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Cape May County Municipal Utilities Authority

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December 21, 2018
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Mr. Michael Winka
Senior Policy Advisor
STATE OF NEW JERSEY
BOARD OF PUBLIC UTILITIES
44 S. Clinton Avenue
Trenton, NJ 08625

Re: Cape May County Municipal Utilities Authority
NJBPU Funded Crest Haven Complex TC DER
Microgrid Feasibility Study Final Report

Dear Mr. Winka:

As per agreed upon in the Memorandum of Understanding ("MOU"), adopted by the Authority's Commissioners per Resolution 121-17 on September 6, 2017, attached is the final report for the Crest Haven Complex TC DER Microgrid Feasibility Study, completed by the consultant Global Commons, LLC. The report has been reviewed by the CMCMUA and Project Partners. CMCMUA staff found the final report to contain all of the items set forth in the "Town Center Distributed Energy Resources Microgrid Feasibility Study Report Requirements" (see Attachment A).

Very truly yours,

CAPE MAY COUNTY
MUNICIPAL UTILITIES AUTHORITY

Emily Zidanic

Emily R. Zidanic
Wastewater Program Manager

ERZ:pem
Enclosure
cc: Mr. Bradley T. Rosenthal

Cape May County Municipal Utilities Authority

Attachment A:

Town Center Distributed Energy Resources Microgrid Feasibility Study Report Requirements Checklist

Section	Description	Submitted
A	Table Of Contents	X
B	Executive Summary including all project definitions and special terms used in the Report.	X
C	Project Name: NJBPU Funded Crest Haven Complex TC DER Microgrid Feasibility Study	X
D	Project Applicant: Cape May County Municipal Utilities Authority	X
E	Project Partners	X
F	Detailed Map of project	X
G	Project Description including a detail of all included critical facilities with a description of why they are critical facilities within the proposed TC DER Microgrid.	X
H	A detailed description of the ownership/business model for the overall project including all procurement issues between the various local government and state government partners. This shall include a detailed description of the statutory and regulatory provisions of proposed ownership models, EDC/GDC utility roles, as well as any billing systems for electricity and thermal energy.	X
I	A detailed description of the technology, business and operational protocol to be developed and/or utilized, and the location within the TC DER Microgrid.	X
J	A detailed description of the overall cost including site preparation, equipment and equipment installation, construction, operations, and maintenance, including a detailed construction schedule.	X
K	A detailed cash flow evaluation.	X
L	A detailed description of the potential financing of each location/critical facility and/or the overall project	X
M	A detailed description of the benefits of the proposed TC DER Microgrid as well as the need for the proposed project.	X
N	A general description of the communication system between the TC DER Microgrid and the EDC's system. This should include a detailed description of distribution management systems and controls and all building controls	X
O	The estimated timeframe for the completion of the construction and commencement of operations of the individual critical facilities and the overall project	X
P	A description of the on-going work with the EDC and GDC	X
Q	Included in the Feasibility Study shall be a Conceptual Design that shall be of sufficient detail to demonstrate how the TC DER Microgrid functional and technical requirements will be executed, the proposed approach to solve technical problems, and how project goals will be accomplished.	X

Feasibility Study for Cape May County Municipal Utilities Authority

Final Report

For:

Crest Haven Complex Microgrid Feasibility Study

Global Common, Inc.

GE Energy Consulting

Smith Engineering

December 20, 2018

ACKNOWLEDGEMENTS

The project team would like to acknowledge the contribution of those who facilitated this work.

Global Common

- Mr. Robert Foxen, P.E., CEM

GE Energy Consulting

- Mr. Lavelle Freeman
- Dr. Bahman Daryanian
- Dr. Suresh Gautam
- Dr. Ratan Das
- Ms. Kaita Albanese
- Mr. Phillip de Mello

Smith Engineering

- Mr. Nitin Pathakji, CEM

This work would not have been possible without valuable input and guidance from Emily Zidanic, Cape May County Municipal Utilities Authority and Mr. David Andrews and others at Atlantic City Electric.

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TABLES AND FIGURES

Tables

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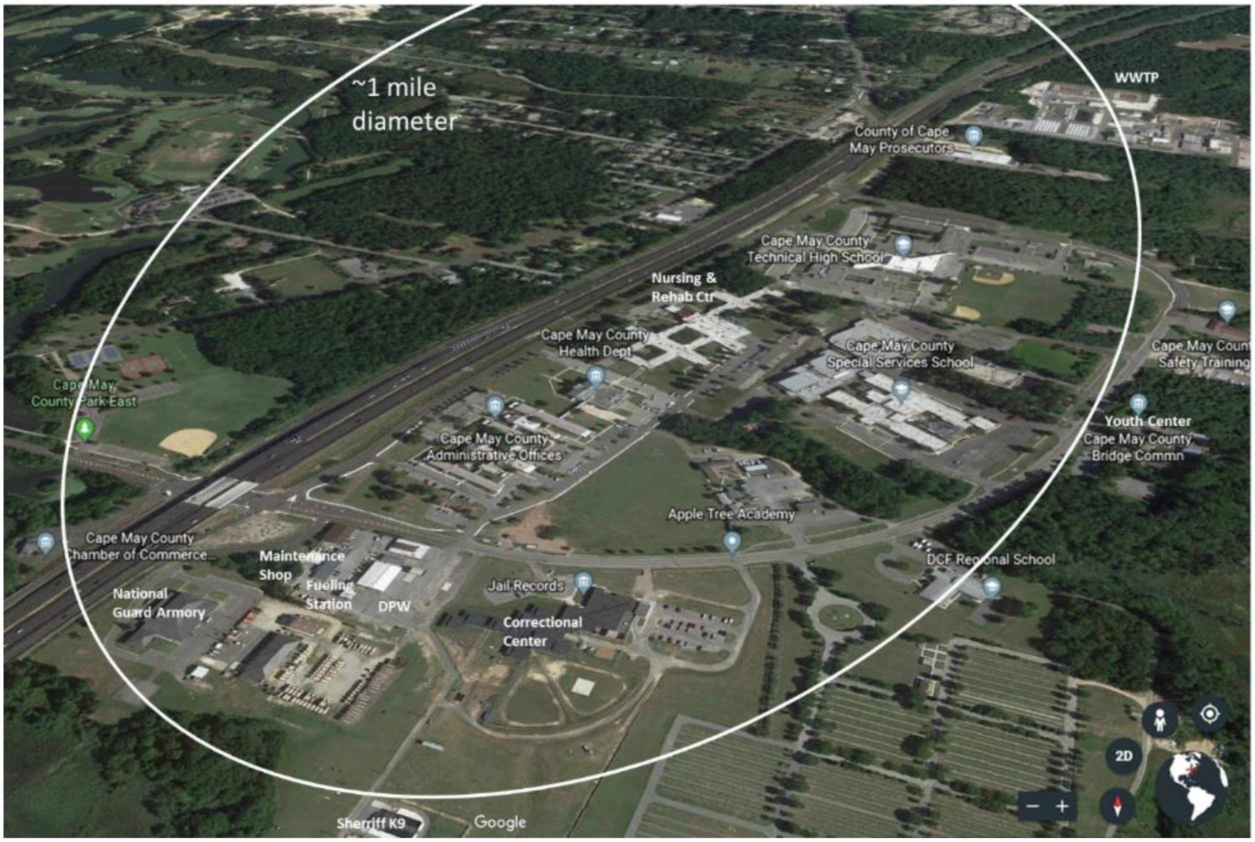
ACRONYMNS

ACE	Atlantic City Electric
EDC	Electric Distribution Company
CAIDI	Customer Average Interruption Duration Index
CHP	Combined Heat and Power
CMCMUA	Cape May County Municipal Utilities Authority
COGS	Cost of Goods Sold
DR	Demand Response
DER	Distributed Energy Resource(s)
DER-CAM	Distributed Energy Resource Customer Adoption Model
DOE	Department of Energy
DSCR	Debt Service Coverage Ratio
EBITDA	Earnings Before Interest, Taxes, Depreciation and Amortization
EV	Electric Vehicle
GDC	Gas Distribution Company
ICE	Interruption Cost Estimate
IEEE	Institute of Electrical and Electronics Engineers
MESCO	Microgrid Energy Services Company
NJDEP	New Jersey Department of Environmental Protection
OH	Overhead
PCC/POI	Point of Common Coupling/Point of Interconnection
PV	Photovoltaic (Solar)
RICE	Reciprocating Internal Combustion Engine
ROW	Right of Way
RNG	Renewable Natural Gas
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
SCADA	Supervisory Control and Data Acquisition
SJG	South Jersey Gas
THS	Technical High School
UG	Underground
VOM	Variable Operation and Maintenance
WWTP	Waste Water Treatment Plant

B. EXECUTIVE SUMMARY

The Crest Haven Complex is a large complex of Cape May County Government buildings and associated agencies in Cape May Court House, Middle Township, New Jersey adjacent to the Garden State Parkway at Exit 11. The figure below shows the location of the critical facilities within the microgrid footprint and their approximate distance from each other.



Coordination with Atlantic City Electric (ACE) and Project Partners

ACE and other project partners provided key energy use data for the critical facilities that was used as the basis for developing the conceptual microgrid plan and selecting proposed distributed energy resources (DER). ACE also provided preliminary information relating to the local electric distribution system and constraints that could impact design of the DER and distribution infrastructure. However, the work scope of this Feasibility Study (FS) stage did not involve system engineering studies, interconnection requirements, and detailed cost estimates that would be needed to evaluate the proposed DER, distribution and protection and control systems. It is expected that ACE and the project team would collaborate to perform these studies as part of the next phase of the microgrid design and development process. ACE has indicated that these studies would take approximately 12 weeks to complete and would be necessary to confirm that the proposed design is feasible and would not adversely impact customers or grid operations of the grid. The follow-on detailed engineering design would also identify mitigation measures or additional assets that would be needed to implement the proposed design. Finally, ACE has indicated that although they support the goals of the microgrid program, there are many regulatory, engineering, and cost issues which must be addressed and resolved in the course of considering the program.

A summary of the peak demand and energy use for the critical facilities is presented in the first table below. As shown, the total non-coincident peak load (i.e. sum of individual peaks without accounting for diversity) is approximately 4,200 kW, and the facilities use approximately 14.4GWh per year of electric energy, which has a total annual cost of approximately $1.9 million. The peak measured load is approximately 3,735 kW. The difference between the measured and billed loads are due to the "ratchet" provisions in the tariff. The peak coincident load is estimated to be approximately 3,400 kW based on results of the DER-CAM modeling analysis.

The second table shows the annual gas usage for facilities in the microgrid. As shown, the facilities use approximately 269,000 therms per year of natural gas, at a cost of approximately $325,000 per year, an average of $1.21 per therm. The largest gas user is the Cape May County Technical High School, which uses approximately 154,260 therms per year (15,426 MMBTU/year). As explained below, this presents an opportunity to utilize cogeneration (CHP) to reduce energy costs.

In addition to these existing energy uses, the Cape May County Municipal Utilities Authority (CMCMUA) intends to install an anaerobic digester at the wastewater treatment plant. Hazen & Sawyer (H&S), a consultant to CMCMUA, has estimated that the digester would produce approximately 41 million cubic feet per year of biogas, or about 2.8 MMBTU's per hour. This output varies significantly over different times of the year, with peak summer gas production over 6x more than winter gas output.

Facility Name	Energy use (kWh)	% of use	Peak loads (billed) (kW)	% of load	Load factor	Gas (MMBTU/yr)
CMCMUA Seven Mile/Middle Wastewater Treatment Plant (WWTP)	3,724,121	26%	838	20%	50.7%	304
CMCMUA Crest Haven Wastewater Pump Station	40,769	0%	24	1%	19.7%	-
CMC Prosecutor's Office/Crime Lab	485,432	3%	131	3%	42.4%	1,218
CMC Sheriff's K9 Unit	47,715	0%	23	1%	24.2%	210
CMC County Correctional Center/Jail	1,646,113	11%	531	13%	35.4%	4,445
CMC County Police & Fire Academies	309,013	2%	123	3%	28.7%	612
CMC County Administration Building	1,078,289	7%	278	7%	44.2%	3,264
CMC Health Department	443,200	3%	173	4%	29.3%	1,742
CMC Nursing/Rehabilitation Center	2,013,060	14%	472	11%	48.7%	407
CMC F&S Warehouse	43,985	0%	15	0%	33.3%	1,849
CMC F&S Maintenance Shop	68,493	0%	31	1%	25.4%	558
CMC Bridge Commission	-	-	-	-	-	282
CMC Special Services School	1,645,500	11%	621	15%	30.2%	9,490
CMC Technical High School (THS)	2,763,856	19%	854	20%	36.9%	23,299
New Jersey National Guard	91,610	1%	61	1%	17.2%	437
Total	14,401,156	100%	4,174	100%	39.4%	44,806

Month	Month	Natural Gas (Therm)	Natural Gas ($)
Jan	1	46,414	58,657
Feb	2	42,478	52,935
Mar	3	44,357	51,995
Apr	4	27,695	30,044
May	5	13,429	14,323
Jun	6	9,144	10,973
Jul	7	4,914	8,178
Aug	8	4,033	6,993
Sep	9	5,373	8,314
Oct	10	10,614	11,823
Nov	11	23,591	27,671
Dec	12	36,996	43,494
Total		269,037	325,400

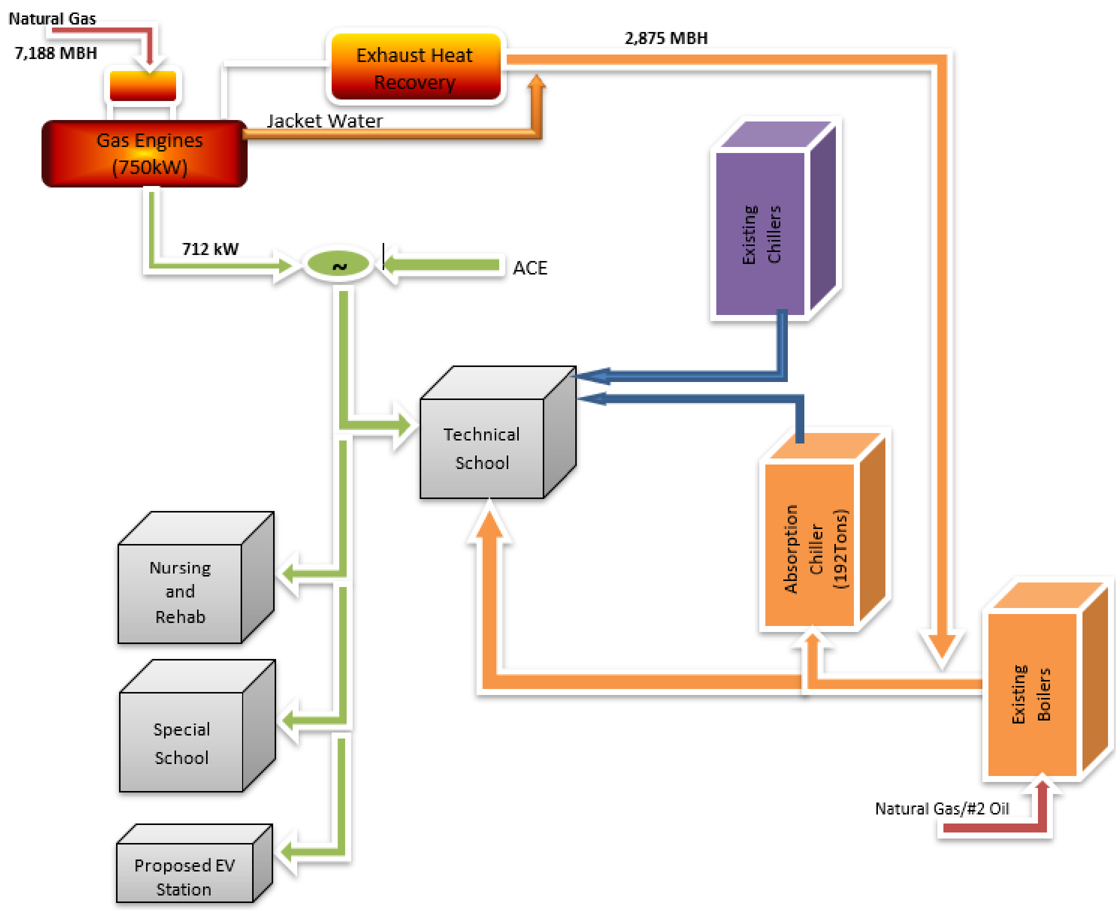
Distributed Energy Resources (DER)

Based on results of the DER-CAM analysis, we established the design capacity for the microgrid of 3,800 kW, based on the peak coincident load of 3,400 kW plus 415 kW of reserve capacity in case the anaerobic digester is out of service and cannot provide gas for the CHP unit there. Therefore, the proposed project will involve use of the DER in the following table.

