Hudson County Town Center
Distributed Energy Resource
Microgrid Feasibility Study Report

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Project Name

We are pleased to submit the Hudson County Advanced Microgrid (HCAM) Feasibility Study to the New Jersey Board of Public Utilities (NJBPU). Greener by Design, LLC (GbD), CHA Consulting, Inc. (CHA), and GI Energy (GI) collaborated on behalf of Hudson County to analyze the energy consumption, systems, and infrastructure for a number of critical facilities in the Town of Secaucus, New Jersey, in order to recommend measures for successful advanced microgrid implementation to further improve the energy resiliency and emergency preparedness of Hudson County, which are presented in this report below.

Project Applicant

Hudson County submitted their application for the NJBPU Town Center Distributed Energy Resources (TCDER) Microgrid Feasibility Study Incentive Program on March 27, 2017. HCAM Feasibility Study partners include: Hudson County, which owns the Meadowview Complex, the Town of Secaucus, Alaris Health at the Fountains, Secaucus Housing Authority, Secaucus Fire Station (Engine Company #1), Secaucus Public Library, Clarendon Elementary School, Meadowlands Hospital and Medical Center, Mill Creek Mall, Secaucus Municipal Utilities Authority, and the Secaucus Recreation Center. Meadowview Complex contains fifteen buildings, including the Meadowview Psychiatric Hospital, a wastewater treatment facility, various drug rehabilitation centers, and a number of Hudson County offices.

Based on the list of proposed critical facilities, initial estimates for the main microgrid cluster included four FEMA Tier IV facilities, ten FEMA Tier III facilities, and five FEMA Tier II facilities, encompassing a total of approximately 813,000 square feet and consuming approximately 147,000 MMBTU of energy annually. A possible extended microgrid cluster would also include the Secaucus Fire Station, Secaucus Office of Emergency Management, and Secaucus Public Library, all of which provide incredibly critical functionality during emergency situations. Finally, the emergency-circuit only facilities were included as facilities that could potentially be integrated into the HCAM Feasibility Study if the PSE&G circuitry allows for it, which includes the remainder of the facilities listed above.

Project Partners

Lead: Greener by Design, LLC

Greener by Design, LLC

Greener by Design, LLC, an Energy Investment and Environmental Asset Management firm, and its multidisciplinary staff of energy, engineering and environmental, financial, project management and grant writing professionals, is pleased to present this Town Center Distributed Energy Resource Microgrid Feasibility Study proposed to Hudson County. GbD brings a comprehensive understanding of the economic and policy underpinnings of a rapidly changing energy and environmental landscape as well as a fresh perspective on how technology, innovation and legislation will influence the market in years to come.

GbD presently provides or has provided Energy Investment and Environmental Asset Management planning and grants services to a number of private and public clients. Of these, New Jersey municipalities include Hoboken, Seaside Heights, Mantoloking, Woodbridge, Paterson, Linden, Rahway, Dover, Jersey City, Newark, Greenwich, Harding Township, Parsippany-Troy Hills, Warren and Monmouth Counties, CCMUA (Camden County Municipal Utilities Authority), and grant writing and management/compliance services for the Hudson County Improvement Authority (2011-2018). Additionally, under contract to the non-profit New Jersey Clean Cities Coalition (NJCCC), GbD managed a $15 million DOE grant to offset the cost of the conversion of 305 garbage trucks and shuttle buses to Compressed Natural Gas (CNG) and the installation of six CNG fueling stations. The major public/private participants in the NJCCC Project include the City of Newark, Atlantic County Utilities Authority (ACUA), Waste Management, Central Jersey Waste, Atlantic City Jitney Association, and the Clean Energy Program.

GbD specializes in facilitating several programs offered by the New Jersey Clean Energy Program. Our detailed project management and familiarity with the programs has allowed our team to successfully secure incentive monies from Direct Install, Pay for Performance, Local Government Energy Audit, Combined Heat and Power and Fuel Cells, and Prescriptive and Custom Upgrades for Indoor Lighting.

GbD’s staff has recently worked on a variety of post-Hurricane Sandy planning projects for energy master planning. Under a sub-contract with NJIT, GbD worked with Neptune, Galloway and Newark to create a toolkit and academic program for resiliency planning and the preliminary feasibility of back-up power or microgrids. GbD also obtained a Gardinier Environmental Fund Grant through the Sustainable Jersey Small Grants Program in December 2015 to examine the potential development of a microgrid in the Township of Woodbridge. The study identified public and private stakeholders that would need the ability to operate critical functions and provide necessary support for the town and the surrounding area.

Sub-Contractors: CHA Consulting, Inc. | GI Energy

CHA Consulting, Inc.

CHA is a full-service engineering consulting firm and is ranked among Engineering News-Record's Top 100 firms in the nation. A staff of 700 highly qualified and skilled professionals provide a wide range of engineering and support services. They are extremely active in the energy audit market as well as energy conservation and renewable energy design. Their energy audits have saved clients over $50 million dollars in energy costs. CHA has many years of experience and has successfully completed over 10,000 projects in the engineering of building systems (structural, mechanical, electrical and plumbing) and the design and installation of roof mounted telecommunications equipment. CHA is currently working on renewable projects throughout the U.S. Most notably, they are completing a wind/solar roof mounted system at the Rochester International Airport and are in the preliminary planning of a 20MW solar farm in southern New Jersey.

CHA has served the energy industry nationwide from offices throughout the United States. Their project management expertise, efficient production methods, and fast-track project scheduling enables them to quickly and effectively plan, design, permit, and construct energy systems of all sizes and scopes. Expertise gained from their long successful history of designing building systems can be applied to a wide variety of renewable energy solutions including structural analysis and design, utility coordination and design, zoning, permitting, preparation of construction documents, permitting, grounding design and photo simulations. With regard to roof-mounted equipment, whether it is solar arrays, HVAC equipment or communication antennas, the issues are very similar and their ability to effectively execute these types of projects is solid.

GI Energy

GI Energy is an innovative integrator of distributed energy and sustainability resources for large commercial facilities, campuses, municipalities and large real estate developers. As a technology agnostic provider, their team focuses on delivering bespoke solutions for their clients, leveraging the latest in commercial technologies including geo-exchange HVAC, energy storage, renewable electricity generation, fuel cells and combined heat and power. They seek opportunities where multiple technological solutions can be brought to bear on a complex set of economic and environmental problems.

GI Energy specializes in providing consulting, development, underwriting, engineering, management, construction and advisory services to facility owners and property developers with a specific focus on distributed energy resources (DERs). GI Energy operates with offices in California, Illinois and New York and includes seasoned energy and financial analysts, engineers, project development professionals, and operations and maintenance technicians. GI Energy's development group possesses unique commercial and technical expertise in developing sustainable and efficient distributed energy resources.

Project Location

Figure 1: Conceptual Overview of Hudson County Advanced Microgrid illustrates the main cluster for the Hudson County Advanced Microgrid, within the Town of Secaucus in Hudson County.

Figure 1: Conceptual Overview of Hudson County Advanced Microgrid

Project Description

Executive Summary

Hudson County has taken new steps on their road to becoming a more resilient community by participating as one of the thirteen NJBPU Town Center Distributed Energy Resource (TCDER) Microgrid Feasibility Study Incentive Program Applicants. The study contemplates the development of a microgrid comprised of various highly reliable and available distributive energy resource (DER) technologies embedded within the main cluster of the facilities residing on County Avenue. At the beginning of the study, our team utilized NJIT's Town Center report to scan the local area around the Meadowview Complex for other facilities that could potentially be integrated into the HCAM project. Three clusters were created based on their distance from the Meadowview Complex, criticality in emergency situations, and anticipated energy loads.

The main cluster included Alaris Health at the Fountains (Alaris), Secaucus Housing Authority #1 (SHA #1), Secaucus Housing Authority #2 (SHA #2), and the Secaucus Town Hall / Police Station (Town Hall), and was considered by our team for both electrical and thermal connection to the HCAM during blue-sky, or normal operating conditions, as well as black-sky, or utility outage, conditions. The extended cluster included the Secaucus Fire Station (Engine Company #1), the Secaucus Office of Emergency Management, and the Secaucus Public Library, and was located farther away from the Meadowview Complex, so it was only considered for electric connection during blue-sky and black-sky conditions to the HCAM. Finally, the emergency circuit cluster included Secaucus Housing Authority #3, Clarendon Elementary School, the Meadowlands Hospital and Medical Center, Mill Creek Mall, Secaucus Municipal Utilities Authority, and the Secaucus Recreation Center. These facilities were far from the Meadowview Complex, but could potentially be connected to the HCAM by utilizing existing PSE&G infrastructure and sectionalizing a portion of their grid. Upon review of the existing infrastructure and electrical circuitry of PSE&G in the area, our team determined that the extended cluster and emergency circuit cluster could not practically be connected to the HCAM.

HCAM Original Critical Facility List			
Cluster	**Facility Name**	**Address**	**FEMA**
Main	Meadowview Complex	595 County Avenue, Secaucus, NJ 07094	2,3,4
	Alaris Health at the Fountains	505/595 County Avenue, Secaucus, NJ 07094	3
	Secaucus Housing Authority #1	600 County Avenue, Secaucus, NJ 07094	3
	Secaucus Housing Authority #2	700 County Avenue, Secaucus, NJ 07094	3
	Secaucus Town Hall / Police Station	1203 Paterson Plank Road, Secaucus, NJ 07094	4
Extended	Secaucus Fire Station (Engine Company #1)	150 Plaza Center Road, Secaucus, NJ 07094	4
	Secaucus Office of Emergency Management	1377 Paterson Plank Road, Secaucus, NJ 07094	4
	Secaucus Public Library	1379 Paterson Plank Road, Secaucus, NJ 07094	3
Emergency-Circuit Only	Secaucus Housing Authority #3	777 Fifth Street, Secaucus, NJ 07094	3
	Clarendon Elementary School	685 Fifth Street, Secaucus, NJ 07094	3
	Meadowlands Hospital and Medical Center	55 Meadowlands Parkway, Secaucus, NJ 07094	4
	Mill Creek Mall	3 Mill Creek Dr, Secaucus, NJ 07094	3
	Secaucus Municipal Utilities Authority	1100 Koelle Boulevard, Secaucus, NJ 07094	3
	Secaucus Recreation Center	1200 Koelle Boulevard, Secaucus, NJ 07094	3

Table 1: Microgrid Cluster Breakdown

The facilities within the microgrid boundary include: four FEMA Category IV facilities (Secaucus Town Hall/Police Station, and the Psychiatric Hospital, Powerhouse, and 911 Call Center residing within the Meadowview Complex), ten FEMA Category III facilities (Alaris, SHA #1, SHA #2, and Buildings #4-9, and 13 residing within the Meadowview Complex) and five FEMA Category II buildings (Buildings #1-3, 12, and 15 residing within the Meadowview Complex). In addition, United Parcel Service (UPS), located adjacent to Alaris Health at the Fountains, was included as the study progressed, due to its proximity to the HCAM and its existing solar photovoltaic (PV) system on its roof. These will support the surrounding population and emergency services, totaling twenty buildings. The distances between the critical facilities can be seen in the "Project Location" section of this report. No Right-of-Way crossings are anticipated to be required for the HCAM because Hudson County owns the only road that needs to be crossed (County Avenue), and the microgrid plans to use existing PSE&G infrastructure to connect to Town Hall.

To determine the economic viability of the proposed microgrid serving Hudson County, the existing facility thermal and electrical load profiles were represented in the Distributed Energy Resources Customer Adoption Model (DERCAM™) to allow for the selection, optimization and placement of a variety of DERs to be considered for this project. The DERCAM software (developed by the Berkeley Lab) can be used to find the optimal portfolio, sizing, placement, and dispatch of a wide range of DERs, while co-optimizing aspects of load shifting, peak shaving, and power exporting via participation in ancillary service markets. In the process of finding optimal DER solutions for the project, several attributes must be satisfied, including:

- What is the optimal portfolio of DER that meet the specific needs of the County?
- What is the ideal installed capacity of these technologies to minimize costs?

•How should the installed capacity be operated to minimize the total customer energy bill?

•What is the optimal DER solution that minimizes costs while ensuring resiliency targets?

In satisfying these key considerations for Hudson County, the selection of DERs respective of facility was contingent upon the selected DER's technology spatial requirements, heat-to-power ratio to be displaced by the host facility(s) and the attributes of the DER's generative capacity on the respective PSE&G circuit serving the facility. The optimal selection and configuration of DERs for the County are best described in the block-chain diagram DERCAM Microgrid Topology found in Appendix A. This diagram, in conjunction with the DERs recommended for further implementation and their prescribed mode(s) of operation are depicted in section 8 herein.

HCAM Final Critical Facility List					
Facility Name	**Address**	**Risk Category**	**Area (Sq. Ft)**	**Annual Electric Consumption (kWh)**	**Annual Gas Consumption (therms)**
Secaucus Town Hall/ Police Station	1203 Paterson Plank Rd, Secaucus, NJ 07094	4	32,451	709,914	24,017
Meadowview Complex	505/595 County Ave, Secaucus, NJ 07094	2,3,4	414,704	6,224,267	754,319
Alaris Health at the Fountains	505/595 County Ave, Secaucus, NJ 07094	3	209,849	Partially included in Meadowview	Partially included in Meadowview
Secaucus Housing Authority #1	600 County Ave, Secaucus, NJ 07094	3	95,000	644,346	19,552
Secaucus Housing Authority #2	700 County Ave, Secaucus, NJ 07094	3	61,000	147,900	23,418
United Parcel Service (UPS)	493 County Ave, Secaucus, NJ 07094	2	400,340	N/A	N/A

Table 2: HCAM Final Critical Facility List

The proposed DER assets to be integrated with each building are estimated to be able to generate over 10,000,000 kWh of electricity annually. Coincidentally, the DER assets will generate approximately 328,000 therms of usable heat to serve the following facilities: Meadowview Complex, Alaris, and the SHA #2. Meadowview Complex and Alaris are currently interconnected by way of a utility corridor (underground tunnel network) which houses a high-pressure steam and condensate circuit in addition to various power distribution schemes which emanate from the Powerhouse. This existing distribution infrastructure is a key attribute of the microgrid project's feasibility, and is the back-bone for an integrated microturbine combined heat and power scheme to serve as the main DER for this project.

The DER solution developed to serve the connected facilities in blue-sky and black-sky modes of operation consist of an array of seven 200kW microturbine generators producing electricity and steam. It is envisioned that the turbine-generators will operate in electrical load-following mode, producing enough power to essentially satisfy all of the connected facilities electrical load (demand) while the waste heat produced will be used to generate steam for distribution throughout the campus network. This type of DER was selected as the basis of the microgrid design, as the technology is robust, reliable, efficient and achieves one of the highest availability targets compared to other available technologies. In addition to the microturbine generators, solar photovoltaic (PV) systems are recommended to complement the electrical output of the microturbine generators.

The distance of the proposed microgrid spans approximately 0.54 miles from the farthest point of connected facilities and comprises an area of approximately 0.25 square mile.

The result of the DERCAM model and subsequent analysis for the facilities studied finds that the Hudson County Advanced Microgrid is technically feasible and financeable. The recommendation of this study is for Hudson County to work closely with the NJBPU on the contracting and implementation of the microgrid buildout, with a potential Phase II feasibility study in the near future.

Critical Facility Descriptions

Secaucus Town Hall/Police Station

Town Hall shares a building with the Police Station, providing a myriad of essential municipal services in one location. Critical administrative and planning activities occur at Town Hall, where municipal professionals store and share information. Meanwhile, the Police Department serves as an emergency communication and response center for the Town of Secaucus. The Municipal Court also shares this space, which was constructed in 1979 and encompasses 32,451 square feet. This facility is classified in FEMA’s Tier IV Risk Category.

This facility has one electric meter and one gas meter. Its primary space heating is generated from two Weil-McLain Boilers with the Model Number 588, while its domestic hot water comes from a Bradford White Corporation Automatic Storage Water Heater with the Model Number M280R6DS. Primary cooling comes from a chilled water system, with smaller spaces being cooled by individual mini-split systems. The site has a diesel standby generator with a one-hundred gallon diesel fuel aboveground storage tank. In addition, the site contains solar photovoltaic (PV) canopies of approximately 130 kW, and two electric vehicle (EV) Class II charging stations.

Potential energy conservation measures (ECMs) for this facility include upgrading the current back-up generator to a new dual fuel (diesel and natural gas) that will prove to be more reliable and offer greater resiliency in time of need. It is further recommended that this facility consider an upgrade of their aging boiler system and convert to newer, high efficiency boilers and unit heaters.

Secaucus Town Hall Electric and Gas Data				
Month	**Consumption (kWh)**	**Total Electric Cost ($)**	**Consumption (Therms)**	**Total Thermal Cost ($)**
January	54,821	$6,782.61	3,947	$3,647.28
February	57,290	$7,043.95	4,024	$3,704.03
March	50,738	$6,341.83	4,302	$3,908.58
April	43,208	$5,679.53	2,727	$1,805.52
May	56,754	$7,007.71	571	$413.06
June	62,607	$8,074.47	88	$153.91
July	76,802	$9,876.46	0	$107.00
August	64,772	$8,574.35	2	$108.32
September	64,847	$8,344.91	36	$129.42
October	58,788	$6,124.20	608	$488.69
November	55,106	$6,687.85	3,019	$3,045.39
December	64,181	$7,682.57	4,694	$4,170.97
Annual:	**709,914**	**$88,220.44**	**24,017**	**$21,682.18**

Table 3: Secaucus Town Hall Electric and Gas Data

Meadowview Complex

The Meadowview Complex consists of fifteen different buildings and/or facilities. Buildings #1-3 serve primarily as Hudson County offices, and will become the Prosecutor's Office in the near future. Full occupancy is expected for early 2020. Buildings #4-9 mainly serve as drug treatment and rehabilitation centers, while Building #10 is the Meadowview Psychiatric Hospital. Building #11 is the Hudson County Office of Emergency Management. Building #12 previously was the Hudson County Juvenile Detention Center, but has not been occupied since March 2015. Part of the building is planned to be retrofitted to function as a full time Police and Fire Training Academy over the next few years. Building #13 is the Meadowview Complex Wastewater Treatment Plant, while Building #14 is the Powerhouse. Finally, Building #15 is the Hudson County Archives Building. The Meadowview Complex is incredibly critical, as it contains inpatient and outpatient medical services, emergency communication functionality, and wastewater treatment.

The Meadowview Complex Buildings #1-9, as well as the Center Core building that connects Building #1 to Building #9, were originally built in 1920's as a part of a Psychiatric Hospital campus. The buildings are interconnected and form a large square courtyard in the middle. Building #14 contains a central steam boiler plant, which supplies heat to a majority of the buildings at the Complex. Buildings #1-9, Meadowview Psychiatric Hospital, Building #12, the

Hudson County Archives Building, and the neighboring Alaris Complex are all served by a high-pressure steam circuit (125 psig) emanating from the Powerhouse. Various quantities of steam are conditioned within a dedicated mechanical room at each respective buildings' energy transfer station (ETS) where the steam pressure is reduced to 35 psig and interfaced with each building's closed loop hot water circuit via shell and tube heat exchanger(s). Each loop consists of a set of two hot water pumps in every pump room. All resulting condensate is returned back to the steam circuit (and subsequent condensate receiver located within the Powerhouse). The high-pressure steam circuit (and subsequent condensate return loops) are distributed to the above buildings via a network of underground tunnels and piping trenches (chases) that were constructed from cast in place concrete (circa 1984). Currently, there is no central cooling plant for these buildings.

The PSE&G Circuit delivers power to the Meadowview Campus via four feeders to the various 13/4.16kV individual pad-mount step down transformers (PD), namely:

1. PD #1, serving the Meadowview Complex Buildings 4-9.
2. PD #2, serving the Control Room at the Meadowview Psychiatric Hospital and Powerhouse. Switchgear internal to the Powerhouse adjusts the voltage and distributes power to the following buildings: Archives Building (formerly Laundry), Building #12, Powerhouse, Kitchen, and Meadowview Complex Buildings #1-3. The switchgear in the Powerhouse can also supply power to areas (to be defined) within the Alaris Complex via a kirk-key tie breaker located within the switchgear residing in the basement of the Alaris Complex.
3. PD #3 serving the Alaris Complex.
4. PD #4 serving the Alaris Complex.

