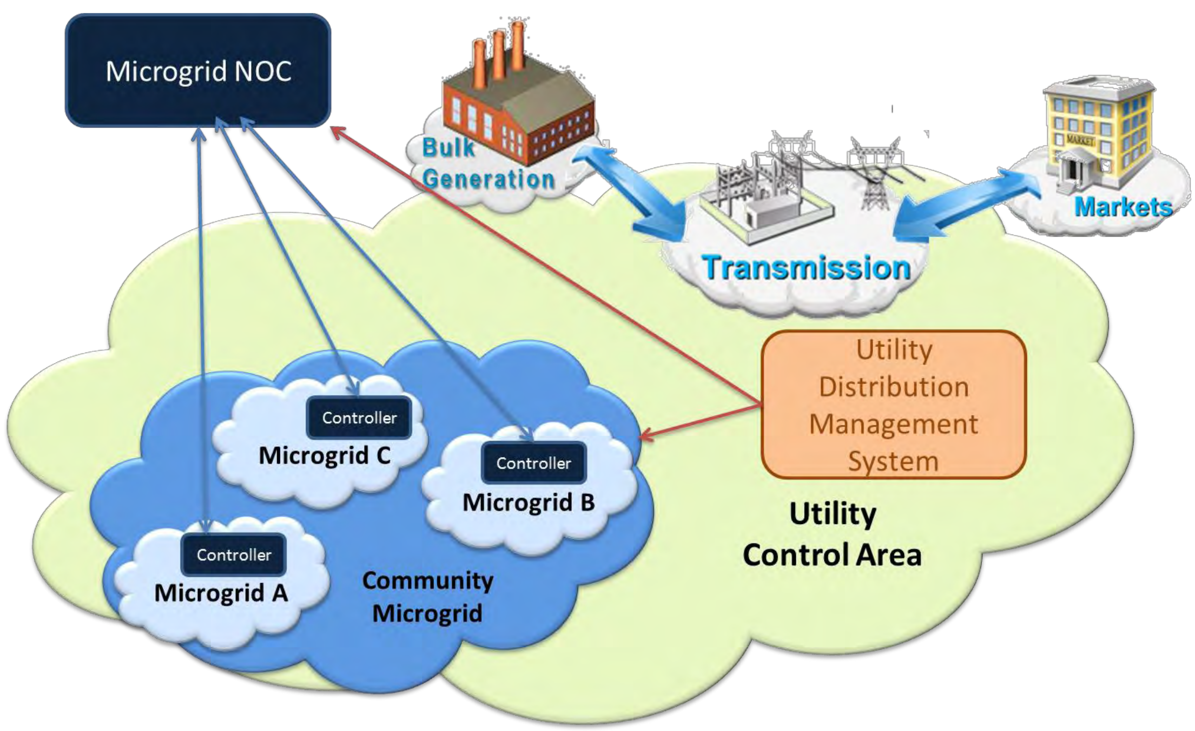


Figure 7: Project Concept for Community Microgrid

This approach provides for control of multiple microgrids in the community as well as coordination with the local utility. In the grid-connected mode, the primary operations will focus on maximizing economic benefits and minimizing emissions, which is similar 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. During a reliability event, the operation of each microgrid controller is focused on the load and generation assets within its control. The local controller will transition to island mode while maintaining proper voltage and frequency.

The anticipated microgrid controller will be based a microgrid control system that allows low latency messaging and secure transport to communicate with clients on field devices, the microgrid data center and the utility distribution management system. Prospectively, the Green Energy Corp. GreenBus suite of service interfaces would allow application developers to focus on building their application, while GreenBus abstracts out the work of managing the field data:

- Provides data automation and control features typical in the utility industry;
- Provides a cross-platform suite of developer APIs that allow many subject matter experts to leverage the platform without becoming experts; and
- Supports integration of intelligent field devices and back-office systems through the use of an industry standard wire level protocol (AMQP), common enterprise integration patterns (EIP), and a suite of near-real time special purpose services (APIs).

GreenBus supports both a DNP3.0 level 2 compliant slave and master operation, Modbus and over 80 proprietary field protocols for data acquisition and control. This package provides the basics of a traditional SCADA (supervisory control and data acquisition) system built on a service oriented architecture. This includes control features like select before operate (SBO), direct operate (DO), and set points, as well as support of measurement streams for analogs, status, and counters over a common bus architecture regardless of the device type. Other functions include *Not in Service, Manually Replace*, *Control Blocks*, *Limits*, definable alarms and events, and system and device timestamps.

GreenBus is also the platform being leveraged to demonstrate the Open Field Message Bus[2]. The demonstration is of a machine –to-machine control architecture for microgrid operation is shown in Figure 8 below.

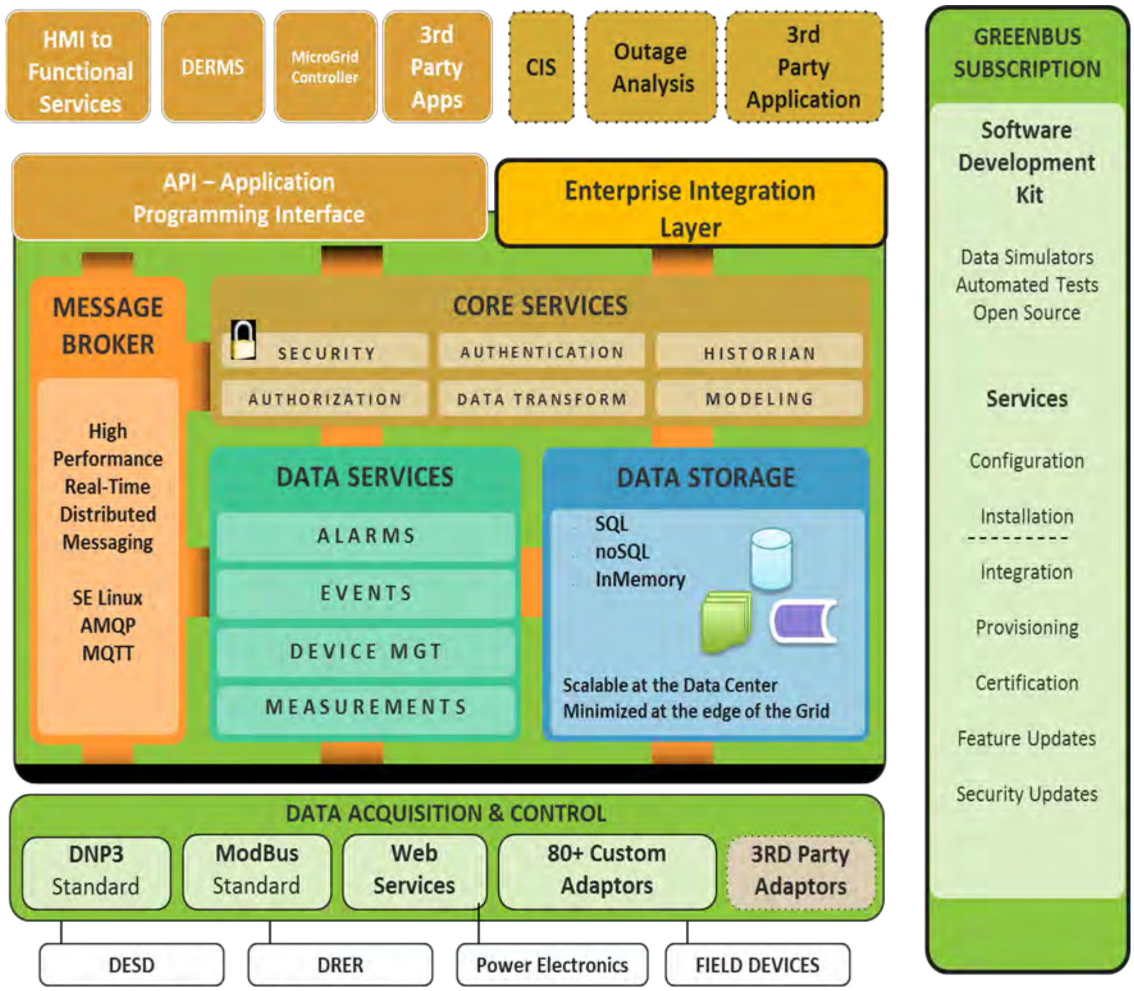


Figure 8: Control Architecture

The GreenBus is designed to leverage applicable security controls as defined by NIST and specifically the NISTIR 7628 of operations technology (OT) and information technology (IT) systems in the seven-domain NIST interoperability model. The trust model has many dimensions where the first tangible one is that nothing is trusted on the wire unless authenticated. Denial of Services (DOS) attacks are considered high and the system employs various techniques and deployment architectures to mitigate this type of malicious cyber-attack. The elevation of privilege threats is considered high in all subsystems.

The GreenBus system uses a concept called "agents" to represent processes and humans in the system. All agents must be authenticated to the system and all permissions are based on Access Control Lists (ACL) with a *deny-all* rule as default. ACLs are granularly applied to objects for each agent in the system. The ACL works by specifying the resource (service), the "create, read, update, and delete" (CRUD)

[2] Open Field Message Bus is copyrighted by the Smart Grid Interoperability Panel

operation required, and an optional selector to narrow it down by entity type, entity parent, or to the agent's self (i.e., update your own password).

GreenBus is designed to run across multiple electronic security perimeters with an encrypted pipe for all forms of traffic. This is typically on top of AMQP. This simplifies network configuration and allows for better auditing of the overall system connection health.

GreenBus is certified on RHEL 6, which inherits Security Enhanced Linux (developed by the US National Security Agency and Red Hat) for setting security policies. GreenBus also supports multiple modeling types such as equipment models, communication models, and generic configuration files to support application configurations. Finally, every connection to the system is authenticated and granular level authorizations can be applied to suit the system requirements

The GreenBus Microgrid Master Controller (MMC) Application Suite is layered on top of the GreenBus Platform. The GreenBus MMC is design to address the use cases described above. The architecture of this solution allows the microgrid controller running locally in each microgrid to be autonomous from the cloud based system for extended periods of time. The Microgrid NOC runs the same GreenBus software as the local microgrid controller and support coordination features between each microgrid as well as a single panel of glass to govern the entire system.

b. Energy Efficiency Options

For energy efficiency, the Team's philosophy is *"Lead with Energy Efficiency."* To avoid over-sizing generation and storage systems, it makes great sense to use energy efficiency options first to reduce the total energy load before sizing the microgrid's distributed energy resources.

The Team included an analysis of energy performance improvement opportunities in the microgrid design. The Project Team followed a six-step process covering data collection, analysis, on-site evaluations, technology retrofit selection, installation, and operation.

Data Collection – The Team worked with the facilities considered in this feasibility assessment to collect the following information:

- Energy Consumption: Twelve months of utility usage data
- Drawings: Mechanical and Electrical
- Lighting: Number, type, wattage, and controls
- HVAC: Number, type, nameplate, horsepower, vintage, and controls
- Energy Management System: type and sequence of operation
- Refrigeration Units: Number, type, nameplate, controls
- Refrigeration Cases: Number, type of doors, type of lighting, condition of seals and gaskets
- Operations: Store hours of operation identifying open, close, maintenance, and stocking schedules

Data Analysis – The information collected was used to conduct energy performance benchmarking for the portfolio of facilities – normalized by square footage, water, operating hours and, if applicable, facility type. This analysis was used to identify any trends in energy use intensity across, time, geography, or technologies employed.

On-Site Evaluations – Findings of the data analysis was used to determine high and low performers across the portfolio. The Team identified the facilities with the highest and with the lowest normalized energy intensity to perform on-site energy audits. The findings of these audits will be used to develop general best practices that the Team can use as a framework for incorporating energy efficiency into the microgrid project.

Technology Retrofit Recommendations – The Team used information from the three previous steps to identify energy efficiency retrofits for the critical facilities. The Team focused on identifying measures that can be deployed across the entire portfolio and that have a payback of less than five years. Areas of focus included (but were not necessarily limited to): lighting, HVAC, controls, and refrigeration efficiency.

Installation – The Team incorporated the selected energy efficiency measures into the microgrid project. The Team evaluated the procurement and installation of the measures as coordinated with the microgrid installation. Since there is a potential that some energy efficiency measure will take place in non-critical facilities, the Team evaluated installation activities with commercial businesses in mind to ensure minimal impact to operations and customers.

Operation – The microgrid Team evaluated the "installed" energy efficiency measures to ensure proper operation in concert with the microgrid. As part of the microgrid control system, energy usage is continuously monitored. This will provide a tool to validate the energy savings realized by the portfolio of energy efficiency measures installed at each facility. Facilities that are not meeting the energy savings goals will be re-evaluated to identify and correct the short fall in energy savings.

c. Installation, Operations, Maintenance, and Communications for the System to be Interconnected

Microgrid assets and operations are expected to be financed and managed by a Special Purpose Entity (SPE), which may be owned by both public and private entities. The SPE will be accountable for the execution of all tasks associated with project development, finance, ownership, and operation. The SPE will engage a Plan-Design-Build Team to perform planning, design, development, financing, and construction. An Engineering, Procurement, and Construction (EPC) Team will be responsible final engineering as well as procurement and installation of major equipment, civil engineering, and network system integration and security for microgrid controls and communications. The Finance Team will arrange and manage all funding for project development, construction, commissioning, and integration; the Operations and Maintenance Team will manage and maintain all physical microgrid systems; and the Energy Services Team will arrange and manage all energy transactions and services.

Functional relationships and processes for this structure are illustrated in Figure 9.

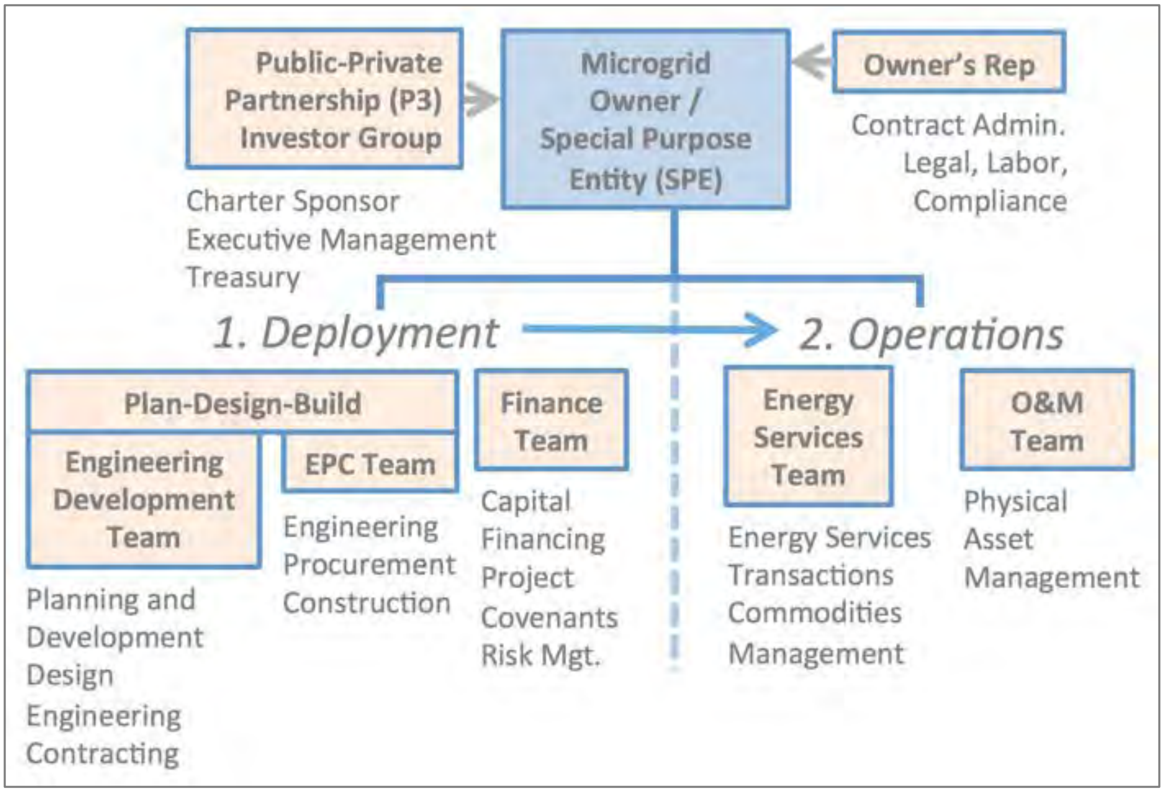


Figure 9:
Special Purpose Entity – Functional Diagram

To ensure proper operation of the individual microgrid resources, the EPC contractor 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 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 15 to 25 years. The operation will leverage the autonomous functionality of the microgrid controller and minimize the need for on site operators. The controller will operate the microgrid in a manner to maximize safety and security, economic and environmental benefits, and 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 NOC and dispatch a service technician that 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 a failure and at a time period that will be the least impactful to the overall operation of the microgrid.

d. Coordinate with REV Process – Platform for Innovative Services

1) Microgrid and REV Objectives: Key objectives of the proposed microgrid include modernizing local grid infrastructure and establishing a platform for development and operation of innovative and competitive energy assets and resources. These microgrid objectives are consistent with the objectives of New York's Reforming the Energy Vision (REV). Achieving these objectives will involve two primary processes:

a. Enabling safe and reliable dispatch of distributed resources within the community microgrid service area through:
    i. Physical reconfiguration and upgrades of local distribution systems (including installing buried cable to connect some nodes)
    ii. Deployment of distributed data acquisition and control systems
b. Enabling economic dispatch of microgrid energy and capacity resources (including customer loads), primarily through:
    i. Deployment of resource management and information management applications (microgrid controls)
    ii. Establishment of counterparty contracting and clearing mechanisms supporting deployment and operation of distributed energy assets.

2) Platform for Energy Development: A successful community microgrid will establish an engineering and economic platform that supports efficient ongoing development and investments in local energy assets, and provides incentives for operation of assets to achieve optimal outcomes consistent with microgrid objectives – *e.g.,* improved local resilience, energy self-reliance, environmental performance, and financial economics. Specifically, the proposed microgrid would establish a physical platform for various entities to install, integrate, and operate DG, ESS, and demand-side management systems (DSM) – as well as an economic platform for dispatching resources and managing economic transactions among counterparties within the microgrid service area.

a. Comprehensive Energy Services Model: The New Paltz Microgrid's economic platform is expected to facilitate commercial investments and business transactions by providing a menu of new energy service options for all community members (*Fig. 10*), including three tiers of service options:
    i. Tier 1 – Resilient power supplies for critical facilities and opt-in customers
    ii. Tier 2 – Local clean energy development opportunities
    iii. Tier 3 – Community choice aggregation

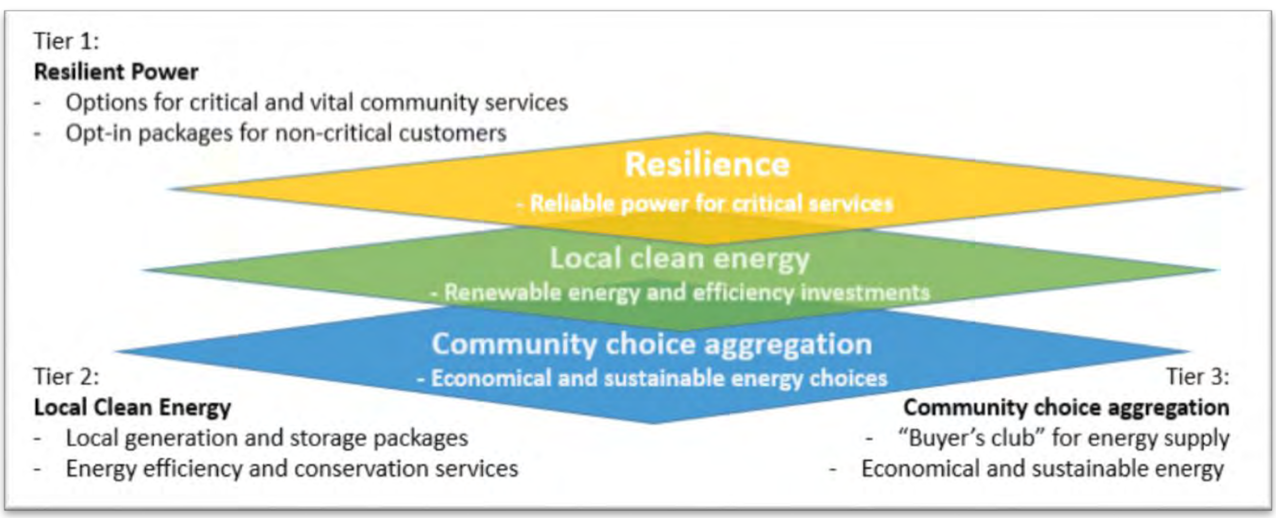


Fig. 10: Comprehensive Energy Services Model

The New Paltz Microgrid energy services model will provide resilient electricity services for facilities identified as critical for the safety, health, and vitality of the New Paltz community, while also offering resilient power packages for non-critical customers on an opt-in basis (Tier 1 Options). Additionally, the New Paltz Microgrid would establish an economic platform for investment in local clean energy resources (Tier 2 Options) – providing opportunities for customers and third-parties to invest in DG, ESS, and DSM assets to serve the New Paltz community. Such assets may be located within the footprint of the islandable microgrid, to supply power for resilient operations, and they also may be located at other sites in and around New Paltz. Finally, the New Paltz Microgrid would provide opportunities for New Paltz residents, businesses, and institutions to participate in community choice aggregation (CCA) for procuring more sustainable and economical energy supplies (Tier 3 Options).

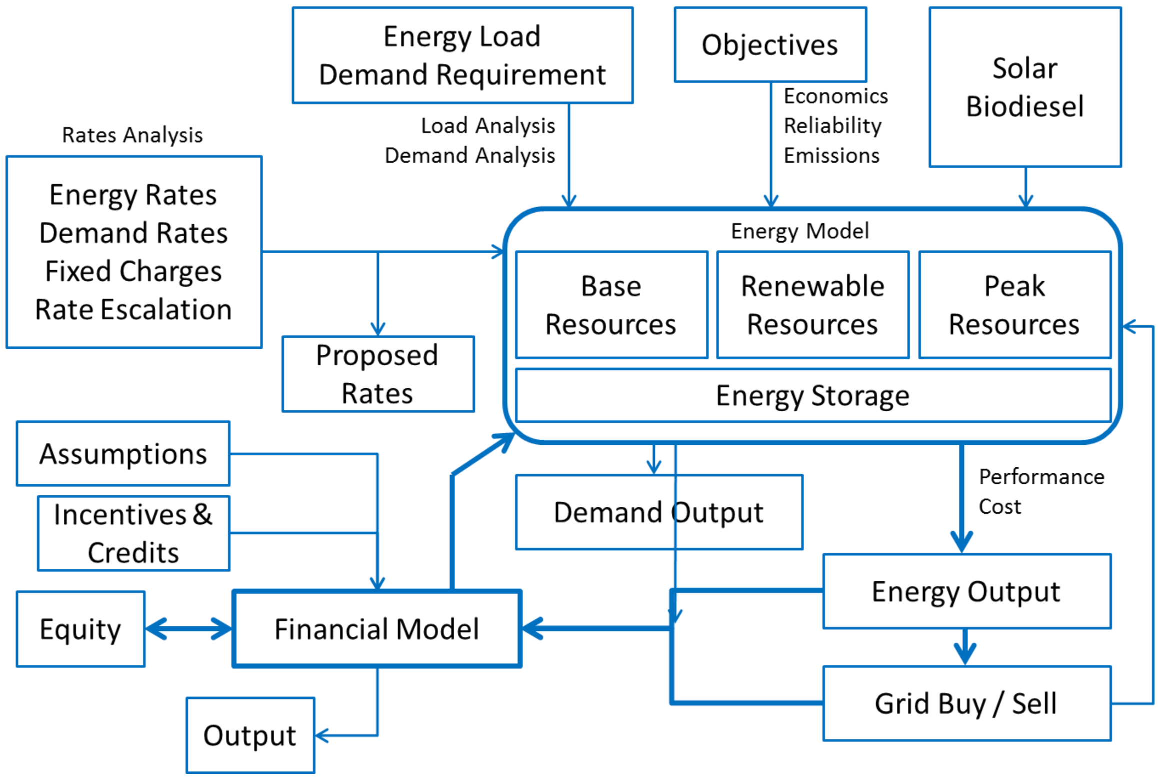
b. Valuing Local Energy Resources and Demand: The New Paltz Microgrid's energy services model increases the value of community investments in several important ways.
   i. Optimized capital deployment: Ensures distributed resources (including generation, storage, and demand management) are compensated for service at prices commensurate with the value they provide to New Paltz customers and the community as a whole.
   ii. Streamlined clean energy investments: Establishes market-based transaction and contracting frameworks to simplify private investments and facilitate increasingly cost-efficient, timely, and replicable deployment of local clean energy assets.
   iii. Aggregated purchasing power: Provides all New Paltz customers with the opportunity to reduce their overall energy spending and support expansion of clean energy resources.

c. Investigating Micro-Market Potential: The New Paltz Microgrid's energy services model provides a unique opportunity to investigate the potential of establishing a micro-market for buying and selling energy resources in the New Paltz community and driving real-time economic dispatch of microgrid resources. The Project Team will consider options for establishing a local market for long-term contracting and short-term trading of energy resources. In such a transactive energy (TE) micro-market, resource supply, demand, and engineering conditions would produce dynamic price signals to drive long-term asset investments and energy-use responses.

e. Comprehensive Benefit-Cost Analysis

In addition to producing data inputs for the NY Prize cost-benefit model and analysis, the Project Team will employ the GEC converged energy and financial model (CEFM) to assist in the design of the actual microgrid for the community. The GEC CEFM has been used in the design of more than 40 microgrids and is based on detailed energy balancing, total cost of ownership, and the interaction of the two.

This model, presented in Figure 11 below, has proven valuable in properly sizing and siting microgrid resources and load modulation programs to support a microgrid design. The modeling tool helps ensure that the design meets the technical objectives of the project as well as the financial requirements related the price of energy generated by the microgrid and the return on investment required by the SPE investors.



<u>Figure 11: Converged Energy and Financial Model</u>

The Project Team understands that NYSERDA has developed its own cost benefit model and has contracted with a consultant to support the Team in applying that model. Additionally, however, the Team will take advantage of the CEFM to evaluate options and identify those that are most promising. The Team then will provide for the NYSERDA model the required inputs reflecting the selected design. This will help the Project Team to optimize the design and will complement the modeling effort by the NYSERDA cost-benefit model consultant.

f. Leverage Maximum Private Capital

The Team evaluated multiple options to determine the most effective ownership structure for the microgrid. The Team believes the best structure will be a public-private community development entity with shared ownership between public agencies and private entities, including individuals and companies, both for-profit and not-for-profit owners.

In addition to ensuring strong community involvement in executive and treasury decisions affecting the community microgrid, this public-private partnership (P3) ownership structure provides the greatest possible flexibility for capital financing. This flexibility will allow access to the lowest-cost sources of both debt and equity funds for each layer of the project's capital stack – including development financing, construction financing, and long-term financing.

As described in *c.* above, the vehicle for structuring the public-private development will be an SPE (or more than one SPE) designed to serve the specific needs of the project and its stakeholders and partners (*See Figure 9*). Careful planning, legal review, and negotiations will be required for various scenarios. For example:

A. Microgrid assets behind the meter on public/government facilities – the SPE may be co-owned by the public/government authority, a special non-profit funding agency, and/or third-party investors
B. Microgrid assets behind the meter on private facilities – the SPE may be co-owned by third-party investors, local economic development agency, community group, and/or utility (likely a non-regulated business unit)
C. Microgrid assets behind the meter on private facilities – the SPE could be owned by third-party investors alone
D. Microgrid assets above the meter – the SPE may be co-owned by the public/government authority, a special non-profit funding agency, the utility, and/or third-party investors
E. Microgrid assets above the meter – the utility, customers, or third-party investors could be sole owners

Private capital can be accessed effectively through each of the five options A through E. For example, tax credits and depreciation benefits can allow access to equity capital from private investors that carry qualifying tax liabilities. Public owners can access tax-exempt public capital sources, potentially including municipal bonds and federally insured public infrastructure development funds. And public entities with taxing authority can facilitate access to Property Assessed Clean Energy (PACE) funds for qualifying energy improvements. Each type of financing may contribute to a cost-effective capital financing strategy for the project.

In option A, the special non-profit funding agency is an IRS tax-exempt entity that uses private capital for passive taxation offsets, and the third-party investors are private capital firms.

In option B, the third-party investors are private capital firms, and the utility affiliate will utilize private capital for its ownership share.

In option C, the third-party investors are private capital firms.

In option D, the special non-profit funding agency is an IRS tax-exempt entity that uses private capital for passive taxation offsets. The utility will utilize private capital for its ownership share, and the third-party investors are private capital firms.

In option E, the utility will utilize private capital.

In any of these scenarios, the utility will continue to own and operate its existing electric distribution systems throughout the community. New microgrid assets – including generation, storage, demand management, and interconnection and distribution systems – may be owned by any combination or variation on the ownership structures described above.

g. Clean Power Resources

As discussed in the section on the microgrid portfolio of resources and the goal of reduced emissions, clean and renewable resources are key elements of our design approach. The primary types of clean power resources that are considered for this microgrid design, at this stage of the project, are solar PV and biofuels. PV serves as a resource with a generation profile similar to the electric load of the microgrid (afternoon peak). Consequently, although PV generates electricity only during the day and output can vary on cloudy days, PV complements other microgrid resources and adds the benefit of having no fuel cost and very low maintenance cost, supporting the microgrid's operational economics. In the Team's experience in designing microgrids, PV can provide cost-effectively provide approximately 20 percent of a microgrid's annual energy consumption.

Biofuels are considered in areas with substantial agriculture, cattle farms, poultry farms, wood processing, or wastewater treatment facilities. In these instances, the evaluation may include the addition or use of an anaerobic digester that can produce sufficient methane to operate a generator or fuel cell. Such biogas opportunities are determined by digester input sources, capacity, and likely rate of methane production and its heating value. In some cases, digester gas can be generated outside the microgrid control area, cleaned to specific standards, and injected into the local natural gas distribution system. In such cases, an arrangement can be made with the natural gas utility to effectively offset a portion of the microgrid's natural gas consumption with renewable resources. The Team will evaluate the potential for biogas to serve energy needs in New Paltz, as well as solid fuel opportunities to serve thermal or CHP loads.

The team has evaluated other renewable energy resources and found limited opportunities in the New Paltz area. For example, review of wind and micro-hydroelectric resources in the New Paltz area indicates that neither wind nor hydro generation will be viable in this microgrid design. Ground-source geothermal heat pumps may offer opportunities at some locations, but the Team's review has not identified large-scale geothermal resources in the New Paltz area.

h. Demonstrate Tangible Community Benefits

The New Paltz Microgrid will provide the community with substantial opportunities to hedge against increasing energy rates, with the continuous operation of on-site generation resources. The microgrid will also provide improved power quality to customers that have sensitive electronic equipment and systems requiring uninterrupted electric service, and thereby will reduce production losses.

Microgrid resiliency benefits extend beyond customers within the microgrid footprint to nearby residents in New Paltz and Ulster County. During times of extended grid outages and major storms, when public safety and health services are needed throughout such events, continuously powering those facilities is essential. As the grid outage extends into the second day and beyond, additional services become critical, such as shelter, food, prescription medicines, and fuel.

Additionally, the New Paltz Microgrid SPE will provide extended opportunities for all New Paltz energy users to obtain clean and low-cost energy supplies – through onsite energy services and collective negotiation for offsite energy supplies through Community Choice Aggregation (CCA). In this way, the New Paltz Microgrid will support continued development of renewable energy and efficiency resources throughout the community, saving costs and keeping more energy dollars in the local economy.

2. Incorporate Innovation that Strengthens the Surrounding Grid and Increases Actionable Information Available to Customers

Strengthening the New Paltz Grid: The New Paltz Microgrid will strengthen the local electricity system in several key ways. Most notably, it will convert 13.2 kV overhead lines and service drops for critical assets to underground cables, reducing vulnerability to storms and other physical assaults that cause outages and power quality issues. Additionally the energy resources installed throughout New Paltz will reduce local dependence on long-distance power transmission lines. Utility-controlled remotely operated isolation switches will allow the local distribution company to manage islanding microgrid systems to support local grid stability. Moreover, to the degree the New Paltz Microgrid implements TE micro-market systems to dispatch energy assets, the utility may apply those resources for demand response, voltage and VAr support, and other ancillary services in support of local network stability.

Among the key objectives of the New Paltz Microgrid, the Team is considering options for enabling economic dispatch of local energy and capacity resources, including customer loads. A platform for such economic dispatch would include two key solution sets:

a. Resource management and information management applications allowing direct control of local generation, storage, and demand resources
b. Counterparty contracting and clearing mechanisms supporting deployment and economic dispatch of distributed energy assets

Specifically, the proposed microgrid would establish a physical platform for various entities to install, integrate, and operate DG, ESS, and demand-side management systems (DSM) – as well as an economic platform for dispatching resources and managing economic transactions among counterparties within the community. This micro-market platform would provide actionable information enabling customers to minimize their energy expenditures and maximize the value of their assets. Specifically, market-based contracting frameworks would facilitate cost-efficient, timely, and replicable deployment of local clean energy assets, and transaction-clearing mechanisms would enable seamless and transparent exchange of energy resources – through both long-term and spot trades. In short, resource supply, demand, and engineering conditions would produce actionable dynamic price signals to drive energy-use responses and asset investments.