Microgrid DER	Capacity (kW)	Function/comment
Tech HS CHP	750	Electric for THS, Nursing Home and SS School
WWTP CHP	390	Heats AD influent to increase biogas output
New electric only	200	Rounded up to meet peak load plus reserve
Existing emergency gen	2,475	Behind-the-meter load modifiers
Total generation	**3,815**	Coincident load plus 415 kW reserve

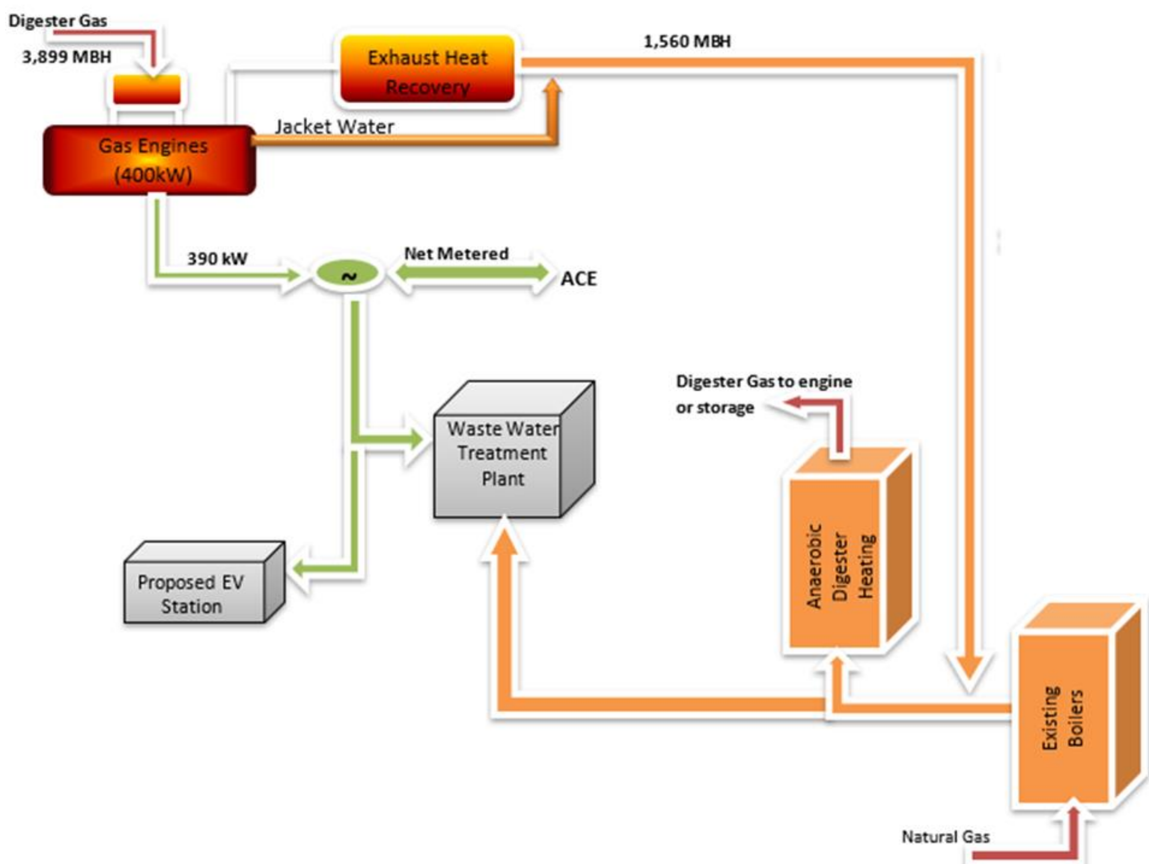
As shown, the project will involve 1,140 of new CHP generation at the Cape May County Technical High School (THS) and the WWTP, and an additional 200 kW of new electric-only generation, which would be located at the administration building so that this facility could participate in demand response programs. During outages to the main grid, the project will also rely on 2,475 kW of existing emergency generation at the WWTP, Nursing Center, County Administration Building and Correctional Center. These emergency generators would operate as load modifiers to reduce the load on the microgrid. However, the project would include transfer switches at the WWTP and County Administration Building that are integrated with the microgrid controller to allow the generating units at these facilities to dispatch to the microgrid during outages, if needed. The electric-only generation would operate during grid outages, dispatching energy to the microgrid as needed to balance supply and demand, or in demand response mode during normal times.

The schematic layout of the CHP system for the THS is shown in the figure below.



As shown above, the CHP units at the THS would provide electric and thermal energy for the THS. This unit will also provide most of the electric needs for the Nursing & Rehabilitation Center and Special Services School via new, dedicated low-voltage service lines that would connect behind the meters of these facilities. The CHP unit would produce over 97% of the electrical energy used by these three facilities. In addition, the CHP unit would reduce gas purchases for the THS by approximately 12,000 MMBTU/year, or a reduction of approximately 80%. These facilities would all remain connected to the Atlantic City Electric (ACE) grid and purchase the balance of their electric energy needs from the grid as needed based on existing tariffs.

The schematic layout of the CHP system for the WWTP is shown in the figure below.



The CHP at the WWTP would be fueled entirely with biogas from the anaerobic digester (AD). Thermal energy from the CHP unit would be used to increase biogas production from the AD by increasing the temperature of the AD influent, thus enhancing the activity of the bacteria in the digester. We estimate that this thermal energy would increase gas production by 25%-35% compared to the H&S estimates of gas production, which would result in a corresponding increase in electric generation.

Based on this analysis, we estimate that this CHP unit would produce almost 80% of the total electric energy usage of the WWTP facility per year. Any excess electric energy that may be available during periods of low energy usage would be net metered to the grid through the existing connection to the ACE distribution lines.

Renewable Natural Gas (RNG) Powered EV Charging

The CHP system at the WWTP will also include five electric vehicle-charging stations that would be powered by the new CHP unit. Thus, vehicles charged here would ultimately be powered with renewable natural gas (RNG). In addition, the project would include five EV charging stations at the THS. The locations of the EV charging stations are shown in Figure I-4.

A breakdown of project costs is shown in the following table. As shown, the total cost after rebates is estimated to be approximately $6.5 million.

Project Costs

Cost item		Amount ($)	Comment
THS CHP		$3,908,654	Includes contingency
WWTP CHP		$3,050,000	Includes contingency
Electric only generation		$130,000	
Microgrid Controller/feeders		$500,000	
EV charging		$100,000	
Subtotal		**$7,688,654**	
Additional contingency	15%	$1,153,298	
Total project cost		**$8,841,952**	
Rebates/grants		$2,290,693	
Net project cost		**$6,551,259**	

Operating Scenarios

During normal operation, when the microgrid is operating in grid-parallel mode, the microgrid facilities will be connected to ACE feeders NJ0042 and NJ0381 via the existing infrastructure as shown in the ACE Portal GIS Map in Figure I-5. It is expected the microgrid will operate in the grid-parallel mode most of the time with the ACE distribution system, supplying power to, or receiving power from, ACE through connections to the two feeders.

During outages, switches on the ACE grid would be configured so that the microgrid could operate in islanded mode with only the critical facilities. In islanded mode, the CHP units will remain base-loaded and provide power to the entire microgrid (not just the facility loads). The new 200-kW reciprocating gas engine at the County Administration Building will also dispatch power to the microgrid facilities. In addition, backup generation at the individual facilities (Correctional Center, Nursing & Rehab Center, WWTP) will come online to reduce the total load on the microgrid.

The microgrid controller continuously monitors the available generation and load, and automatically dispatches new onsite DER to meet the load, optimizes economic operation (as far as possible) and maintains a reserve (or exercises load control) to handle short duration events. The dispatch curves in Section I.6 (DER-CAM Modeling) show operation of the microgrid in grid connected and islanded mode.

Business Model Options

The study considered the following potential business models:

- Publicly-owned microgrid
- Privately-owned microgrid

Under both options, ACE would continue to own and operate the distribution and microgrid control systems. However, CMCMUA or a private party would own and operate the DER.

In a privately-owned microgrid, a private party would design, build, finance, own and operate the DER. The privately-owned microgrid company is referred to as a Microgrid Energy Services Company (MESCO). Under this business model, the energy users and microgrid participants would pay the MESCO for the electric energy it supplies. The MESCO would provide thermal energy for the Technical High School and WWTP at no cost to CMC or the WWTP. The MESCO would have a Power Purchase Agreement (PPA) with CMCMUA that would provide assurance required to finance the project.

Financial Analysis

An analysis of the publicly-owned microgrid is shown in the table below. The data in the table below relate only to the Technical high School, Nursing Home and Rehabilitation Center, Special Services School and WWTP, since the new DER would not affect energy costs at any other facilities. (We have not included revenue from possible participation in a DR program at the County Administration Building.)

CMC Savings Analysis for Publicly Owned Business Model

Current electric costs	$1,295,355	$/year
Current gas costs for Technical High School	$179,367	$/year
Total current energy costs	**$1,474,722**	$/year
Future ACE WWTP electric costs	$98,149	$/year
CHP Fuel	$440,400	$/year
CHP VOM	$183,538	$/year
Future ACE CMC electric costs	$19,157	$/year
Future gas costs at CMC facilities	$37,720	$/year
Total future energy costs	**$778,964**	**$/year**
Gross savings before debt service	**$695,758**	$/year
Debt service	$787,732	$/year
Net additional cost	($91,974)	$/year
Initial investment	$6,551,259	$
Payback	**9.4**	**years**

Note: VOM is variable operations and maintenance for the CHP units

Under the publicly owned scenario, CMCMUA would provide approximately $6.5 million to fund the project. In addition, the anaerobic digester would cost an additional $40.2 million to process peak summer sludge flows, or approximately $18.5 million based on off-peak flows.

As shown, the project would reduce energy costs by approximately $695,000 before debt service and would have a payback period of 9.4 years (excluding costs for the digesters). Including debt service, the energy costs would be approximately $91,000 more than current energy costs. (This assumes a 10-year financing term at 3.5% interest.) However, the project would also provide increased reliability and resiliency for facilities in the microgrid as discussed in Section M.1.

Financial Analysis for Privately Owned Business Model

A simplified income statement for the MESCO that would own and operate the DER is presented below.

MESCO Income Statement

Revenue			
County	$0.020	$/kWh	$124,830
WWTP	0.020	$/kWh	$58,708
Capacity payment	$24.16	$/kW-mo	$1,300,000
Total revenue			**$1,483,538**
COGS			
VOM	$0.02	$/kWh	$183,538
Fuel	$7.35	$/MMBTU	$0
Subtotal COGS			**$183,538**
Gross profit			**$1,300,000**
Gross margin			*87.6%*
SG&A			
Outside services			$25,000
Insurance			$25,000
Property taxes			$25,000
Management fee			$60,000
Other			$25,000
Subtotal SG&A			**$160,000**
EBITDA			**$1,140,000**
Debt service	*$17.34*	*$/kW-mo*	$932,752
Cash flow			$207,248
DSCR			*1.2*

Under this scenario, CMCMUA would pay the MESCO energy payments pursuant to the PPA based on the variable costs of operating the CHP units, and a capacity payment that would be paid regardless of whether the CHP units operate. CMCMUA would also be responsible for purchasing fuel for the THS CHP unit. (This structure is referred to as a "tolling" arrangement.) The capacity payment would be based on the income required to pay all fixed and variable costs plus debt service and achieve the lender's required debt coverage ratio.

The costs for CMCMUA under this scenario are presented in the table below. As shown, the annual cost to CMCMUA would be approximately $424,000 more than current energy costs. However, CMCMUA would not have to borrow approximately $6.5 million to fund the project.

Revenue and Expenses for CMCMUA with MESCO Model		
Energy payment to MESCO-county	$124,830	$/year
Energy payment to MESCO-WWTP	$58,708	$/year
Capacity payment to MESCO	$1,300,000	$/year
Fuel purchases for CHP at Tech HS	$440,400	$/year
Additional electric purchases from ACE	$117,306	$/year
Fuel savings from CHP thermal supply	($141,648)	$/year
Net outlays	**$1,899,597**	**$/year**
Current CMCMUA energy costs	$1,474,722	$/year
Net additional costs to CMCMUA	**($424,875)**	**$/year**

Project Financing

The proposed tolling structure with a capacity payment would mitigate risk for a lender and enable the MESCO to attract 100% debt financing from a traditional lender at very low rates.

C. PROJECT NAME

NJBPU Funded Crest Haven Complex TC DER Microgrid Feasibility Study

D. PROJECT APPLICANT

Cape May County Municipal Utilities Authority (CMCMUA)

E. PROJECT PARTNERS

The project partners are listed below.

i. Cape May County Municipal Utilities Authority
ii. County of Cape May
iii. Cape May County Special Services School
iv. Cape May County Technical High School
v. State of New Jersey Department of Military and Veterans Affairs, New Jersey Army National Guard
vi. Atlantic City Electric (EDC)
vii. South Jersey Gas (GDC)

F. PROJECT LOCATION

A site location map is shown on Figure G-1 below.

G. PROJECT DESCRIPTION

This section includes detail of all included critical facilities with a description of why they are critical facilities within the proposed TC DER Microgrid.

Scope and Purpose

This Feasibility Study (FS) is intended to be the first phase of a multi-phase process that would design, develop, build and operate facilities needed to enhance the resiliency of the energy supply for critical facilities within the microgrid. The results of the study are based on energy use data and other information provided by the project partners, including Atlantic City Electric (ACE) and South Jersey Gas (SJG), as well as the energy users within the microgrid. The purpose of the study is to define, on a preliminary conceptual basis, proposed distributed energy resources (DER), power distribution and control systems that would be used. However, the scope of the study does not include detailed engineering design, interconnection requirements and detailed cost estimates that would be developed during the next phase of study to finalize the microgrid design. It is possible that these more detailed studies could indicate that additional facilities and associated costs are required to implement the project, or that certain facilities need to be modified, or possibly are not feasible.

ACE provided data relating to electric energy usage and costs, as well as preliminary information relating to the local electric distribution system and constraints that could impact design of the DER and distribution infrastructure. However, as mentioned earlier, the study did not involve detailed interconnection studies and related analyses that ACE would need to perform to evaluate the proposed design. It is expected that ACE and the project team would perform these studies as part of the next phase of the microgrid design and development process. ACE has indicated that these studies would take approximately 12 weeks to complete and would be necessary to confirm that the proposed system is feasible and would not adversely impact customers or grid operations. The studies could also possibly identify mitigation measures and additional assets that would be needed to implement the design. Finally, ACE has indicated that although they support the goals of the microgrid program, there are many regulatory, engineering, and cost issues which must be addressed and resolved in the course of considering the program.

G.1 Critical Facilities and Loads

The Crest Haven Complex is a large complex of Cape May County Government buildings and associated agencies in Cape May Court House, Middle Township, New Jersey adjacent to the Garden State Parkway at Exit 11. Most, if not all, of these facilities have completed NJBPU funded Local Government Energy Audits and are served by Atlantic City Electric (ACE) and South Jersey Gas (SJG). The Crest Haven Complex houses the following Critical Facilities:

i. CMCMUA Seven Mile Beach / Middle Wastewater Treatment Facility
ii. CMCMUA Crest Haven Wastewater Pump Station
iii. CMCMUA/County Reclaimed Water for Beneficial Reuse Supply System (Fire Hydrants and other Non-Potable Water Uses)

iv. Cape May County Prosecutor's Office / Crime Lab
v. Cape May County Sheriffs K9 Unit
vi. Cape May County Correctional Center
vii. Cape May County Police and Fire Academies (Public Safety Training Center)
viii. Cape May County Administration Building
ix. Cape May County Health Department
x. Cape May County Road and Bridge Department (Middle Section)
xi. Cape May County Fueling Station (Diesel and Gasoline)
xii. Cape May County Crest Haven Nursing and Rehabilitation Center
xiii. Cape May County Special Services School
xiv. Cape May County Technical High School
xv. New Jersey Army National Guard Armory
xvi. Federal Aviation Administration Navigational Beacon
xvii. Various wireless communication carriers and emergency communication equipment is hosted on towers within the Complex

Figure G-1 shows the location of the critical facilities within the microgrid footprint and their approximate distance from each other.

A summary of the peak demand and energy use for the critical facilities is presented in Table G-1. The electric data shown in this table was provided by Atlantic City Electric (ACE) based on 2017 energy usage. The gas data are based on data from the gas bills provided by the facilities.