Meadowview Complex – Central Core Building

The Center Core is an approximately 43,500 SF single story building with a basement. It is interconnected to the buildings #1 and #9 through conditioned first level and basement level corridors. The building houses Hudson County and New Jersey State Administrative Offices, conference rooms, computer training center in the first floor and storage spaces in the basement. The typical hours of operation for this facility are between 8:00 am and 4:30 pm. Exterior walls are brick construction. The amount of insulation within the walls is unknown. The building has an intersecting type slate roof with asphalt shingles. There is a large attic space over the corridors between the buildings. Attic is insulated with loosely laid mineral fiber insulation material. The building was built in 1920s as a part of the Psychiatric Hospital campus and has been adapted over time for multiple uses. The east end of the building is air conditioned via a split system, while the core and west side of the building is air conditioned via an air-cooled water chiller.

Meadowview Complex - Building #1-9

Buildings #1-9 are two story buildings with a basement that form a square with the Center Core Building and are generally connected through the first level and basement corridors, except for Buildings #4-6, which are connected to each other on all levels. The buildings were built in 1920s as a part of the Psychiatric Hospital campus and have been adapted over time for multiple uses. Exterior walls are brick construction. The amount of insulation within the wall is unknown. The building has slate roof with asphalt shingles. There is a large attic space over the corridors between the buildings. Attic is insulated with loosely laid mineral fiber insulation material.

Building #1 houses the Facility Management Offices and the Transcend Office in the first floor, Planning Department Office in the second floor, and storage spaces in the basement, while Building #2 houses the County Department of Health and Human Services in the first and second floors and storage spaces in the basement. Both have typical hours of operation between 8:00 am and 5:00 pm. Building #2 has the domestic water pumping station for Buildings #1-9 and the Psychiatric Hospital in the basement. A set of three 20 HP, uni-mount booster pumps provide city water to the campus. The pumps are enabled at all times and sequenced based on supply pressure. There is also a maintenance shop in the second-floor basement. The shop houses carpentry equipment with local exhaust hoods. The equipment and the hoods are seldom used or operated. Building #3 includes the Hudson County Board of Education in the first floor, Hudson County Engineering Offices in the second floor, and storage spaces in the basement. The typical hours of operation for this facility are between 8:00 am and 4:30 pm. Buildings #1-3 have split air conditioning units, and receive their heat from the Powerhouse for both space heating via hot water baseboards and domestic hot water. All three buildings are currently being retrofitted to become the Hudson County Prosecutor's Offices.

Building #4-9 house a variety of non-profit organizations running drug treatment and rehabilitation programs in the county, including the Offices of Integrity, Inc. (Integrity House), Cura, Inc., and Turning Point, Inc. The buildings are comprised of day rooms, dormitories, laundry rooms, kitchens, dining rooms, storage areas, and office spaces, and typically operate twenty-four hours a day, seven days a week. Building #8, in addition to the drug treatment and rehabilitation non-profit organizations, contains some of the county department of internal affairs offices and storage areas and office spaces for the Marshalls office.

Buildings #4-6 have a combination of window air conditioning units and packaged air conditioning units. Their heat comes from cast iron hot water heaters, with the pump station located in the first level of Building #6. Building #7 has window air conditioning units, along with two different ducted central air conditioning systems. It receives their heat from the Powerhouse for space heating via hot water radiators. Building #8 contains window and packaged air conditioning units, receiving its heat from the Powerhouse, while Building #9 utilizes window air conditioners and cast-iron hot water heaters for its space heating.

Meadowview Complex - Building #10- Psychiatric Hospital

The Meadowview Psychiatric Hospital is a specialized psychiatric facility that houses and treats those with severe mental illness. Covering 63,775 square feet, the hospital is an eighty-four-bed county psychiatric facility that offers three levels of in-patient care for mentally ill adults. The facility was built in 1864 and includes patient rooms, day rooms, therapy rooms, kitchen and dining rooms, laundry rooms, office spaces, a library, storage spaces, and mechanical spaces. Since its recovery in 2011, the hospital has been a critical facility for the mentally ill in Hudson and neighboring Bergen, Morris, Passaic, and Essex counties.

The Psychiatric Hospital was built in 1958. This facility is a four-story building with a fifth floor mechanical penthouse. The facility is comprised of patient rooms, office spaces, kitchen and dining room, storage spaces and mechanical rooms. The facility operates twenty-four hours per day, seven days per week. The building construction consists of CMU block walls with a variety of façade types including brick, stucco, and concrete. The amount of insulation within the wall structure is unknown. The roof structure is made up of a rubber roof membrane with rigid insulation below the membrane.

The majority of the building is heated and cooled by a central air handling unit found on the fifth floor (AHU-1), and utilizes steam coils to provide space heating and chilled water cooling coils to provide space cooling. An additional two air handler units found on the first floor (AHU-2 and AHU-3) provide heating and cooling to the facilities support spaces, including the kitchen and storage rooms. Steam for the steam coils is provided from the Powerhouse. That steam is also utilized for two domestic hot water heaters of approximately 2,500 gallons each. The kitchen also utilizes an additional booster heater for the kitchen's hot water needs.

Meadowview Complex - Building #12

The 55,476 square foot building was previously a single-story correctional facility comprised of housing units, kitchen and dining room, laundry, classrooms, office spaces, gymnasium, storage spaces and mechanical spaces. The exterior of this building is constructed of concrete walls with partial brick façade. The amount of insulation within the wall is unknown.

The majority of the roof is standing seam metal roof system. A small portion of the roof is constructed of a built-up roof with light rubber covering, where all rooftop HVAC equipment is located. The amount of insulation below the roofing is unknown. The building was built in 1996 with a housing unit extension added after the original building construction.

The major source of cooling is an electric driven air-cooled chiller, while the major source of heating comes from steam from the Powerhouse, which is converted to hot water in one of Building #12's mechanical room. There is a total of nine air handling units, each equipped with chilled water and hot water coils. Domestic hot water is generated on-site via two steam domestic hot water tank heaters.

Meadowview Complex - Building #13 – Wastewater Treatment Facility

Meadowview Complex collects, manages, and moves wastewater from multiple source points within the Meadowview Complex, and treats it behind the Powerhouse. A small building houses the electrical equipment and pumps for the Wastewater Treatment Facility, east of the treatment ponds. Proper operation of the plant prevents sewer overflows, leaks, and other infrastructure and public health issues.

Meadowview Complex - Building #14 - Powerhouse/Central Boiler Plant

The Powerhouse functions as a Central Steam Plant for the Meadowview Complex, containing four boilers which provide steam to satisfy partial campus winter heating loads and domestic hot water demand for Building #1-9, 10, 12, and 15. The Powerhouse must be operational in the case of a black-sky day, since it supports several facilities with full-time residents. The building is approximately 15,000 square feet, and is constructed of concrete masonry unit (CMU) interior and brick exterior walls. Building #14's boiler control room, administrative offices, kitchens, lavatories, and locker rooms are heated and cooled by package-type air conditioning units, while the boiler room and domestic hot water room's space heat is provided passively from the boilers and heat exchangers.

Meadowview Complex - Building #15- Archive Center

The Building #15, also known as the archives building is approximately 22,000 SF, single story building with a basement. The building was built in 1924 and renovated around 1997. The building has a precast concrete wall and partly glass façade. The building houses primarily the Hudson County's archives in the first floor and the basement storage spaces. There are also a small number of office spaces, meeting room, a kitchenette, shredding room, microfilm room, server room, and mechanical rooms. The typical hours of operation for this facility are between 8:00 am and 5:00 pm. The archives building roof is built up as flat roof with light stone covering, where the roof top air conditioners for the building are located.

Air conditioning is provided with seven rooftop air conditioners, each one serving a single zone in the building without any variable air flow capability. The units are equipped with direct expansion (DX) cooling coils. The major source of heating for the building is the high-pressure steam, which is delivered from the Powerhouse, and used in hot water baseboard radiators throughout the building. Domestic hot water for the restrooms and office lounge are provided by an electric hot water heater located in the basement.

Meadowview Complex Energy Conservation Measures

The Meadowview Complex is a relatively old facility, and has a large opportunity to lower its electric and gas consumption by implementing a variety of energy conservation measures, which would impact its major building systems. Hudson County Improvement Authority (HCIA) has proactively began the process to implement an Energy Savings Improvement Plan (ESIP), which is a state program that allows government agencies to make energy-related improvements to their facilities and pay for the costs using the value of the energy savings that result from those improvements. They have selected Honeywell Building Solutions as their contractor, who have completed an Energy Savings Plan that includes the Meadowview Complex as well as other Hudson County facilities. Some of the energy conservation measures that were recommended for implementation at the Meadowview Complex include lighting upgrades (LED retrofits), vending misers, plug load management via WiFi, de-stratification fans, domestic water booster skid replacement, rooftop unit replacements, split system replacements, premium efficiency motors and VFDs, walk-in freezer/cooler controllers, chiller replacements, chiller refurbishments, building management system upgrades, building envelope improvements, a permanent load reduction program, high efficiency transformers, and various water conservation measures.

Consumption and Cost Information

Meadowview Complex: Meter List	
Location	**Meter #**
Electric	
Primary Meter - Serves Buildings #1-3 (Hudson County Offices), Building #10 (Psychiatric Hospital), Building #12, Building #14 (Powerhouse), and Building #15 (Archives)	9209684
Serves Buildings #4, 5, and 6 (Drug Treatment and Rehabilitation)	9211586
Serves Buildings #7, 8, and 9 (Drug Treatment and Rehabilitation)	9207317
Serves Building #11 (Hudson County Office of Emergency Management)	16427913
Serves Facility #13 (Wastewater Treatment Plant)	626049391
Gas	
Powerhouse Boiler Meter - Serves Buildings #1-3 (Hudson County Offices), Buildings #7-9 (Drug Treatment), Building #10 (Psychiatric Hospital), Building #12, and Building #15 (Archives)	1784801
Serves Building #5 and 6 (includes Building #6 Integrity House Kitchen)	3216834
Serves Building #10 (Psychiatric Hospital) Kitchen	3007747
Serves Building #11 (Hudson County Office of Emergency Management)	2369009
Building #12 Domestic Hot Water	3739806
Building #14 (Powerhouse) Office Heating Units	2033790

Table 4: Meadowview Meter Locations

Meadowview Complex - Electric Data						
Meter #:	**9209684**		**9211586**		**9207317**	
Month	**Consumption (kWh)**	**Total Electric Cost ($)**	**Consumption (kWh)**	**Total Electric Cost ($)**	**Consumption (kWh)**	**Total Electric Cost ($)**
January	401,957	$38,309.07	47,984	$5,502.57	30,073	$3,405.27
February	363,963	$34,952.99	42,898	$4,992.28	27,403	$3,096.78
March	372,564	$35,550.58	44,236	$5,134.05	27,161	$3,073.92
April	413,911	$46,655.99	41,135	$5,710.44	25,677	$3,422.16
May	388,014	$43,404.99	43,601	$6,232.26	25,026	$3,502.76
June	448,009	$56,193.96	56,822	$9,348.37	32,327	$5,341.05
July	559,150	$63,190.01	80,641	$10,611.26	48,856	$6,772.04
August	499,004	$57,528.32	67,969	$9,258.14	42,835	$6,048.45
September	468,356	$53,760.09	55,847	$7,758.18	38,706	$5,464.77
October	475,479	$45,677.03	51,863	$6,140.11	34,112	$3,997.72
November	378,774	$36,550.15	41,217	$4,856.93	23,831	$2,705.42
December	370,832	$35,505.95	45,192	$5,239.81	25,099	$2,847.97
Annual:	**5,140,013**	**$547,279**	**619,405**	**$80,784**	**381,106**	**$49,678**

Table 5: Meadowview Complex Electric Data

Meadowview Complex - Electric Data				
Meter #:	**16427913**		**626049391**	
Month	**Consumption (kWh)**	**Total Electric Cost ($)**	**Consumption (kWh)**	**Total Electric Cost ($)**
January	7,673	$865.44	895	$128.40
February	6,229	$715.50	1,773	$234.62
March	6,357	$727.06	1,596	$214.56
April	6432	$843.36	1,293	$188.34
May	5772	$763.81	991	$144.42
June	5750	$914.33	179	$44.83
July	6570	$914.67	172	$41.23
August	5225	$751.24	507	$80.72
September	5460	$751.54	1,009	$115.59
October	6125	$710.97	45	$18.54

November	5997	$692.11	399	$66.21
December	6547	$749.77	747	$107.83
Annual:	**74,137**	**$9,399.80**	**9,606**	**$1,385.29**
*Includes two months of cost estimates, based on data available.				

Table 6: Meadowview Complex Electric Data Continued

Meadowview Complex - Gas Data						
Meter #:	1784801		3216834		3007747	
Month	**Consumption (Therms)**	**Total Thermal Cost ($)**	**Consumption (Therms)**	**Total Thermal Cost ($)**	**Consumption (Therms)**	Total Thermal Cost ($)
January	100,667	$74,138.92	373	$360.32	226	$248.27
February	86,959	$53,615.31	333	$315.71	214	$231.04
March	93,037	$55,864.63	320	$277.95	226	$224.32
April	58,458	$36,262.25	435	$394.02	0	$11.59
May	48,073	$29,923.32	399	$361.88	0	$11.59
June	37,518	$23,758.62	412	$373.68	0	$11.59
July	34,714	$22,066.04	414	$375.75	0	$11.59
August	36,259	$23,041.41	385	$349.93	0	$11.59
September	38,160	$24,266.03	391	$357.64	40	$47.31
October	47,531	$29,890.82	396	$364.10	126	$124.14
November	69,400	$39,329.79	433	$400.76	209	$220.35
December	95,847	$64,114.50	368	$339.54	233	$244.11
Annual:	**746,623**	**$476,271.64**	**4,659**	**$4,271.28**	**1,274**	**$1,397.49**
*Includes some supply cost estimates based on the data available.						

Table 7: Meadowview Complex Gas Data

Meadowview Complex - Gas Data						
Meter #:	2369009		3739806		2033790	
Month	**Consumption (Therms)**	**Total Thermal Cost ($)**	**Consumption (Therms)**	**Total Thermal Cost ($)**	**Consumption (Therms)**	**Total Thermal Cost ($)**
January	187	$202.42	0	$12.87	291	$365.76
February	115	$129.54	1	$13.99	184	$237.18
March	125	$67.26	0	$13.04	103	$109.43

April	16	$26.53	202	$192.66	43	$51.05
May	0	$12.39	178	$171.21	20	$30.33
June	0	$12.39	37	$45.16	0	$12.39
July	0	$12.39	0	$12.39	0	$12.39
August	0	$12.39	0	$12.39	0	$12.39
September	0	$12.42	0	$12.42	0	$12.42
October	0	$12.85	0	$12.85	0	$12.85
November	8	$20.90	0	$12.44	46	$55.80
December	58	$70.57	0	$12.44	150	$183.59
Annual:	**508**	**$592.05**	**417**	**$523.86**	**836**	**$1,095.58**
*Includes some cost estimates based on the data available.						

Table 8: Meadowview Complex Gas Data Continued

Alaris Health at the Fountains

Alaris Health at the Fountains (Alaris) is a short-term post-hospital rehabilitation and long-term and specialty care center that encompasses 209,848 square feet. The center offers behavioral health services, ventilator care, enteral feeding, and dialysis care. It is critical for Alaris Health to remain operational during black sky days to protect the well-being of vulnerable patients.

Alaris and Hudson County share some of the same utility services. Hudson County presently supplies Alaris' kitchen electrically. In addition, the Powerhouse supplies steam to Alaris' six northern buildings, but have their own independent heat in their three southern-most buildings. Alaris also has its own gas service for their kitchen's space heating and domestic hot water.

ECMs suggested for this facility include integrating a direct fired natural gas domestic hot water heater to supply hot water to the residences and administrative area(s) within this building. This ECM would provide redundancy for the domestic water heating system; the primary system being the centralized steam-to-water heating and storage system residing in the Powerhouse, whereas the secondary would be the new natural gas direct fired unit residing in the building. This redundant (secondary) system would provide the opportunity for operators to maintain (inspect and repair) the campus-wide steam and condensate system without disruption to the building's hot water supply.

Secaucus Housing Authority #1

Secaucus Housing Authority #1 (SHA #1), also called the R. Impreveduto building, is located at 600 County Avenue, Secaucus, NJ. The building is a twelve-story residential building with a total floor area of 95,000 square feet. The building was built in 1986 and contains 100 apartment units for senior housing. It is their principal mission to provide decent, safe, and sanitary housing to lower income residents who meet their program guidelines. The original structure has undergone various renovations such as roof and window replacements, appliance and lighting upgrades, and an exterior EIFS insulation system. The building has individual space heating and cooling units in each apartment, along with a twenty-gallon individual electric domestic hot water heater.

The HVAC and plumbing infrastructure within this building are connected in such a way that each residence has dedicated unit heaters for heating of living space and domestic hot water needs. These heating needs (loads) are served by electricity. The only centralized utility is the cooling system which is also electrically driven. Therefore, the suggested ECM for this building is to connect the building's electrical distribution network to the microgrid for all modes of operation; displacing the utility entirely.

Secaucus Housing Authority 1 Electric and Gas Data				
Month	**Consumption (kWh)**	**Total Electric Cost ($)**	**Consumption (Therms)**	**Total Thermal Cost ($)**
January	98,434	$12,244.16	3,848	$3,159.19
February	89,017	$11,159.51	3,283	$3,182.51
March	82,085	$10,337.60	3,234	$2,879.18
April	46,043	$6,168.73	1,565	$1,053.42
May	27,268	$3,750.91	11	$33.84
June	33,239	$5,158.33	0	$24.78
July	36,045	$5,523.03	0	$24.78
August	31,455	$4,852.89	0	$23.96
September	30,697	$4,968.85	83	$94.96
October	31,732	$4,313.25	489	$438.88
November	56,470	$7,160.17	2,566	$2,455.12
December	81,861	$10,310.46	4,475	$3,680.87
Annual:	**644,346**	**$85,947.89**	**19,552**	**$17,051.49**

Table 9: Secaucus Housing Authority 1 Electric and Gas Data

Secaucus Housing Authority #2

Secaucus Housing Authority #2 (SHA #2), also known as Kroll Heights, is a five-story facility located at 700 County Avenue, Secaucus, NJ and is approximately 61,000 square feet. The building was built in 1993 and contains seventy-five apartment units for senior housing. The original structure has not undergone any major renovations or additions. Heat is provided to the building via seven boilers in the first-floor mechanical room, three of which are primarily used for domestic hot water and four of which are used for baseboard heating. Each apartment contains two air conditioning units, one in the living room and one in the bedroom.

ECMs suggested for this facility include converting the existing hot water heating and domestic loops from a direct fired/indirect contact method to that of a steam-to-hot water system for each spacing heating and domestic water application.

Secaucus Housing Authority 2 Electric and Gas Data				
Month	**Consumption (kWh)**	**Total Electric Cost ($)**	**Consumption (Therms)**	**Total Thermal Cost ($)**
January	9,750	$1,189.18	3,886	$3,397.23
February	11,400	$1,387.35	3,553	$3,427.09
March	10,800	$1,320.85	3,499	$3,064.18
April	10,950	$1,404.32	2,455	$1,593.80
May	11,400	$1,352.05	735	$576.76
June	13,950	$2,053.65	617	$508.04
July	13,050	$2,062.24	31	$987.17
August	23,100	$3,766.89	380	$492.42
September	12,000	$1,887.95	693	$561.89
October	10,800	$1,324.21	1,022	$764.05
November	10,050	$1,273.61	2,474	$2,327.54
December	10,650	$2,374.55	4,072	$3,627.84
Annual:	**147,900**	**$21,396.85**	**23,418**	**$21,328.01**

Table 10: Secaucus Housing Authority 2 Electric and Gas Data

UPS Customer Center

The UPS Customer Center is located at 493 County Avenue in Secaucus, New Jersey. The facility is open Monday through Friday, from 8 AM until 6 PM. It is approximately 338,238 square feet, and contains a 1.2 MW PV system on its roof. This additional DER could provide great benefit to the HCAM during black-sky conditions, while at the same time potentially generating some additional revenue.

