GALLOWAY TOWNSHIP ADVANCED MICROGRID

Microgrid Feasibility Study Report

December 2018

Contents

I. Project Name

Greener by Design, LLC (GbD), GridIntellect (GI), and Dynamic Energy Networks (DEN) are pleased to submit this report of analysis, findings, and recommendations for the implementation of the Galloway Township Advanced Microgrid (GTAM) in Galloway, New Jersey. The New Jersey Board of Public Utilities (NJBPU) Town Center Distributed Energy Resource (TCDER) Microgrid Feasibility Program incentivized our analysis. This effort is in conjunction with the New Jersey Energy Master Plan, which aims to improve emergency preparedness and energy infrastructure resiliency as a whole, but especially following extreme weather events.

II. Project Applicant

Galloway Township submitted the initial NJBPU grant funding assistance application on March 27, 2018. Project partners include Galloway Township, Atlantic City Electric, South Jersey Industries, ShopRite, AtlantiCare Regional Medical Center, Bacharach Institute for Rehabilitation, Stockton University, the Galloway Township Board of Education, Absegami High School, Spring Village, and Seashore Gardens Living Center. Critical facilities involved include the Galloway Township Municipal Complex, ShopRite, AtlantiCare Regional Medical Center (Mainland Campus), Bacharach Institute for Rehabilitation, Stockton University, Reeds Road Elementary School, Roland Rogers Elementary School, Galloway Middle School, Absegami High School, Spring Village at Galloway, and Seashore Gardens Living Center. Of the critical facilities included, three (3) are classified as FEMA Category IV and eight (8) are classified as FEMA Category III.

III. Project Partners

Lead: Greener by Design, LLC

Greener by Design, LLC (**GbD**), 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 the Township of Galloway. **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: GridIntellect | Dynamic Energy Networks

GridIntellect

GridIntellect 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, our team focuses on delivering bespoke solutions for our clients, leveraging the latest in commercial technologies including geo-exchange HVAC, energy storage, renewable electricity generation, fuel cells and combined heat and power. We seek opportunities where multiple technological solutions can be brought to bear on a complex set of economic and environmental problems.

GridIntellect 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). GridIntellect 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.

GridIntellect development group possesses unique commercial and technical expertise in developing sustainable and efficient distributed energy resources.

Dynamic Energy Networks

Dynamic Energy Networks is a global independent energy infrastructure platform. As developer, owner, and operator of discrete power systems in the commercial and industrial (C&I), healthcare, municipal, and military markets, DEN combines world class modular technology solutions, deep industry expertise, and is backed by the Carlyle Group to deliver best-in-class, holistic energy infrastructure solutions to our customers.

DEN owns and operates microgrids and distributed energy resources (DER). Their infrastructure can work in parallel with or independent of the current utility grid and will be deployed in the commercial and industrial sector, as well as the municipality, healthcare, institutional campus, and military sectors. As owners and operators, they enable dynamism across microgrid infrastructure and innovate around contractual structures, providing bespoke solutions efficiently.

DEN will lead and influence the energy industry's revolutionary shift from one-way static power grids to two-way dynamic power infrastructure. As long-time investors and experts in clean energy, they are shaping the industry's next phase through innovative financing and technology solutions. They will continue to align themselves with "best-in-class" partnerships to guide their investors, partners, and customers to transformative energy markets.

DEN is committed to providing holistic solutions to address the breadth of our customer's energy needs. They are connecting customers to emerging two-way dynamic power infrastructure through the energy cloud. They provide cost effective, resilient, and secure clean energy that ensures a constant flow of high-quality power, through bespoke microgrids and distributed energy resources. Their microgrids deliver customers more flexibility, predictability, and control of energy usage to facilitate their transition to the grid of tomorrow, minimizing risk and maximizing benefits. They remove the capital risk for the end user to streamline implementation of new technology and achieve organizational goals.

DEN'S EXPERIENCE:

- Designed 60+ microgrids (including the commercial and industrial sectors), accounting for 200+ MW of capacity
- Built the first utility microgrid and the first community microgrid in the US
- Integrated twenty energy storage systems, up to 1,500 kWh (utility scale)

IV. Project Location

The Galloway Township Advanced Microgrid (GTAM)’s physical boundaries and distances between critical facilities is shown below in Figure 1: Map of Potential Stakeholders in Galloway Township Advanced Microgrid.

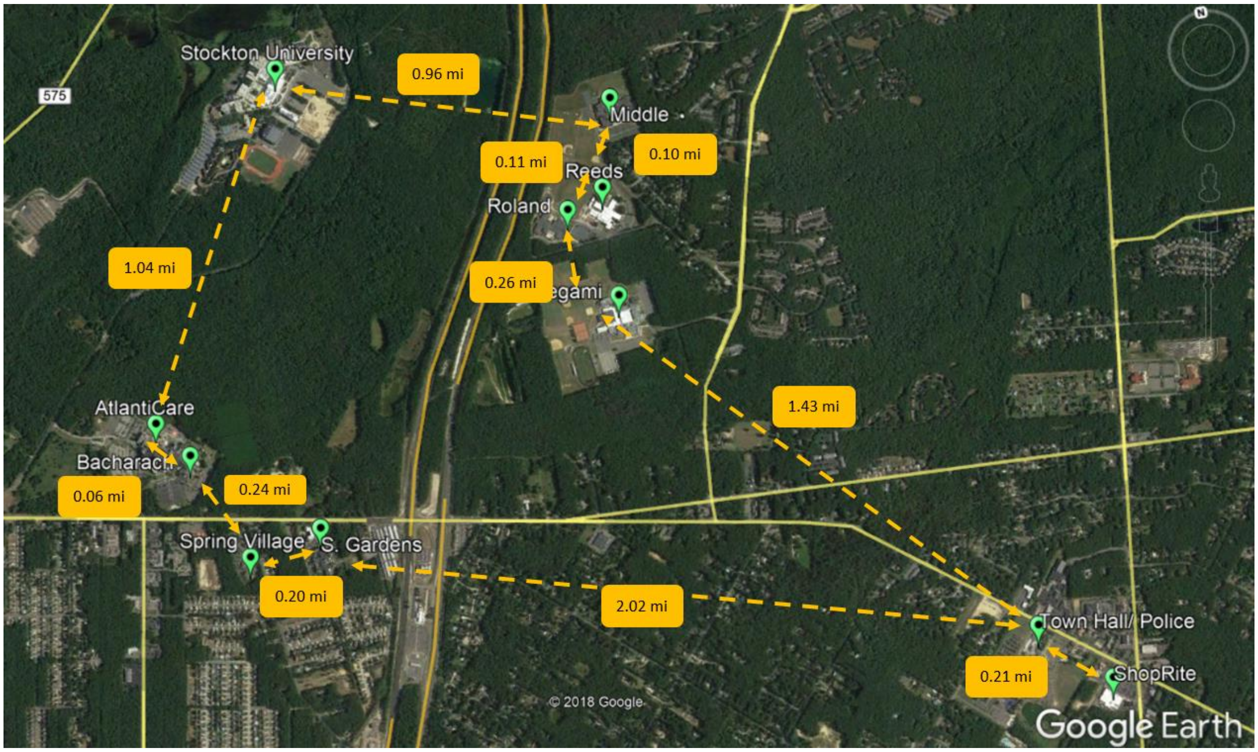


Figure 1: Map of Potential Stakeholders in Galloway Township Advanced Microgrid

V. Project Description

A. Executive Summary

Galloway Township has developed the concept for a mesh of microgrids that serves a diverse set of critical facilities in the local area. The system would connect facilities focused on public safety, healthcare, senior care, and education. A feasibility assessment determined whether these facilities could be connected with an underground cable, using existing utility infrastructure, or grouped into smaller, coordinated nodes.

At the onset of the GTAM TCDER Microgrid Feasibility Study, our team analyzed ten facilities, including the Galloway Township Municipal Complex, Reeds Road Elementary School, Roland Rogers Elementary School, Galloway Middle School, Absegami High School, Seashore Gardens Living Center, Sunrise of Galloway (presently called Spring Village at Galloway), AtlantiCare Regional Medical Center, Stockton University, and ShopRite. Given the large distance between critical facilities, our team determined that it was not feasible to connect all the facilities into one microgrid. Alternatively, the facilities were grouped into five individual "nodes," based on proximity to one another, facility characteristics and load profiles, and electrical circuitry in the area. Each node functions as its own microgrid by supplying energy to the facilities within that node, but all of the nodes can be operated together from the same software. In addition, it is not anticipated that any Right-of-Ways will be required for this project. Unfortunately, due to cost constraints, ShopRite was not determined feasible to be included at this time, although it potentially could be added on in a second phase of the GTAM.

Each node would incorporate its own suite of distributed energy resource (DER) technologies, such as solar photovoltaic (PV) systems, energy storage system (ESS), and combined heat and power (CHP) units. These technologies would be run during "blue-sky," or normal conditions, and generate revenue mainly from the sale of electricity, hot water, and steam to the node they are connected to. During "black-sky" conditions, or conditions were the local utility grid is experiencing an outage, the microgrid will utilize all its generation assets, along with the emergency backup generator assets already in place, to provide power and potentially heat to the critical facilities identified in each node.

The strength of the GTAM approach lies in the diversity of critical facilities it leverages, their proximity to each other, and their accessible location for citizens of Galloway. The primary driver of this application is the Galloway Township government, but the inclusion of other facilities will broaden its resiliency and sustainability benefits while also increasing the total system size and, therefore, the ability to finance it as a project. Resiliency benefits of the targeted sites include:

- Node 1: The Municipal Complex houses the town hall and police station, which are critical for serving public safety, coordinating disaster response, and maintaining public services.
- Node 2: Stockton University (Stockton) teaches almost nine thousand students. In addition to protecting their security and the integrity of on-going research, a microgrid would enable Stockton to leverage its facilities for shelter and triage should that become necessary. The recently expanded AtlantiCare Regional Medical Center (AtlantiCare) has 540 beds and was recently ranked the fifth best hospital in New Jersey by US News and World Report, located on Stockton University's property. Keeping this facility operating at full strength is a critical lynch pin in the energy resiliency throughout this part of New Jersey. Finally, Bacharach Institute for Rehabilitation's Outpatient Physical Therapy Center (Bacharach) is located adjacent to AtlantiCare and provides essential services to those recovering from injury. This facility was added to the critical facility list during the GTAM Study.
- Node 3: Reeds Road Elementary School, Roland Rogers Elementary School, Galloway Middle School, and Absegami High School are located on a tightly clustered campus across the Garden State Parkway from Stockton University. Maintaining the safety and security of Galloway's youth is an extremely high priority of this system. In addition, school facilities could be utilized for shelter, triage, and response coordination in the event of an emergency.
- Node 4 and 5: Spring Village of Galloway (Node 4) and Seashore Gardens Living Center (Node 5) serve over one hundred of Galloway's senior citizens. These residents rely on additional energy requirements in terms of safety and cannot easily relocate in times of emergency.

The microgrid nodes were modeled with HOMER Pro and DER-CAM software, using an Energy First Portfolio Approach. The Energy First Approach optimizes asset-level operations for economic benefit. This includes operating combined heat and power (CHP) in continuous-duty full loading, instead of load-following operation, to minimize fuel cost, maintenance, and under-utilized capital assets. The PV generation supplements with available energy, while the ESS operates to maximize economic and resiliency benefits. The grid fulfills any gaps in a load-following mode. The connection to the grid will also be used to manage the voltage and frequency of the microgrid in blue-sky conditions. During black-sky operations, such as a utility outage, the microgrid will utilize all distributed energy resources (DERs) on-site, including existing emergency backup generator assets. The Energy First Portfolio Approach relies on integrating ESS to provide multiple functions, even at the same time, to the microgrid. These include basics like voltage support and frequency support. The preferred design implies that the hours of operation when the load is met using on-site generation is very high throughout a year (greater than eighty percent), while the rest of the hours are met with assistance from the utility grid.

The suite of DERs selected for each node accounts for electrical and thermal distributions. Sites that utilize ground source heat pump systems prominently (Node 1 and Node 2) are best paired with PV and ESS. Large thermal loads, like healthcare steam system or heated pools, are best paired with CHP. New automated switchgear is required at existing utility interconnections. In all nodes, one point of common coupling (PCC) will operate closed while all others will normally remain open. This will focus more reliance on new or existing underground infrastructure, which is more resilient. A single PCC makes synchronization and feeder management more manageable for the microgrid operator and utility.

B. Critical Facility Electrical and Thermal Loads

Galloway Township Municipal Complex

Galloway Township Municipal Complex	
Address	300 E. Jimmie Leeds Road, Galloway, NJ
Risk Category	IV
Area (Sq. Ft.)	64,929
Annual Electric Consumption (kWh)	542,494
Annual Gas Consumption (Therms)	7,627
Node Number	1

The Municipal Complex, built in 1940, consists of four buildings including the main building, the multipurpose building, municipal building, and police department, which are configured in in the shape of a U. The main building consists of offices, conference rooms, and break rooms. The multipurpose building consists of offices on the upper level, a post-office on the main level, and storage in the basement. The building loops around to the courtroom, which contains the prosecutors' offices at the rear of the building, adjacent to the police station. The Galloway Township Municipal Complex is a critical facility for the GTAM because it is responsible for maintaining public order and safety in the case of back-sky occurrence.

The Municipal Complex is prepared with two natural gas generators, including a 125-kW generator for the municipal building and a 100-kW generator for the police department and AT&T tower.

Retrofit options exist to improve controlling, monitoring, and scheduling more efficient operations, especially in preparation for a microgrid. These include installing smart, communicating thermostats that include WiFi and standard equipment communication protocols (i.e. BACnet, Modbus, Lonworks, etc) and LED light dimming. The thermostats are appropriate for air-source HVAC units and ground-source heat pumps. LED dimmers should operate with WiFi and other smart home protocols (i.e. Z-Wave, Zigbee, Alexa, Apple HomeKit, Ecobee, Google, Logitech Harmony, Lutron, Nest, Proprietary App, Samsung SmartThings, Siri, Wink).

Galloway Township Municipal Complex: Electric and Gas Data					
Month	**Consumption (kWh)**	**Total Electric Cost ($)**	**Electric Demand (kW)**	**Consumption (Therms)**	**Total Natural Gas Cost ($)**
January	64,845	$8,453.49	131.1	2,414	$3,113.07
February	37,570	$5,041.50	129.2	1,345	$1,774.73
March	47,881	$6,346.58	120.3	1,253	$1,687.91
April	38,685	$5,161.00	111.3	592	$814.29
May	15,432	$3,056.95	118.2	106	$226.19
June	64,672	$8,175.25	123.3	6	$108.08
July	56,384	$7,525.77	141	2	$93.88
August	52,157	$6,955.45	129	190	$323.96
September	42,278	$5,804.42	127.8	13	$94.95
October	38,476	$5,053.76	117.6	32	$122.32
November	46,849	$6,171.45	117.9	634	$913.69
December	37,265	$4,824.22	123.9	1,040	$1,450.36
Annual:	**542,494**	**$72,569.84**	**124.2**	**7,627**	**$10,723.43**
	**Some natural gas costs are estimated, based on the data available.*				

Table 1: Galloway Township Municipal Complex Electric and Gas Data

ShopRite

ShopRite	
Address	401 S Pitney Road, Galloway, NJ
Risk Category	III
Area (Sq. Ft.)	54,815
Annual Electric Consumption (kWh)	2,669,491
Annual Gas Consumption (Therms)	32,897
Node Number	-

The ShopRite (grocery store and pharmacy) is located next to the Municipal Complex and can play a critical role in maintaining services during an energy outage event. ShopRite is a regional grocery store chain that operates every day from 7 AM to 11 PM. It is based in Keasbey, New Jersey and is owned by the Wakefern Food Corporation. The ShopRite of Galloway is approximately 54,815 square feet and is rated as a Tier III in the FEMA risk category. ShopRite houses large quantities of perishable food and water. In a black sky scenario, ShopRite connected to the microgrid can maintain the capability to distribute food, water, and supplies to those in the surrounding area. In addition, many medications require refrigeration and extended power loss at this facility could leave local residents without access to those medications for some period of time.

Unfortunately, given the physical distance between the Municipal Complex and ShopRite, it was not feasible to include it in Node #1. Given the critical nature of ShopRite, its viability can be determined as a second phase to Node #1 in the future.

Stockton University

Stockton University	
Address	101 Vera King Farris Drive, Galloway, NJ
Risk Category	III
Area (Sq. Ft.)	1,010,882
Annual Electric Consumption (kWh)	28,723,130
Annual Gas Consumption (Therms)	607,151.09
Node Number	2

Stockton University is a public university that was established in 1969. It serves about nine thousand students from in and out of state and contains six housing units on campus. Though Stockton University emphasizes sustainable energy, it can still benefit from connection to the GTAM. Connection to the microgrid would add an extra layer of energy resiliency to the campus, helping to protect students, staff, technology, and information from emergency circumstances, like hurricanes, cyber-attacks, or power outages. Moreover, the university generates significant amounts of thermal and electric energy, making it the perfect addition to the advanced microgrid.

On Stockton University's 1600 acres, there are over 2.5 MW of PV systems, including both roof-mounted PV arrays and PV parking lot canopies, which generate electricity throughout Stockton's campus. In addition, Stockton has a closed loop system of four hundred geothermal wells which supplies heating and cooling to a few hundred-thousand square feet of their buildings on their academic campus. Electric Vehicle (EV) Charging Stations were recently added to some of the parking lots and Stockton has the goal to implement a total of sixteen EV Charging Stations throughout campus. There are four main electric meters for the campus, including one for the Main Campus, two for the Housing Units, and one for Plant Management, with the main electrical service coming from the north. There is one main gas account for the entire Stockton campus.

Stockton University: Electric and Gas Data					
Month	**Consumption (kWh)**	**Total Electric Cost ($)**	**Electric Demand (kW)**	**Consumption (Therms)**	**Total Thermal Cost ($)**
January	2,240,176	$208,063.51	5,202	75,163.92	$56,621.53
February	2,223,799	$206,577.65	5,248	90,292.70	$67,927.49
March	2,183,708	$200,645.83	5,110	50,623.27	$38,216.91
April	2,188,109	$194,301.01	5,007	48,634.27	$36,747.35
May	2,070,818	$184,451.47	4,999	48,335.49	$36,568.67
June	2,179,122	$185,559.81	5,715	39,137.14	$29,721.69
July	2,433,639	$213,564.43	5,757	28,953.35	$22,023.34
August	2,721,893	$234,287.73	5,586	26,964.68	$20,542.75
September	2,832,421	$258,213.86	6,439	31,497.16	$23,940.65
October	2,845,723	$256,057.23	5,216	40,334.90	$30,572.94
November	2,504,133	$224,536.62	5,179	48,719.00	$36,958.13
December	2,299,589	$208,660.59	5,156	78,495.22	$59,172.38
Annual:	**28,723,130**	**$2,574,919.74**	**6,439**	**607,151.09**	**$459,013.42**
**There are five electric meters and nine natural gas meters included.* ***Some estimations were used on the cost data.*					

Table 2: Stockton University Electric and Gas Data

AtlantiCare Regional Medical Center, Mainland Campus

AtlantiCare Regional Medical Center, Mainland Campus	
Address	65 W. Jimmie Leeds Road, Galloway, NJ
Risk Category	IV
Area (Sq. Ft.)	434,743
Annual Electric Consumption (kWh)	16,394,400
Annual Gas Consumption (Therms)	756,820.97
Node Number	2

AtlantiCare is a health system based out of Atlantic County, serving mainly southeastern New Jersey. The AtlantiCare Regional Medical Center provides a number of services to the area, including an Ambulatory Care Center, Center for Childbirth, Emergency Department, Inpatient Care, Pharmacy, and Primary Stoke Center. Connection to the GTAM would provide additional resiliency to a facility that requires to function on a 24/7 basis. In addition, its high thermal load makes a CHP system feasible at this location.

AtlantiCare's primary heating comes from four Cleaver Brooks boilers, and contains three separate steam systems, including one for sterilization, one for hot water reheat, and one for domestic hot water. The facility is primarily cooled by three chillers, with a total cooling capacity of 2,240 tons, and condenser water cooled by a few cooling towers. AtlantiCare receives two separate 13 kV feeds, with none of their equipment currently back feeding the grid. It has two electric meters, as well as two gas meters. AtlantiCare has three generators on-site, with approximately 1,900 kW of capacity.

Retrofit options exist, beyond steam CHP, to improve controlling, monitoring, and scheduling more efficient operations. This includes upgrading outdoor air dampers to integrate with the Building Automation System (BAS) for load modulation based on occupancy and installing LED light dimming with commercial standard wireless controls.

AtlantiCare Regional Medical Center: Electric and Gas Data					
Month	**Consumption (kWh)**	**Total Electric Cost ($)**	**Electric Demand (kW)**	**Consumption (Therms)**	**Total Thermal Cost ($)**
January	1,195,200	$153,611.49	2,145.6	81,229.23	$57,041.05
February	1,101,600	$142,148.12	2,224.8	75,795.20	$58,839.81
March	1,202,400	$147,882,33	2,217.6	70,966.32	$55,091.15
April	1,231,200	$151,424.42	2,347.2	66,137.43	$51,342.49
May	1,504,800	$185,074.29	2,779.2	61,308.55	$48,166.98
June	1,519,200	$186,845.34	2,836.8	49,620.45	$40,976.84
July	1,656,000	$203,541.53	2,822.4	44,983.12	$37,890.40
August	1,785,600	$193,545.30	2,988	45,369.36	$36,709.49
September	1,440,000	$176,993.65	2,534.4	47,899.03	$36,685.88
October	1,368,000	$165,679.20	2,433.6	53,550.90	$41,285.30
November	1,188,000	$145,026.76	2,260.8	74,351.94	$55,219.85
December	1,202,400	$155,049.21	2,059.2	85,609.44	$63,549.02
Annual:	**16,394,400**	**$2,006,821.63**	**2,470.8**	**756,820.97**	**$582,789.26**
**There are five electric meters and nine natural gas meters included.* ***Some estimations were used on the cost data.*					

Table 3: AtlantiCare Regional Medical Center Electric and Gas Data

Bacharach Institute for Rehabilitation

Bacharach Institute for Rehabilitation	
Address	61 W Jimmie Leeds Road, Pomona, NJ
Risk Category	IV
Area (Sq. Ft.)	51,327
Annual Electric Consumption (kWh)	2,965,977
Annual Gas Consumption (Therms)	85,801.30
Node Number	2

The Bacharach Institute for Rehabilitation is an acute medical rehabilitation hospital adjacent to the AtlantiCare Regional Medical Center, Mainland Campus. The facility itself encompasses over 50,000 square feet and is occupied 24/7. It has eighty patient beds in two wings. Patients released from the hospital often spend additional recovery time at Bacharach, where staff specializes in stroke, spinal cord injury, brain injury, sports medicine, and physical therapy. With in- and out-patients, Bacharach demands high electric and thermal loads. It is critical to include this facility in the planned microgrid because of its proximity to AtlantiCare, the vulnerability of its patients, and its high energy loads. Connection to the microgrid will help patients continue to receive medical treatment, regardless of massive grid failures or storms. The facility lost power for ten hours during Hurricane Sandy, which put patients and staff at risk; in addition, the facility often loses power during summer storms.