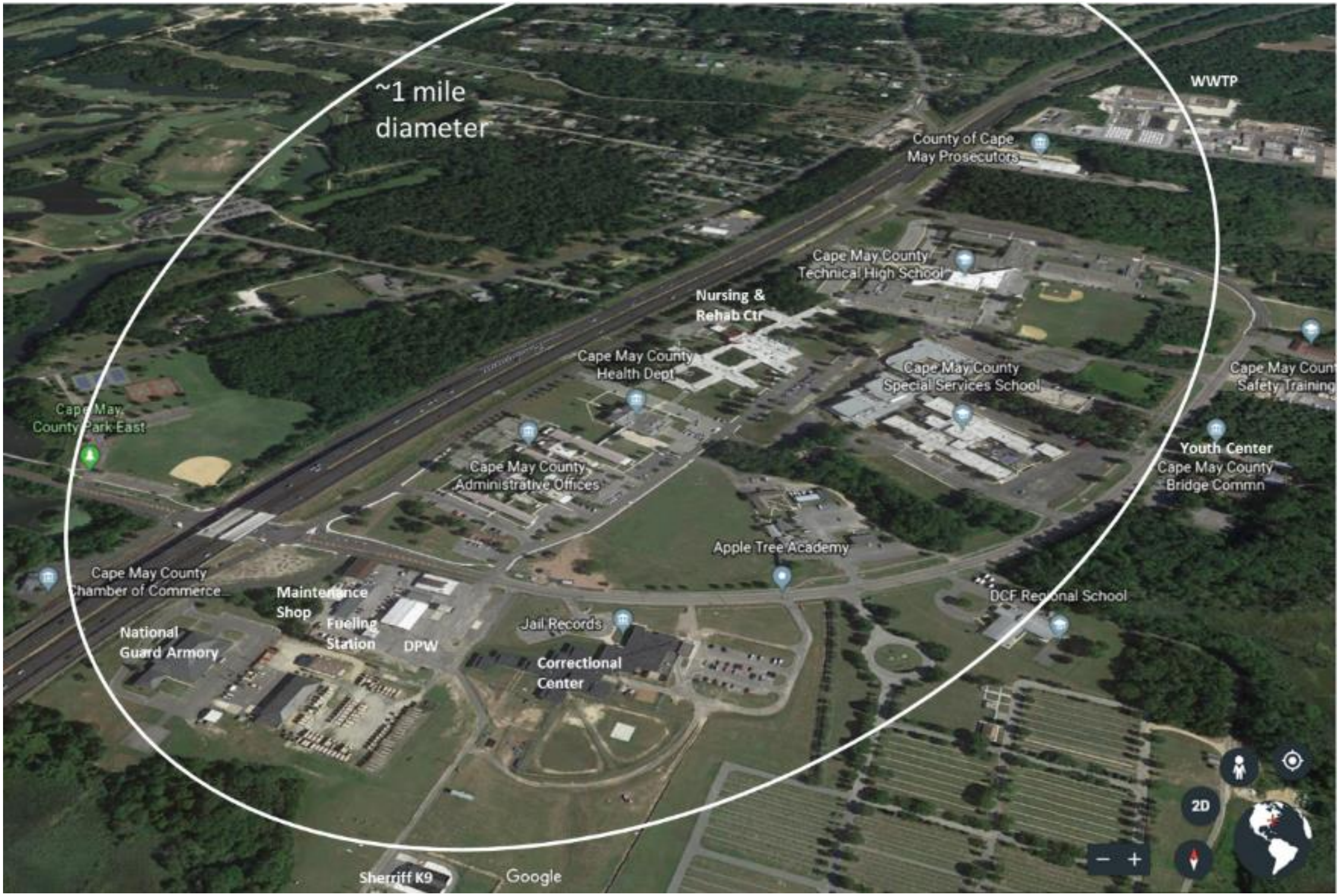


Figure G-1. Map Showing Location of Microgrid Critical Facilities

Table G-1. Summary of Energy Usage

Facility Name	Energy use (kWh)	% of use	Peak load (kW)	% of load	Load factor	Gas (MMBTU/yr)
CMCMUA Crest Haven WWTF	3,724,121	26%	838	20%	50.7%	304
CMCMUA Crest Haven WW Pump Station	40,769	0%	24	1%	19.7%	-
CMC Prosecutor's Office/Crime Lab	485,432	3%	131	3%	42.4%	1,218
CMC Sheriff's K9 Unit	47,715	0%	23	1%	24.2%	210
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New Jersey National Guard	91,610	1%	61	1%	17.2%	437
Total	14,401,156	100%	4,174	100%	39.4%	44,806

As shown in Table G-1, the total *non-coincident* peak electric demand is approximately 4,174 kW, and energy use is approximately 14.4 million kWh/year. The largest electric users are the WWTP and the Technical High School (THS), which combined comprise 45% of the total energy use, and 40% of the peak electric demand. The THS is by far the largest user of natural gas, comprising over 50% of the total gas usage.

A summary of monthly energy usage and non-coincident for the entire microgrid is shown in Table G-2 below. Based on DER-CAM modeling results, the coincident peak load is estimated to be 3,400 kW. Monthly electric data for each facility is presented in the Appendices. As expected, the peak monthly electric demand and usage occurred from June-September. The peak monthly demand ranges from 2,911 kW in November to 3,736 kW in June (which is the coincident peak load for the microgrid). Energy use ranges from a low of approximately 943,000 kWh in November to 1,481,000 kWh in June.

Table G-2 shows that the demand charges comprised nearly 20% of the total electric bills. Facilities that have an Annual General Service tariff, such as the Wastewater Treatment Plant, do not pay delivery charges, but pay a higher demand charge than facilities that have Monthly General Service tariffs. For example, as shown later in Table G-3, the demand charge for the CMC Services School is about 27% of the total annual charges. In contrast, Table G-4 shows that the demand charges for the Sheriff's K9 Unit are only about 5.3% of the total annual charges.

Since the demand charges for the facilities with the Annual General Services tariff have a 12-month "ratchet" based on the highest 15-minute interval in a given month, these facilities may have an opportunity to significantly reduce their costs by reducing demand during relatively short intervals, depending on their load profile. It may be cost-effective to reduce these peaks by some type of demand response program. The Feasibility Study will examine these potential opportunities as part of the next stage of the study when the 15-minute interval data is evaluated (where this data is available.)

Table G-2. Cape May Microgrid (All Facilities)

Month	Billed KWH/CCF	Billed KW	Measured KW	Delta kW	Delivery Cost ($)	Delivery Demand Cost ($)	Delivery Minus Demand Cost ($)	Supply Cost ($)	Total Cost ($)
1	1,022,755	3,307	2,958	349.1	61,088	29,329	31,759	74,676	135,764
2	1,081,707	3,280	2,913	367.1	63,690	29,052	34,638	79,207	142,896
3	1,099,592	3,322	2,939	383.1	65,689	28,852	36,837	80,822	146,512
4	1,164,713	3,349	3,304	45.3	65,836	29,225	36,610	92,779	158,615
5	1,383,375	3,539	3,538	0.8	71,715	31,114	40,601	109,830	181,545
6	1,491,379	4,056	3,736	0.0	77,437	33,904	43,533	110,926	188,363
7	1,471,628	3,903	3,544	39.0	75,138	32,553	42,585	110,086	185,224
8	1,353,005	3,789	3,447	22.8	70,943	31,325	39,619	101,379	172,322
9	1,072,666	3,671	3,267	113.3	61,110	30,532	30,579	78,661	139,772
10	1,012,212	3,604	3,156	168.9	58,419	30,041	28,378	74,000	132,419
11	993,498	3,584	2,911	416.4	57,616	29,690	27,925	72,439	130,055
12	1,254,626	3,702	3,080	342.6	74,002	30,615	43,387	91,692	165,694
	14,401,156	4,056	3,736	416.4	802,683	366,233	436,450	1,076,497	1,879,180
				% of total	42.7%	19.5%	23.2%	57.3%	100.0%

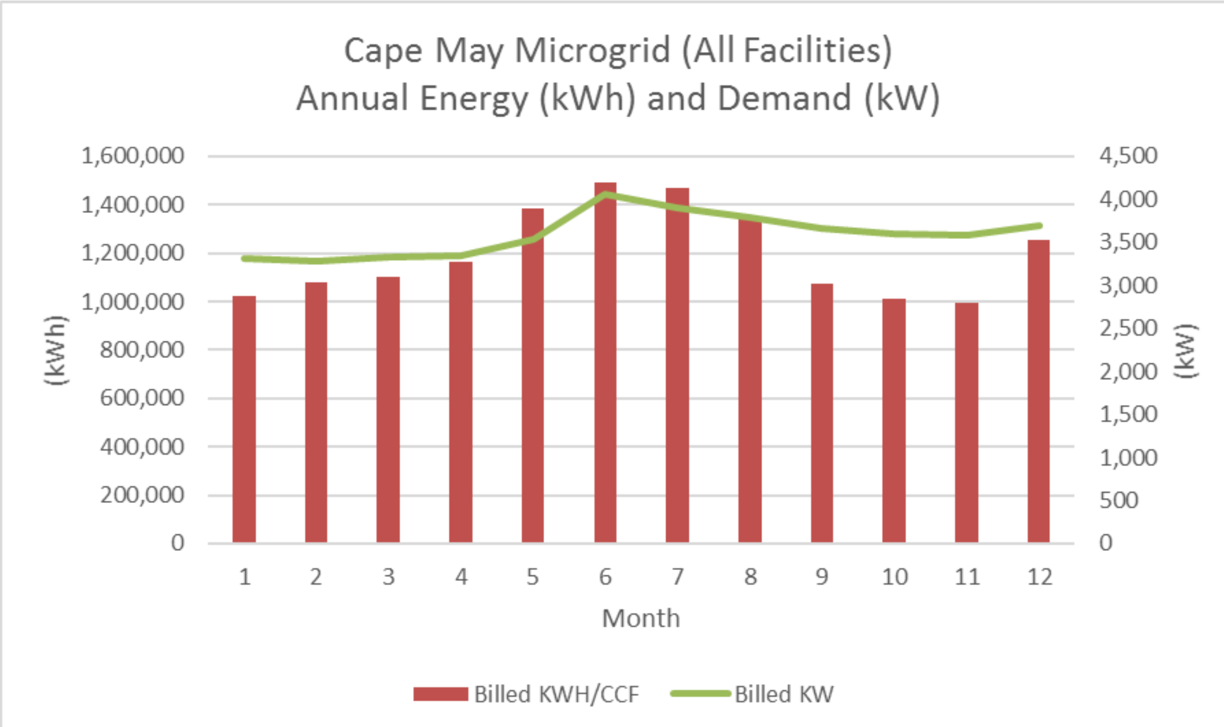


Figure G-2. Monthly Microgrid Electric Data

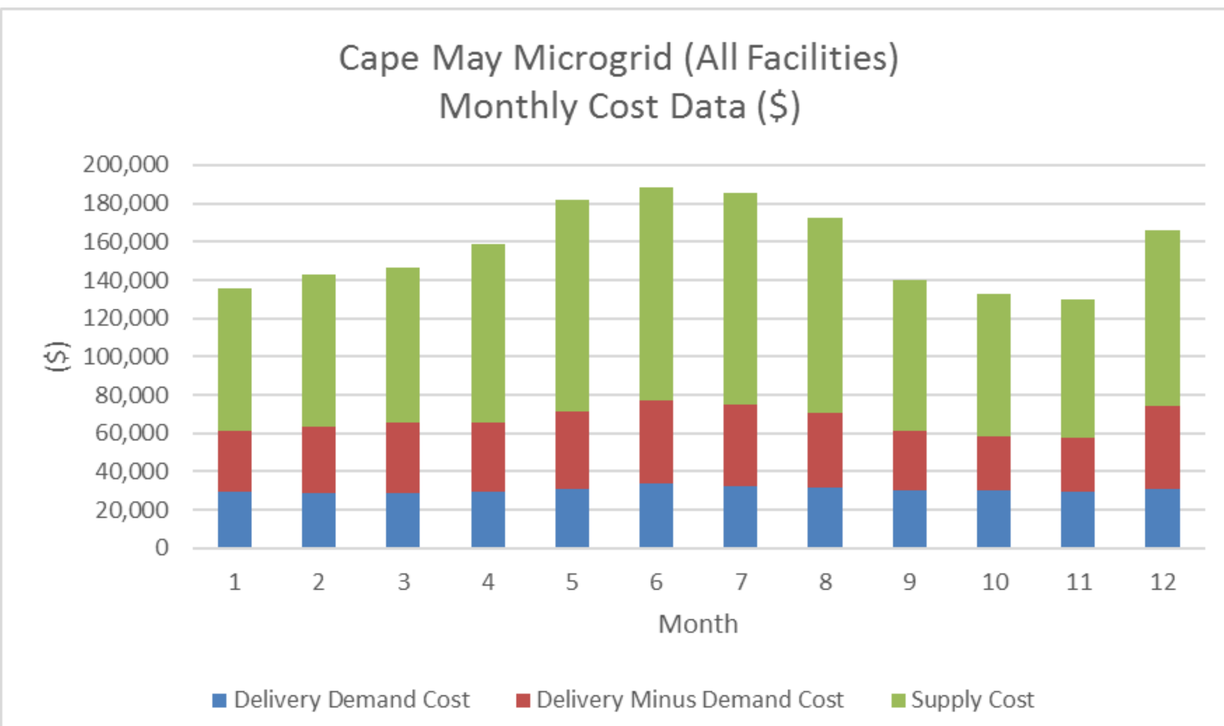


Figure G-3. Monthly Microgrid Electric Cost Analysis

Table G-3. CMC Services School

Month	Billed KWH/CCF	Billed KW	Measured KW	Delta kW	Delivery Cost	Delivery Demand Cost ($)	Delivery Minus Demand Cost ($)	Supply Cost ($)	Total Cost ($)
1	124,800	496.8	435.0	61.8	8,097	4,690	3,407	8,772	16,869
2	121,800	496.8	342.0	154.8	8,009	4,690	3,319	8,561	16,569
3	116,700	496.8	360.0	136.8	8,261	4,690	3,571	8,202	16,464
4	135,000	496.8	489.0	7.8	8,219	4,690	3,529	10,602	18,821
5	167,400	579.0	579.0	0.0	10,071	5,466	4,605	13,147	23,217
6	170,700	621.0	621.0	0.0	10,282	5,862	4,420	12,026	22,308
7	135,000	528.0	528.0	0.0	8,196	4,984	3,212	9,511	17,707
8	151,800	496.8	489.0	7.8	8,714	4,690	4,024	10,694	19,408
9	144,600	567.0	567.0	0.0	8,689	5,352	3,337	10,187	18,876
10	123,300	567.0	567.0	0.0	8,162	5,352	2,810	8,686	16,849
11	118,500	496.8	387.0	109.8	7,419	4,690	2,729	8,348	15,767
12	135,900	496.8	351.0	145.8	9,037	4,690	4,347	9,552	18,589
	1,645,500	621.0	621.0	154.8	103,156	59,846	43,310	118,288	221,444
					46.6%	27.0%	19.6%	53.4%	100.0%

Table G-4. Sheriff's K9 Unit

Month	Billed KWH/CCF	Billed KW	Measured KW	Delta kW	Delivery Cost	Delivery Demand Cost ($)	Delivery Minus Demand Cost ($)	Supply Cost ($)	Total Cost ($)
1	3,985	13.2	13.2	0.0	325	22	303	292	617
2	3,966	20.1	20.1	0.0	335	34	301	291	626
3	3,358	23.3	23.3	0.0	298	40	259	246	545
4	2,325	19.6	19.6	0.0	212	33	179	187	400
5	3,844	14.8	14.8	0.0	324	25	299	310	634
6	5,940	15.2	15.2	0.0	494	31	462	442	936
7	5,091	14.8	14.8	0.0	426	31	395	381	807
8	3,383	14.6	14.6	0.0	299	30	269	257	556
9	3,041	22.5	22.5	0.0	268	47	221	224	492
10	3,113	22.5	22.5	0.0	270	38	231	229	498
11	3,564	20.2	20.2	0.0	297	34	262	262	559
12	6,105	22.1	22.1	0.0	496	38	458	448	944
	47,715	23.3	23.3	0.0	4,044	404	3,640	3,570	7,614
					53.1%	5.3%	47.8%	46.9%	100.0%

G.2 Gas Use Data

A summary of the gas use data based on information in gas bills provided by the facilities is presented in Table G-5 and Figure G-4 below. Detailed monthly gas data for each of the facilities are presented in the Appendices.