Overall Microgrid Description

The monthly and annual total electric consumption, electric cost, thermal consumption, and thermal cost can be seen in Table 11 below. The HCAM critical facilities' energy consumption characteristics are typical for a public campus of similar size and shape and depend primarily on occupancy and the outside air temperature. While occupancy and dynamic heat loads are scheduled, repetitive and predictable, the weather is variable. Accordingly, the Cluster uses more electric in the warmer summer months to accommodate space cooling. Conversely as electric consumption reduces, natural gas consumption increases to provide heating during the colder months.

HCAM Monthly Electric and Gas Consumption and Cost Data				
Month	**Total Electric Consumption (kWh)**	**Total Electric Cost ($)**	**Total Thermal Consumption (Therms)**	**Total Thermal Cost ($)**
January	651,587	68,427	113,424	85,532
February	599,973	63,583	98,666	64,856
March	595,537	62,700	104,846	66,409
April	588,649	70,073	65,901	41,391
May	558,826	66,159	49,985	31,534
June	652,883	87,129	38,672	24,901
July	821,286	98,991	35,160	23,610
August	734,867	90,861	37,026	24,065
September	676,922	83,052	39,403	25,495
October	668,944	68,306	50,172	32,109
November	571,844	59,992	78,156	47,868
December	605,109	64,819	109,895	76,444
Annual:	**7,726,427**	**884,092**	**821,306**	**544,214**
*Based on available data, not including Alaris' estimated load and associated costs.				

Table 11: HCAM Electric and Gas Data

Emergency Shelter Facilities

During black-sky events, shelter, life safety and human services will be provided in the Emergency Sheltering Facilities (ESFs). The extent of services, staffing and capacity will be prescribed in advance to maintain adequate resources and manage critical supply logistics throughout the microgrid area. The Hudson County and Secaucus OEM leadership, microgrid operator and relevant stakeholder representatives will continuously monitor the status of each ESF and provide reporting of operating status and availability of services in real time using a standard communication protocol. The reporting will be readily dispatchable to media outlets and emergency broadcast systems.

The available black-sky shelter area has been estimated based on the practical and supportable resources and, contingency sheltering space for special needs (EMS, Police, Fire, Homeland Security, etc.) in the below table.

Emergency Shelter Facilities			
Facility Name	Description	Potential Shelter Area (SF)	Potential Emergency Shelter Hours
Buildings #1-9	Hudson County Offices and Drug Rehab	51,425	9 AM to 5 PM
Building #12	Future Police/Fire Training Academy	27,738	9 AM to 5 PM
Building #15	Archives Building	11,000	9 AM to 5 PM

Table 12: Potential Emergency Shelter Facility Capabilities

Permits

Permitting consideration for various generation types and sources must be done early in the process. Many areas in New Jersey are "Non-Attainment" areas as classified by US EPA. This means that in those areas, New Jersey's Department of Environmental Protection (NJDEP) maintains a tight threshold for air emissions and thus any generation type must be compliant with those thresholds. Today, there are many technologies and systems that are compliant with NJDEP and NJEPA rules for run time and emissions, but they must be specked as part of the process of identifying generation sources.

In addition, the utility and PJM play a special role in the connection of various generation sources to the overall grid. Having a contact person in the utility to work with is critical and should also happen early in the process. Each County has its own Utility point person and that individual can help understand the steps necessary to make sure that all the various generation sources are connected and operational in a timely manner.

Lastly, each generation source comes with its own warranties and operational guidelines. It is important that the specifications that you want to see in those warranties are closely pointed out in any bid documents that get created.

Permit Outline by Generation

Type: Cogeneration full time:

NJ DEP Air Compliance Permit

Air Preconstruction permit N.J.A.C. 7.27-8.2©1

Air Operating permits N.J.A.C. 7:27--22.1

Air Permits Upgrade 7:27-18

Time Line: 120 Days Depending on Answers above

Note:	This assumes permitting for full operation and run time of 8760
Cost	$1,500
Requirement:	Air Model

Water: If the systems will require an additional flow rate of 2000 gallons a day, the following definitions should be used to assist in identifying discharge activities: Industrial wastewater is any wastewater or discharge which is not sanitary or domestic in nature, including non-contact or contact cooling water, process wastewater, discharges from floor drains, air conditioner condensate, etc.

IP for general water withdraw	100 Days under 2k
	240 Days over 2k
Permit Cost	$1,500

Permit Outline for Solar Generation:

NJBPU GATTS Register

Local Planning Board Approval and Fire Safety

PJM Interconnection and Utility Metering Approvals

Time Line:	90 to 120 Days
Cost:	$1500

CAFRA Note: If area is in CAFRA zone for ground-based systems, then impervious cover calculations will be necessary.

Permit Outline for Storage

NJBPU	Approval
Utility:	Interconnection

Local Inspection and Fire Safety

Cost: $3,500 Note: Assuming some interconnection studies to determine battery discharge impact

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Note: Although wind and fuel cells were not considered for the study, changes in public policy or incentives may make them economically feasible in the future. The permitting for them is as follows:

Permits Necessary for Wind:

NJDEP	Land Use, Habitat and T/E impact study
NJBPU	Registration and go forward potential WREC registration via GATTS

Interconnection for Utility and PJM

Local Approvals including planning, zoning and council.

One Year local anemometer readings

Time Line: 18 to 24 Months

Cost: $35,000

Permits for Fuel Cell

NJBPU Registration

Local Approval and Fire Safety

Utility Interconnection

Time Line: 8 Months

Cost: $2,500

Ownership/ Business Model

Overview

Microgrids utilize one or more distributed energy resources (DERs) to generate energy for multiple facilities independent of the local utility distribution grid. Potential business approaches to microgrid financing thus are highly influenced by state energy policy, incentive programs, current regulatory landscape, and local utility delivery tariff structures that either limit or enable behind-the-meter (BTM) DER development. These factors vary between states and utility territories and continue to evolve as the need for microgrids becomes more evident in the wake of local natural disasters.

Navigating both BTM and utility energy regulations is unique to microgrids because they inherently touch multiple buildings. Often, microgrid projects seek to distribute energy between facilities which otherwise separately purchase their energy from the electric distribution company (EDC) and gas distribution company (GDC), and sometimes cross public rights of way, both of which are circumstances regulated closely by the NJBPU. As wheeling power and thermal energy distribution closely resembles the distribution utility's role, careful understanding of regulatory limitations and close collaboration with the EDC and GDC is integral to the success of a given microgrid project.

Beyond the regulatory hurdles, microgrids are tailor-made technical solutions shaped by existing energy load profiles and the resiliency needs of the various microgrid customers. Microgrid resiliency must ultimately be financeable while delivering energy services to microgrid customers at or below conventional energy costs.

Black-sky events may be result from failure of grid components, cyberattacks, or natural disasters. The goal of the HCAM is to ensure resiliency and uninterrupted service to critical loads during black-sky events. The experience from Superstorm Sandy demonstrated the considerable damage and costs resulting from grid failure during natural disaster events. Although the duration and probability of major grid failure is historically low, the New Jersey Department of Environmental Protection raises concern that they will become more frequent over time.[1] In order to finance a project that can power critical facilities during unpredictable and inconsistent black-sky events, the DERs are sized and configured to operate during normal, or blue-sky operations. The business model formed for the microgrid, then, uses blue-sky operations to generate revenues to repay the capital investment for microgrids that can also operate in black-sky events.

Microgrids might be developed under various business models, each with different ownership roles for the utility and microgrid owner. Business models summarized in **Table 13: Microgrid Business**

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[1] State of New Jersey, Department of Environmental Protection: Adapting to a Changing Environment. Retrieved from: https://www.state.nj.us/dep/aqes/adapting.html

Model below are influenced by interconnection standards, tariff structures, incentives, and rules governing the generation, delivery, and sale of energy.

Business Model	Description
Entirely Private	The Entirely Private model involves financing, owning and operating the microgrid by a non-utility, third-party or municipal entity. The role of the utility is minimal. Existing and/or new generation and distribution assets are installed, owned and operated by the non-utility entity. DERs in this model may be sited at various locations among the microgrid with the owner determining the economic dispatch. Revenues are generated through energy services, demand reduction and/or microgrid resilience premiums. Customers would purchase most or all their energy from the microgrid.
Entirely Utility	The Entirely Utility model assumes ownership and control of all infrastructure and generation assets lies with the utility. The utility and microgrid customers enter into an agreement regarding fees for resiliency services. The customers continue their interaction with the utility as they would without the microgrid, i.e. paying regular utility bills. However, they may pay a premium for microgrid services over and above their existing rates. In general, complete utility-owned microgrids are not feasible in deregulated states where there are restrictions on utilities owning distributed, dispatchable generation assets.
Hybrid (Private & Utility)	The Hybrid model assumes a non-utility entity owns the generating assets and controls their dispatch during normal blue-sky conditions. Typically, DERs would be sited BTM at one or more customer sites. Power would then be wheeled during blue-sky and/or black-sky conditions to other microgrid customers through utility-owned distribution assets. Close coordination is required between the utility and microgrid owner to sequence the islanding and paralleling modes of the microgrid. Revenues to the microgrid owner would come from energy sales to customers, services sold into wholesale energy markets, and services rendered to the local distribution utility (ex: demand reduction). The microgrid customers might pay for services through the utility billing mechanism, or may receive separate bills from both the utility and the microgrid owner. This model allows the utility to play a role in microgrid distribution asset ownership and operations, even within deregulated states where utility ownership of generation may be prohibited.

Table 13: Microgrid Business Model

Facility Description

Annual energy use and costs for these facilities are summarized below. Data is from 2017.

Critical Facility	Annual Electric Consumption (kWh)	Annual Electric Cost	Annual Gas Consumption (Therms)	Annual Gas Cost*
Meadowview Complex	6,138,189	$701,704	778,509	$398,809
Alaris Health	4,146,263*	$473,991	292,580*	$149,881
Secaucus Housing #2	130,050	$18,921	23,931	$21,443
Secaucus Housing #1	579,102	46,328	7,644	$6,884
Town Hall/Police Station	707,266	$88,173	22,752	$8,775
Total	**11,700,870**	**$1,329,117**	**1,125,416**	**$585,792**
*Some values estimated.				

Table 14: Critical Facility Annual Electric and Gas Data

Alaris Health energy use is estimated as there were no energy bills available to the microgrid study team for this report. The annual electrical and natural gas consumption for all critical facilities totals approximately 11,700,870 kWh and 1,125,416 therms of gas.

Unit prices for electricity and gas for each location are summarized below. This study assumes these facilities would be able to purchase energy from the microgrid at these current rates during blue-sky conditions.

Critical Facility	$/kWh	$/therm
Meadowview Complex/Alaris Health	$0.11	$0.64
Secaucus Housing #2	$0.15	$0.86
Secaucus Housing #1	$0.08	$1.19
Town Hall/Police Station	$0.13	$0.90

Table 15: Unit Prices for Electricity and Gas

In addition to the aforementioned sites, the Town Hall and UPS were identified as black-sky only additions to the microgrid.

The UPS Facility is located directly adjacent to Alaris Health and at the end of the utility feeder. It is not a County-owned critical facility; however, it hosts an existing 1.2 MW rooftop PV array.

During grid outages, this solar PV array, as currently interconnected, does not generate power. The team has identified a potential partnership opportunity to utilize the existing PV array for a nominal fee per use during black sky events. As will be described in further detail below, the microgrid will not cover 100% of the microgrid electrical loads. The microgrid is economically sized to generate and sell energy during blue-sky conditions. The 1.2 MW PV array could be used to increase the microgrid's generation capacity during black-sky events.

Meadowview Complex is expected to enter a Solar Power Purchasing Agreement (PPA) with Honeywell for a new 600 kW PV array located in the field north of the Psychiatric Hospital as a part of the aforementioned ESIP project. Similar to the UPS Facility, the microgrid team plans to work with Honeywell to allow the microgrid to access it during black-sky events to increase capacity of the microgrid in black-sky events. This will not interfere with Honeywell's proposed PPA agreement as the microgrid would not interact with the PV array during blue-sky conditions.

There are five residential buildings sited between the Meadowview Complex and the Town Hall which receive electric power via the overhead wires connecting the critical facilities. In black-sky events, these residential homes would continue to be powered along with the other critical facilities. The microgrid team included these five residences in the DERCAM model using typical residential load profiles. Because their loads during black sky mode are estimated to be low, we have determined that is not economic to invest in switching infrastructure to disconnect them in black-sky mode. Each of the five houses are individually connected to utility poles, which would require five separate disconnection switches. As connected microgrid facilities, these houses would receive power from the microgrid DERs during black-sky events.

Hudson County Advanced Microgrid Business Model

The microgrid team envisions using a hybrid model (as described above) for the HCAM. A hybrid approach is necessary because, according to New Jersey regulatory rules, an Entirely Utility model is not permissible under deregulation in the state-market rules restrict utilities from owning dispatchable generation assets. Similarly, an Entirely Private model would likely run afoul of the utilities franchise rights and would also add tremendous costs for installing dedicated conductors between each of the critical facilities.

The microgrid business model relies on provisions within N.J.S.A. 48:3-77.1 to allow the sale of electricity and thermal energy to an off-site customer using the utility's distribution infrastructure. In the case of the HCAM, steam and electricity from the Meadowview Campus would be delivered and sold to the Secaucus Housing Authority #2 during blue-sky conditions.

The proposed blue-sky configuration would satisfy the provisions as the Power House and Secaucus Housing Authority #2 are separated by only one public right-of-way. However, the black-sky configuration will also require the use of EDC wires to deliver electricity to the Town Hall/Police Station. Wheeling power under black-sky conditions to a non-thermal customer through the EDC's distribution system may not be explicitly allowed today. Yet, the ability to do so is essential to achieving the resiliency benefits for the surrounding community.

The microgrid will use a design, build, own, operate, and maintain (DBOOM) development model financed by a non-utility third-party developer-owner. Microgrid-generated electricity and thermal energy will be sold to microgrid customers at the microgrid customers' current energy costs during both blue-sky and black-sky conditions. Aside from steam distribution extension from the Meadowview Complex to the Secaucus Housing Authority #2, the steam sold to Alaris, the Meadowview Complex, and Secaucus Housing #2 will use the existing steam distribution system. Each blue-sky off-taker (including Meadowview Complex, Alaris, Secaucus Housing #2, and Secaucus Housing Authority #1) will purchase steam and electricity generated by the CHP plant through an Energy Services Agreement (ESA), with the exception of Secaucus Housing Authority #1 which will only purchase electricity.

The business model for the CHP system and the PV systems during blue-sky conditions will reflect industry standard ESA / PPA agreements and BTM interconnections. The utility will continue to own, operate, and maintain the existing electric distribution assets that normally deliver power to the critical facilities. During blue-sky operations, the Town Hall and UPS will purchase electricity and distribution services from the EDC and GDC. Any supplemental electricity or natural gas purchased by Alaris Health, Meadowview Complex, Secaucus Housing Authority #1 or #2 will continue to be provided by the EDC or GDC and billed directly to the customer.

A nominal Access fee agreement will be negotiated between the DBOOM entity and UPS to allow the microgrid to use the existing PV during black-sky conditions. This Access fee is intended to compensate UPS for allowing the microgrid to access its PV when it otherwise would have been disconnected during black-sky events.

The microgrid assets as modeled will generate approximately 9,286,289 kWh of electricity annually, or approximately 79% of the total annual electricity load of the microgrid customers. Combined with Honeywell's 600 kW PV array (which will produce approximately 786,600 kWh/year), DER generation will provide 91.6% of blue-sky electric load and 86% of black-sky load. The proposed off-taker relationship is depicted in the diagram below, which allows the project to utilize both state incentive funding and Federal tax incentives.

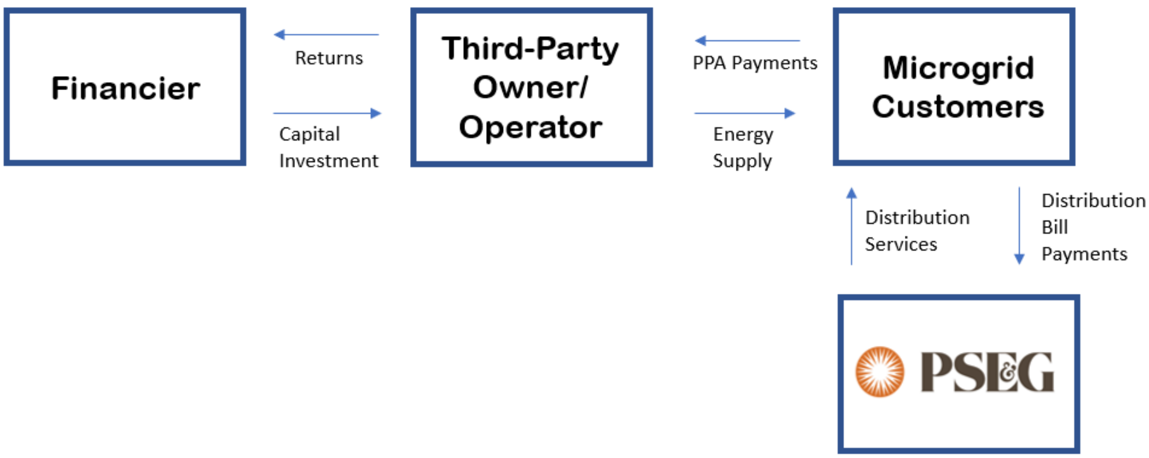


Figure 2: HCAM Basic Model

The energy to support the microgrid during both blue-sky and black-sky conditions comes from the CHP sited at the Meadowview Power House and rooftop PV arrays across various sites. The specific business model for each microgrid asset derives from the general structure depicted in the illustration.

CHP Business Model

The 1,200 kW CHP system sited at the Meadowview Power House will generate approximately 90% of electricity required for the Meadowview Complex and Alaris Health during blue-sky conditions. As modeled, the 10% of electricity not covered by CHP generation is provided by PV. The facilities will remain connected to PSE&G and will purchase any electricity not supplied by the microgrid during blue-sky conditions.

During black-sky events, the CHP system can be used in combination with the PV to provide up to 100% of the critical facilities' electrical load. Facilities powered by the CHP plant during black-sky conditions are: Meadowview Complex (except for the OEM building), Alaris, Secaucus Housing Authority #2, Secaucus Housing Authority #1, the Town Hall/Police Station, and residential buildings located between Meadowview Complex and the Town Hall / Police Station.

The Meadowview Complex primarily uses steam for domestic hot water and for space heating. An existing steam distribution system at the Meadowview Complex delivers steam from the Power House to various buildings on the campus. Under the microgrid, steam generated from the CHP plant will be used for domestic hot water and space heating. In the future, steam could also be used to power absorption chillers for chilled water production during the summer months. The microgrid configuration makes use of the existing steam infrastructure to distribute steam within the Meadowview Complex and Alaris. In addition, the microgrid would introduces a new steam connection from the existing Meadowview Complex to Secaucus Housing Authority #2. The new steam connection will allow the sale of steam generated by the microgrid's CHP system to the residents at Secaucus Housing Authority #2 during blue-sky and black-sky conditions. Approximately 80-90% of thermal loads (primarily domestic hot water) will be supplied by the CHP plant during the summer months, while about 10% of thermal load is supplied by the CHP plant during winter months.