The primary heating for the facility comes from one Weil-McLain boiler and three packaged Thermal Solutions boilers, with a total heating capacity of approximately 9,500 MBH. There are no steam or sterilization requirements at the facility. Bacharach contains a pool, which is kept at 92°F. The primary cooling comes from two 450-ton centrifugal chillers, with one additional chiller in reserve. Electrically, the service comes from two feeds, and the facility has three meters. There are two backup diesel generators on site, including a 1000 kW generator for the entire building and a 192-kW life safety generator, with a 1200-amp automatic transfer switch. Bacharach has two gas meters. The facility used to have a cogeneration unit, but it has been nonoperational for about twenty years.

Retrofit options exist, beyond hot water CHP, to improve controlling, monitoring, and scheduling more efficient operations when included in the microgrid. This includes adding control points in the BAS for the cooling tower VFD and optimizing the boiler and chiller plant with an all-variable speed operation that specifically maximizes the existing York centrifugal chillers. This recommendation will allow the BAS to operate, but will enhance its capabilities, and better enable the microgrid to respond in emergencies, while still maintaining thermal comfort.

Bacharach Institute for Rehabilitation: Electric and Gas Data

Month	**Consumption (kWh)**	**Total Electric Cost ($)**	**Electric Demand (kW)**	**Consumption (Therms)**	**Total Natural Gas Cost ($)**
January	246,725	$30,846.50	504	16,804.86	$13,045.62
February	197,866	$25,767.11	502	9,963.41	$7,734.60
March	207,727	$26,413.96	499	11,455.16	$8,892.64
April	219,773	$28,621.12	535	7,197.47	$5,587.40
May	254,709	$32,284.27	583	3,950.60	$3,066.85
June	272,224	$33,366.60	591	3,914.16	$3,038.56
July	330,811	$40,464.78	639	3,195.87	$2,480.95
August	310,640	$40,544.72	613	5,081.12	$3,944.47
September	275,210	$35,778.64	585	3,936.02	$3,055.53
October	254,530	$33,852.95	585	4,196.27	$3,257.57
November	196,841	$26,479.58	499	6,420.89	$4,984.54
December	198,921	$31,776.50	498	9,685.46	$7,518.83
Annual:	**2,965,977**	**$386,196.73**	**639.08**	**85,801.30**	**$66,607.55**

**Gas cost data estimated using AtlantiCare data.*

Table 4: Bacharach Electric and Gas Data

Reeds Road Elementary School

Reeds Road Elementary School	
Address	103 S Reeds Road, Galloway, NJ
Risk Category	III
Area (Sq. Ft.)	89,638
Annual Electric Consumption (kWh)	1,033,200
Annual Gas Consumption (Therms)	27,588
Node Number	3

Reeds Road Elementary School (Reeds) is an approximately 84,000 square foot facility, built around thirty years ago. It is located on Reeds Road and serves children from kindergarten to grade six and is adjacent to the Roland Rogers Elementary School and the Galloway Middle School. It has the capacity to serve as a shelter in case of an emergency. For these reasons, Reeds Road Elementary School should be included as a critical facility in the advanced microgrid.

There is only one mechanical room in the school, with a boiler and domestic hot water heater. The Metasys Building Management System (BMS) controls individual units within the school and adjacent schools. Reeds Road Elementary School has one electric and one gas meter. The gas meter for Roland Rogers is included in the data below, as they have the same account number. The roof is about ten to fifteen years old. The school has recently implemented a replacement of exterior lighting with LED exterior wall packs and parking lot lights. In addition, Reeds Road Elementary School has a 100-kW on-site generator.

The primary energy efficiency options that exist to improve controlling, monitoring, and scheduling more efficient operations in the microgrid are related to the BAS. These include retro commissioning of the BAS, increasing the hot water and cold water temperature differences between the supply and return sides to 20 degrees F (i.e. implementing occupancy-based temperature setbacks or demand-based setbacks), and cooling tower temperature setbacks. Others include continuing to upgrade lighting to dimmable LEDs.

Reeds Road Elementary School: Electric and Gas Data

Month	Consumption (kWh)	Total Electric Cost ($)	Electric Demand (kW)	Consumption (Therms)	Total Natural Gas Cost ($)
January	103,280	$13,189.35	220.0	6,478	$9,108.43
February	80,720	$10,440.81	212.0	2,751	$3,868.49
March	90,560	$11,767.73	180.0	3,175	$4,464.20
April	73,680	$9,866.95	203.2	1,898	$2,668.27
May	68,240	$9,518.94	271.2	524	$736.23
June	97,600	$13,291.86	328.8	373	$523.99

July	88,560	$11,411.52	268.0	80	$112.70
August	94,880	$11,665.13	299.2	123	$172.71
September	90,240	$11,727.56	300.0	228	$320.54
October	99,440	$12,509.83	315.2	1,065	$1,497.34
November	62,800	$8,678.10	284.8	3,516	$4,944.28
December	83,200	$10,517.86	212.0	7,377	$10,371.58
Annual:	**1,033,200**	**$134,585.64**	**257.9**	**27,588**	**$38,788.77**
**There are two gas meters included, one for Reeds Road and one for Roland Rogers Elementary Schools.* ***Natural gas costs are estimated, based on the data available.*					

Table 5: Reeds Road Elementary Electric and Gas Data

Roland Rogers Elementary School

Roland Rogers Elementary School	
Address	105 S Reeds Road, Galloway, NJ
Risk Category	III
Area (Sq. Ft.)	98,579
Annual Electric Consumption (kWh)	693,300
Annual Gas Consumption (Therms)	Included in Reeds Road data
Node Number	3

Located on Reeds Road, the Roland Rogers Elementary School (Roland Rogers) is an approximately 92,000 square foot facility, built around twenty-six years ago. It serves children from kindergarten to grade six in the Galloway Public School District. Roland Rogers is a critical facility to include in the advanced microgrid, as it is adjacent to two other schools, serves as a shelter-in-place, and produces reasonable electric and thermal loads.

The primary heating is provided by two boilers for space heating, and two boilers for domestic hot water. The Metasys BMS controls individual units within the school and adjacent schools. Roland Rogers Elementary School has one electric and one gas meter. The school has recently implemented a replacement of exterior lighting with LED exterior wall packs and parking lot lights, as well as a replacement of an older rooftop unit for the cafeteria. In addition, Roland Rogers Elementary School has a 70-kW on-site generator.

Roland Rogers has similar BAS controls as Reeds and could benefit from similar energy efficiency upgrades.

Roland Rogers Elementary School: Electric and Gas Data			
Month	**Consumption (kWh)**	**Total Electric Cost ($)**	**Electric Demand (kW)**
January	70,800	$9,566.22	225.0
February	61,800	$7,808.81	0.0
March	57,300	$7,627.13	177.0

April	52,500	$7,550.44	240.0
May	50,400	$7,076.09	201.0
June	63,300	$8,836.40	228.0
July	56,100	$7,554.71	198.0
August	58,200	$7,544.28	201.0
September	58,500	$7,935.74	216.0
October	57,300	$7,583.80	219.0
November	51,300	$6,878.25	204.0
December	55,800	$7,192.39	189.0
Annual:	**693,300**	**$93,152.26**	**191.5**

Table 6: Roland Rogers Elementary School Electric and Gas Data

Galloway Middle School

Galloway Middle School	
Address	100 S Reeds Road, Galloway, NJ
Risk Category	III
Area (Sq. Ft.)	158,791
Annual Electric Consumption (kWh)	756,900
Annual Gas Consumption (Therms)	46,366.14
Node Number	3

Galloway Middle School is an approximately 150,000 square foot facility, built around eighteen years ago, located within a quarter mile of Reeds and Roland Rogers. Maintaining the safety and security of Galloway’s youth is an extremely high priority of this system. In addition, the school facility could be utilized for shelter, triage, and response coordination in the event of an emergency.

The primary heating is provided by two 4,000 MBH Unilux flexible water tube boilers, and the primary cooling is provided by a York centrifugal chiller. The Metasys BMS controls individual units within the school and adjacent schools. Galloway Middle School has one electric and one gas meter. The school has recently implemented a replacement of exterior lighting with LED exterior wall packs and parking lot lights. The facility has 305.67 kW DC of rooftop PV, currently covering most of the roof, as well as a back-up generator.

The primary energy efficiency options that exist to improve controlling, monitoring, and scheduling more efficient operations influence the chiller plant operations and equipment. The school will benefit from optimizing the boiler and chiller plant with an all-variable speed operation that specifically maximizes the existing York centrifugal chiller. This recommendation will allow the BAS to operate, but will enhance its capabilities, and better enable the microgrid to respond in emergencies, while still maintaining thermal comfort.

Middle School: Electric and Gas Data					
Month	Consumption (kWh)	Total Electric Cost ($)	Electric Demand (kW)	Consumption (Therms)	Total Natural Gas Cost ($)
January	65,700	$9,875.15	243	10,118.52	$14,226.89
February	51,600	$7,776.42	225	5,579.76	$7,845.28
March	51,000	$7,789.60	249	6,485.43	$9,118.68
April	34,200	$5,266.56	231	3,466.53	$4,874.03
May	62,100	$9,704.55	363	1,946.67	$2,737.07
June	81,900	$12,987.07	408	2,862.75	$4,025.10
July	68,700	$10,966.40	387	1,780.11	$2,502.88
August	59,700	$9,298.05	363	1,769.70	$2,488.24
September	77,100	$12,251.97	420	2,321.43	$3,263.99
October	83,100	$12,534.53	429	2,134.05	$3,000.53
November	63,300	$9,619.55	417	3,039.72	$4,273.92
December	58,500	$8,704.75	276	4,861.47	$6,835.35
Annual:	**756,900**	**$116,774.60**	**429**	**46,366.14**	**$65,191.96**
**Natural gas costs are estimated, based on the data available.*					

Table 7: Middle School Electric and Gas Data

Absegami High School

Absegami High School	
Address	201 S Wrangleboro Road, Galloway, NJ
Risk Category	III
Area (Sq. Ft.)	290,428
Annual Electric Consumption (kWh)	3,976,173
Annual Gas Consumption (Therms)	62,480.82
Node Number	3

Absegami High School is part of the Greater Egg Harbor Regional High School District and serves about 1,300 kids in grades nine through twelve. The approximately 300,000 square foot facility was designed in 1980 and built in 1982, with an addition built in 1990. Microgrid connection would ensure the safety of students and staff during an emergency. It would also ensure consistent power supply to the school in case of black-sky conditions, which would otherwise impede learning and other activities. Finally, the school's significant electric and thermal loads, in addition to its PV generation, make it an obvious choice for the microgrid.

Absegami High School is heated and cooled by a boiler / chiller system to serve eleven hallways and eighty of the 126 classrooms, as well as thirty-five heat pump rooftop units for the rest of the facility. The heat pumps use electricity to power the pumps but gas to heat the air. There is one main electric meter and four smaller meters, two of which are for lighting. Absegami High

School also has one gas meter. The high school has PV parking canopies and roof-mounted arrays, as well as a 255-kW on-site generator.

One energy efficiency option is installation hot water CHP with the kitchen hot water tanks and locker room facilities, which is included in the microgrid designs. This requires an investment grade audit for the CHP to confirm the equipment sizing, the heat recovery capabilities available, and the control capabilities to allow hot water temperatures to float above minimum setpoints with equipment engine and storage vessel parameters.

Absegami High School: Electric and Gas Data					
Month	**Consumption (kWh)**	**Total Electric Cost ($)**	**Electric Demand (kW)**	**Consumption (Therms)**	**Total Natural Gas Cost ($)**
January	421,227	$89,249.07	871.4	18,144.63	$25,511.81
February	324,438	$44,294.60	795.5	9,598.02	$13,495.06
March	334,232	$90,496.61	793.1	11,503.05	$16,173.58
April	267,899	$38,513.84	861.1	5,954.52	$8,372.20
May	323,344	$84,454.37	823.8	874.44	$1,229.48
June	326,849	$123,475.48	858.3	541.32	$761.11
July	351,112	$80,361.99	785.3	239.43	$336.64
August	344,299	$40,847.21	805.4	270.66	$380.55
September	341,137	$42,239.74	962	395.58	$556.20
October	319,938	$81,976.28	877.9	811.98	$1,141.66
November	292,912	$35,790.58	793.7	5,048.85	$7,098.81
December	328,786	$38,752.66	769	9,098.34	$12,792.49
Annual:	**3,976,173**	**$790,452.43**	**962**	**62,480.82**	**$87,849.60**
**Natural gas costs are estimated, based on the data available.*					

Table 8: Absegami High School Electric and Gas Data

Spring Village at Galloway

Spring Village at Galloway	
Address	46 W Jimmie Leeds Road, Galloway, Nj
Risk Category	III
Area (Sq. Ft.)	118,660
Annual Electric Consumption (kWh)	1,139,100
Annual Gas Consumption (Therms)	74,536
Node Number	4

Spring Village is a senior residential and community center. About 130 elders reside at Spring Village and are cared for by medical and nursing staff. Patients with advanced memory loss are closely monitored by full-time nurses and aids through the Memory Care Program. In addition to communal and outdoor spaces, residents can enjoy a beauty salon, psychiatrist, occupational therapist, dental and hearing specialists, and in-house nurse practitioners. Spring Village is a critical facility to the microgrid project because of its proximity to other critical facilities and its vulnerable clientele that rely on consistent power for their wellbeing. The facility has a 100-kW generator and a 125-kW generator.

The conversion of lighting to LEDs with dimming capabilities is a great energy efficiency option for these buildings.

Spring Village: Electric Data			
Month	Consumption (kWh)	Electric Demand (kW)	Total Electric Cost ($)
January	129,470	281	$16,246.35
February	94,154	244	$11,814.77
March	97,840	264	$12,277.30
April	98,160	218	$12,317.46
May	89,449	198	$11,224.37
June	82,455	146	$10,346.74
July	111,706	193	$14,017.26
August	102,429	181	$12,853.15
September	80,140	149	$10,056.25
October	86,677	150	$10,876.53
November	77,273	140	$9,696.48
December	89,347	165	$11,211.57
Annual:	**1,139,100**	**194**	**$142,938.23**
**Consumption based on Homer modeling. **Electric cost data estimated from Seashore Gardens data.*			

Table 9: Spring Village Electric and Gas Data

Seashore Gardens Living Center

Seashore Gardens Living Center	
Address	22 W Jimmie Leeds Road, Galloway, NJ
Risk Category	III
Area (Sq. Ft.)	137,922
Annual Electric Consumption (kWh)	2,211,600
Annual Gas Consumption (Therms)	53,205.51
Node Number	5

Seashore Gardens is an elder care residence and community center located in Galloway Township. The facility is approximately 125,000 square feet and is about seventeen years old. The center offers several services like nursing, Alzheimer's and Dementia care, rehabilitation, home health care, independent housing, long term care, recreational therapies, physical therapy, and respite. Many elders rely on medical equipment to monitor and regulate bodily functions, so reliable energy supply is crucial to the safety and wellbeing of residents. For this reason, the

Seashore Gardens Living Centers should be included in the GTAM as a critical facility. The facility currently has a 500-kW generator, but GTAM would offer them additional benefits to better help them to serve the people who rely on it.

The conversion of lighting to LEDs with dimming capabilities is a great energy efficiency option for these buildings.

Seashore Garden Living Center: Electric and Gas Data					
Month	**Consumption (kWh)**	**Total Electric Cost ($)**	**Electric Demand (kW)**	**Consumption (Therms)**	**Total Natural Gas Cost ($)**
January	220,800	$27,200.44	381	10,430.82	$14,665.99
February	162,400	$19,928.87	381	6,599.94	$9,279.68
March	167,200	$21,754.94	381	6,360.51	$8,943.04
April	172,400	$21,769.95	381	4,871.88	$6,849.99
May	158,400	$20,094.97	381	2,893.98	$4,069.01
June	200,400	$24,523.09	428	2,862.75	$4,025.10
July	254,000	$33,135.34	640	2,373.48	$3,337.17
August	201,600	$25,140.53	476	2,435.94	$3,424.99
September	183,200	$22,741.22	396	2,935.62	$4,127.56
October	181,200	$22,379.72	381	2,311.02	$3,249.35
November	155,200	$19,484.15	381	3,570.63	$5,020.40
December	154,800	$19,366.04	381	5,558.94	$7,816.01
Annual:	**2,211,600**	**$277,519.26**	**640**	**53,205.51**	**$74,808.28**
**Natural gas costs are estimated, based on the data available.*					

Table 10: Seashore Garden Living Center Electric and Gas Data

C. Total Microgrid Project Electrical and Thermal Load

Each group of buildings located along similar utility feeders were grouped together into microgrid nodes. Each nodes' electric utility data, followed by natural gas data, can be seen below. Subsequent energy modeling required modification and calibration to the interval load curves to account for all on-site usage, as shown in later sections. The size of each node also varied, with Node 1 being 64,929 square feet, Node 2 being 1,496,952 square feet, Node 3 being 637,436 square feet, Node 4 being 118,660 square feet, and Node 5 being 137,922 square feet.

The energy consumption characteristics for each facility included in the microgrid, as well as the microgrid as a whole, are typical for a facility 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, each facility 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.

Node 1 – Galloway Township Municipal Complex

Node 1 Total					
Month	**Energy (kWh)**	**Demand (kW)**	**Electric Cost**	**Usage (Therm)**	**Total Natural Gas Cost ($)**
Jan	64,845	131.1	$8,453.49	2,409	$3,113.07
Feb	37,570	129.2	$5,041.50	1,345	$1,774.73
Mar	47,881	120.3	$6,346.58	1,254	$1,687.91
Apr	38,685	111.3	$5,161.00	592	$814.29
May	51,032	118.2	$3,056.95	106	$226.19
Jun	64,672	123.3	$8,175.25	8	$108.08
Jul	56,384	141	$7,525.77	210	$93.88
Aug*	52,157	129	$6,955.45	3	$323.96
Sept*	42,278	127.8	$5,804.42	14	$94.95
Oct*	38,476	117.6	$5,053.76	293	$122.32
Nov*	46,849	117.9	$6,171.45	721	$913.69
Dec*	37,265	123.9	$4,824.22	689	$1,450.36
Total kWh /Peak kW	578,094	141	**$72,569.84**	*7,645*	**$10,723.43**

Table 11: Node 1 Total Projected Electrical and Thermal Loads

Node 2- Stockton University, Bacharach, and AtlantiCare

Month	**Node 2 Total**				
***2017**	**Energy (kWh)**	**Demand (kW)**	**Energy Cost ($)**	**Usage (Therm)**	**Gas Cost ($)**
Jan	3,682,101	7,852	$392,521.50	173,198	$126,708.20
Feb	3,523,265	7,975	$374,492.88	176,051	$134,501.90
Mar	3,593,835	7,827	$227,059.79	133,045	$102,200.70
Apr	3,639,082	7,889	$374,346.55	121,969	$93,677.24
May	3,830,327	8,362	$401,810.03	113,595	$87,802.50
Jun	3,970,546	9,143	$405,771.75	92,672	$73,737.09
Jul	4,420,450	9,218	$457,570.74	77,132	$62,394.69
Aug*	4,818,133	9,187	$468,377.75	77,415	$61,196.71
Sept*	4,547,631	9,559	$470,986.15	83,332	$63,682.06
Oct*	4,468,253	8,235	$455,589.38	98,082	$75,115.81
Nov*	3,888,974	7,939	$396,042.96	129,492	$97,162.52
Dec*	3,700,910	7,713	$395,486.30	173,790	$130,240.23
Total kWh /Peak kW	48,083,507	*9,558.6*	$4,967,938.10	*1,449,773*	$1,108,410.23

Table 12: Node 2 Total Projected Electric and Thermal Loads

Node 3 –Reeds, Roland Rogers, Galloway Middle School, and Absegami High School

Month	**Node 3 Total**				
***2017**	**Energy (kWh)**	**Demand (kW)**	**Electric Cost ($)**	**Usage (Therm)**	**Gas Cost ($)**
Jan	661,007	1,606	$121,879.79	34,741	$48,847.13
Feb	518,558	1,467	$70,320.64	17,929	$25,208.83
Mar	533,092	1,489	$117,681.07	21,163	$29,756.46
Apr	428,279	1,599	$61,197.79	11,319	$15,914.50
May	504,084	1,659	$110,753.95	3,345	$4,702.78
Jun	569,649	1,823	$158,590.81	3,777	$5,310.20
Jul	564,472	1,638	$110,294.64	2,100	$2,952.22
Aug*	557,079	1,696	$69,354.67	2,163	$3,041.50
Sept*	566,977	1,910	$74,155.01	2,945	$4,140.73
Oct*	559,778	1,841	$114,604.44	4,011	$5,639.53
Nov*	470,312	1,700	$60,966.48	11,605	$16,317.01
Dec*	526,286	1,501	$65,167.66	21,337	$29,999.42
Total kWh /Peak kW	6,459,573	***1,910***	$1,134,964.93	136,435	$191,830.33

Table 13: Node 3 Total Projected Electric and Thermal Loads

Nodes 4 and 5 – Spring Valley at Galloway and Seashore Gardens Living Center

Month	**Node 4**			**Node 5**		
***2017**	**Energy (kWh)**	**Demand (kW)**	**Electric Cost**	**Energy (kWh)**	**Demand (kW)**	**Electric Cost ($)**
Jan	129,470	561	$16,246.35	220,800	381	$27,200.44
Feb	94,154	608	$11,814.77	162,400	381	$19,928.87
Mar	97,840	820	$12,277.30	167,200	381	$21,754.94
Apr	98,160	606	$12,317.46	172,400	381	$21,769.95
May	89,449	496	$11,224.37	158,400	381	$20,094.97
Jun	82,455	491	$10,346.74	200,400	428	$24,523.09
Jul	111,706	481	$14,017.26	254,000	640	$33,135.34
Aug*	102,429	501	$12,853.15	201,600	476	$25,140.53
Sept*	80,140	516	$10,056.25	183,200	396	$22,741.22
Oct*	86,677	551	$10,876.53	181,200	381	$22,379.72
Nov*	77,273	561	$9,696.48	155,200	381	$19,484.15
Dec*	89,347	561	$11,211.57	154,800	381	$19,366.04
Total kWh /Peak kW	**1,139,100**	*820*	**$142,938.23**	**2,211,600**	640	**$277,519.26**

Table 14: Nodes 4 and 5 Total Projected Electric and Thermal Loads

D. Critical Facility and Overall Project Energy Costs

As Galloway's Electric Distribution Company (EDC), Atlantic City Electric (ACE) serves proposed microgrid customers under the Annual General Service-Primary (AGSP), Annual General Service-Secondary (AGSS), and Monthly General Service-Secondary (MGSS) tariffs, which includes the following components, as per the October 1, 2018 effective notice. ***Error! Reference source not found.***_15_ shows these values including NJ Sales and Use Tax (SUT), below. Slight variations from these published values were present on available 2016-2017 customer bills (PDF) and, as a result, customer billing and modeled load curves using rate structures do not match exactly.