Table G-5. Cape May Microgrid Gas Data (All Facilities)

Month	Month	Natural Gas (Therm)	Natural Gas ($)
Jan	1	46,414	58,657
Feb	2	42,478	52,935
Mar	3	44,357	51,995
Apr	4	27,695	30,044
May	5	13,429	14,323
Jun	6	9,144	10,973
Jul	7	4,914	8,178
Aug	8	4,033	6,993
Sep	9	5,373	8,314
Oct	10	10,614	11,823
Nov	11	23,591	27,671
Dec	12	36,996	43,494
Total		269,037	325,400

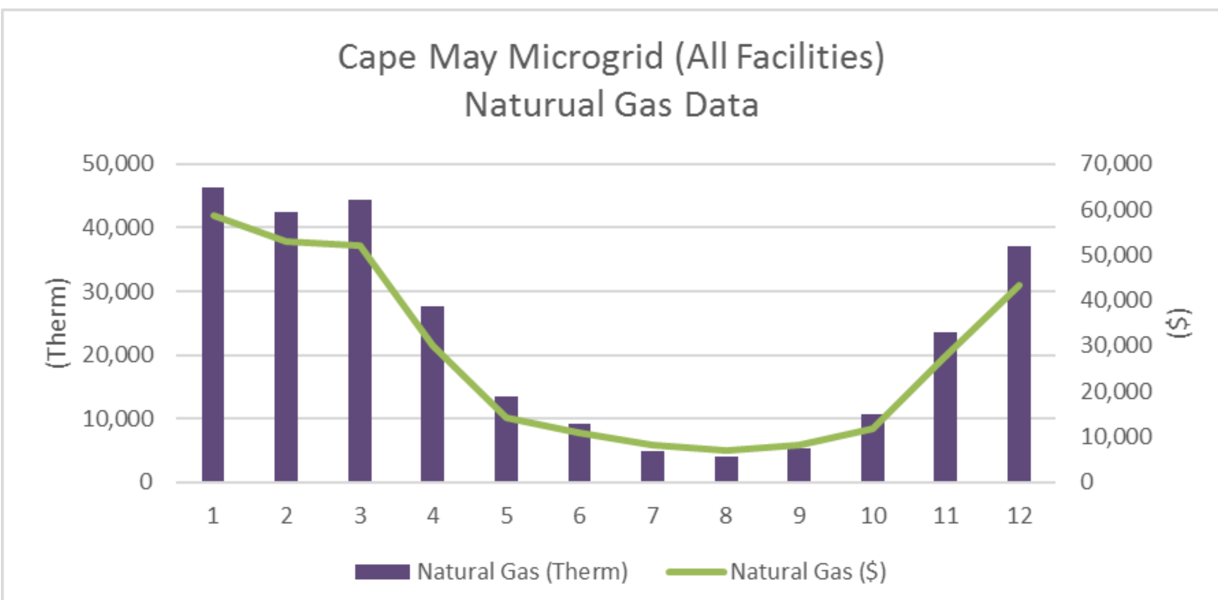


Figure G-4. Monthly Gas Usage Data

As shown, the facilities use approximately 269,000 therms per year of gas, and pay a total of $325,000 per year, or an average of $1.21 per therm. As expected, most of the gas is used during cold weather months. The facilities used approximately 169,000 therms during December-March, or about 63% of the total annual usage.

The largest gas users are the Technical High School and the Services school, which account approximately 56% of the total consumption. It should also be noted that the electric loads for these facilities increases during June-September, most likely due to air conditioning usage. Thus, it may be economical to install a cogeneration system at one or both of these facilities that would use waste heat for space heating during the winter, and for cooling during the summer.

G.3 Facility Information

The square footage and FEMA designations of the critical facilities, along with Energy Efficiency and Energy Conservation Measures previously implemented, are shown in the Table G-6 below. There are no designated emergency shelters facilities in this project.

Table G-6. Square Footage, FEMA Categories, and EE/ECM for Critical Facilities

Facility Name	Area (SF)	FEMA Cat.	Energy Efficiency/Energy Conservation Measures
CMCMUA Crest Haven Wastewater Treatment Plant	135,000	III	Variable speed pump, high efficiency motors, lighting upgrades
CMCMUA Crest Haven Wastewater Pump Station	250	III	Variable speed pump, high efficiency motors, lighting upgrades
CMC Prosecutor’s Office/Crime Lab	41,166	IV	LED lighting, upgraded boilers, BMS
CMC Sheriff's K9 Unit	3,487	IV	LED lighting, upgraded boilers, BMS
CMC County Correctional Center/Jail	46,872	III	LED lighting, upgraded boilers, BMS
CMC County Police and Fire Academies	4,482	IV	LED lighting, upgraded boilers, BMS
CMC County Administration Building	65,634	III	LED lighting, upgraded boilers, BMS
CMC Health Department	31,229	III	LED lighting, upgraded boilers, BMS
CMC Crest Haven Nursing and Rehabilitation Center	95,669	III	LED lighting, upgraded boilers, BMS, New energy efficient windows
CMC Facilities and Services Warehouse	10,000	IV	LED lighting, upgraded boilers, BMS
CMC Facilities and Service, Maintenance Shop	1,500	IV	LED lighting, upgraded boilers, BMS
CMC Bridge Commission	3,427	III	LED lighting, upgraded boilers, BMS
CMC Special Services School	176,000	III	LED lighting, upgraded boilers, BMS
CMC Technical High School	249,800	III	LED lighting, upgraded boilers, BMS
New Jersey National Guard	32,052	IV	Upgraded lighting, new roof, energy efficient doors and windows, smart electric meters
Total	896,568		

G.4 Environmental Permits

The CHP and electric only generating units will require air permits pursuant to requirements of the New Jersey Department of Environmental Protection (NJDEP). No other environmental permits are anticipated for this project. The timeframe to obtain these permits is typically six months after filing applications.

G.5 Energy Efficiency, Conservation and Demand Response Measures

The Crest Haven facilities have implemented several energy efficiency and energy conservation measures in the past. These are summarized in Table G-6 above.

In the proposed microgrid configuration, we have proposed installing a 200-kW Natural Gas fired generator at the CMC County Administration building. We have proposed to use this generator under demand response. No other demand response measures are included in the proposed scheme.

H. OWNERSHIP/BUSINESS MODEL

The study considered the following potential business models:

- Publicly-owned microgrid
- Privately-owned microgrid

Under both options, ACE would continue to own and operate the distribution and microgrid control systems. However, CMC or a private party would own and operate the DER, as explained below.

H.1 Publicly-Owned Microgrid

Under the publicly-owned microgrid option, Cape May County (CMC), or another public entity, would own and operate all microgrid DER. However, CMC would install and own new, dedicated feeders to connect the new CHP generation at the Technical High School to the Nursing Home and the Special Services School. Since these connections would all be behind the meters, would not cross any public rights of way, and would be exclusively on county property, this configuration would not conflict with any ACE distribution or franchise rules. CMC and its consultants would work in collaboration with ACE to design and deploy an appropriate microgrid control system.

The advantage of the publicly-owned microgrid is that the cost of capital would likely be lower than if the project is privately financed. In addition, CMC would receive 100% of any savings resulting from use of the DER. However, CMC would also have the responsibility and risk of operating the DER under this scenario. One way to address this risk could be for CMC to finance and own the microgrid and lease the assets to a microgrid service company or developer that would be responsible for operating the system. If a lease structure is used, the lessee would have a Power Purchase Agreement (PPA) with CMC that would provide terms for sale of the power from the CHP unit to CMC. Alternatives for different PPA structures are described in the following section.

H.2 Privately-Owned Microgrid

In a privately-owned microgrid, a private party would design, build, finance, own and operate the DER, and ACE would continue to own and operate the distribution system. The privately-owned microgrid company is referred to as a Microgrid Energy Services Company (MESCO). Under this business model, the energy users and microgrid participants would pay the MESCO for energy it supplies, and for the resiliency benefits provided by the microgrid.

As with the public microgrid option, the private owner would also install and be responsible for dedicated feeders to supply electricity by the CHP unit at the Technical High School to the Nursing Home and Special services school.

The MESCO would have a Power Purchase Agreement (PPA) with CMC that would provide assurance required to finance the project. The terms of the PPA would need to be structured to assure that the lender would be repaid under all circumstances. One option would be to establish a take or pay type of contract for sale of electricity, and an indexation formula that would adjust the price of energy based on the price of fuel.

Another option would be to use a Tolling Agreement, which is used frequently with power purchase contracts. Under this structure, CMC would purchase the fuel needed to operate the CHP system at the Technical High School and provide it to the MESCO at no cost. CMC would also pay the MESCO a Capacity Payment that would cover the fixed costs, debt service and return for the MESCO, and assure loan repayment even if CMC did not require any power. However, CMC would not be obligated to pay the Capacity Payment if the system were not able to operate due to the fault of the MESCO. The MESCO would only charge CMC for the variable costs of operation, which would be passed on to CMC with no mark up or profit margin.

Under all privately-owned business models, the MESCO would provide thermal energy for the Technical High School and WWTP at no cost to CMC or the WWTP. This thermal energy would benefit the WWTP by increasing biogas production, which would produce more electric energy to offset purchases from ACE.

Under both privately-owned models, and with the lease structure mentioned previously, the MESCO would submit invoices to the Technical High School, Special Services School, and Nursing home, based on terms of the PPA.

An evaluation of the microgrid cash flow for the MESCO option is presented in Section K below.

H.3 Compliance with Statutory Rules

We do not anticipate any issues relating to statutory rules under either business model, since the DER would function behind the meters consistent with all existing rules and requirements. In all business models, the project would comply with all ACE tariff and interconnection requirements.

H.4 EDC/GDC Roles

As stated, ACE would continue to own and operate the distribution system and microgrid controller based on their existing business arrangements, and South Jersey Gas would supply gas for the CHP system at the Technical High School. We also do not anticipate any issues regarding EDC/GDC roles, since the EDC/GDC would continue to supply all the microgrid loads during normal times based on current electric and gas tariffs.

During outages to the main grid, ACE would utilize the microgrid controller to open switches that would isolate the microgrid and manage operation of the DER within the microgrid.

I. TECHNOLOGY, BUSINESS AND OPERATIONAL PROTOCOL

This section describes the technology, business and operational protocol to be developed and/or utilized, and the location within the TC DER Microgrid.

I.1 Proposed Connections

The DER type, location and sizes proposed for the Crest Haven Microgrid are listed in Table I-1 and Table I-2 below. A total of 3,727 kW of new and existing generation will be deployed to serve the microgrid load in islanded mode.

Table I-1. New DER, Location, Size, Type

Location	Size (kW)	Type/Fuel
Technical HS	750	CHP/gas
WWTP	390	CHP/biogas
County Administration Building	200	Recip/gas
Total New Generation	**1,440**	

Table I-2. Existing DER, Location, Size, Type

Location	Size (kW)	Type/Fuel
Correctional Center	600	N/A
Nursing & Rehab Center	625	Natural Gas
Nursing & Rehab Center	100	Natural Gas
WWTP	1,000	Diesel
County Administration Bldg.	150	NG
Total Existing Generation	**2,475**	

I.1.1 CHP at Technical High School (THS)

Detailed reports on the CHP systems for the THS and WWTP are contained in the Appendices.

The 750-kW CHP system at the Technical school will recover waste heat in the form of hot water and chilled water for consumption within the technical school. Excess power produced by the CHP system will be provided to adjacent facilities, Nursing and Rehab center and Special School, via low-voltage electrical (service) cables from the Technical HS. The service concept is shown in Figure I-6 below.

The recovered heat from the 750-kW CHP system will be piped from the CHP module to the building heating system. The estimated peak heating available from the CHP system is 2,875 MBH. The connection will be such that the waste heat will act as supplement to the boilers and incase the CHP system is down for maintenance or for emergency, the existing boilers will automatically pick up the building heating load.

The recovered heat will provide source energy to a new proposed absorption chiller. The estimated peak cooling capacity available from waste heat is 192 TR. The chilled water generated from the absorption chiller will be circulated within the technical school. New fan coil units located in classrooms and common area will provide cooling to the building. The existing air conditioners will remain in place and will provide cooling needs for the rest of the campus and in case the CHP is not available for any reason.

The power generated by the CHP system will be supplied to the Technical High School and also to the adjacent Nursing and Rehab Center and the Special Services School. A new common low-voltage service line from the machine will route the electrical power to the three facilities. The Nursing and Rehabilitation facility and the Special Services School are approximately 150 ft from the technical school. The proposed routing for the line will be underground direct-buried cabling.

Figure I-1 shows the concept of the proposed CHP system and the energy balance of the CHP system.

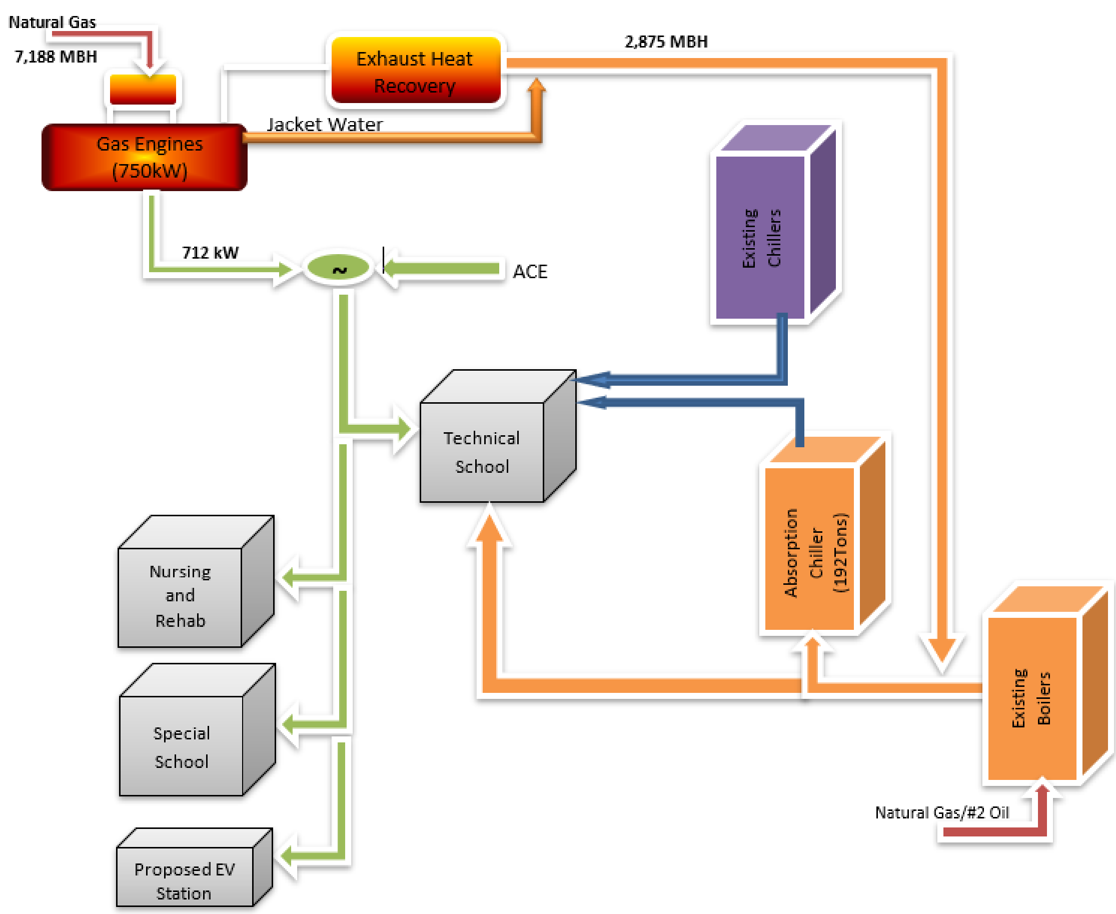


Figure I-1. CHP Concept for Technical HS Showing Secondary Electrical Service to Adjacent Facilities & EV Station

Figure I-2 shows the approximate location of the CHP unit and the EV charging station at the Technical High School, as well as the low-voltage service drops to the adjacent facilities.

The electrical connections for the Technical HS CHP as well as other microgrid DER are further discussed with reference to the electrical layout and one-line diagrams in Section I.2.

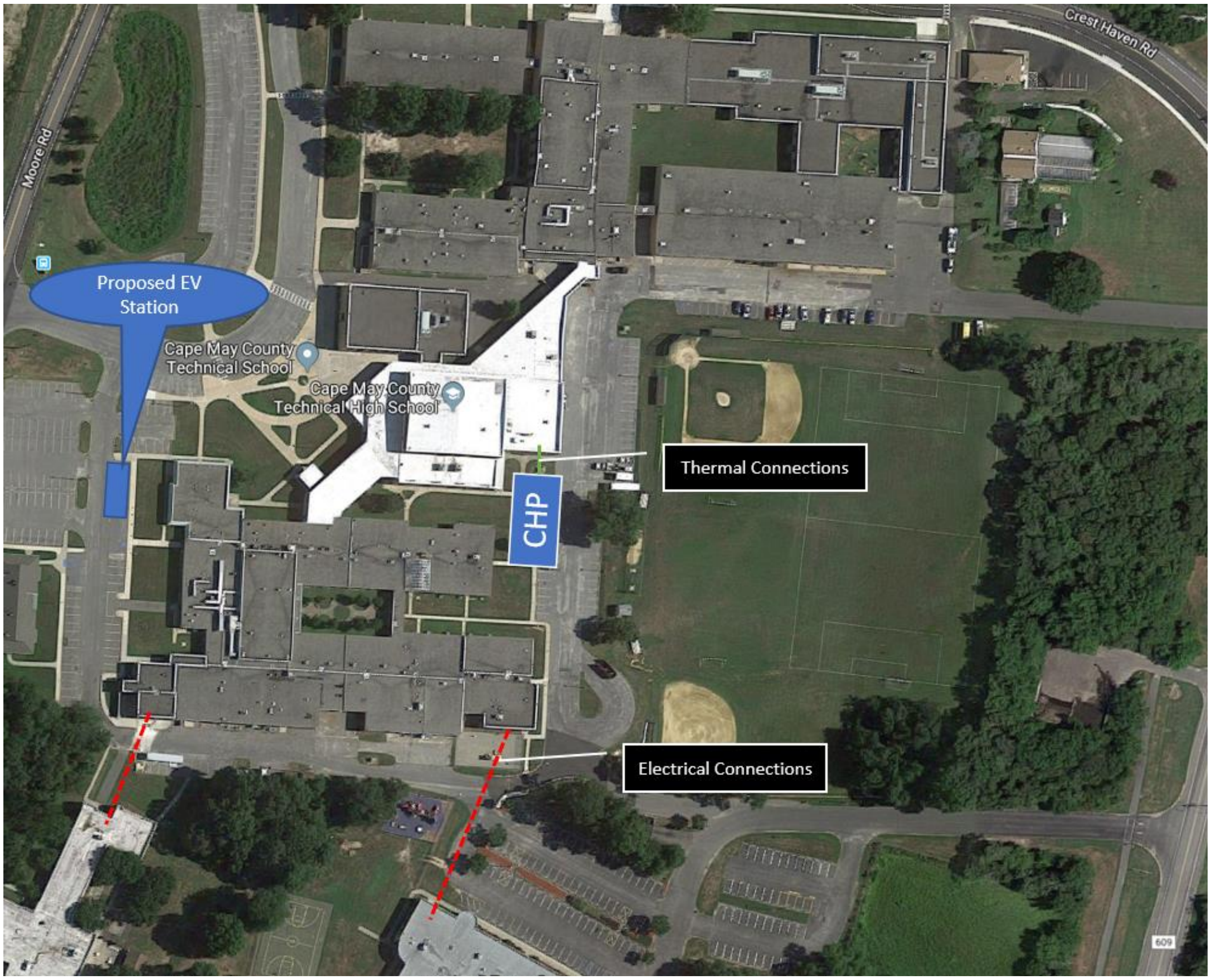


Figure I-2. Proposed Location of CHP and EV Charging System at THS and Connections to Facilities

I.1.2 Digester Gas CHP at Waste Water Treatment Plant

The proposed 390-kW CHP system will operate using low BTU digester gas that is produced by the anaerobic digester that is planned at the wastewater treatment plant. The recovered heat from the engine generator shall be used to heat the sludge to enhance the digestion and produce more digester gas. During the winter months, since the sludge supply is very small, the excess heat will be used to heat the adjacent wastewater treatment office buildings. During the summer months, all the waste heat will be used to heat the incoming sludge.