The CHP system would be owned and operated by a third-party under the DBOOM model. The revenue streams for the system are:

- Electricity sales to the Meadowview Complex, Alaris Health, Secaucus Housing Authority #2, and Secaucus Housing Authority #1
- Steam sales to Meadowview Complex, Alaris Health, and Secaucus Housing Authority #2

The DBOOM model requires a long-term Energy Sales Agreement (ESA) between the third-party owner and the microgrid customers, including the County and Alaris for both steam and electric energy.

Steam and electricity will be sold at rates comparable to what the sites currently pay for their energy. The ESA contract will last the length of a CHP system's accepted useful life, typically twenty years.

Solar PV Business Model

The proposed microgrid will install 497 kW of new solar PV at the locations listed below. All solar PV will be sited within the Meadowview Campus.

Location	Proposed Solar Installation (kW)	Est. Annual Solar PV Production (kWh)
Meadowview Southwest Parking area	97	136,500
Meadowview Power House Parking area	21	27,180
Juvenile Center Parking lot	36	49,780

Psychiatric Hospital Parking	251	341,800
Secaucus Housing Authority #2 Roof	44	58,310
Secaucus Housing Authority #2 Parking	48	67,770
Total	**497**	**681,340**

Table 11: Solar PV Business Model

Meadowview Complex, Alaris Health, and Secaucus Housing Authority #2 will purchase electricity from the microgrid's PV array through a PPA. Electricity unit rates will match the rates at which the facilities currently pay for electricity, and the PPA contract term will match the contract term for the CHP plant (i.e. 20 years). The PV assets are expected to operate during both blue-sky and black-sky conditions.

During various times, there may be excess energy produced by the PV assets. We assume that the facilities included in this microgrid would be able to purchase excess solar PV energy via a community solar program currently being piloted in New Jersey. The ability to net-meter and sell electricity via community solar allows for the productive use of energy being generated and helps to support consistent revenues for the microgrid.

Technology, Business and Operational Protocol

Summary of Proposed DER Technologies

Summary of the Proposed DER Technologies					
Facility Name	**Address**	**DER Technology**	**Existing Capacity (kW)**	**New Capacity (kW)**	**Total Capacity (kW)**
Meadowview Complex	505/595 County Avenue, Secaucus, NJ 07094	Microturbine	0	1,200	1,200
Meadowview Complex	505/595 County Avenue, Secaucus, NJ 07094	Photovoltaic	600	405	1,005
Secaucus Housing Authority (2)- Kroll Heights	700 County Avenue, Secaucus, NJ 07094	Photovoltaic	0	92	92
Secaucus Town Hall/ Police Station	1203 Paterson Plank Road, Secaucus, NJ 07094	Photovoltaic	153	0	153

Table 12: Summary of Proposed DER Technologies

DER technologies selected for the microgrid include a combination of PV arrays and microturbines for power generation and steam production to serve the electrical and thermal demands of the connected facilities.

Microturbines produce electricity and "waste-heat" in the form of hot exhaust gas which can be transferred to usable thermal energy in the form of hot water, steam or chilled water.

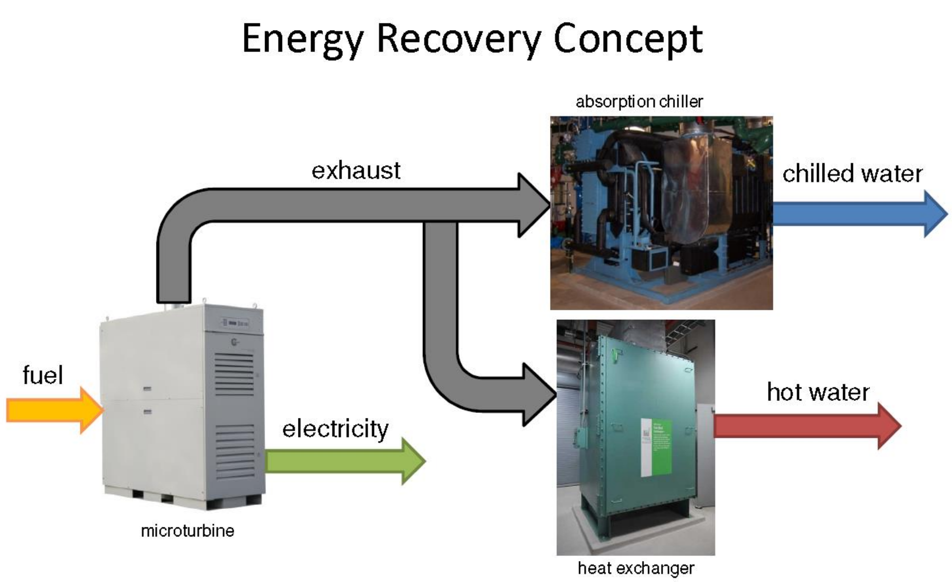


Figure 3: Energy Recovery Concept

Graphic Credit GEM Energy

The primary applications for this technology in the commercial/institutional and residential sectors are those building types with relatively high and coincident electric and hot water demand such as institutional facilities, multifamily residential buildings, and lodging. Host facilities with relatively high space heating and hot water requirements or facilities connected via a thermal heating loop (aka District Energy Heating System) are excellent candidates for this type of CHP technology.

Capstone's C1000S microturbine combined with Cain's heat recovery unit (exhaust steam generator) is indicative of a suitable microturbine array.

Figure 4: C1000S Microturbine

Natural gas fueled microturbines for power generation are clean-burning, mechanically simple, and very compact. They have a small number of moving parts, are light weight and require no cooling. These small combustion turbines can be connected in parallel to serve larger loads and provide power reliability. They can also be operated to follow loads, albeit with some efficiency penalties. Since the steam produced by the microturbines will not meet the thermal loads of the microgrid facilities, supplementary boilers will be required at the Power House.

PV devices convert light energy to electricity. When semiconducting materials are exposed to light, they absorb some of the sun's energy in the form of photons and emit electrons in the form of electricity. PV systems are made up of multiple components that collect the sun's radiated energy, convert it to electricity and transmit the electricity in a usable form. The performance of the PV array is affected on-site by geographic, meteorological, and seasonal conditions, as electricity production is dependent on the amount of solar irradiance the array is able to receive at any one location, cloud cover, and other environmental factors such as smog and dust. Electricity produced by individual panels is direct current (DC) which is brought together in a combiner box and fed as a single DC flow to an inverter which converts the electricity to alternating current (AC), a form that can be distributed, transmitted or exported by the electrical grid.

District energy is a long-term investment to improve the physical infrastructure of the community it serves. It consists of a network of underground pipes carrying hot water, steam, or chilled water from a central plant to the buildings using the service. District energy networks offer a complementary infrastructure to gas and electricity networks. When coupled with appropriate DERs they can exploit a variety of fuel sources, both fossil and renewable, such as natural gas, geothermal, and PV. The proposed addition to the district energy network will be able to capture and distribute heat from the CHP technology within the microgrid to satisfy the thermal demand of Secaucus Housing Authority #2 which enables the use of technologies with higher efficiencies, or ones that may otherwise not prove to be economical to deploy at the individual building level.

Proposed Connections

All DERs irrespective of facility and location will be electrically connected in parallel through new switchgear (a combination of electrical disconnect switches, fuses or circuit breakers used to control, protect and isolate electrical equipment) residing in the Meadowview Powerhouse. The new switchgear will serve as the single point of connection to PSE&G's Homestead Substation via circuit no. HOM8042. This connection will be achieved by installing a new over-head (O/H) pole-line and circuit on the Meadowview Complex where denoted in the Site Plan (Appendix B). The current schematic of PSE&G circuit no. HOM8042 is provided in Appendix C. A section of this schematic is provided below in **Figure 5: PSE&G Circuit Modified for Microgrid Black Sky Mode of Operation** denoting the modifications to PSE&G's circuitry and subsequent modes of operation for the microgrid DERs where outlined in **Table 13: Hudson County Advanced Microgrid DER Modes of Operation**. The microgrid will base load the proposed generating equipment to satisfy the electrical demands of the connected facilities, while utilizing the resulting thermal by product for space heating and production of domestic hot water.

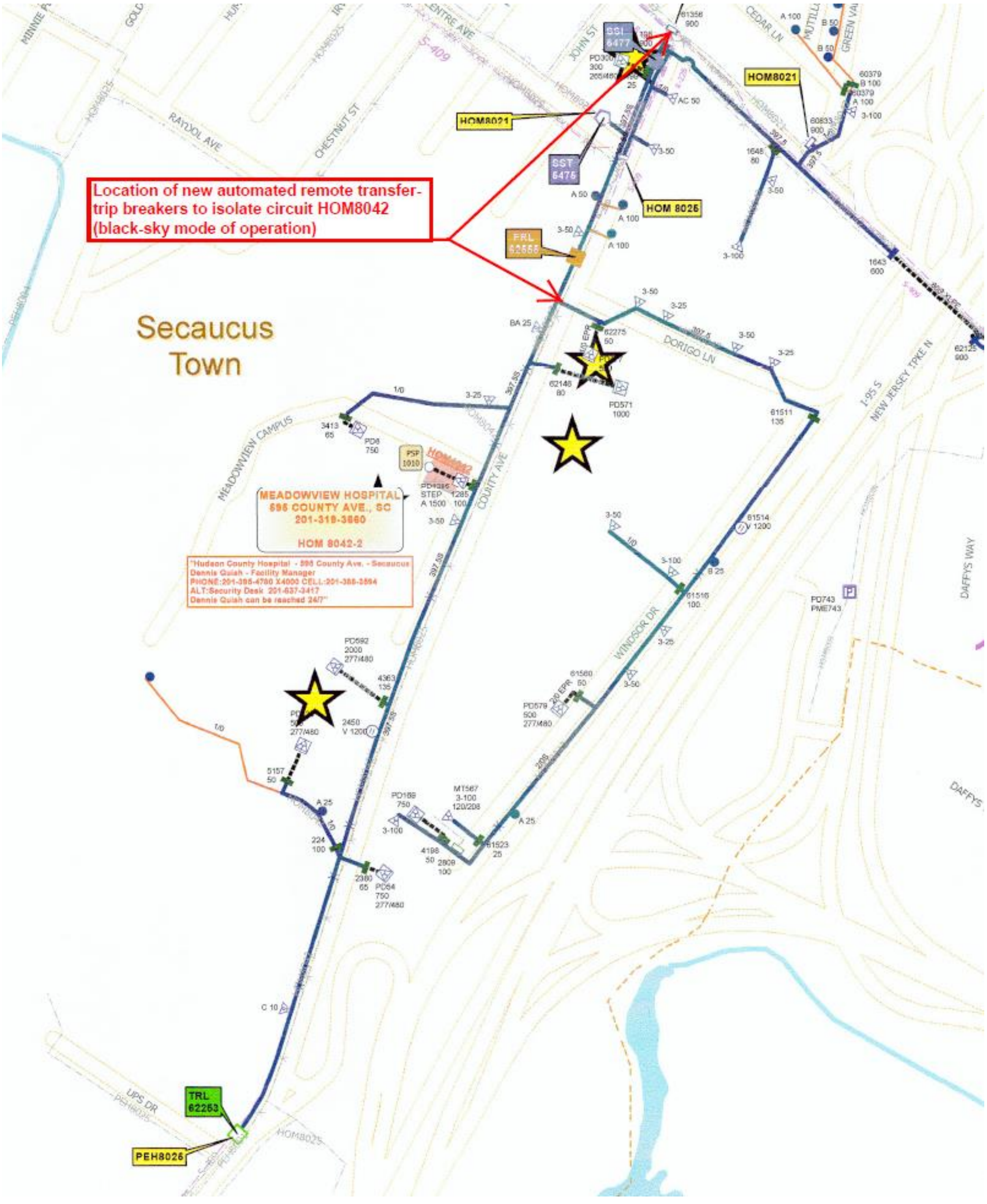


Figure 5: PSE&G Circuit Modified for Microgrid Black Sky Mode of Operation

Hudson County Advanced Microgrid DER Modes of Operation			
Facility Name	**DER Technology**	**Proposed DER Electrical Connection (Blue-sky Mode of Operation)**	**Proposed DER Electrical Connection (Black-sky Mode of Operation)**
Meadowview Complex	1200 kW Microturbine	DER will remain connected to circuit HOM8042. Additional load beyond the capacity of all parallel connected DERs for the facility will be served by PSE&G	DER will remain connected to the **isolated portion** of circuit HOM8042. DER will operate in parallel with all other connected DERs to serve connected loads on the isolated circuit.
Meadowview Complex	600 kW PV	DER will remain connected to circuit HOM8042. Additional load beyond the capacity of all parallel connected DERs for the facility will be served by PSE&G	DER will remain connected to the **isolated portion** of circuit HOM8042. DER will operate in parallel with all other connected DERs to serve connected loads on the isolated circuit.
Secaucus Housing Authority (2)- Kroll Heights	92 kW PV	DER will remain connected to circuit HOM8042. Additional load beyond the capacity of all parallel connected DERs for the facility will be served by PSE&G	DER will remain connected to the **isolated portion** of circuit HOM8042. DER will operate in parallel with all other connected DERs to serve connected loads on the isolated circuit.
Secaucus Town Hall/ Police Station	Existing Photovoltaic Array	The existing photovoltaic arrays will continue to operate in parallel with the utility under the current net-metering scheme.	The existing DER will remain connected to the **isolated portion** of circuit HOM8042. The mode of operation for the existing ATS and rental back-up generator will be modified to suit the microgrids available generation capacity.
United Parcel Supply (UPS) Facility	1200 kW PV	The existing photovoltaic arrays will continue to operate in parallel with the utility under the current net-metering scheme.	The connection to the utility for the existing DER will need to be modified with the capability to be connected to the isolated portion of circuit HOM8042.

Table 13: Hudson County Advanced Microgrid DER Modes of Operation

Although not explicitly included in the microgrid boundary for blue-sky mode of operation, the installed capacity of the PV roof-top array at the United Parcel Supply (UPS) warrants further discussion with the facility/array owner(s) wherein under black-sky mode the capacity of the PV could serve the microgrid under a dedicated power purchase agreement (PPA) with modest modifications to the facility's connection scheme; at the point of common coupling (PCC) to PSE&G.

Natural Gas Supply

The size of the existing natural gas connection at the Meadowview Powerhouse will meet the requirements for the incremental volume of natural gas required for the 1,200kW natural gas fired bank of microturbine generators and supplemental boilers. However, the incremental volume (new demand of natural gas) and higher supply pressure requirement of the microturbine generators may warrant the need for commercial discussions between Hudson County and Elizabethtown Gas to leverage a separate rate class and supply pressure to optimize this utility cost. Alternatively, if a higher supply pressure is not attainable from the utility, the new microturbine generators will require the installation of a fuel gas booster compressor station adjacent (and external) to the Powerhouse.

Thermal District Energy System

The current configuration of the underground thermal network (steam supply and condensate return lines) serving the Meadowview Complex will be expanded to serve the thermal load of Secaucus Housing Authority #2. This will be achieved by extending the steam and condensate lines that emanating from the Powerhouse to the Psychiatric Hospital. Existing schematic drawing of these piping systems denote that the system formerly served the "Youth House" building residing west Psychiatric Hospital. The Youth House has since been demolished and the respective connections to the steam/condensate piping system have been capped. As a result, the size of the branch connections of the steam/condensate system serving the Psychiatric Hospital have spare capacity to serve the incremental thermal load of Secaucus Housing Authority #2. Expanding this system to serve the thermal and electrical loads of Secaucus Housing Authority #2 will simply involve running extensions of steam, condensate and a set of electrical conductors in a new trench/tunnel system east of the Psychiatric Hospital crossing underneath County Avenue to integrate with modified mechanical and electrical systems residing within Secaucus Housing Authority #2. This configuration is denoted schematically in the attached Site Plan - Appendix B.

Single-Line Diagram

The electrical configuration of the DER assets integrated with PSE&G's grid are that of a network. This configuration is presented in the attached Overall Single Line Diagram for the microgrid boundary – Appendix D.

Local Utility Distribution System Description

Recent super storms, such as "Sandy" emphasize the need for distributed generation of electrical power and thermal energy at critical facilities such as hospitals, municipal centers etc. In case of a loss of grid incident, whether on account of a weather event or otherwise, a microgrid can be "islanded" (i.e. isolated from the utility) and the connected facilities can continue operating as usual. In the absence of a distributed energy generation microgrid, the facilities would have had to significantly reduce their power consumption by switching over to respective back-up generators, which present limitations that impede status-quo operations.

This proposed scheme will enable Hudson County to maintain power to Meadowview Campus, Alaris, Secaucus Housing Authority #2, Secaucus Town Hall/Police Station and five residences on County Avenue utilizing PV and microturbine assets from Meadowview Campus, Secaucus Housing Authority #2, and the nearby UPS facility provided that the utilities network controller is replaced or reconfigured at the UPS and Town Hall/Police Station facilities (connection to the utility) to allow for PV arrays to export to HOM8042 for black-sky operation.

The electrical configuration of the existing distribution system serving the Alaris currently has the capability to select from one of two feeders (conductors) from which the facility draws its power supply. This is achieved by manually enabling a kirk-key interlock within the switch gear residing in the basement of the Alaris Complex; providing the operator with the option to power the Complex from a dedicated point of common coupling with PSE&G feeder HOM802 OR from the switchgear and resulting microgrid DERs residing in the Powerhouse. However, it should be noted that the switchgear residing in the Alaris Complex is antiquated and has served far beyond its original economic lifespan and would need to be replaced to accommodate the proposed DER generation and distribution scheme.

Black-Start and Operation

When power from the utility is lost, all DERs within the microgrid will be tripped. If power from the utility is not restored within a prescribed period (~10s) the direct transfer trip looking out on the utility will be commanded by PSE&G to open breaker no. 52-U1, isolating circuit no HOM8042 from the utility (Homestead Substation) at Paterson Plank Road and at the east branch at Dorigo Ln which also serves the facilities on Windsor Dr, where denoted on the Single Line Diagram (SLD) - Appendix D. Once breaker no. 52-U1 has proven its position as “open”, a relay will provide the command to enable the black-start and/or synchronization and auto-close of all new DERs connected to the medium voltage (13kV) switchgear residing in the Meadowview Powerhouse. Power for black-starting of the microturbine array will be served by a 24 VDC battery bank residing in the Powerhouse. Alternatively, the back-up power switchgear could be modified such that the array was powered from this system. Regardless, the black-start procedure will require operator supervision/intervention to ensure that the DERs are reloaded in a priority sequence such as not to over/underload any given DER (to be defined at the detail design stages of this project).

Alternatives

If any of the proposed thermal or electrical loads that were used as the basis for sizing the respective DERs of the proposed centralized microgrid model are to be served by alternative generation sources (e.g. dedicated hot-water boilers located within the building or heating space served) then alternative measures will be considered to support the optimization of the microgrids capability to displace the prescribed electrical load (currently 98%). These measures would need to consume the corresponding thermal footprint that would otherwise be displaced an alternative heating supply technology (e.g. a decentralized boiler used for space heating). Potential measures that would fit such a displaced thermal demand profile lie in replacement of the existing electrical drives on the various vapor compression chiller systems with steam drives - where located within the Psychiatric Hospital and Building #12. Although the inclusion of dedicated, direct fired domestic hot water heaters within each building would further impact the efficiency of the microgrid model, our opinion is such that consideration should be given to install these measures regardless as there will be no net impact on the thermal load to be served by the microgrid DERs. This ECM, it is further recommended to integrate a direct fired natural gas domestic hot water heater to supply hot water to the residences and administrative area(s) within each building. This will provide redundancy for the domestic water heating system; the primary system being the centralized steam-to-water heating and storage system residing in the Powerhouse, whereas the secondary would be the new natural gas direct fired unit residing in the building. This redundant (secondary) system would provide the opportunity for operators to maintain (inspect and repair) the campus-wide steam and condensate system without disruption to the building's hot water supply.

Energy Procurement and Planning

GbD recommends separating all electric and natural gas accounts associated with the microgrid project as well as the County's ESIP project. These accounts should be organized into a separate portfolio and competitively contracted in a way that compliments the future enrollment and inclusion in the microgrid and ESIP project Measurement and Verification processes. GbD recommends this action begin in advance of the next phases for the microgrid and ESIP projects. Suggested timing to begin account separation is 1Q2019.