Itemized Charges in Tariffs	**AGSP, with SUT (pg. 21 of 79)**		**AGSS, with SUT (pg. 19 of 79)**		**MGSS, with SUT (pg. 13 of 79)**	
Seasons	**Summer**	**Winter**	**Summer**	**Winter**	**Summer**	**Winter**
Service Charge = ($/month)	581.03		160.86		8.29 (1ph)/9.65 (3ph)	
All-Included Usage Charge ($/kWh)	0.0706	0.0697	0.0747	0.0746	0.1300	0.1243
Distribution Charge ($/kWh)	N/A	N/A	N/A	N/A	0.049023	0.044283
Basic Service Charge ($/kWh)	0.063112	0.062255	0.067249	0.067141	0.073478	0.072515
Societal Benefits Charge ($/kWh)	0.009533		0.009789		0.0064	
Third-Party Supplier	Customer Specific					
Solar PPA	Customer Specific					
Standby Service Charge ($/kW)	1.15 (N/A)		1.32 (N/A)		0.46 (N/A)	
Distribution Demand ($/kW)	7.50		9.38		2.06	1.69
Transmission Demand ($/kW)	3.80		3.68		3.43	3.05
Winter Season: Defined as October 1 to May 31 Summer Season: Defined as June 1 to September 30 On-Peak: 8am – 10pm weekdays Off-Peak: all other times						

Table 15: ACE Rate Tariffs for Galloway Microgrid Customers

As Galloway's Gas Distribution Company (GDC), South Jersey Industries (SJI) serves proposed microgrid customers under the General Service (GSG), General Service – Large Volume (GSG-LV), and Electric Generation Service (EGS) tariffs, which includes the following components, as per the October 1, 2018 effective notice. ***Error! Reference source not found.***_16_ shows these values including NJ Sales and Use Tax (SUT), below.

Itemized Charges in Tariffs As of 10/1/2018	**GSG, with SUT (pg. 10 of 178)**		**GSG-LV, with SUT (pg. 14 of 178)**		**EGS, with SUT (pg. 38 of 178)**	
Seasons	**Summer**	**Winter**	**Summer**	**Winter**	**Summer**	**Winter**
Service Charge = ($/month)	31.955513		159.9375		67.478925	
Firm Delivery Charge ($/therm)	0.687784		0.408384		0.211346	0.243334

Basic Service Charge ($/therm)	0.427864	0.427864	N/A
Societal Benefits Charge ($/therm)	0.151528	0.151528	0.151528
Third-Party Supplier	Customer Specific		
Delivery Demand ($/Mcf)	N/A	10.245170	8.362812
Winter Season: Defined as billing months of November through March Summer Season: Defined as billing months of April through October *Must be less than 20Mcf per day			

Table 16: SJG Rate Tariffs for Galloway Microgrid Customers

The summary table of the electric and natural gas data received demonstrates the type of information received and the engineering opinions and modeling required to apply it to the microgrid modeling.

Fuel Type	Electric	Natural Gas
Months of continuous usage	Twelve to twenty-four	Most accounts, twelve months
Time Period of Data	2015-2018	2015-2018
Interval Data	For large accounts (four at Stockton University, and one at Absegami High)	N/A
Cost Data	Most accounts, twelve months	Few months
Data Used in Model	Calibrated, hourly interval data (or load estimations), including DER production estimates.	Calibrated, hourly interval data (or load estimations), including DER production estimates.
Modifications Required	Interpolations from charts and graphs, calibrations of prototype building load profiles within 5 percent of actual data, averaging nearby data points to fill in exclusions or erroneous information. See section VI.A for more details.	Calibrations of prototype building load profiles within 5 percent of actual data, averaging nearby data points to fill in exclusions or erroneous information. See section VI.A for more details.

Table 17: Summary of Customer Utility Load Data Provided and Used

E. 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 Galloway Township 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.

	Facility Name	Address	Shelter Area (SF)	Potential Emergency Shelter Hours
1	Galloway Township Municipal Complex	300 E. Jimmie Leeds Road, Galloway, NJ	O	N/A
2	Stockton University	101 Vera King Farris Drive, Galloway, NJ	505,441	24/7
2	AtlantiCare Regional Medical Center	65 W Jimmie Leeds Road, Pomona, NJ	0	N/A
2	Bacharach Institute for Rehabilitation (Mainland Campus)	61 W Jimmie Leeds Road, Pomona, NJ	0	N/A
3	Absegami High School	201 S Wrangleboro Road, Galloway, NJ	145,214	24/7
3	Galloway Middle School	100 South Reeds Road, Galloway, NJ	79,396	24/7
3	Reeds Road Elementary / Roland Rogers Elementary	103 S Reeds Road, Galloway, NJ	94,109	24/7
4	Spring Village at Galloway	46 W Jimmie Leeds Road, Galloway, NJ	0	N/A
5	Seashore Gardens Living Center	22 W Jimmie Leeds Road, Galloway, NJ	0	N/A

F. 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

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

VI. Ownership and Business Model

A. Ownership Model

Galloway Township may act as a lead agency for the Galloway Township Advanced Microgrid Cooperative (GTAM-Cooperative). Each GTAM local contracting unit can participate in compliant procurement activities with Galloway Township acting on each local contracting unit’s behalf. Private partners may enter a public-private partnership or redevelopment agreement with the GTAM Cooperative, potentially forming a common holding company or special-purpose corporate entity.

There are various ownership structures and business models that will affect the economics of the project. Depending on each stakeholders’ financial, operational, and risk appetite, below are several structures to consider:

a) Direct Ownership: the stakeholders will individually or jointly own, build, operate and maintain the microgrid project. This option will usually result in an on-balance sheet transaction, and require a combination of internal capital budgeting, grant, incentives, bank financing or bonding capability.

b) Third-Party Ownership: under this structure, a third-party will own, build, operate, and maintain the microgrid. Most of the financial, construction, operation and maintenance risks are transferred to the third-party owner.

As discussed in further detail below in the “NJBPU and EDC Tariff Requirements” section of the report, it may be most beneficial to the GTAM for the utility to own some or all of the distribution assets, while the generation assets could be owned by any of the above structures, especially given that the EDC has the current maintenance and oversight capabilities and expertise to upkeep those distribution assets.

B. Business Model

Based on the Energy Service Agreement (ESA) structure, the billing structure is envisioned to bill electricity and thermal energy as follows:

a) Electricity: the owner of the microgrid will bill each off-taker for the energy delivered from the project at point of delivery measured by kWh on a monthly basis.
b) Thermal: Hot Water/Steam will be measured in BTU or other agreed units at the delivery point. It can also be converted to kWh by using a pre-agreed engineering model for the purpose of billing.

Other potential markets, including PJM demand response, are detailed in the "NJBPU and EDC Tariff Requirements" section of the report, and will depend on microgrid tariffs and future interconnection procedures and regulations.

C. Other Contractual Considerations

Projects are sized to meet the technical and financial requirements of the community stakeholder. A contractual approach safeguards that these objectives are met during the term of the project. The energy producer can then ensure that minimum energy production levels are reached and delivered on a regular schedule.

Long-term contract vehicles are structured to quantify the level of these services to be provided in the form of equipment, service delivery, and energy pricing. This provides the off-takers with price certainty for the services delivered by the project over the life of the contract. Depending on individual circumstances, contracts may have provisions that address performance requirements such as minimum delivery or equipment availability. Pricing and payment mechanisms are based on the delivery of the energy at determined rates (i.e. $/kWh and/or $/MMBTU). The contract will also include provisions to address the risk and responsibility of natural gas purchases, equipment maintenance and replacement.

Striking the balance between governance and risk can be best managed with aligned objectives and best captured in contractual agreements. Governance obligations and protections facilitate alignment of interests and transparency through provisions that address stewardship obligations, step-in rights, and termination rights. Within these arrangements, matters such as governance and stewardship obligations, along with other protections, serve to facilitate complementary interests and transparency. The addition of Key Performance Indicators (KPIs) ensures further alignment of mutual objectives.

Equipment disposition is another key element of the contract where the DER owners have flexibility in structure. Options include buyout provisions during the contract, asset transfer at the end of the contract, extension of the contract, or equipment removal at the end of the contract.

VII. Technology, Business, and Operational Protocol

A. Node Descriptions

Each of the node energy data sets required a series of modifications and assumptions to make the information useful for modeling microgrids. The general process included:

- Collecting the last twelve months of data (electric or natural gas) and twelve months of fifteen minute to one-hour interval data;
- Averaging previous months or years consumption to fill gaps of a continuous twelve months;
- Identifying the closest building usage to the Prototype Commercial Buildings, developed by national labs and the model of the same climate region to find a corresponding electrical load curve for the full facility and natural gas load curve for the full facility;
- Calibrate the load curves to the twelve months of electric (kWh and kW, when available) and natural gas (therms), thereby using 36 data points, of different dimensions, to align the Prototype load curve to create an estimated load curve for the customer;
- Identify the size of existing DER resources (i.e. solar panel arrays) and collect any available data for their actual production;
- Create an energy production load curve for the DER asset; and
- Adapt the facility load curve by adding the DER production to account for the full facility consumption and demand, prior to the net metering of the assets.

Each customer's interval load curves were compiled and utilized for microgrid modeling. Based on the design approach to provide seamless transitions from grid-connected to islanded operations, and the reverse, each node required a minimum amount of energy storage, given the other capacities of existing or planned DER in the node. Table 18: Sizing Minimum Energy Storage System for Microgrid Without Existing Backup Generators shows the results for sizing.

Sizing Minimum Energy Storage System for Microgrid w/o Existing Back Up Generators (EDGs)					
Nodes	**1**	**2**	**3**	**4**	**5**
MG or BUG as primary during Outage	MG	MG	MG	MG	MG
Peak (kW)	143	8,687	1,910	315	640
CHP (kW)	-	2,720	762	-	130
Load Mod (kW)	-	500	50	-	-
BUG (kW, excluded)	225	2,192	2,305	225	500
BUG exceeds Peak	Y	N	Y	N	N
Likely Separate or Entire Emergency Bus	Entire	Separate	Entire	Separate	Separate

Transition (kW)	143	4,787	908	315	478
ESS (kWh)	72	2,394	454	158	239
PCS/Inverter (kW)	36	1,197	227	79	119
Sizing Minimum Energy Storage System for Microgrid w/ Existing Back Up Generators (EDGs)					
Likely Separate or Entire Emergency Bus	Entire	Separate	Entire	Separate	Separate
PV (kW DC)	292	6,066	350	71	133
Transition	(138)	2,047	(1,974)	34	(148)
ESS (kWh)	73	1,024	88	17	33
PCS/Inverter	(35)	512	(493)	8	(37)

Table 18: Sizing Minimum Energy Storage System for Microgrid Without Existing Backup Generators

Node 1 is a geographically dense and small system that includes existing emergency diesel gensets (EDG), a ground source heat pump system for HVAC needs at the police station, and individual thermostat controls. See Figure 2: Node 1 Conceptual Design Overview below. New resources can utilize roof space for 65 kW of PV arrays and a PV parking canopy of 227 kW (see Appendix A for PV Helioscope Summaries and Potential Layouts), which could include an EV charger. The ESS was sized to incorporate the short-term ramp time of the diesel gensets and immediate load shedding control, while addressing the momentary power requirements from an unintentional islanding event. A microgrid controller (MGC) may be able to interoperate with building systems for load modulation (i.e. shedding, ramping, shifting) with appropriate upgrades to thermostats for immediate temperature setbacks and lighting sensors for dimming, although not required. More attention is required to integrate the MGC with the existing ground source heat pump system, since varying pumping speeds to match PV production in outage scenarios could provide substantially longer times of islanding in resilience events.


Conceptual Design Overview – Node 1

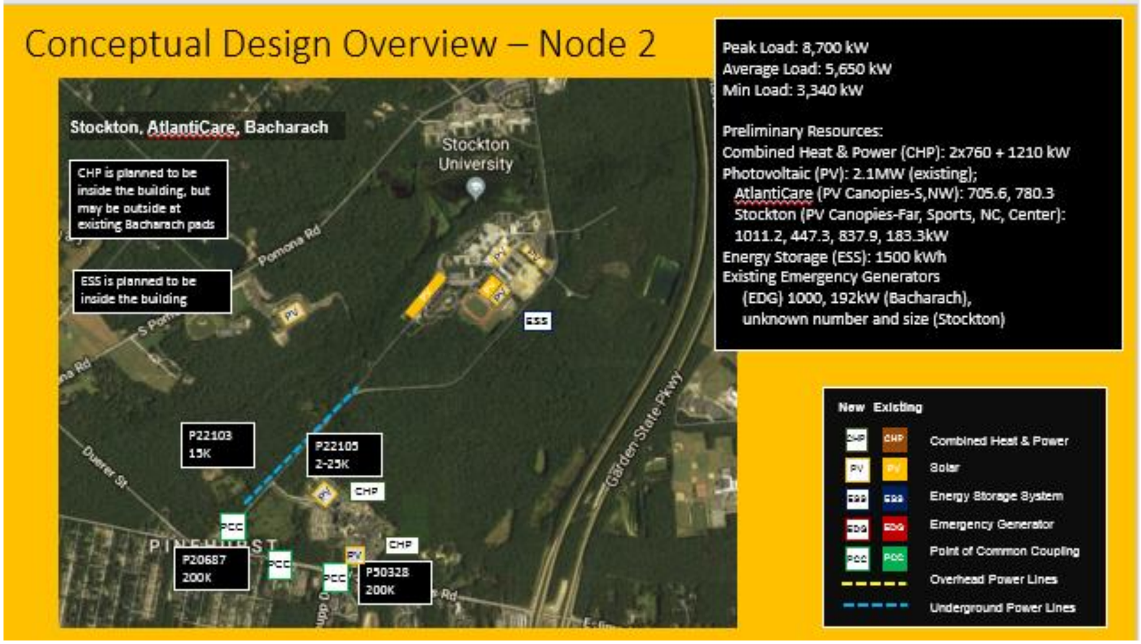
Peak Load: 143 kW
Average Load: 65 kW
Min Load: 10 kW

Preliminary Resources:
Existing Emergency Generators
(EDG) 125, 100 kW
Photovoltaic (PV): 65.2kW (roof max);
226.8kW (canopy max)
Energy Storage (ESS): 70kWh

ESS is planned to be inside the building

Figure 2: Node 1 Conceptual Design Overview

Node 2 is a geographically large and dispersed design, encompassing the length of the Stockton University property from the edge of Jimmie Leeds Road to the main university campus. See Figure 3: Node 2 Conceptual Design Overview. There are two healthcare buildings with large thermal demands, including both steam and hot water, with a robust, electrically-based campus utilizing various PV canopies and ground source heat pumps. These disparate campuses combine ideally through a combination of new CHP at the major thermal loads, with steady electrical output to add firm capacity to the large electrical network with variable, controllable loads and predictable, variable generation in PV canopies. The CHP provides large inertia for the large active and reactive power balancing required for the university campus, due to the number of large motors and variable frequency drives on equipment. Other resources at Stockton include EDGs, defined and validated demand response sequences, a network of underground cables, EV charging stations as potential scheduled loads. Bacharach has existing pads from a previous CHP design for the pool. AtlantiCare was in the process of installing and commissioning an all variable speed chiller plant design that is a great asset for load modulation in emergencies, energy efficiency, increased flexibility to receive and reject thermal energy (i.e. excess heat recovery) and peak demand control. The greatest area of further study is the thermal heat recovery capacities at each healthcare center and the space for interconnection to the chiller and boiler plants.



Conceptual Design Overview – Node 2

Peak Load: 8,700 kW
Average Load: 5,650 kW
Min Load: 3,340 kW

Preliminary Resources:
Combined Heat & Power (CHP): 2x760 + 1210 kW
Photovoltaic (PV): 2.1MW (existing);
AtlantiCare (PV Canopies-S,NW): 705.6, 780.3
Stockton (PV Canopies-Far, Sports, NC, Center): 1011.2, 447.3, 837.9, 183.3kW
Energy Storage (ESS): 1500 kWh
Existing Emergency Generators
(EDG) 1000, 192kW (Bacharach),
unknown number and size (Stockton)

Stockton, AtlantiCare, Bacharach

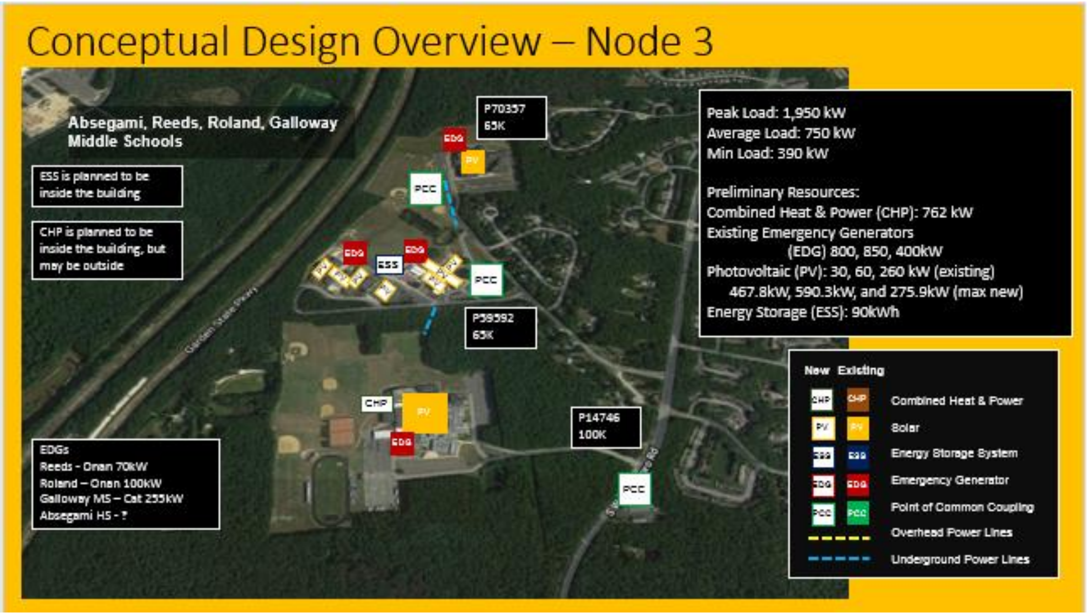
CHP is planned to be inside the building, but may be outside at existing Bacharach pads

ESS is planned to be inside the building

New	Existing	
CHP	CHP	Combined Heat & Power
PV	PV	Solar
ESS	ESS	Energy Storage System
EDG	EDG	Emergency Generator
PCC	PCC	Point of Common Coupling
- - - - -	- - - - -	Overhead Power Lines
- - - - -	- - - - -	Underground Power Lines

Figure 3: Node 2 Conceptual Design Overview

Node 3 is a contiguous group of spacious properties for educational purposes. See Figure 4: Node 3 Conceptual Design Overview. The primary and secondary schools host an EDG at each location and rooftop PV arrays covering significant portions of two schools. The elementary schools support ample space for additional PV systems. While the elementary schools have limited options for heat recovery, there are some opportunities at Absegami High School with its aging boilers and storage tanks for locker rooms and kitchen use. Another option is Galloway Middle School, although those systems were both newer and included excess capacity already. Given the high variability in daytime usage and large seasonal variation related to building usage and academic schedules, the system benefits from more ESS than a standard commercial space. Valuable areas for further investigation include MGC integration with the various building management systems utilized at each building and developing the critical load prioritization to aid load modulation for emergency events. The resilient design requires a modest amount of underground cabling between parking lots along emergency roadways and the Galloway Middle School entrance.



Conceptual Design Overview – Node 3

Absegami, Reeds, Roland, Galloway Middle Schools

ESS is planned to be inside the building

CHP is planned to be inside the building, but may be outside

EDGs
Reeds - Onan 70kW
Roland – Onan 100kW
Galloway MS – Cat 255kW
Absegami HS - ?