Alternatively, the excess heat can be used to dry the sludge to save on transportation cost. The value of the transport savings will need to be evaluated in more details, with proper transport cost estimation and secondary issues of contaminants for the terminal points at the incinerators.

Due to the seasonal variation in incoming sludge, it is proposed to store the digester gas at the waste water treatment site. The excess digester gas produced during the summer months and stored in the tank will be used in the winter months to operate the generator.

Since this is a renewable energy source, we propose to net meter the electrical energy produced by the engine generator. Figure I-4 shows the proposed location for the CHP system at the waste water treatment plant.

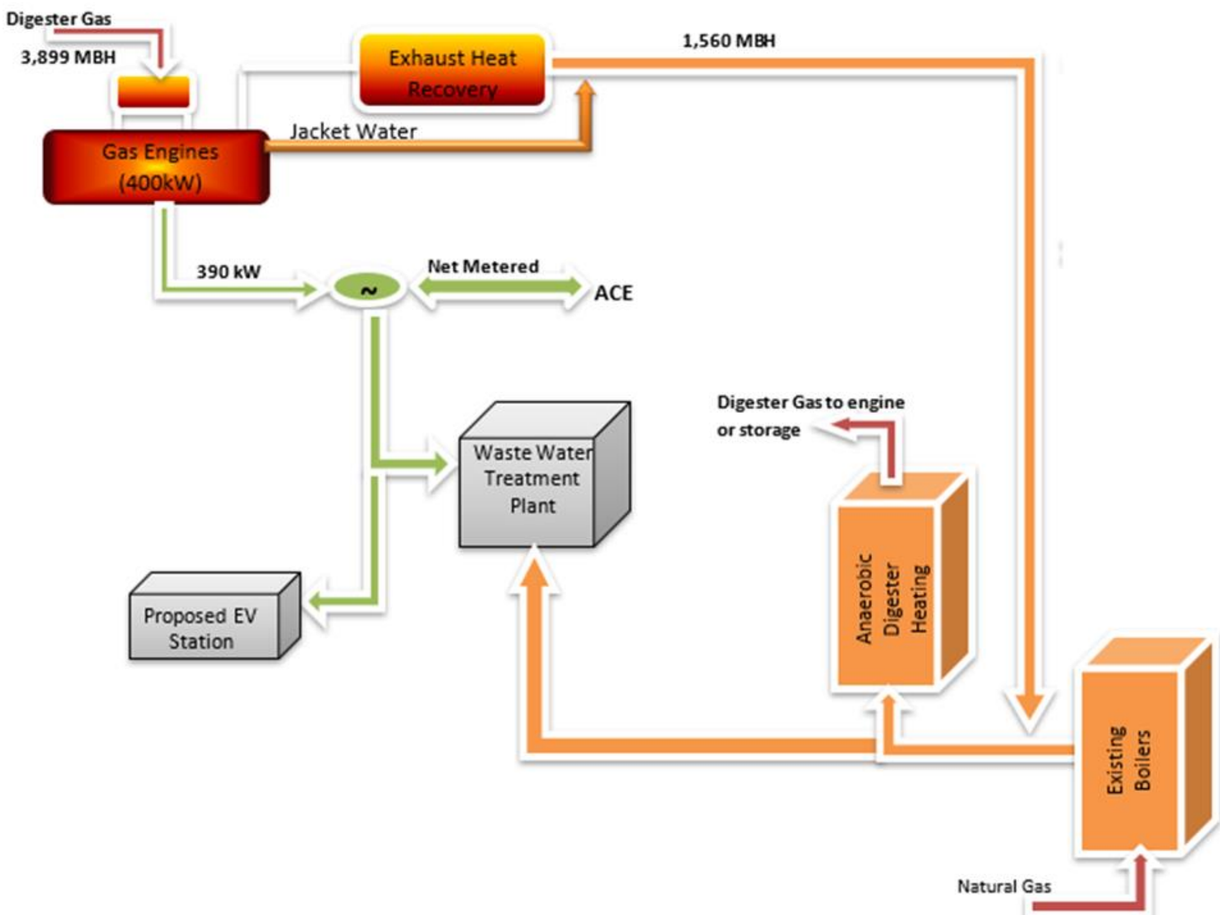


Figure I-3. CHP Concept for WWTP Showing EV Charging Station

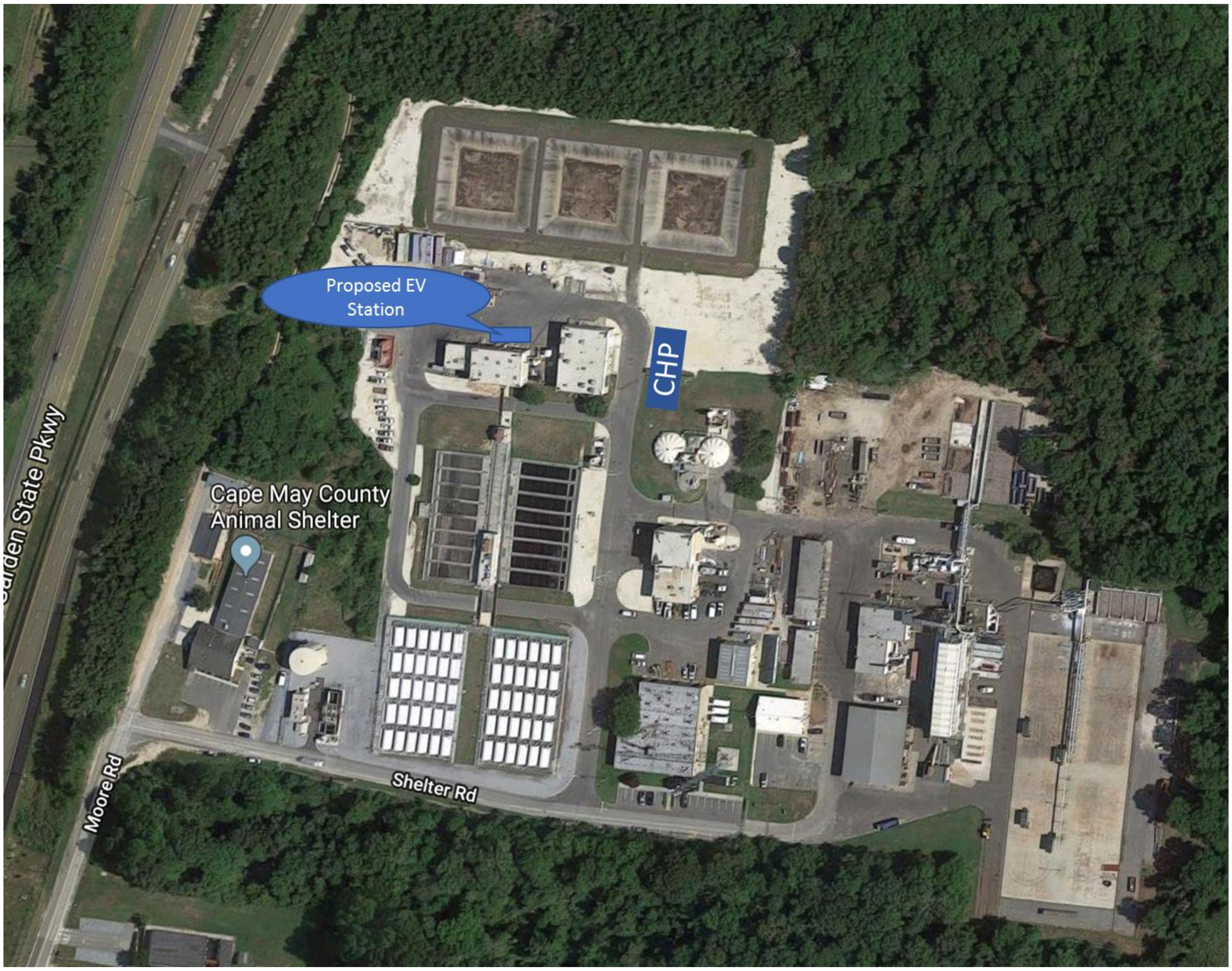


Figure I-4. Proposed Location of Digester Gas Fired CHP System and EV Charging System at WWTP

I.2 Power Delivery System

The GIS map from Atlantic City Electric (ACE) in Figure I-5 below shows the distribution service in and around the facilities in the Crest Haven complex. On the map, dashed magenta lines represent radial, overhead (OH), three-phase, 15-kV class medium voltage distribution feeders and solid magenta lines represent underground (UG) three-phase lines. The heavy dashed yellow line shows the boundary between the two primary feeders (NJ0381 Court North and NJ0042 Swainton Swainton) that serve the microgrid facilities. These two feeders emanate from two different ACE distribution substations and are tied together by normally open (NOP) switches at two points within the complex (along the dashed yellow line).

- NJ0042 normally serves the northernmost facilities (Water Treatment Plant, County Prosecutors Office) and can absorb an additional 1,500 kW of DER (hosting capacity)
- NJ0381 serves most of the other facilities and can absorb an additional 1,700 kW of DER (hosting capacity)

I.2.1 Interconnection

The hosting stated capacity of these two feeders is based on studies performed by ACE to determine the impact of DER on feeder performance. Any incremental DER planned for these two feeders would be entered into the interconnection queue and studied (along with other prospective projects) to determine impact and mitigation measures for operating the feeders with the level of DER. This is relevant to the proposed CHP units at the Technical HS and the Waste Water Treatment Plant (WTTP) and the gas reciprocating engine at the County Admin Building. The rated capacities of these planned installations do not exceed the hosting capacity of the feeders but would still be subject to Pepco Holdings (PHI) standard for Interconnection of Distributed Energy Resources.[1]

I.2.2 Distribution Assets

The existing system is predominantly typical OH distribution construction with 8-inch horizontal crossarms. It is trimmed on a 4-year cycle, and like most feeders of this kind, is impacted by outages primarily due to vegetation, wildlife and severe weather. There are some UG segments within the complex, particularly toward the WTTP, toward the Technical HS, and the radial tap toward the Nursing & Rehabilitation Center and the Special Services School. In conversations with ACE, they indicated that they have started replacing some OH wire with spacer cable to improve the reliability of the feeders in the area.

The existing distribution system will be used as the primary power delivery system for the microgrid in island mode. To accomplish this, the following (high-level) modifications are recommended for the distribution assets in the area:

1. Automate the two existing tie switches between NJ 0042 and NJ0381 or replace with high-speed reclosers to allow remote monitoring and control of the tie points
2. Install two new high-speed reclosers with controls at microgrid boundary (POI) on both feeders to isolate the upstream portions of the two feeders
3. Install automated (SCADA-controlled) isolation switches at strategic locations on laterals and taps to remove non-critical loads from the microgrid during islanding
4. Install a new auto-sectionalizing switch near the Correctional Center to improve operational flexibility in islanded mode
5. Accelerate conversion of bare OH wire to spacer cable within the microgrid footprint, particularly along the three-phase backbone between the DCF Regional School tap and the Safety Training Center (1,750 ft), and between the Technical HS and the WTTP (3,000 ft)
6. Upgrade selected segments of smaller conductor to improve voltage regulation in island mode (particularly UG run between Safety Training Center and Technical HS)

[1] http://www.pepco.com/SiteCollectionDocuments/PHI%20Interconnection%20of%20Distributed%20Energy%20Resources.pdf

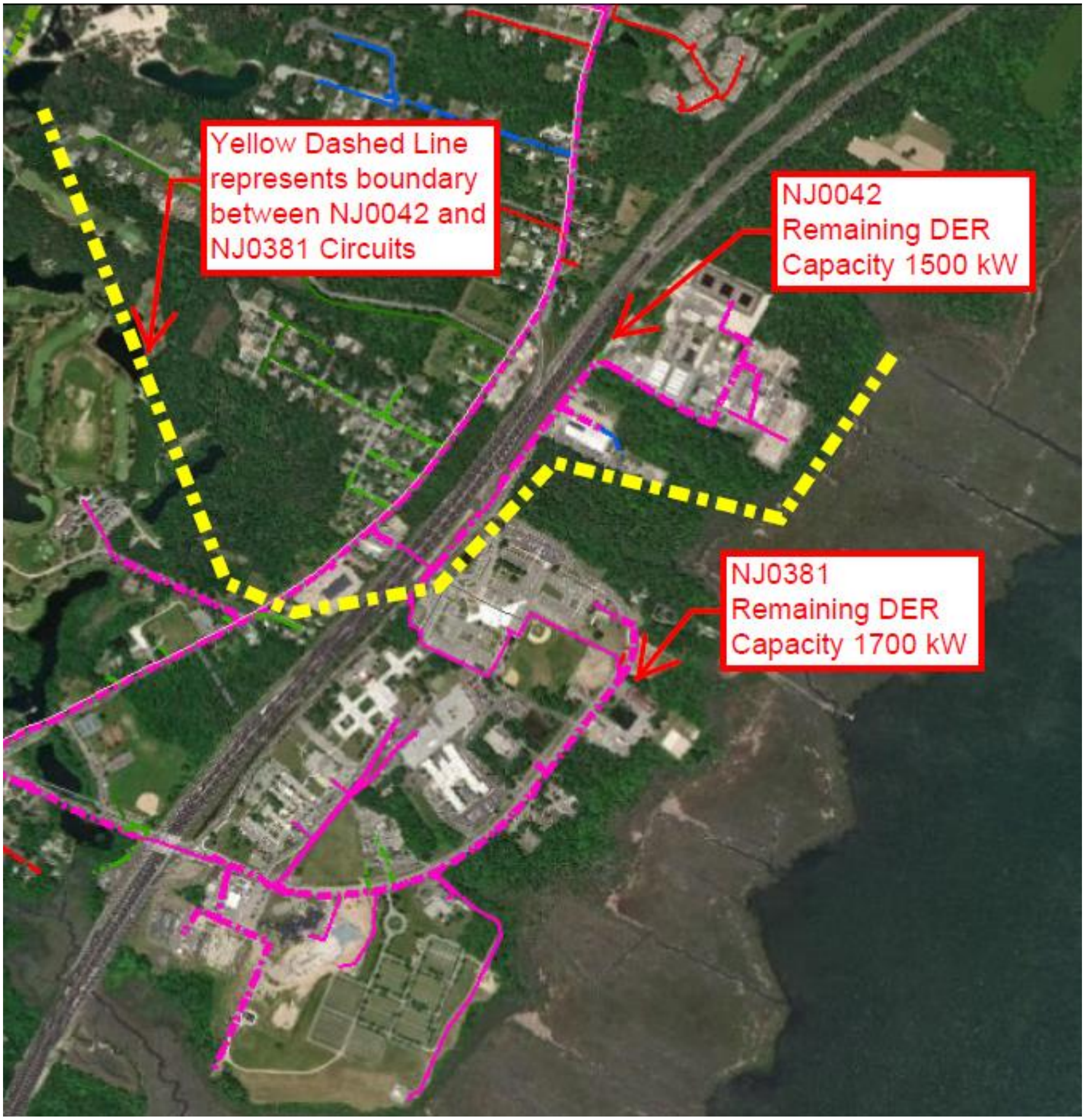


Figure I-5. ACE Portal GIS Map Showing Existing Distribution Service and Constraints

Figure I-6 below shows the primary electrical infrastructure needed to support islanding of the Cape May microgrid. The green circles represent new switchgear devices that will be installed for isolating the microgrid facilities when a desirable islanding condition is detected. The red circles indicate existing devices that may be automated (or replaced) to connect portions of Feeders NJ0042 and NJ0381 together to form a contiguous microgrid power delivery system. As described later in subsection N, these devices will be integrated in the microgrid control system via an area-wide communications network.