The Hosting Contracting Unit (HCU) and/or Microgrid operator will employ a long-term collaborative procurement strategy to assist with the most economical methods for utilizing distributed and renewable energy to offset market cost premiums and risk exposure. The approach is based on managing the component costs of power and transmission associated with the stakeholder accounts and seeks to utilize a portfolio management approach to effectively aggregate the retail accounts and mange market supply resources.

The supply strategy will include a block/index approach, supplemented by physical DER and energy purchases and capacity management. The strategy will entail purchasing wholesale fixed-price blocks of power to control price risk, and marginal purchases on the hourly market with most load scheduled on the Day-Ahead market, receiving physical energy from internal sources within PJM (e.g., PV, and receiving RECs/SRECs from contracted sources, some of which may be resold). Total energy price risk will include all component costs and will be managed by the Microgrid Operator and/or HCU and the Sustainable Energy Management consultant.

The energy supply strategy will provide the HCAM with a secure first-line reliable revenue stream and provide leverage of creditworthiness and contract flexibility to compress wholesale margins to the lowest possible level.

The HCAM stakeholder group represents over eight electric and nine natural gas accounts. The total annual consumption for all stakeholder facilities is 7.5 GWh and over 820,000 Therms. To maximize the potential energy revenue, the study contemplates the application of an Energy Revenue Optimization Model (EROM) that will include the following:

- All accounts for all stakeholders (wherever possible) will be enrolled into a single procurement portfolio
- Accounts will be aggregated by rate class and competitively supplied at the wholesale electric market trading level
- Load profile and consumption patterns will be meshed, where possible for source-to-sync transmission
- HCAM Registers for PJM Membership
- All interconnected facilities will include fifteen minute interval meters
- PSE&G / HCAM consolidated billing for electric
- PSE&G / HCAM consolidated billing for natural gas
- 12-month Electric supply service begins June 2019
- 12-month Natural Gas supply service begins April 2019
- Generator Maintenance and Fueling contracts integrated into HCAM utility service
- Stakeholder energy supply procurement agreements

Analyze and quantify future energy needs

The HCAM cluster facilities should be monitored monthly for all utility consumption and cost. Furthermore it is imperative the HCAM capacity planning include detailed programming and timing information regarding facility renovation and occupancy. Concurrently, using the monthly utility data the HCAM planning activities will include annual and long-term utility forecasting.

Identify the most economical energy sourcing options

HCAM will utilize dynamic energy procurement and supply management strategies to leverage margin compression opportunities using auctions and other competitive platforms for hedging advantages and cost control.

Evaluate purchasing RECs

The HCAM economic findings indicate a financial interdependence with Solar Renewable Energy Certificates (SRECs). The financial viability of the PV portion of the proposed distributed energy resource allocation depends on the revenue forecasted from the SREC sale proceeds. Because the HCAM is expected to operate with renewable generation and consumption on-site, purchasing Renewable Energy Certificates (RECs) is not recommended or and anticipated future obligation.

NJBPU and EDC Tariff Requirements

Introduction

The purpose of this section is to provide a detailed description of the governing tariff requirements and issues, tariff controls on distributed generation interconnection requirements, and the potential impacts on tariffs by planned scenarios for smart grid distribution automation improvements. This section also includes discussion of proposed changes to the various tariffs that would address factors that have inhibited the implementation of advanced microgrids and potentially improve project financial performance. These changes generally include removing barriers to interconnection and establishing standard terms for the value of services exchanged between the microgrid operator and the utility.

The development of an advanced (multi-user) microgrid challenges the existing tariff structure in multiple ways that were not anticipated in the historic development of the centralized transmission grid, nor in the subsequent decades of deregulation of the energy industry. To address these varied and overlapping issues and to identify current applicable tariff requirements in a systematic way, a techno/economic model of the advanced microgrid is provided in Appendix E to identify the six principal metered energy flows that comprise the proposed system. Each of these six energy flows are then described in detail. These energy flows include: 1) the local Electric Distribution Company (EDC), including feeders and distribution equipment installed onto the feeders; 2) the localized microgrid generation meshed network modelled as an AC bus; 3) a captured portion of the EDC distribution grid repurposed for use of power distribution between the advanced microgrid host facilities and with the larger grid; 4) natural gas distribution by the Gas Distribution Company (GDC); 5) the advanced microgrid thermal energy loop; and 6) a Virtual Microgrid residing outside of the advanced microgrid boundaries, but connected to advanced microgrid generation resources.

Regulatory Framework

In the United States, jurisdiction over energy industry operating standards and commodity prices are generally divided between the federal government and the states. The Federal Energy Regulatory Commission (FERC) of the U.S. Department of Energy (DOE) regulates the interstate transmission of electricity, natural gas, and oil, while the states govern intra-state retail markets. In the thirteen-state area that includes all of New Jersey, FERC delegates administrative authority over the power transmission grid on a regional basis to the PJM Interconnection (PJM) Regional Transmission Organization subject to the Open Access Transmission Tariff (OATT). FERC sets natural gas and oil wholesale transportation rates directly through approved tariffs for interstate pipeline services.

In New Jersey, the Board of Public Utilities (NJBPU) authorizes Electric Distribution Companies (EDC) and Gas Distribution Companies (GDC) to act as public utilities offering basic delivery and retail services. Due to New Jersey's energy industry deregulation, supply and distribution charges provided for in the governing tariffs are separate to open competition from Third Party Suppliers (TPS) who are licensed and regulated by NJBPU. The EDC and GDC continue to deliver energy as a monopoly through their wires and pipes and maintain ownership and responsibility for the maintenance and repair of the delivery infrastructure.

It should be noted that several of the energy flows in the advanced microgrid are non-tariff, in that they are flows between generating resources and co-located loads on the same premises or inside the advanced microgrid boundary, which for purposes of this discussion are assumed to operate free of the EDC franchise on the distribution of electric power. These energy flows within the advanced microgrid, where properties are contiguous or otherwise separated by an easement, public thoroughfare, transportation or utility-owned Right-of-Way, are considered non-tariff due to provisions of N.J.S.A. 48:3-51 et seq., ("Electric Discount and Energy Competition Act") that allows on-site generation facilities to make sales of electricity without being considered a public utility.

Tariff Structure

Tariffs are complex. They do double duty of setting industry prices and terms and conditions for service and are necessarily detailed and multi-layered. Retail electricity tariffs generally offer single or "flat" rates (non-time-dependent), time-of-use rates, which are dependent on time of day to capture peak demand, and rates for controlled loads. Tariffs typically identify various service categories dependent on the customer type (i.e., residential, commercial, industrial, institutional, transportation, etc.) and selected rate type. Tariffs also provide for rate riders for additional (sometimes temporary) charges or refunds separate from the basic monthly rates. These can include rate riders for generation services such as energy, transmission and capacity charges which are a pass-through from the wholesale provider of electric power; societal benefits charges; and sales and use taxes. The final monthly bill will therefore be an aggregate of the many applicable charges, fees and possible refunds broken down into the basic separable categories of: generation, transmission, distribution, and retail services. The single bill is delivered by the local utility, who serves as an agent for others, such as PJM and Third-Party Suppliers, who receive portions of the customer payment for their particular contribution to the metered energy flow.

Natural gas tariffs typically only provide a single non-time varying rate type but will offer price discrimination based on the quantity of gas delivered within a certain time block (i.e. daily, monthly or quarterly delivery). Natural gas prices also vary with the season with increases expected in winter months due to increased demand for space heating. Basic natural gas rates, like electricity rates, include separable charges for customer use (per meter), demand, and delivery charges. Service categories include use for commercial natural gas customers using distributed generation technologies such as microturbines and fuel cells, and also for large consumers of natural gas (greater than 10,000 therms daily) for the sole purpose of generating electricity.

Distributed Generation Interconnection Requirements

One tariff jurisdictional issue of particular importance to advanced microgrid projects is the threshold question for *small generator projects* falling under the PJM or the EDC interconnection process. The EDC, as governed by NJBPU, manages retail applications. PJM, as governed by FERC, is responsible for managing all wholesale interconnections to member EDC systems.[2]

Three basic factors determine the jurisdiction of the small generator project: 1) the type of facility to which the Project proposes to interconnect; 2) whether the output of the generator would only serve local load, and 3) whether all or some of the output of the generator may be available for wholesale sales under the OATT (the FERC-approved tariff). As the advanced microgrid anticipates connection only to the EDC retail distribution network (a non-FERC network) and the advanced microgrid generation will not be selling into the wholesale market under a FERC tariff but will only be consuming the power locally, the project does not anticipate a typical "Merchant Generator" utility interconnection however, a PJM interconnection application will be reviewed with PJM and possibly submitted as required to qualify the project's generating and storage assets for future capacity, demand management and other utility and/or PJM incentives. However, as potential export markets, including to the PJM wholesale markets for energy, capacity and ancillary services are attractive sources of future income, this potential pathway is included in the detailed tariff structure analysis.

Retail interconnection to the EDC system is defined in the operating tariff and requires a detailed application process to avoid violations of the tariff's *Single Source of Energy Supply* requirements. Interconnection fees and costs for distributed generation, standby service and demand charges are also applicable. The interconnection process consists of three levels based on the type and capacity of the generator. Levels 1 and 2 applies to inverter-based facilities limited to 2 MW and apply principally in the case of the advanced microgrid to PV systems installed at the host facilities. Level 3 applies to facilities which do not qualify for either the Level 1 or Level 2 and applies to the larger fuel-fired existing and planned generation at the advanced microgrid facilities. Distributed generation systems that want to sell or provide their excess energy and capacity to the PJM wholesale market must be interconnected per PJM requirements through a separate application process. The PJM interconnection requirements are provided in Manual 14A

[2] Interconnections are restricted to "Qualifying Facilities" as defined in the Public Utility Regulatory Policies Act of 1978 (PURPA). These include renewable generation facilities and small (i.e. less than 80 MW) cogeneration (such as Combined Heat & Power) but does not include battery storage.

(Generation and Interconnection Process) and follow the small generator interconnection procedures included in the OATT.

Customers that wish to sell power to the EDC are restricted by the terms and conditions of the EDC tariff for Cogeneration and Small Power Production Service. For generators larger than 1 MW, specific contract arrangements must be negotiated as part of the interconnection process to determine the price of delivered energy and capacity, which are controlled by the utility's ability to receive compensation for resale of the energy and capacity at PJM wholesale market prices. All such contracts are subject to NJBPU approval and the EDC may require significant restrictions on delivery of energy based on local circuit conditions and may refuse to allow such an interconnection should it not be technically feasible for feed-in to the meshed network. For example, energy capacity is typically limited to 15% of the connecting circuit's peak load to prevent overloading at the distributed resource on the connected feeder.

The interconnection of more than one type of distributed generation technology at the same site would also be complicated by net metering requirements. Net metering is a type of feed-in tariff that can generate offsets against EDC charges for owners of Class 1 renewable BTM generation assets in the advanced microgrid. Therefore, if CHP (not a Class 1 renewable) and the PV system are combined, a conflict may arise as net metered electricity from the Class 1 assets must be recorded and reported separately from other components of the advanced microgrid system.

Another potential complication for the interconnection of assets is the feed-in to a meshed network, rather than a radial system. The TCDER Advanced Microgrids are typically located in downtown areas served by a secondary network system of the distribution grid. There are many of these types of systems across New Jersey. These systems typically employ network protectors to prevent reverse flow onto the primary feeders. BTM distributed generation on the secondary network may be prevented from exporting power to the grid, particularly if they are on a dedicated spot network or on a smaller secondary network.

Smart Grid Distribution Automation

In response to demand to improve reliability and efficiency of the power system, smart grid communication and control enhancements, paired with increased automation, is being implemented on distribution systems. Advanced microgrids, through their use of interconnected distributed energy resources and automated interfaces with end-users, can provide opportunities for the development of new automation scenarios that build off primary distribution smart grid and automation functions implemented by the EDC at the substation and feeder distribution equipment. These functions currently include monitoring and control of distributed equipment to perform system protection actions when necessary, such as in the case of undetected faults or unplanned islanding of the advanced microgrid. Improved automation and smart grid enhancements by the local utility could provide enhanced demand response and load management to the advanced microgrid, and assist in contingency planning and analysis, monitoring of non-operational data (e.g. reference and historical data for making short and mid-term load predictions) and market operations of the distributed equipment, and assisting with predicative maintenance.

Smart grid distribution automation functions can provide both benefits and costs. The potential benefits include: 1) financial benefits such as lower costs (to customers), avoided costs (to utilities), and price stability; 2) power reliability and quality improvements; 3) increased visibility for utilities and field personnel into unsafe situations providing increased safety performance; 4) energy efficiency improvements, reduced energy usage and reduced peak demand; and 5) environmental and conservation benefits. Benefits that directly reduce costs for utilities, should result in lower tariffs or avoiding increased tariffs, although the connection may not be direct. Societal benefits are often harder to quantify but can be equally critical in assessing the overall benefits of a particular function.

The Advanced Microgrid Tariff Structure

Distribution Grid (EDC)

This system includes local feeders servicing the advanced microgrid and distribution equipment installed onto the feeders. These feeders are not dedicated solely to the advanced microgrid and are energized through one or more local substations. Metered flows include the following:

1) Retail Distribution: Retail sale of electricity by the EDC to the advanced microgrid through an aggregated Point of Common Connection (PCC). One or more meters is anticipated with aggregated monthly billing paid by either by the Special Purpose Entity (SPE) that will own and operate the advanced microgrid assets, or by the host advanced microgrid facilities directly responsible for their own consumption of grid-supplied power.
2) Retail Interconnection: Levels 1, 2 or 3 Interconnection to the EDC distribution grid for resale by the utility at rates pegged to PJM wholesale rates. Also includes any net metering from Class 1 renewables at the advanced microgrid (principally PV system). As indicated, many technical factors currently inhibit the full functioning of this interconnection to reach its maximum economic value.
3) Wholesale Interconnection: Small generator interconnection[3] allowing access to the PJM wholesale market. In this interconnection, the EDC wheels the energy through its system to PJM. The owner of the advanced microgrid assets deals with PJM directly for sales of services on the wholesale markets.

Advanced Microgrid Generation Bus (Non-Tariff)

[3] As per FERC/PJM standards, small generator includes less than 80 MW capacity.

This energy flow resides on a localized advanced microgrid generation meshed network modelled as an AC bus. Metered flows for use inside the advanced microgrid, which are not subject to any tariff, include PV, battery storage, conventional (fuel-fired) generation, and service to co-located loads. As per the Ownership and Business Model of the Feasibility Study Report, a host site would first take energy from the coincident production of the microgrid. In other words, each facility will use resources on its property to provide baseload, and then consume imported power to make up its residual load. Inherent in the structure of the advanced microgrid is the ability to use non-tariff metering between various local distributed energy resources and across advanced microgrid connected facilities.

This cost offset, from facility-to-facility and from customer-to-customer, is a major contributor to the overall value proposition of the advanced microgrid. Any excess energy from the distributed generation that is fed back into the grid through the captured EDC infrastructure (see below) will be sold to other advanced microgrid customers sites, proportionate to their overall energy consumption. Each advanced microgrid generating asset will be paired with a dedicated meter (as shown on the diagram) that will measure the output for internal accounting.

Captured EDC Distribution Grid (Non-Tariff)

Portions of the feeders and attached distribution equipment of the EDC distribution grid will be repurposed for use of the advanced microgrid power distribution between host facilities and with the larger grid. Excess power exported from the host facilities will be distributed and sold to other advanced microgrid customers sites, proportionate to their overall energy consumption. Individual host facilities importing energy from this internal network will have a meter to capture in-flows for internal accounting.

The repurposing of existing EDC infrastructure and possible expansions of service with new wires and equipment may take many forms and result in various economic and financial terms for payment of use of the infrastructure for delivery of energy. In some cases, host sites can continue to pay EDC via the delivery charge on the monthly bill while amending their existing bi-lateral supply agreements to account for the fact that a portion of their supply would now come from the microgrid. In other cases, where the value of the distribution in the energy flows becomes an increasingly smaller percentage of the value of the energy delivery, payments to EDC should be decreased accordingly to preserve the economic feasibility of the advanced microgrid.

Full privatization of the captured infrastructure would not appear to be a feasible option. If the captured portion of the feeder was purchased by the advanced microgrid to absorb any distribution charges into the price of on-site energy delivery, this benefit would almost certainly be entirely offset by the cost to purchase the assets and the on-going cost to maintain and operate them.

Natural Gas Distribution

Natural gas will be provided by the local GDC and used directly at the host facilities to power conventional generation such as combined heat and power (CHP) units, and for elements of the thermal loop including absorption chillers and boilers. Each type of service (i.e. electrical generation and thermal production) is shown with a separate meter.

Microgrid Thermal Energy Loop (Non-Tariff)

The thermal energy loop includes the use of co-located thermal energy resources at the host facilities, and the circulation of thermal energy from CHP units, boilers, etc. Exhaust from the CHP units will also be used in the thermal loop and is therefore metered to compensate the owner of the CHP asset. Like the flow energy on the Microgrid Generation Bus and the Captured EDC Distribution Grid, the energy flows in the thermal loop to Microgrid facilities is not subject to tariff.

Virtual Microgrid

The Virtual Microgrid refers to loads residing outside of the advanced microgrid boundaries but connected by feeders to microgrid generation resources. Using the EDC Level 3 interconnection, these advanced microgrid DER may, in theory, be able to energize the feeder and bring these loads back on line in the case of contingencies lasting anywhere from a few minutes to several days or weeks (depending on the flow of natural gas and state of the EDC infrastructure). As indicated, there are multiple technical challenges involved with making this potential revenue stream a reality, including access to the meshed network in a way that is safe and reliable. Primary critical loads are those that provide critical services and are the priority targets for service restoration in contingencies. Secondary loads are those loads on the feeder between the critical loads and the microgrid that will be energized incidentally as primary critical loads are brought back on line. These loads will continue to pay for their service under normal tariffs to the EDC however, a tariff rider that compensates the microgrid distributed resource asset owners for the reliability and resiliency services should be developed to service and avoided costs to the utility.

Conclusions and Recommendations

Microgrid Tariff

The interconnection standards in the EDC/NJBPU tariff is based, in part, on the IEEE 1547 series that addresses the interconnection of distributed generation to the distribution grid. As the use of distributed generation clusters, embedded networks and microgrids (especially advanced microgrids) have grown, there has been additional work done on advanced topics, such as IEEE 1547.4, which addresses the standard related to islanding of microgrids. As such, special microgrid tariffs have been proposed in certain jurisdictions to address the unique nature of the emerging business models. These tariffs would address factors that have inhibited the implementation of advanced microgrids and potentially improve financial performance. These changes generally include 1) establishing standard terms for the value of services exchanged between the advanced microgrid operator and the utility; and 2) removing technical barriers to interconnection. Each are described in more detail below.

The Value of Microgrids to the Distribution Systems

Several studies have been completed that review the current state of distributed generation deployment and how a proper economic framework for determining their value to the wider electrical system may be determined. In one study completed by the Analysis Group on deployments of distributed generation in the Con Ed system (New York City), different tracks of value chains were established for distributed generation resources to various parts of the electric system (including the power generation system, the high-voltage transmission system, and the distribution system) and separately, the external value to society. One finding of particular note is that current incentives for use of distributed generation are based on renewable portfolio goals and more recently resiliency goals, which can act as a rather "blunt and imprecise pricing instrument" that may not accurately reflect the value of distributed generation resources – particularly to the distribution system.[4]

Recommendations provided by the Analysis Group to achieve a more precise valuation framework include: 1) proceeding with more location-based analyses that focus on both expected and actual performance of distributed generation assets as cost-effective substitutes for traditional distribution-system reinforcements; 2) encouraging market-based competitive prices for procurement distributed generation services, rather than at avoided cost for maintenance and capacity expansion, and 3) development of forward contracting by utilities for distributed generation resource capacity. Improved valuation schemes may lead to a viable rate-basing scenario for utility investments in distributed generation resources and other improvements to distribution infrastructure that will be needed for the advanced microgrid to achieve full functionality, such as automated sectionalizing gear.