Such a TE platform would integrate all three tiers of energy services to be provided by the New Paltz Microgrid (Fig. 10), ensuring the greatest possible diversity of resource profiles and customer optionality, and thereby improving price-discovery and transparency in a micro-market environment limited by local geographic and network constraints.

The Team's experience suggests that such a TE micro-market will produce the greatest efficiencies if it enables programmatic resource management without ongoing customer intervention. In other words, dynamic price signals would trigger device responses consistent with customers' pre-established energy priorities, allowing rapid prosumer responses independent of active customer decisions. In this way, the New Paltz Microgrid would demonstrate the substantial evolution of local energy services toward an advanced Utility 2.0 economic and operational model.

-END OF REPORT-

NY Prize Stage 1 – New Paltz Community Microgrid Project

Task #2: Preliminary Technical Design Costs and Configuration

Jan. 4, 2015

Prepared For:

NYSERDA

Prepared By:

<u>New Paltz Microgrid Project Technical Team</u>

<u>In cooperation with Project Stakeholders including the Town and Village of New Paltz</u>

Table of Contents

New Paltz Microgrid Project – NY Prize Stage I
Task 2: Technical Design Costs and Configuration

Summary: This report outlines the preliminary assessment of the technical design and system configuration for the Village of New Paltz (New Paltz) in Ulster County, New York. The Project Team believes this microgrid design will serve as a leading example for New York, and will be beneficial and replicable for hundreds of other communities across the state and beyond. The approach to microgrid design and architecture described below incorporates lessons learned and best practices from other existing microgrid projects that the technical team has designed and developed. It also aims to support New York State initiatives to foster innovation and competition in energy services, including the Reforming the Energy Vision proceeding.

The New Paltz microgrid design is focused on the development of an overall energy strategy that incorporates both load management and new distributed generation and energy storage resources to support the microgrid's strategic and operational objectives. The operational objectives for this microgrid include improved resiliency, increased energy efficiency, reduced environmental emissions, and reduced energy cost for customers in the New Paltz community.

This report is organized in accordance with the sub tasks outlined for Task #2 in the New York Prize Feasibility Assessment statement of work.

2.1: Proposed Microgrid Infrastructure and Operations

Microgrid Layout

The New Paltz microgrid is expected to provide resilient energy services to a group of facilities with critical and vital loads in the project area. These include fire and rescue stations, water treatment facilities, state government offices, multiple schools, several facilities on the SUNY New Paltz campus, affordable housing units, and commercial facilities, such as grocery stores and healthcare operations, that are important to the region for continued operations during extended grid outages and major storms.

In addition to directly protecting residents in affordable housing, the New Paltz Microgrid will support the resiliency of other vital services that will directly or indirectly benefit all 20,000 residents and students in New Paltz, and many more across the region.

The proposed community microgrid will include multiple clusters of buildings across New Paltz to provide resilient energy services for isolated critical facilities, as part of the community's safety and resource planning strategies. Collectively, 10 "nodes" comprise the New Paltz Microgrid.

The 10 New Paltz nodes and included facilities and functions are listed in the table below.

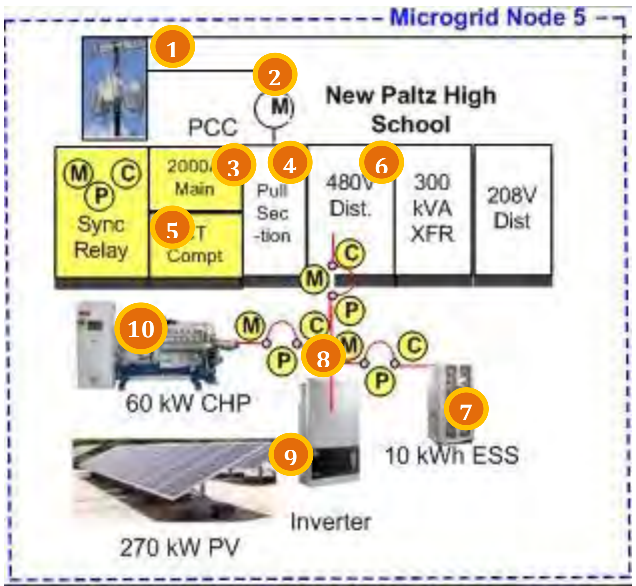
Table 1 – Overview of Microgrid Portfolio

Microgrid Node #	Facilities	Functions
1	• Wastewater Treatment Plant	• Water treatment
2	• Woodland Pond Care Center	• Elder living and care
3	• Mt. Rest Rd. Pumping Station	• Water treatment
4	• SUNY New Paltz Elting Gym • SUNY New Paltz Wellness Center • SUNY New Paltz Student Health Center	• Fitness / Health • Healthcare
5	• New Paltz High School	• Education
6	• New Paltz Rescue Squad	• Emergency response
7	• Stop & Shop Grocery • ShopRite Grocery • New York State Department of Environmental Conservation • Institute for Family Health • Sunoco Gas Station • True Value Hardware • Meadowbrook Farms II Apartments (affordable housing) • Additional Businesses	• Grocery • Healthcare • Auto fuel • State Government • Housing • Other business
8	• New Paltz Middle School • Dedrick's Pharmacy	• Education • Pharmacy
9	• Duzine Elementary School • Municipal Center • Community Center & Municipal Pool • My Market Grocery • Stewart's Convenience Store • ZNE Housing	• Education • Potential shelter • Community engagement • Grocery • Housing • Other retail
10	• Fire Station #2	• Fire and rescue • Emergency response

A complete layout of the design showing all microgrid nodes in 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 points of common coupling (POC) are shown with associated monitoring (M), control (C), and protection (P) devices.

Figure 1 – One-Line Diagram Explanation



1. Transformer to the critical facility
2. Utility meter
3. Synchronizing relay controls / main breaker (2000 Amp) with monitoring, protection relays and controls
4. Main disconnect (pull section)
5. Instrument current transformer compartment
6. Main 480V 3-phase distribution panel; step-down transformer and 208V 1-phase distribution panel
7. Energy storage system (ESS) with M, C, P
8. New 480V 3-phase cable (red)
9. Solar PV array and associated inverter
10. Combined heat and power (CHP)

The following pages highlight the layout design and one-line diagram subsection for key areas of the 10 nodes as well as a brief explanation of included energy resources.

Notes:

- The Task 2 model includes three New Paltz Central School District facilities that provide public shelter and other community resiliency benefits. Solutions to serve these schools may be revised or omitted, pending the School District's finalization of alternate long-term supply arrangements (*e.g.,* a Solar City remote net-metered solar installation) and revised resiliency objectives.
- Central Hudson has reviewed the microgrid design plan but had not provided inputs for timely report submission.
- The project team anticipates updating and refining proposed solutions and configurations in Stage II, pending further analysis that may yield changes and inputs.

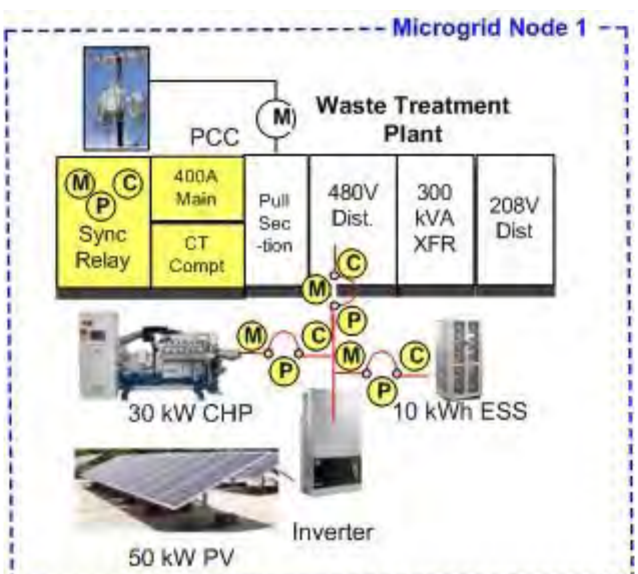
Geospatial Diagrams and One-Line Subsections

Node 1 Overview

Node 1 System Configuration

Geospatial Diagram

One-Line Diagram



Facility

- **New Paltz Wastewater Treatment Plant**

Description

Node 1 is a single facility node, covering just the structures of the New Paltz Wastewater Treatment Plant. The POC for this node will be located to the south of the property, near Huguenot St.

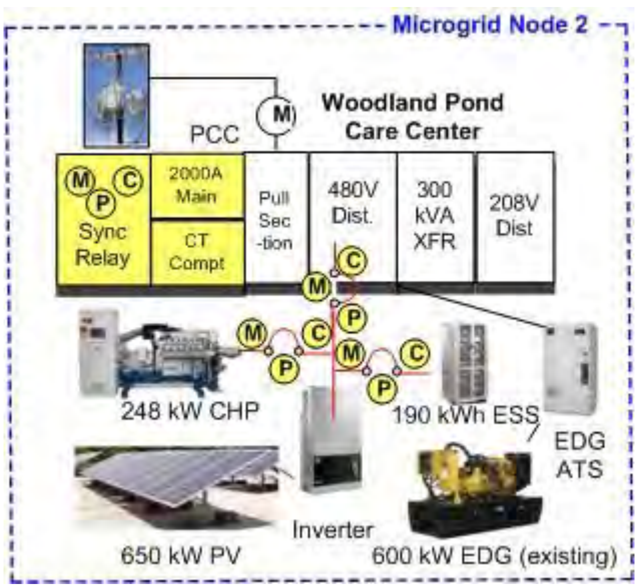
As part of the microgrid, the following will be installed:

- **PV (50 kW):** A PV system will be installed on the south facing roofs of the buildings on the north end of the property.
- **CHP (30 kW):** A small CHP unit will be installed adjacent to the structure at the south end of the property, near the entrance.
- **ESS (10 kWh):** An ESS unit will be installed inside the structure to the east of the CHP unit.

Node 2 System Configuration

Geospatial Diagram

One-Line Diagram



Facility

- **Woodland Pond Care Center**

Description

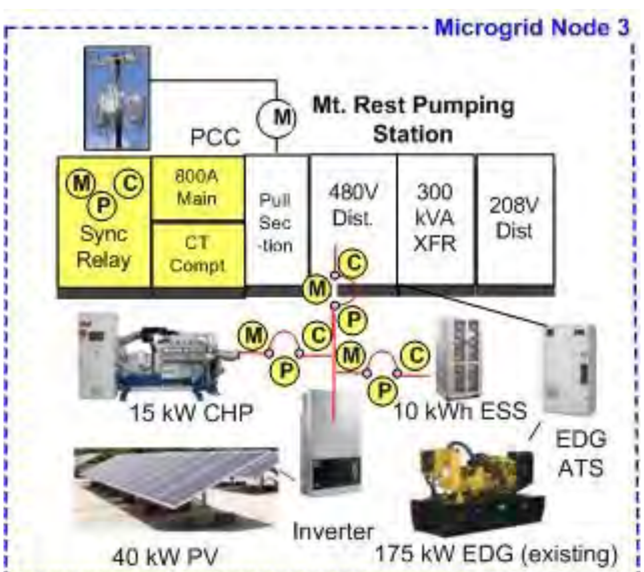
Node 2 covers Woodland Pond at New Paltz, a 500-bed assisted living complex with onsite healthcare facilities. The facility has an existing emergency diesel generator (600 kW) that powers a critical load circuit to maintain life safety and emergency lighting when there is a loss of utility service. The POC for this node will be located close to the entrance to the facility along N. Putt Corners Road.

- **PV (650 kW):** Multiple PV systems will be installed on the roof of the Center's main structure. A third, ground-mounted system will be installed in an open area west of the center if the available roof space cannot accommodate the targeted system capacity.
- **CHP (248 kW):** A CHP unit will be placed outside, adjacent to the northern most building at the Center.
- **ESS (190 kWh):** An ESS unit will be placed in the main structure, between the two PV installations.

Node 3 System Configuration

Geospatial Diagram

One-Line Diagram



Facility

- **Mountain Rest Rd. Pumping Station**

Description

Node 3 addresses the Mt. Rest pumping station. The facility has an existing emergency diesel generator (175 kW) that can power the entire facility. The POC for this node is located along Mountain Rest Road.

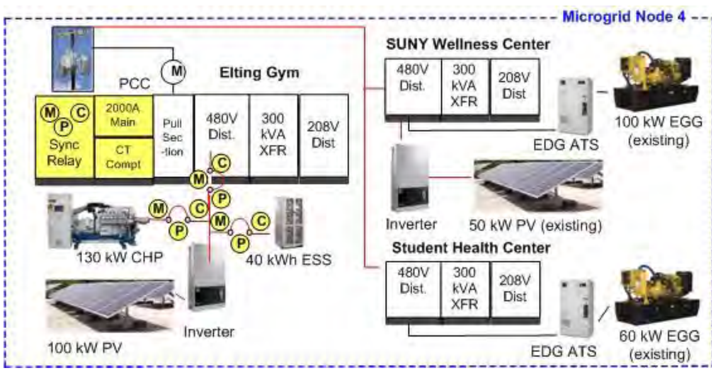
As part of the microgrid, the following will be installed:

- **PV (40 kW):** A rooftop PV system will cover the main facility of the pumping station.
- **CHP (15 kW):** A small CHP unit will be placed to the south of this facility.
- **ESS (10 kWh):** An ESS unit will be placed inside the facility, near the inverter for the PV system.

Node 4 System Configuration

<u>Geospatial Diagram</u>

<u>One-Line Diagram</u>



<u>Facilities</u>

- **SUNY Elting Gym and Pool**
- **SUNY Wellness Center**
- **SUNY Student Health Center**

<u>Description</u>

Node 4 includes several facilities on the campus of SUNY New Paltz related to health and wellness. There is an existing PV system on the roof of the Wellness Center (50 kW), and existing EGG units in the Wellness Center (100 kW) and Health Center (60 kW). The POC for this node will be located along Southside Loop Rd. in front of the Elting Gym.

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

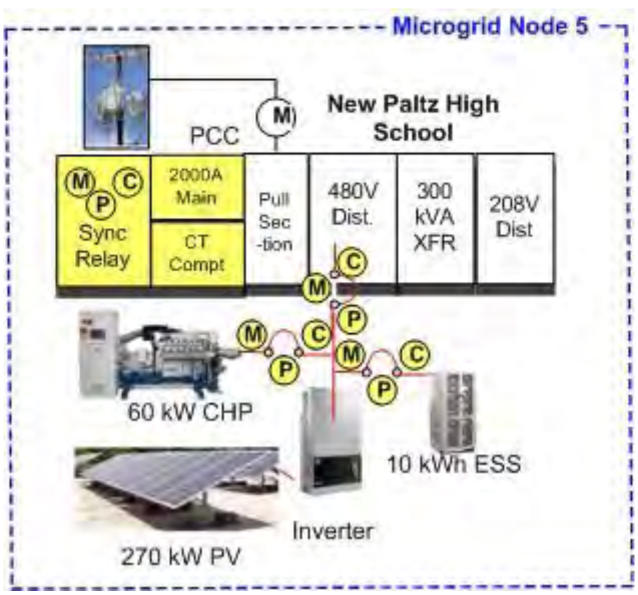
- **PV (100 kW):** A rooftop PV system will be installed on Elting Gym to augment the existing PV at the Wellness Center.
- **CHP (130 kW):** A CHP system will be placed outside behind the Elting Gym.
- **ESS (40kWh):** An ESS unit will be placed inside the Elting Gym in an electrical room.

Note: Pending finalization of SUNY plans, Node 4 also will integrate 100 kW of PV and advanced inverter systems planned for installation at the Elting Gym, as part of an Electric Power Research Institute (EPRI) smart inverter study project, supported by SUNY and the New York Power Authority (NYPA). SUNY administration has confirmed continued support for the New Paltz Microgrid, and the project team anticipates the NYPA project will incrementally improve the microgrid's technical and financial viability.

Node 5 System Configuration

Geospatial Diagram

One-Line Diagram



Facility

- **New Paltz High School**

Description

Node 5 will cover the facilities of the New Paltz High School. The POC for this node is located at the entrance to the school along Route 17.

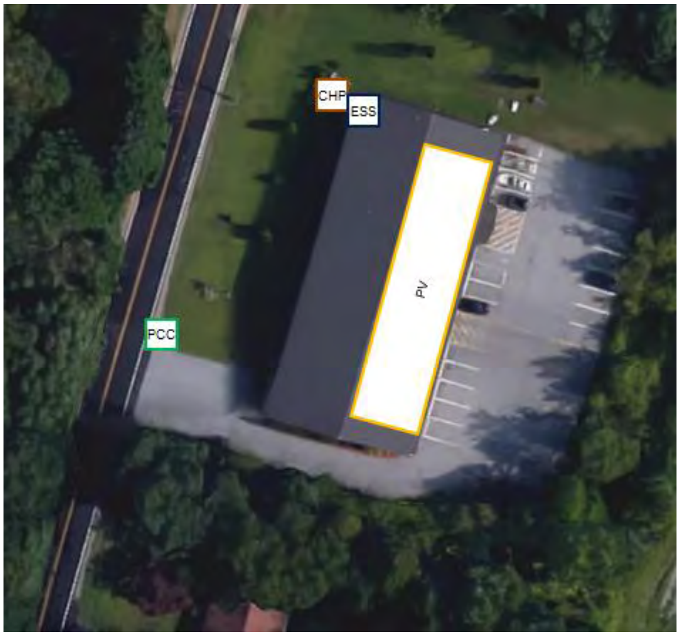
As part of the microgrid, the following will be installed:

- **PV (270 kW):** A PV system will be installed on the flat portion of the roof the main building. Additional PV will be installed as covered parking over the school parking lot.
- **CHP (60 kW):** A CHP system will be placed inside the facility's boiler room.
- **ESS (10 kWh):** An ESS unit will be placed inside the building, in an electrical room.

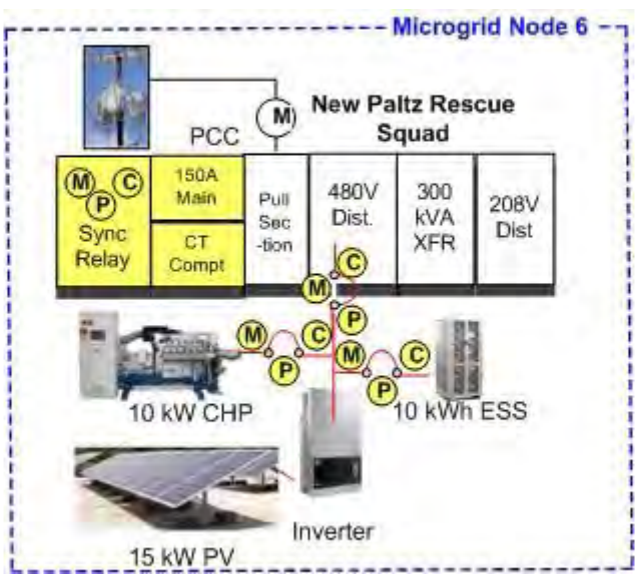
Note: The New Paltz High School node may be revised or omitted in Stage II, pending finalization of School District solar net-metering plans and revised resiliency objectives.

Node 6 System Configuration

Geospatial Diagram



One-Line Diagram



Facility

- **New Paltz Rescue Squad**

Description

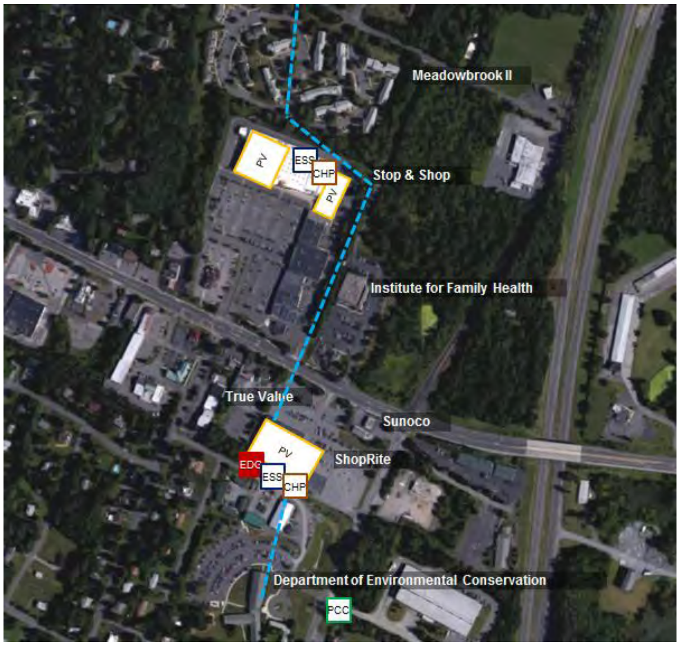
Node 6 includes the New Paltz Rescue Squad facility. The POC is located at the entrance to this facility along North Putt Corners Rd.

The following resources will be added to this facility.

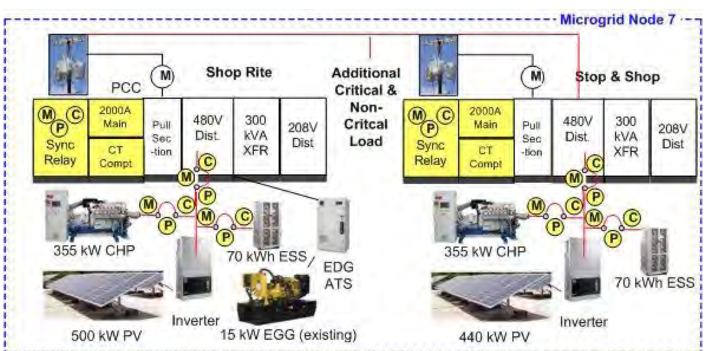
- **PV (15 kW):** A rooftop PV system will be installed on the south facing roof of the building.
- **CHP (10 kW):** A small CHP unit will be placed outside of the building, near the northwest corner.
- **ESS (10 kWh):** An ESS unit will be placed next to the CHP unit.

Node 7 System Configuration

Geospatial Diagram



One-Line Diagram



Facilities

- **Stop & Shop Plaza** including grocery store and pharmacy
- **Institute for Family Health**
- **Sunoco Gas Station**
- **ShopRite**
- **True Value Hardware & Equipment Rental**
- **NYS Dept. of Environmental Conservation**
- **Meadowbrook II Affordable Housing**

Description

Node 7 includes a number of facilities in the eastern portion of downtown New Paltz. These facilities include two major grocery stores, a pharmacy, a health clinic, subsidized housing complexes, a state government office (NYS DEC), and a variety of retail and other businesses. The POC for this node will be located to the west of the NY State Department of Environmental Conservation office. A new underground power line will be installed north to south to connect the facilities in this node.

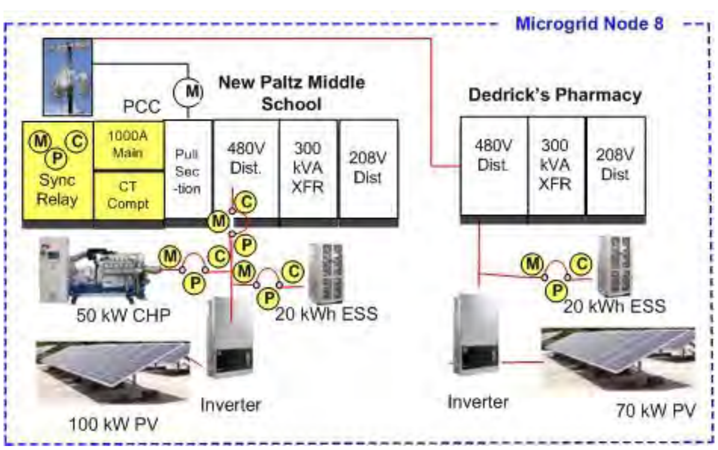
As part of the microgrid, the following will be installed:

- **PV (500 kW):** Multiple PV systems will be installed on the roofs of NYS DEC and ShopRite buildings.
- **PV (440 kW):** Multiple PV systems will be installed on the roofs of the commercial buildings in the Stop & Shop Plaza.
- **CHP (355 kW):** A large CHP unit will be placed near or inside ShopRite.
- **CHP (355 kW):** Another large CHP unit will be placed near or inside the Stop & Shop Plaza.
- **ESS (70 kWh x 2):** ESS units will be placed next to the CHP units at ShopRite and Stop & Shop Plaza.

Node 8 System Configuration

Geospatial Diagram

One-Line Diagram



Facilities

- **New Paltz Middle School**
- **Dedrick's Pharmacy**

Description

Node 8 will cover the New Paltz Middle School and Dedrick's Pharmacy, across the street. The POC will be located near the entrance to the school along Main Street. The two buildings will be interconnected with a new underground circuit.

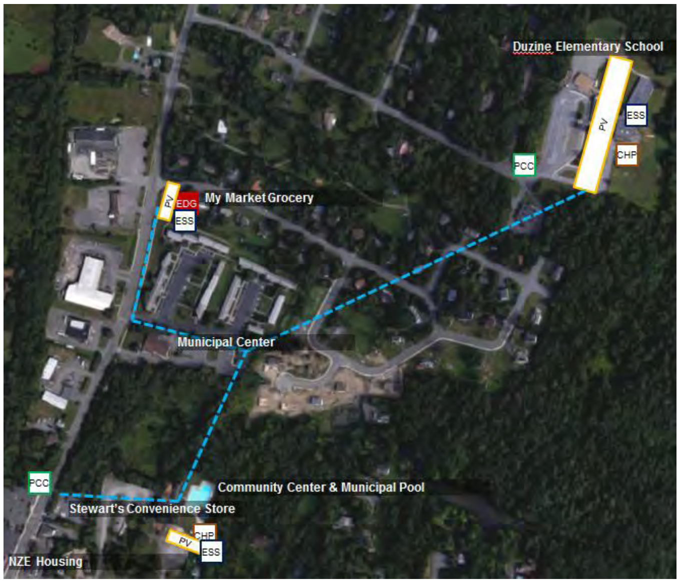
As part of the microgrid, the following will be installed:

- **PV (100 kW):** A PV system will be installed on the roof of the middle school
- **PV (70 kW):** An additional PV system will be installed on the roof of the pharmacy.
- **CHP (50 kW):** A small CHP unit will be placed behind the middle school.
- **ESS (20 kWh):** An ESS unit will be placed inside the middle school in an electrical room.
- **ESS (20 kWh):** An ESS unit will be placed inside the pharmacy near the PV inverter.

Note: Node 8 may be revised or omitted in Stage II, pending finalization of School District solar net-metering plans and revised resiliency objectives.

Node 9 System Configuration

Geospatial Diagram



One-Line Diagram

Facilities

- **Municipal Center (Town, Village, Police)**
- **Community Center & Municipal Pool**
- **Duzine Elementary School**
- **Stewart's Convenience Store**
- **Zero Net Energy (ZNE) Housing**
- **My Market Grocery**

Description

Node 9 includes Town and Village government and command center facilities, police station, elementary school, net-zero energy housing, and neighborhood grocery, convenience, and gasoline businesses. This node will include two PCCs, one near the entrance to the elementary school, and one in front of Stewart's Convenience Store along Route 32. An existing emergency gas generator is located at the My Market Grocery (375 kW). Except where underground cables already exist (in the NZE housing development) new underground cable will be installed to connect the facilities in Node 9.

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

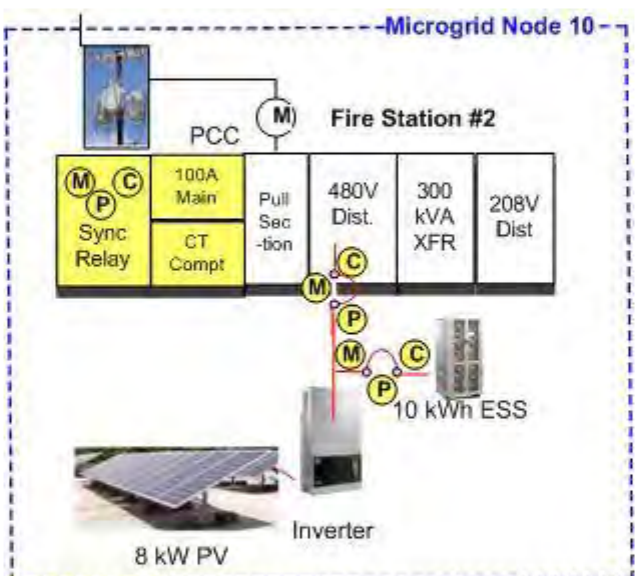
- **PV (280 W):** A PV system will be installed on the roof of the school.
- **PV (10 W):** A small PV system will be installed on the roof of the My Market Grocery store.
- **PV (10 W):** A small PV system will be installed on the roof of the community center.
- **CHP (70 kW):** A CHP unit will be placed behind the school
- **CHP (10 kW):** A small CHP unit will be placed near the municipal pool.
- **ESS (40 kWh):** An ESS unit will be placed inside the school in an electrical room.
- **ESS (10 kWh):** An ESS unit will be placed inside the My Market Grocery store.
- **ESS (10 kWh):** An ESS unit will be placed inside the community center near the outdoor CHP unit.

Note: Node 9 may be revised in Stage II, pending finalization of School District solar net-metering plans and revised resiliency objectives, and finalization of Town and Village plans to build the new Municipal Center and police station.

Node 10 System Configuration

Geospatial Diagram

One-Line Diagram



Facility

- **Fire Station #2**

Description

Node 10 is a single facility node, comprised of the fire station. The POC for this node is located along North Putt Corners Road.

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

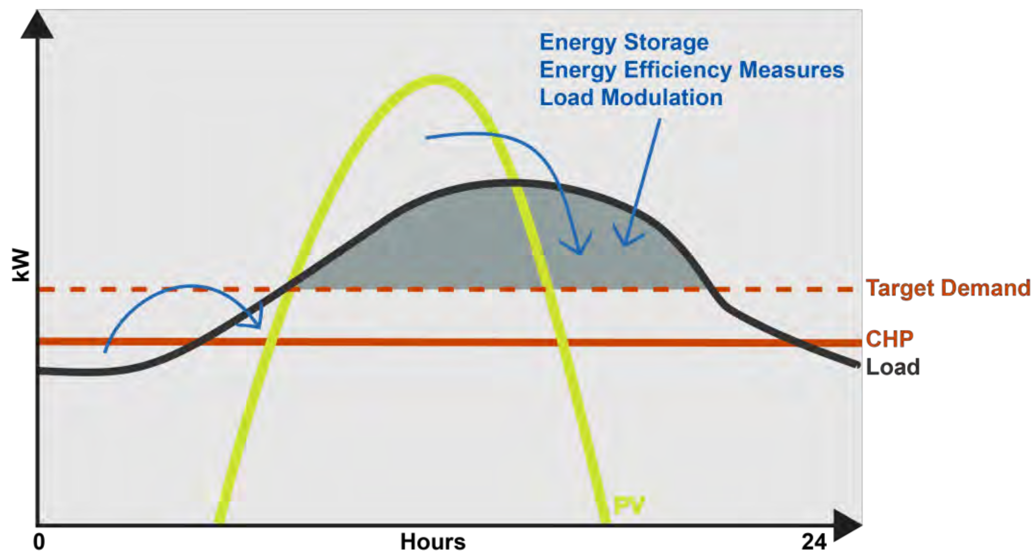
- **PV (8 kW):** A small rooftop PV system will cover half of the roof.
- **ESS (10 kWh):** An ESS unit will be placed inside the small outside building to the west of the fire station.

Normal and Emergency Operations

The microgrid distributed energy resource (DER) selection is based on a *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 "always-on" 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 will be designed to run at design output for at least 8,000 hours per year. To meet the load that varies above the base load, resources such as PV and energy storage will be integrated into the system. Energy storage systems will be specified based on their capability to change their output rapidly and address the ramp rate issue to support load following, and buffering the differences between CHP, electrical load, and PV throughout the day. This concept is presented in Figure 2.

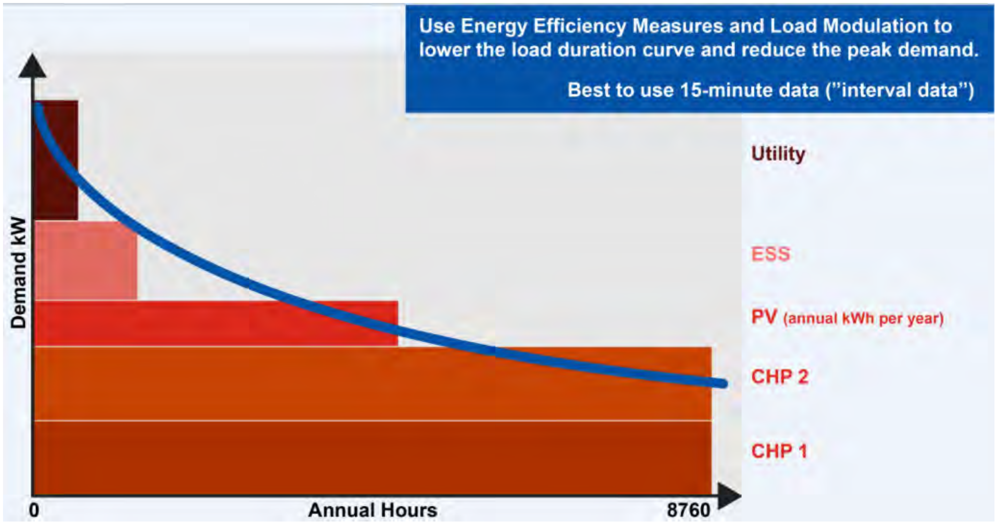
Figure 2 – Microgrid Portfolio Approach



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 3 illustrates another element of the resource selection and sizing strategy for the New Paltz 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 3 – Load Duration Curve



One of the most important attributes of the New Paltz 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 which requires the microgrid to establish itself through a black start sequence of operation.