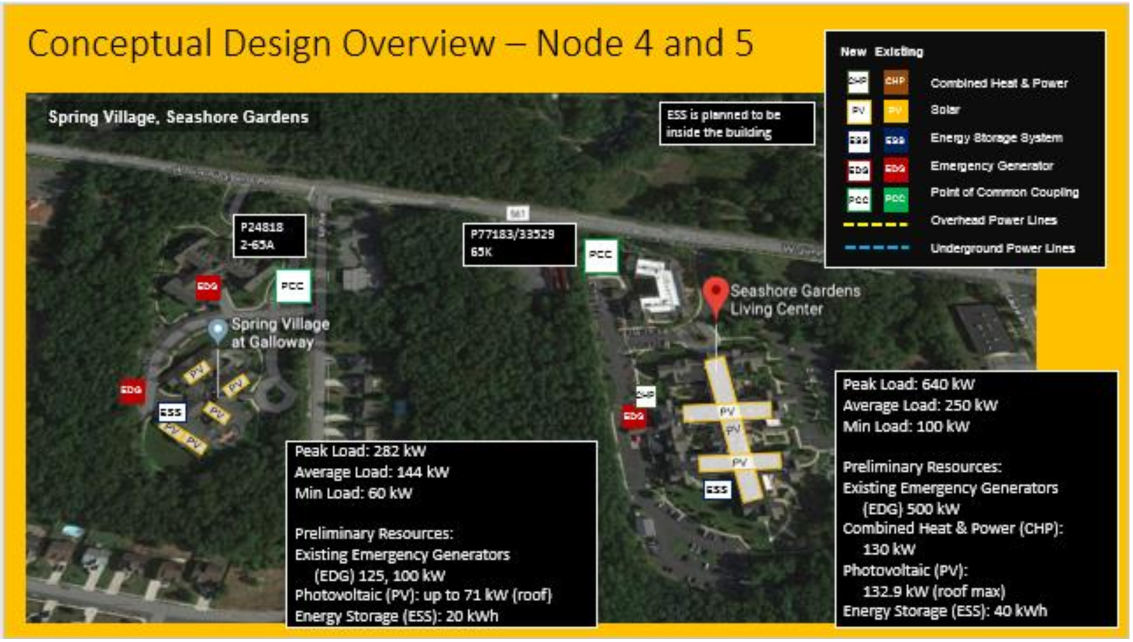
Peak Load: 1,950 kW
Average Load: 750 kW
Min Load: 390 kW

Preliminary Resources:
Combined Heat & Power (CHP): 762 kW
Existing Emergency Generators
(EDG) 800, 850, 400kW
Photovoltaic (PV): 30, 60, 260 kW (existing)
467.8kW, 590.3kW, and 275.9kW (max new)
Energy Storage (ESS): 90kWh

Figure 4: Node 3 Conceptual Design Overview

Node 4 is a more traditional, single site design for residential loads at Spring Village. Due to the nature of smaller HVAC equipment and a majority of lighting loads without a robust building management system, load modulation controls are limited to smart thermostat integration and retrofit dimming capabilities. See Figure 5 below. The EDG can meet a significant portion of the load for the majority of the year. The roof space, tilt angle, and shading created major limitations to the amount of new PV capacity. Therefore, the ESS needs to compensate for less on-site production, or said differently, the larger gap between the on-site power production and the potential islanded power demand. The basic system components and limited communication integrations allows for a much simpler and less expensive MGC. The areas to investigate further include the addition of energy efficiency and load control measures, like dimmable LEDs, smart thermostats, and higher efficiency PV panels.

Node 5 is similar to Node 4 in many ways, including its simplicity, a basic MGC, and single site residential loads at Seashore Gardens. See Figure 5 below. It differs in operating one CHP unit as well as a single EDG, larger HVAC equipment like cooling towers and multi-stage boilers, and more ample, suitable roof space for PV arrays or PV canopies. Areas to explain further include a firm investment-grade evaluation of the heat recovery opportunities in replacing the heat loading for one, two, or more of the staged boilers and an integration with the cooling tower to reject heat in the rare cases when excess thermal energy is available.



Conceptual Design Overview – Node 4 and 5

Spring Village, Seashore Gardens

ESS is planned to be inside the building

Peak Load: 282 kW
Average Load: 144 kW
Min Load: 60 kW

Preliminary Resources:
Existing Emergency Generators (EDG) 125, 100 kW
Photovoltaic (PV): up to 71 kW (roof)
Energy Storage (ESS): 20 kWh

Peak Load: 640 kW
Average Load: 250 kW
Min Load: 100 kW

Preliminary Resources:
Existing Emergency Generators (EDG) 500 kW
Combined Heat & Power (CHP): 130 kW
Photovoltaic (PV): 132.9 kW (roof max)
Energy Storage (ESS): 40 kWh

Figure 5: Nodes 4 and 5 Conceptual Design Overview

B. Proposed Connections

The Galloway Township microgrids are designed within the ACE distribution network on the Lenox Pomona, Absecon Whitehorse, Absecon Highland, and Moss Mill Wrangleboro 12kV feeders. Node 1 requires a single PCC to island three municipal buildings, normally closed and synchronized with the grid (NJ0995). Node 2 requires at least three, but possibly up to six PCCs to island the healthcare operations and the group of university loads. Two or more of the PCCs will normally operate open, with one PCC closed along the main feeder, as opposed to one PCC closed on the 2ph lateral to the Stockton campus. Node 2 also requires undergrounding cable to connect customer loads between the healthcare operations (Entrance Road) and the lateral feeder (NJ0933) to the campus (Vera King Farris Drive). Maintaining closed connection with the preferred feeder (NJ0993) will support greater synchronization with the grid, allow for faster response to support grid ancillary services, and align with the Stockton Master Planning upgrades. Node 3 can operate in a similar manner to Node 2. The microgrid requires additional underground cable between a non-public access road (Emergency Road) from Absegami High School and the elementary schools, and a second underground cable from the elementary schools to the Galloway Middle School (northern parking lot exit along Reeds Road). Node 3 requires three PCCs, such that two are open and one along the main feeder (NJ2545) is closed. This preferred connection results in higher utility synchronization, improved longevity in the energy storage operations, and reduced variability on feeder sections from different PV installations. Node 4 and Node 5 are similarly sized and designed nodes. Both require one PCC to the main feeder (NJ0993), although both have limited space for adding PV installations. Instead, these both rely on utilizing their existing assets (EDGs) during grid outages, but instead of partial circuits, these will operate to support full building loads in concert with the PV and ESS. With microgrid controls to manage ESS state of charge, the EDGs will run more efficiently and less often, leading to increased services and reduced carbon impact for the services.

C. Connection Diagram

The One-Line Diagrams are shown below in Figures 6 through 10, representing each nodes' connection to the ACE feeders.

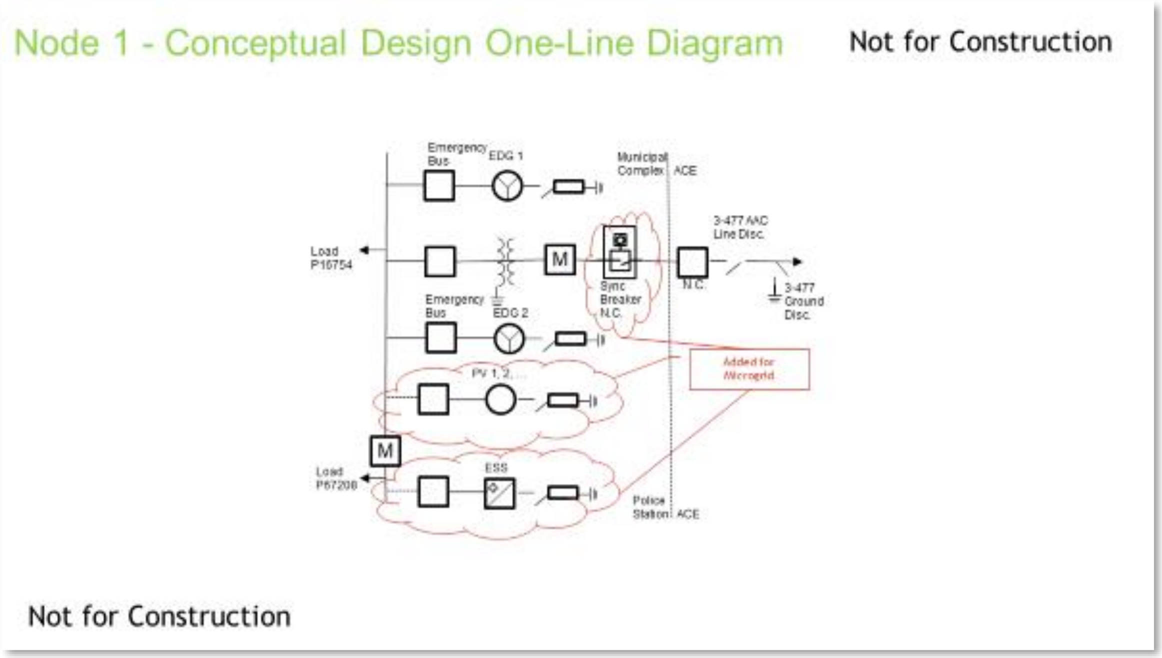
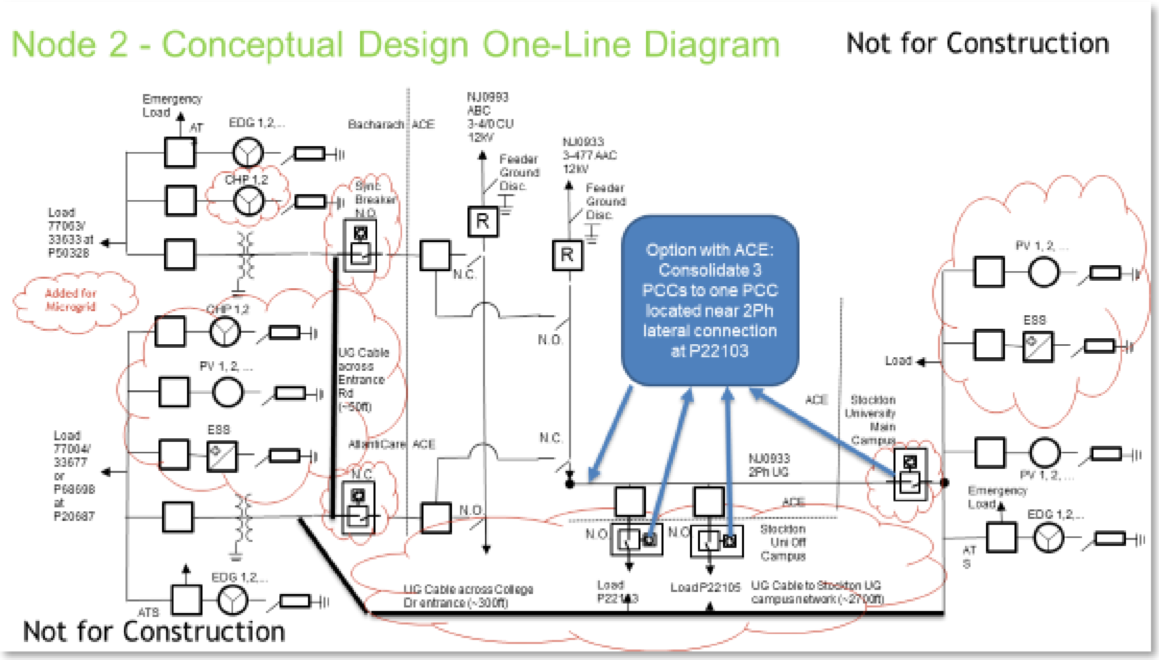
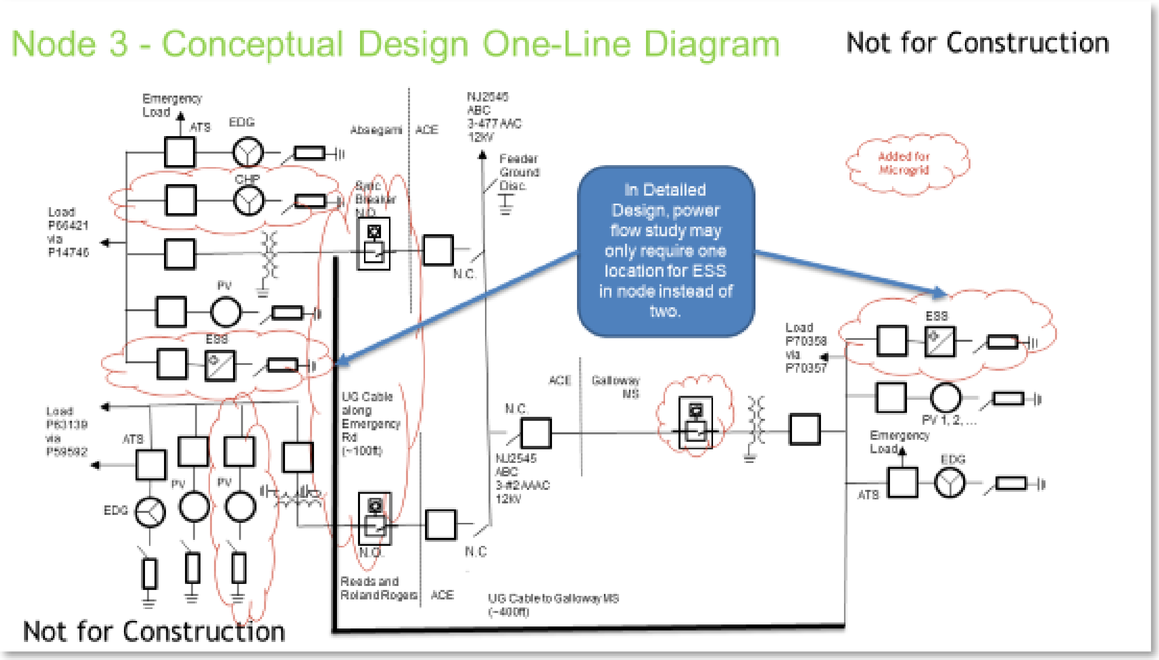


Figure 6: Node 1 Conceptual Microgrid One-Line Diagram



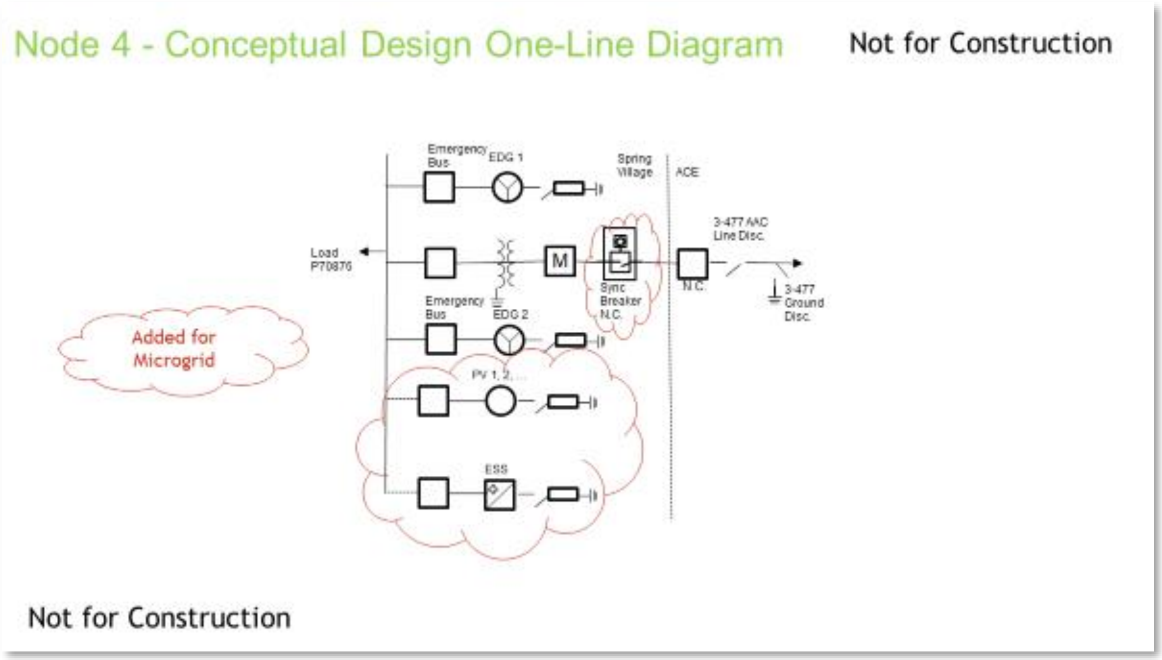
Option with ACE: Consolidate 3 PCCs to one PCC located near 2Ph lateral connection at P22103

Figure 7: Node 2 Conceptual Microgrid One-Line Diagram



In Detailed Design, power flow study may only require one location for ESS in node instead of two.

Figure 8: Node 3 Conceptual Microgrid One-Line Diagram

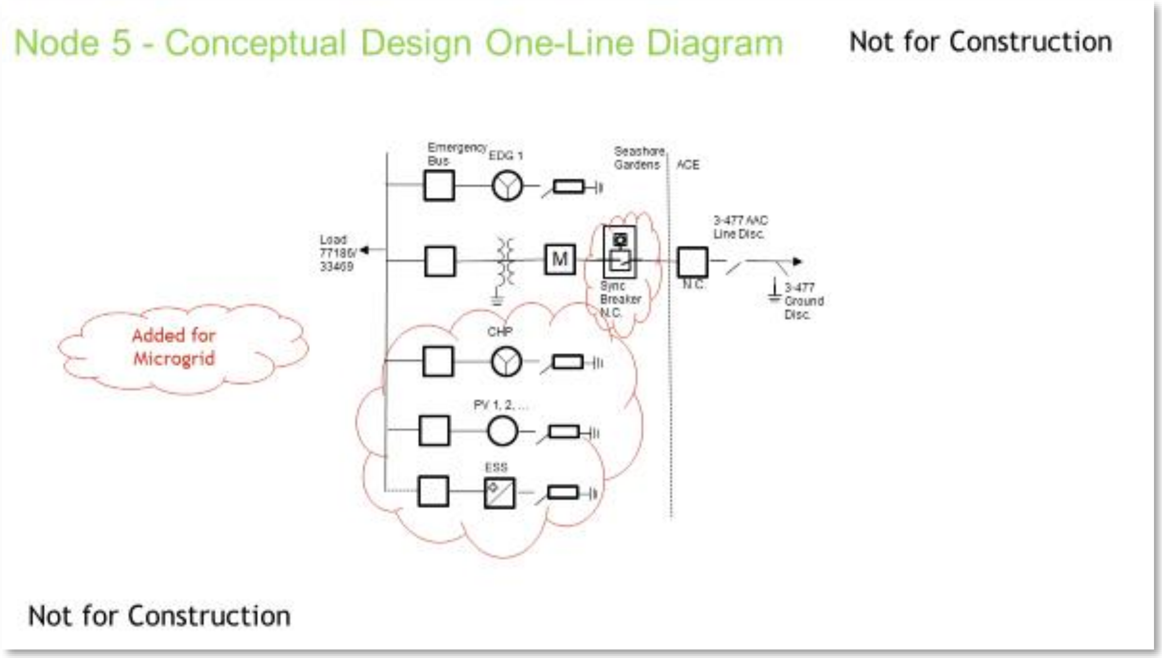


Node 4 - Conceptual Design One-Line Diagram

Not for Construction

Not for Construction

Figure 9: Node 4 Conceptual Microgrid One-Line Diagram



Node 5 - Conceptual Design One-Line Diagram

Not for Construction

Not for Construction

Figure 10: Node 5 Conceptual Microgrid One-Line Diagram

D. Distribution System and Interconnections

The first item in considering the distribution system interconnection for the microgrids is the Point of Common Coupling (PCC). As shown in *Figure 11: Point of Common Coupling Two Breaker Control Scheme for Interconnections*, the PCC includes off-the-shelf components that either already exist in the system or are common in the utility system, plus a synchronizing breaker or switch. This structure, coupled with additional analysis compliant with IEEE 1547.4, enables the utility-controlled breaker or switch to immediately open (frequency = 59.3 Hz) on loss of the grid. The microgrid-managed synchronizing breaker will remain closed for a few more milliseconds until microgrid frequency reaches 57.0 Hz. Since the inverters and generator controls are operating based on the synchronizing breaker signals, these few additional milliseconds enable the energy storage and power electronics to better manage the transient as the microgrid resources pick up the portion of the load served by the utility grid just before the grid was lost. When, or if, the frequency dips to 57.0 Hz and the synchronizing breaker opens, the microgrid moves into island mode. The microgrid controller (MGC) will adjust all microgrid resources for island mode operational and performance objectives.

There is a large level of data inherently available in a microgrid. There is an opportunity to share operational information with the utility to provide greater transparency and monitoring on the network, to further understand behind-the-meter (BTM) DER behaviors in grid-connected and islanded operations, and consider grid-services that could be provided. Given the large number of various protocols that could communicate with utility SCADA, one way to enable monitoring and control capabilities is to apply an open architecture or framework to manage DER that communicate via common semantics and federate data locally for control and reporting.

E. TCDER Start and Operations

The microgrid design is focused on the development of an overall energy strategy that incorporates both demand-side management and new distributed generation resources to support the microgrid’s operational objectives. Steady-state, normal “blue sky” operations for the microgrid and islanded, “dark sky” operations are managed, monitored, and controlled by an MGC.