Other important improvements that could be established with microgrid tariffs that recognize the value imparted by the microgrid to the distribution grid for increased reliability and resilience should include special microgrid rates for imported power and by mitigating or eliminating standby and demand charges. The implementation of demand charges for installed distributed generation in the current tariff should be reexamined in light of the high reliability of these units and how

[4] Tierney, S., *The Value of "DER" to "D": The Role of Distributed Energy Resources in Supporting Local Electric Distribution System Reliability*. Boston, MA: The Analysis Group, 2016.

much reserve is actually required to serve a large and growing distributed generation capacity. Rather than pricing standby service for installed distributed generation based on a highly improbable emergency outage of the CHP system (for example), the tariff should instead recognize the benefits that highly efficient distributed generation systems provide, including increased system reliability and power quality, and reduced distribution losses. In other words, standby service is a value to distribution systems that may not need compensation from the distributed resources.

Improved Interconnection Procedures

With improved interconnection procedures that address the technical challenges of adding fully functional distributed generation to the grid, advanced microgrids could provide a host of generation services to support a substation during contingencies that would provide an alternative to distribution-system capacity improvements. These generation services, when combined with load reduction could provide utilities a very valuable resource to minimize customer loss of service and power quality problems during contingencies. Studies produced by the Pacific Northwest National Laboratory have evaluated the potential for use of microgrids as a resiliency resource to local grids in the event of a severe weather events and has found that, given the right conditions, microgrids can supply critical loads outside of the microgrid during contingencies where the utility power is unavailable for days or even weeks.[5]

In return for these services microgrids could receive payments for deliberate islanding to manage load, payments for exporting power, and payments for maintaining critical loads during a larger system outage. A contract between the microgrid and the local utility for resiliency and reliability resources could call for immediate response in local contingencies, not just to reduce peak system demand. Short-term markets for local service would include local voltage and VAR support, short-term substation relief, and emergency services. Microgrids could make on-call energy exports to the grid or assume pre-determined load shapes or provide circuit-by-circuit grid restoration services to ensure local reliability. These potential markets should be studied by NJBPU and included into future tariffs. However, to achieve this variety of services to the grid, the interconnection process must become more robust allowing full integration of distributed generation resources into the larger grid.

FERC and PJM Tariff Requirements

Please see the "NJBPU and EDC Tariff Requirements" section of the report.

[5] K. P. Schneider, F. K. Tuffner, M. A. Elizondo, C. Liu, Y. Xu and D. Ton, "Evaluating the Feasibility to Use Microgrids as a Resiliency Resource," in IEEE Transactions on Smart Grid, vol. 8, no. 2, pp. 687-696, March 2017.

Description of Overall Costs

The Hudson County Advanced Microgrid relies on generation from newly installed CHP and solar PV systems. The system components are as follows:

- New Solar PV at various locations within the Meadowview Complex
- New CHP at the existing Meadowview Power House
- Access to the existing steam distribution system at the Meadowview Complex
- New steam distribution connecting the existing steam distribution system at Meadowview Complex to the Secaucus Housing #2
- New electrical distribution wires
- Switchgear
- Transformer
- New supplemental boiler at the Meadowview Power House

Capital costs as modeled in the project proforma for the major components are listed below. Refer to the Excel model attached to this report for yearly cashflow modelling.

Microgrid Component	Cost
Ground-mount/Rooftop Solar PV	$110,500
Carport Solar PV	$1,138,621
CHP generator sets at the Meadowview Power House	$2,675,200
Steam distribution to Secaucus Housing #2, electric distribution to Secaucus Housing #2 and #1	$1,512,000
SCADA and Switchgear (Transfer-Trip Switch, ATS, Switchgear, Transformer at Town Hall)	$850,000
Soft Costs (Contractor Fees, Development Fees, Project Management, Engineering Support, Permitting, Interconnection Applications)	$1,645,041
Boiler at the Meadowview Power House	$1,103,360
Total Project Cost Estimate	**$9,034,722**

Table 14: Total Estimated Project Cost by Component

This analysis assumes that a non-utility, third party will develop the microgrid through a DBOOM model (design, build, own, operate and maintain). Revenues are generated from both electricity and steam sales during blue-sky conditions. The below table outlines the year 1 energy sales modeled for each system component.

Energy	Annual Production	Unit Price	Year 1 Energy Sales
Solar PV Electricity to Alaris Health / Meadowview Complex	555,261 kWh	$0.112 / kWh	$62,189
Solar PV Electricity to Secaucus Housing Authority #2	126,080 kWh	$0.150 / kWh	$18,912
CHP Electricity to Alaris Health / Meadowview Complex	7,959,250 kWh	$0.112 / kWh	$891,436
CHP Electricity to Secaucus Housing Authority #2	69,244 kWh	$0.150 / kWh	$10,387
CHP Electricity to Secaucus Housing Authority #1	576,454 kWh	$0.080 / kWh	$46,116
CHP Steam to Alaris Health / Meadowview Complex	277,796 therms	$0.7529 / therm	$209,153
CHP Steam to Secaucus Housing Authority #2	34,700 therms	$1.0118 / therm	$35,108
Total Revenue from Energy Sales			**$1,273,301**

Table 15: Year 1 HCAM Energy Sale Revenue

Operations and maintenance costs are estimated for all systems. These costs are covered by the PPA and ESA payments and are paid for by the microgrid system owner. Maintenance assumptions are listed below.

Microgrid Component	Assumption	Year 1 Cost
Solar PV across all facilities	$7.50 / kW	$3,728
CHP Natural Gas Cost	$0.64 / therm	$662,788
CHP Maintenance	$0.035 / kWh	$301,173

Table 16: Maintenance Assumptions

Project Financing Summary

The proposed microgrid's twenty year operational and financial performance was modeled through a proforma analysis. The model includes up-front capital expenditures for the solar PV and CHP systems and incentives. In addition, the distribution infrastructure to connect Secaucus Housing Authority #2 and #1 and a new supplemental boiler are included. Annual revenues and operational expenses, including fuel costs and maintenance, was modelled to determine the microgrid's rate of return and ability to attract investors.

The model assumes the following.

- CHP electricity sales to Meadowview Complex, Alaris, Secaucus Housing Authority #2, and Secaucus Housing Authority #1 during blue-sky conditions at rates on par with their current electric rates
- CHP steam sales to Meadowview Complex, Alaris, and Secaucus Housing Authority #2 during blue-sky conditions at current all-in gas rate, respectively.
    - Assumed that 99% of steam produced is sold
- The project is financed through 80% equity and 20% debt at 5%

The Solar PV follows the below operating conditions:

- Solar PV electricity sales via a PPA to Meadowview Complex, Alaris, Secaucus Housing Authority #2, and Secaucus Housing Authority #1 during blue-sky conditions at rates on par with their current electric rates
- SREC revenues at $210/MWh for the first 10 years of the project
    - Assumes sufficient demand in the New Jersey REC market to offtake all of the generated SRECs for compliance or voluntary use
- Assumes any excess solar PV electricity would be sold via New Jersey's Community Solar Program (in development)

One of the drivers of success for the proposed microgrid project is the available incentives. This includes the following:

- New Jersey Clean Energy Program CHP incentive ($1,720,000)
    - To qualify, it is necessary to use the thermal energy productively so that the minimum fuel conversion efficiency is at least 60%
- 30% Federal Investment Tax Credit (ITC) for Solar PV ($370,110)
- 10% Federal Investment Tax Credit (ITC) for CHP ($427,142)
- 100% accelerated depreciation[6] for the Solar PV, CHP, and steam distribution infrastructure
- SREC sales at $210/MWh

The New Jersey Environmental Infrastructure Trust (NJIET), which supports water infrastructure projects, may be a source of attractive financing. Projects under the NJEIT purview which protect and enhance water resources are eligible for low interest loans. The Meadowview Complex, which operates a wastewater treatment plant, is a prime example of the types of projects which NJIET could support. The microgrid's ability to continue to treat wastewater even during black-sky events is an obvious resiliency benefit for the community. The financial model does not currently include low interest loans from NJIET.

[6] http://programs.dsireusa.org/system/program/detail/676

Lastly, the model assumes the availability of state or local grants to contribute to support necessary upgrades. Specifically, Secaucus Housing Authority #1 would purchase a significant portion of the CHP electricity at their existing electric rate. However, revenues would not pay for the electrical distribution infrastructure that is required. The project also includes a supplemental steam boiler upgrade for the Meadowview Power House. The CHP plant does not provide 100% of the microgrid's steam requirements, and all existing boilers at the Power House have exceeded their rated lifetimes and will need replacement in the coming years. The CHP system displaces the need for installing 119 HP of boiler capacity to supply the steam-connected facilities. In order to generate enough return to attract third-party investors, we estimate that a contribution of approximately $1,450,000 would be needed.

Analysis of Financial Model

Table 17 summarizes key revenue results from the microgrid proforma analysis. The model assumes a DBOOM microgrid owner who finances, owns, and operates all aspects of the microgrid, and all tax and other state incentives are fully monetized. Because most microgrid development costs are fixed—capital costs reflect typical market rates, while unit revenue costs are fixed to microgrid customer's current rates—the microgrid model is limited in its flexibility without significant changes in its configuration.

Scenario	Energy Sale Price	IRR
CHP and Solar PV systems operate continuously during blue-sky conditions and all energy produced is sold	$0.112/kWh, $0.15/kWh Solar PPA $0.08/kWh, $0.112/kWh, $0.15/kWh for CHP electricity $0.7529/therm, $1.012/therm for Steam	9%

Table 17: Key Revenue Results from Pro Forma Analysis

Despite the limited flexibility of the model inputs, our financial model suggests that the proposed microgrid has fair finance ability while maintaining customers' current energy costs. This also assumes a $1,450,000 grant from the state or county. The greatest boost to the microgrid model is the existing steam distribution infrastructure that can be reused for CHP steam. By leveraging this existing thermal distribution infrastructure, the financial model suggests a reasonable IRR. Financial results in Table 17 do not contemplate thermal loop repairs. In addition, it is assumed that PSE&G installs and owns transfer switching necessary to isolate the microgrid during black sky events.

Important to note, the financial model assumes full monetization of all available incentives, including federal ITC, incentive grants, and SREC revenues. Project returns are reduced by 2-3 percentage points where any incentive doesn't materialize. In addition, the third-party financing partner is assumed to be able to monetize all the solar PV and CHP ITC incentives available; this may require a partnership with a tax equity investor if the project owner does not have sufficient tax liability.

There are multiple risk factors to this project. Namely, a twenty year time horizon, multiple off-take agreements, the reuse of infrastructure, and potential changes to future loads. These multiple risks will require the project to maintain a reasonable rate of return. To do this, Hudson County could support the microgrid by guaranteeing a minimum revenue to the microgrid owner.

If upon further investigation our assumptions don't hold true, the State of New Jersey, through the BPU, can assist in a few different ways to maintain a reasonable rate of return to ensure financing. The state can earmark Resiliency Funding in order to secure the state incentives on which the financial model relies heavily, or provide a grant to cover non-revenue generating capital costs like the steam distribution addition/upgrades, Meadowview Complex electric distribution additions, or the SCADA controls system. Were PSE&G to refuse paying for transfer switching for microgrid isolation, the project may need financial infusion from the state to assist with this expense. The NJBPU could also support the development of a specific tariff that would reduce fixed delivery charges for microgrid accounts to improve the project's operating revenues.

Recommendations

This analysis finds that the Hudson County Advanced Microgrid is technically feasible and financeable. This is owed in large part to the original investment in district steam heating for Meadowview Complex and Alaris and will likely hold true in other campus settings where steam distribution infrastructure can be reused and coupled to new CHP installations.

The project itself can generate significant on-site energy to provide clean electricity, operating during both blue and black sky events. Additionally, the CHP system will deliver high-efficiency electricity and steam when compared to the existing boilers currently in use. By powering hospitals, the police station, and the existing wastewater treatment plant, the proposed microgrid will be an asset to the community during black sky conditions, providing much-needed first response services. In addition, the microgrid makes use of the neighboring UPS solar PV array that is otherwise unusable when the utility grid is down to provide critical services.

The analysis reveals several opportunities for policy and/or regulatory solutions that may improve the business model from the perspective of the microgrid owner, customers, and EDC. We recommend that the New Jersey Board of Public Utilities explore the following options:

- Provide grant funding and access to cheaper forms of capital for resiliency projects, which also contemplate the first-cost or upgrade costs for thermal loop distribution infrastructure.
- Provide capital infusion to the existing Energy Resilience Bank (currently de-funded and no longer funding additional resiliency projects) or a New Jersey State Green Bank with a specific carve-out for microgrid resiliency projects.

- Compel utilities to create a resiliency roadmap, which would require utilities to invest in critical facility distribution isolation and create resources for developers to help identify island-able distribution circuits.
- Create tariff provisions for microgrid CHP host sites that reduce stand-by charges, as it is installed for the benefit of the larger community and not only for the host site exclusively.
- Adjust back-feed interconnection requirements for DERs that are used for the purposes of providing microgrid back-up power.
- Adjust net metering rules to allow multiple sites which are electricality connected as a microgrid to participate in net-metering.

Cash Flow Evaluation

The HCAM Cash Flow Evaluation can be seen in Appendix F, HCAM Pro Forma and Cash Flow Evaluation.

Benefits

Hudson County is the most densely populated and fastest growing county in New Jersey. Because of its proximity to New York City, the region hosts a range of industry, from international shipping and cold storage to oil refineries and hospitality services. Unfortunately, the county was not immune to the destruction of Hurricane Sandy, which left residents and critical services without power for over a week. Consequently, county officials began contemplating energy resiliency and reliability to ensure public health, safety, and productivity. The implementation of the Hudson County Advanced Town Center Distributed Energy Resources (DER) Microgrid a significant step in ensuring that those goals are met.

Primarily, the Hudson County Advanced Town Center DER Microgrid serves to keep essential services functioning regardless of storms, black-outs, heat-waves, cyber-attacks, or other grid disruptions. Emergency service personnel rely on power to serve and communicate to the community. Inconsistent power supply to facilities like Alaris Health at the Fountains, Meadowview Psychiatric Hospital, and the Meadowview wastewater treatment plant has the potential to put many people at risk.

The microgrid also provides a long list of additional benefits. The new generation and improved operational efficiencies both create concrete value, with associated revenue streams, meaning that most elements of the microgrid pay for themselves, thus minimizing the capital cost associated with achieving the desired resiliency and emergency response capabilities. Other benefits include the environmental benefits of zero carbon emissions from the PV systems' electricity generation, and increased energy efficiency from utilizing the waste heat from the CHP units.

Communication and Connection of the Proposed Microgrid DER technologies to PSE&G's Grid

Communication between the microgrid DERs and the utility will occur through remote terminal units utilizing intertie network protection for the generation assets under blue-sky mode of operation. Under this mode of operation all DERs will operate in parallel with the utility under a displacement, net-metering or community solar generation scheme.

Load management for powering the microgrid will be accomplished using a variant on the smart grid technology, in that the microgrid isolation and islanding, and dispatch of the generation will be controlled by PSE&G's distribution SCADA, coordinated with control of the building loads by building automation systems. The two will be firewall isolated, yet will provide coordinated load management, such that the ability to maximize the generating assets will be accomplished, i.e., if a significant solar PV component becomes feasible, its variability need to be accommodated by control of conventional generation assets and building load management. Additionally, the energization of large loads will be managed to effectively accommodate the block loading capability of the generating assets.

It is proposed that the microgrid control system shall employ SCADA technology, contained entirely within the microgrid. This will utilize fiberoptic communication and is intended to exclude internet connection to any of the control system.

Estimated Timeframe

The estimated timeframe for the completion of the construction and commencement of operations of the individual critical facilities and the overall Project is shown in Appendix G.

Ongoing Work with EDC and GDC

The HCAM development team will require direct collaboration with the EDC and GDC. The HCAM implementation priority is to identify and plan for the complete interoperability of the DER resources and facilities within the proposed HCAM while providing maximum benefit to the local grid circuits. The information developed to that end will be included within the overall HCAM investment-grade implementation plan. Once documented, the EDC and GDC requirements will be quantified and integrated in the tariff development and project financing models.

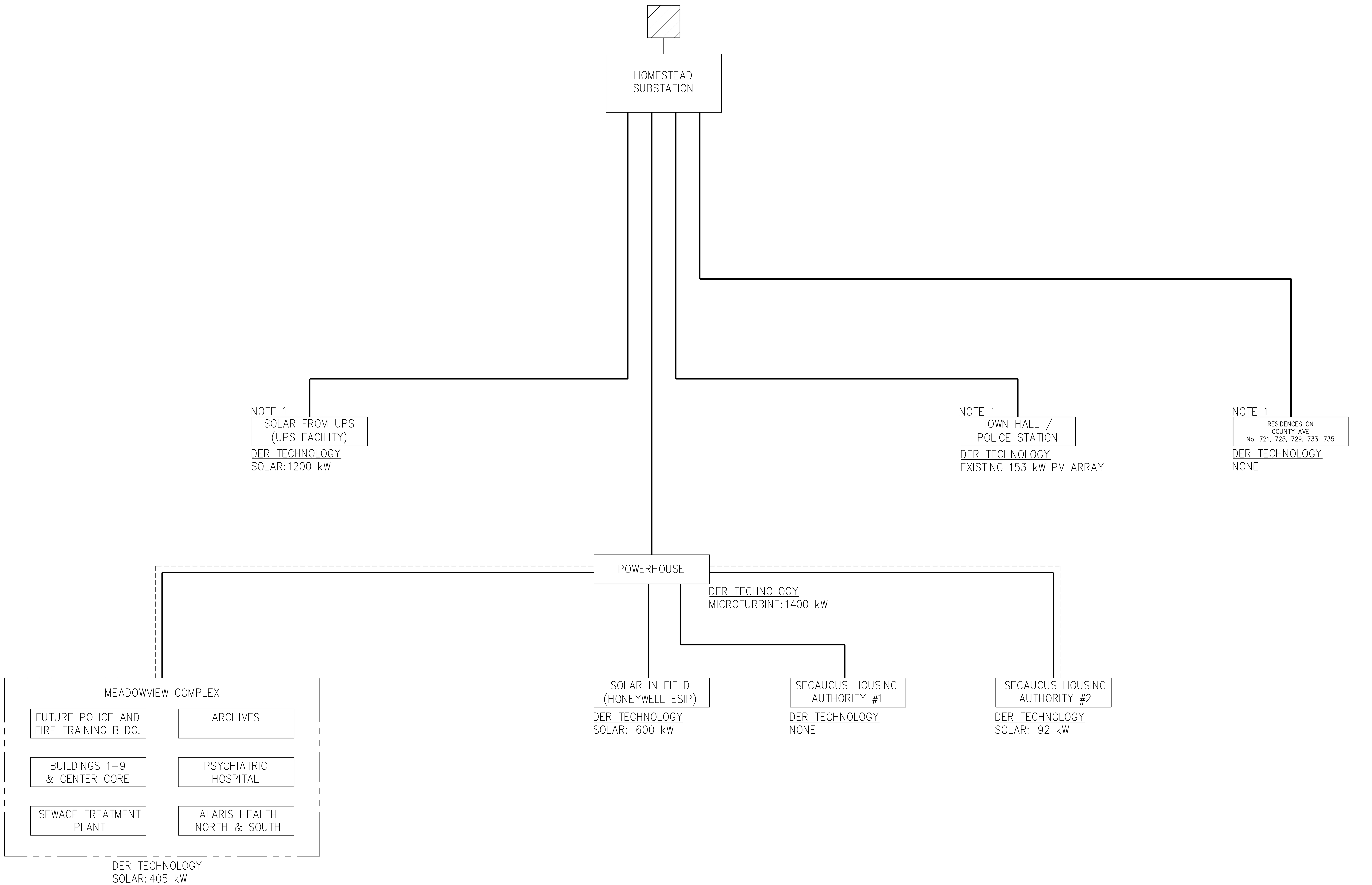
Appendix

Appendix A – Microgrid Topology

LEGEND

- - - - - - - - - - THERMAL
———————— ELECTRICAL

NOTES
1. Connected in Black-Sky operation only.
2. Data is based on outputs from DER-CAM.