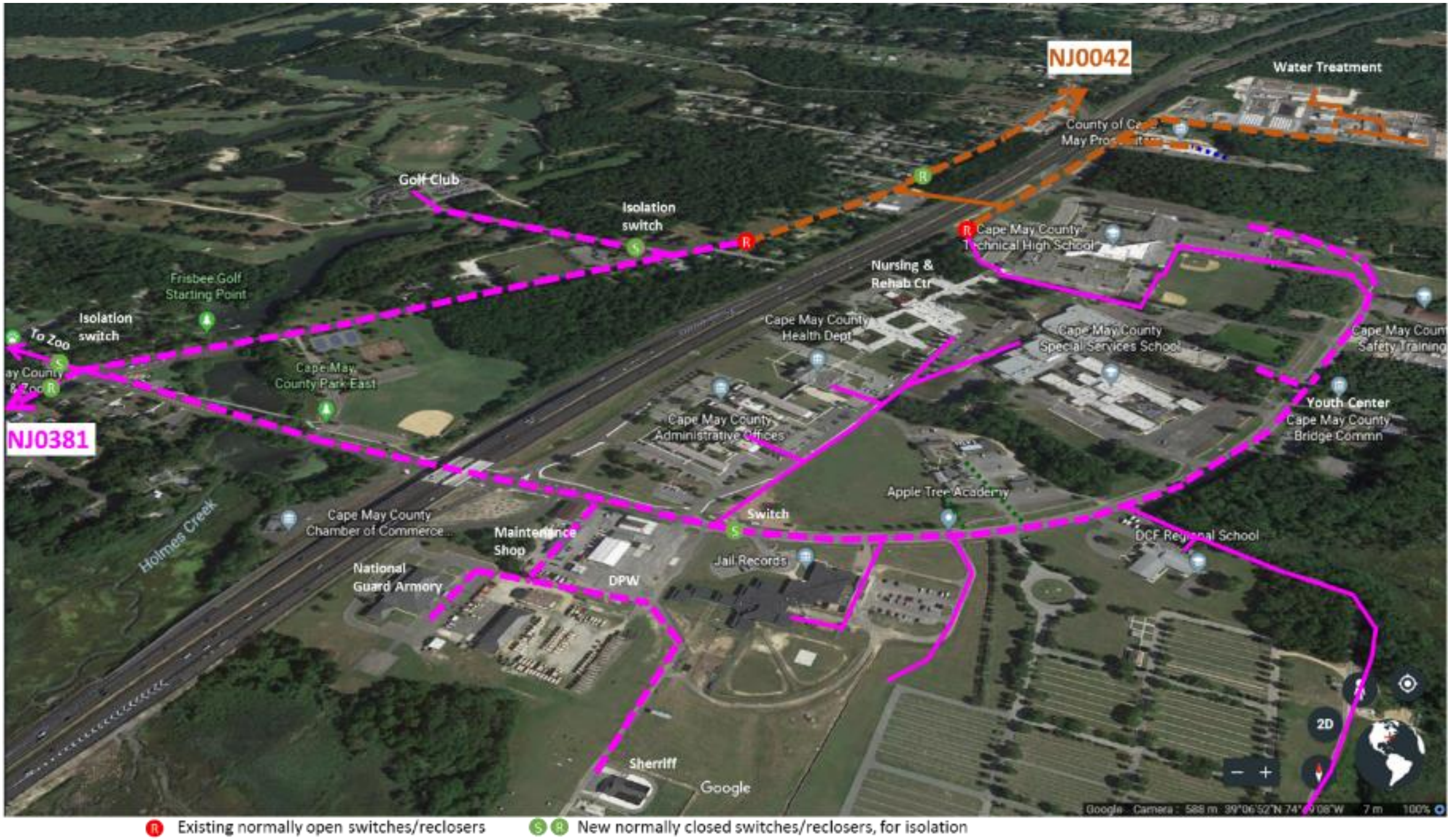


Figure I-6. Cape May Microgrid Primary Electric Layout

I.3 Electrical Layout and One-Line Diagram

Figure I-7 below shows the electrical one-line diagram for the microgrid identifying utility points of interconnection (POI), primary and secondary connections, line lengths, major electrical equipment, and new and proposed DER.

The microgrid has POI to the Atlantic City Electric grid. At each of these POI, a recloser (or breaker) is used to interface with ACE feeder NJ0042 and NJ0381. These are shown as green boxes in Figure I-7. In island mode, both of these would be opened to isolate the critical facilties from the upstream portions of the feeders.

Two other reclosers (red boxes) represent existing switchgear at tie-points between NJ0042 and NJ0381. In island mode these would both be closed to connect the critical facilities on NJ0042 to the critical facilities on NJ0381. However, either one could be opened to avoid closed-loop operation (particularly if the new auto-sectionalizing switch described below is closed).

The microgrid includes two new auto-isolation switches (on the tap to the Zoo and the tap to the Golf Club) to isolate these two sizable loads from the microgrid during islanded operation.

An auto-sectionalizing switch is included near the Correctional Center to failiate operational flexibility. During normal operation, this switch is closed, but during islanded operation, the switch may be opened to prevent closed-loop operation.

I.4 Microgrid Operation

The proposed microgrid consists of number of generating assets. These include standby natural gas engines, diesel generators and two new CHP systems (see Table I-1 and Table I-2).

During normal operation, when the microgrid is operating in grid-parallel mode, the microgrid facilities will be connected to ACE feeder NJ0042 and NJ0381 via the existing infrastructure. It is expected that the microgrid will operate in the grid-parallel mode most of the time with the ACE distribution system, supplying power to, or receiving power from ACE through connections to the two feeders. As shown earlier in Figure I-6, the WTTP and the Cunty Prosecutor's Office are normally served by NJ042 and most of the other facilities are served by NJ0381. This is not expected to change during normal operations. However, ACE has the option (with the new and existing switchgear) to normally serve all the microgrid facilities from one feeder or the other (as opposed to splitting them among the two feeders). However, this arrangement impacts loading and voltage regulation on the feeders and is solely at ACE's discretion.

During normal, grid-parallel operation, the microgrid CHP generation is expected to be operational base-loaded, meeting anywhere from 50% to 80% of the total electrical demand for the WWTP, the Technical High School, the Special Services School and the Nursing & Rehabilitation Center on most days.

In islanded mode, the CHP units will remain base-loaded and provide power to the entire microgrid (not just the facility loads). The new reciprocating gas engine at the County Admin Building will be available to follow load. In addition, backup generation at the individual facilities shown in Table I-2 (Correctional Center, Nursing & Rehab Center, WWTP) will come online to reduce the total load on the microgrid.

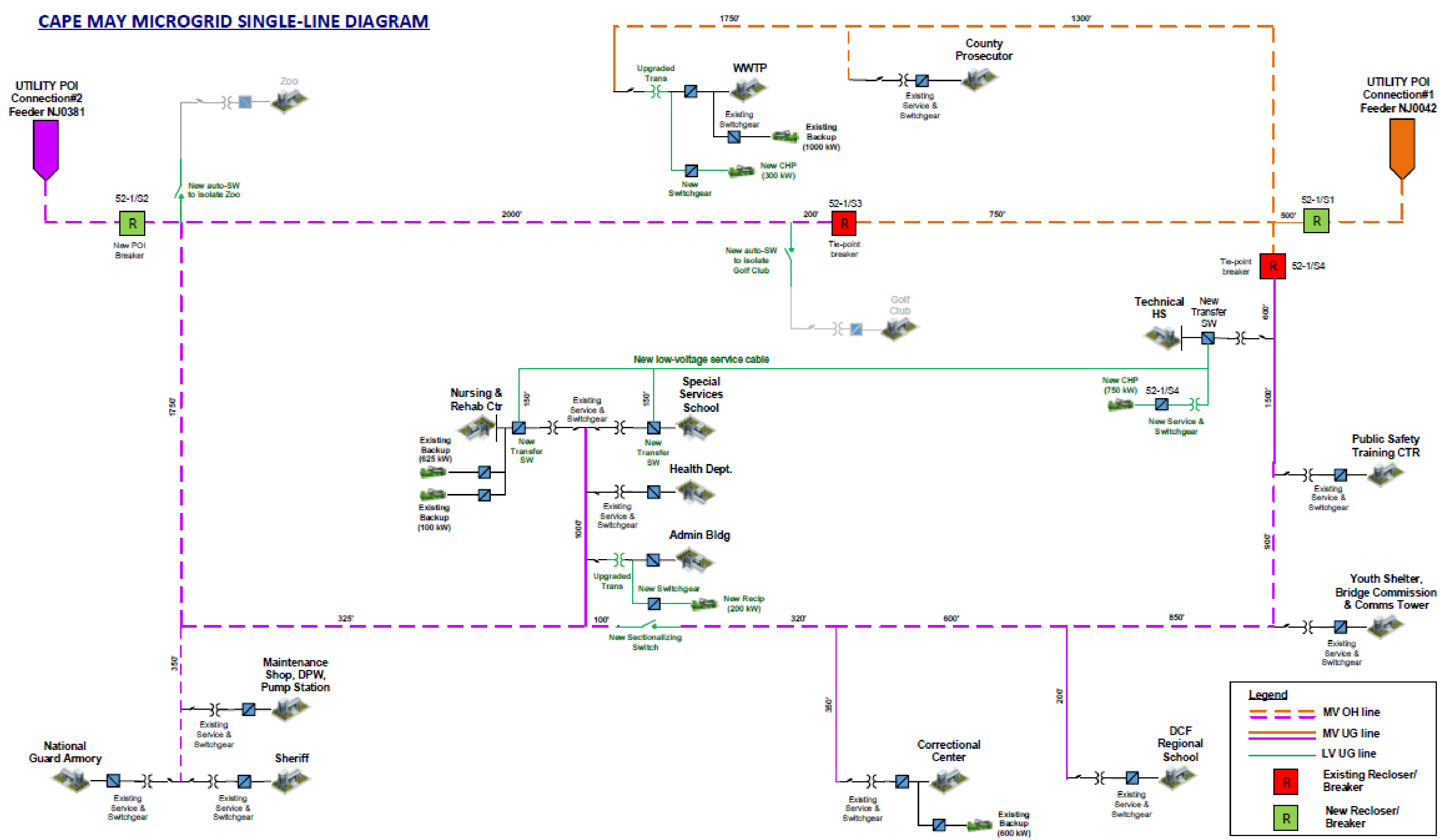


Figure I-7. Microgrid Electrical One-Line Diagram

The microgrid controller continuously monitors the available generation and load, and automatically dispatches onsite CHP and the new reciprocating engine to meet the load, optimizes economic operation (as far as possible), and maintains a reserve (or exercises load control) to handle short duration events. The dispatch curves in Section I.6.6 (from DER-CAM analysis) show the operation of the microgrid in grid connected and islanded mode.

Microgrid operations that lead to islanded operation fall into two distinct categories, planned and unplanned.

Planned operations are those that afford the time to make a systematic separation from the bulk power grid minimizing or preventing any loss of power to the microgrid loads. Examples of planned operations would include: the preemptive separation for forecasted severe weather events such as ice storms, heavy snow events, wind events, or severe thunder storms; the preemptive separation for planned bulk system or feeder maintenance; or the preemptive separation to help reduce load on the area T&D system. Planned operations might allow for seamless transition in some cases because there is time to ensure that there is load-generation balance within the microgrid before separation occurs. However, for the Cape May microgrid, because of the number of field switching operations that be required and the fact that a large portion of the microgrid generation is not under the central control, seamless transition is not envision. Therefore, even planned operation will necessarily entail black start of the microgrid.

Unplanned operations are those that do not necessarily afford the time to make a systematic separation from the grid and would result in some interruption for microgrid critical facilities. An example of an unplanned emergency operation would be a fault on the feeder supplying the microgrid that results in outage that is not immediately restored. As unplanned outages would likely result in the microgrid facilities losing power, at least one generator with black start capability will be needed to restore the microgrid.

Generators with black start capability have a DC auxiliary support system capable of providing power to both the generator's control system and to its starting, ignition, and auxiliary systems. The DC system needs to have enough capacity to attempt multiple starts to ensure the system can be reenergized in a timely manner. The microgrid includes over 2,300 kW of diesel and lean burn natural gas backup generation, which are self-starting and can be used for black start. In addition, the new CHP machines at the WWTP and the THS as well as the new reciprocating natural gas generator at the County Admin Building will be black start capable.

During both planned and unplanned operations that result in islanding, the microgrid central controller will continuously monitor the microgrid's load and dispatch the DER or initiate prioritized load shedding (as needed) to maintain and operate the greatest proportion of the microgrid with power.

The following table provides a list of the steps to transition the microgrid from a grid-parallel state to an islanded state for both planned and unplanned operations.

Table I-3. Summary of Microgrid Operation for Both Planned and Unplanned Events

Step	Operational Actions
Initial State of Microgrid	Microgrid is operating in a stable state in grid-parallel mode with facilities connected to both ACE primary feeders. The microgrid's onsite CHP is operating, supplying a portion majority of the facilities' electrical demand.
0	Initializing event occurs: • Fault on both ACE feeders supplying the critical facilities, or • Bulk power system failure (due to major event) causing the ACE grid to de-energize. • Pre-emptive separation is needed due to impending event
1	POI reclosers (or breakers) are opened separating the microgrid facilities from the upstream portions of the feeders. Utility might attempt reclosing. Online DER (CHP) goes offline to per IEEE 1547 anti-islanding requirements
2	Utility reclosing sequence is completed without success and feeders lockout. The microgrid controller initiates the islanding procedure.
3	Standby generators at individual microgrid facilities (Correctional Center, Nursing & Rehab, WWTP) start as normal and begin to supply emergency power to those entities. Controlled transfer switches at those entities transfer from the grid to the emergency power source.
4	Microgrid central controller isolates non-critical load from the microgrid by opening auto-switches. Microgrid protection relay settings are automatically changed from grid-parallel settings to island settings.
5	Microgrid central controller black starts the microgrid: i. Open all loads with controlled switches ii. Open primary sectionalizing switch near the Correctional Center iii. Start the new 200-kW machine at County Admin Center in isochronous control mode or to energize the portion of the line between the Sectionalizing Switch and tie-point Recloser 51-1/S3. (Alternatively, or one of the new CHP machines could be started first.) iv. Black start generation begins to pick-up loads not being served by emergency generation and energize the microgrid distribution system v. Close tie- Recloser 52-1/S3 to energize line segment with the WWTP vi. Start the WWTP CHP and bring up to synchronous speed vii. Close tie- Recloser 52-1/S4 to energize line segment with the Technical HS viii. Start the Technical HS CHP and bring up to synchronous speed ix. Add load that was previously shed to the energized line in a controlled manner
Final State of Microgrid	Microgrid is in an islanded state with all load being supplied by the microgrid onsite DER. The microgrid controller is continuously monitoring both generation and load and adjusting the dispatch as needed to maintain secure, reliable, economic operation.

Once the utility power grid has been restored and is operating in stable condition, the microgrid can be resynchronized to the power grid and placed in grid-parallel operation. The steps to resynchronize with the bulk power grid are in the following table.

Table I-4. Steps to Resynchronize with the Grid

Step	Description
Initial State of Microgrid	Microgrid is operating in a stable state in islanded mode. The microgrid DER are operating, supplying 100% of microgrid electrical demand.
0	Decision is made to transfer to grid-parallel mode and the utility is notified and prepared to pick some amount of the microgrid demand.
1	The microgrid controller begins to adjust the onsite microgrid generation to match the bulk power system operating parameters to ensure the microgrid is operating within the synchronizing parameters of IEEE 1547 (Δf: 0.1Hz, ΔV: 3%, and Δϕ: 10^{p}).
2	Once synchronizing parameters are met, the microgrid controller under utility supervision will close the grid tie breakers/switches at the POI placing the microgrid in parallel with the utility power system
3	The operating modes of microgrid's generators are switched to droop mode
4	Microgrid protection relay settings are automatically changed from island settings to grid-parallel settings
5	If needed, microgrid load that was shed during island operation is brought back online in a systematic controlled manner by controller
Final State of Microgrid	Microgrid is operating in a stable state in grid-parallel mode on the two ACE feeders. The microgrid CHP units are operating, supplying a portion amount of the facilities' load.

I.5 Tariff Requirements/Issues

For the evaluation of the proposed microgrid systems, we have used existing EDC and GDC tariffs.

The proposed CHP system at the Technical High School will change the existing tariff for the school and would require standby rates for electric distribution. The natural gas rates considered for the CHP was under ESG rate structure of South Jersey Gas Company. The details of the utility rates are as below:

I.5.1 Power Cost

The power cost considered for CHP evaluation is as follows:

- The Generation and Transmission cost is $0.10009223/kWh
- The demand cost is $9.44/kW

Due to the size of the generator, we assume standby charges at 0.96/kW/month based on the ACE tariff "Rider STB-Standby Service" applicable for AGS – Secondary Service.