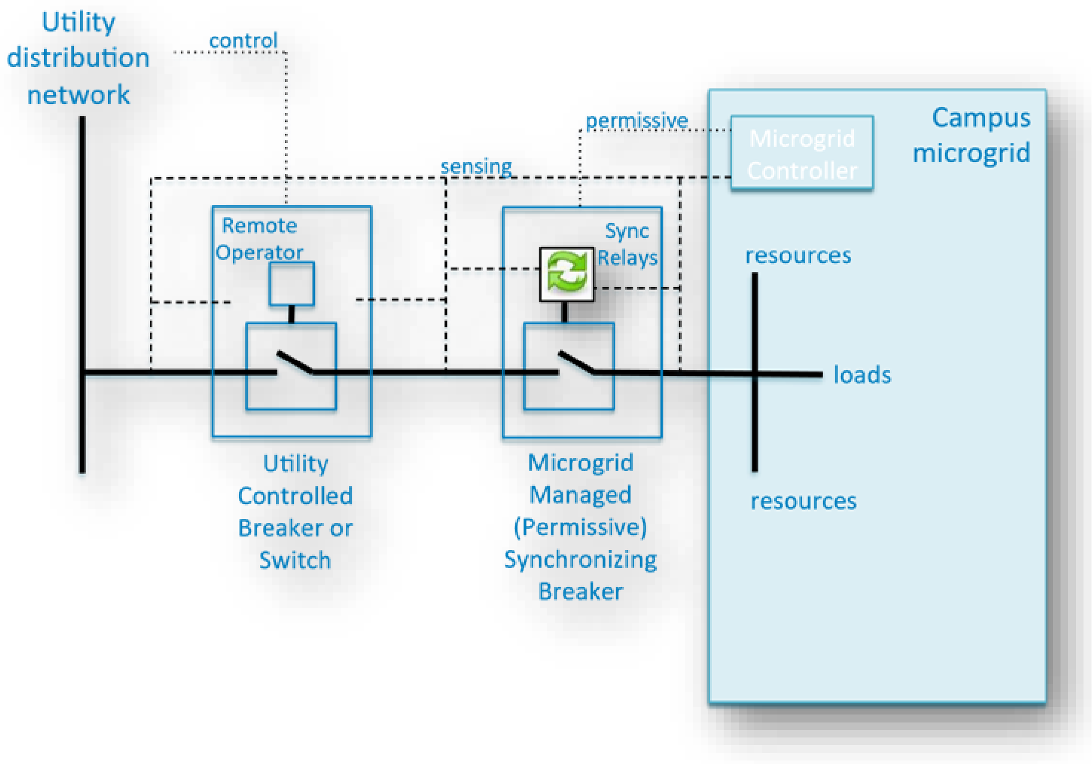


Figure 11: Point of Common Coupling Two Breaker Control Scheme for Interconnections

The microgrid will take advantage of DER to remain in operation when the utility grid is not available. The MGC will monitor island mode frequency and voltage and adjust equipment operation accordingly to maintain circuit stability. The microgrid will also support the transition back to the grid when the utility service is restored. The design ensures that the return to the grid is a seamless transition and is coordinated with the utility through appropriate protocols, safety mechanisms, and switching plans (to be communicated to the MGC by the utility distribution management system and discussed later in the report). Given the variation in resources, difference in magnitude of critical loads and important loads, existing available assets, each node has a different resilience duration in islanded operations. The time in islanded operation is limited by either the diesel fuel storage on-site or the customer's natural gas interruption. Given that the diesel storage tanks and generators for each node were originally designed to meet reliability and resilience concerns for critical loads and continuity of operations, the microgrid will exceed each of the previous requirements, while providing renewable energy, higher efficiencies for the diesel fuel used, and cleaner diesel

Microgrid Controller & PCC Protection Scheme	
Underfrequency	Overvoltage
Undervoltage	Phase to phase fault
Overfrequency	Phase to ground fault
Protection Mitigation Controls	
Phase angle	Real-time droop

Table 19: Microgrid Controller & PCC Protection Scheme

emissions. Designs with CHP, like Node 2, 3, and 5, significantly extend the operating expectations, since the transmission and distribution system of underground pipelines are less susceptible to interruption.

Sequence of Operations
Normal (steady-state)
Enable/Disable MGC, Select Auto/Manual, Monitor Operations and Benefits.
In Auto mode, MGC operates system for maximum economic benefits.
In Manual mode, facility operator has direct control over assets.
Grid failure (transition)
PCC senses loss of grid, transfers from grid-connected (export-only) to islanded (no export), PV trips offline, Demand Response and Load Modulation initiated.
When CHP: customers loads supplied by rotating generation, acting as voltage and frequency source, ESS switches to primary resiliency services (Peak Load Management, Frequency Regulation, Voltage Support, Reactive Power Support, Load Smoothing). When no CHP: customer loads supplied by ESS, acting as voltage source. EDG starts.
PV reconnects after IEEE 1547 programmed delay.
ESS charges to near-maximum state of charge, MGC sends recommended output setpoints to modulate generation to match demand, if necessary.
Grid recovery (transition)
PCC senses grid recovery and switches to grid-connected position.
PV trips offline; PV comes online after set delay.
MGC resumes using ESS for economic optimization.
Black Start (grid outage, microgrid outage)
All utility switches open. Microgrid synchronizing switches open.
ESS provides voltage source to start rotating generation (CHP or EDG). Turn on life safety circuits. Delay turning on resistive and inductive loads (i.e. other buildings or circuits) until life safety circuit reaches steady-state running current.
MGC determines on-site DER and electric bus operating status for non-life safety loads. Synchronizing switch matches voltage, frequency, phase angle, with zero power exchange. Energizes additional buses.
PV reconnects after IEEE 1547 programmed delay.

MGC monitors utility signal to provide power export and support to main feeder.
PCC reconnects to utility and follows frequency. PV trips offline. Microgrid and ESS switches to economic optimization.
PV reconnects after IEEE 1547 programmed delay.

Table 20: Microgrid Sequence of Operations

To support steady-state frequency requirements, as well as the ANSI 84.1-2006 standard voltage requirements and to support the customer power quality requirements at the PCC, the MGC will actively manage the dispatch of generation resources; actively manage the charge and discharge of energy storage; provide observability of microgrid-wide telemetry including frequency, power factor, voltage, currents and harmonics; provide active load management at each facility (in emergencies only); and provide advance volt-VAR variability algorithms and other stability algorithms based on steady state telemetry of the system. Notable protections schemes are noted in **Error! Reference source not found.**, including Black Start.

Each customer will need to undergo a power flow analysis study, after selecting an MGC, to quantify and clarify the sequence of operation during black-start, the starting currents, operating currents, and site SCADA interaction with the MGC to automate the process. After these studies, the MGC can operate accordingly to minimize large step changes in power draw, manage starting in-rush current vs running current, and leverage the smaller CHP or EDG to extend the ESS support.

F. 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 B 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.[1]

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 (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

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[1] 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.

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[2] 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.

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

Advanced Microgrid Generation Bus (Non-Tariff)
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.[3]

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.

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[3] 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.

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 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.[4]

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,

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[4] 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.

the interconnection process must become more robust allowing full integration of distributed generation resources into the larger grid.

G. FERC and PJM Tariff Requirements

Please see the “NJBPU and EDC Tariff Requirements” section of this report.

H. Energy Procurement and Planning

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 manage 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 GTAM 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 GTAM stakeholder group represents 20 electric and 11 natural gas accounts. The total annual consumption for all stakeholder facilities is 57 GWh and over 1,500,000 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;
- GTAM Registers for PJM Membership;

- All interconnected facilities will include fifteen-minute interval meters;
- Atlantic City Electric (ACE) / GTAM consolidated billing for electric;
- South Jersey Industries / GTAM 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 GTAM utility service; and
- Stakeholder energy supply procurement agreements.

Identify the most economical energy sourcing options

The GTAM 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.

Analyze and quantify future energy needs

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

Evaluate purchasing RECs

The GTAM 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 GTAM is expected to operate with renewable generation and consumption on-site, purchasing Renewable Energy Certificates (RECs) is not recommended.

VIII. Overall Cost

The cost for the components of the five microgrids are specified in Table 21: Microgrid Cost per Node. The following table shows that the total estimated project cost for all nodes is $33.6 million which corresponds to an average cost of $3,879 per kW of capacity installed. The analysis shows that the installed cost per node ranges from $3,474 per kW for the schools' node to $6,736 per kW for the Spring Village node.

To develop the capital costs for the project, the team has not directly requested quotes to specific vendors during the feasibility assessment stage. The team has utilized cost assumptions through experience on similar projects, which is subject to change during the detail design phase.

- Equipment Costs: represents the installed costs for major DER equipment, controls, and points of common coupling (PCCs).
- Other Costs: includes the underground cable, conduits, junction boxes and switches.
- Interconnection: represents the interconnection fees to the utility for each node.
- Design and Construction Management: includes detailed engineering costs and fees required to obtain equipment quotes, quotes from third-party vendors, and obtaining construction permits. The assumption is for third-party financing in which case a third-party construction manager is assumed to oversee the project construction activities between notice of proceed and commercial operations.
- Contingency: represents about 5% of the total installed costs.
- Sales Tax: except PV assumed exempt from sales tax based on current NJ incentives on sales tax exemption[5], all other equipment and other costs incur a sales tax of 7%.
- Transaction costs: assumed at 2% of the total project costs. This represents the cost for the owners of the microgrid(s) to develop the contractual instruments, conduct due diligence the project, and negotiate and execute agreements with each off-taker. Note that the assumed cost of ~$660,000 assumes that Galloway Township will support the project and help facilitate a methodology for procurement and contracting. Individual contacting, procurement processes, and negotiation will result in higher transaction costs.

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[5] http://programs.dsireusa.org/system/program/detail/219

Installed Capital Cost Assumptions	Combined	Municipal Complex	Stockton, AtlantiCare, Bacharach	Reeds, Roland Rogers, MS, HS	Spring Village	Seashore Gardens
Total Generating Assets (kW)	8,662	292	6,699	1,351	58	263
CHP (kW)	3,620	0	2,730	760	0	130
PV (kW)	5,042	292	3,969	591	58	133
ESS (kWh)	1,680	30	1,500	70	40	40
# of PCC	9	1	3	3	1	1
CHP ($/kW)	$2,064	$0	$2,256	$1,444	$0	$1,680
PV ($/kW)	$2,808	$2,766	$2,877	$2,503	$2,300	$2,400
ESS ($/kWh)	$800	$800	$800	$800	$800	$800
PCC ($/PCC)	$130,556	$100,000	$150,000	$150,000	$75,000	$100,000
Controls	$588,000	$26,000	$255,000	$255,000	$26,000	$26,000
Equipment Costs	$24,736,000	$957,680	$19,480,000	$3,338,000	$265,000	$695,000
Other Costs	$2,600,000	$10,000	$2,200,000	$390,000	$0	$0
Interconnection	$560,000	$100,000	$150,000	$150,000	$60,000	$100,000
Design and Construction Management	$2,600,000	$91,930	$2,060,000	$354,000	$28,000	$66,000
Contingency	$1,525,000	$57,980	$1,194,000	$212,000	$18,000	$43,000
Sales Tax	$923,000	$11,200	$718,000	$157,000	$9,000	$26,000
Transaction Cost	$659,000	$24,576	$516,000	$92,000	$8,000	$19,000
Total CAPEX	$33,603,000	$1,253,366	$26,318,000	$4,693,000	$388,000	$949,000
CAPEX ($/kW)	$3,879	$4,292	$3,929	$3,474	$6,736	$3,610

Table 21: Microgrid Cost per Node

IX. Cash Flow Evaluation/Potential Financing

The following table presents the baseline cash flow analysis for the consolidated project. The revenue represents the sales of electricity and hot water to the respective nodes. The price of the electricity and natural gas are assumed to be at the rate that each participant is currently paying (i.e. 2017 – 2018 prices) in the first year of operation. Fuel costs are estimated for the CHP units. The model also includes annual operation and maintenance costs through contracts with equipment vendors and continuous monitoring through an off-site network operating center (NOC). This helps the project owner and operator ensure proper operation and key performance indicators (KPIs) that will be identified in the long-term energy contract.

General	**Capital Expenditures**
Third-Party ownership and operation	Equipment
20-year contract	Engineering
KPI's to ensure the solution meets customer requirements	Installation
	Construction Management
Ongoing Expenses	Permitting
Operations & Maintenance	Interconnection
Fuel Costs	Commissioning
Equipment Replacement	Transaction Costs
Monitoring & Control	ITC
Revenues	
Electricity sales ($/kWh delivered) with a 2.2% escalation • **PV degradation at 0.5% per annum.** • **PV production based on NREL simulation models.** • **No CHP degradation is assumed.** • **CHP production based on Homer model.**	
Thermal sales ($/MMBTU), with a 2.2% escalation • **Thermal output from CHP assumes constant for the contract term**	
Natural gas costs equal to current cost ($/MMBTU) with a 2.4% escalation	
Federal investment tax credits (ITC) based on assumed installation date (PV = 26% and CHP = 10%). Due to the size of the project, the investor may need to pay a premium to a tax equity investor which have a premium and transaction cost that will reduce the benefit to the project by 25%.	

Figure 12: Key Financial Model Assumptions

Annual Cash Flow Analysis - Combined	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
in US$								
Electricity Revenue	$4,658,154.42	$4,756,432.59	$4,856,801.91	$4,959,307.21	$5,063,994.25	$5,170,909.78	$5,280,101.59	$5,391,618.45
Hot Water Revenue	$912,546.91	$932,622.94	$953,140.65	$974,109.74	$995,540.16	$1,017,442.04	$1,039,825.76	$1,062,701.93
SREC Revenue	$1,265,320.14	$1,258,993.54	$1,252,698.58	$1,246,435.08	$1,240,202.91	$1,234,001.89	$1,227,831.88	$1,221,692.72
Total Revenue	**$6,836,021.47**	**$6,948,049.07**	**$7,062,641.14**	**$7,179,852.03**	**$7,299,737.31**	**$7,422,353.71**	**$7,547,759.23**	**$7,676,013.10**
Fuel Costs	$2,355,394.06	$2,411,923.52	$2,469,809.68	$2,529,085.12	$2,589,783.16	$2,651,937.95	$2,715,584.46	$2,780,758.49
O&M Cost	$703,196.06	$717,259.98	$731,605.18	$746,237.28	$761,162.02	$776,385.27	$791,912.97	$807,751.23
NOC Cost	$83,560.52	$85,335.83	$87,149.14	$89,001.25	$90,893.02	$92,825.28	$94,798.91	$96,814.81
Asset Management	$136,720.43	$138,960.98	$141,252.82	$143,597.04	$145,994.75	$14,8447.07	$15,0955.18	$153,520.26
Insurance	$112,070.90	$114,312.32	$116,598.56	$118,930.53	$121,309.14	$123,735.33	$126,210.03	$128,734.23
Property Tax	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Land Lease	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Other/Contingencies	$51,777.40	$52,793.46	$53,830.28	$54,888.31	$55,967.95	$57,069.65	$58,193.85	$59,341.03
Total Operating Expenses	**$3,442,719.36**	**$3,520,586.08**	**$3,600,245.67**	**$3,681,739.53**	**$3,765,110.04**	**$3,850,400.55**	**$3,937,655.42**	**$4,026,920.05**
EBITDA	**$3,393,302.11**	**$3,427,462.99**	**$3,462,395.47**	**$3,498,112.51**	**$3,534,627.27**	**$3,571,953.17**	**$3,610,103.81**	**$3,649,093.05**

Table 22: Annual Cash Flow for Combined Nodes

The analysis shows that in the first year, the project will generate $6.8 million in revenue and incur $3.4 million in expenses which represents a pre-tax profit of $3.4 million.

A. Other Potential Revenue

The project is designed primarily to provide resilience to off-takers in a cost-effective manner. As such the DER assets are not oversized to provide capacity to external markets. However, utilizing a MGC at each node will enable the ability for systems to participate in utility demand response programs and PJM programs as follows:

- Synchronized Reserve Program: These services serve as a backstop against errors in the market load forecast or unexpected energy losses. Synchronized reserves must be available to perform within ten minutes of a market notice.
- Fast Regulation Program: These services serve to respond to small local load changes that cause the power system to operate out of balance. Regulation resources must respond within five minutes of a market signal, and react to changes in the levels of frequency (Hz) on the grid.
- Capacity Program: PJM's capacity market ensures the adequate availability of necessary resources that can be called upon to ensure the reliability of the grid. There are several ways that customers can participate in PJM's capacity market.

B. Detail Assumptions

To develop detailed cash flow, we used the following assumptions:

1. Revenue Assumptions:

   We assume an Energy Services Agreement structure, where the customer agrees to buy all, or a portion of the electricity and/or thermal output generated by the microgrid for a specific term (e.g. 20 years) with capital, ownership and operation provided by a third-party.

ESA Pricing Assumptions	Combined	Municipal Complex	Stockton, AtlantiCare, Bacharach	High School, Reeds Elem., Roland Elem., MS	Spring Village	Seashore Gardens
Electricity Price ($/kWh)	$0.13	$0.13	$0.13	$0.13	$0.17	$0.13
Hot Water ($/MMBTU)	$8.47	$0.00	$7.75	$11.51	$0.00	$11.48
ESA Price Annual Escalation	2.2%	2.2%	2.2%	2.2%	2.2%	2.2%

Table 23: ESA Rate Assumptions by Node

2. Production Assumptions:

   We used the first-year output generation numbers derived from HomerPro in Table 24: Estimated First Year Energy Delivery by Node as the base case for electricity and hot water delivered to each node. Future year production estimates considered PV and CHP degradation.

Production by ESA Category - Year 1	Combined	Municipal Complex	Stockton, AtlantiCare, Bacharach	High School, Reeds Elem., Roland Elem., MS	Spring Village	Seashore Gardens
Energy Production (kWh)	35,947,938	378,142	28,243,151	6,131,069	70,945	1,124,631
Hot Water (MMBTU)	107,690	0	86,798	16,667	0	4,224

Table 24: Estimated First Year Energy Delivery by Node

3. Operating Cost Assumptions:

   Table 25: Operating Cost Assumptions by Node and Table 26: Operating Cost Escalation Assumptions by Node summarize the operating costs assumed in the cash flow analysis, which includes fuel costs, operation and maintenance costs, NOC operating costs, asset management costs, property tax and land lease costs. Depending on the owner and site location, some of the costs may or may not apply. Note that the contracted KPI's influence the O&M costs of the project in the form of extended warranties, service contracts, fuel hedges, SREC hedges, insurance, and cash reserves. The values presented below are assumed to be representative for a microgrid and the proposed technologies.

Operating Cost Assumptions	Municipal Complex	Stockton, AtlantiCare, Bacharach	High School, Reeds Elem., Roland Elem., MS	Spring Village	Seashore Gardens
Fuel Costs ($/MMBtu)	$0.00	$7.75	$11.51	$0.00	$11.48
O&M:					
CHP O&M ($/kWh)	$0.02	$0.02	$0.02	$0.02	$0.02
PV O&M ($/kW/yr)	$15.00	$15.00	$15.00	$15.00	$15.00
ESS O&M ($/kWh/yr)	$40.00	$40.00	$40.00	$40.00	$40.00
PCC O&M ($/PCC/yr)	$2,500.00	$7,500.00	$7,500.00	$2,500.00	$2,500.00
Controls ($/yr)	$0.00	$4,500.00	$4,500.00	$0.00	$0.00
Other ($/yr)	$600.00	$600.00	$600.00	$600.00	$600.00
NOC Annual Cost (% of Revenue)	1.5%	1.5%	1.5%	1.5%	1.5%
Asset Management Annual Cost (% of Revenue)	2.0%	2.0%	2.0%	2.0%	2.0%

Insurance Costs % of CAPEX	0.4%	0.4%	0.4%	0.4%	0.4%
Property Tax Annual Cost (% of CAPEX)	0.0%	0.0%	0.0%	0.0%	0.0%
Land Lease Annual Cost	$ -	$ -	$ -	$ -	$ -
Operating Cost Contingency	5.0%	5.0%	5.0%	5.0%	5.0%

Table 25: Operating Cost Assumptions by Node

_Operating Cost Annual Escalation Assumptions	**Municipal Complex**	**Stockton, AtlantiCare, Bacharach**	**High School, Reeds Elem., Roland Elem., MS**	**Spring Village**	**Seashore Gardens**
Fuel Cost	2.4%	2.4%	2.4%	2.4%	2.4%
O&M	2.0%	2.0%	2.0%	2.0%	2.0%
G&A	2.0%	2.0%	2.0%	2.0%	2.0%

Table 26: Operating Cost Escalation Assumptions by Node

4. Other Assumptions:
   - SREC at the price of $200/MWh for 10 years.
   - Investment tax credit (ITC) on both PV and CHP is considered in the analysis based on the projected year of installation.

For detail cash flow analysis by node, please refer to Appendix C.

X. Potential Financing

Combination of potential funding sources may be available for the stakeholders in different stages of microgrid project development process.

a) Grant or incentives from state or local agency:
   Some of the nodes, including Spring Village, may not be economically viable without grant(s) as a standalone node, while others require additional incentives to provide enough economic return to attract third-party financings. As an example of currently available incentives, New Jersey's Clean Energy Program provides financial incentives for CHP to reduce upfront CAPEX for the owner of the assets.

b) Revenue bond:
   State and local government may have the ability to issue bonds to raise funding for the project. For example, a revenue bond can be issued by the municipality to support the microgrid project which will be secured through revenue generated by energy sold.

c) Incentives from utilities:
   Potential incentives from utilities can reduce upfront capital costs as well as increase cash flow through ongoing performance-based incentives. The level of certainty around the ability to secure the incentives will impact if the incentives are included in the financial analysis.

d) Third-party financing:
   Equity and/or debt financing from institutional investors and financial institutions can also provide funding at different project stages including development, construction, and/or operational phases.

Depending on the combination of financing mechanisms, the resulting cost/benefit to the off-taker will be different. Take third-party financing as an example. Assuming the market for third-party capital for a microgrid project is a pre-tax unlevered internal rate of return (IRR) of approximately 10%, Table 27: Unlevered Return Base Case without Grant shows that the consolidated project IRR is about 8.1% with the best node returning 8.5% and the worst node having a negative return of -3.3%. Table 28: Unlevered Return Base Case with Grant shows the impact of future grant/incentives funding for the project that gets the project and each individual node to the 10% level so that the third-party capital approach can be achieved. The estimated level of grant/incentives funding required to move forward with all five nodes is around $4.44 million. Most likely, multiple funding sources will need to be utilized if the goal is to have all nodes benefit from the microgrid solution.