CHA
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Albany, NY 12205-0269
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HUDSON COUNTY
ADVANCED MICROGRID
(HCAM) PROJECT
Hudson County, NJ

No.	Submittal / Revision	App'd.	By	Date
PA	ISSUED FOR REVIEW	JJ	CC	12/20/18

DERCAM
MICROGRID
TOPOLOGY

Designed By:	Drawn By:	Checked By:
CC	CC	JJ
Date:	Project No:	Scale:
DEC. 2018	34062	NONE

Drawing No.:
MSK-001

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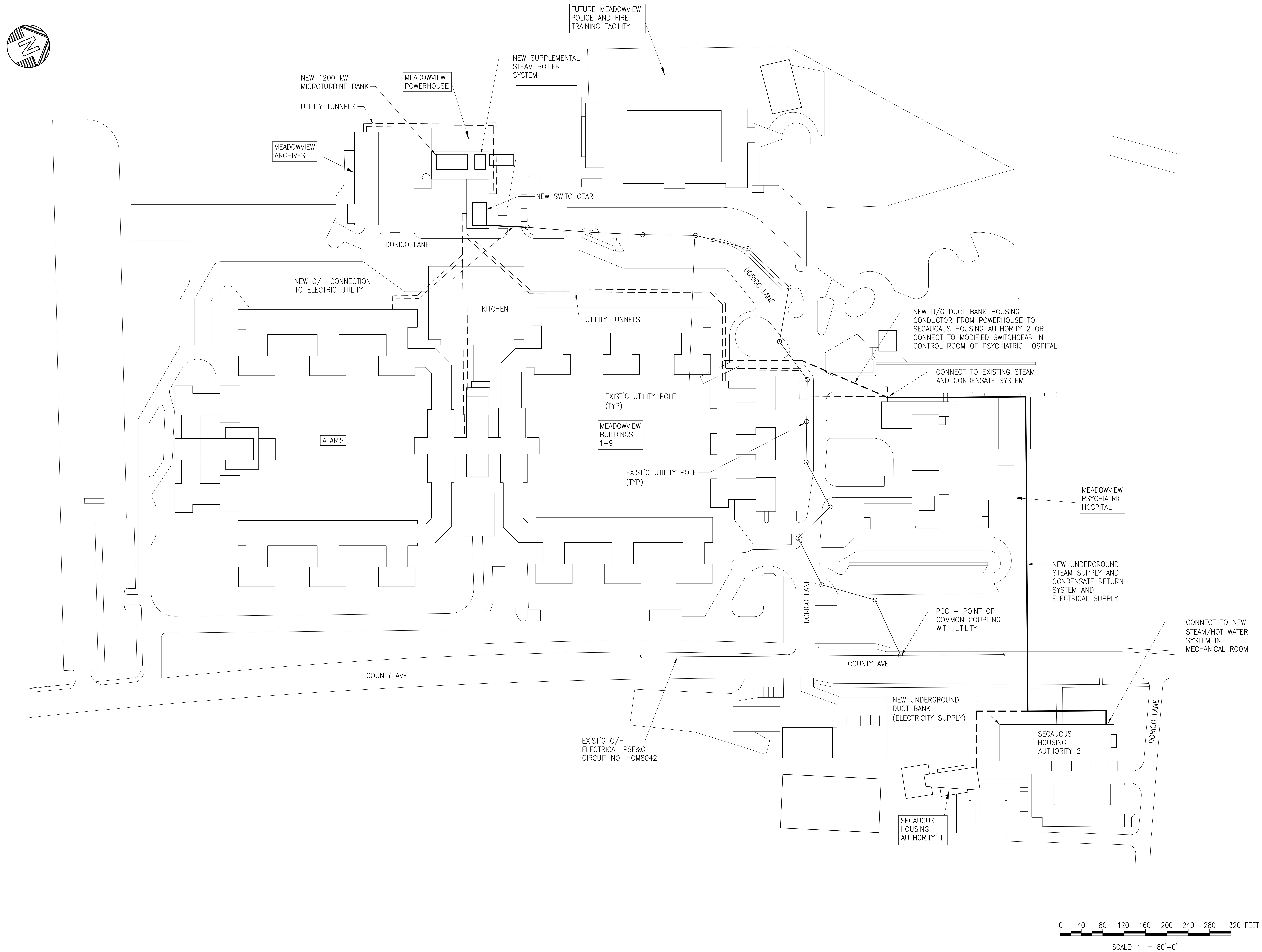
Appendix B – Microgrid Site Plan



CHA

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Main: (518) 453-4500 • www.chacompanies.com

HUDSON COUNTY
MICROGRID
Secaucus, NJ

No.	Submittal / Revision	App'd.	By	Date
PA	ISSUED FOR REVIEW	HTL	DM	18/12/14
PB	ISSUED FOR REVIEW	JJ	BG	18/12/17

MEADOWVIEW COMPLEX
SITE PLAN

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HT	DM	HT
Issue Date:	Project No:	Scale:
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Drawing No.:

M-200

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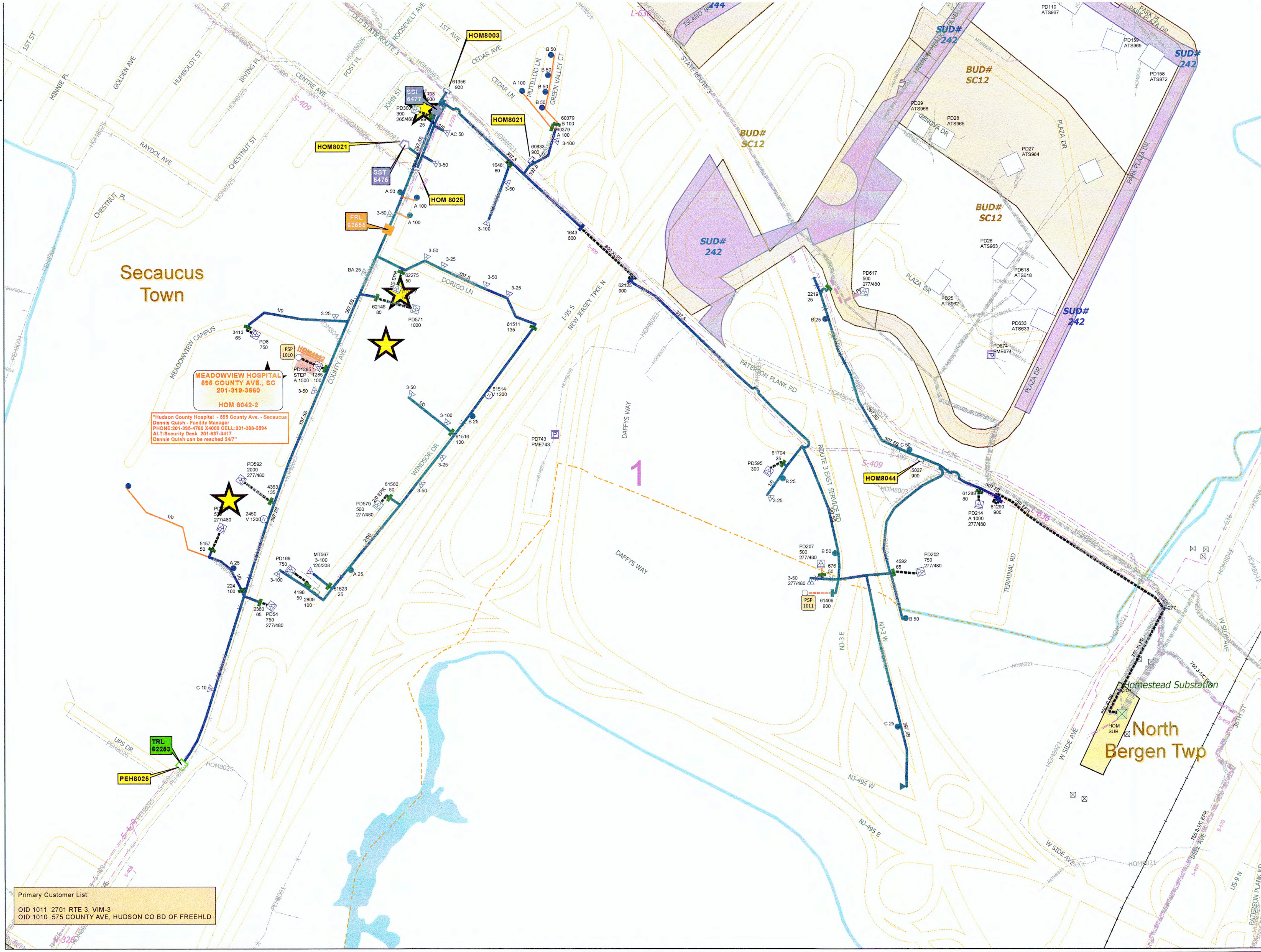
Appendix C – Current Schematic of PSE&G’s Circuit Number HOM8042



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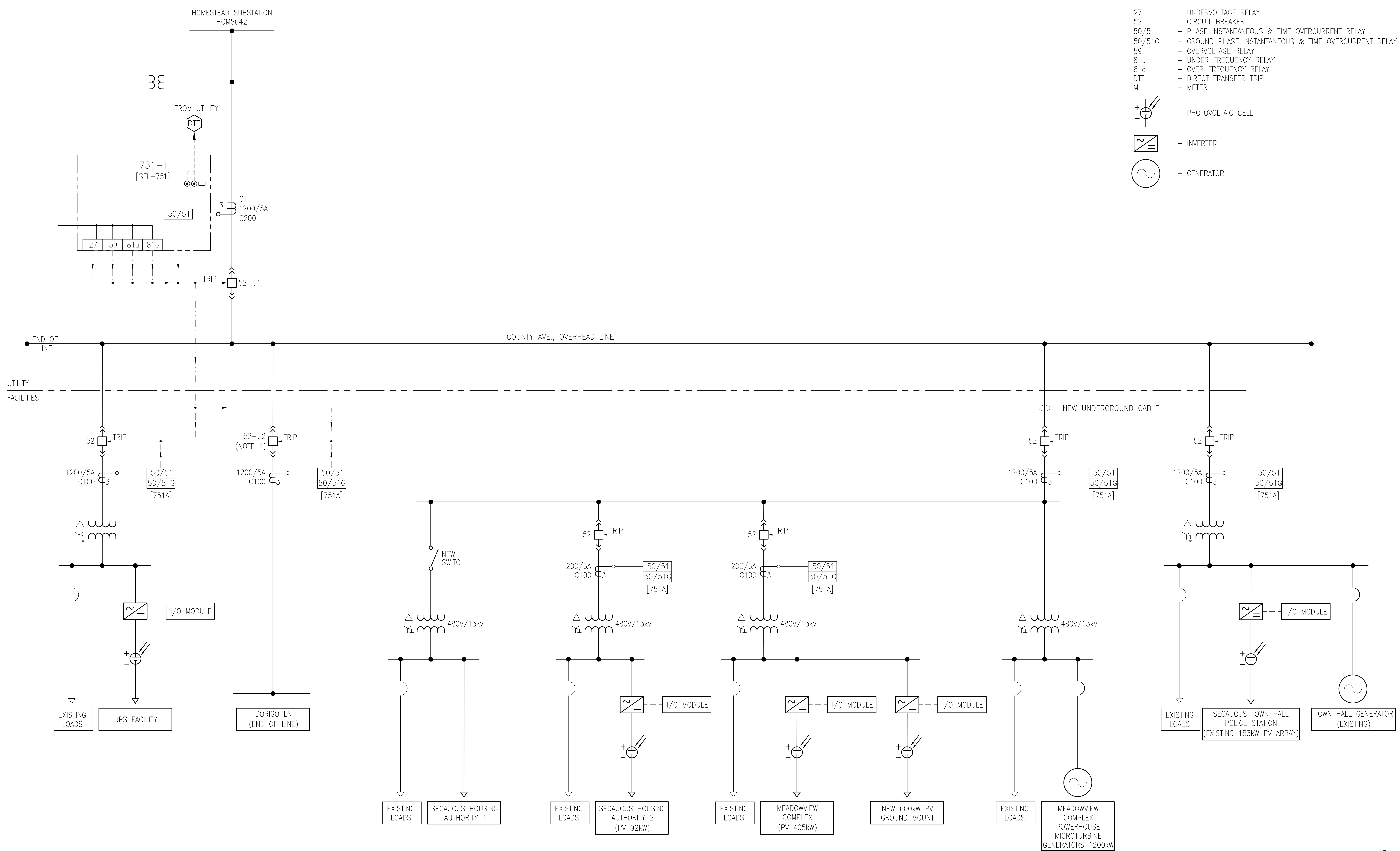
SCALE: 1" = 300 FT	Checked :	Title :				

Appendix D – HCAM Single-Line Diagram



NOTES:

1. FACILITY LOADS ON DORIGO LANE WINDSOR DRIVE TO BE ISOLATED IN BLACK-SKY MODE OF OPERATION.

LEGEND:

27 – UNDERVOLTAGE RELAY
52 – CIRCUIT BREAKER
50/51 – PHASE INSTANTANEOUS & TIME OVERCURRENT RELAY
50/51G – GROUND PHASE INSTANTANEOUS & TIME OVERCURRENT RELAY
59 – OVERVOLTAGE RELAY
81u – UNDER FREQUENCY RELAY
81o – OVER FREQUENCY RELAY
DTT – DIRECT TRANSFER TRIP
M – METER
– PHOTOVOLTAIC CELL
– INVERTER
– GENERATOR

NOT FOR CONSTRUCTION

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MAIN CLUSTER
HUDSON COUNTY
MICROGRID PROJECT
BLACK-SKY MODE OF OPERATION

No.	Submittal / Revision	App'd.	By	Date
PA	ISSUED FOR REVIEW	SK	JDC	12/14/18

OVERALL SINGLE LINE DIAGRAM

Designed By:	Drawn By:	Checked By:
SK	MS	SK
Issue Date:	Project No:	Scale:
12/14/2018	34062	NONE

Drawing No.:

ESK-001

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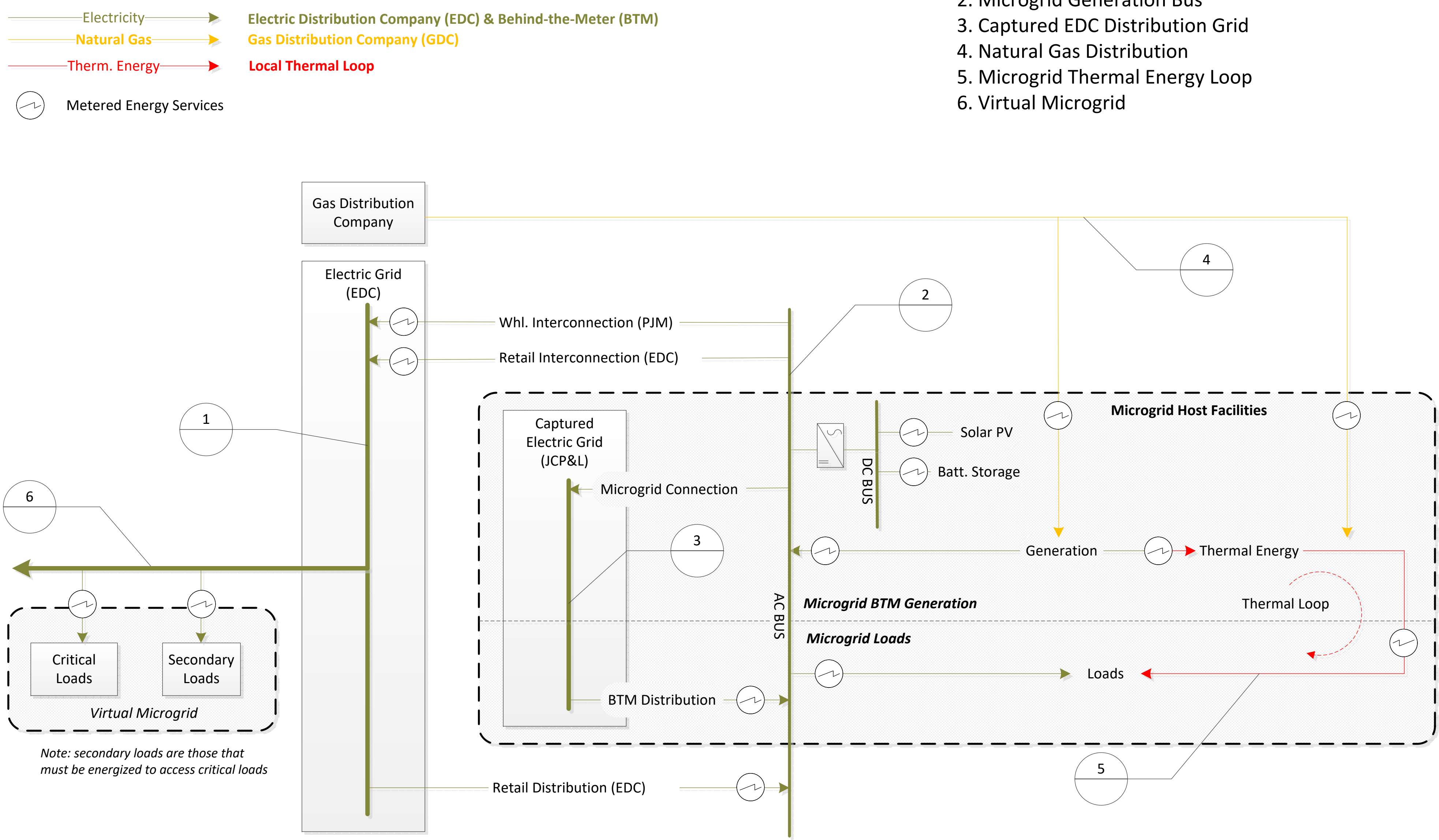
Appendix E – Techno/Economic Model of the Advanced Microgrid

"Unbundled Utility" Tariff Structure

Energy Flows



Microgrid Tariff Structure

1. Distribution Grid
2. Microgrid Generation Bus
3. Captured EDC Distribution Grid
4. Natural Gas Distribution
5. Microgrid Thermal Energy Loop
6. Virtual Microgrid

Contact: Matthew Brener, BRS, Inc., (267) 688-7301 |matthew@brsinc.com

Appendix F – HCAM Pro Forma and Cash Flow Evaluation

Appendix F

Hudson County Microgrid 20-Year Pro Forma Financial Analysis

Financing assumptions			
Elec Sale Price - Meadowview		0.112	$/kWh
Elec Sale Price - SHA #2		0.150	$/kWh
Elec Sale Price - SHA #1		0.080	$/kWh
Steam Sale Price - Meadowview		7.529	$/MMBtu
Steam Sale Price - SHA #2		10.118	$/MMBtu
Solar PV PPA Price - Meadowview	$	0.112	$/kWh
Solar PV PPA Price - SHA #2		0.150	$/kWh
Debt Cap		20%	% of total
Loan tenure		20	years
Interest Rate		5.0%	%
Effective tax rate		30%	%
IRR (Realized)		9.6%	%
Expected IRR		10%	%

Incentive assumptions			
CHP Incentive Amt	$	1,720,000	total $
CHP ITC Rate		10%	%
CHP ITC Amount	$	427,142	$
CHP Depreciable basis	$	6,348,129	$
Solar PV ITC Rate		30%	%
Solar PV ITC Amount	$	370,110	total $
SREC Price	$	210.00	$/MWh
Solar PV Depreciable basis	$	1,048,645	$
State or Local Grant	$	925,000	$
Incentive Discount Factor		100%	%