The resources included in the New Paltz microgrid will be 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. The project team anticipates that the resources available to be controlled during island operations will include CHP, fossil fuel generators, PV systems, energy storage, and building load. The team also expects 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 New Paltz microgrid is to supply the critical load at a level that enables the critical services that keep the community functioning at an "80% 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 residents. This will reduce the stress on emergency services and on residents

2.2: Load Characterization

Modeling Methodology

The microgrid was modeled using HOMER Pro (Hybrid Optimization Model for Multiple Energy Resources). 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 each of the six nodes separately. Table 2 presents an overview of the energy operations of the microgrid for annual and monthly average values. The microgrid will have a maximum demand of 6,498 kW and an average demand of 1,922 kW. The microgrid will deliver approximately 16,800,000 kWh per year. The thermal loads in the microgrid will be approximately 44,600,000 kBTU per year, of which approximately 26,000,000 kBTU will be recovered from the CHP systems and reused to support on-site thermal loads.

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	129	37	321,769	26,814	656,315	54,693	476,830	39,736
2	1,355	419	3,669,426	305,786	18,023,168	1,501,931	8,180,847	681,737
3	171	25	218,254	18,188	232,746	19,396	87,218	7,268
4	510	177	1,549,655	129,138	1,383,616	115,301	1,210,550	100,879
5	496	111	974,992	81,249	1,235,417	102,951	668,957	55,746
6	52	15	134,408	11,201	256,548	21,379	119,333	9,944
7	2,815	924	8,091,466	674,289	18,498,912	1,541,576	13,511,386	1,125,949
8	413	77	675,681	56,307	886,711	73,893	509,016	42,418
9	544	136	1,190,548	99,212	3,267,873	272,323	1,238,709	103,226
10*	13	1	12,257	1,021	245,341	20,445	-	-
Total	**6,498**	**1,922**	**16,838,456**	**1,403,205**	**44,686,647**	**3,723,888**	**26,002,846**	**2,166,903**

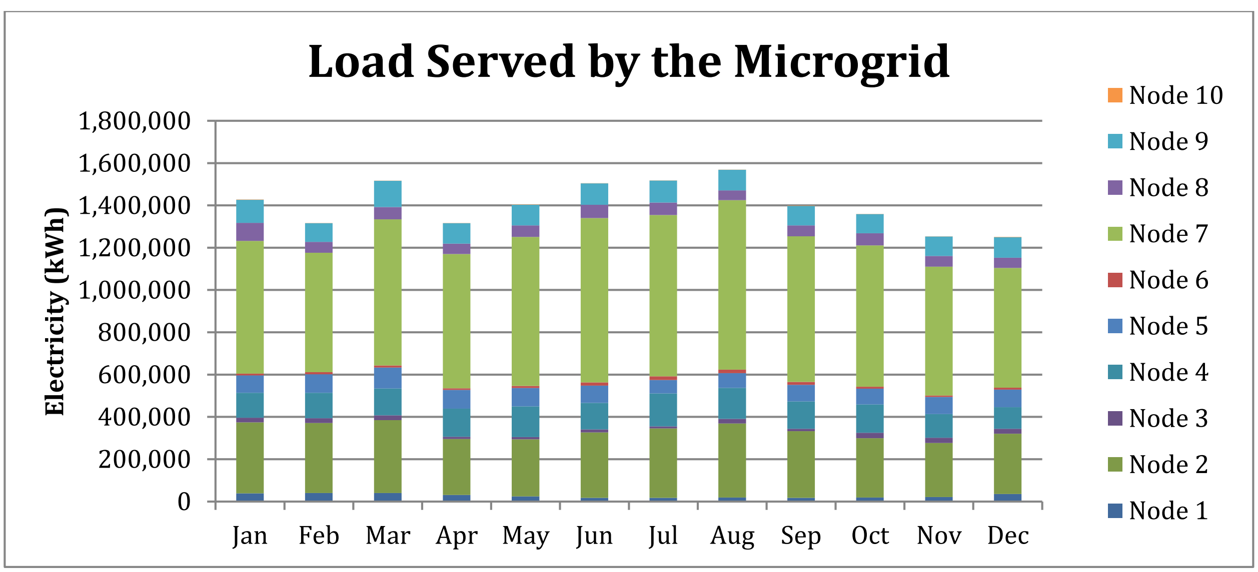
**** Node does not include CHP***

The monthly energy delivery by microgrid node is described in Table 3 and presented graphically in Fig. 4.

Table 3 –Monthly Grid Connected Operation by Node

Month	Node 1	Node 2	Node 3	Node 4	Node 5	Node 6	Node 7	Node 8	Node 9	Node 10	Total
	(kWh)										
Jan	38,547	335,480	22,000	118,109	82,009	8,836	627,121	85,639	108,434	1,186	1,427,361
Feb	40,390	331,157	22,380	120,090	87,758	9,803	564,348	51,844	88,217	847	1,316,835
Mar	39,884	344,994	22,542	127,283	98,544	9,911	691,044	58,314	123,770	918	1,517,203
Apr	31,057	264,646	10,189	132,944	89,129	7,463	634,213	49,214	96,746	789	1,316,390
May	24,573	269,763	10,623	145,142	86,840	9,783	704,059	54,387	98,706	1,104	1,404,980
Jun	17,117	309,447	14,511	125,582	81,318	15,351	776,467	63,269	100,701	1,290	1,505,053
Jul	17,585	327,768	10,203	155,521	63,578	16,918	762,705	58,988	104,352	1,134	1,518,753
Aug	19,255	349,867	21,487	147,134	69,206	17,011	800,397	46,222	97,347	1,382	1,569,309
Sep	17,450	315,453	10,810	129,722	78,118	14,050	688,210	51,266	92,608	1,167	1,398,853
Oct	18,669	280,710	25,422	134,154	74,556	9,270	667,656	57,665	90,474	751	1,359,329
Nov	21,602	254,921	25,251	111,446	81,301	6,344	609,150	50,742	92,289	813	1,253,858
Dec	35,639	285,220	22,836	102,530	82,635	9,668	566,095	48,131	96,903	874	1,250,531
Total	**321,768**	**3,669,426**	**218,254**	**1,549,657**	**974,992**	**134,408**	**8,091,465**	**675,681**	**1,190,547**	**12,255**	**16,838,456**

Figure 4 - Monthly Grid Connected Operation by Node



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 which represent an outage during the winter and an outage during the summer. Energy flows during the outages are presented as weekly averages in Table 4.

Table 4 –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	94	42	7,044	32,587	19,966
	Summer	60	25	4,202	641	641
2	Winter	1,013	453	76,139	914,428	234,231
	Summer	979	369	61,922	131,234	129,338
3	Winter	145	34	5,785	11,958	2,665
	Summer	97	15	2,491	-	-
4	Winter	245	154	25,898	82,099	61,819
	Summer	281	170	28,487	613	613
5	Winter	322	96	16,054	70,487	28,329
	Summer	254	81	13,530	602	602
6	Winter	19	12	2,069	14,755	4,807
	Summer	23	15	2,450	-	-
7	Winter	1,748	859	144,298	890,154	511,165
	Summer	1,656	849	142,685	95,608	95,608
8	Winter	250	87	14,617	50,696	25,118
	Summer	267	74	12,400	350	350
9	Winter	446	150	25,163	173,363	37,982
	Summer	333	133	22,349	11,027	10,456
10*	Winter	11	1	188	12,627	-
	Summer	9	1	223	1,281	-
Total	**Winter**	**4,293**	**1,888**	**317,255**	**2,253,154**	**926,082**
	Summer	**3,958**	**1,731**	**290,739**	**241,357**	**237,609**

**** Node does not have CHP***

Development of Hourly Load Profiles

The project team developed hourly load profiles for the microgrid using the approach and assumptions described below.

Electric Load Profile

The project team used licensed HOMER Pro microgrid modeling software (as described above) to generate electrical load profiles for the proposed New Paltz microgrid design. The project team employed a data retrieval and pre-modeling process in order to generate inputs for the software. First, the project team requested the most recent twelve-month period of electric usage (kWh), peak demand (kW), and cost data from community stakeholders for each facility under consideration for inclusion in the design. Using a proprietary Hitachi pre-modeling tool, this data was used to estimate hourly load by facility over a twelve-month period.

The Hitachi pre-modeling tool was designed to take the set of available monthly usage and peak demand data, and, based on preset hourly loads for a variety of building types (commercial, industrial, residential, etc.) defined by the HOMER Pro microgrid modeling software, generate an hourly load profile per month for each building. Then, the set of available peak demand data was used to manually adjust the pre-populated hourly load profile until the total usage for each month was within +/- 10% of the actual given usage. The project team determined that +/- 10% was an acceptable confidence interval to satisfy the overall +/- 30% confidence interval required for this NY Prize Stage 1 analysis. This manual manipulation was employed only in instances where the pre-populated hourly load profile yielded total monthly usage values outside of the +/- 10% confidence interval, generating a more accurate depiction of peak and hourly load profiles that are characteristic across the portfolio of unique buildings within New Paltz.

The output values from this pre-modeling step were then inserted into the HOMER Pro microgrid modeling software for simulation, optimization, and analysis (as described above). The HOMER Pro tool allows for the input of daily load profiles and then adds in some randomness. This process produces one year of hourly load data. To address the potential randomness, HOMER Pro applies a 10% day-to-day variability and a 20% time-step variability. This level of variability provides for appropriate diversity from estimated loads and potential changes in operation for the clients, due to business needs.

Complete sets of electric data were collected for many of the facilities included in the microgrid as indicated in Table 5. However, for some buildings, stakeholders provided either a subset or none of the requested twelve-month set of data. In these cases, the data from similar-type buildings within the region were used to estimate monthly usage and peak demand based on the relative building area. The project team then applied the same pre-modeling process described above to these sets of data to estimate hourly load. This approach was applied to 12 buildings in New Paltz: Dedrick's Pharmacy, Elting Gym/Emergency Shelter, Fire Station #2, My Market Grocery, New Paltz Municipal Center, New Paltz Pump Station, New Paltz Rescue Squad, ShopRite, Stewart's Convenience Store, Stop & Shop, Sunoco, and SUNY Wellness Center.

In other cases, when limited data was available, and the project team did not have access to any similar (in terms of operating characteristics) buildings' data within the region from which the project team could estimate usage, the project team used data from The Energy Index for Commercial Buildings, which is based on the Energy Information Administration's (EIA) 2003 Commercial Buildings Energy Consumption Survey (CBECS). This data was used to generate an annual per-square-foot energy consumption amount for each building, which was scaled to each building's total square footage. The project team then applied the same pre-modeling process described above to these sets of data to estimate hourly load. This approach applied to three buildings in New Paltz: Institute for Family Health, Meadowbrook II subsidized housing, and ZNE housing development.

Table 5 summarizes the electric data collection and load estimate approach for each facility:

Table 5: Monthly Electric Data Provided to Project Team for Analysis

Facility		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Dedrick's Pharmacy	Usage	*Estimated using similar-type building data*											
	Demand												
Duzine Elementary	Usage	X	X	X	X	X	X	X	X	X	X	X	X
	Demand		X						X				
Elting Gym/Emergency Shelter	Usage	*Estimated using similar-type building data*											
	Demand												
Fire Station #2	Usage	*Estimated using similar-type building data*											
	Demand												
Institute for Family Health	Usage	*Estimated using CBECS 2003 data*											
	Demand												
Meadowbrook II Affordable Housing	Usage	*Estimated using CBECS 2003 data*											
	Demand												
My Market Grocery	Usage	*Estimated using similar-type building data*											
	Demand												
New Paltz Community Center & Municipal Pool	Usage	X	X	X	X	X	X	X	X	X	X	X	X
	Demand	X	X	X	X	X	X	X	X	X	X	X	X
New Paltz High School	Usage	X	X	X	X	X	X	X	X	X	X	X	X
	Demand	X	X	X	X	X	X	X	X	X	X	X	X
New Paltz Middle School	Usage	X	X	X	X	X	X	X	X	X	X	X	X
	Demand	X	X	X	X	X	X	X	X	X	X	X	X
New Paltz Municipal Center	Usage	*Estimated using similar-type building data*											
	Demand												
New Paltz Pump Station	Usage	*Estimated using similar-type building data*											
	Demand												
New Paltz Rescue Squad	Usage	*Estimated using similar-type building data*											
	Demand												
New Paltz Wastewater Treatment Facility	Usage	X	X	X	X	X	X		X	X	X	X	X
	Demand		X				X						
NYS Dept. of Environmental Conservation	Usage	X	X	X	X	X	X	X	X	X	X	X	X
	Demand	X	X	X	X	X	X	X	X	X	X	X	X
ShopRite	Usage	*Estimated using similar-type building data*											
	Demand												

Stewart's Convenience Store	Usage	*Estimated using similar-type building data*											
	Demand												
Stop & Shop	Usage	*Estimated using similar-type building data*											
	Demand												
Sunoco	Usage	*Estimated using similar-type building data*											
	Demand												
	Demand												
SUNY Student Health Center	Usage	X	X	X	X	X	X	X	X	X	X	X	X
	Demand	X	X	X	X	X	X	X	X	X	X	X	X
SUNY Wellness Center	Usage	*Estimated using similar-type building data*											
	Demand												
SUNY Student Health Center	Usage	X	X	X	X	X	X	X	X	X	X	X	X
	Demand	X	X	X	X	X	X	X	X	X	X	X	X
True Value Hardware	Usage		X					X					
	Demand	*Estimated based on presets provided in HOMER PRO*											
Water Pump Station	Usage	X	X	X	X	X	X	X	X	X	X	X	X
	Demand		X				X	X	X	X	X		X
Woodland Pond	Usage	X	X	X	X	X	X	X	X	X	X	X	X
	Demand	X	X	X	X	X	X	X	X	X	X	X	X
ZNE Housing	Usage	*Estimated using CBECS 2003 data*											
	Demand												

<u>Natural Gas Load Profile</u>

Similar to the process for modeling hourly electric load profiles, the project team used licensed HOMER Pro microgrid modeling software to generate thermal load profiles for the proposed New Paltz microgrid design. The project team requested the most recent twelve-month period of available natural gas (or fuel oil if applicable) and billing data from community stakeholders for each facility under consideration for inclusion in the design. Using a proprietary Hitachi pre-modeling tool, this data was used to estimate hourly thermal load by facility over a 12-month period. The output values from this pre-modeling step were then inserted into HOMER Pro in the same manner as the electric load data discussed above.

Complete sets of natural gas data were collected for many of the facilities included in the microgrid as indicated in Table 6. However, for some buildings, stakeholders provided either a subset or none of the requested 12-month set of data. In these cases, the data from similar-type buildings within the region were used to estimate monthly usage and peak demand based on the relative building area. The project team then applied the same pre-modeling process described above to these sets of data to estimate hourly load. This approach applied to 15 buildings in New Paltz: Dedrick's Pharmacy, Duzine Elementary, Elting Gym/Emergency Shelter, Fire Station #2, Institute for Family Health, My Market Grocery, New Paltz Community Center & Municipal Pool, New Paltz High School, New Paltz Municipal Center, New Paltz Wastewater Treatment Facility, ShopRite, Stop & Shop, SUNY Wellness Center, True Value Hardware, and ZNE housing development.

In other cases, when limited data was available, and the project team did not have access to any similar (in terms of operating characteristics) buildings' data within the region from which the project team could estimate usage, the project team used data from The Energy Index for Commercial Buildings, based on the EIA 2003 CBECS. This data was used to generate an annual per-square-foot energy consumption amount for each building, which was scaled to each building's total square footage. The project team then applied the same pre-modeling process described above to these sets of data to estimate hourly load. This approach applied to five buildings in New Paltz: Meadowbrook II, New Paltz Rescue Squad, Stewart's Convenience Store, Sunoco, and SUNY Student Health Center.

Table 6 summarizes the natural gas data collection and load estimate approach for each facility:

Table 6: Monthly Natural Gas Data Provided to Project Team for Analysis

Facility	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Dedrick's Pharmacy	*Estimated using similar-type building data*											
Duzine Elementary	*Estimated using similar-type building data*											
Elting Gym/Emergency Shelter	*Estimated using similar-type building data*											
Fire Station #2	*Estimated using similar-type building data*											
Institute for Family Health	*Estimated using similar-type building data*											
Meadowbrook II Association	*Estimated using CBECS 2003 data*											
My Market Grocery	*Estimated using similar-type building data*											
New Paltz Community Center & Municipal Pool	*Estimated using similar-type building data*											
New Paltz High School	*Estimated using similar-type building data*											
New Paltz Middle School	X	X	X	X	X	X	X	X	X	X	X	X
New Paltz Municipal Center	*Estimated using similar-type building data*											
New Paltz Rescue Squad	*Estimated using CBECS 2003 data*											
New Paltz Wastewater Treatment Facility	*Estimated using similar-type building data*											
NYS Dept. of Environmental Conservation	X	X	X	X	X	X	X	X	X	X	X	X
ShopRite	*Estimated using similar-type building data*											
Stewart's Convenience Store	*Estimated using CBECS 2003 data*											
Stop & Shop	*Estimated using similar-type building data*											
Sunoco	*Estimated using CBECS 2003 data*											
SUNY Student Health Center	*Estimated using CBECS 2003 data*											
SUNY Wellness Center	*Estimated using similar-type building data*											
True Value Hardware	*Estimated using similar-type building data*											
Woodland Pond	X	X	X	X	X	X	X	X	X	X	X	X
ZNE Housing Development	*Estimated using similar-type building data*											

Sizing Loads and System Redundancy

The traditional reserve margins and redundancy that the utility industry uses to describe elements of reliability do not necessarily apply to microgrids. For example, the utility grid employs reserve margins at 15% to 23% and N-1 contingency criteria where the grid can accommodate the loss of the largest single unit in a utility control area. However, this approach assumes the transmission and distribution line infrastructure is intact, yet experience shows that the major contributors to loss of grid supply to customers are related to line infrastructure. A long history of grid performance data demonstrates that “redundancy” (reserve margin and N-1 contingency criteria) has little to do with reliability at the customer site.

In contrast to this, experience with operating microgrids within the US and overseas s that this microgrid approach yields a great deal more uptime for the customer than the utility by itself, which employs reserve margins and redundancy measures for the grid.

The New Paltz microgrid is designed for 80% to 86% 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 includes reliability history of the grid into reliability optimization.

The reliability of the New Paltz 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 New Paltz 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 7 summarizes the microgrid resources in each node in terms of number of devices and the total installed capacity by technology.

Table 7 - Microgrid Node Resources Comparison

Node	Operation Scenario	Grid	PV		Battery Energy Storage		Natural Gas Engine or CHP		Backup Generators	
		Peak kW	# of Inverters	kW	Quantity	kW / kWh	Quantity	kW	Quantity	kW
1	Business as Usual	129	-	-	-	-	-	-	-	-
	Microgrid	55	1	50	1	5 / 10	1	30	-	-
2	Business as Usual	1355	-	-	-	-	-	-	1	600
	Microgrid	580	3	650	1	95 / 190	1	248	1	600
3	Business as Usual	171	-	-	-	-	-	-	1	175
	Microgrid	110	1	40	1	5 / 10	1	15	1	175
4	Business as Usual	510	1	50	-	-	-	-	2	160
	Microgrid	200	1	100	1	20 / 40	1	130	2	160
5	Business as Usual	496	-	-	-	-	-	-	-	-
	Microgrid	220	1	270	1	5 / 10	1	60	-	-
6	Business as Usual	52	-	-	-	-	-	-	-	-
	Microgrid	22	1	15	1	5 / 10	1	10	-	-
7	Business as Usual	2815	-	-	-	-	-	-	1	15
	Microgrid	1100	2	940	2	70 / 140	2	710	1	15
8	Business as Usual	413	-	-	-	-	-	-	-	-
	Microgrid	160	2	170	2	20 / 40	1	50	-	-
9	Business as Usual	544	-	-	-	-	-	-	1	375
	Microgrid	180	3	300	3	30 / 60	2	80	1	375
10	Business as Usual	13	-	-	-	-	-	-	-	-
	Microgrid	6	1	8	1	5 / 10	-	-	-	-

2.3: Distributed Energy Resources Characterization

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

- Combined Heat and Power (CHP)
- Solar Photovoltaics (PV)
- Energy Storage System (ESS)
- Building Load Control
- Energy Efficiency Measures (EEMs)
- Utility Grid
- Backup Generators

The energy efficiency measures (EEM) that are planned for the New Paltz microgrid have been taken into account for the final sizing of the microgrid portfolio of resources. This ensures that the microgrid resources are not oversized. Some of the EEM measures selected for this project include the installation of LED lighting, premium efficiency motors, variable speed drives, and advanced building controls.

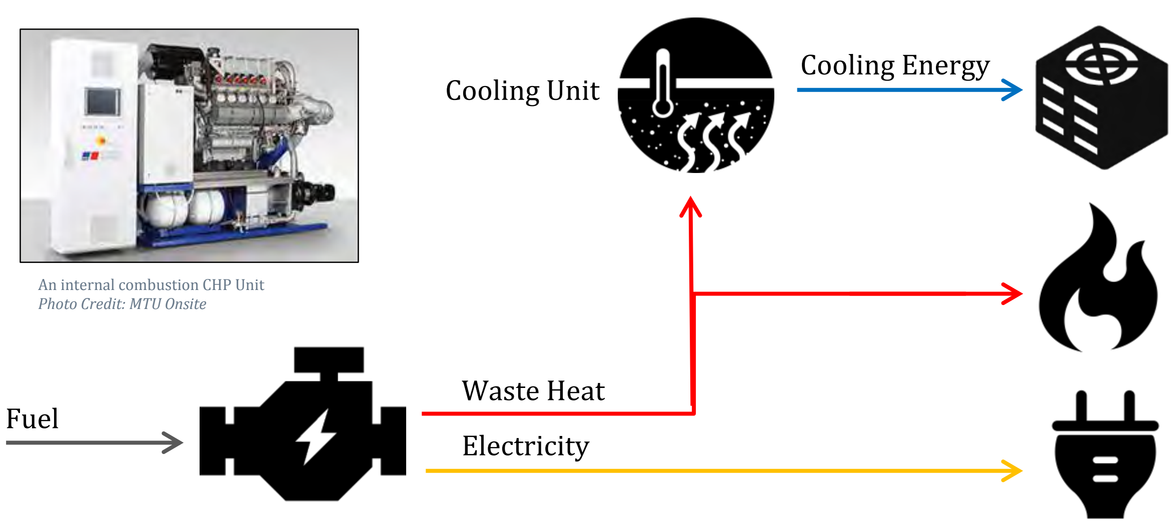
CHP units will be co-located with the thermal loads of targeted buildings. Solar PV arrays will be located opportunistically on suitable rooftops, in parking areas, and in locations where opportunities for ground mount arrays exist. Energy storage units will be sited near the solar PV arrays, with preference for indoor locations. 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.

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

Combined Heat and Power (CHP)

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 collated 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 5.

Figure 5 – CHP System Overview



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 and investment tax credits available for eligible customers

CHP Approach

- Co-Locate generators near thermal loads on the customer-side of the meter
- Design for base load operation of ~8,500 hours/year, 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 8 summarizes the CHP components by node of the microgrid.

Table 8 - Microgrid CHP Resources by Node

Node	Natural Gas Engine or CHP	
	Quantity	Total kW
1	1	30
2	1	248
3	1	15
4	1	130
5	1	60
6	1	10
7	2	710
8	1	50
9	2	80
10	-	-
Total	**11**	**1,333**

Table 9 and 10 and Figs. 6, 7 and 8 describe the annual operation of the CHP fleet in the New Paltz microgrid.

Table 9 - Microgrid CHP Electric Production by Node

Month	Node 1	Node 2	Node 3	Node 4	Node 5	Node 6	Node 7	Node 8	Node 9	Node 10	Total
	Electric Production (kWh)										
Jan	21,456	175,322	5,830	83,954	31,314	6,489	470,680	36,001	45,195	-	876,241
Feb	19,670	162,052	5,208	81,079	33,053	6,497	418,826	22,156	38,345	-	786,885
Mar	21,647	170,992	5,955	84,727	32,347	6,605	481,747	24,471	52,706	-	881,197
Apr	20,075	157,864	4,091	86,786	32,110	5,282	435,950	23,078	42,931	-	808,169
May	17,125	163,336	4,224	85,076	31,858	6,358	466,406	24,248	43,947	-	842,578
Jun	10,112	155,562	5,281	74,757	31,313	7,185	462,250	27,141	45,208	-	818,809
Jul	10,576	168,899	4,423	88,631	22,733	7,436	461,926	26,611	47,854	-	839,090
Aug	11,464	171,574	6,229	88,362	28,855	7,426	480,592	20,324	45,894	-	860,720
Sep	10,499	159,533	4,576	83,370	30,697	7,193	457,598	22,847	43,267	-	819,579
Oct	12,350	167,235	6,147	87,256	30,879	6,660	463,719	26,515	43,830	-	844,591
Nov	16,614	156,951	5,907	80,941	30,991	4,678	449,495	24,384	42,735	-	812,696
Dec	21,755	145,016	5,871	77,178	32,028	6,813	389,770	24,572	45,097	-	748,100
Total	**193,342**	**1,954,336**	**63,742**	**1,002,117**	**368,178**	**78,622**	**5,438,959**	**302,348**	**537,009**	**-**	**9,938,655**

Figure 6 – Microgrid CHP Electric Production

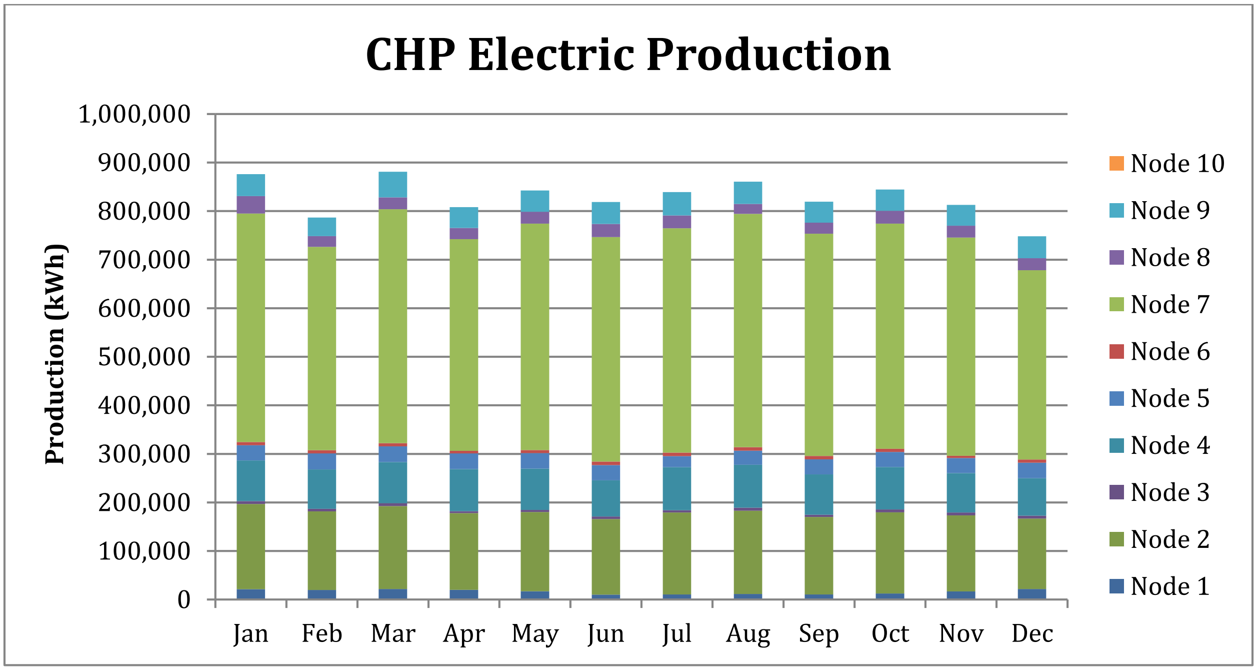


Table 10 - Microgrid CHP Heat Recovery by Node

Month	Node 1	Node 2	Node 3	Node 4	Node 5	Node 6	Node 7	Node 8	Node 9	Node 10	Total
	Heat Recovery (kBTU)										
Jan	76,057	935,135	19,617	245,927	110,658	18,804	1,984,703	95,739	160,691	-	3,647,331
Feb	69,510	846,401	18,522	229,024	99,431	18,952	1,771,391	75,819	136,398	-	3,265,449
Mar	76,241	900,745	19,285	197,797	101,319	16,892	1,829,707	75,074	175,259	-	3,392,318
Apr	55,159	782,427	8,928	85,110	62,854	12,314	1,266,546	40,300	128,624	-	2,442,263
May	22,195	630,920	8	9,697	11,757	2,308	835,323	8,255	79,372	-	1,599,834
Jun	9,571	553,161	-	4,001	5,866	1,049	639,949	3,804	48,579	-	1,265,981
Jul	2,528	501,153	-	2,423	2,394	-	378,257	1,376	41,871	-	930,003
Aug	5,273	499,033	-	3,983	4,315	1,112	400,862	2,643	35,183	-	952,404
Sep	7,419	524,378	-	8,826	11,519	2,308	487,497	8,293	42,076	-	1,092,316
Oct	17,789	595,459	-	62,414	52,316	11,160	733,872	40,986	82,795	-	1,596,791
Nov	58,434	718,538	-	164,287	96,711	15,572	1,533,678	73,666	147,863	-	2,808,748
Dec	76,653	693,498	20,858	197,061	109,818	18,861	1,649,600	83,062	159,997	-	3,009,407
Total	**476,830**	**8,180,847**	**87,218**	**1,210,550**	**668,957**	**119,333**	**13,511,386**	**509,016**	**1,238,709**	**-**	**26,002,846**

Figure 7 – Microgrid CHP Heat Recovery

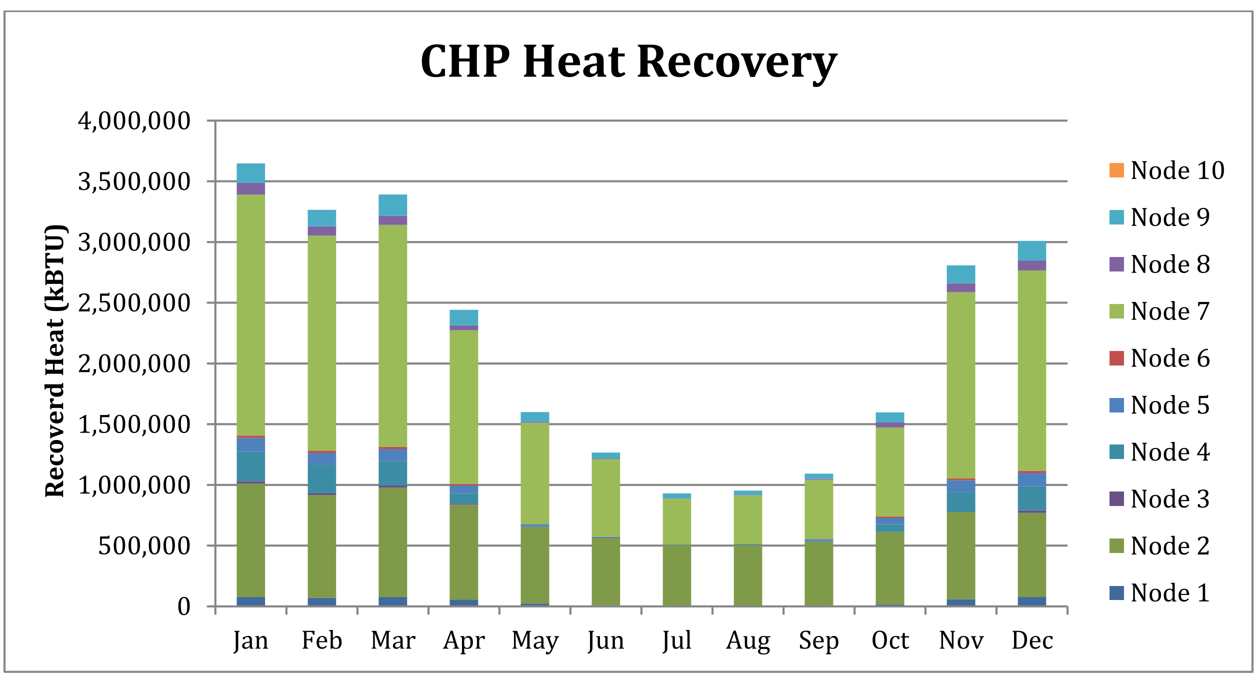
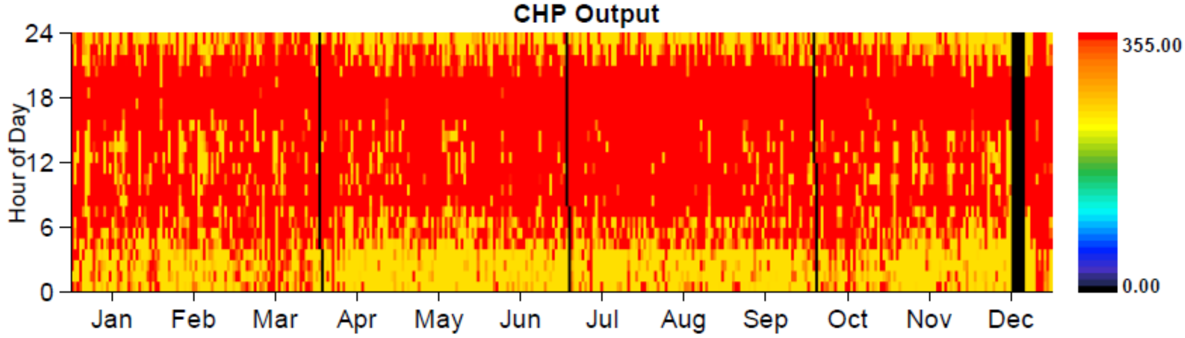


Figure 8 presents the hourly operation of the CHP in node 7 in the form of a heat map. This representation demonstrates how the CHP unit is operating a near full capacity during normal business hours (red) and then does some electric load following during the non-business hours (yellow) but is loaded at an overall high level of output during the course of the year.