Unlevered Return - Base Case without Grant	**Combined**	**Municipal Complex**	**Stockton, AtlantiCare, Bacharach**	**High School, Reeds Elem., Roland Elem., MS**	**Spring Village**	**Seashore Gardens**
Unlevered Pre-tax Return with ITC	8.16%	4.61%	8.51%	8.12%	-3.34%	4.98%

Table 27: Unlevered Return Base Case without Grant

Unlevered Return - Base Case with Grant	**Combined**	**Municipal Complex**	**Stockton, AtlantiCare, Bacharach**	**High School, Reeds Elem., Roland Elem., MS**	**Spring Village**	**Seashore Gardens**
Grant/Incentives Amount by Node	$4,440,000.00	$382,000.00	$2,895,000.00	$629,000.00	$237,000.00	$297,000.00
Unlevered Pre-tax Return with ITC	10.00%	10.00%	10.00%	10.00%	10.00%	10.00%

Table 28: Unlevered Return Base Case with Grant

XI. Project Benefits

The need for microgrids is ever increasing with volatile weather conditions such as Hurricane Sandy and Polar Vortexes as well as constraints on our aging electrical distribution infrastructure and cyber-attacks on our electrical supply chain. Microgrids provide a reliable backbone to local resiliency, while also providing the opportunity for locally produced clean energy and a secure energy supply. The advantages of a microgrid system include reliability, redundancy, fuel flexibility, energy efficiency, a cleaner environment locally and regionally, reductions of energy transmission loss, and improved grid security.

XII. Communication System

EDC operators have a unique problem pertaining to the management of distributed energy resources. They must manage DERs in concert with grid operations, even though most of the DERs are not owned by the distribution grid operator. A DER Management System (DERMS) must enable them to manage all functions from provisioning and visualizing DERs to coordinating their dispatch with other grid management assets and quantifying and settling the benefits of using DERs.

With any building operation assets, a suitable data and IT system to monitor, control, and protect assets is critical. Often times, industrial buildings may use a SCADA or BAS. Any viable MGC will need an active management and control architecture that supports the ten EPRI/ORNL Use Cases, at minimum. These include frequency control, voltage control, intentional islanding, unintentional islanding, islanding to grid-connected transition, energy management, microgrid protection, ancillary services, black start, and user interface and data management. In addition to these core competencies, an MGC should include the following capabilities:

- Forecast variable aspects: load, wind, PV, and storage
- Dispatch of DER to maximize economic benefit, including on-site controllable or curtailable loads
- Continuously monitor and trend health of all system components
- Send, receive, and consider signals from utility tariffs, demand response programs, and ancillary service opportunities
- Understand operational constraints of various DER and vendor-specific equipment
- Interface to ACE
- Meet rigid and proven cyber security protocols

In the microgrids, the MGC interfaces with all new assets (ESS, PCC, meters, weather station, etc.), but also existing DERs (PV and Inverter, CHP, meters, boilers, turbines, BAS). Typically, standard protocols are used for accessing monitoring and controlling points, such as Modbus, BACnet, CANbus, or TCP/IP, but additional options are available with most MGCs.

MGC software can be configured to serve as a facility microgrid control software and as DER management software that can connect to multiple sites for coordinated operations. The relationships between conventional grid management systems such as SCADA/DMS and DERMS, DER and microgrids are shown in Figure 13: Relational Communication between Grid Operations, DERMS Operations, and the Microgrid(s).

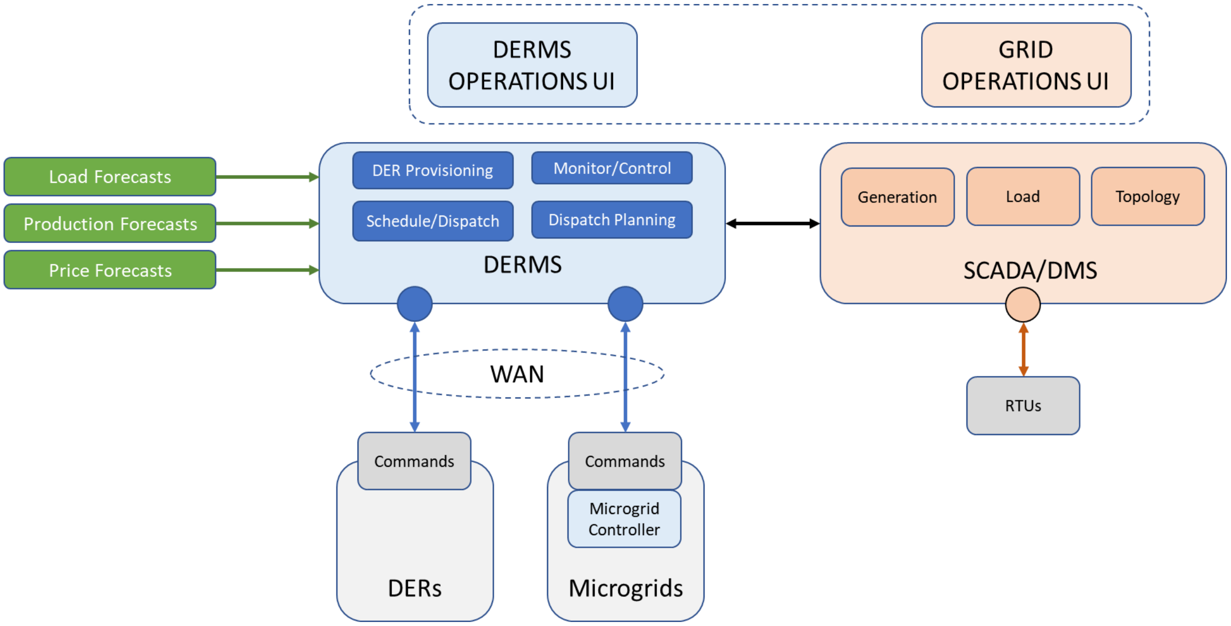


Figure 13: Relational Communication between Grid Operations, DERMS Operations, and the Microgrid(s)

The microgrid proposed for this project will be set up to exchange information, including supervisory commands, to and from compatible distribution operations systems. Typical integration points are:

- Data exchange with SCADA/DMS system pertaining to generation, load and topology (networked switched state)
- Point of Control transfer between SCADA/DMA and DERMS to avoid hunting between control actions initiated from the respective systems
- Direct access to DERs that are not connected through SCADA
- Forecast data ingestion, normalization, storage and visualization
- User Interfaces and workflow integration (“single pane of glass”)
- Data integration and report generation from normalized forecast, operations status and history, schedules and dispatch by DERMS, and grid operations data

The proposed system will be operated from a control room with secure access provided to authorized stakeholders. Initial stakeholders are anticipated to be ACE, microgrid operator, and microgrid node participants.

XIII. Estimated Timeframe

The schedule for executing the GTAM begins with stakeholder Notice to Proceed and the Grant Award. The schedule is illustrative of the level of effort, range of contingency required for activities, and process of system delivery. A similar schedule is necessary for each node, although slightly longer or shorter, depending on complexity.

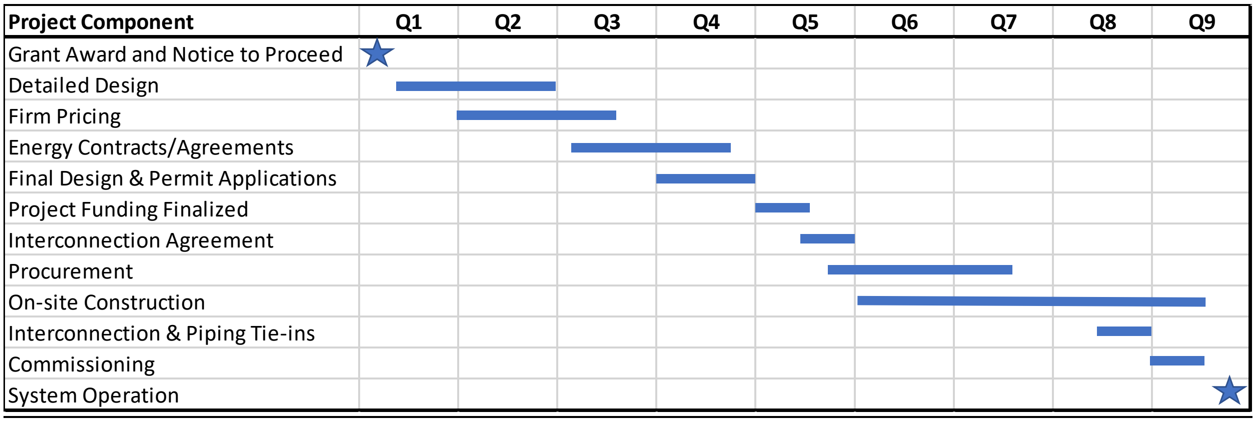


Figure 14: Estimated Project Timeframe

XIV. On-going Work with the EDC and GDC

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

XV. Appendices

Appendix A – PV Helioscope Summaries and Layouts

Municipal Complex Roofs Galloway MG - Municipal Complex, 300 E. Jimmie Leeds Rd. Galloway NJ

Design

Design	Municipal Complex Roofs
DC Nameplate	65.2 kW
AC Nameplate	54.0 kW (1.21 DC/AC)
Last Modified	Tom Brys (Today at 4:04 PM)

Project Location

Components

Component	Name	Count
Inverters	SE9KUS (SolarEdge)	6 (54.0 kW)
Strings	10 AWG (Copper)	10 (269.5 ft)
Optimizers	P800S (SolarEdge)	107 (85.6 kW)
Module	Trina Solar, TSM-PEG14 315W (315W)	207 (65.2 kW)

Field Segments

Description	Racking	Orientation	Tilt	Azimuth	Intrarow Spacing	Frame Size	Frames	Modules	Power
Peaked Small Roof	Flush Mount	Landscape (Horizontal)	25°	132°	0.0 ft	1x1	26	26	8.19 kW
Peak Roof West	Flush Mount	Landscape (Horizontal)	25°	217.388°	0.0 ft	1x1	125	125	39.4 kW
Field Segment 3	Flush Mount	Landscape (Horizontal)	15°	218.567°	0.0 ft	1x1	21	21	6.62 kW
Field Segment 4	Flush Mount	Landscape (Horizontal)	27°	36.5639°	0.0 ft	1x1			0
Flat Roof	Fixed Tilt	Landscape (Horizontal)	5°	221°	0.7 ft	1x1	35	35	11.0 kW

Wiring Zones

Description	Combiner Poles	String Size	Stringing Strategy
Wiring Zone	12	7-21	Along Racking

Detailed Layout

Municipal Complex Canopy Galloway MG - Municipal Complex, 300 E. Jimmie Leeds Rd. Galloway NJ

Design

Design	Municipal Complex Canopy
DC Nameplate	226.8 kW
AC Nameplate	200.0 kW (1.13 DC/AC)
Last Modified	Tom Brys (Today at 4:12 PM)

Project Location

Components

Component	Name	Count
Inverters	Sunny Central SC 100 outdoor HE (SMA)	2 (200.0 kW)
Strings	10 AWG (Copper)	40 (5,086.2 ft)
Module	Trina Solar, TSM-PEG14 315W (315W)	720 (226.8 kW)

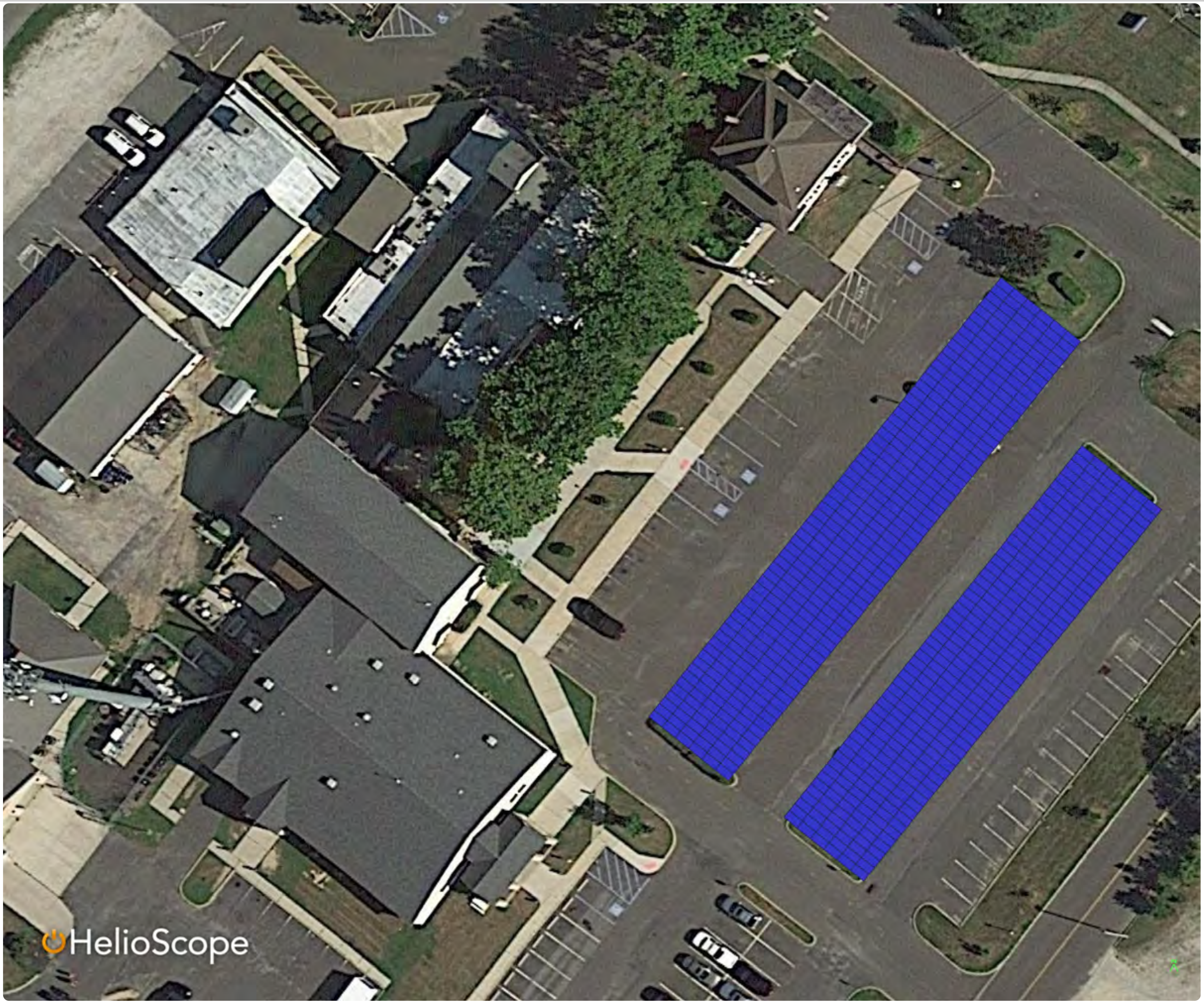
Field Segments

Description	Racking	Orientation	Tilt	Azimuth	Intrarow Spacing	Frame Size	Frames	Modules	Power
Peaked Small Roof	Flush Mount	Landscape (Horizontal)	25°	132°	0.0 ft	1x1			0
Peak Roof West	Flush Mount	Landscape (Horizontal)	25°	217.388°	0.0 ft	1x1			0
Peak Roof Small 2	Flush Mount	Landscape (Horizontal)	15°	218.567°	0.0 ft	1x1			0
Field Segment 4	Flush Mount	Landscape (Horizontal)	27°	36.5639°	0.0 ft	1x1			0
Flat Roof	Fixed Tilt	Landscape (Horizontal)	5°	221°	0.7 ft	1x1			0
Canopy 1	Carport	Portrait (Vertical)	7.5°	128.715°	0.0 ft	1x1	390	390	122.9 kW
Canopy 2	Carport	Portrait (Vertical)	7.5°	128.715°	0.0 ft	1x1	330	330	104.0 kW

Wiring Zones

Description	Combiner Poles	String Size	Stringing Strategy
Wiring Zone	12	13-19	Along Racking

Detailed Layout



Campus Center Roof Stockton University, 101 Vera King Farris Dr, Galloway, NJ 08205

Design

Design	Campus Center Roof
DC Nameplate	183.3 kW
AC Nameplate	150.0 kW (1.22 DC/AC)
Last Modified	Tom Brys (Today at 12:54 PM)

Project Location

Components

Component	Name	Count
Inverters	Sunny Tripower_Core1 50-US-41 (SMA)	3 (150.0 kW)
Strings	10 AWG (Copper)	30 (6,871.3 ft)
Module	Trina Solar, TSM-315 PD14 2014_05 (315W)	582 (183.3 kW)

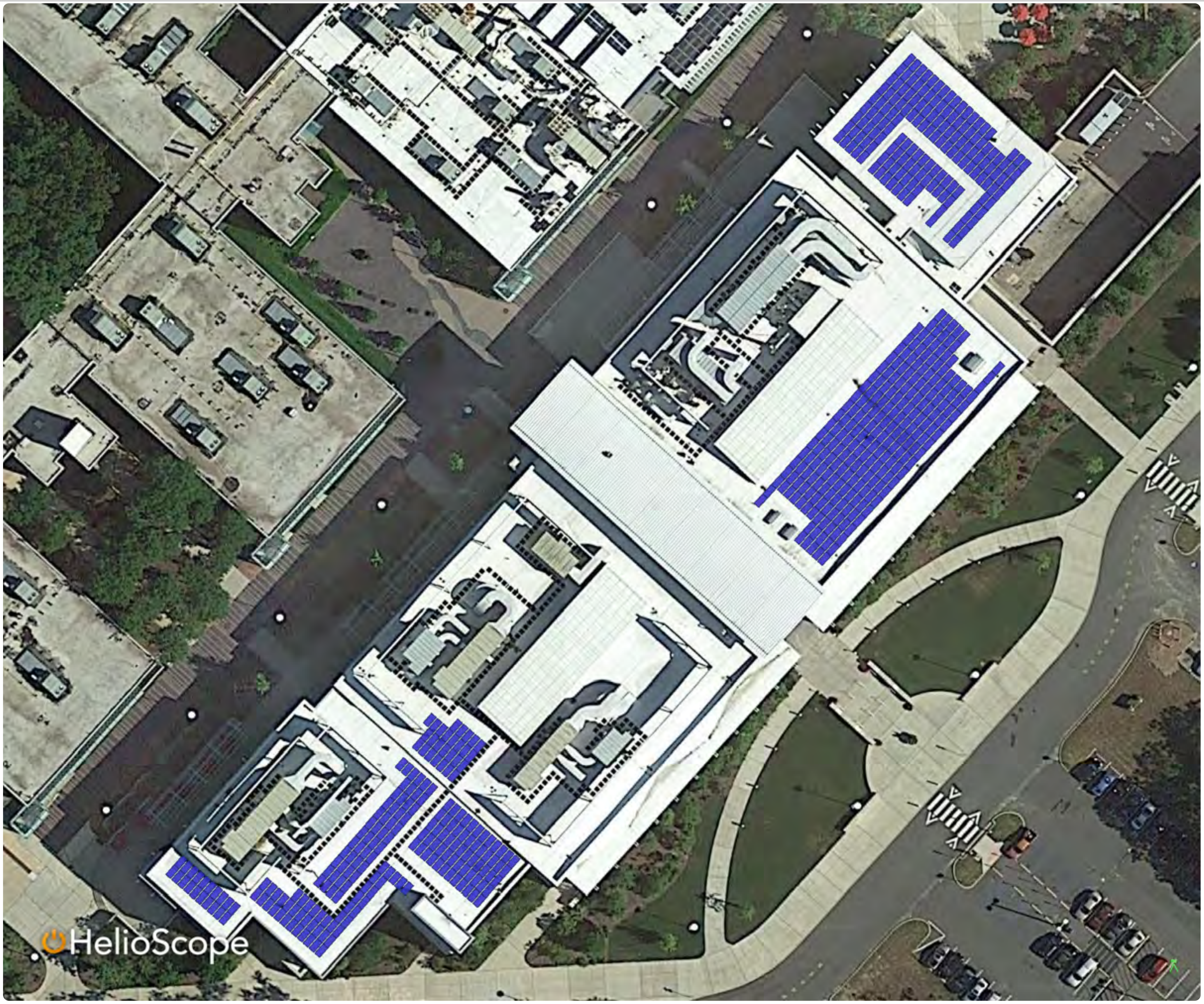
Field Segments

Description	Racking	Orientation	Tilt	Azimuth	Intrarow Spacing	Frame Size	Frames	Modules	Power
West Portion of Roof	Fixed Tilt	Landscape (Horizontal)	5°	131.173°	0.7 ft	1x1	204	204	64.3 kW
East portion of roof	Fixed Tilt	Landscape (Horizontal)	5°	132.426°	0.7 ft	1x1	378	378	119.1 kW

Wiring Zones

Description	Combiner Poles	String Size	Stringing Strategy
Wiring Zone	12	5-21	Along Racking

Detailed Layout



New Construction Canopy Stockton University, 101 Vera King Farris Dr, Galloway, NJ 08205

Design

Design	New Construction Canopy
DC Nameplate	837.9 kW
AC Nameplate	700.0 kW (1.20 DC/AC)
Last Modified	Tom Brys (Today at 12:32 PM)

Project Location

Components

Component	Name	Count
Inverters	Sunny Central SC 100 outdoor HE (SMA)	7 (700.0 kW)
Strings	10 AWG (Copper)	133 (43,923.7 ft)
Module	Trina Solar, TSM-315 PD14 2014_05 (315W)	2,660 (837.9 kW)

Field Segments

Description	Racking	Orientation	Tilt	Azimuth	Intrarow Spacing	Frame Size	Frames	Modules	Power
Canopy 1	Carport	Landscape (Horizontal)	7.5°	222.212°	0.0 ft	1x1	1,428	1,428	449.8 kW
Canopy 2	Carport	Landscape (Horizontal)	7.5°	222.212°	0.0 ft	1x1	1,232	1,232	388.1 kW