I.5.2 Natural Gas Cost

The natural gas cost considered for the CHP evaluation is as follows:

- For CHP, South Jersey Gas Company (SJGC) has a tariff of EGS for natural gas consumption below 200MCF that we anticipate will be the CHP gas consumption.
- The generation cost based on South Jersey Gas Company (SJGC) BGSS prices published for 2017 averaged $0.46307/therm. The CHP evaluation assumes the generation cost to be $0.5/therm.
- The delivery charge of natural gas as per SJGC ESG rate is $0.219463/therm for summer months and $0.251451/therm for winter. The summer season is from April through October.
- The demand charge is $8.362812/MCF per month.

I.6 DER-CAM Analysis

Model Description

The microgrid distributed energy resources (DER) were chosen based on several factors. Analysis of the overall system optimization and initial asset selection, sizing, and configuration was performed using the Distributed Energy Resources Customer Adoption Model (DER-CAM+) tool developed (and under continuous improvement since 2000) by Lawrence Berkeley National Laboratory (LBNL) under DOE funding.

The objective of the model is to minimize the cost of operating on-site distributed generation (DG) and combined heat and power (CHP) systems, either for individual customer sites or a microgrid.

The tool takes a wide range of detailed inputs regarding DER assets, site loads, participant tariffs, site location weather, energy prices, and environmental parameters as inputs to optimize the selection and operation of DERs in the microgrid.

DER selections were further refined by considering the specific types of loads, available space, detailed asset performance characteristics and limitations given their intended function (e.g., base or peak generation) in the microgrid. Due to the significant electric and thermal base load of the hospital, cogeneration was an appropriate technology to deliver electricity and hot water.

The main reason for proposing to use DER-CAM+ is that it is a multi-nodal model. The multi-nodal capability of DER-CAM+ enables modeling of individual electrical and thermal (heating and cooling) nodes, and proper sizing of the DER generation that would target providing energy to the individual or inter-connected facilities (particularly importance for CHP).

Furthermore, DER-CAM+ has load flow capabilities, which enables proper modeling of the microgrid's electrical network and any thermal (heating/cooling) conduits connecting buildings that share thermal resources.

GE Energy Consulting is the leading commercial and industry partner of LBNL in supporting further development of DER-CAM+ by providing feedback from its practical experience using DER-CAM+ in microgrid design projects. GE Energy Consulting is also collaborating with LBNL in a DOE project, which involves other national energy laboratories, to test and validate the model's new features.

A schematic representation of the DER-CAM+ model is shown in Figure I-8 below.

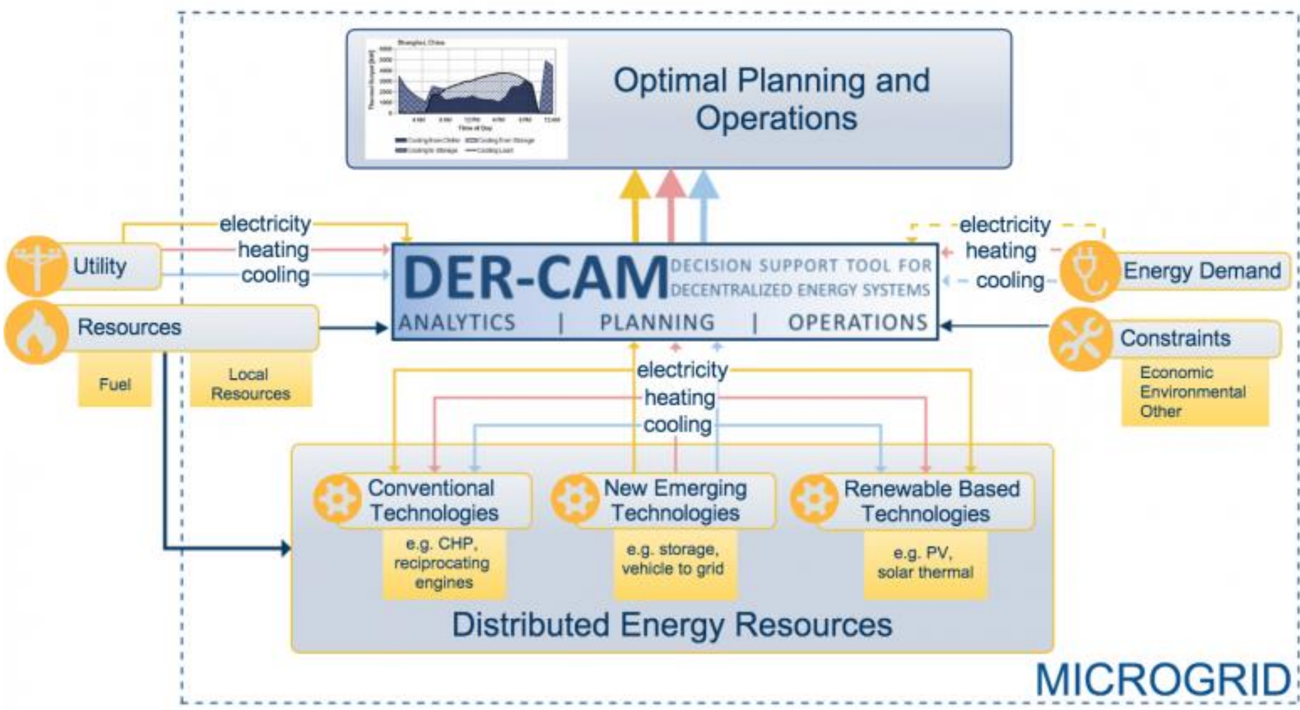


Figure I-8. DER-CAM+ Schematic

I.6.1 Dispatch Modeling

The DER-CAM+ model, in addition to selection of least-cost portfolio of DER assets needed to meet the microgrid load (incremental to DER assets already existing or proposed), also performs hourly dispatch of the microgrid DER assets in both grid-connected mode and islanded modes.

The steady-state dispatch modeling is based on the 12-Month x 24-Hour representation of average monthly weekday and weekend loads. Based on the electric utility delivery rates and electricity commodity prices relative to the microgrid's marginal cost of generation, DER-CAM+ allows power purchase from the grid in place of self-generation, and also allows sale of power to grid, to minimize the cost of operations. Key assumptions and data used in the modeling were provided in previous sections.

The multi-nodal capability of DER-CAM+ enables modeling of electrical and thermal loads by individual facilities, and hence provides a node-by-node view of generation and consumption, including import of electric and thermal energy from other connected nodes.

The chart in Figure I-9 shows the network topology of the microgrid modeled in DER-CAM+.

The model includes definition of loads, CHP units, Solar PV resources, and other DER assets such as fuel cell and energy storage by each node/facility.

I.6.2 Key Input Assumptions

The key inputs assumptions include the microgrid electrical and thermal loads, fuel prices, electricity rates, and DER asset performance parameters and fixed and variable cost estimates. Fuel prices and electricity rates used in the modeling, the list of major thermal equipment and gas consuming appliances, and the full list of DER assets in the microgrid, are provided later in this section.

The following table (Table I-5) provides additional information on the type, size, cost assumptions and efficiencies of individual electrical and thermal generation resources.

I.6.3 Load Profile Development Process

The main sources of electrical load data for Cape May sites are based on information collected from the utility billing statements. The DER-CAM+ analysis required load data in a 12-Month x 24-Hour matrix (typical day in the month) format for both weekdays and weekends.

The original interval load data was simply averaged for each hour across the month during weekdays and weekends, using a 2020 calendar for weekdays and weekends (assuming that the microgrid will be operational in 2020). This was an Excel-based post processing of the hourly load data.

For the facilities with only utility billing data available, a multi-step process was used for the development of the 12 x 24 electrical and heating load matrices:

- Information from utility bills for electrical and heating loads of each facility were extracted based on their monthly values.
- Based on the approximate overlap of calendar months and billing months, monthly tables of electrical loads and heating loads were tabulated (kWh and kW for electrical loads, and Therms for heating loads).

- Daily electrical and heating load profiles in 12 x 24 format were extracted from the DER-CAM+ database of load profiles for similar facility types. If an exact match to the facility type was not available, the closest match for the building or facility type was used.
- For each facility, Excel-based data processing was applied to scale the 12 x 24 weekday and weekend profiles (i.e., to adjust the hourly load values up or down, without significantly changing the overall shape of load profiles), until the total monthly loads of 12 x 24 weekday and weekend loads equaled the monthly total load from the utility bids.
- For electrical loads, it was possible to develop load profiles that matched the monthly utility bills in terms of monthly peaks and monthly energy (i.e., kW and kWh).
- The utility heating load data based on the amount of fuel consumed (Therms) only included total Therms used by billing month. Therefore, the total monthly energy could be matched exactly, with monthly heating load peaks resulting from the assumed heating load shapes.
- For the one site with absorption chillers, the summer cooling load was calculated based on the difference between each summer month's electrical load and the average monthly load for the first four and last two months of the year. This assumes that the increase in electrical load in the summer is mainly due to the additional central chiller cooling operation. The absorption chiller will only provide cooling at THS, and therefore, partially displacing the central chillers at the facility. Cooling loads at other sites will be met by their on-site systems and will not be displaced by the absorption chiller at THS.

I.6.4 DER Included in the Model

The following table includes all the existing backup and new DER that were included in the DER-CAM model based on the recommendations of the project team. The model did not select any additional DER, which is an indication of the fact that the selected generation resources are more than sufficient to meet the microgrid load in islanded mode.

Table I-5. Existing and New DER Included in the DER-CAM Model

Type	Description	Location	Cap (kW)	Capital Cost ($/kW)	Fixed Cost ($/kW-Year)	VOM ($/kWh)	Fuel	Tech	Eff (η)	Heat to Power Ratio	CHP Capable	Backup Only
Backup	BU-Amin-150	Admin Bld.	150	0	0	0.014	NG	RICE	0.30	0.000	0	1
Backup	BU-CorCntr-600	Correctional Center	600	0	0	0.012	DS	RICE	0.32	0.000	0	1
Backup	BU-NurHome-625	Nursing & Rehab	625	0	0	0.012	NG	RICE	0.32	0.000	0	1
Backup	BU-NurHome-100	Nursing & Rehab	100	0	0	0.014	NG	RICE	0.30	0.000	0	1
Backup	BU-WWPT-1000	WWTP	1000	0	0	0.011	DS	RICE	0.33	0.000	0	1
New	N-CHP-THS-750	Technical School	750	3378	0	0.020	NG	CHP	0.36	1.123	1	0
New	N-CHP-WWTP-3890	WWTP	390	3378	0	0.020	NG	CHP	0.36	1.123	1	0
New	N-RICE-Admin-200	Admin Bld.	200	3378	0	0.020	NG	RICE	0.36	0.000	1	0

I.6.5 Modeled Topology

A high-level topology of the physical electrical and thermal connections and networks (as modeled in DER-CAM+) is provided in Figure I-9. In the figure, loads at each node are represented by arrows. Electrical network connections are represented by thin black lines.

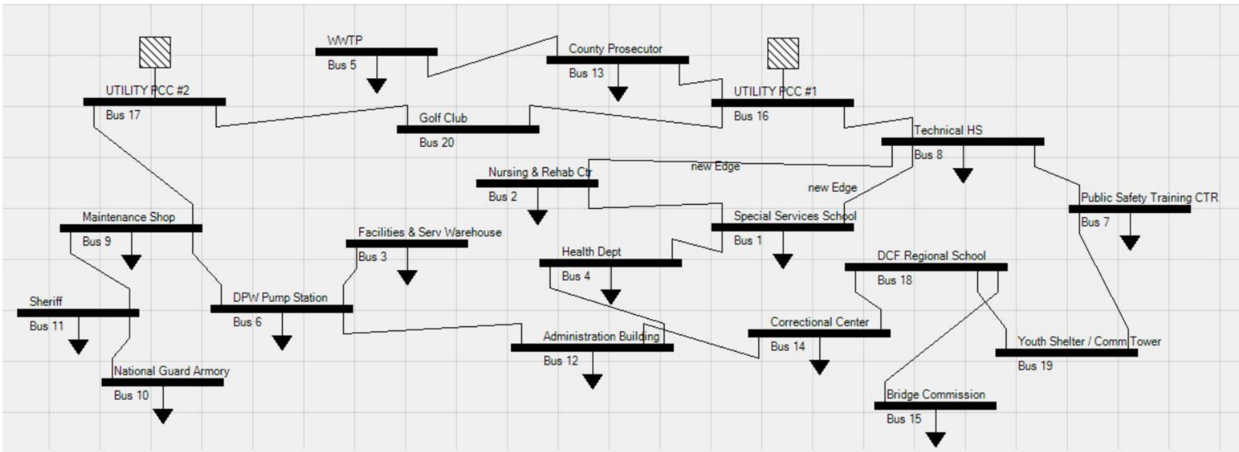


Figure I-9. Microgrid Topology in DER-CAM+[2]

I.6.6 Dispatch Charts

Electricity and Heating dispatch charts included in this section are direct outputs of the DER-CAM+ model, depicting the microgrid DER dispatch and any power purchase from the utility grid during a representative weekday in January and August. It should be noted that August is the month with the highest coincident peak load of the microgrid (at about 3,400 kW).

DER-CAM+ determines the electricity dispatch through a minimum cost optimization, and the operational efficiency constraints imposed on the DER assets. Utility purchases during grid-connected mode operations are represented by green colored areas. The electrical generation of the new and backup generation including the CHP and RICE units are represented by the red/brown colored areas.

In the electricity dispatch profiles, any generation above the load is credited under net-metering rates.

In the heating dispatch profiles, heating provided by boilers are represented by gray colored areas. Heating provided by the CHPs are represented by the red/brown colored areas. It should be noted that a great part of the grey areas represents heating loads in facilities in the microgrid that do not have access to the CHP-based heating.

[2] Note that the topology and bus numbering may be slightly different from that inputted into the RULESS model.

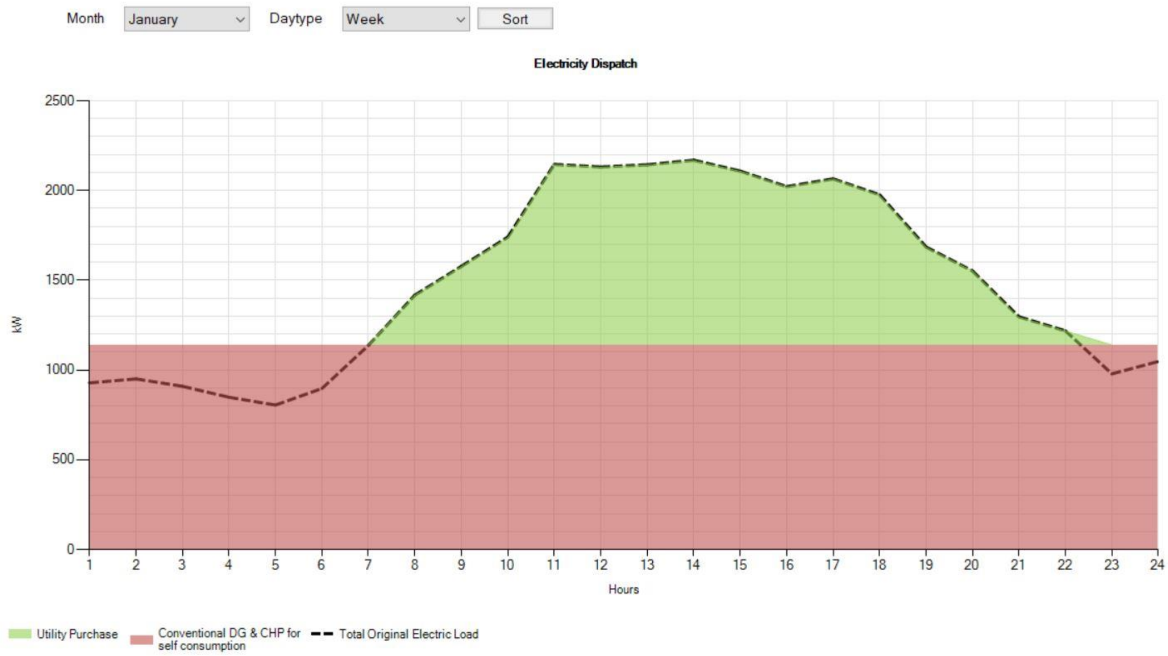


Figure I-10. Electricity Dispatch Profile - Grid Connected Mode - January Weekday