CHP Conversion factors		
Heat Rate	12,035	BTU/kWh
Btu per kWh (Conversion)	3.412	Btu
CHP Elec Conversion Efficiency	28.4%	%
Steam Output (% of Fuel Energy)	30.5%	%
Total Thermal Efficiency (Steam & HW)	58%	%

CHP System parameters		
Average Uptime of Engines	100%	%
Average Engine Load Rating	81%	%
CHP Elec Capacity	1,400	kW
Minimum utility import	100	kW
Parasitic Load Losses	5%	%
Annual Elec Production	8,604,948	kWh
Annual Elec Production to SHA #2	69,244	kWh
Annual Elec Production to SHA #1	576,454	kWh
Annual CHP Fuel Input	103,561	MMBtu
Annual Elec Production	29,360	MMBtu
Annual Steam Production	31,565	MMBtu
Thermal Utilization (% used of total avail	99%	%
CHP Steam Used	31,249.60	MMBtu
SHA #2 Steam Purchases	3,470.0	MMBtu
CHP Capex	$1,021	$/kW

Thermal Loop Parameters		
Length of HW Thermal Loop	1,900	feet
Thermal loop Capex	$800	$/feet

Solar PV System parameters		
PV System total capacity size	497	kW
PV System size (non carport)	65	kW
PV System size (carport)	432	kW
Annual solar resource	1,311	kWh/kw
Annual PV Dispatch (calculated)	651,567	kWh
Annual PV Dispatch (Helioscope)	681,341	kWh
Year 1 PV Sales to Alaris / Meadowview	555,261	kWh
Year 1 PV Sales to SHA #2	126,080	kWh
Annual PV Degradation	1%	%
PV Capex (carport)	$2,600	$/kW
PV Capex (non-carport)	$1,700	$/kW

Capital Expenses				O&M				Escalation		
CHP Capex	$	4,271,416	$	CHP O&M Costs	$	0.035	$/kWh	Elec Sale Price	3.0%	%
Solar PV Capex	$	1,249,121	$	PV O&M Costs		$7.50	$/kW	Thermal Sale Pric	2.0%	%
Distribution Loop Capex	$	2,410,825	$	NG Fuel Costs	$	0.640	$/therm	Natural Gas Price	2.0%	%
Boiler	$	1,103,360	$	NG Fuel Costs	$	6.40	$/MMBTU	O&M	2.0%	%
			$	CHP NG Fuel Costs	$	6.40	$/MMBTU			
Total Capex	$	9,034,722	$	UPS Access Fee		$1,000	$/access			

INCOME STATEMENT					
Year	2018	2019	2020	2021	2022
	0	1	2	3	4
Solar PV Sales		$ 81,101	$ 83,534	$ 86,040	$ 88,622
SREC sales		$ 136,829	$ 136,145	$ 135,464	$ 134,787
CHP Electricity sales		$ 891,436	$ 918,179	$ 945,724	$ 974,096
SHA #2 CHP Electricity Sales		$ 10,387	$ 10,698	$ 11,019	$ 11,350
SHA #1 CHP Electricity Sales		$ 46,116	$ 47,500	$ 48,925	$ 50,393
Steam Sales		$ 209,164	$ 213,347	$ 217,614	$ 221,967
SHA #2 Steam Sales		$ 35,108	$ 35,810	$ 36,527	$ 37,257
Total revenue		**$ 1,410,142**	**$ 1,445,214**	**$ 1,481,314**	**$ 1,518,471**
Annual PV O&M Costs		$ (3,728)	$ (3,802)	$ (3,878)	$ (3,956)
Annual CHP Fuel Costs		$ (662,788)	$ (676,043)	$ (689,564)	$ (703,355)
Annual CHP O&M costs		$ (301,173)	$ (307,197)	$ (313,341)	$ (319,607)
UPS Access fee costs			$ -	$ (1,000)	$ -
Total Expenses		**$ (967,688)**	**$ (987,042)**	**$ (1,007,783)**	**$ (1,026,918)**
EBITDA		**$ 442,453**	**$ 458,172**	**$ 473,531**	**$ 491,552**
Incentives					
CHP Incentives	$ 516,000	$ 860,000	$ 344,000	$ -	$ -
CHP ITC		$ 427,142			
Solar PV ITC	$ -	$ 370,110	$ -	$ -	$ -
State/Local Grant		$ 1,475,000	$ -	$ -	$ -
Cash Taxes					
EBITDA		$ 442,453	$ 458,172	$ 473,531	$ 491,552
Depreciation (MACRS %)		100%	0%	0%	0%
CHP Depreciation ($)		$ 6,348,128.84	$ -	$ -	$ -
Solar PV Depreciation ($)		$ 1,048,645.00	$ -	$ -	$ -
EBIT		$ (6,954,321)	$ 458,172	$ 473,531	$ 491,552
Interest		$ 64,547	$ 62,595	$ 43,345	$ 40,333
EBT		$ (7,018,868)	$ 395,577	$ 430,186	$ 451,219
Cash Taxes		$ (2,105,660.32)	$ 118,673.07	$ 129,056	$ 135,366
Cash Taxes (effective after NOL)		$ -	$ -	$ -	$ -
Net-Operating Loss					
NOL Beginning balance	$ -	$ 2,105,660	$ 2,105,660	$ 1,986,987	$ 1,857,932
NOL Used	$ -	$ -	$ 118,673	$ 129,056	$ 135,366
NOL Ending Balanced	$ -	$ 2,105,660	$ 1,986,987	$ 1,857,932	$ 1,722,566
Debt Financing					
CFADS (Cash Flow Available for Debt Service)		$ 5,680,365	$ 683,499	$ 344,475	$ 356,186
Debt Outstanding (BOP)	$ 1,290,944.43	$ 1,290,944	$ 1,251,903	$ 866,909	$ 806,666
Principal Payment		$ 39,041.50	$ 40,993.57	$ 60,243.25	$ 63,255.42
Interest Payment		$ 64,547	$ 62,595	$ 43,345	$ 40,333
Debt Outstanding (EOP)		$ 1,251,903	$ 866,909	$ 806,666	$ 743,411
Equity Financing					
Cash Flow to Equity	$ (7,743,778)	$ 5,576,777	$ 579,910	$ 240,887	$ 252,598
Present Value of Cash Flows	$ 7,638,614	$ 5,069,797	$ 479,265	$ 180,982	$ 172,528
NPV	**$ (105,163)**				

INCOME STATEMENT										
Year		2023		2024		2025		2026		2027
		5		6		7		8		9
Solar PV Sales	$	91,280	$	94,019	$	96,839	$	99,744	$	102,737
SREC sales	$	134,113	$	133,442	$	132,775	$	132,111	$	131,451
CHP Electricity sales	$	1,003,319	$	1,033,419	$	1,064,421	$	1,096,354	$	1,129,244
SHA #2 CHP Electricity Sales	$	11,690	$	12,041	$	12,402	$	12,774	$	13,157
SHA #1 CHP Electricity Sales	$	51,904	$	53,461	$	55,065	$	56,717	$	58,419
Steam Sales	$	226,406	$	230,934	$	235,553	$	240,264	$	245,069
SHA #2 Steam Sales	$	38,002	$	38,762	$	39,538	$	40,328	$	41,135
Total revenue	**$**	**1,556,715**	**$**	**1,596,078**	**$**	**1,636,593**	**$**	**1,678,293**	**$**	**1,721,212**
Annual PV O&M Costs	$	(4,035)	$	(4,115)	$	(4,198)	$	(4,282)	$	(4,367)
Annual CHP Fuel Costs	$	(717,423)	$	(731,771)	$	(746,406)	$	(761,335)	$	(776,561)
Annual CHP O&M costs	$	(326,000)	$	(332,520)	$	(339,170)	$	(345,953)	$	(352,872)
UPS Access fee costs			$	-	$	(1,000)	$	-	$	-
Total Expenses	**$**	**(1,047,457)**	**$**	**(1,068,406)**	**$**	**(1,090,774)**	**$**	**(1,111,570)**	**$**	**(1,133,801)**
EBITDA	**$**	**509,258**	**$**	**527,672**	**$**	**545,819**	**$**	**566,723**	**$**	**587,411**
Incentives										
CHP Incentives	$	-	$	-	$	-	$	-	$	-
CHP ITC										
Solar PV ITC	$	-	$	-	$	-	$	-	$	-
State/Local Grant	$	-	$	-	$	-	$	-	$	-
Cash Taxes										
EBITDA	$	509,258	$	527,672	$	545,819	$	566,723	$	587,411
Depreciation (MACRS %)		0%		0%						
CHP Depreciation ($)	$	-	$	-	$	-	$	-	$	-
Solar PV Depreciation ($)	$	-	$	-	$	-	$	-	$	-
EBIT	$	509,258	$	527,672	$	545,819	$	566,723	$	587,411
Interest	$	37,171	$	33,850	$	30,363	$	26,701	$	22,857
EBT	$	472,088	$	493,823	$	515,456	$	540,022	$	564,554
Cash Taxes	$	141,626	$	148,147	$	154,637	$	162,007	$	169,366
Cash Taxes (effective after NOL)	$	-	$	-	$	-	$	-	$	-
Net-Operating Loss										
NOL Beginning balance	$	1,722,566	$	1,580,940	$	1,432,793	$	1,278,156	$	1,116,149
NOL Used	$	141,626	$	148,147	$	154,637	$	162,007	$	169,366
NOL Ending Balanced	$	1,580,940	$	1,432,793	$	1,278,156	$	1,116,149	$	946,783
Debt Financing										
CFADS (Cash Flow Available for Debt Service)	$	367,632	$	379,526	$	391,182	$	404,717	$	418,045
Debt Outstanding (BOP)	$	743,411	$	676,992	$	607,253	$	534,027	$	457,140
Principal Payment	$	66,418.19	$	69,739.10	$	73,226.05	$	76,887.35	$	80,731.72
Interest Payment	$	37,171	$	33,850	$	30,363	$	26,701	$	22,857
Debt Outstanding (EOP)	$	676,992	$	607,253	$	534,027	$	457,140	$	376,408
Equity Financing										
Cash Flow to Equity	$	264,043	$	275,937	$	287,593	$	301,128	$	314,456
Present Value of Cash Flows	$	163,950	$	155,759	$	147,581	$	140,478	$	133,360
NPV										

INCOME STATEMENT					
Year	2028	2029	2030	2031	2032
	10	11	12	13	14
Solar PV Sales	$ 105,819	$ 108,993	$ 112,263	$ 115,631	$ 119,100
SREC sales	$ 130,793				
CHP Electricity sales	$ 1,163,122	$ 1,198,015	$ 1,233,956	$ 1,270,975	$ 1,309,104
SHA #2 CHP Electricity Sales	$ 13,552	$ 13,959	$ 14,377	$ 14,809	$ 15,253
SHA #1 CHP Electricity Sales	$ 60,171	$ 61,976	$ 63,836	$ 65,751	$ 67,723
Steam Sales	$ 249,970	$ 254,970	$ 260,069	$ 265,271	$ 270,576
SHA #2 Steam Sales	$ 41,958	$ 42,797	$ 43,653	$ 44,526	$ 45,416
Total revenue	**$ 1,765,385**	**$ 1,680,710**	**$ 1,728,154**	**$ 1,776,962**	**$ 1,827,172**
Annual PV O&M Costs	$ (4,455)	$ (4,544)	$ (4,635)	$ (4,727)	$ (4,822)
Annual CHP Fuel Costs	$ (792,092)	$ (807,934)	$ (824,093)	$ (840,575)	$ (857,386)
Annual CHP O&M costs	$ (359,930)	$ (367,128)	$ (374,471)	$ (381,960)	$ (389,600)
UPS Access fee costs	$ -	$ (1,000)	$ -	$ -	$ -
Total Expenses	**$ (1,156,477)**	**$ (1,180,607)**	**$ (1,203,199)**	**$ (1,227,263)**	**$ (1,251,808)**
EBITDA	**$ 608,909**	**$ 500,104**	**$ 524,955**	**$ 549,699**	**$ 575,365**
Incentives					
CHP Incentives	$ -	$ -	$ -	$ -	$ -
CHP ITC					
Solar PV ITC	$ -	$ -	$ -	$ -	$ -
State/Local Grant	$ -	$ -	$ -	$ -	$ -
Cash Taxes					
EBITDA	$ 608,909	$ 500,104	$ 524,955	$ 549,699	$ 575,365
Depreciation (MACRS %)					
CHP Depreciation ($)	$ -	$ -	$ -	$ -	$ -
Solar PV Depreciation ($)	$ -	$ -	$ -	$ -	$ -
EBIT	$ 608,909	$ 500,104	$ 524,955	$ 549,699	$ 575,365
Interest	$ 18,820	$ 14,582	$ 10,132	$ 5,459	$ 552
EBT	$ 590,088	$ 485,522	$ 514,824	$ 544,240	$ 574,812
Cash Taxes	$ 177,026	$ 145,657	$ 154,447	$ 163,272	$ 172,444
Cash Taxes (effective after NOL)	$ -	$ -	$ -	$ -	$ -
Net-Operating Loss					
NOL Beginning balance	$ 946,783	$ 769,757	$ 624,100	$ 469,653	$ 306,381
NOL Used	$ 177,026	$ 145,657	$ 154,447	$ 163,272	$ 172,444
NOL Ending Balanced	$ 769,757	$ 624,100	$ 469,653	$ 306,381	$ 133,937
Debt Financing					
CFADS (Cash Flow Available for Debt Service)	$ 431,882	$ 354,447	$ 370,508	$ 386,427	$ 402,921
Debt Outstanding (BOP)	$ 376,408	$ 291,640	$ 202,633	$ 109,176	$ 11,046
Principal Payment	$ 84,768.31	$ 89,006.72	$ 93,457.06	$ 98,129.91	$ 103,036.41
Interest Payment	$ 18,820	$ 14,582	$ 10,132	$ 5,459	$ 552
Debt Outstanding (EOP)	$ 291,640	$ 202,633	$ 109,176	$ 11,046	$ (91,990)
Equity Financing					
Cash Flow to Equity	$ 328,293	$ 250,859	$ 266,920	$ 282,838	$ 299,332
Present Value of Cash Flows	$ 126,571	$ 87,924	$ 85,049	$ 81,928	$ 78,824
NPV					

INCOME STATEMENT						
Year	2033	2034	2035	2036	2037	2038
	15	16	17	18	19	20
Solar PV Sales	$ 122,673	$ 126,353	$ 130,144	$ 134,048	$ 138,069	$ 142,212
SREC sales						
CHP Electricity sales	$ 1,348,377	$ 1,388,828	$ 1,430,493	$ 1,473,408	$ 1,517,610	$ 1,563,138
SHA #2 CHP Electricity Sales	$ 15,711	$ 16,182	$ 16,667	$ 17,167	$ 17,682	$ 18,213
SHA #1 CHP Electricity Sales	$ 69,755	$ 71,848	$ 74,003	$ 76,223	$ 78,510	$ 80,865
Steam Sales	$ 275,988	$ 281,507	$ 287,137	$ 292,880	$ 298,738	$ 304,713
SHA #2 Steam Sales	$ 46,325	$ 47,251	$ 48,196	$ 49,160	$ 50,143	$ 51,146
Total revenue	**$ 1,878,828**	**$ 1,931,969**	**$ 1,986,641**	**$ 2,042,887**	**$ 2,100,753**	**$ 2,160,287**
Annual PV O&M Costs	$ (4,918)	$ (5,017)	$ (5,117)	$ (5,219)	$ (5,324)	$ (5,430)
Annual CHP Fuel Costs	$ (874,534)	$ (892,025)	$ (909,865)	$ (928,063)	$ (946,624)	$ (965,556)
Annual CHP O&M costs	$ (397,392)	$ (405,339)	$ (413,446)	$ (421,715)	$ (430,149)	$ (438,752)
UPS Access fee costs	$ (1,000)		$ -		$ (1,000)	
Total Expenses	**$ (1,277,844)**	**$ (1,302,381)**	**$ (1,328,429)**	**$ (1,354,997)**	**$ (1,383,097)**	**$ (1,409,739)**
EBITDA	**$ 600,984**	**$ 629,588**	**$ 658,212**	**$ 687,890**	**$ 717,656**	**$ 750,548**
Incentives						
CHP Incentives	$ -	$ -	$ -	$ -	$ -	$ -
CHP ITC						
Solar PV ITC	$ -	$ -	$ -	$ -	$ -	$ -
State/Local Grant	$ -	$ -	$ -	$ -	$ -	$ -
Cash Taxes						
EBITDA	$ 600,984	$ 629,588	$ 658,212	$ 687,890	$ 717,656	$ 750,548
Depreciation (MACRS %)						
CHP Depreciation ($)	$ -	$ -	$ -	$ -	$ -	$ -
Solar PV Depreciation ($)	$ -	$ -	$ -	$ -	$ -	$ -
EBIT	$ 600,984	$ 629,588	$ 658,212	$ 687,890	$ 717,656	$ 750,548
Interest	$ -	$ -	$ -	$ -	$ -	$ -
EBT	$ 600,984	$ 629,588	$ 658,212	$ 687,890	$ 717,656	$ 750,548
Cash Taxes	$ 180,295	$ 188,877	$ 197,464	$ 206,367	$ 215,297	$ 225,164
Cash Taxes (effective after NOL)	$ 46,358	$ 188,877	$ 197,464	$ 206,367	$ 215,297	$ 225,164
Net-Operating Loss						
NOL Beginning balance	$ 133,937	$ -	$ -	$ -	$ -	$ -
NOL Used	$ 133,937	$ -	$ -	$ -	$ -	$ -
NOL Ending Balanced	$ -	$ -	$ -	$ -	$ -	$ -
Debt Financing						
CFADS (Cash Flow Available for Debt Service)	$ 420,689	$ 440,712	$ 460,749	$ 481,523	$ 502,359	$ 525,383
Debt Outstanding (BOP)	$ -	$ -	$ -	$ -	$ -	$ -
Principal Payment	$ -	$ -	$ -	$ -	$ -	$ -
Interest Payment	$ -	$ -	$ -	$ -	$ -	$ -
Debt Outstanding (EOP)	$ -	$ -	$ -	$ -	$ -	$ -
Equity Financing						
Cash Flow to Equity	$ 420,689	$ 440,712	$ 460,749	$ 481,523	$ 502,359	$ 525,383
Present Value of Cash Flows	$ 100,709	$ 95,912	$ 91,157	$ 86,606	$ 82,140	$ 78,095
NPV						

Appendix G – Estimated Timeframe

HCAM Implementation Timeline for Completion																													
					2018												2019												2020
	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Prepare Final Feasibility Study Report	X																												
Submit Final Report to BPU	X																												
Present Final Report to Stakeholders		X																											
Review and Accommodate BPU Comments	X	X																											
Submit BPU Investment-grade Planning Application				X	X																								
Prepare Implementation Plan						X	X	X	X	X																			
Prepare 70% Design Documents								X	X	X																			
Apply for Cooperative Contracting Unit / MUA						X	X																						
Perform Interconnection Study						X	X	X																					
Design Interconnection Facilities									X	X																			
Coordinate Utility Tariff Development						X	X	X	X	X																			
Facilitate Letter of Intent (LOI) with Project Operator										X																			
Serve Utility Accounts with Master Procurement Portfolio								X																					
Prepare Design, Build, Own, Operate and Maintain Contract							X	X	X																				
Submit Draft Implementation Plan to BPU											X																		
Review and Accommodate BPU Comments											X	X																	
Prepare 100% Design Documents												X	X	X															
Submit for Local and State Approvals														X	X														
Begin Construction																X													
Implement Energy Conservation Measures																X	X	X	X	X	X	X	X	X	X	X			
Install EV Charging Stations																					X	X	X						
Install PV and Electric Storage																					X	X	X	X	X	X			
Install CHP / Prime mover(s)																			X	X	X	X	X	X	X	X	X		
Install Thermal Distribution Piping																						X	X	X	X		X		
Install Thermal Storage																				X	X	X							
Complete Utility Interconnection																							X						
Complete Equipment Commissioning																											X		
Commercial Operation																												X	