Wiring Zones

Description	Combiner Poles	String Size	Stringing Strategy
Wiring Zone	12	13-21	Along Racking

Detailed Layout

Sports Field Canopy Stockton University, 101 Vera King Farris Dr, Galloway, NJ 08205

Design

Design	Sports Field Canopy
DC Nameplate	447.3 kW
AC Nameplate	400.0 kW (1.12 DC/AC)
Last Modified	Tom Brys (Today at 6:22 AM)

Project Location

Components

Component	Name	Count
Inverters	Sunny Central SC 100 outdoor HE (SMA)	4 (400.0 kW)
Strings	10 AWG (Copper)	76 (10,199.6 ft)
Module	Trina Solar, TSM-315 PD14 2014_05 (315W)	1,420 (447.3 kW)

Field Segments

Description	Racking	Orientation	Tilt	Azimuth	Intrarow Spacing	Frame Size	Frames	Modules	Power
Canopy 1	Carport	Portrait (Vertical)	7.5°	132.296°	0.0 ft	1x1	355	355	111.8 kW
Canopy 2	Carport	Portrait (Vertical)	7.5°	132.296°	0.0 ft	1x1	355	355	111.8 kW
Canopy 3	Carport	Portrait (Vertical)	7.5°	132.296°	0.0 ft	1x1	355	355	111.8 kW
Canopy 4	Carport	Portrait (Vertical)	7.5°	132.296°	0.0 ft	1x1	355	355	111.8 kW

Wiring Zones

Description	Combiner Poles	String Size	Stringing Strategy
Wiring Zone	12	13-21	Along Racking

Detailed Layout

Furthest Away Canopy Stockton University, 101 Vera King Farris Dr, Galloway, NJ 08205

Design

Design	Furthest Away Canopy
DC Nameplate	1.01 MW
AC Nameplate	900.0 kW (1.12 DC/AC)
Last Modified	Tom Brys (Today at 6:16 AM)

Project Location

Components

Component	Name	Count
Inverters	Sunny Central SC 100 outdoor HE (SMA)	9 (900.0 kW)
Strings	10 AWG (Copper)	156 (28,361.7 ft)
Module	Trina Solar, TSM-315 PD14 2014_05 (315W)	3,210 (1.01 MW)

Field Segments

Description	Racking	Orientation	Tilt	Azimuth	Intrarow Spacing	Frame Size	Frames	Modules	Power
Field Segment 1	Fixed Tilt	Portrait (Vertical)	7.5°	240.945°	0.0 ft	1x1	317	317	99.9 kW
Field Segment 1 (copy)	Fixed Tilt	Portrait (Vertical)	7.5°	240.945°	0.0 ft	1x1	322	322	101.4 kW
Field Segment 1 (copy 1)	Fixed Tilt	Portrait (Vertical)	7.5°	240.945°	0.0 ft	1x1	322	322	101.4 kW
Field Segment 1 (copy 2)	Fixed Tilt	Portrait (Vertical)	7.5°	240.945°	0.0 ft	1x1	322	322	101.4 kW
Field Segment 1 (copy 3)	Fixed Tilt	Portrait (Vertical)	7.5°	240.945°	0.0 ft	1x1	322	322	101.4 kW
Field Segment 1 (copy 4)	Fixed Tilt	Portrait (Vertical)	7.5°	240.945°	0.0 ft	1x1	317	317	99.9 kW
Field Segment 1 (copy 5)	Fixed Tilt	Portrait (Vertical)	7.5°	240.945°	0.0 ft	1x1	322	322	101.4 kW
Field Segment 1 (copy 6)	Fixed Tilt	Portrait (Vertical)	7.5°	240.945°	0.0 ft	1x1	322	322	101.4 kW
Field Segment 1 (copy 7)	Fixed Tilt	Portrait (Vertical)	7.5°	240.945°	0.0 ft	1x1	322	322	101.4 kW
Field Segment 1 (copy 8)	Fixed Tilt	Portrait (Vertical)	7.5°	240.945°	0.0 ft	1x1	322	322	101.4 kW

Wiring Zones

Description	Combiner Poles	String Size	Stringing Strategy
Wiring Zone	12	13-21	Along Racking

Detailed Layout

Carport Galloway MG - Atlanticare, 65 W Jimmie Leeds Road Pomona NJ 08240

Design

Design	Carport
DC Nameplate	1.49 MW
AC Nameplate	1.10 MW (1.35 DC/AC)
Last Modified	Tom Brys (Today at 6:06 AM)

Project Location

Components

Component	Name	Count
Inverters	SC 500CP-US (SMA)	2 (1.10 MW)
Strings	10 AWG (Copper)	254 (205,935.6 ft)
Module	Trina Solar, TSM-PEG14 315W (315W)	4,716 (1.49 MW)

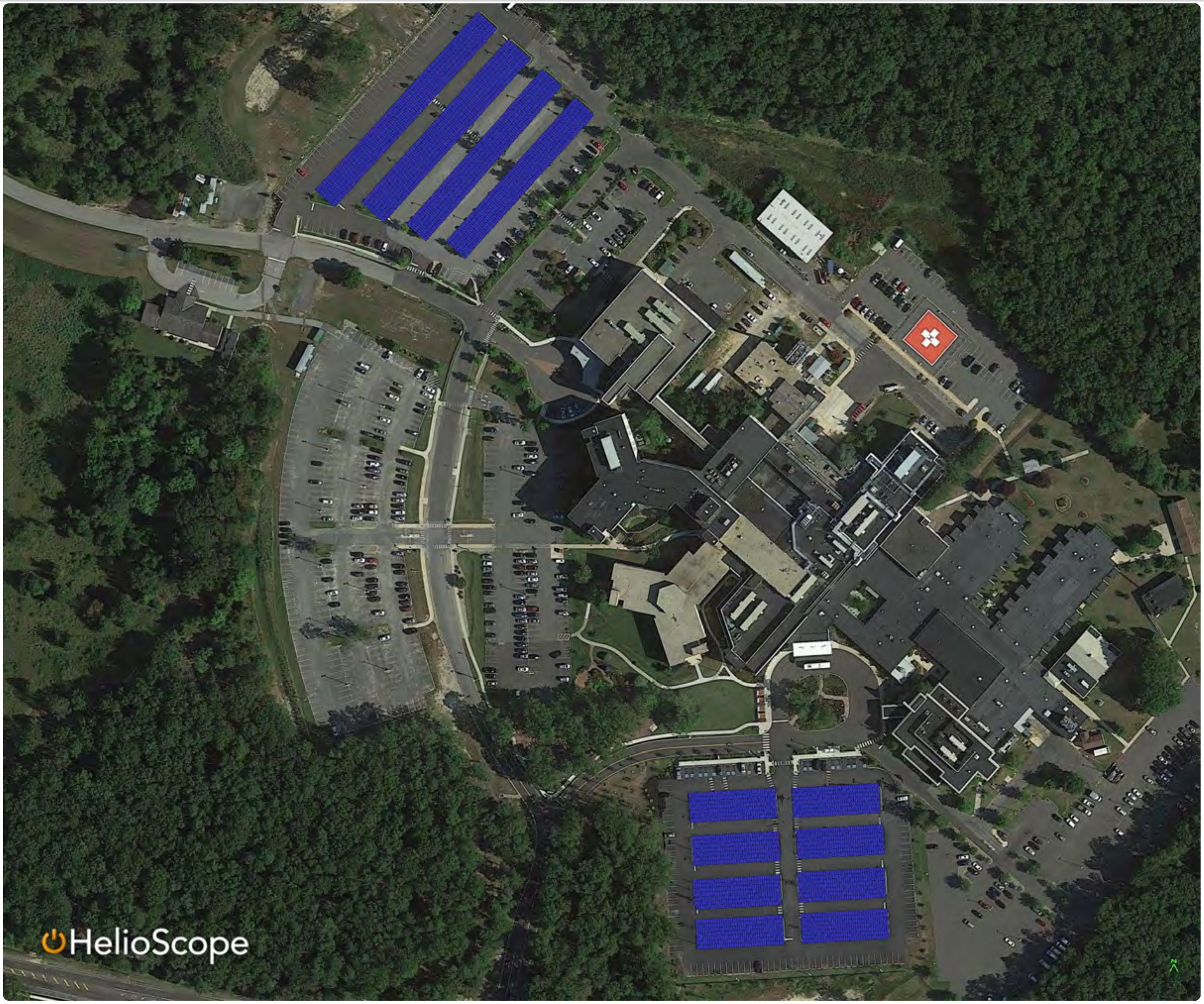
Field Segments

Description	Racking	Orientation	Tilt	Azimuth	Intrarow Spacing	Frame Size	Frames	Modules	Power
1 Canopy - southern array	Carport	Portrait (Vertical)	7.5°	176.667°	0.0 ft	1x1	280	280	88.2 kW
8 Canopy - southern array	Carport	Portrait (Vertical)	7.5°	176.667°	0.0 ft	1x1	280	280	88.2 kW
2 Canopy - southern array	Carport	Portrait (Vertical)	7.5°	176.667°	0.0 ft	1x1	280	280	88.2 kW
3 Canopy - southern array	Carport	Portrait (Vertical)	7.5°	176.667°	0.0 ft	1x1	279	279	87.9 kW
4 Canopy - southern array	Carport	Portrait (Vertical)	7.5°	176.667°	0.0 ft	1x1	280	280	88.2 kW
5 Canopy - southern array	Carport	Portrait (Vertical)	7.5°	176.667°	0.0 ft	1x1	280	280	88.2 kW
6 Canopy - southern array	Carport	Portrait (Vertical)	7.5°	176.667°	0.0 ft	1x1	280	280	88.2 kW
7 Canopy - southern array	Carport	Portrait (Vertical)	7.5°	176.667°	0.0 ft	1x1	280	280	88.2 kW
9 Canopy - north west array	Carport	Portrait (Vertical)	7.5°	131.948°	0.0 ft	1x1	534	534	168.2 kW
10 Canopy - north west array	Carport	Portrait (Vertical)	7.5°	131.269°	0.0 ft	1x1	570	570	179.6 kW
11 Canopy - north west array	Carport	Portrait (Vertical)	7.5°	131.944°	0.0 ft	1x1	707	707	222.7 kW
12 Canopy - north west array	Carport	Portrait (Vertical)	7.5°	132.459°	0.0 ft	1x1	666	666	209.8 kW

Wiring Zones

Description	Combiner Poles	String Size	Stringing Strategy
Wiring Zone	12	13-19	Along Racking

Detailed Layout



Roland School Roof Galloway MG - Reeds and Rogers, 103 S Reeds Road, Galloway, NJ

Design

Design	Roland School Roof
DC Nameplate	590.3 kW
AC Nameplate	501.0 kW (1.18 DC/AC)
Last Modified	Tom Brys (Today at 2:47 PM)

Project Location

Components

Component	Name	Count
Inverters	SE33.3KUS (SolarEdge Technologies)	15 (501.0 kW)
Strings	10 AWG (Copper)	40 (5,549.8 ft)
Optimizers	P800S (SolarEdge)	954 (763.2 kW)
Module	Trina Solar, TSM-315 PD14 2014_05 (315W)	1,874 (590.3 kW)

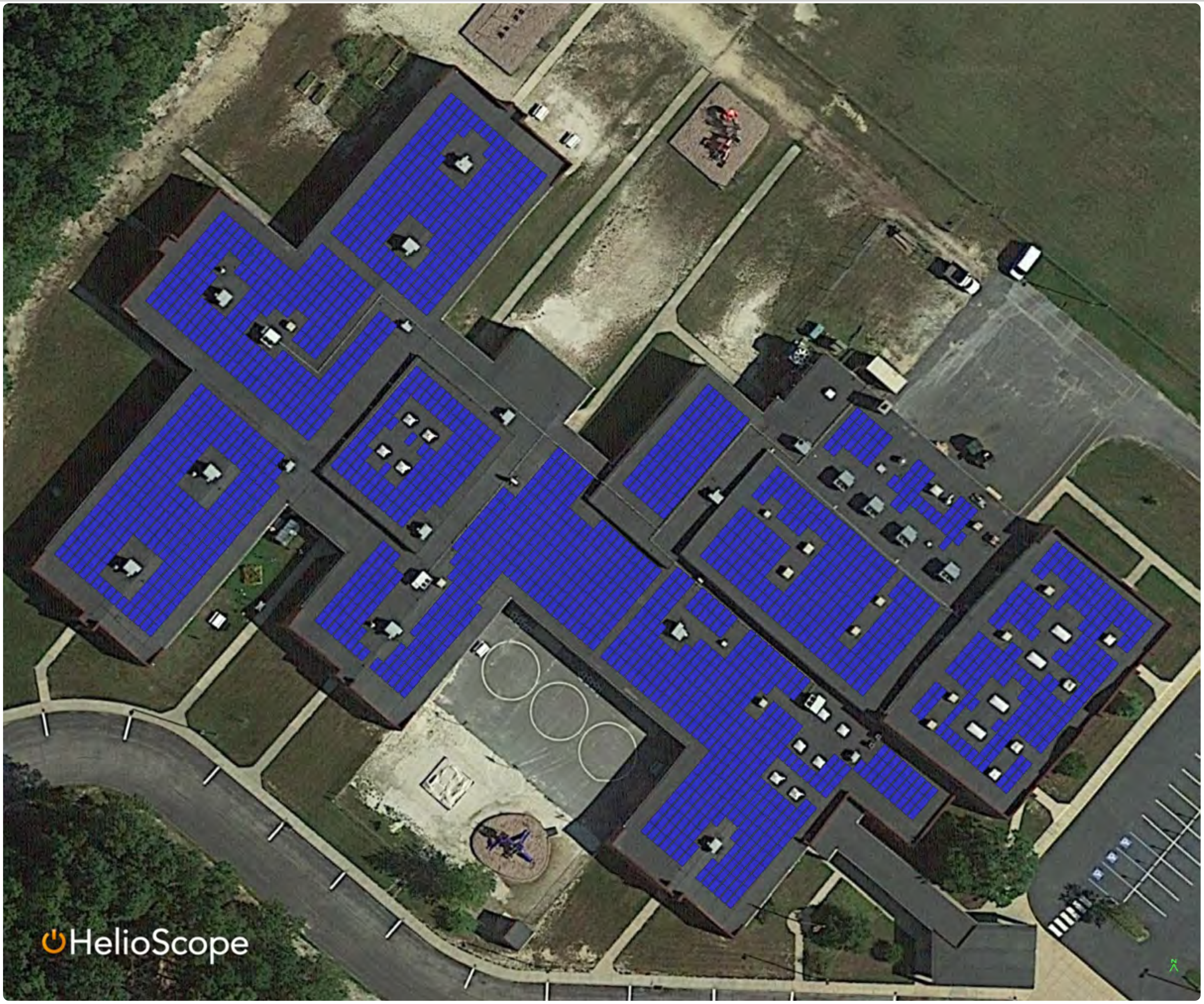
Field Segments

Description	Racking	Orientation	Tilt	Azimuth	Intrarow Spacing	Frame Size	Frames	Modules	Power
Main Roof	Fixed Tilt	Landscape (Horizontal)	5°	130.684°	0.7 ft	1x1	1,391	1,391	438.2 kW
Upper Roof 1	Fixed Tilt	Landscape (Horizontal)	5°	130.684°	0.7 ft	1x1	206	206	64.9 kW
Upper Roof 2	Fixed Tilt	Landscape (Horizontal)	5°	130.684°	0.7 ft	1x1	102	102	32.1 kW
Southern Roof	Fixed Tilt	Landscape (Horizontal)	5°	130.684°	0.7 ft	1x1	175	175	55.1 kW

Wiring Zones

Description	Combiner Poles	String Size	Stringing Strategy
Wiring Zone	12	13-48	Along Racking

Detailed Layout



Reeds School Roof

Galloway MG - Reeds and Rogers, 103 S Reeds Road, Galloway, NJ

Design

Design	Reeds School Roof
DC Nameplate	467.8 kW
AC Nameplate	400.8 kW (1.17 DC/AC)
Last Modified	Tom Brys (Today at 2:10 PM)

Project Location

Components

Component	Name	Count
Inverters	SE33.3KUS (SolarEdge Technologies)	12 (400.8 kW)
Strings	10 AWG (Copper)	31 (2,973.9 ft)
Optimizers	P800S (SolarEdge)	744 (595.2 kW)
Module	Trina Solar, TSM-PEG14 315W (315W)	1,485 (467.8 kW)

Field Segments

Description	Racking	Orientation	Tilt	Azimuth	Intrarow Spacing	Frame Size	Frames	Modules	Power
Upper West Roof	Fixed Tilt	Landscape (Horizontal)	5°	131°	0.7 ft	1x1	139	139	43.8 kW
Largest Roof	Fixed Tilt	Landscape (Horizontal)	5°	131°	0.7 ft	1x1	1,108	1,108	349.0 kW
Small Upper Roof 1	Fixed Tilt	Landscape (Horizontal)	5°	131°	0.7 ft	1x1	20	20	6.30 kW
Small Upper Roof 2	Fixed Tilt	Landscape (Horizontal)	5°	131°	0.7 ft	1x1	156	156	49.1 kW
Small Upper Roof 3	Fixed Tilt	Landscape (Horizontal)	5°	131°	0.7 ft	1x1	62	62	19.5 kW

Wiring Zones

Description	Combiner Poles	String Size	Stringing Strategy
Wiring Zone	12	13-48	Along Racking

Detailed Layout

Canopy between Schools Galloway MG - Reeds and Rogers, 103 S Reeds Road, Galloway, NJ

Design

Design	Canopy between Schools
DC Nameplate	275.9 kW
AC Nameplate	200.0 kW (1.38 DC/AC)
Last Modified	Tom Brys (Today at 2:17 PM)

Project Location

Components

Component	Name	Count
Inverters	Sunny Central SC 100 outdoor HE (SMA)	2 (200.0 kW)
Strings	10 AWG (Copper)	44 (6,012.9 ft)
Module	Trina Solar, TSM-315 PD14 2014_05 (315W)	876 (275.9 kW)

Field Segments

Description	Racking	Orientation	Tilt	Azimuth	Intrarow Spacing	Frame Size	Frames	Modules	Power
Canopy 1	Carport	Portrait (Vertical)	7.5°	130.768°	0.0 ft	1x1	282	282	88.8 kW
Canopy 2	Carport	Portrait (Vertical)	7.5°	130.768°	0.0 ft	1x1	330	330	104.0 kW
Canopy 3	Carport	Portrait (Vertical)	7.5°	130.768°	0.0 ft	1x1	264	264	83.2 kW

Wiring Zones

Description	Combiner Poles	String Size	Stringing Strategy
Wiring Zone	12	13-21	Along Racking

Detailed Layout

Spring Village at Galloway Roof Galloway MG - Spring Village, 46 W Jimmie Leeds Rd, Galloway, NJ

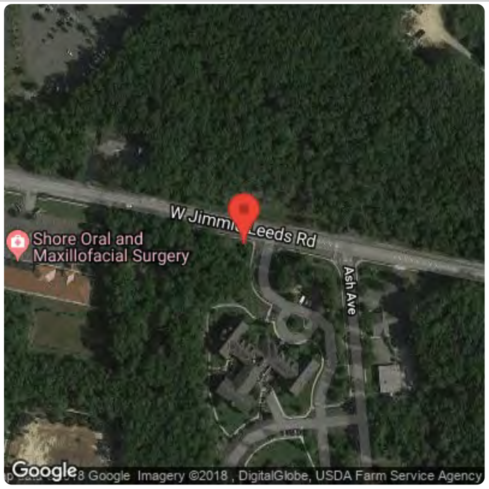
Report

Project Name	Galloway MG - Spring Village
Project Address	46 W Jimmie Leeds Rd, Galloway, NJ
Prepared By	Tom Brys tom@tb-tech.net

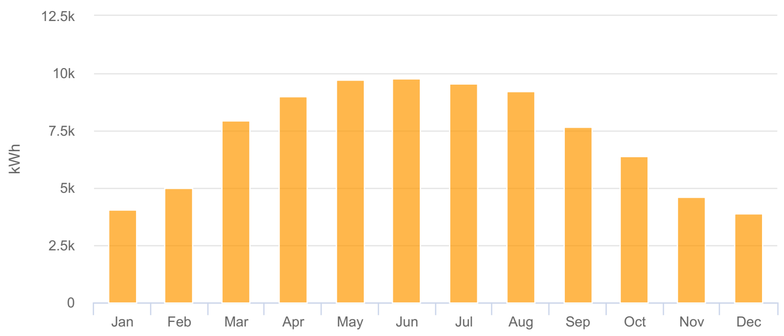
System Metrics

Design	Spring Village at Galloway Roof
Module DC Nameplate	70.9 kW
Inverter AC Nameplate	63.0 kW Load Ratio: 1.13
Annual Production	86.84 MWh
Performance Ratio	78.5%
kWh/kWp	1,225.2
Weather Dataset	TMY, ATLANTIC CITY INTL AP, NSRDB (tmy3, I)
Simulator Version	a36d904014-4b77413718-cab88881b0-f5d77519c2

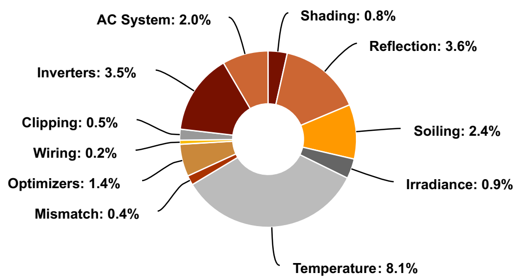
Project Location



Monthly Production



Sources of System Loss



Annual Production

	Description	Output	% Delta
Irradiance (kWh/m²)	Annual Global Horizontal Irradiance	1,480.0	
	POA Irradiance	1,560.0	5.4%
	Shaded Irradiance	1,547.1	-0.8%
	Irradiance after Reflection	1,491.4	-3.6%
	Irradiance after Soiling	1,455.9	-2.4%
	Total Collector Irradiance	**1,455.8**	**0.0%**
Energy (kWh)	Nameplate	103,343.7	
	Output at Irradiance Levels	102,450.0	-0.9%
	Output at Cell Temperature Derate	94,147.6	-8.1%
	Output After Mismatch	93,754.8	-0.4%
	Optimizer Output	92,433.5	-1.4%
	Optimal DC Output	92,268.7	-0.2%
	Constrained DC Output	91,829.2	-0.5%
	Inverter Output	88,608.2	-3.5%
	Energy to Grid	**86,836.0**	**-2.0%**
Temperature Metrics			
	Avg. Operating Ambient Temp		15.2 °C
	Avg. Operating Cell Temp		30.6 °C
Simulation Metrics			
	Operating Hours		4519
	Solved Hours		4519