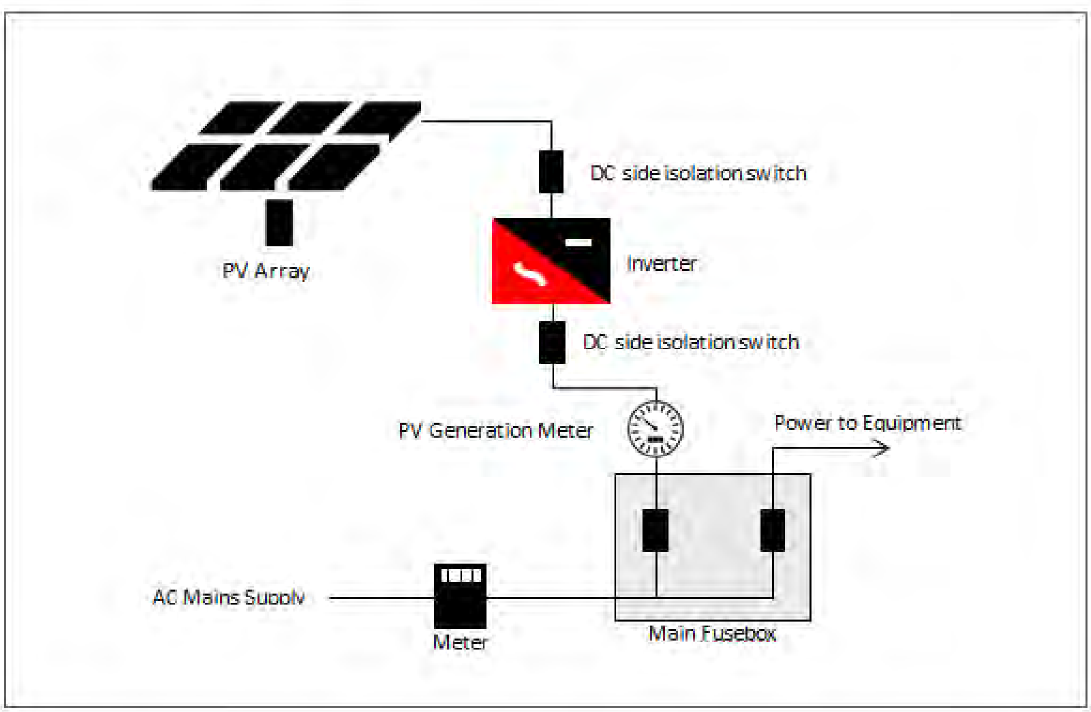
Figure 8 – Node #7 CHP Operational Summary



Solar Photovoltaics

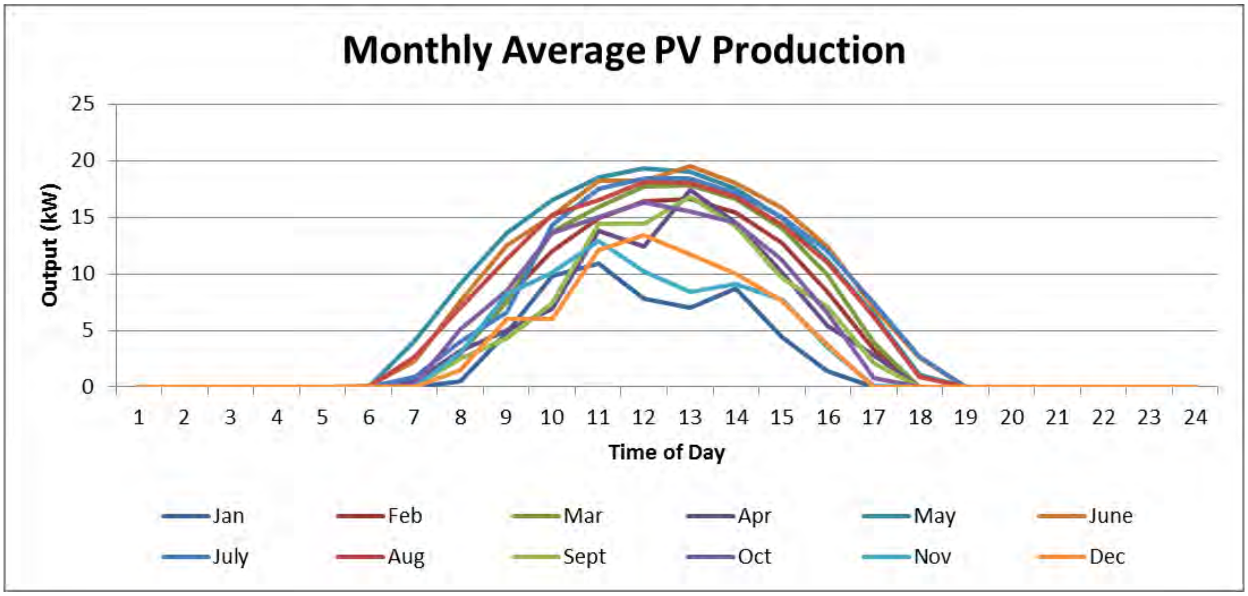
The solar photovoltaic systems (PV) will be rooftop, parking lot or ground mounted using hail-rated solar panels. PV devices generate electricity directly from sunlight via an electronic process that occurs naturally in certain types of material, called semiconductors. Electrons in these materials are freed by photons and can be induced to travel through an electrical circuit resulting in the flow of electrons to create energy 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 9.

Figure 9 – 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 10 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 10 – Typical PV Daily Generation Profiles



PV systems are planned for rooftops, parking spaces, and ground-mount configurations. Figure 11 presents examples of each these types of installations

Figure 11 – PV Installation Options.

Ballasted Roof-mount Installation

Ground-mount Installation

Covered Parking Installation (Solar Trees)

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 11 summarizes the PV components by node of the microgrid.

Table 11 - Microgrid PV Resources by Node

Node	PV	
	# of Inverters	Total kW
1	1	50
2	3	650
3	1	40
4	2	150
5	1	270
6	1	15
7	2	940
8	2	170
9	3	300
10	1	8
Total	**17**	**2,593**

The table and figure below present the monthly production by node for the PV fleet.

Table 12 – Microgrid PV Fleet Electric Production

Month	Node 1	Node 2	Node 3	Node 4	Node 5	Node 6	Node 7	Node 8	Node 9	Node 10	Total
	Electric Production (kWh)										
Jan	4,409	61,541	5,207	14,202	25,563	1,420	88,997	16,095	28,403	757	246,595
Feb	4,904	67,002	5,669	15,462	27,832	1,546	96,896	17,524	30,924	825	268,584
Mar	6,814	87,873	7,435	20,278	36,501	2,028	127,079	22,982	40,557	1,082	352,630
Apr	6,145	79,814	6,754	18,419	33,154	1,842	115,423	20,874	36,837	982	320,244
May	6,522	85,391	7,225	19,706	35,470	1,971	123,489	22,333	39,411	1,051	342,570
Jun	6,211	80,985	6,853	18,689	33,640	1,869	117,116	21,181	37,377	997	324,916
Jul	6,215	81,571	6,902	18,824	33,884	1,882	117,965	21,334	37,648	1,004	327,230
Aug	6,101	80,435	6,806	18,562	33,411	1,856	116,321	21,037	37,124	990	322,643
Sep	6,006	78,114	6,610	18,026	32,447	1,803	112,964	20,430	36,052	961	313,413
Oct	5,570	71,478	6,048	16,495	29,691	1,649	103,368	18,694	32,990	880	286,862
Nov	4,288	54,760	4,634	12,637	22,747	1,264	79,192	14,322	25,274	674	219,791
Dec	4,020	53,940	4,564	12,448	22,406	1,245	78,006	14,108	24,896	664	216,297
Total	**67,205**	**882,904**	**74,707**	**203,748**	**366,746**	**20,375**	**1,276,816**	**230,914**	**407,493**	**10,867**	**3,541,775**

Figure 12 – Microgrid PV Fleet Electric Production

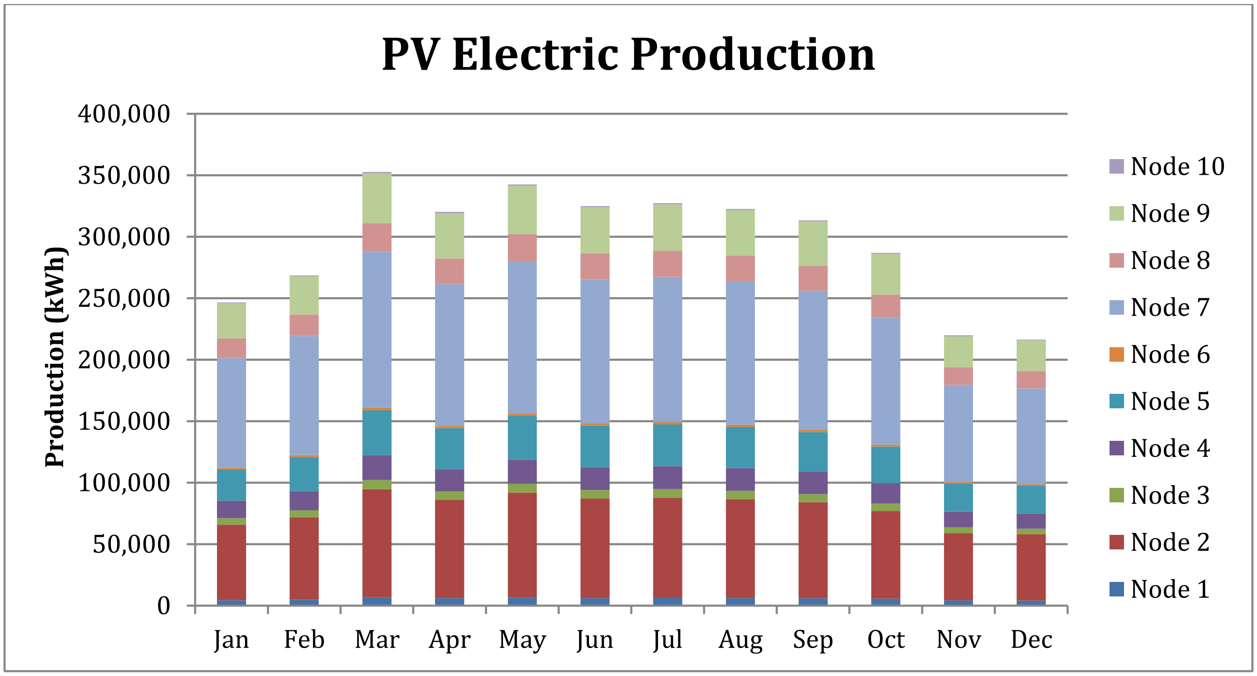
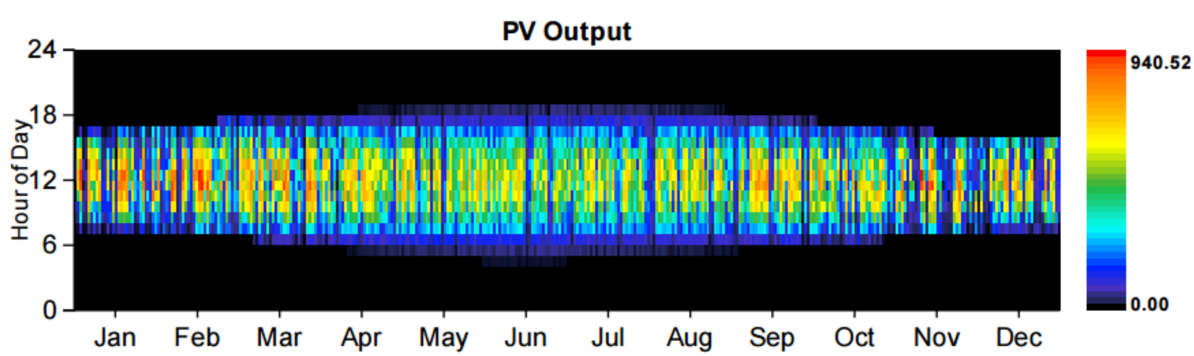


Figure 13 presents the hourly operation of the PV in node 7 in the form of a heat map. This representation demonstrates how the PV units operate during hours of sunshine with maximum production in the middle of the day, ramping up in the mornings and ramping down in the afternoon hours. This also illustrates the trend of narrower daily bands of production in the winter and then expanding to maximum production in the summer.

Figure 13 – Node #7 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 New Paltz microgrid is Lithium Ion (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 several 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 0% state 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 14 presents examples of energy storage installations for the technologies addressed for this microgrid design.

Figure 14 – 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, energy storage, 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 13 summarizes the ESS components by node of the microgrid.

Table 13 - Microgrid ESS Resources by Node

Node	Battery Energy Storage		
	Quantity	kW	kWh
1	1	5	10
2	1	95	190
3	1	5	10
4	1	20	40
5	1	5	10
6	1	5	10
7	2	70	140
8	2	20	40
9	3	30	60
10	1	5	10
Total	**14**	**260**	**520**

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 Node 7 ESS fleet is presented in Table 14, presenting both the charge and discharge modes of operation. The net value is positive which takes into account the operational losses for the systems.

Table 14 - Microgrid Node 7 ESS Operation

Month	Charge	Discharge (kWh)	Net
Jan	8,420	7,678	742
Feb	7,192	6,571	621
Mar	9,395	8,643	752
Apr	7,155	6,583	572
May	7,589	6,982	607
Jun	5,957	5,521	436
Jul	5,752	5,251	501
Aug	5,390	4,958	431
Sep	6,844	6,297	548
Oct	7,648	7,036	612
Nov	6,595	6,067	528
Dec	5,567	5,121	445
Total	**83,503**	**76,709**	**6,794**

Figure 15 – Microgrid Node 7 ESS Operation

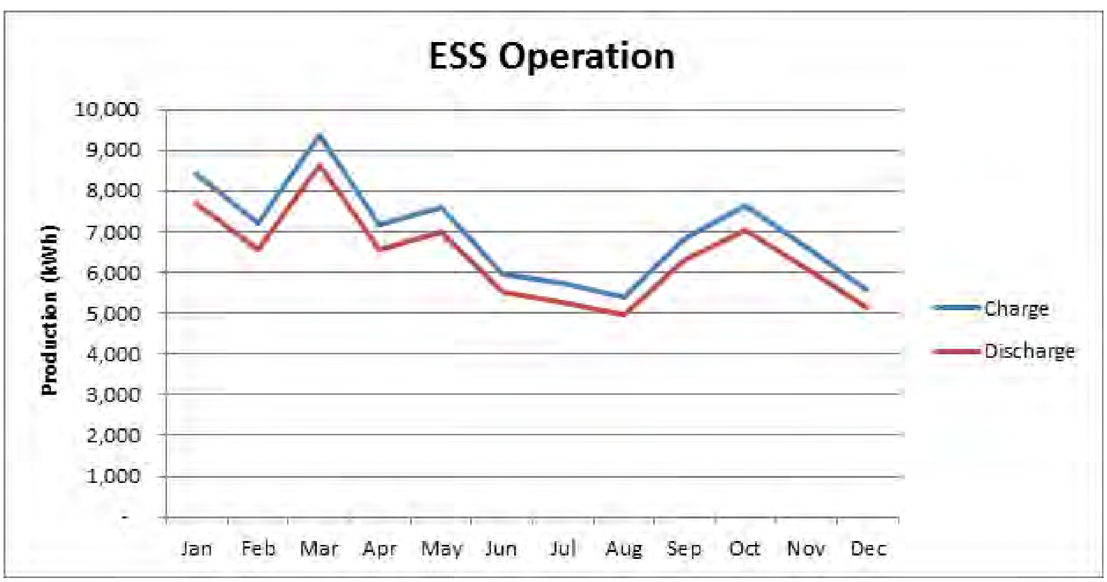
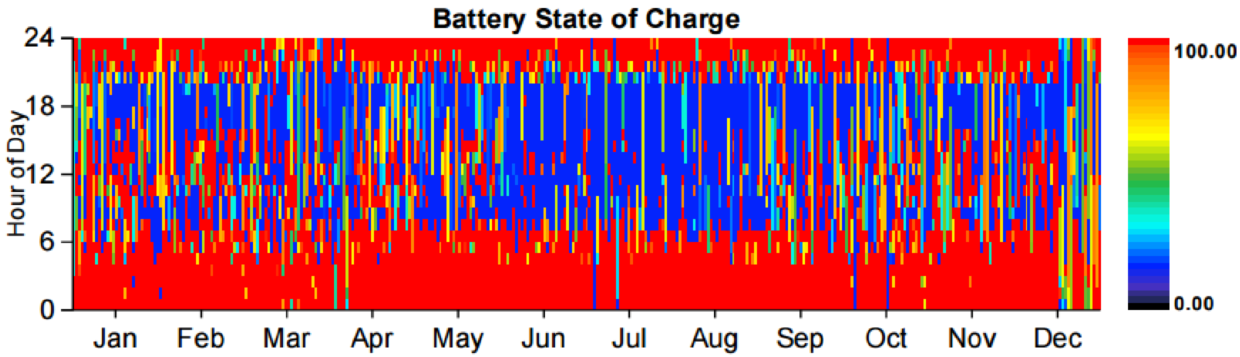


Figure 16 presents the hourly operation of the ESS in Node 7 in the form of heat map. This representation demonstrates how the ESS units operate. Typically, the units are charged to a high SOC to start each day and are operated during normal business hours. The operations represent PV intermittency support, PV load shifting and peak shaving (to manage utility imports).

Figure 16 – Node 7 ESS Operational Summary



Portfolio of Microgrid Distributed Energy Resources

The design for the New Paltz microgrid incorporates resources into non-intrusive areas available at critical facilities. Refer to the microgrid layout diagram (*Appendix A*) and one-line diagram (*Appendix B*) for general locations of resources.

Modeling the proposed microgrid reveals that the most economical total onsite DER generation requirement is in the range of 80% to 86% by energy (kWh) in grid-connected mode. Since specific DER sizes are discrete capacities, the matching of generation to load is imprecise, hence the range 80% to 86% by energy.

The electrical and thermal demand can also be modulated to meet total available DER production in a range of timeframes, from a few minutes to several hours. This modulation of load may have some comfort impacts, but will not impact mission critical functions within the critical facilities of the microgrid. In grid-connected mode, load modulation is not expected to take place unless driven by economic optimization, within the customer's stated objectives. In island mode, reliability and resiliency are the primary objectives, and load modulation may occasionally be used at certain times of the most energy-intensive days. If additional load modulation is needed, then critical facilities will be affected, but not in a way that would result in a material impact on the mission of that facility.

Upon loss of the grid, a sliding scale of importance of facilities in island mode will be used to make decisions about load modulation. During the first hours of a grid outage from a major storm, facilities providing emergency services (police, fire, emergency medical, hospital, etc.) will be prioritized. However, for extended outages, such as those during a major storm, other facilities may become more critical with time. For example, by the second or third day, the need for medications and food may drive grocery stores and pharmacies onto the critical list. By the fourth day, gasoline for home generators, mobile phone charging, cash, and emergency shelter may become very important to enable residents to shelter in place, elevating gas stations, ATMs, and public shelters onto the critical list.

This microgrid design is based on a portfolio of resources, including base generation fueled via resilient underground lines, PV operating when the sun is available (requiring no delivery), and energy storage systems (ESS) that store excess PV production for later use. Unlike an emergency diesel generator, this structure has no duration limit.

This microgrid design supplies all critical loads throughout the duration of a grid outage. In addition, some non-critical loads may continue to operate throughout the event when microgrid generation resources produce more energy than is required to serve the critical loads. Preliminary analysis suggests the sum of critical load and non-critical load served in island mode will be about 80% of the normal total load.

Since the microgrid design eliminates the need for temporary generation such as backup diesel generators, it will protect the New Paltz facilities covered by the microgrid from the need to shared fuel and equipment with other communities, as is common during extended utility grid outages.

Microgrid DERs Resiliency

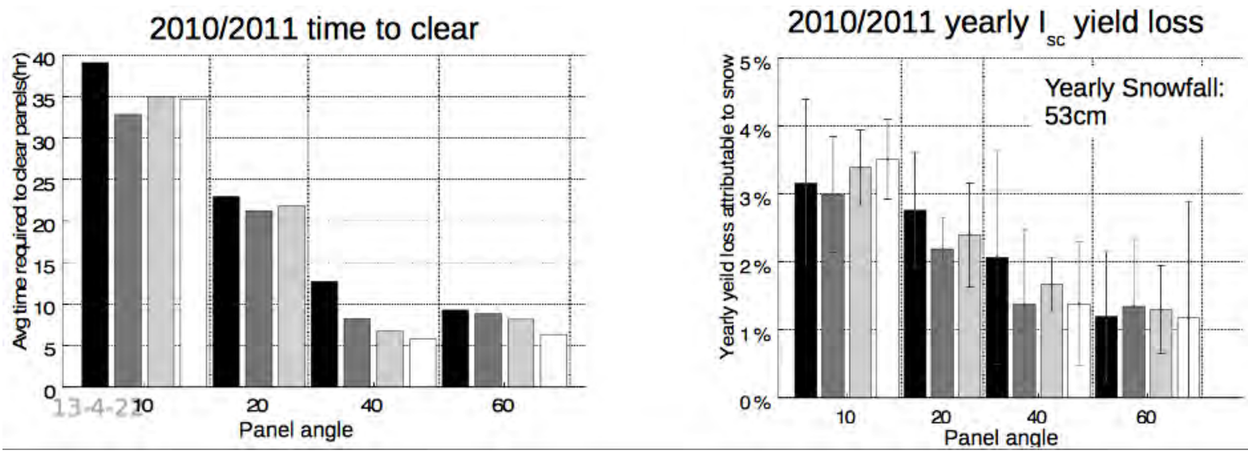
Under Task 1, the project team assessed the resiliency risk profile for various forces of nature to inform the microgrid design. This profile was evaluated in the following areas, with the associated design emphasis results:

1. Wind, tornado: The design of the DER structures (base foundations, enclosures, and connections) for distributed generators, fuel cells, CHP, outdoor energy storage, solar PV panels (hail rated) and racking, and electrical and thermal distribution equipment will withstand Category F2 wind speeds for this area. Installation of energy storage systems will be inside interior building electrical or mechanical rooms wherever possible.
2. Rain, flooding, hurricane: The design of the structures (base foundations, enclosures, and connections) for distributed generators, fuel cells, CHP, outdoor energy storage, solar PV panels (hail rated) and racking, and electrical and thermal distribution equipment will withstand Category 4 Hurricane (Staffer-Simpson scale, same maximum wind speed as the Category F2 tornado on the Fujita scale). In addition, the height of the base foundation for outdoor units is designed to assure the equipment is 1 to 1.5 feet above the 100-year flood plain level. Installation of energy storage systems will be inside interior building electrical or mechanical rooms wherever possible.
3. Earthquake: The design of the structures (base foundations, enclosures, and connections) for distributed generators, fuel cells, CHP, outdoor energy storage, solar PV panels (hail rated) and racking, and electrical distribution equipment will withstand seismic event magnitude 6.9 (Richter scale), or 100-year local seismic event, whichever is lesser. Due consideration is given to the design to overhead risk from buildings and other structures located above the microgrid equipment.
4. Extreme heat: the design the structures (base foundations, enclosures, and connections) for distributed generators, fuel cells, CHP, outdoor energy storage, solar PV panels (hail rated) and racking, and electrical distribution equipment will withstand 125˚F (50˚C) continuous operating temperatures. Where equipment enclosure temperatures are expected to exceed these temperatures for more than 10 minutes, space cooling is added.
5. Cold, ice: The design of the structures (base foundations, enclosures, and connections) for distributed generators, fuel cells, CHP, outdoor energy storage, solar PV panels (hail rated) and racking, and electrical distribution equipment will withstand 15˚F (-24˚C) continuous operating temperatures. Where equipment enclosure temperatures are expected to exceed these temperatures for more than 10 minutes, space heating is added. Enclosure design includes mitigation of ice formations that block airflow.

While deep snow on PV arrays can affect production, the typical effects are not as severe as one might guess. The performance criteria for snow cover on PV panels are based on annual loss of energy generation. A study published by Sandia National Laboratory, conducted by Queens University and

Calama Consulting in Canada, on a set of PV arrays totaling 8 MW in Kingston, Ontario, Canada using 2010-2012 data (annual snowfall 21 inches) shows that snow affects about 1% to 3% annual production loss – similar to the annual production loss from sand and dust in San Diego, California.

Figure 17 – PV Impedance from Snowfall



The first graph shows the time required to clear the snow. The second graph shows the yield loss rate for having the snow in place for the duration of the first graph. Both are based on panel angle.

Reliability of Fuel Sources

Microgrid installations of natural-gas-fired generation systems at multiple locations provide opportunities to improve the quality and reliability of gas distribution that will benefit a wide range of customers throughout the New Paltz.

The natural gas network is considered an uninterruptable fuel supply for the community in the face of major storms because:

(1) there are multiple network sources of natural gas

(2) the actual natural gas network load decreases in a major storm because the non-critical loads are not operating

(3) there is no history of loss of service in past major storms

In addition, interruptible service is a financial construct, not a technical limitation. Home heating is considered the highest priority for continuity of supply in the face of challenges to the natural gas network. Since this microgrid will use natural gas for CHP (heating of critical facilities), it will be given the highest priority for continuity of supply in the face of a major storm.

The operation of the microgrid will minimize the use of existing emergency diesel generators, and extend the typical three-day onsite fuel load for the emergency diesel generators to one week.

Microgrid DER Capabilities

The New Paltz 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 typically will 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 equal to or lower than the cost of electricity from the utility grid. In this scenario, the CHP 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 also will be used to manage the voltage and frequency of the microgrid.

The microgrid will take advantage of DERs 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. The microgrid also will 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 POC, 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.

2.4: Electrical and Thermal Infrastructure Characterization

The proposed microgrid nodes are supplied by two feeders off the same substation. The utility feeders are mainly overhead lines, which cannot be relied upon in the event of a major storm. The microgrid design employs underground cabling to support each microgrid node in key areas where it is cost effective for the overall project. While this greatly improves resiliency within a microgrid node, the cost of the underground cabling limits the reach of the node. The same general protection schemes are employed in each microgrid node as are used in utility distribution networks (see Microgrid Protection Scheme below). Some pole-top transformers will be replaced with pad-mount distribution transformers, and additional isolating switches and breakers will be added at the POC as described above. The design team and Central Hudson's engineering team will continue cooperating to refine the anticipated microgrid design, including potential for system sectionalizing with the addition of three strategically located disconnects on each feeder.

The existing thermal infrastructure consists mainly of hot water systems. Microgrid DERs will not attach to steam systems because the output temperatures of the natural gas engines do not meet specifications for a steam system. The CHP connections to the hot water systems are expected to be installed in parallel with existing boilers, and fed into existing supply and return headers.

Table 15 - Microgrid Electrical and Thermal Infrastructure Plan

Infrastructure	Class	Associated Device	Comment / Description
4.16 kV, 3 phase, 4 wire underground cabling	New	Nodes 4, 7, 8 & 9	Added for microgrid nodes that have multiple electric accounts
POC (All Nodes)	New	4.16 kV line to distribution transformer	Transition from overhead to underground
4.16 kV transformers	Updated	Critical Facilities	Conversion from pole-top to pad mount
Synchronizing switches	New	CHP	Each CHP at a critical facility will require a synchronizing switch with protection to enable remote synchronization with the microgrid bus
M, C, P	New	All resources	Monitoring (sensing), control, and protection relays for proper management of resources in all modes
Automatic transfer switch	Existing	Emergency Generators	All emergency generation (diesel or gas) have automatic transfer switches installed in critical facilities. This will remain unchanged.
HW supply connection	New	CHP & heating	Tie-in from CHP to facility thermal loop for each facility with new CHP
HW return connection	New	CHP & heating	Tie-in from CHP to facility thermal loop for each facility with new CHP

Infrastructure Resiliency

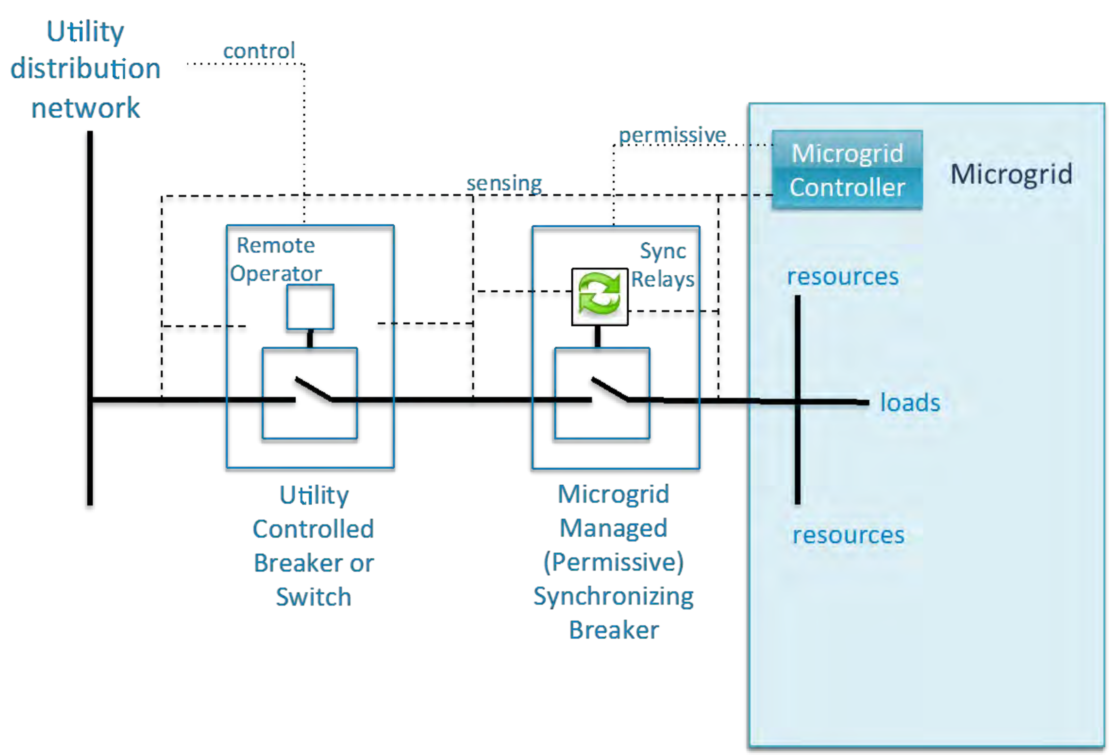
The electrical infrastructure currently consists of overhead distribution lines with pole-mounted transformers. The microgrid design calls for one or more underground 4.16 kV circuits to be established between the substation and the microgrid node points of common coupling. The team is engaged with Central Hudson to determine the most cost-effective approach for organizing and installing new underground segments. Critical new electric distribution infrastructure will be located in Nodes #4, 7, 8, and 9 where the microgrid distribution resources are shared among multiple facilities. In these cases, the common distribution segments need to be undergrounded. In the other nodes, the microgrid distributed energy resources will be behind the meter of a single customer, and the node design will support standalone island operation when the grid goes down. The discussion of resiliency of resources to forces of nature in section 2.3 is relevant to electrical and thermal infrastructure as well. Outdoor switches for the underground electric distribution network will be installed in enclosures in in-ground vaults. The natural gas infrastructure relied upon for resiliency is underground, which greatly reduces the risk of damage from forces of nature.

Point of Common Coupling Design Detail

The process of islanding a microgrid can create instability (in the form of an electrical transient) and added risk to operations. To minimize this, the design incorporates a Point of Common Coupling structure will help to protect the microgrid from danger, as presented in the Figure 18. This 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 moves into island mode. The microgrid controller will adjust all microgrid resources for island mode operational and performance objectives.

When the island transition is too small to generate instability (such as during an intentional island operation), the microgrid controller will open the synchronizing breaker when voltage, frequency, and phase angle are matched and stable across the breaker.

Figure 18 - Point of Common Coupling Structure



The microgrid design ensures a seamless transition back to the grid when power is restored. The microgrid controller (and/or operator) will connect with the utility distribution management according to all appropriate protocols, safety mechanisms, and switching plans.

The sequence of events for transitioning from an island mode to grid-connected mode is formed in accordance with the EPRI/ORNL Use Case 5. A summary of the transition plan is as follows:

- Utility determines it is acceptable for the microgrid to reconnect to the grid and closes the utility controlled breaker (see POC figure above).
- Microgrid controller senses voltage, frequency, and phase angle on the bus between the utility controlled breaker and the microgrid synchronizing breaker. The controller also senses voltage, frequency, and phase angle within the microgrid.
- Microgrid controller (and/or operator) decides to reconnect the microgrid to the utility grid.
- Microgrid controller adjusts controllable resources and loads to match voltage, frequency, and phase angle across the microgrid synchronizing breaker. This minimizes differences and power flows.
- When matched, the microgrid controller gives a "permission to close" signal to the microgrid synchronizing breaker.
- The synchronizing breaker does its own checking of voltage, frequency, and phase angle matching, and closes when matched.
- The microgrid controller places some microgrid load on the utility grid, and re-optimizes for economics and emissions reduction.

Microgrid Protection Scheme

The Microgrid protection scheme is similar to a standard utility distribution level protection scheme. However, since power flow is two-way in the microgrid and more actively managed, a more aggressive protection scheme is required. At every site where a resource interfaces with the microgrid (inverter, breaker, controller, etc.), the microgrid will feature a protection envelope with the following components:

- Underfrequency
- Undervoltage
- Overfrequency
- Overvoltage
- Phase to phase fault
- Phase to ground fault

Because of the two-way power flow within the microgrid, no reverse power trip protection is applied within the microgrid, except at the utility-side breaker (switch) at the POC.

In addition, real-time droop algorithms and phase angle measurements are utilized to mitigate protection requirements. For example, with voltage-source energy storage, continuous phase angle correction is applied, which also enables power factor correction.

2.5: Microgrid and Building Controls Characterization

Microgrid Control Architecture

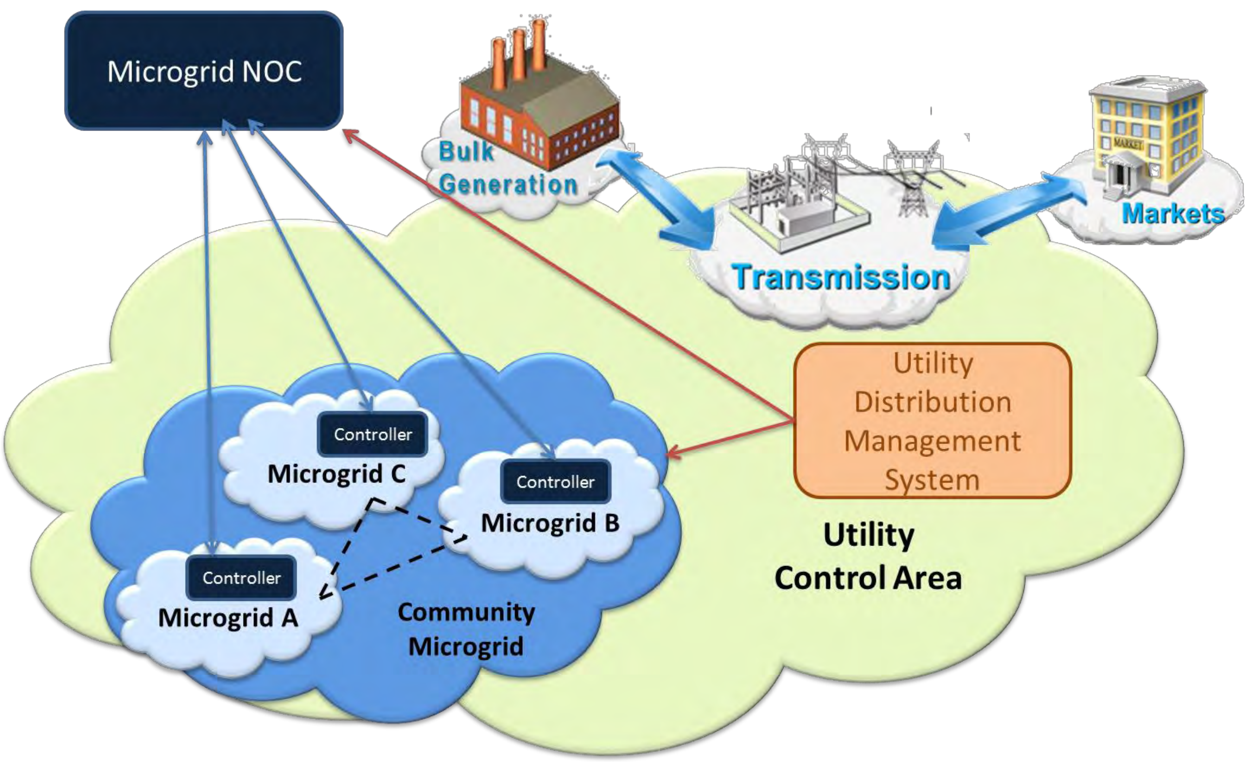
One of the challenges of community microgrids is that the facilities and the microgrid resources are distributed. To maximize the economics, reliability, and emissions reduction potential of the community microgrid, the microgrid controller architecture must have the capability to coordinate and control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

The project team 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 Operations 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 19 presents the project team's design approach for the community microgrid controller architecture.

Figure 19: Project Concept for Community Microgrid



Control Capabilities and Services

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 POC. The utility operator will provide the appropriate permissions for opening the POC. 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 POC structure (see Figure 18), 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 POC. 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

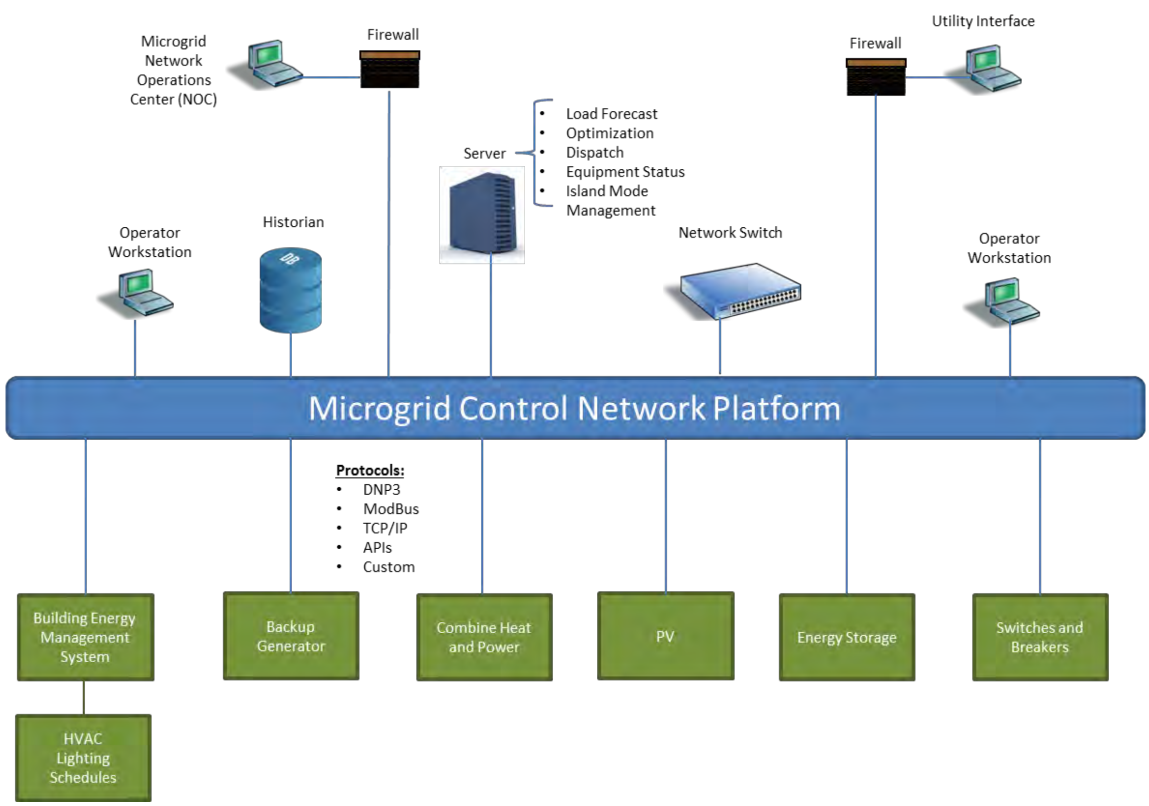
Ultimately, the control system will perform all of the functions above to continuously optimize the operation of the microgrid for economic, resiliency and emissions performance.

2.6: Information Technology (IT)/Telecommunications Infrastructure Characterization

IT Infrastructure

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 20.

Figure 20 – 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 permissions 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 assure reliable onboard communications.

The architecture will conform to requirements established by the Smart Grid Interoperability Panel (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 since it is currently the most prominent communications protocol within the DER and inverter community. Communications with the utility distribution management systems will use DNP3, since 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 assure 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 distribution management system (DMS) will interface with the microgrid controls for monitoring and managing the POC 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.

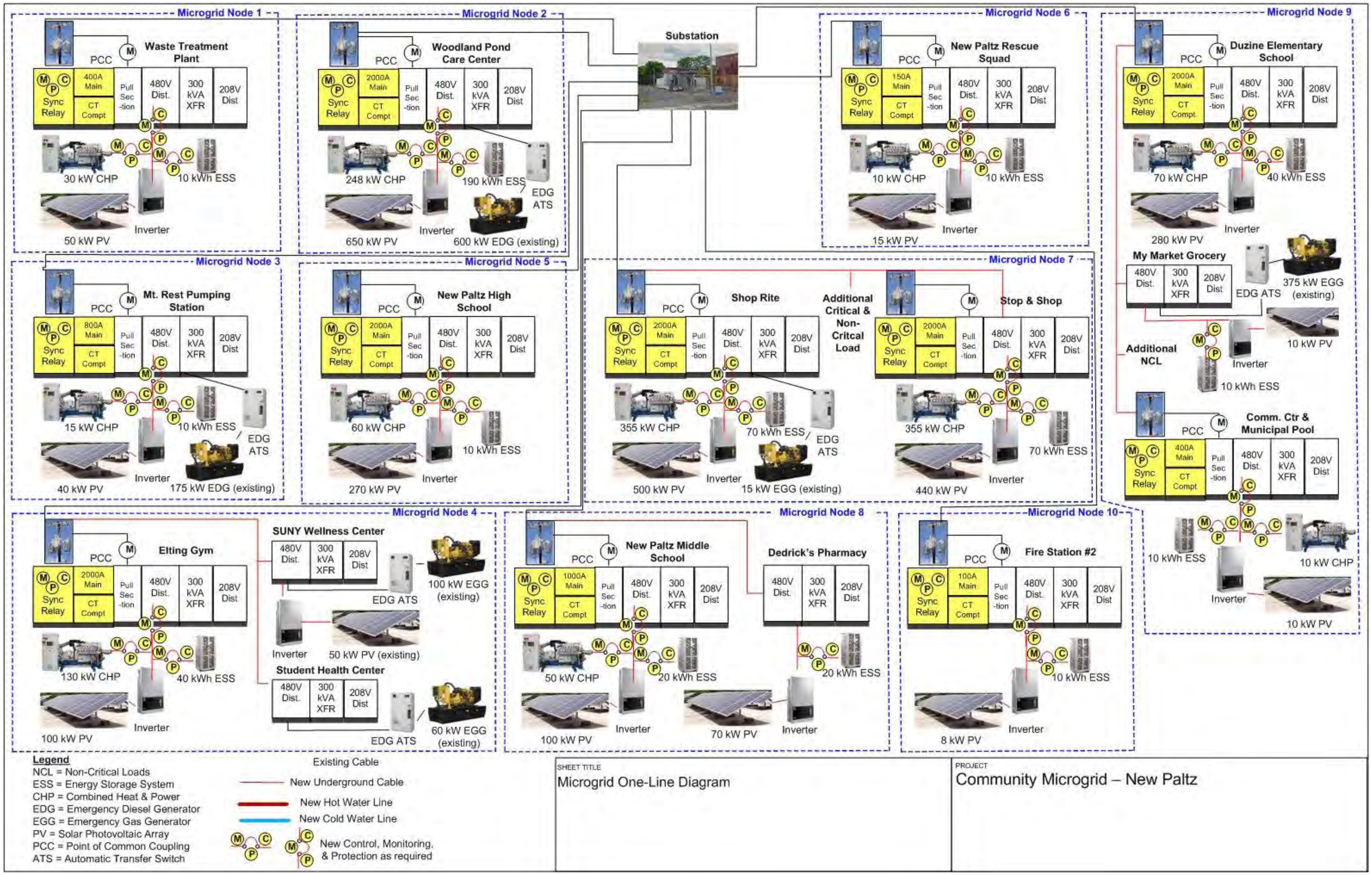
The microgrid control system will be local to the microgrid node in a secure, conditioned space, (e.g., electrical room) in one of the critical facilities within the microgrid node. This assures that real-time control of the microgrid resources and loads will be maintained in the event of a loss of communications with the utility 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.

(End of Report)

Appendix A: New Paltz Microgrid Layout Diagram

Appendix B: New Paltz Microgrid One-Line Diagram



NY Prize Stage 1 – New Paltz Community Microgrid Project
Task #3: Commercial and Financial Feasibility

Jan. 11, 2015

Prepared For:

Prepared By:

New Paltz Microgrid Project Technical Team

In cooperation with Project Stakeholders including the Town and Village of New Paltz

Contents

Summary

This report describes the preliminary assessment of commercial and financial feasibility for the proposed New Paltz Microgrid in Ulster County, N.Y. The project team's iterative modeling and analysis yielded an economically viable microgrid design. The team believes the New Paltz microgrid will serve as a leading example for New York, and will be beneficial and replicable for numerous communities across the state and beyond.

The New Paltz Microgrid business model is designed to serve six strategic energy goals established by the community: (1) Empower the community to implement its own energy strategy, as part of integrated community planning and development; (2) Improve the resiliency of services that are critical to the health, safety, and vitality of the community; (3) Increase the community's use of local resilient renewable energy assets, and facilitate ongoing local renewable energy investment; (4) Reduce the community's fossil energy consumption and related environmental footprint, and facilitate ongoing reductions; (5) Increase opportunities for local ownership of energy resources, keeping more energy dollars in the New Paltz economy; and (6) Support future economic development and growth by modernizing community energy infrastructure.

The proposed approach to commercial and legal structures incorporates lessons learned from the project team's microgrid experience and industry best practices. The proposed approach also aims to support New York State initiatives to foster innovation and competition in energy services, including the Reforming the Energy Vision proceeding.

This report is organized in accordance with the sub tasks outlined for Task #2 in the NY Prize Feasibility Assessment statement of work, with introductory summary and background added to establish the structural context and objectives for feasibility analysis.

Business model summary: The New Paltz Microgrid ("the microgrid") is designed to address the community's critical resiliency priorities while also serving its renewable energy and environmental priorities. The proposed business model uses a public private partnership (P3) ownership structure to support capital investments and operational capacities necessary to achieve the community's strategic goals. The microgrid is envisioned to provide service for the New Paltz community[1] via a three-tiered energy services strategy, offering a menu of services to substantially all energy customers in the community. Specifically:

> *Tier 1 Resilient energy services:* Delivered via resilient microgrid network
> *Tier 2 Green energy services:* Community renewable energy and efficiency services
> *Tier 3 Community choice aggregation:* Aggregated customer loads for more cost-effective and resilient green energy procurement

This approach provides a comprehensive but flexible structure enabling the community to leverage investments that best support resiliency for critical services, while improving the community's energy and environmental infrastructure and supporting ongoing economic development.

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[1] The term "New Paltz community" refers collectively to the Town of New Paltz, the Village of New Paltz, the New Paltz Central School District, and all energy customers and stakeholders in and around New Paltz, N.Y.

Transactive energy study potential: The team's design and planning process included consideration of whether and how the proposed microgrid could serve as a demonstration platform for studying transactive energy (TE) micro-market dispatch of distributed energy resources (DER), and questions such study would address. Accordingly, where appropriate, the Task 3 report includes notes addressing TE study potential.

In general, the team determined that the proposed New Paltz Microgrid would serve as an effective platform for a pilot project to demonstrate TE micro-markets. Such a project would allow further study of prosumer participation and distributed controls for real-time micro-market dispatch of DERs, to achieve maximum economic and environmental objectives for the community.

3.1 Commercial Viability – Customers

Through an iterative process of community outreach and planning, the team has identified customers in four categories of viability for Tier 1 resiliency services – High, Moderate, Weak, and Not Viable (*see Figure 3.1-A*). All major customer facilities modeled for the Task 2 report are categorized as either High or Moderate viability, supporting a strong likelihood of onboarding all identified customers.

NOTES:

- Customers determined to be Not Viable were omitted from the proposed microgrid during Task 2 and Task 3 analysis.
- The proposed microgrid includes three New Paltz Central School District facilities. Nodes containing these facilities may be revised or omitted pending finalization of alternate long-term supply arrangements and revised School District resiliency plans.
- Detailed analysis of onboarding prospects for Tier 2 and Tier 3 service customers is out of scope for the Stage I assessment and therefore is omitted. Observations about Tier 2 and Tier 3 customer viability are included in other sections of this report.

Fig. 3.1-A: Customer Viability Matrix

CUSTOMER	Viability Grade (A-F)	Viability Rating (1-5)	Economic	Technical	Legal & Market	Process	Other
CRITICAL / VITAL FACILITY CUSTOMERS							
Town of New Paltz	A	3.71	4	1	3	4	4
Village of New Paltz	A	3.71	4	1	3	4	4
SUNY at New Paltz	A	4.20	4	2	3	4	3
New Paltz Central School District ⱡ	B	3.42	2	2	3	3	3
NYS DEC Region #3 Office	A	3.96	3	2	3	4	2
Woodland Pond at New Paltz	A	4.09	3	3	3	4	4
Stop & Shop Plaza	B	3.59	2	2	3	3	4
ShopRite Grocery	B	3.53	2	2	3	3	4
Institute for Family Health*	C	2.58	1	2	3	-1	3
Meadowbrook II Apartments*	C	2.62	1	2	3	0	3
Fire Station #2*	B	2.84	2	1	3	1	2
New Paltz Rescue Squad*	B	2.84	2	1	3	1	2
AVERAGE ⱡⱡ	B	3.42	3	2	3	2	3
ECO / TECHNICAL CUSTOMERS							
ZNE Housing ⱡ	B	3.04	0	2	3	4	4
True Value Hardware*	C	2.68	1	2	3	1	4
Dedrick's Pharmacy*	C	2.42	1	1	3	0	4
My Market Grocery*	C	2.69	0	2	3	1	4
Stewart's Convenience Store*	C	2.62	1	2	3	0	4
AVERAGE	C	2.69	1	2	3	1	4

Notes:
Some viability factors can represent "deal-killer" thresholds. For example if a customer is strongly viable in other categories but is technically Not Viable, then that customer would be deemed Not Viable.
Viability grade (A to B=High; B- to C-=Moderate; D=Low; F=Not viable)
Factor score: -4 strongly detrimental; -3 detrimental; -2 somewhat detrimental; -1 slightly detrimental; 0 neutral; 1 slightly supportive; 2 somewhat supportive; 3 supportive; 4 strongly supportive
* Customer not yet fully engaged; some factor scores uncertain
ⱡ Viability factors likely will change if NPCSD implements Solar City project.
ⱡⱡ Average viability of customers considered strongly supportive or indispensable for project objectives.
See also Appendix A: Customer Viability Methodology

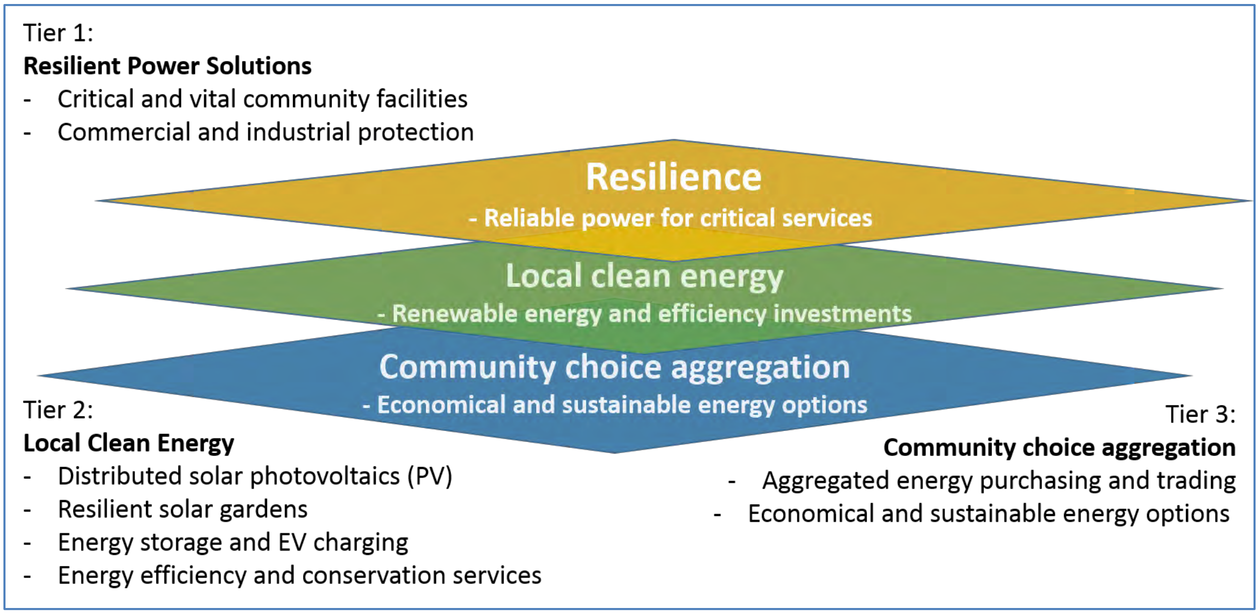
3.1.1 Commercial terms and relationships

A. *Tiered energy services model:* As noted in "Business model summary" above, the New Paltz Microgrid is designed to address the community's critical resiliency priorities while also serving its renewable energy and environmental priorities. In consultation with community stakeholders, the project team determined that a three-tiered energy services approach would provide maximum benefits for the New Paltz community.

This energy services focus enables New Paltz stakeholders to guide and leverage investments to best support resiliency for critical services, while improving the community's energy and environmental infrastructure and supporting ongoing economic development.

Note: Task 2 design and modeling efforts focused on systems required to fulfill Tier 1 customers' energy services requirements. Detailed technical and commercial analysis of Tier 2 and Tier 3 requirements are deemed out of scope for the current phase of study, except to establish business model context and describe the proposed project's strategic benefits and overall value proposition for the community.

Fig. 3.1-A: Three-Tiered Energy Services Model



B. *Resiliency and synergistic benefits:* The three-tiered energy services structure is designed to strengthen community resiliency and produce value by meeting the energy needs of a broad range of customers in the New Paltz area.
   a. Integrated Planning Benefits and Synergies: By providing a full range of energy service options for all New Paltz customers, the microgrid will ensure that to the greatest extent possible, capital and other resources invested in DERs and energy management services will be planned and deployed in ways that serve the community's resiliency requirements. For example, prospective community solar gardens will be sited, designed, interconnected, and managed to ensure their energy output will be:
      i. Available for resilient energy operations during utility outage events (if technically and economically feasible); and
      ii. Structured and financed in ways that *support and do not impair* the microgrid's ability to provide resilient energy services – as, for example, large net-metered solar arrays can do by displacing all of a critical facility's energy purchases and thereby eliminating options for other DERs (including generation, storage, and demand) that are necessary to maintain resiliency.
   b. Supporting Economics for Tier-1 Customers: Offering Tier 2 and Tier 3 services for all customers will strengthen the microgrid's customer diversity, cash flow, and debt service coverage potential, supporting its ability to provide high-value Tier 1 Resiliency Services for critical customers. By using microgrid capabilities and resources to produce

value for the most diverse possible range of customers, the microgrid will improve the relative proportions of customers with various service-cost and service-value profiles, strengthening the microgrid's overall financial viability and therefore its capability to provide Tier 1 Resiliency Services for critical customers.

c. Sharing Customer-Service Resources: Administrative and operational resources (staff, space, equipment, contracted services, etc.) that are required to provide Tier 1 Resiliency Services also will be used to provide Tier 2 and Tier 3 services. Accordingly incremental costs of providing and administrating services for more customers will decline as the number of additional customers increases.

C. *Energy services agreements:* The study team considered commercial contracting and transactional options for meeting community objectives, and found that the most applicable options involve uniform, long-term, bilateral agreements to provide resilient energy services and sustainable resources. Such commercial structures allow the New Paltz Microgrid to closely match asset investments and energy service capacities to the needs and wants of customers, while also establishing a financeable business model enabling access to sources of low-cost financing. Exemplary models are drawn from ESCO and energy savings performance contracting (ESPC) practices.

a. Tier 1 microgrid resiliency customers and the P3 will enter long-term (~25-year) service agreements for microgrid operations to meet Tier 1 objectives.
    i. Microgrid energy services: The microgrid P3 will serve as the New Paltz community's ESCO, arranging for full-scope energy supply, storage, efficiency, and load management necessary to provide Tier 1 resiliency services throughout the contract term.
    ii. Microgrid Platform/Distribution Service Platform Provider (DSPP): The microgrid P3 will provide electricity control and transport services for Tier 1 customers under transferable uniform service agreements, separate from energy services agreements.

b. Tier 2 Green energy customers and the P3 will enter service agreements of varying lengths, as appropriate to related asset characteristics and financing requirements.
    i. Shared solar and renewable energy: The P3 will manage customer enrollment and account servicing for community energy production assets such as shared solar gardens and regional bio-energy facilities.
    ii. Onsite and neighborhood generation and storage: The P3 will manage long-term agreements for customer-sited energy production assets, including distributed solar and storage systems.
    iii. Energy management: The P3 will provide energy efficiency, conservation, and load management services for Tier 2 customers under energy services agreements.

c. Tier 3 Community choice aggregation (CCA) customers:
    i. The microgrid P3 would implement and manage a CCA program to be established by municipal ordinance. Through a New York State-approved CCA program, the P3 will engage CCA customers to support the community's strategic goals. Most notably, managing the New Paltz CCA through the P3 will ensure that resources procured to meet aggregated customer loads will, to the optimal degree, support the need for resilient energy services to maintain critical community services.

D. *Partner and vendor agreements:* The New Paltz Microgrid P3 will engage various services, technology, and equipment vendors as:
    d. Partner: Along with third-party entities, the P3 may co-own assets and obligations for performing contracted services.
    e. Contractor: The P3 would contract with vendors and service companies to provide a range of products and services necessary to meeting the P3's objectives. These services may include, for example, design engineering, capital equipment, installation, operations and maintenance, energy supply and delivery, finance, administration, management, and customer service.

E. *TE study notes:*
    f. The proposed approach to commercial terms and relationships supports potential to further understand how TE micro-markets may yield more cost-effective DERs. TE works with bilateral transactions among market participants ("counterparties"). The classes of counterparties in TE are:
        i. Energy services counterparties: The parties that consume, produce and store energy (both internal microgrid parties and external parties)
        ii. Transport services counterparties: The parties that provide energy transmission/transportation and distribution services (resilient or otherwise)
        iii. Intermediaries: the parties such as the microgrid P3 or other ESCOs or aggregators that facilitate both long-term contracts and spot transactions among energy services counterparties to balance supply and demand, both long-term and operationally in both islanded and connected microgrid operations.
    g. Each energy services counterparty can make its own investments in generation, storage, and energy use devices or it will transact with other counterparties to meet its needs. Operationally, each counterparty either will use its own generation and storage or will buy from other counterparties as needed. The New Paltz Microgrid would serve as an automated market-maker intermediary, continually posting buy-and-sell tenders with forward prices that counterparties can use to efficiently self-dispatch while helping to balance supply and demand.
    h. Counterparties can chose to invest in resilient devices and transact only with counterparties providing resilient energy services over resilient transport. Additionally they can select the portions and types of green energy resources they want to invest in or secure by contract.
    i. Tier 1 customers would enter long-term contracts for assured access to the resilient elements of the microgrid, and could also rely on spot-market transactions for some portion of resilient energy services.
    j. Any counterparty could choose to buy and sell directly with internal and external parties (when connected) or with an ESCO or aggregator.
    k. Any counterparty could choose to sell spot ancillary service products to the NYISO.

3.1.2 Baseline situation

A. *Retail utility services baseline:* Central Hudson Gas & Electric provides retail electricity and gas distribution services to customers in New Paltz, using regulated retail rates. Additionally Central Hudson supplies electricity and natural gas using standard offer service rates.

    a. Tier 1 customers pay on average 13.6 cents/kWh for delivered electricity.
    b. Central Hudson's electric distribution system in New Paltz and surrounding communities relies heavily on overhead lines, exposing critical and vital facilities to substantial T&D outage risks.[2]

B. *Competitive gas and electricity baseline:* New Paltz customers may choose from among a variety of gas and electricity suppliers. Several customers to be served by the New Paltz Microgrid currently receive energy services from Direct Energy. Agreements with third-party energy suppliers generally are short in duration, and thus are not expected to prevent contracting with the P3.

C. *CCA baseline:* Nearby jurisdictions are pursuing CCA, and the Town and Village of New Paltz are considering initiatives that could facilitate the adoption of CCA. The P3 would be expected to manage the community's CCA program as part of an integrated planning and development approach.

3.1.3 Utility benefits and ancillary services

The proposed microgrid will support the electric utility in several important ways, including:

A. *Congestion relief:* The microgrid would help relieve distribution system congestion. By providing additional year-round local generation and demand management capabilities, the microgrid will reduce stress on the existing system, potentially allowing the utility to reduce or defer some distribution upgrades, enabling investments in other priority areas.

B. *Outage response:* During utility grid outages, the project is expected to support Central Hudson's ability to restore service in New Paltz and neighboring communities, by freeing utility resources for system restoration priorities affecting other circuits. Finally, the proposed microgrid may provide black-start support for nearby generation stations, pending coordination with and approval from the utility.

C. *Distribution system modernization:* The microgrid is expected to modernize and upgrade local distribution systems in the New Paltz community. Specifically:
    a. Microgrid control systems will substantially extend the utility's capabilities to control and integrate distributed generation and energy storage system (ESS) capacity and resources capable of providing localized support for power quality and distribution grid stability.
    b. The New Paltz Microgrid's underground cable network, serving contiguous Tier 1 customers, will substantially reduce vulnerability to outages caused by local weather events and other assaults on overhead lines.

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[2] Approximately 90 percent of end-user outages are attributable to distribution system failures, and not transmission or generation failures. See *Understanding the Cost of Power Interruptions to U.S. Electricity Consumers,* Kristina Hamachi LaCommare and Joseph H. Eto, Lawrence Berkeley National Laboratory, Sept. 2004.
https://emp.lbl.gov/sites/all/files/REPORT%20lbnl%20-%2055718.pdf

D. *Reduced line losses:* By incorporating more local generation assets, the microgrid will reduce line losses associated with long-distance transmission of power required to serve local electricity loads.

E. *Community microgrid service options:* The project will provide models and options for deployment of microgrids that enhance the resilience of communities served by Central Hudson. The proposed P3 and build-operate-transfer model will facilitate local public-private investment in local grid modernization, through mutually beneficial cooperation with local communities. This enhanced set of services will strengthen Central Hudson's relationship with community stakeholders and potentially may improve its market position generally.

F. *Ancillary services:* Under normal conditions the microgrid's combined resource portfolio may be operated to achieve economic benefits from dispatching resources in response to ancillary services price signals.

   a. Microgrid objectives and ancillary services: The New Paltz Microgrid operator will determine how to maximize economic benefits for aggregated resources, within the constraints of microgrid objectives, as part of ongoing distributed resource planning and operations.
   b. Utility and ISO support: The proposed microgrid solution has the capability to provide important ancillary services to the Central Hudson 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 the utility to meet regulatory requirements for service reliability improvements without additional capital expenditures.
   c. *TE study notes:* In a TE deployment, the best market-dispatch solution would reduce resource dispatch to trading positions – *e.g.,* certain amounts of energy with given characteristics (most importantly time of delivery), to be served via long-term contracts and spot transactions. The New Paltz Microgrid could serve as a test market to demonstrate micro-market dispatch of energy resources including functions that provide ancillary services for local distribution system or regional grid operations.