Condition Set

Description	Condition Set 1
Weather Dataset	TMY, ATLANTIC CITY INTL AP, NSRDB (tmy3, I)
Solar Angle Location	Meteo Lat/Lng
Transposition Model	Perez Model
Temperature Model	Sandia Model

Temperature Model Parameters

Rack Type	a	b	Temperature Delta
Fixed Tilt	-3.56	-0.075	3°C
Flush Mount	-2.81	-0.0455	0°C
East-West	-3.56	-0.075	3°C
Carport	-3.56	-0.075	3°C

Soiling (%)

J	F	M	A	M	J	J	A	S	O	N	D
10.9	11.3	2.4	0.6	0.3	0.6	1.2	1.2	1.8	1.8	1.2	5.5

Irradiation Variance	5%
Cell Temperature Spread	4° C
Module Binning Range	0% to 0.4%
AC System Derate	2.00%

Module Characterizations

Module	Characterization
TSM-PEG14 315W (Trina Solar)	Spec Sheet Characterization, PAN

Component Characterizations

Device	Characterization
P800S (SolarEdge)	Mfg Spec Sheet
SE9KUS (SolarEdge)	Spec Sheet

Components

Component	Name	Count
Inverters	SE9KUS (SolarEdge)	7 (63.0 kW)
Strings	10 AWG (Copper)	11 (930.0 ft)
Optimizers	P800S (SolarEdge)	115 (92.0 kW)
Module	Trina Solar, TSM-PEG14 315W (315W)	225 (70.9 kW)

Wiring Zones

Description	Combiner Poles	String Size	Stringing Strategy
Wiring Zone	12	7-21	Along Racking

Field Segments

Description	Racking	Orientation	Tilt	Azimuth	Intrarow Spacing	Frame Size	Frames	Modules	Power
South Most Peak	Flush Mount	Landscape (Horizontal)	10°	220.176°	0.0 ft	1x1	66	63	19.8 kW
Mid South Facing Peak	Flush Mount	Landscape (Horizontal)	10°	220.117°	0.0 ft	1x1	28	28	8.82 kW
East Facing Peak 1	Flush Mount	Landscape (Horizontal)	10°	130°	0.0 ft	1x1	41	37	11.7 kW
Field Segment 4	Flush Mount	Landscape (Horizontal)	10°	130°	0.0 ft	1x1	55	55	17.3 kW
Field Segment 5	Flush Mount	Landscape (Horizontal)	10°	220.25706513147065°	0.0 ft	1x1	14	14	4.41 kW
Field Segment 6	Flush Mount	Landscape (Horizontal)	10°	129.8217644613286°	0.0 ft	1x1	18	18	5.67 kW
Field Segment 7	Flush Mount	Landscape (Horizontal)	8°	174.46311763751623°	0.0 ft	1x1	0	0	0
Field Segment 8	Flush Mount	Landscape (Horizontal)	8°	218.04704253182615°	0.0 ft	1x1	10	10	3.15 kW

Detailed Layout

Seashore Gardens Living Center Roof Galloway MG - Seashore Gardens Living Center Roof, 22 W Jimmie Leeds Rd, Galloway, NJ

Design

Design	Seashore Gardens Living Center Roof
DC Nameplate	132.9 kW
AC Nameplate	133.2 kW (1.00 DC/AC)
Last Modified	Tom Brys (Today at 1:42 PM)

Project Location

Components

Component	Name	Count
Inverters	SE33.3K (SolarEdge)	4 (133.2 kW)
Strings	10 AWG (Copper)	9 (772.9 ft)
Optimizers	P800S (SolarEdge)	215 (172.0 kW)
Module	Trina Solar, TSM-PEG14 315W (315W)	422 (132.9 kW)

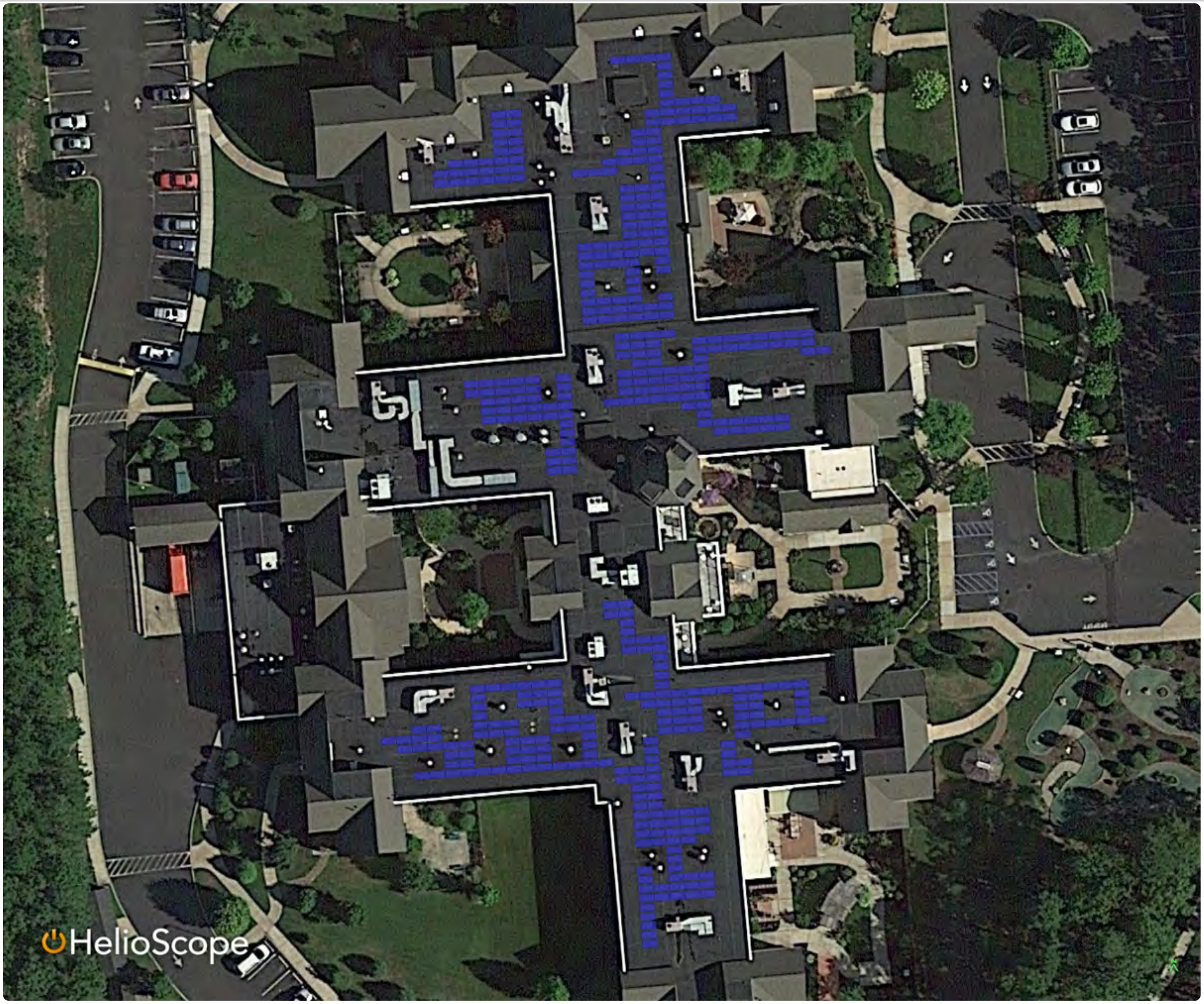
Field Segments

Description	Racking	Orientation	Tilt	Azimuth	Intrarow Spacing	Frame Size	Frames	Modules	Power
Flat Roof	Fixed Tilt	Landscape (Horizontal)	5°	175.914°	0.7 ft	1x1	422	422	132.9 kW

Wiring Zones

Description	Combiner Poles	String Size	Stringing Strategy
Wiring Zone	12	13-48	Along Racking

Detailed Layout



Appendix B – Techno/Economic Model of the GTAM

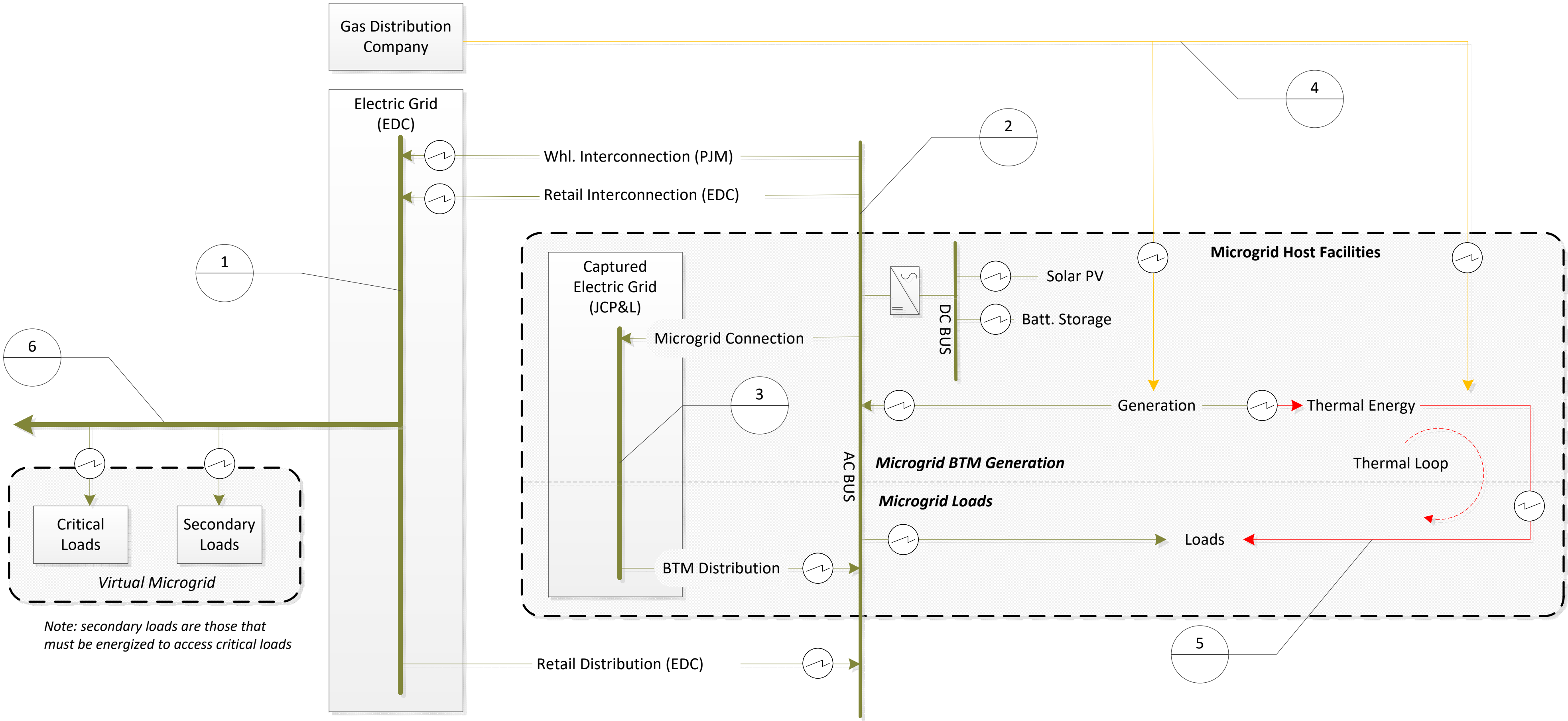
“Unbundled Utility” Tariff Structure

Energy Flows

Electricity → Electric Distribution Company (EDC) & Behind-the-Meter (BTM)
Natural Gas → Gas Distribution Company (GDC)
Therm. Energy → Local Thermal Loop
Metered Energy Services

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



Gas Distribution Company
Electric Grid (EDC)
Whl. Interconnection (PJM)
Retail Interconnection (EDC)
Microgrid Host Facilities
Captured Electric Grid (JCP&L)
Microgrid Connection
Solar PV
Batt. Storage
DC BUS
AC BUS
Generation
Thermal Energy
Microgrid BTM Generation
Thermal Loop
Microgrid Loads
Loads
BTM Distribution
Retail Distribution (EDC)
Critical Loads
Secondary Loads
Virtual Microgrid

Note: secondary loads are those that must be energized to access critical loads

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

Appendix C – Detailed Cash Flow Analysis by Node

Annual Cash Flow for Node 1: Municipal Complex

Annual Cash Flow Analysis - Node 5 in US$	1 2021	2 2022	3 2023	4 2024	5 2025	6 2026	7 2027	8 2028
Electricity Revenue	50,558	51,412	52,280	53,163	54,061	54,974	55,902	56,847
Hot Water Revenue	-	-	-	-	-	-	-	-
SREC Revenue	75,628	75,250	74,874	74,500	74,127	73,757	73,388	73,021
Total Revenue	**126,186**	**126,662**	**127,154**	**127,662**	**128,188**	**128,730**	**129,290**	**129,867**
Fuel Costs	-	-	-	-	-	-	-	-
O&M Cost	(8,680)	(8,854)	(9,031)	(9,211)	(9,396)	(9,583)	(9,775)	(9,971)
NOC Cost	(758)	(771)	(784)	(797)	(811)	(825)	(839)	(853)
Asset Management	(2,524)	(2,533)	(2,543)	(2,553)	(2,564)	(2,575)	(2,586)	(2,597)
Insurance	(4,262)	(4,347)	(4,434)	(4,522)	(4,613)	(4,705)	(4,799)	(4,895)
Property Tax	-	-	-	-	-	-	-	-
Land Lease	-	-	-	-	-	-	-	-
Other/Contingencies	(811)	(825)	(840)	(854)	(869)	(884)	(900)	(916)
Total Operating Expenses	**(17,035)**	**(17,330)**	**(17,631)**	**(17,939)**	**(18,252)**	**(18,572)**	**(18,899)**	**(19,232)**
EBITDA	**109,151**	**109,332**	**109,523**	**109,724**	**109,936**	**110,158**	**110,392**	**110,636**

Annual Cash Flow for Node 2: Stockton, AtlantiCare, Bacharach

Annual Cash Flow Analysis - Node 1 in US$	1 2021	2 2022	3 2023	4 2024	5 2025	6 2026	7 2027	8 2028
Electricity Revenue	3,634,894	3,711,608	3,789,955	3,869,969	3,951,688	4,035,146	4,120,381	4,207,432
Hot Water Revenue	672,252	687,042	702,157	717,604	733,391	749,526	766,016	782,868
SREC Revenue	989,414	984,467	979,545	974,647	969,774	964,925	960,100	955,300
Total Revenue	**5,296,560**	**5,383,117**	**5,471,656**	**5,562,221**	**5,654,853**	**5,749,597**	**5,846,497**	**5,945,600**
Fuel Costs	(1,729,633)	(1,771,144)	(1,813,651)	(1,857,179)	(1,901,751)	(1,947,393)	(1,994,131)	(2,041,990)
O&M Cost	(548,115)	(559,077)	(570,259)	(581,664)	(593,297)	(605,163)	(617,266)	(629,612)
NOC Cost	(64,607)	(65,980)	(67,382)	(68,814)	(70,276)	(71,770)	(73,296)	(74,855)
Asset Management	(105,931)	(107,662)	(109,433)	(111,244)	(113,097)	(114,992)	(116,930)	(118,912)
Insurance	(87,793)	(89,549)	(91,339)	(93,166)	(95,030)	(96,930)	(98,869)	(100,846)
Property Tax	-	-	-	-	-	-	-	-
Land Lease	-	-	-	-	-	-	-	-
Other/Contingencies	(40,322)	(41,113)	(41,921)	(42,744)	(43,585)	(44,443)	(45,318)	(46,211)
Total Operating Expenses	**(2,576,401)**	**(2,634,525)**	**(2,693,985)**	**(2,754,811)**	**(2,817,036)**	**(2,880,691)**	**(2,945,810)**	**(3,012,425)**
EBITDA	**2,720,159**	**2,748,592**	**2,777,671**	**2,807,409**	**2,837,817**	**2,868,905**	**2,900,687**	**2,933,175**

Annual Cash Flow for Node 3: Reeds, Roland Rogers, Galloway Middle School, Absegami High School

Annual Cash Flow Analysis - Node 4	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
in US$	2021	2022	2023	2024	2025	2026	2027	2028
Electricity Revenue	819,724	837,240	855,134	873,412	892,083	911,155	930,638	950,540
Hot Water Revenue	191,808	196,028	200,341	204,748	209,253	213,856	218,561	223,369
SREC Revenue	151,439	150,682	149,928	149,179	148,433	147,690	146,952	146,217
Total Revenue	**1,162,971**	**1,183,950**	**1,205,403**	**1,227,338**	**1,249,768**	**1,272,702**	**1,296,151**	**1,320,127**
Fuel Costs	(511,895)	(524,181)	(536,761)	(549,643)	(562,835)	(576,343)	(590,175)	(604,339)
O&M Cost	(119,873)	(122,271)	(124,716)	(127,210)	(129,755)	(132,350)	(134,997)	(137,697)
NOC Cost	(15,173)	(15,499)	(15,832)	(16,172)	(16,520)	(16,875)	(17,238)	(17,609)
Asset Management	(23,259)	(23,679)	(24,108)	(24,547)	(24,995)	(25,454)	(25,923)	(26,403)
Insurance	(15,552)	(15,863)	(16,181)	(16,504)	(16,834)	(17,171)	(17,514)	(17,865)
Property Tax	-	-	-	-	-	-	-	-
Land Lease	-	-	-	-	-	-	-	-
Other/Contingencies	(8,693)	(8,866)	(9,042)	(9,222)	(9,405)	(9,592)	(9,784)	(9,979)
Total Operating Expenses	**(694,446)**	**(710,358)**	**(726,640)**	**(743,299)**	**(760,344)**	**(777,785)**	**(795,631)**	**(813,890)**
EBITDA	**468,525**	**473,592**	**478,763**	**484,039**	**489,424**	**494,917**	**500,520**	**506,236**

Annual Cash Flow for Node 4: Spring Village

Annual Cash Flow Analysis - Node 2	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
in US$	2021	2022	2023	2024	2025	2026	2027	2028
Electricity Revenue	11,951	12,153	12,358	12,567	12,779	12,995	13,214	13,437
Hot Water Revenue	-	-	-	-	-	-	-	-
SREC Revenue	14,189	14,118	14,047	13,977	13,907	13,838	13,769	13,700
Total Revenue	**26,140**	**26,271**	**26,405**	**26,544**	**26,686**	**26,832**	**26,983**	**27,137**
Fuel Costs	-	-	-	-	-	-	-	-
O&M Cost	(5,564)	(5,675)	(5,789)	(5,905)	(6,023)	(6,143)	(6,266)	(6,391)
NOC Cost	(179)	(182)	(185)	(188)	(192)	(195)	(198)	(202)
Asset Management	(523)	(525)	(528)	(531)	(534)	(537)	(540)	(543)
Insurance	(1,299)	(1,325)	(1,351)	(1,378)	(1,406)	(1,434)	(1,462)	(1,492)
Property Tax	-	-	-	-	-	-	-	-
Land Lease	-	-	-	-	-	-	-	-
Other/Contingencies	(378)	(385)	(393)	(400)	(408)	(415)	(423)	(431)
Total Operating Expenses	**(7,943)**	**(8,093)**	**(8,246)**	**(8,402)**	**(8,561)**	**(8,724)**	**(8,890)**	**(9,059)**
EBITDA	**18,197**	**18,178**	**18,159**	**18,142**	**18,125**	**18,109**	**18,093**	**18,078**

Annual Cash Flow for Node 5: Seashore Gardens Living Center

Annual Cash Flow Analysis - Node 3	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
in US$	2021	2022	2023	2024	2025	2026	2027	2028
Electricity Revenue	141,029	144,020	147,076	150,197	153,384	156,640	159,965	163,362
Hot Water Revenue	48,486	49,553	50,643	51,757	52,896	54,060	55,249	56,465
SREC Revenue	34,650	34,477	34,304	34,133	33,962	33,792	33,623	33,455
Total Revenue	**224,165**	**228,050**	**232,023**	**236,087**	**240,243**	**244,492**	**248,838**	**253,282**
Fuel Costs	(113,866)	(116,599)	(119,397)	(122,263)	(125,197)	(128,202)	(131,278)	(134,429)
O&M Cost	(20,964)	(21,384)	(21,811)	(22,247)	(22,692)	(23,146)	(23,609)	(24,081)
NOC Cost	(2,843)	(2,904)	(2,966)	(3,029)	(3,094)	(3,160)	(3,228)	(3,297)
Asset Management	(4,483)	(4,561)	(4,640)	(4,722)	(4,805)	(4,890)	(4,977)	(5,066)
Insurance	(3,166)	(3,229)	(3,294)	(3,359)	(3,427)	(3,495)	(3,565)	(3,636)
Property Tax	-	-	-	-	-	-	-	-
Land Lease	-	-	-	-	-	-	-	-
Other/Contingencies	(1,573)	(1,604)	(1,636)	(1,668)	(1,701)	(1,735)	(1,769)	(1,804)
Total Operating Expenses	**(146,895)**	**(150,280)**	**(153,744)**	**(157,288)**	**(160,916)**	**(164,628)**	**(168,427)**	**(172,314)**
EBITDA	**77,270**	**77,770**	**78,280**	**78,798**	**79,327**	**79,864**	**80,411**	**80,968**