3.1.4 Identify microgrid customers

The New Paltz Microgrid is intended to provide services that will directly or indirectly benefit substantially all customers in and around New Paltz. (*See Fig. 3.1.4-A for complete list of modeled customers*)

Fig. 3.1.4-A Microgrid nodes and customers

Microgrid Node #	Customer / Facilities	Functions
1	• Village of New Paltz / Wastewater Treatment Plant	• Water treatment
2	• Woodland Pond Care Center	• Elder living and care
3	• Village of New Paltz / Mt. Rest Rd. Pumping Station	• Water treatment
4	• SUNY New Paltz Elting Gym • SUNY New Paltz Wellness Center • SUNY New Paltz Student Health Center	• Fitness / Health • Healthcare
5	• New Paltz High School	• Education
6	• New Paltz Rescue Squad	• Emergency response
7	• Stop & Shop Grocery • ShopRite Grocery • New York State Department of Environmental Conservation • Institute for Family Health • Sunoco Gas Station • True Value Hardware • Meadowbrook Farms II Apartments (affordable housing) • Additional Businesses	• Grocery • Healthcare • Auto fuel • State Government • Housing • Other business
8	• New Paltz Middle School • Dedrick's Pharmacy	• Education • Pharmacy
9	• Municipal Center (Town & Village Admin., Police) • Community Center & Municipal Pool • My Market Grocery • Stewart's Convenience Store • ZNE Housing • Duzine Elementary School	• Education • Potential shelter • Community engagement • Grocery • Housing • Other retail
10	• Fire Station #2	• Fire and rescue • Emergency response

3.1.5 Identify microgrid stakeholders

The Supervisor of the Town of New Paltz initiated the NY Prize Stage 1 application response that led to the New Paltz Microgrid project proposal. The project team includes a broad group of major stakeholders in the New Paltz community. They include both local municipal entities – the Town and Village – along with other government units including the local school district, college campus, and the regional New York State environmental regulatory office serving seven counties. Together these entities provide local first response, law enforcement, and public water supplies for a large area of the mid-Hudson Valley region, centered on a vibrant community that totals up to 20,000 residents (including SUNY students). Commercial stakeholders include multiple grocery stores, pharmacies, gas stations, and a 500-bed senior living and healthcare facility.

These energy customers are deemed by the Town and Village of New Paltz to be critical to the community's health, safety, and vitality during a long-duration grid outage.[3]

Fig. 3.1.5-A: New Paltz Microgrid stakeholders

Role	Name	Title	Organization
Local Admin	Neil Bettez	Supervisor (as of 1/1/16)	Town of New Paltz
Local Admin	Marty Irwin	Board Member	Town of New Paltz
Local Admin	Tim Rogers	Mayor	Village of New Paltz
Local Admin	Maria Rice	Superintendent	New Paltz Central School District
Local Admin	Richard Linden	Assistant Sup.	New Paltz Central School District
Local Admin	Dominick Profaci	Chair, Facils. Committee	New Paltz Board of Education
Shelter	Lisa Mitten	Sustainability Coordinator	SUNY at New Paltz
Shelter	Brian Pine	Energy Mgt. Coordinator	SUNY at New Paltz
NYS DEC	Martin Brand	Regional Director	NYS Dept of Env Cons Region 3
NYS DEC	Ernest Lucantonio	Supervisor of Operations	NYS Dept of Env Cons Region 3
Healthcare	Michelle Gramoglia	Executive Director	Health Alliance of the Hudson Valley
Healthcare	John Smith	Facilities Director	Health Alliance of the Hudson Valley
Commercial	David Shepler	Developer	Zero Place Apartments
Utility	Steve Burger	Senior Project Director	Central Hudson Gas & Electric
Utility	Angelo Onelevo	Elec Ops Engineer	Central Hudson Gas & Electric
Utility	Heather Adams	Director, Elec Dist & Standards Engineering	Central Hudson Gas & Electric

[3] Not all of the community's critical facilities are included in the microgrid model. Omitted facilities may be eligible for opt-in Tier-1 resilient energy service. Detailed technical engineering and development may yield changes in the proposed microgrid.

3.1.6 Stakeholder/customer relationship

Several customer organizations (including units of local government) and their representatives are among stakeholders in the New Paltz Microgrid Project. Among the facilities included in the Task 2 model (approximately 30 facilities with a total 6.5 MW peak electricity load), about half are owned and operated by five administrative agencies: the Town and Village of New Paltz, the New Paltz Central School District, SUNY at New Paltz, and the New York State Department of Environmental Conservation. Other customers with stakeholder roles include Health Alliance of the Hudson Valley's Woodland Pond senior housing and healthcare complex, as well as the New Paltz Fire District and Rescue Squad. The modeled project includes subsidized housing complexes (Meadowbrook Farms II and New Paltz Housing).

The Village and Town of New Paltz assist in outreach and engagement with other groups of stakeholders and customers, including local businesses, nonprofit organizations, and residents eligible to receive microgrid service. Examples include grocery stores, pharmacies, gas stations, and a health clinic. Other commercial stakeholders include local developers, entrepreneurs, contractors, and employers whose capacity to provide services may benefit from improved local resilience.

Finally, energy business stakeholders include Central Hudson Gas & Electric, the distribution utility serving New Paltz. As a general matter, all microgrid customers are expected to remain Central Hudson customers while also receiving services from the New Paltz Microgrid.

3.1.7 Identify microgrid customers: Normal operations vs island operation

During normal operations, Central Hudson is expected to provide standard retail delivery service to the microgrid point of common coupling (PCC). Approximately 15 percent of annual electricity consumption by microgrid Tier 1 customers' is expected to be served by generation from non-resilient energy supplies – *e.g.,* offsite power plants and grid-tied onsite resources. Resilient energy resources – *e.g.,* microgrid-controlled distributed generation – are expected to serve approximately 85 percent of Tier 1 customers' annual electricity consumption.

During a planned or unplanned outage, the modeled microgrid will perform safe islanding and maintain stable operation through the transition from grid-connected to island mode. microgrid generation, energy storage, and demand response capabilities are sized to support stable transition to island mode during peak seasonal and time-of-day peak load cycles, and to support island operation for a minimum of seven days, with multi-week operation possible. The microgrid will dispatch storage, generation, and demand-response resources to support resilient energy supplies for microgrid Tier 1 customer loads throughout the duration of an outage. Based on the nature of the outage and the utility's estimated restoration time, the microgrid control system will dispatch resources to maintain service essentially indefinitely at 80 percent of normal demand levels.

A. *Electricity supply:* Proposed local generation resources are expected to serve approximately 85 percent of microgrid Tier 1 customers' annual electricity purchases. Remaining microgrid energy requirements are expected to be met by multiple energy service providers, including the microgrid P3. Central Hudson is expected to provide retail delivery service to the microgrid PCC.

B. *Electricity storage:* Battery energy storage systems (ESS) are specified to support seamless transitioning from one operating mode to another (islanding and re-connection), with load-following and economic dispatch performed to support optimal resiliency, renewable integration, emissions reduction, and financial performance.

C. *Thermal energy supply:* Onsite combined heat and power systems will augment or replace existing thermal heating and cooling systems. CHP units are sized to meet baseload energy requirements, with some capacity for load following, in coordination with peaking generation, storage, and load management resources.

D. *Thermal energy storage:* Thermal storage is modeled to assume potential improvements in onsite hot water systems that may increase effective thermal storage. Additionally ice storage for off-peak pre-cooling may reduce building cooling costs during summertime and provide load-management capacity to support resilience.

E. *Load-management systems:* Demand-side management tools including automation to support peak load shifting, dynamic demand response, resource scheduling, and system balancing.

3.1.8 Planned contractual agreements

(*See also 3.1.1 Commercial Terms and Relationships*)

Primary contractual agreements involve energy services agreements (ESA) and a build-operate-transfer (BOT) agreement. Microgrid infrastructure and systems will be installed pursuant to contracts the P3 enters with vendors and service providers. Other forms of agreements, covenants, and policies may support financing resilience assets such as solar gardens, neighborhood energy storage, and other infrastructure. Finally, the microgrid P3 will be incorporated as the result of partnership agreements among public and private owners.

Fig. 3.1.8-A: Counterparty agreements – Energy transactions

Counterparty A	Counterparty B	Type of Agreement	Term	Notes
New Paltz Microgrid P3	Tier 1 customers	ESA	25 years	terms TBD
	Tier 1.x customers	ESA	varies	terms TBD
	Tier 2 customers	ESA	varies	terms TBD
	Tier 3 customers	CCA policy	TBD	local enabling ordinance required
	Central Hudson Gas & Electric	BOT	6-25 years	Wires assets and obligations to be transferred to utility; BOT terms TBD
Third-Party Suppliers	New Paltz Microgrid P3	ESAs, spot contracts	varies	terms TBD

3.1.9 Customer recruitment and onboarding

The proposed project is well suited to serving the strategic energy and resilience goals of the New Paltz community, and provides an outstanding value proposition for customers. Robust and ongoing engagement processes with several key stakeholders has served to maintain and strengthen engagement with several key stakeholders that account for more than half of the microgrid's Tier 1 energy loads. For most other prospective customers, the proposed microgrid offers obvious customer resilience benefit and economic value. Accordingly the team estimates that with few exceptions, prospects are excellent for recruiting substantially all customers included in the Task 2 model. Noteworthy exceptions include two school facilities whose solutions may need to be omitted or reconfigured, pending school district execution of a remote net-metered solar contract with Solar City.

The New Paltz Microgrid P3 will be responsible for marketing and promoting service offerings at all phases of implementation:

- Phase I: Continued outreach and engagement with customers who operate facilities identified as critical and vital. The NY Prize Stage 1 study process effectively initiated Phase I onboarding for Tier 1 customers, via the project team's stakeholder outreach, education, and collaborative planning efforts.
- Phase II: Completion of onboarding for all Tier 1 customers. Marketing, promotion, and engagement with Tier 2 and Tier 3 customers.
- Phase III: Outreach and engagement with additional customers to expand and extend community benefits.

3.1.10 Describe other commodities provided

The microgrid will offer energy commodities in addition to electricity, specifically at sites where combined heat and power (CHP) units are required to support resilience. Additionally, the community's strategic goals include continuing to reduce reliance on fossil energy and continuing to increase reliance on local renewable resources. Accordingly, the proposed P3 could expand the commodities it provides in the future.

A. Heating, cooling, and domestic hot water: CHP systems in the microgrid will provide thermal energy, primarily hot water, to customers where the systems are located. Cooling may be provided via absorption chilling at some microgrid nodes. Phased implementation may provide future opportunities for integrated community heat planning and district energy implementation – with solar thermal, geothermal, and CHP resources – effectively expanding the community's baseload generation resources and saving additional costs and emissions.

B. Biomass fuel: The project team determined that available local biomass resources are insufficient to support cost-effective deployment to meet the microgrid's objectives. Nevertheless, the community remains supportive of biomass development and would seek to offset its fossil fuel consumption with biomass energy production as such options become available. Potential examples include participation in regional anaerobic digestion or biomass pelletizing projects. Accordingly, the proposed business structure could become a producer of biomass or biogas fuels.

3.2 Commercial Viability - Value Proposition

(*See also 3.1 above.*)

The New Paltz Microgrid value proposition is based on three key principles: 1) It will produce net economic benefits to customers and the community in excess of its life-cycle costs; 2) It will increase the community's energy resiliency, especially at critical facilities; and 3) It will serve the community's strategic goals, most notably providing a platform for ongoing reductions in fossil fuel consumption.

The technical team performed an iterative modeling process to arrive at a resource mix that produces a positive economic return to the microgrid P3 with an optimized mix of electric and thermal energy system upgrades. The proposed investments in Tier 1 resiliency systems also would support a range of other community benefits, which would be further enhanced by prospective Tier 2 and Tier 3 resources.

Note: Economic benefits from Tier 2 and Tier 3 development are omitted from the modeled microgrid, as being out of scope for the current phase of study. The project team anticipates economic benefits from Tier 2 and Tier 2 would be positive both for customers and the microgrid P3, and would strengthen the base value proposition for the modeled Tier 1 resiliency microgrid.

A. *Life-Cycle Economic Benefits:*
    a. Customer Cost Savings: The team's Task 2 analysis indicated that the New Paltz Microgrid is financially viable, even while providing services to Tier 1 resiliency customers at costs equal to or less than current costs.
    b. Positive Revenue/Cost Outlook: The team's analysis indicated that projected revenues would exceed estimated costs by enough to support a positive internal financial return (6.4%).

B. *Improved Community Resiliency*
    a. The project envisions infrastructure modernization investments, selectively aimed at ensuring maximum community resilience outcomes. This infrastructure improvement will benefit a broad range of stakeholders in the New Paltz area. Examples:
        i. Vulnerable populations will be better prepared to shelter in place in emergency situations that often accompany extended outages
        ii. Residents will have continuous access to municipal water and sewer service
        iii. Area residents will have continued access to grocery stores, pharmacies, and clinic facilities within the New Paltz Microgrid

C. *Community Strategic Goals*

The New Paltz Microgrid business model is designed to support six strategic energy goals established by the New Paltz community. (*See Fig. 3.2-A*)

Fig. 3.2-A: Community goals and microgrid P3 strategy

Goal	Objectives	Strategy	Implementation
Empower integrated community planning	Plan, site, market, and install energy assets to assure greatest community resilience plus economic and environmental benefits	Establish microgrid P3 structure to implement community's energy strategy, as part of integrated community planning and development	- Integrated resilient energy and environmental planning - Support for ongoing inter-agency collaboration and cooperation, e.g., Municipal Center design and planning; economic development planning and zoning
Improve community resiliency	Improve the resiliency of services that are critical to the health, safety, and vitality of the community	Install resilient energy microgrid infrastructure, control system, and DERs to serve critical facilities	- Multi-node microgrid - Three-tiered energy services model - Future expansions of microgrid services
Expand local renewable energy production	Increase community's use of local renewable energy assets, and facilitate ongoing local renewable energy investment	Establish and market energy services to increase local renewable energy development and investment	- Three-tiered energy services model - Resilient shared solar and storage investments - Regional biomass investments
Reduce fossil dependence and environmental footprint	Reduce the community's fossil energy consumption and related emissions, and facilitate ongoing reductions	Establish and market energy services to increase local renewable energy and conservation investments	- Renewable energy deployments - Energy conservation upgrades and expansions
Retain energy dollars in local economy	Expand and improve opportunities for local ownership of energy resources, retaining more energy value in the local New Paltz economy	Develop, market, and deliver options for local ownership of energy assets, such as onsite photovoltaic (PV) and shared solar arrays	- Resilient community solar gardens - Rooftop PV - PV+storage/EV integration
Cultivate economic growth	Update and position local infrastructure for business development and expansion	Modernize and improve power system, supporting community service capacity, new business development, and potential new jobs	- Advanced microgrid infrastructure - Multi-node, extensible microgrid control system - Three-tiered energy services model - Integrated resilient energy and environmental planning

3.2.1 Community costs and benefits

A. *Community benefits summary:* The proposed microgrid produces a wide range of benefits, as described above and throughout the Task 2 and Task 3 reports. They can be summarized as: 1) Improved resilience for critical facilities; 2) opportunities to expand local investment in renewable energy and conservation; and 3) support for economic growth and development.

Additionally the team's analysis indicates the proposed microgrid can produce direct economic benefits, providing enhanced services to customers for costs that are equal to or lower than current costs.

B. *Capital requirements:* The proposed microgrid can cost-effectively provide energy for Tier 1 customers through 25-year ESAs at costs equal to or lower than current electricity rates. The proposed business model would support commercial financing for a substantial portion of the project's estimated $12 million initial capital cost. Capital contributions – in the forms of equity investments, in-kind assets, or concessions – will reduce the financed portion of project capital requirements and accelerate simple payback.

C. *Cash-flow viability:* Operating revenues for the modeled microgrid are projected to exceed operating costs – sufficiently to produce a 6.4% internal rate of return to the P3. Positive cash flow will ensure economic stability and creditworthiness to support continued access to low-cost operating and investment capital.

D. *TE study notes:* Implementation of a TE pilot project would provide an opportunity to demonstrate micro-market mechanisms to produce true geotemporal values for DERs. In other words, a TE approach would be expected to more faithfully reflect the true costs and benefits of energy service for a given party at a given time. Collectively, loads served by a TE microgrid would produce incremental community benefits by reducing energy consumption and shifting energy spending toward local resources. A TE micro-market would be based on a combination of long-term contracting and spot-market transactions, enabling customers to obtain the degree of resilience they need at the most competitive price. Consequently, the community's overall costs and benefits' would depend in large part on customers' energy consumption and investment choices, resulting in market-based outcomes that serve customers' priority needs.

3.2.2 Utility benefits

(*See 3.1.3 above*)

As discussed in section 3.1.3, the proposed microgrid will provide numerous utility system benefits, including congestion relief, outage response support, distribution system modernization, reduced line losses, enhanced community microgrid service options, and ancillary services benefits.

3.2.3 Proposed business model

The microgrid P3 will operate using an energy services company (ESCo) business model, providing a range of energy services under long-term and short-term agreements with customers.

The project team anticipates resolving operational details about terms of contracts and transactional approaches in Stage 2 study and development.

3.2.4 SWOT analysis

A. Strengths

a. Diverse and committed stakeholder group: Key stakeholders have demonstrated ongoing and substantive engagement in project planning and execution processes
b. Demonstrated need for resilience improvements: Identified critical community assets lacking resilience to extended energy disruptions
c. Positive benefit-cost analysis: Iterative modeling yielded financially viable configuration

d. Strong community support: Demonstrated community interest in energy resource and efficiency improvements
e. NY REV and modernization support: Opportunities to foster innovation and competitiveness, and deliver life-cycle benefits through customer-centered P3 business structure and operational model

B. Weaknesses

a. Geographic dispersion: Economics challenged by multiple small nodes and load profiles
b. Complex business structure: P3 complexity impairs access to some forms of commercial financing
c. Stakeholder capital limitations: Capital investment priorities focused on core activities
d. Industry acceptance: P3 and BOT structures unconventional for U.S. utility assets (although common in other energy and infrastructure areas, in the U.S. and abroad)
e. Administrative burden: Requires sustained management support by sponsors for P3 business entity

C. Opportunities

a. Modernize resilient energy systems: Improve resilience of several facilities critical to the health, safety, and vitality of the New Paltz community, by modernizing and upgrading critical energy infrastructure
b. Leverage local support: Capitalize on community commitment to clean energy and environmental improvements
c. Diverse capital stack: Leverage P3 structuring, financing benefits, and risk management
d. Integrated community planning: Support integrated community development and economic planning among local government units, stakeholders, and the utility
e. Support local self-reliance: Reduce dependence on imported energy supplies
f. Capture local energy resource value: Ongoing opportunities to invest in stronger and greener local energy infrastructure

D. Threats

a. Onboarding risks: Final business and contractual structures must address all key customers' needs and concerns and improve risk allocation and management
b. Utility business or legal challenges: Collaborative planning required to engage utility, resolve conflicts, and align goals and opportunities with policy and program support from New York State agencies
c. Market alternatives: Competitive energy suppliers offering similar ESAs and net-metering arrangements as part of retail energy marketing
d. Integrated planning challenges: Need to maintain ongoing, consistent commitment to microgrid objectives by government units, community stakeholders, and the utility

3.2.5 Unique features of the site or technologies

A. Innovative technology architecture: The proposed project envisions an innovative approach at the systems level that utilizes commercial, off-the-shelf technologies to create a community microgrid that serves multiple critical facilities and community partners at non-contiguous locations. Members of the project team have proven the distributed microgrid model in several successful prior projects. The approach involves three steps:

1) Organize clusters of nearby critical facilities into microgrid nodes, and optimize reliability and resiliency within each;

2) Coordinate all microgrid nodes to optimize financial performance and emissions reduction across the entire community; and
3) Size the total energy resource portfolio to support some non-critical loads within the community (after the local substation) in the event of a grid loss originating outside the community (before the local substation). In this approach, if there is a grid loss within the community, service to non-critical loads may interrupted to support critical facility loads.

In New Paltz, this means serving a very diverse set of loads – from water and wastewater treatment systems, to community shelters, to gas stations and grocery stores. The New Paltz Microgrid design will provide true energy resilience for the community – not just emergency services.

B. Community economic development plans: The Village of New Paltz enacted a special zoning provision to encourage development of a vibrant neighborhood in the vicinity of the new Municipal Center and Moriello Park recreation facilities. The ordinance changed the building zone to multi-story mixed-use real estate, to encourage commercial and residential development together. Accordingly, medium-term development phases envision expanding the microgrid to serve new facilities in the Chestnut Street neighborhood, with longer-term plans potentially to include extending the microgrid node to combine with the nearby municipal sewer plant node for both nodes' benefit. In that future phase the microgrid's underground extension would further serve community interests in beautifying the Historic Huguenot Street historic settlement area, in support of area historic restoration and preservation priorities, in harmony with green development initiatives.

3.2.6 Project replicability and scalability

The New Paltz Microgrid Project establishes a highly replicable and scalable approach to providing resilient energy and other energy services for New York communities.

A. *Structures:* Ownership and management structures developed for the New Paltz Microgrid can be used in other community microgrid situations. Additionally these structures are highly adaptive and scalable, being viable and supportive for projects of various sizes and strategic purposes.

B. *Multi-tiered service model:* The New Paltz Microgrid three-tiered service model establishes an approach that is readily adaptable for application in any community that can benefit from integrated sustainable-planning and economic development.

C. *Design and technology approach:* By specifying resilient infrastructure and resources in standard configurations, and by providing controls for managing clusters and portfolios of facilities that serve community resilience, the New Paltz Microgrid's design and technology approach establishes a roadmap for community resilience in New York and jurisdictions with analogous market and regulatory conditions.

D. *Financing:* By structuring community microgrid agreements and covenants to support commercial financing, the project will help establish programmatic financing models for adaptation in other communities with similar needs and wants.

E. *Phased development strategy:* The project team's integrated planning and multi-phase development approach demonstrates methodologies for communities to meet immediate needs while planning and preparing for future growth and development.

3.2.7 Community need for resiliency

The benefits of the New Paltz Microgrid extend not only to local agencies and businesses, but also to residents in the greater New Paltz area, as well as Ulster County and the six other counties served by the NYS DEC Region 3 headquarters (Dutchess, Orange, Putnam, Rockland, Sullivan, and Westchester).

The New Paltz Microgrid will serve a group of facilities that are critical to the health, safety, and vitality of the community. This mix includes government facilities (Village, Town, State, and School District), public safety and infrastructure, private healthcare and assisted living, and private business interests. In addition to critical facilities, the microgrid footprint includes other essential services, including pharmacies, grocery stores, and gas stations.

In addition to operational resilience, the microgrid system will contribute to the economic resilience of the community. By facilitating the deployment of DERs throughout the community, and providing service to customers under long-term agreements, the microgrid will help New Paltz customers to hedge against anticipated energy cost increases and volatility. Additionally the proposed microgrid will create a modernized energy infrastructure to attract new businesses and jobs to the community.

3.2.8 Overall project value proposition

(*See also sections 3.1 and 3.2*)

The New Paltz Microgrid overall value proposition is based on three key principles:

A. *Positive business case:* The proposed microgrid will produce net economic benefits to customers and the community in excess of its life-cycle costs. The project team estimates that the proposed microgrid will save the community approximately $95,000 per year in energy costs, in current dollars;
B. *Improve community resiliency:* The microgrid will increase the community's energy resiliency, to support both emergency services and vital commercial activity. The proposed microgrid will provide resilient energy services to numerous critical facilities in New Paltz; and
C. *Enhance local energy economy:* The microgrid will serve several strategic goals, most notably providing a platform for ongoing reductions in fossil fuel consumption. The proposed microgrid's integrated planning approach and three-tiered energy services structure support many strategic goals including enhancing local energy infrastructure and economics.

3.2.9 Added revenue streams for the off taker

A. *Prosumer opportunities:* As a partnership that includes local public entities among its ownership group, the proposed microgrid would generate new energy services revenue for P3 owners who also are energy customers in New Paltz. In addition, the proposed microgrid would, in part, establish a platform for other energy consumers to become energy producers if they choose to invest in DERs. Examples:

   a. Shared solar production: The microgrid P3 would offer customers opportunities to participate in community solar gardens or other shared energy resources, especially those that are sited, designed, and developed to support critical facility resiliency. Shareowners or subscribers in such facilities would generate revenue by selling electric output in excess of their offset electricity consumption, and potentially by re-marketing their asset shares after subscription limits are reached;

   b. Onsite green energy production: The microgrid P3 would offer customers options for onsite energy systems, including for example rooftop PV systems that would generate revenue by selling electric output in excess of offset electricity consumption; and
   c. Thermal energy services: Some microgrid P3 customers may have the opportunity to sell thermal energy output from onsite CHP facilities to onsite or nearby thermal customers.

B. *TE study notes:* The purpose of implementing a TE micro-market includes establishing opportunities for prosumer investments and market competition. The prospective TE implementation would allow further study of opportunities for customers to engage fully in DER micro-markets, from acquiring shared solar assets to developing neighborhood storage systems. Such opportunities would allow energy customers to earn revenue by selling energy and capacity to other counterparties in TE micro-markets.

3.2.10 State policy implementation

The New Paltz Microgrid directly promotes several New York State policy goals.

A. Reforming the Energy Vision (REV): The New Paltz Microgrid serves several major goals of the REV process, including providing project development and analysis to guide regulatory change, inform development of DSP functionality, measure and monetize customer participation, and guide effective DER implementation. Notably, the project team proposes an innovative P3 business model and energy services model, which establish new approaches for communities to facilitate local investments to serve communities' defined needs. The proposed microgrid establishes a framework for communities to perform integrated planning necessary for DER investments to achieve resiliency improvements and related energy and economic goals. The project also establishes innovative mechanisms for partnering with utilities to obtain their technical support for community microgrids, while also informing the advancement of DSP functions and practices.

B. Renewable energy goals including RPS: As designed the proposed microgrid would incorporate substantial new renewable energy and storage capacity to serve its Tier 1 resilient energy customers, while also facilitating ongoing community investments in renewable energy and energy efficiency improvements. As a result the New Paltz community will substantially increase its reliance on renewable resources, and many such resources will be optimized to serve local resiliency needs, thereby producing greater value to the community and the state than non-optimized renewable assets.

C. Community Choice Aggregation: The proposed microgrid's three-tiered energy services structure includes managing the community's CCA program, to be established through municipal ordinances.

D. CHP, conservation, and demand-side management: The proposed microgrid will demonstrate the use of modular CHP systems and load-management systems and methodologies to achieve a range of objectives, including resiliency and economic and environmental benefits.

Discussion: The project serves New York grid modernization objectives, including increasing community resiliency and reducing the effects of outages and lost economic productivity. The project will also optimize demand including reducing system and customer costs by better managing peak demand, load factors (of the system and by customer class), and reductions in system line losses. The project will also offer a better integration of distributed resources. The project also offers the opportunity to improve workforce and asset management within the state for the benefit of customers and the community served.

Sophisticated systems included in the microgrid will provide important benefits centered on community control, as New York is promoting that the grid itself will fundamentally change under the NY REV process. Microgrid projects offer the opportunity for integration of resilient energy supply, renewables and energy efficiency, load-management capabilities, and battery energy storage systems at the distribution and consumer level. Information technology and operating environments will become flatter with more interactions with the customer and increasing opportunity to engage in real-time operations. This is centered in a market and regulatory environment in which a wider array of viable energy substitutes are appearing in the marketplace. The proposed microgrid enables the community to exploit these market changes and technology advances to serve a variety of local objectives.

Successful communities will assume the role of energy integrators, including the business and technical responsibilities for providing all sources of energy supply safely and reliably to customers. This encompasses both demand and supply side strategies, and it requires information technology (IT) and operations technology (OT) infrastructure that is more sophisticated and robust than existing grid systems. While per-capita energy usage may increase with increased electrification, the proposed microgrid offers the community a platform for integrating multiple solutions to enhance resiliency and reduce energy consumption.

The New York REV process recognizes that with these changes, the business and technical structures for delivering energy services must adapt to accommodate innovation, competition, and increased customer optionality. Accordingly utilities are expected to expand and develop their platform services to enable and manage these changes and produce customer outcomes based on geotemporal resource value and data analytics rather than formulaic rate-regulated cost recovery. Moreover, historical utility business models will change as customer service requirements and cash-flow sources change. The proposed microgrid will demonstrate new revenue-generating platform service opportunities for utilities, on the foundation of state goals to ensure the delivery of safe, reliable, and affordable energy services.

The proposed project serves State objectives to develop better and best practices to foster more optimal business outcomes for local community leaders, in support of their public service and economic development goals. NY Prize projects and the New York REV process create opportunities to develop such optimal outcomes using new business models and approaches to providing service, rather than relying solely on legacy rate-based utility business structures and practices, which regulatory processes in many states (IRP, PBR, RPS, DSM, net metering, etc.) are struggling to manage in a 21st Century market.

Finally, the proposed project supports integrated community planning efforts, demonstrating methodologies enabling communities to capture greater benefits and cost efficiencies. This serves State goals to enhance community resiliency and opportunities for sustainable economic development.

3.2.11 Commercializing advanced technologies

(*See also 3.2.5*)

A. *Microgrid platform:* The New Paltz Microgrid establishes a technology and business platform for deployment and operation of numerous technologies to exploit DER. The platform itself represents innovative technology – specifically, the microgrid controller and optimization software required to perform active energy management and system balancing among various DER systems.

The microgrid platform will enable autonomous functionality of the microgrid 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 addition, the microgrid controller will monitor the performance, operation, and alarms of the distributed resources. In the event of an alarm, the microgrid operator will be notified through the network operations center, and dispatch a service technician engaged through a service contract. The microgrid controller also will 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, it will generate a history of performance, trending and signature analyses, whichwill enhance the microgrid's ability to anticipate failures.

B. *Utility integration:* The microgrid controller will provide a means for the utility to integrate the microgrid into its distribution management system, giving the utility insight into the microgrid status and operations and the ability to manage island-mode operations to ensure the safety of line workers and community members.

C. *Resilient DER deployments:* DERs are most valuable when they are designed, installed, and operated to produce a full range of customer benefits – including resilience. The New Paltz Microgrid will directly promote adoption and development of advanced DERs by optimizing their use to support community resilience while also producing environmental and economic value.

The New Paltz Microgrid project will seek to leverage turn-key CHP systems, as identified by the NYSERDA CHP Acceleration Program. The complete set of the community's reliability, financial, and emissions objectives will drive the type of CHP units selected and their mode of operation. Battery energy storage systems will be distributed with CHCP and PV to provide voltage and frequency support, smoothing and time-of-day shifting of solar PV output, island mode transition support, VAR management, and black start capabilities.

D. *TE micro-market demonstration:* The proposed New Paltz Microgrid would serve as an effective platform for a pilot or demonstration project to implement TE micro-markets. Such a project would allow further study of prosumer participation and distributed controls for real-time micro-market dispatch of DERs, to achieve maximum economic and environmental objectives for the community. Additionally it would provide the opportunity to develop, demonstrate, and refine approaches that continuously exploit DER units' specific real-time locational (*e.g.,* geotemporal) value.

3.3 Project team

The project team, comprised of Microgrid Institute, Hitachi Consulting, Green Energy Corp., and TeMix Inc., is well positioned to continue project efforts in subsequent phases. The team has collaborated to execute the NY Prize Stage 1 feasibility analysis, effectively managing and executing a variety of project tasks with expert resources drawn from existing staff. Team members are committed to the project and anticipate continued engagement with New Paltz stakeholders to further develop and refine engineering design, business model, and financing structures.

3.3.1 Community engagement and support

Ongoing engagement has ensured continued support and involvement by a variety of New Paltz stakeholders. The community of New Paltz generally has a high degree of support for renewable energy and environmental initiatives, and the New Paltz Microgrid has leveraged this support by establishing an ownership structure and energy services model that directly serves community interests.

A. *Integrated planning and collaboration:* The project team anticipates continued collaboration with community stakeholders in Stage 2 and subsequent project phases. Key community stakeholders – most notably leaders at the Town and Village of New Paltz and SUNY at New Paltz – have maintained consistent and productive cooperation with the project technical team, supporting a robust integrated planning approach. Stakeholder representatives have contributed direct assistance by providing information about energy usage and strategic plans, facilitating outreach and engagement with other community members, and participating in project update calls and briefings. This engagement has continued growing through election changes in administration at both the Town (Supervisor and two board members) and Village (mayor), and has accommodated substantial changes in community objectives, including plans to consolidate Town and Village administrative and law enforcement facilities. Additionally leaders at New Paltz Central School District and Board of Education have continued their engagement with the project, enabling the project team to develop adaptive strategies to accommodate the schools' plans to install a net-metered solar array.

B. *Public outreach:* The technical team anticipates continued outreach and education efforts to build upon Stage 1 progress. The technical team collaborated with Town and Village stakeholders to convene a public meeting and presentation for New Paltz community members on Dec. 15, 2015. Additionally the team has developed and distributed project background materials in various forms, to support ongoing outreach and engagement. The technical team has either physically visited or conducted phone outreach with most prospective Tier 1 resilient energy customers.

C. *NYSERDA engagement with community:* The technical team has assisted NYSERDA efforts to engage with the New Paltz community, facilitating a community visit for NY Prize Director Micah Kotch to tour project sites and meet with several key stakeholders.

3.3.2 Team member roles

Team members in the Stage I feasibility assessment are expected to continue supporting the project in subsequent Stage II and Stage III development phases. Additionally the project team anticipates expanding its capabilities in subsequent project phases to meet expanded project role requirements. Such roles may include, for example, project financial structuring and risk management, full-scope engineering-procurement-construction, and operations, maintenance, and administration.

Fig. 3.3.2-A: Team member roles

Team Member	Roles	Relationship
Microgrid Institute	Principal investigator, project manager *- Microgrid design, development, outreach, economic and legal structuring and analysis, and financing*	Prime contractor
Hitachi Consulting	Technical partner *- Microgrid design, modeling, and technology and resource assessment for development, financing, and deployment*	Subcontractor
Green Energy Corp.	Technical partner *- Microgrid control system analysis*	Subcontractor
TeMix Inc.	Technical consultant *- Transactive energy micro-market analysis*	Subcontractor

3.3.3 Public-private partnerships

The project team anticipates that the proposed New Paltz Microgrid will be owned and operated by a public-private partnership (P3), combining private business and public organizational models to enable integrated planning, ensure strategic focus on community objectives, and provide access to a full range of funding and financing options. The P3 approach provides a comprehensive but flexible structure enabling the community to leverage investments that best support resiliency for critical services, while improving the community's energy and environmental infrastructure and supporting ongoing economic development. The team anticipates the P3 ownership structure will be formalized in Stage 2.

Fig. 3.3.3-A Public-private partnership structure

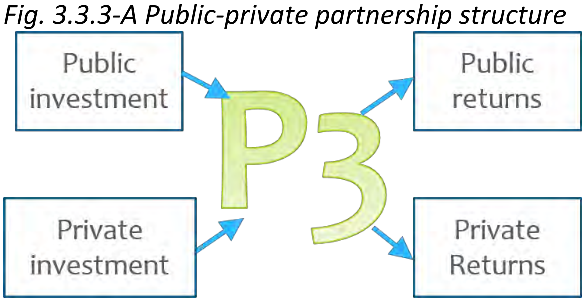
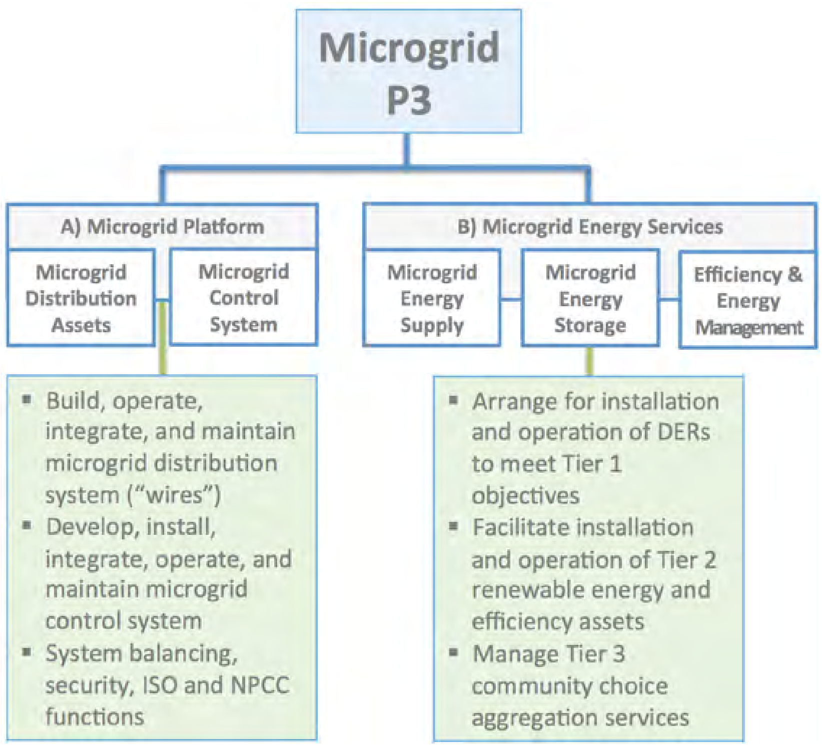


Fig. 3.3.3-B: P3 equity partners

Category	Prospective Owners
Public	Town of New Paltz, Village of New Paltz, SUNY at New Paltz, New Paltz Central School District, NYS DEC Region #3
Prosumer	Health Alliance of Hudson Valley (Woodland Pond), Stop and Shop Plaza, ShopRite, True Value Hardware, and individual businesses, institutions, and residential co-owners of microgrid resources
Private	Microgrid Institute, Hitachi, Central Hudson Gas & Electric, third-party investors

Fig. 3.2.3-B Microgrid P3 operating structure



3.3.4 Utility engagement and support

The project team is discussing with Central Hudson Gas & Electric what commitment is required to enable Stage 2 progress. Central Hudson provided a letter of support for the New Paltz Microgrid NY Prize Stage 1 application, and has supported assessment efforts with utility system information, guidance, and engineering analysis. The team anticipates continued engagement with the utility as the project proceeds.

3.3.5 Financial strength of the applicant

The applicant (Burr Energy LLC *dba* Microgrid Institute; DUNS 051595854) is a small business established in 2013. The company's primary revenue sources are derived from contracts with government entities (U.S. Department of Energy, the State of Minnesota, and the State of New York). The applicant's active and inactive accounts with clients, subcontractors, and vendors all are in good standing. Project team members have engaged in multiple contracts with the applicant, and their continued involvement assures continued resource capacity and stability for the project. The applicant will facilitate project financing and implementation in subsequent phases in close collaboration with other team members, affiliates, government entities, and third-party participants.

3.3.6 Team qualifications

The proposed New Paltz Microgrid project team is comprised of a collaborative group of companies with substantial expertise in microgrid technology, development, engineering, and deployment.

- *Microgrid Institute:* A collaborative organization that leads multidisciplinary projects focusing on microgrid development, Microgrid Institute serves as prime contractor and principal investigator for the New Paltz Microgrid project. In addition to expertise in community microgrid planning, design, research, development, and financing, Microgrid Institute brings demonstrated stakeholder engagement and facilitation capabilities, and experience managing government project contracts and subcontracts. The company leads the Olney Town Center Microgrid project, a U.S. DOE project to develop and test control systems for multi-node community microgrids in Maryland.
- *Hitachi America Ltd. / Hitachi Consulting Corp.:* A U.S. corporation with project staff offices in New York, Hitachi is a major infrastructure and consumer services company with substantial experience designing and implementing community resiliency and smart city projects. In addition to market-leading expertise in advanced energy efficiency and conservation, Hitachi brings microgrid design, engineering, and financing capabilities to the project team.
- *Green Energy Corp.:* GEC is a small business and a C-corporation incorporated in Colorado. GEC brings substantial experience designing and developing microgrids for a variety of purposes, as well as the open-source GreenBus DER control platform and market-leading expertise in multi-node community microgrids. The GEC team worked with multiple stakeholders to build the first operating community microgrid in the United States, in Borrego Springs, Calif. The company is leading R&D and design efforts for the Olney Town Center Microgrid, a project to develop and test control systems for multi-node community microgrids in Maryland.
- *TeMIX Inc./Ed Cazalet:* TeMIX Inc. is a provider of transactive systems and services to the power and energy industry. CEO Ed Cazalet is an acknowledged expert on transactive energy micro-markets, with extensive experience with high-speed, reliable transaction systems for electric power. Cazalet founded Automated Power Exchange (APX, now part of NYSE Euronext), and served as interim CEO and vice chairman of the California Independent System Operator (CAISO) board of governors. He contributes to several industry standards initiatives including NIST Priority Action Projects and OASIS technical committees and working groups.

The project team anticipates expanding its capabilities in subsequent project phases to meet expanded project scope requirements. Such capabilities may include, for example, partners or consultants with commensurate project financial structuring and risk management, full-scope engineering-procurement-construction, operations, maintenance, and administration expertise.

3.3.7 Are contractors and suppliers identified? Describe

The model for the proposed microgrid is based on standard equipment specifications for multiple types and sizes of photovoltaic systems, lithium-ion battery energy storage systems, combined heat and power units, and PCC components. The project team anticipates engaging a variety of contractors and suppliers to implement and operate the proposed microgrid. The microgrid P3 will seek to serve as a procurement agent for its owners and customers. Accordingly the project team anticipates maintaining optionality in contracting and procurement until the appropriate phases of implementation, and at that time, the microgrid P3 will execute a combination of competitive procurement and best-of-breed selection to ensure technology and materials are selected to meet all project objectives, including optimal financial economics and technical performance.

3.3.8 Are project financers/investors identified? Describe

The project team anticipates a financial structure with a capital stack containing elements of more than one form of financing. Prospective capital sources have been identified for some portions of the capital stack, but the team has not initiated financial structuring activities in the current preliminary phase of assessment. Stage II progress is expected to include further development of cash-flow and return expectations, and access to capital necessary to fund the project's long-term (25 years) value proposition.

Fig. 3.3.8-A: Project capital sources

Capital component	Identified capital sources	Other potential sources
Equity (cash and capital assets)	Town of New Paltz Village of New Paltz SUNY at New Paltz	Private prosumers (consumer/producers) Vendor financing (construction) Commercial equity investors
Grants	NYSERDA (including NY Prize), NYPA	U.S. DOE, HUD
Construction financing	NY Green Bank	Vendors, EPC firms, commercial banks
Long-term debt financing	NY Green Bank, Energy Finance Solutions (on-bill recovery financing)	Institutional investors, commercial finance consortia
Tax-based financing (TIF, PACE, municipal bonds)	Energize NY	Municipal bond investors

3.3.9 Legal and regulatory advisors

Microgrid Institute Washington Counsel Michael Zimmer serves as the team's legal and regulatory advisor. Mr. Zimmer previously served as senior counsel with Thompson Hine LLP, practicing in the law firm's Energy Unit in the Corporate Transactions Group in Washington, D.C. He has been involved since 1985 in industry transactions exceeding $15 billion in value, including project development, financing, construction, mergers and acquisitions in the non-utility generation, renewables, natural gas and electric, rural cooperatives, clean tech energy, emissions trading, and manufacturing sectors. He served as national co-chair of the American Bar Association Renewables and Distributed Energy Committee and the ABA's Energy & Environmental Markets and Finance Committees from 2008-2012. He serves as a fellow and executive in residence at the Voinovich School of Leadership & Public Affairs and the Russ School of Engineering at Ohio University. Mr. Zimmer is admitted to practice in the District of Columbia.

3.4 Creating and Delivering Value

(*See 3.1, 3.1.1, 3.2, and 3.2.8*)

The proposed project will create and deliver value for the community using a three-tiered energy services model. The microgrid P3 will serve as the New Paltz community's ESCo, arranging for full-scope energy supply, storage, efficiency, and load management necessary to provide Tier 1 resiliency services, Tier 2 green energy services, and Tier 3 community choice aggregation, throughout the term of customer contracts.

3.4.1 DER technology selection and challenges

As the DER portfolio is structured, the project team will determine the size, manner of use, and specifications of each piece of DER equipment, and identify vendors to provide the equipment. The project team made some of these decisions (resource type, sizing, operation, and location) as part of the NY Prize Stage 1 feasibility assessment, and reported these decisions in the Task 2 report. Other decisions (such as specifications and vendors) will be made in the detailed design phase of the project (Stage 2).

The project team will give preference to the most mature technologies available for each purpose that meet or exceed the stakeholder and design objectives. Where the project must use emerging technology (namely microgrid controls and energy storage) the project team will take special measures to prove each product before including it in the microgrid. These measures will include detailed and thorough testing and commissioning, and securing strong vendor warranties that include obligations to quickly fix any issues that may arise.

The project team used the following criteria to make design and technology selection decisions.

A. *Combined Heat and Power units*

Selection Factors: The project design specifies the following criteria to support CHP procurement:

- High overall performance
- High availability (hours per year)
- Low $/MWh
- Low emissions/MWh
- Proven continuous duty
- Low capital cost ($/kW installed)
- Low O&M cost ($/kWh)
- Readily available troubleshooting and maintenance service
- Manufacturer reputation
- Warranty provisions

Benefits: Fulfills the need for base generation in the microgrid resource portfolio approach. CHP applications provide high overall efficiencies.

Challenges: Typically fueled with fossil energy, fuel costs, maintenance and overhaul costs.

Design Considerations:

- Fuel Supply
- Available Space
- Siting
- Sound levels
- Heat Recovery Opportunities
- Load Following Operations
- Maintenance Requirements

Current Resources to be Leveraged: None

B. Photovoltaics

Selection Factors: The project design specifies the following criteria to support PV procurement:

- Hail rated
- Low annual degradation < 0.5%/yr
- High watts per panel
- Capital cost ($/kW installed)
- Low maintenance
- Manufacturer production capacity
- Manufacturer history
- Manufacturer reputation
- Warranty provisions

Benefit: Generation profile generally aligns well with the load profile, which is energy efficient; very low O&M, zero fuel cost.

Challenges: Low overall capacity factor and intermittency due to clouds. Installation locations can be challenging due to structural integrity of roofs, shading and space.

Design Considerations:

- Available Space
- Installation Locations
- Shading Issues
- Intermittency
- Orientation and tilt
- Maintenance Requirements
- Resiliency to wind and snow

Current Resources to be Leveraged: New Paltz currently has one PV installation (SUNY Wellness Center, 50 kW) that will be leveraged by the proposed microgrid. The SPE will incorporate these systems into the operational microgrid so that they can continue to generate energy for their host facilities when the system is operating in island mode. Additional customer-owned generation including rooftop PV systems currently installed on some private facilities may be leveraged if doing so is supported by Stage 2 project engineering analysis.

C. Energy storage systems (ESS)

Selection Factors: The project design specifies the following criteria to support ESS procurement:

- Compatible sizes and performance to our needs

- Low annual degradation
- Ramp rates
- Charge and discharge rates
- High AC – AC round trip efficiency
- Rated number of cycles
- Total capacity requirements (kWh per cycle)
- History in the field beyond the laboratory
- PCS and battery management system integration
- Available modes of operation
- Manufacturer reputation
- Warranty provisions

Benefits: Provides many functions in one efficiently operating unit (PV smoothing, peak shifting, VAR management, frequency support, voltage support, black start, mode transition management, etc)

Challenges: High installed capital cost, risk of shortened life from mismanagement.

Design Considerations:

- Selection
    - Technology
    - Battery System
    - Power Conversion System (PCS)
    - Integration
- Sizing
- Siting
- Modes of Operation
- Control Optimization

Current Resources to be Leveraged: None

D. Microgrid Controls

Selection Factors: The project design specifies the following criteria to support procurement of microgrid controls:

- Multi-objective optimization
- Real-time operational background
- Ability to actively communicate with devices and resources in real-time
- Manufacturer reputation / likelihood of being around for more than 5 years

Benefits: Active microgrid controls provide economic optimization, reliability optimization, resiliency optimization, and emissions optimization, provides a data rich environment for trending, signature analysis, and sharing with stakeholders.

Challenges: Immature technology with few quality vendors holding solid track records. Many traditional vendors are offering programmed logic controls, which cannot provide the optimization functions expected of microgrid controls.

Design Considerations:

- Platform
- Vendor Experience
- Architecture

- Control Approach
- Optimization
- Communications
- Cyber Security
- Integration experience with selected DER
- Overall system experience with integration, startup, and commissioning
- Cost structure

Current Resources to be Leveraged: None

E. PCC and underground cabling

The local utility will need to analyze and approve the final engineered design for system interconnection, switching, and protection systems that provide disconnect, islanding, and restoration functions in case of power disruption. The utility will also need to approve any plans to use of sections of utility distribution equipment while in island mode.

The utility will coordinate protection and switching schemes for the PCC and the distribution system. The SPE will address these needs in the interconnection agreement and the studies that support it. The proposed PCC solution simplifies the interconnection agreement and interconnection study by using a straightforward approach to isolate the microgrid from the distribution grid with control by the utility in accordance with the IEEE 1547 interconnection standard. This gives the utility control of the interconnected system and makes the interconnection agreement easier to execute.

Where feasible, the proposed microgrid will use underground cabling to connect loads in multi-facility nodes. Overhead distribution lines do not provide the resiliency or reliability required to meet project objectives, and so the microgrid design is optimized to minimize reliance on vulnerable above-ground systems. Ownership of new purchased and installed underground cabling may be retained by the P3 or transferred to the utility pursuant to a BOT agreement, based on the objectives of community stakeholders. The REV proceedings include a consideration of such arrangements.

The project team anticipates the proposed project will utilize underground cable currently installed at the Woodland Pond campus. The project also may leverage existing underground cable on the SUNY at New Paltz campus, and in the Net-Zero Energy housing development. To the degree the proposed microgrid uses utility-owned underground cable, it will do so via access agreements allowing technically viable and cost-effective operations and maintenance of these systems.

Selection Factors: High quality switches and breakers, long lifetime performance, and manufacturer reputation.

Benefits: Simplifies the interconnection between the microgrid and the distribution utility, affords a data rich environment for the system owner and the utility as this important electrical junction.

Challenges: High installed capital cost.

Design Considerations:

- Communication protocol
- Synchronizing capabilities

Current Resources to be Leveraged: None

F. TE study notes:

The objectives of a project to implement a TE micro-market would include establishing opportunities for prosumer investments and market competition. As part of its microgrid modeling and assessment efforts, the project team specified several configurations of PV, ESS, and CHP systems to meet all Tier 1 resilient energy requirements. The proposed three-tiered energy services model, however, would accommodate other technology options that meet criteria for microgrid integration and utility interconnection. Moreover, a TE implementation would allow further study of opportunities for customers to engage fully in DER micro-markets, from acquiring shared solar assets to developing neighborhood storage systems.

3.4.2 Existing assets being leveraged

(*See 3.4.1 above*.)

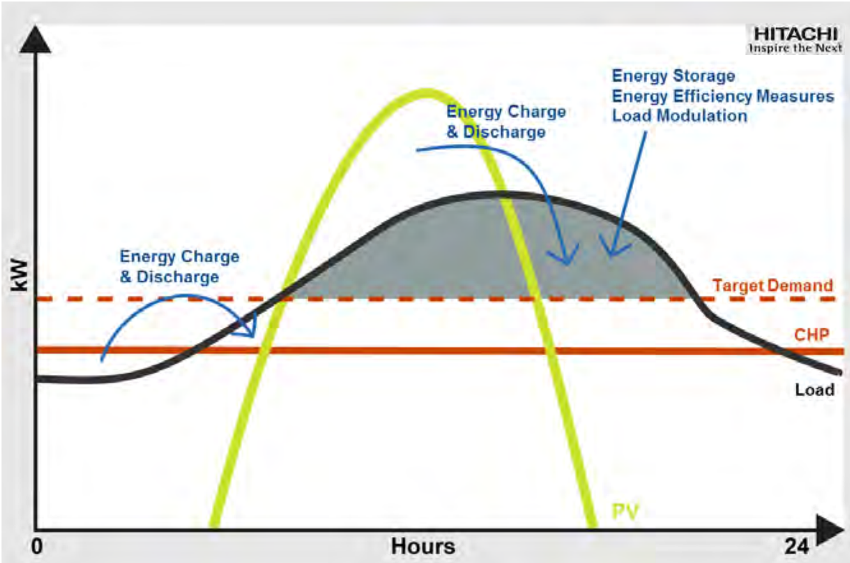
A general lack of suitable DERs and underground cable infrastructure in the New Paltz area limits the opportunity to leverage existing physical assets. Noteworthy existing assets to be leveraged include a 50 kW PV array at the SUNY Wellness Center, backup generation systems at several locations (for backup only, not baseload or peaking generation), and underground cabling at Woodland Pond and potentially at SUNY and in the Net-Zero Housing development.

3.4.3 Approach to generation and load balance

The project team will use a microgrid portfolio approach to select DERs for the microgrid. This approach focuses on analysis of the energy requirements of covered facilities, and is intended to achieve a close match between the DER portfolio and the electric load profile of those facilities. Instead of sizing the DER portfolio to match the sum of the peak loads at each critical facility in the microgrid, the portfolio approach allows DER to be sized to meet the loads of these facilities almost all the time, without over-building. This approach enables the 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 will be designed to run at design output for at least 8,000 hours per year. PV and energy storage will be integrated into the system to meet loads that vary above the base load. Energy storage systems will be specified based on their capability to change their output rapidly in response to dynamic transient conditions, perform load following, and provide an energy buffer among CHP, PV, and electric load throughout the day. Figure 3.4.3-A illustrates this concept.

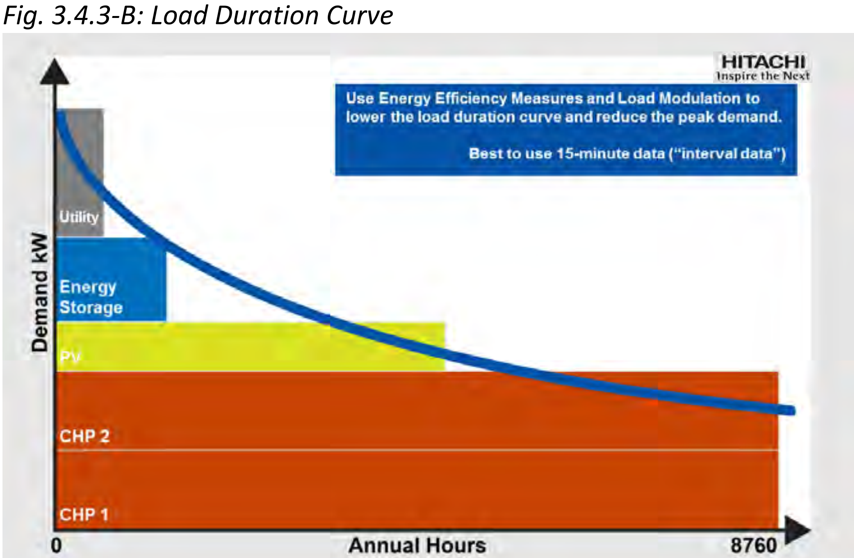
Figure 3.4.3-A: Microgrid Portfolio Approach



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. This design approach 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.

Another element of our strategy for resource selection and sizing is based on the load duration curve presented in Fig. 3.4.3-B. 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 dispatching microgrid generation, load management, and minimal use of existing backup generation to sustain lower operating costs. This methodology allows the designers to evaluate the appropriate balance of grid service, generation resources, and load management capabilities. The resulting solution will be sound both technically and financially.

Fig. 3.4.3-B: Load Duration Curve



TE study notes: A TE implementation within the proposed microgrid would perform operational dispatch of resources on the basis of long-term contracts and spot transactions. For the purposes of microgrid modeling and assessment, the project team outlined operational dispatch protocols to meet all Tier 1 resilient energy requirements. A TE implementation would allow further study of opportunities for competitive market clearing and dispatch of resources – long-term and short-term energy needs – on the basis of real-time geotemporal value to resource owners.

3.4.4 Permitting requirements

The specified generation and storage systems will be subject to customary permitting and siting regulations, codes, and requirements.

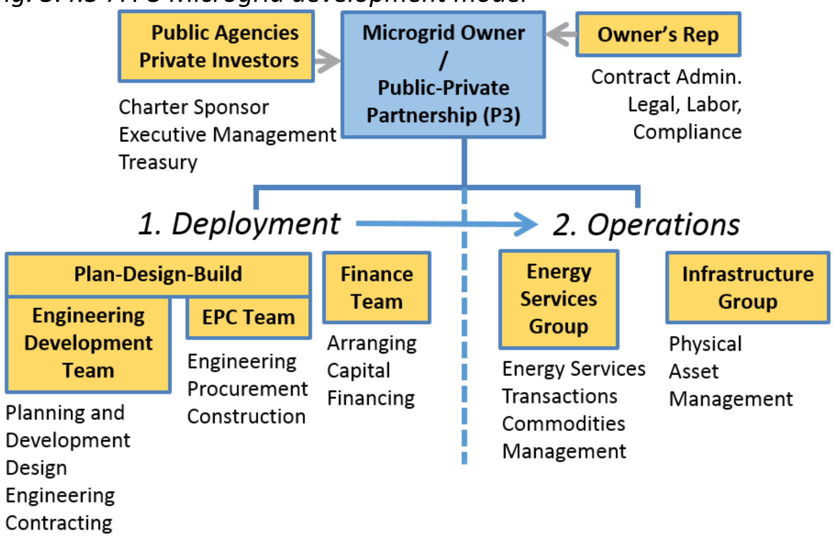
Installation of DER and distribution hardware, cable, and gas pipeline extensions will comply with local and state review and permitting requirements, building and electrical permit requirements, and prevailing codes such as the NYS fire code and construction loading standards. Fuel-burning systems (CHP) will be subject to standards for air emissions, noise emissions, water use, zoning, and site constraints such as height restrictions and architectural or historic preservation requirements. Project equipment specifications will require equipment to meet or exceed federal, state, or local emissions standards, as well as prevailing industry and technical standards and certifications.

3.4.5 Development, construction and operating approach

The project team anticipates developing, implementing, and operating the proposed microgrid using a multi-phase collaborative project management and enterprise management approach. The P3 will oversee all development activities, delegating responsibility and entering contracts to plan, design, build, and commission the microgrid and related assets to serve Tier 1, Tier 2, and Tier 3 customers, and formalizing financial arrangements to provide capital funding for all phases of development. The P3 also will oversee all operational activities, including managing Tier 1, Tier 2, and Tier 3 customer service, energy transactions, and physical asset management.

The project team anticipates that microgrid engineering, procurement, construction, commissioning, financing, customer recruitment and servicing, and other enterprise activities will be performed by a combination of the project team and additional contractors, vendors, suppliers, and consultants retained in accordance with the P3's procurement and governance policies. During initial onboarding and operational phases, P3 organization is expected to retain a minimal management and customer service staff in New Paltz, with operations and maintenance performed by contractors under long-term arrangements.

Fig. 3.4.5-A P3 Microgrid development model



3.4.6 Community benefits (summary)

(*See 3.2 and 3.2.1*)

The proposed microgrid produces a wide range of benefits, as described above and throughout the Task 2 and Task 3 reports. They can be summarized as: 1) Improved resilience for critical facilities; 2) opportunities to expand local investment in renewable energy and conservation; and 3) support for economic growth and development. Additionally the team's analysis indicates the proposed microgrid can produce direct economic benefits, providing enhanced services to customers for costs that are equal to or lower than current costs.

The New Paltz Microgrid is designed to serve six strategic energy goals established by the community: (1) Empower the community to implement its own energy strategy, as part of integrated community planning and development; (2) Improve the resiliency of services that are critical to the health, safety, and vitality of the community; (3) Increase the community's use of local resilient renewable energy assets, and facilitate ongoing local renewable energy investment; (4) Reduce the community's fossil energy consumption and related environmental footprint, and facilitate ongoing reductions; (5) Increase opportunities for local ownership of energy resources, keeping more energy dollars in the New Paltz economy; and (6) Support future economic development and growth by modernizing community energy infrastructure.

3.4.7 – Utility requirements

Utility participation is necessary to ensure the proposed project's feasibility and positive cost-benefit performance for the community. Key utility contributions include the following:

- Technical design input and guidance
- Interconnection requirements and procedural support
- Business model input and guidance
- Operating agreements

- Customer servicing arrangements

In principle the utility also may support the P3 as an equity partner, investing in distribution systems and platform assets necessary to serve microgrid customers.

3.4.8 DER maturity

(*See also 3.4.1*)

The distributed energy systems specified for the New Paltz Microgrid all use thoroughly field-tested, off-the-shelf technologies. Photovoltaics, natural gas-fired CHP systems, and battery energy storage are all well-established technologies that have been proven to be effective and reliable both when installed singly and when deployed as part of a microgrid system.

Microgrid platform systems also will rely on thoroughly field-tested systems. Specified microgrid control systems will support seamless transition from grid-connected to island mode, and will use distributed controls and portfolio management methodologies with demonstrated capabilities to sustain balanced operation in support of project objectives. PCC, protection, and safety systems will support all required operational requirements in compliance with prevailing utility standards (*e.g.,* IEEE 1547).

3.4.9 Describe the operational scheme

Operation of the microgrid will include several key components:

A. *Metering:* The P3 will provide customer services via sub-metering arrangements. The project team will add new sub-metering as necessary to serve microgrid customers.

B. *Technical operations:* The microgrid controls, and microgrid design, are based on the 10 ORNL microgrid Use Cases. The most important use cases address transition to an island mode (planned and unplanned) and return to grid-connected operations. Stage II development will include developing a detailed sequence of operations for transitioning to island and back to grid-connected mode. 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.

C. *Financial operations:* The microgrid P3 will bill system customers monthly for energy used by system resources. The project team anticipates using an ESA approach that simplifies this process, billing consumed $/kWh monthly instead of in each of the 18+ billing determinants in a typical utility electric bill. Depending on how the P3 and operating agreements are established, the customer may also still be billed by the utility. To simplify bill management for the customers of the microgrid, microgrid service may become a pass-through within utility billing, or vice-versa.

D. *Transaction management:* Any additional revenue to customers from shared program participation (community solar gardens, demand response, ancillary services) will be accounted for in the monthly bill that customers receive from the P3 or from the utility if bills are integrated.

E. *TE study notes:* In a TE deployment, market trading activity via long-term contracts and spot transactions would drive operational dispatch of various resources. The New Paltz Microgrid could serve as a test market to demonstrate micro-market dispatch of energy resources supporting balanced and economical microgrid operation.

3.4.10 Replicability of the business model

(*See also 3.2.6*)

The New Paltz Microgrid Project establishes a highly replicable and scalable approach to providing resilient energy and other energy services for New York communities. It applies several key elements that are consistent with commercial viability, technology and modernization objectives, and New York State energy policy goals.

A. *P3 ownership model:* Public-private ownership and management structures developed for the New Paltz Microgrid can be used in other community microgrid situations. Additionally these structures are highly scalable, being viable and supportive for projects of various sizes.

B. *Multi-tiered service model:* The New Paltz Microgrid service model is readily adaptable for application in any community that shares a similar level of local support for development of clean energy resources and resilient energy systems as part of an integrated sustainable-planning and economic development approach.

C. *Design and technology approach:* By specifying resilient infrastructure and resources in standard configurations, and by providing controls for managing clusters and portfolios of facilities that serve community resilience, the New Paltz Microgrid's design and technology approach establishes a roadmap for community resilience in New York and jurisdictions with similar market and regulatory conditions.

D. *Financing:* By structuring community microgrid agreements and covenants to support commercial financing, the project may establish programmatic financing models readily adaptable for communities with similar needs and wants.

E. *Integrated Development Strategy:* The proposed energy services model and integrated community planning approach exemplify methodologies for communities to meet immediate needs while preparing for future growth and development.

3.4.11: Describe the barriers to market entry
-and-
3.4.12 Describe the plan to overcome the barriers

Several barriers require attention for NY Prize projects in general:

A. *Legacy business model:* Approaches to microgrid development that challenge traditional business models or alter customer relationships may prompt market incumbents to delay or prevent project progress.

Proposed project solution: The project team will define appropriate operating agreements, concessions, or exemptions, and facilitate their execution to enable project progress.

Policymakers can consider a variety of solutions to overcome these barriers for eligible projects or statewide. For example, some states are considering strategies to encourage utility support for microgrids. These include: revisions to codes of conduct that would allow utility joint venturing and alliances; policies to encourage or require integrated DER and distribution system planning; and market access and ratemaking policies that enable competitive microgrid development – *e.g.,* adjustments to revenue-decoupling mechanisms, performance-based rate structures that reward utility support for microgrids, and public utility regulatory exemptions for community microgrids. Some jurisdictions have provided alternative regulation and special legal exemptions for community microgrids and district energy projects that cross public rights of way and serve multiple customers. Such tools would substantially encourage innovation and competition in providing resiliency solutions for communities.

B. *Vulnerable resource lock-in:* Net metering policies provide incentives for non-resilient, grid-tied DER deployments that are vulnerable to outage risks can prevent investments in resilient assets to serve critical community facilities.

Proposed project solution: Pending finalization of net-metered solar contract, collaborate with school district to revise resiliency objectives, identify options, and define appropriate solutions. Encourage right-sizing of new net-metered resources to allow critical school district loads to be served by resilient resources.

Net metering policies in New York present a substantial problem for community P3 microgrids – especially remote net-metering policies that provide incentives for major energy customers (most notably school districts) to enter long-term arrangements under which substantially all of their utility energy purchases are offset by output from large solar arrays. Such projects tend to be developed and sited to provide the greatest economic benefits for investors and vendors, with little or no consideration for community resiliency needs or options. Because net-metering customers must continue purchasing energy from the utility in order to qualify for production credits, they are effectively excluded from any resilient energy or efficiency-improvement initiatives that would be financed on the basis of energy purchases. In effect, by locking-in facility loads for power from non-resilient DERs, remote net-metered energy projects tend to limit options and impair resiliency.

Policies to encourage investments in renewable energy and DERs in particular will yield the greatest value for customers – and the greatest resiliency benefits for communities – if they accurately attribute and monetize true geotemporal energy value. State net-metering policies bear review and revision to ensure they avoid unintended negative consequences for communities.

C. *Monetization gap:* Inadequate methodologies for attributing and monetizing the geotemporal value of DERs constrain cash flow and discourage investment in resilient assets.

Proposed project solutions: The project proposes two solutions to appropriately monetize DER value: 1) Microgrid resource portfolio and three-tiered service model, providing multiple modular service options to meet a wide range of customer profiles; 2) Transactive energy micro-market deployment, demonstrating market-clearing mechanisms to establish geotemporal DER values with long-term contracts and spot transactions.

D. *Regulatory risk:* Regulatory risk associated with REV and other New York policy initiatives, and uncertainty about market access and regulatory models, deter commitments by market participants.

Proposed project solution: Ensure sustained legal viability by establishing contingency options for implementation in the event of regulatory changes. Monitor regulatory developments and provide supportive policy inputs as appropriate, building upon New York customer choice, power marketing, and alternative energy policy frameworks to support a workable regulatory approach for community resilience priorities.

E. *Procurement hurdles:* Government procurement policies may compel state entities to apply competitive procurement requirements to microgrid participation, deterring early-stage commitment from qualified developers and vendors.

Proposed project solution: The proposed microgrid public-private partnership structure is intended, in part, to address this conflict by acting as a procurement agent for the P3's public owners and customers. This role will be most effective if the State of New York provides public entities with confidence that they can participate in the P3 and purchase energy services from the microgrid without violating procurement regulations or triggering burdensome administrative requirements.

To the degree public entities apply to microgrid services the same competitive procurement processes they use for other procured products, procurement requirements may have a chilling effect on community microgrids. The State of New York could encourage community microgrid development by providing supportive exemptions or administrative guidance enabling workable procurement options.

F. *Taxes and prevailing wages:* State and local taxes and prevailing-wage standards increase project costs compared to projects in some other U.S. jurisdictions.

Proposed Project Solution: Develop structures to capture tax benefits. Seek grant and incentive funding to levelize project benefit-cost potential.

High project costs effectively reduce the scope of services that a microgrid can cost-effectively provide, limit P3 returns, and constrain access to commercial capital sources. Separate tax policy review of microgrids may ensure that taxes do not unintentionally impede mobilization of private capital for community resilience and economic development benefits.

G. *Inadequate development funding support:* In New Paltz, as in many New York communities, access to development capital is severely constrained, and usually insufficient to complete advanced design feasibility analysis, engineering development, and finance and legal structuring, in preparation for construction financing. Available development capital is very limited, and communities may be compelled to abandon options for lack of early-stage support.
Proposed Project Solutions: Seek NY Prize Stage 2 and Stage 3 funding. Leverage complementary programs. Seek financing wrap with funding for development.

3.4.13 Microgrid market for this approach

(*See also 3.4.10*)

The community microgrid market is a unique and emerging market. Projects in this market face unique challenges, including serving critical facilities that are not necessarily close to each other; establishing contractual agreements with a diverse set of parties; and supporting multiple strategic priorities (resilience, cost savings, sustainability) within a single system. Accomplishing all of this with proven, off-the-shelf technologies (required to achieve scale rapidly) requires innovative technical approaches and business models, deployed by experienced market players. The New Paltz Microgrid project team has identified a technical approach and group of project partners that can achieve this.

With weather patterns becoming more extreme and contributing to more frequent and widespread electric outages, more communities will seek to develop comprehensive emergency preparedness plans that include community microgrids following the approach being developed for New Paltz. Additionally, community stakeholders increasingly recognize the value – and difficulty – of comprehensive integrated planning and development to maximize community benefits and minimize the costs of interrelated initiatives and investments. The market for community microgrids will benefit directly from successful demonstration of development models that support ongoing collaboration and integrated planning among community stakeholders.

3.5 Financial viability

The proposed microgrid was designed on the basis of the following key elements necessary to support financial viability:

- The critical nature of the identified facilities to support community operations in the event a major electric outage,
- The electrical and natural gas infrastructure in the community,
- Each facility's energy requirements,
- Each facility's energy systems and infrastructure,
- Improved resiliency to withstand extended power outages,
- Increased reliance on renewable energy,
- Improved emissions footprint, and
- Supply of energy at a competitive cost

The design incorporates the installation of new DERs including CHP, PV, and energy storage. Other microgrid resources include the conventional electric grid, energy efficiency measures, and load control strategies. The overall system sizing provides for meeting the baseline energy requirements of the facility with the grid, DER, and energy efficiency. The proposed design will deliver 13.4 million kilowatt hours of energy per year from the microgrid on-site distributed energy resources.

At this feasibility stage of the project, a high-level project budget was developed and incorporated into the sizing model to ensure that the design meets both the technical and economic elements of the project. Cost elements include engineering, permitting, capital equipment, site preparation, construction, controls, start-up, commissioning, and training. Site preparation also includes the addition and modification of electrical infrastructure for undergrounding distribution lines, PCC controls, monitoring, and protection equipment. Some of these infrastructure costs may be paid to the electric utility. The estimated project budget for this project is $12 million with an accuracy of +/- 25%. *Note:* This cost includes an applicable deduction for the federal investment tax credit, which recently was extended by the U.S. Congress. The project cost excludes any other incentives that may be applicable to the project. Nevertheless, the team anticipates efforts to take advantage of all applicable incentives for the project, including NY Prize Stage II and Stage III awards. These potential incentives are addressed in section 3.5.2 of this report.

The proposed microgrid creates savings to the community in the form of energy cost savings, resiliency savings, and carbon savings due to GHG reductions. Resiliency savings include likely business costs saved by avoiding anticipated outages. GHG savings are generated as the proposed system would produce fewer tons of greenhouse gases each year, due to an emissions profile that is much cleaner than that of the utility. The value of GHG reductions is based on the U.S. Environmental Protection Agency's CO_2 offset price of $40 per ton. A summary of the estimated microgrid savings for the first full year of operation of the proposed microgrid are presented in Fig. 3.5-A*:*

Fig. 3.5-A: Estimated Microgrid Year 1 Savings

Estimated Annual Energy Savings	$95,000
Estimated Annual Resilience Savings	$514,900
Estimated Annual Carbon Savings	$146,600

This report proposes a business structure whereby the microgrid would be owned and operated by a P3 entity that would arrange funding for the project. The P3 would generate revenue through energy service agreements for a 25-year period. The economics of the project have been analyzed using a life-cycle cost analysis, which shows that the project has a positive net-present value (NPV) and an unlevered internal rate of return (IRR) of 6.4% – which experience demonstrates is sufficient to support an investment in this project.
Based on the estimated energy savings, assumed project financing costs, and the 25-year contract term, the team's assessment indicates that a weighted average ESA electric rate of approximately $0.13/kWh can be achieved for this project. This compares to the current weighted electric rate of the key critical facilities of $0.14/kWh.

TE study notes: The proposed financial structure is consistent with a potential TE micro-market deployment in the project area. In terms of financial viability, a TE approach would be expected to improve financial performance by providing customers with greater optionality. Long-term contracts would preserve the core financial proposition while spot-market transactions allow counterparties to pay or earn the geotemporal value of resources.

3.5.1 Categories and magnitude of revenue streams to the owner

The proposed microgrid is expected to produce between $1.5 million and $2 million in annual revenues from Tier 1 energy services, all in the form of electricity sales to microgrid customers. Additional revenue streams to the microgrid P3 were not modeled for this Stage 1 of this project. Such revenue streams may include electric energy, capacity, demand response, and ancillary services sales in the NY ISO wholesale market; revenues from related energy resource investments, including potential regional biomass production businesses; energy savings performance fees and bonuses; and consulting and service fees.

TE study notes: A TE micro-market would enable participants to execute their own resource investment and operation strategies to serve their own objectives as asset owners. As a result, the decisions of TE market participants may affect total microgrid revenues. A TE deployment would enable further study of how micro-market behavior might affect overall system economics including revenue streams to P3 owners.

3.5.2 Other incentives identified

In addition to NY Prize Stage 2 and Stage 3 incentives, the project would seek leverage various incentive programs and similar initiatives to support investments in resilient DERs and related systems and infrastructure. Examples may include:

A. *Federal incentives:* Federal investment tax credits, production tax credits, and accelerated depreciation provisions

B. *NYSERDA programs:* NYSERDA K-Solar, NY Sun, BuildSmart NY, New York State Community Partnership, and Combined Heat and Power programs

C. *NYPA programs:* NYPA Energy Efficiency, NYPA Solar MAP programs

D. *Other NY programs:* Energize NY PACE Finance, New York Green Bank support, Community Choice Aggregation

E. *Utility programs:* Central Hudson high-efficiency appliance rebate programs (as applicable)*

F. *Other potential incentive programs* supporting ESS and electric vehicle (EV) charging and vehicle-to-grid system investments (ChargeNY, Clean Fleets NY)

Note: The proposed microgrid does not rely on Central Hudson net-metering provisions for any resources dedicated to serving Tier 1 critical facilities. The microgrid P3 may seek to integrate energy outputs from certain existing or new net-metered solar installations that are owned or contracted by microgrid customers. Additionally, if current New York PSC deliberations yield a Community Net Metering program that is consistent with project objectives, the microgrid P3 may seek to structure qualifying project assets for inclusion in such a program to optimize total system value.

3.5.3 Categories of capital and operating costs (fixed and variable)

Fig. 3.5.3-A: Operating cost categories

Operating cost	Fixed, variable, or both
Finance payments	Fixed
Commodities	Both
O&M	Both
Equipment replacement	Variable
Enterprise*	Fixed

**Administration, management, customer service, and legal costs.*

Fig. 3.5.3-B: Capital cost categories

Capital cost	Phase
Design, engineering, and development	Deployment
DER equipment	Deployment
Distribution equipment	Deployment
Microgrid controls	Deployment
Equipment additions and upgrades	Operation

3.5.4 How does the model ensure profitability?

Ultimately, the project's profitability will derive from the value it produces for the community. The proposed ownership model ensures profitability by defining required Tier 1 resources and establishing a financing model that supports ongoing positive cash flow in excess of debt service and operating expenses. Additionally it ensures profitability by leveraging microgrid P3 capacities to provide Tier 2 and Tier 3 energy services and capture attendant efficiencies and ancillary revenue streams.

3.5.5 Describe the financing structure

The financing strategy for the project will be built on accessing private capital to supplement public capital sources for project financing. For example, tax credits and depreciation can provide access to equity and debt funds from private investors to carry qualifying tax benefits and liabilities. However, the P3's modest expected financial returns likely will limit access to some forms of commercial financing, necessitating a hybrid public-private financing structure. The public owners who support the P3 can access tax-exempt public capital sources, potentially including municipal bonds and federally insured public infrastructure development funding. Public entities with tax authority can also facilitate access to property assessed clean energy (PACE) funds for qualifying energy improvements. Grant funding (potentially including NY Prize Stage II and Stage III) will reduce project debt costs and further leverage P3 equity contributions. Each type of financing may contribute to a cost-effective capital financing strategy for the project, seeking to lower the capital costs of financing for the benefit of community taxpayers.

Generation management would be separated from ownership of the wires, T&D and operating facilities for regulatory purposes and to facilitate better access to capital and management of different risk profile assessments for the project. Important consideration exists for monetizing different value streams from the projects to facilitate financing, the ability to retire debt service, and to provide equity returns. Perhaps, system benefit charges could be expanded to provide recognition of resiliency benefits created by the project. PACE financing and green bonds with local tax authorities would offer an appropriate supplemental source of funding. Finally, tax-increment financing (TIF) may need to be considered with bonds for resiliency improvements in the underlying real estate properties.

Reductions and lower costs from the project and incremental value streams can be coordinated with the amortization schedule associated with the repayment of debt. At a minimum, that debt repayment would need to exceed the tax recapture period of five years from the microgrid's placed-in-service date.

Community microgrids apply a variety of technologies to maintain balanced operation. As a result they pose related challenges and risks. Vendor agreements for the project should address foreseeable issues, including performance guarantees, warranty repairs and replacements, and security implementation. Particularly in the areas of cybersecurity, energy storage, and control systems, project architecture and design should anticipate technology changes to avoid stranded assets with underlying microgrid investments. These risks should be covered in upgrades for software agreements with vendors.

The critical financing risk will be design and construction of the microgrid project. The microgrid P3 would assume the responsibility to access capital and provide construction-period risk coverage. Perhaps this could be managed in the ownership structure by use of a trust whereby the microgrid distribution platform users would be part of that trust, and the generation provider and ESCO would have contracts with that trust for services. This might also separate legal title from beneficial title to project assets for regulatory purposes and facilitate refinancing or exit strategies in the financing structure for the project.

Sources of debt financing for the project may be arranged through the NY Green Bank as well as existing bond programs. The financing resources covered in this review raise important issues regarding equity financing – specifically gaining access to risk capital, to reduce and ultimately eliminate reliance on scarce public debt and development capital.

Economic constraints for municipal projects likely will limit implementation of microgrids in the short term without additional funding support from federal, state government or other county and local entities. The true test of microgrids will be their ability to attract private capital. The NY Prize projects could assist the private financing markets by disseminating substantive, objective information and tools to support access to private capital. Communities could benefit the most from guidance and technical assistance that encourages market-based project assessment and development. Removal of artificial regulatory barriers and a consistent planning horizon for microgrids for the next decade will also be critical. This will likely be experienced in the marketplace upon refinancing of these projects and over the next five years, once the NY REV outcomes are implemented and new business models arise.

Financing challenges and risk management for microgrids exist based upon five critical factors arising in ownership and financing structures:

(1) Multiple technologies used in the microgrid are different from existing financial structures that focus on individual types of generation. Microgrids are multidisciplinary, integrated, involve generation, transmission and distribution to incorporate and aggregate towards linking one or more generation technologies with T&D services.
(2) Multiple credits for financing risk are presented for an evaluation while existing tools for financing projects are structured around customer types of building and the generation technologies deployed. Microgrids may likely serve a network of all customer types within the community from residential and commercial to MUSH markets, and light industrial users all with different levels of individual credit evaluations required.
(3) Microgrids add complexity, which may generate requirements for a credit wrap or guarantee to support access to capital for successful project financing.
(4) Multiple revenue sources are presented around benefits of the microgrid including reduced energy costs, declining GHG emissions, energy security, grid hardening, and reliability. New York is characterizing these benefits in five different ways. Energy savings alone may not pay for the cost of the microgrid investment. The benefits may command a premium, which the utility or the overall system may not be willing to provide. Further work on quantifying value streams needs to be done within New York to support successful microgrid development building upon reviews of value added by solar to include, energy storage and fuller microgrid benefits. These should not be left to mere negotiation with the utilities as a stable revenue framework with quantifiable benefits needs to be structured within the state.
(5) Microgrids are often presented as individual customer solutions. Making microgrids economical and a matter of scale raises demand and supply side analysis in support of financing. The microgrid customers when aggregated must have a demand profile that supports the operating requirements of the generators that may be providing power resources to the microgrid system.

Thoughtful analysis of these considerations will be critical to support final choices in financing strategies from the array of financing tools available to the projects.

3.6 Legal Viability

The project legal viability depends on factors that require resolution in Stage 2:

A. *P3 and BOT ownership structures:* The viability of proposed ownership structure and asset-transfer concepts must be validated through Stage 2 collaboration with prospective P3 owners and Central Hudson. Central Hudson has reviewed the microgrid P3 and BOT structure plans, and the project team anticipates resolving related issues by establishing operating agreements with the utility, and by seeking administrative guidance from the New York Public Service Commission.

B. *Public Service Law and Central Hudson franchise:* Key legal issues may involve New York Public Service Law and utility franchise enforcement as applied to community microgrids serving multiple customers and crossing public rights of way. The team anticipates addressing such legal issues in Stage 2 through development of detailed operating agreements, concessions, PSC administrative guidance, and other requirements for project progress in Stage 2.

C. *Approved procurement policies:* An operating methodology is required for the P3 to serve as a public-customer procurement agent for microgrid services. The project team anticipates collaborating with the proposed microgrid's public-entity owners and customers to establish procurement practices and policies that address applicable procurement requirements. The project team also may request State guidance to establish a workable procurement agency approach that can be replicated in other P3 and similar microgrids serving public entities.

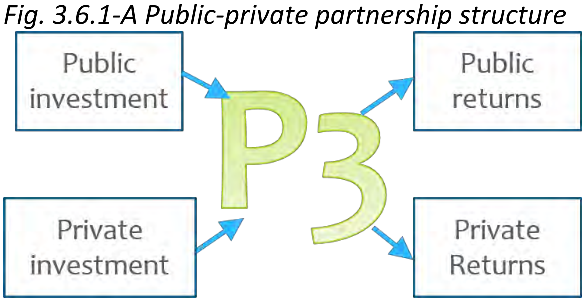
3.6.1 Describe the ownership structure

(*See also 3.3.3*)

A. Microgrid Public-Private Partnership (P3)

The project team anticipates that the proposed New Paltz Microgrid will be owned and operated by a public-private partnership (P3), combining private business and public organizational models to enable integrated planning, ensure strategic focus on community objectives, and provide access to a full range of funding and financing options. The P3 approach provides a comprehensive but flexible structure enabling the community to leverage investments that best support resiliency for critical services, while improving the community's energy and environmental infrastructure and supporting ongoing economic development. The team anticipates the P3 ownership structure will be formalized in Stage 2.

Fig. 3.6.1-A Public-private partnership structure



B. Build-Operate-Transfer Model

The project team proposes a build, own, operate and transfer structure. A BOT is a public-private partnership (P3) project model in which a private organization conducts a larger development project under contract with a public sector partner (such as the NY Prize communities). A P3 can develop a larger public infrastructure project while accessing private funding in the capital stack for the project. A special purpose entity (SPE) would be formed to manage the construction, design, EPC, and operations of the project. The SPE would be structured with separation of generation ownership from actual project wires, T&D system investment, and operational services so that the two value streams from ownership are independent for regulatory purposes. (*See Figs. 3.6.1-A and -B*)

Under this ownership structure, the public sector partner contracts with a private developer who together form an SPE with a suite of different businesses. To the greatest degree possible, the SPE will draw subject matter expertise (SME) from its partners to ensure the likelihood of success in designing and implementing the vision of the community. The public sector project may offer limited funding or some other benefits (such as lower cost tax-exempt status). The private sector partner assumes the risks associated with planning, constructing, operating and maintaining the project for a specified period of time. This would at least cover the period of tax recapture for different project tax benefits,[4] removal of construction and operating risk, with the possibility of an exit strategy preserved in the project structure.

The developer charges customers in the community who use the microgrid infrastructure that has been built to realize a return on investment, cover debt service, and provide a reserve for operations and maintenance. At the end of the term in the project structure, the private-sector partners would transfer ownership to the funding organization, either freely or for an amount stipulated at fair market value for the project, or the project could be refinanced for a further term. Variations on this structure include: (1) build, own, transfer or (2) build, own, operate, or (3) build, lease, transfer and build, lease, operate, transfer depending upon the unique needs of the community.

Ownership structure significantly impacts cost recovery for debt service and financing and the ability to monetize the benefits from the microgrid. This ownership structure for microgrid projects is intended to promote higher levels of cost savings to customers and to ensure that microgrid design and implementation prioritizes community priorities to increase local resilience, penetration of renewables, demand-side management, energy storage, and energy efficiency.

a. Pre-Transfer: The microgrid public-private partnership (P3) will be responsible for all development, financing, design, construction, integration, and operations tasks associated with the microgrid. Its scope, function, and legal basis will be defined by mutual agreement.
    i. Operational Divisions: Through the course of project development and implementation, the microgrid P3 will fulfill its obligations through two distinct operational divisions – Division A) Microgrid Platform and Division B) Microgrid Energy Services.
    ii. O&M Obligations: The microgrid P3 will retain responsibility for operations and maintenance of commissioned assets during the agreed term. O&M is expected to be provided on a long-term performance-contract basis.
    iii. Legal and Financial Obligations: In general the microgrid P3 will bear regulatory and fiduciary responsibility for performance and delivery of microgrid services in accordance with service agreements and cleared market terms, when applicable.

b. Post-Transfer: At the end of the agreed Term, the microgrid P3 will transfer the assets and obligations of Division A) Microgrid Platform to a DSPP. The microgrid P3 will retain ongoing ownership and obligations for Division B) Microgrid Energy Services.

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[4] Tax credit and accelerated depreciation provisions specify five years of ownership at a minimum, except for certain biomass assets which are depreciated in no less than seven years. (*IRS Section 179 – MACRS for listed property*).

The DSPP will operate Division A as a regulated utility asset. The DSPP will be responsible for obtaining PSC approval for tariffs or service fees charged to recover utility costs associated with microgrid Platform operations.

Fig. 3.6.1-A: BOT microgrid - Pre-Transfer Ownership Structure

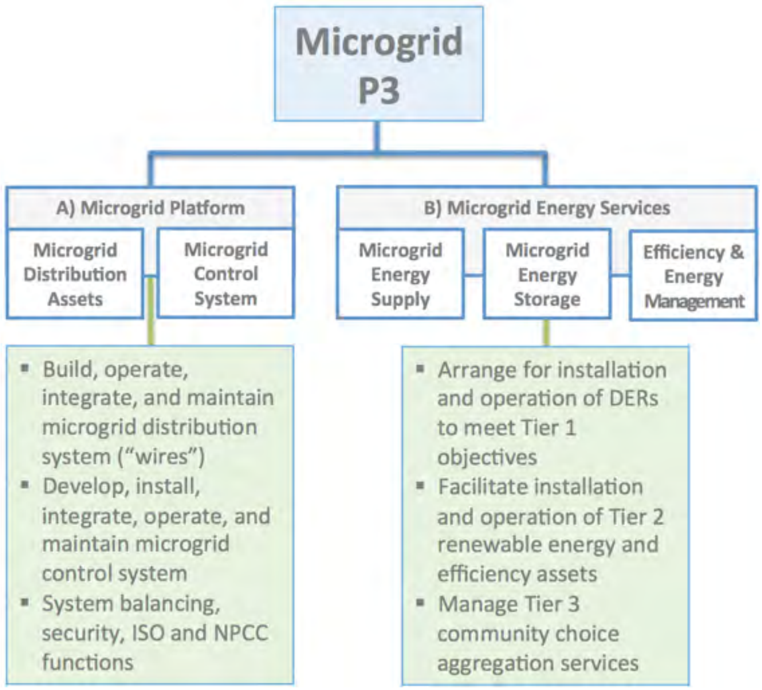
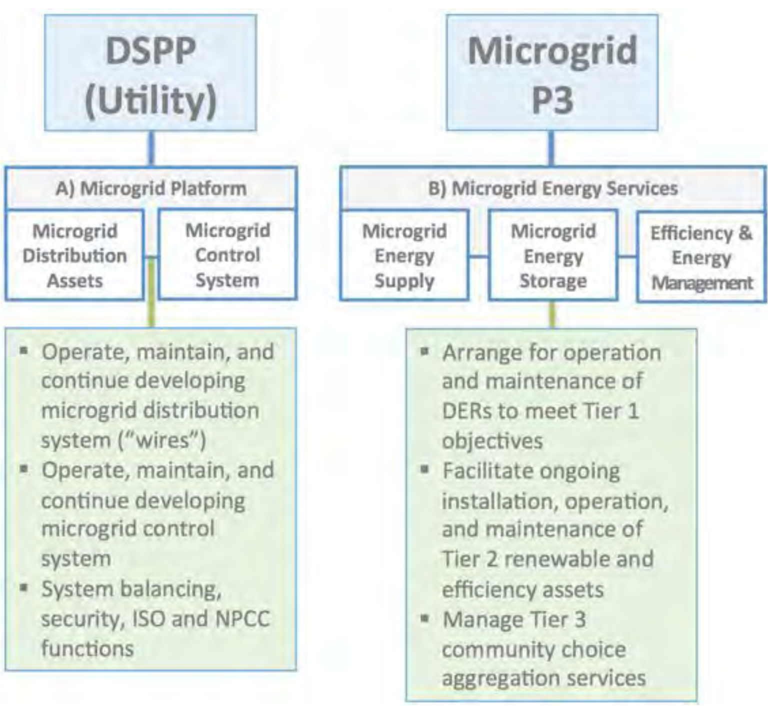


Fig. 3.6.1-B:BOT microgrid - Post-Transfer Ownership Structure



3.6.2 Has the owner been identified? What is the approach?

(*See 3.3.3*)

The project team has discussed options for ownership participation in the microgrid P3, but formal agreements have not been entered. The project team anticipates continuing its involvement at the request of the charter members of the public-private partnership. In general:

Fig. 3.6.2-A New Paltz Microgrid P3 equity partners

Category	Prospective Owners
Public	Town of New Paltz, Village of New Paltz, SUNY at New Paltz, New Paltz Central School District, NYS DEC Region #3
Prosumer	Health Alliance of Hudson Valley (Woodland Pond), Stop and Shop Plaza, ShopRite, True Value Hardware, and individual businesses, institutions, and residential co-owners of microgrid resources
Private	Microgrid Institute, Hitachi, Central Hudson Gas & Electric, third-party investors

3.6.3 Microgrid assets and P3 owners

(*See Fig. 3.1.4-A*)

Any entity could, in principle, hold a stake in a public-private partnership in some form. Three primary public owners are identified, with Tier 1 facilities as described:

- Town of New Paltz: Planned new Municipal Center, prospectively in partnership with the Village of New Paltz. Also owns some water facilities.
- Village of New Paltz: Water and wastewater facilities; Community Center & Municipal Pool; prospective share of Municipal Center.
- New Paltz Central School District: Area schools and adjacent lands.

Other microgrid customers that in principle could own assets used in the microgrid:

- SUNY at New Paltz: SUNY Wellness Center, Elting Gym, and Campus Health Center.
- New York State Department of Environmental Conservation: Region #3 Headquarters offices and DEC State Police facilities
- Health Alliance of Hudson Valley – Woodland Pond at New Paltz facilities
- New Paltz Rescue Squad, Fire Department facilities
- Wakefern Group/ShopRite Supermarkets; Stop and Shop Plaza; and other commercial facility owners
- Prospective local energy customers with microgrid-controlled onsite DERs and shared offsite assets

3.6.4 Data security and privacy

Customer information is subject to best practices and industry standards for privacy and security, as well as data-retention policies. Systems for data entry, access, and storage will be designed to ensure cybersecurity and physical security against intrusion, unauthorized use, and data loss.

The proposed project customer service specifications include full-scope security, privacy, and data management policies.

Appendix A:
Customer Viability Methodology

(*Source: Microgrid Institute Customer Viability Matrix:*
For full-size version, see file: "Fig. 3.1-A Customer Viability Matrix.xlsx")

Microgrid Institute's customer viability screening matrix allows quantitative evaluation of customer prospects, considering economic, technical, legal and market, and process factors, as well as other criteria. Each of the proposed microgrid's customers is assigned estimated values for numerous factors, including: Needs and wants; Financial support options; Current energy supply arrangements; Credit strength; Thermal loads & load profiles; Existing infrastructure; Energy efficiency upgrade options; Siting & permitting; Local energy resources; Technology solution options; Regulation and policy context; Utility support for project objectives; Market costs for alternative services; Clarity of sponsor authority; Level of sponsor support; and Integration factors. The Microgrid Institute Matrix can produce variable weighted outcomes to ensure priority focus. For NY Prize Stage I feasibility analysis, the analyzed results were unweighted; viability ratings would be higher if the Matrix values were weighted to prioritize critical facility resilience, then environmental and economic objectives second and third, as per community goals.

New Paltz Microgrid

Customer Viability Matrix - 12/29/2015

CUSTOMER	Viability Grade (A-F)	Viability Rating (1-5)	Economic Factors	Needs and wants	Financial support options	Current energy supply arr.	Credit strength	Technical Factors	Thermal loads & load profiles	Existing infra.	Energy efficiency upgrade options	Siting & permitting	Local energy resources	Technology solution options	Legal & Market Factors	Regulation and policy context	Utility support for project objectives	Market costs for alternative services	Process Factors	Clarity of sponsor authority	Level of support	Integration factors	Other Factors	Bonus criterion	(Describe bonus criterion)
CRITICAL / VITAL FACILITY CUSTOMERS																									
Town of New Paltz	A	**3.71**	**4**	4	3	4	4	**1**	-1	1	0	2	2	2	**3**	4	1	3	**4**	4	4	4	**4**	4	Policy mot
Village of New Paltz	A	**3.71**	**4**	4	3	4	4	**1**	-1	1	0	2	2	2	**3**	4	1	3	**4**	4	4	4	**4**	4	Policy mot
SUNY at New Paltz	A	**4.20**	**4**	4	4	4	4	**2**	3	4	1	2	2	2	**3**	4	1	3	**4**	4	4	3	**3**	3	Policy mot
New Paltz Central School District	B	**3.42**	**2**	1	3	-1	4	**2**	3	1	3	2	2	2	**3**	4	1	3	**3**	3	2	3	**3**	3	Educationa
NYS DEC Region #3 Office	A	**3.96**	**3**	4	2	3	4	**2**	3	3	2	2	2	2	**3**	4	1	3	**4**	4	4	3	**2**	2	Policy mot
Woodland Pond at New Paltz	A	**4.09**	**3**	3	0	4	4	**3**	4	4	1	2	2	2	**3**	4	1	3	**4**	4	4	4	**4**	4	Optimal fa
Stop & Shop Plaza	B	**3.59**	**2**	4	0	2	3	**2**	3	0	3	2	2	2	**3**	4	1	3	**3**	4	2	3	**4**	4	Commercia
ShopRite Grocery	B	**3.53**	**2**	4	0	2	3	**2**	3	0	3	2	2	2	**3**	4	1	3	**3**	2	3	3	**4**	4	Commercia
Institute for Family Health*	C	**2.58**	**1**	2	0	3	0	**2**	2	0	3	2	2	2	**3**	4	1	3	**-1**	-1	-1	0	**3**	3	Commercia
Meadowbrook II Apartments*	C	**2.62**	**1**	4	1	0	0	**2**	-1	1	3	2	2	2	**3**	4	1	3	**0**	-1	0	2	**3**	3	Commercia
Fire Station #2*	B	**2.84**	**2**	2	2	2	3	**1**	-2	1	3	2	2	2	**3**	4	1	3	**1**	0	0	3	**2**	2	Indispensa
New Paltz Rescue Squad*	B	**2.84**	**2**	2	2	2	3	**1**	-2	1	3	2	2	2	**3**	4	1	3	**1**	0	0	3	**2**	2	Indispensa
AVERAGE	**B**	**3.42**	**3**					**2**							**3**				**2**				**3.2**		
ECO / TECHNICAL CUSTOMERS																									
ZNE Housing ǂ	B	**3.04**	**-0**	1	2	-3	-1	**2**	0	4	0	2	2	2	**3**	4	1	3	**4**	4	4	4	**4**	4	Commercia
True Value Hardware*	C	**2.68**	**1**	3	0	-1	1	**2**	1	0	2	2	2	2	**3**	4	1	3	**1**	0	0	3	**4**	4	Commercia
Dedrick's Pharmacy*	C	**2.42**	**1**	2	0	-1	3	**1**	0	0	1	2	2	2	**3**	4	1	3	**0**	0	0	0	**4**	4	Commercia
My Market Grocery*	C	**2.69**	**0**	2	0	-1	0	**2**	1	1	2	2	2	2	**3**	4	1	3	**1**	4	0	0	**4**	4	Commercia
Stewart's Convenience Store*	C	**2.62**	**1**	2	0	-1	3	**2**	1	1	1	2	2	2	**3**	4	1	3	**0**	0	0	1	**4**	4	Commercia
AVERAGE	**C**	**2.69**	**1**					**2**							**3**				**1**				**4**		

Appendix B: Three-Tiered Energy Services Customer Criteria

Tier 1 Resiliency Customers: The microgrid will provide the highest-value Tier 1 Resiliency Services for customers that:

A. The Town and Village define as critical for health, safety, and vitality and/or that choose to receive Tier 1 services;
B. Meet the microgrid's *technical* criteria for receiving Tier 1 service (*e.g.,* the microgrid can provide resiliency services in a manner that is technically viable); and
C. Meet the microgrid's *economic* criteria for receiving Tier 1 service (e.g., the microgrid can provide resiliency services in a manner that is economically viable).

Tier 2 Green Energy Customers: The microgrid will provide Tier 2 Green Energy Services for all customers in the New Paltz area that:

D. Choose to receive Green Energy Services;
E. Meet the microgrid's technical criteria for receiving Tier 2 service; and
F. Meet the microgrid's economic criteria for receiving Tier 2 service.

Tier 3 CCA Customers: The microgrid will provide Tier 3 CCA Services for all customers who meet eligibility requirements for a CCA program prospectively to be established by municipal ordinance.

Discussion of Customer Criteria:

A. Tier 1 Resilient Energy Service customers: The NY Prize Task 2 report provides a detailed description of customers included in the proposed resilient energy microgrid. Tier 1 customers include facilities in the following three categories:
    a. Critical facilities: Numerous facilities that the community determines are critical to its health, safety, and vitality.
    b. Adjacent non-critical customers: In some circumstances, the microgrid may provide Tier 1 resiliency services for customers located immediately adjacent or in-between critical customers, if providing Tier 1 service is more cost-effective and technically feasible than withholding Tier 1 services from these customers.
    c. Opt-in customers: The microgrid will provide Tier 1 resilience services for non-critical customers who require such services and meet other technical and economic criteria – *e.g.,* if they are willing and able to pay for premium service on terms that are technically and economically viable.
B. Tier 2 Service Customers:
    a. New Paltz onsite generation service customers: The microgrid will offer green energy generation services for all commercial, industrial, institutional, and residential customers in the New Paltz area. Tier 2 customers will be required to meet technical and economic criteria for installation and operation of onsite solar energy systems and combined heat and power systems.
    b. New Paltz energy efficiency service customers: The microgrid will offer energy efficiency audits and energy savings equipment and services for all New Paltz area customers. Tier 3 customers will be required to meet technical and economic criteria for receiving Tier 3 energy efficiency services.
    c. New Paltz Shared Energy customers: The microgrid will offer offsite generation services – *e.g.,* shared community solar gardens or biomass energy production systems – to all New Paltz area customers.

d. Ulster County Tier 2 customers: Through alliances or joint ventures, the microgrid P3 may extend its Tier 2 Green Energy Service capacity to serve all of Ulster County, further extending the synergistic benefits in support of Tier 1 services for critical facilities.

C. Tier 3 CCA customers:

a. New Paltz CCA customers: In principle all residents of the Town and Village of New Paltz may be included in a CCA program established by municipal ordinance. Generally customers are included unless they are deemed ineligible or they opt out.

b. Ulster County Tier 3 customers: The New Paltz CCA program could be integrated with county-wide resilient renewable energy efforts, further extending synergistic benefits in support of Tier 1 services for critical facilities.

[End of Report]