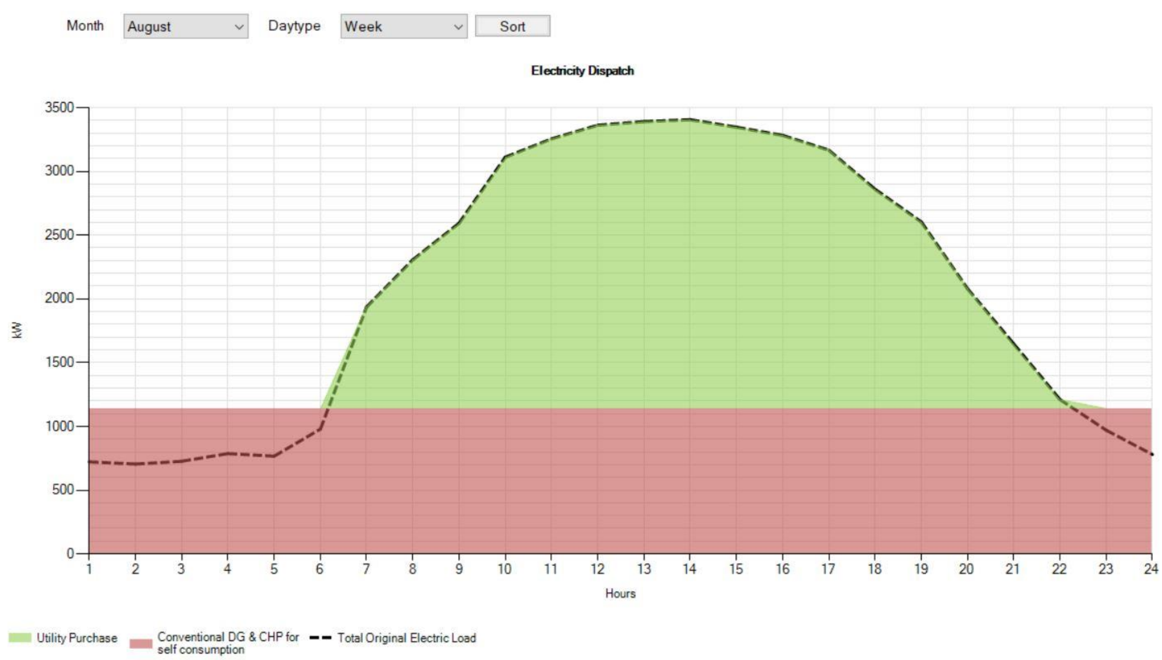


Figure I-11. Electricity Dispatch Profile - Grid Connected Mode - August Weekday

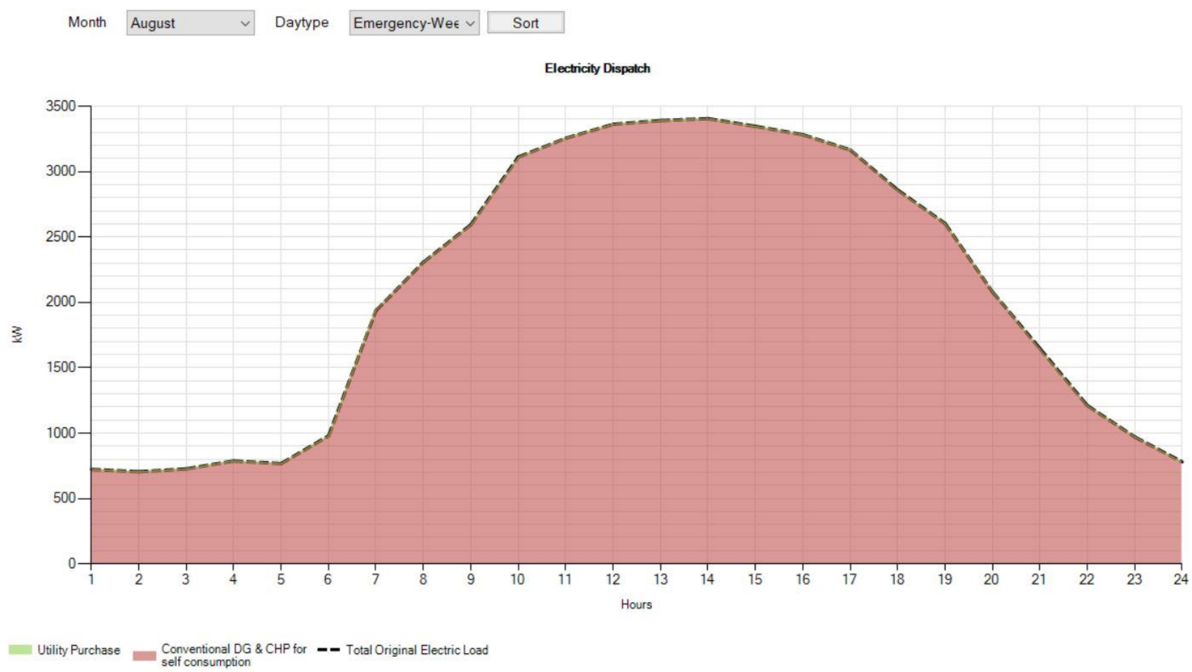


Figure I-12. Electricity Dispatch Profile - Islanded Mode - August Weekday

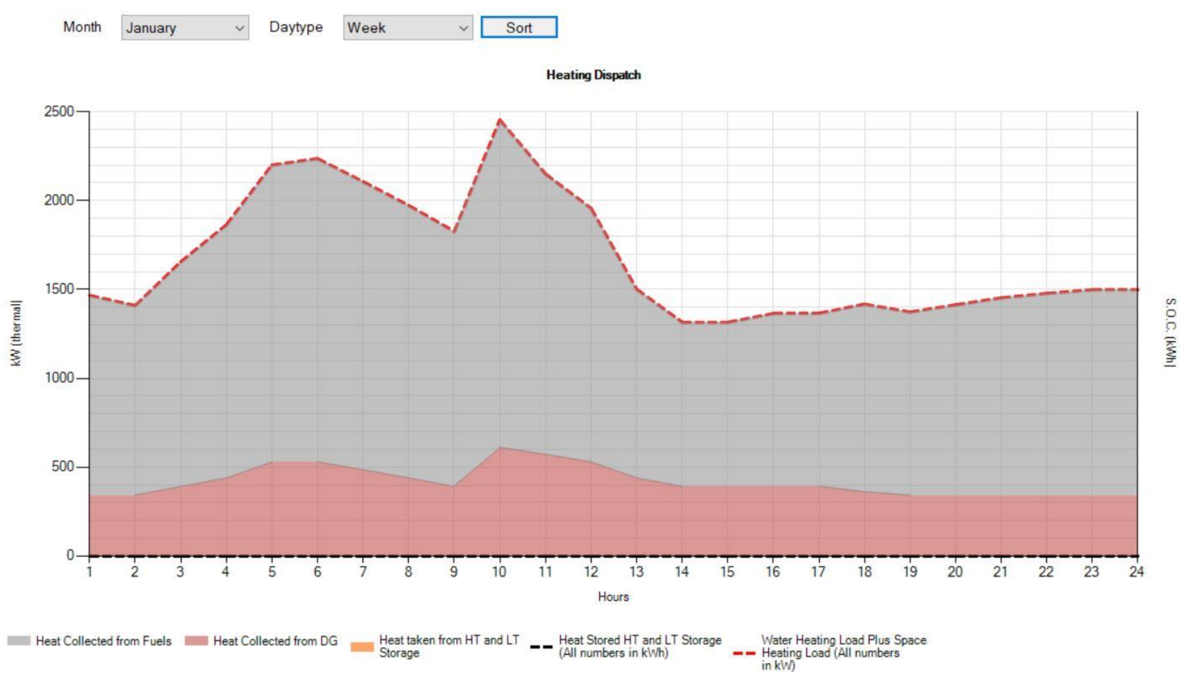


Figure I-13. Heating Dispatch Profile - Grid Connected Mode - January Weekday

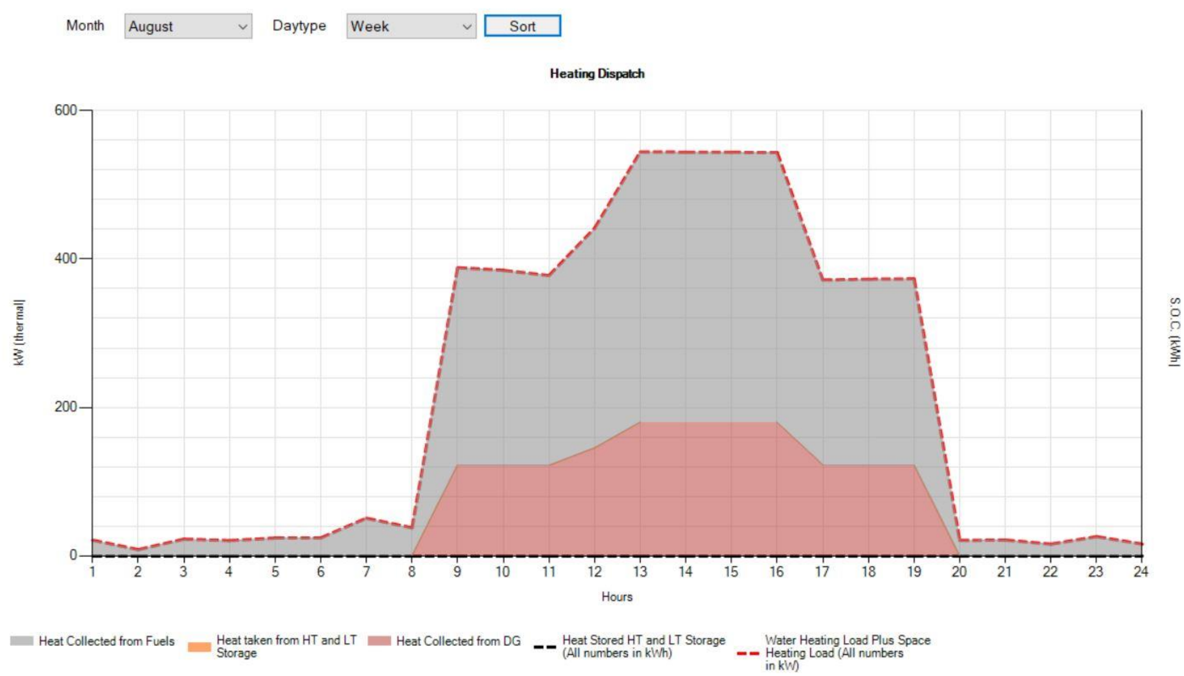


Figure I-14. Heating Dispatch Profile - Grid Connected Mode - August Weekday

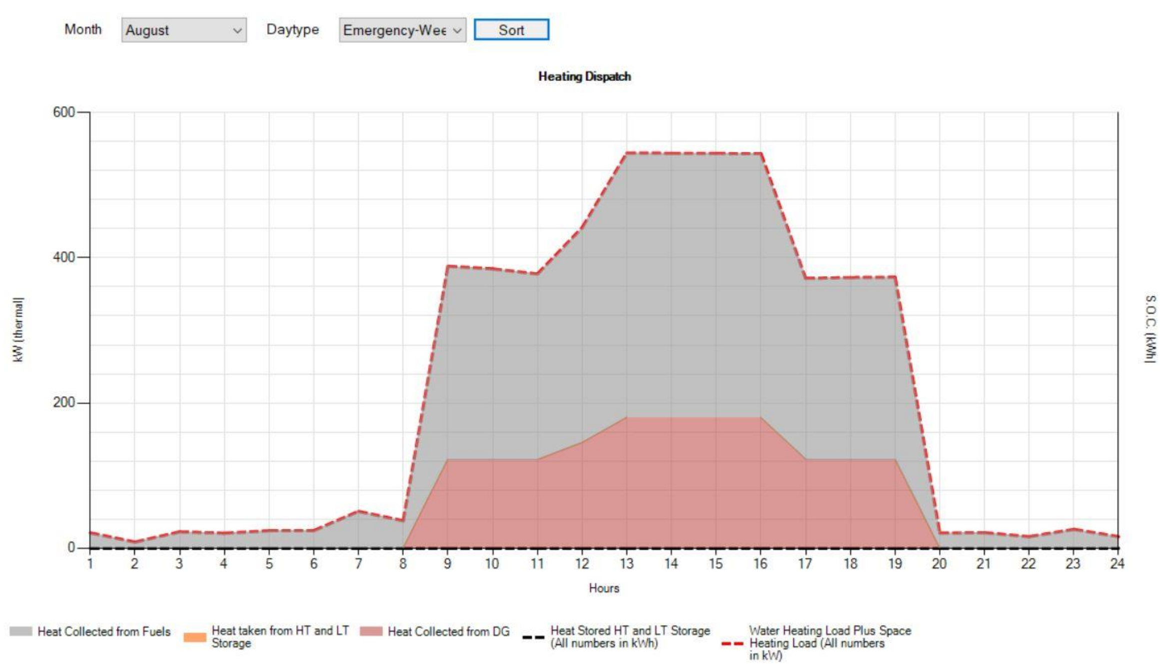


Figure I-15. Heating Dispatch Profile - Islanded Mode - August Weekday

J. OVERALL COST

This section describes the overall cost including site preparation, equipment and equipment installation, construction, operations, and maintenance, including a detailed construction schedule. This includes a detailed description of the overall energy costs for each critical facility and the overall project as well as any proposed ECM or DR measure to be constructed or operated within each critical facility and the overall project and its impact of the overall operation costs.

J.1 Microgrid Annualized Costs Before and After

The DER-CAM simulation does provide “annualized cost” of the microgrid operation – which enables showing costs for the Base Case (meeting microgrid load by power purchase from the grid) and the Microgrid Case (capital and operational cost of added generation, with running CHP units at full load in baseload with some power purchase from the grid and having one week of outage.

The costs in the table do not include any of the network related and microgrid development costs. They only consider capital and operational cost of the DER and any power and fuel purchase from the electric and natural gas providers.

Table J-1. Microgrid Annualized Costs

	Base Case (1 Year with no Outage)	Microgrid Case (1 Year with 1 Week of Outage in August)	Change from Base Case
Total annual electricity purchase (kWh)	14,420,451	4,068,159	-10,352,292
Total annual fuel consumption (kWh)	9,945,330	38,442,341	28,497,011
Total Annual Electric Costs ($)	1,777,040	573,544	-1,203,469
Total Annual Fuel Costs ($)	242,030	710,647	468,617
Total Annual Energy Costs (including annualized capital costs and electricity sales) ($)	**2,019,102**	**1,811,293**	**-207,809**

J.2 Costs Associated with the Installation of the CHPs

The energy requirement and costs for each facility is described and indicated in Section G. The microgrid project does not change the energy requirements except for the proposed CHP systems provided at the Technical High School and the Waste Water Treatment Plant.

The proposed CHP system at the Technical High School includes a 750-kW Engine generator, heat exchangers, 192-TR absorption chiller, cooling tower, pumps and piping.

The CHP system provides an overall efficiency of 72% with an operational cost savings of $350,000. The table below details the electrical and thermal energy savings for the proposed CHP system.

Table J-2. Electrical and Thermal Energy Savings for Proposed THS CHP System

Month	Electrical Energy Saving (kWH)	Total Thermal Savings (MBH)	Total Cooling Savings (TR-Hours)	Total Natural Gas for CHP (MBH)	Total Energy Savings ($)	Electric Demand (kW)	Demand Charges ($)	New Electric Demand (kW)	Ratchet at 80% of peak (kW)	New Electric Demand Charge ($)	Electric Standby Charge ($)	Demand Savings ($)	Gas Demand (MCF)	Gas Demand Charge ($)	Monthly Charge ($)	Gas Charges ($)	Total Monthly Savings ($)
Jan	529,388	2,021,986	7,101	5,340,834	31394	738.2	6969	25.7	90.96	858.71	684	5426.29	7.19	60.15	68	128.15	36692.40
Feb	478,800	1,889,665	2,779	4,830,472	28819	725.8	6851	13.3	90.96	858.71	684	5308.29	7.19	60.15	68	128.15	33999.58
Mar	530,100	1,641,617	31,250	5,348,022	28914	725.8	6851	13.3	90.96	858.71	684	5308.29	7.19	60.15	68	128.15	34094.45
Apr	513,000	1,168,532	53,194	5,175,506	26845	785.4	7415	72.9	90.96	858.71	684	5872.29	7.19	60.15	68	128.15	32589.16
May	530,100	787,026	79,300	5,348,022	24701	802.4	7575	89.9	90.96	858.71	684	6032.29	7.19	60.15	68	128.15	30605.35
Jun	513,000	590,055	89,111	5,175,506	22970	826.2	7799	113.7	113.7	1073.39	684	6041.61	7.19	60.15	68	128.15	28883.00
Jul	530,100	123,323	110,804	5,348,022	19041	768	7250	55.5	90.96	858.71	684	5707.29	7.19	60.15	68	128.15	24619.69
Aug	530,100	59,030	129,626	5,348,022	20465	820.8	7748	108.3	113.7	1073.39	684	5990.61	7.19	60.15	68	128.15	26327.83
Sep	513,000	209,510	105,054	5,175,506	19459	820.4	7745	107.9	113.7	1073.39	684	5987.61	7.19	60.15	68	128.15	25318.16
Oct	530,100	778,833	78,605	5,348,022	24496	748.8	7069	36.3	90.96	858.71	684	5526.29	7.19	60.15	68	128.15	29893.86
Nov	513,000	1,092,410	59,928	5,175,506	24516	772.6	7294	60.1	90.96	858.71	684	5751.29	7.19	60.15	68	128.15	30139.20
Dec	530,813	1,849,528	18,925	5,355,211	30382	774.2	7309	61.7	90.96	858.71	684	5766.29	7.19	60.15	68	128.15	36020.00
Total	6,241,500	12,211,515	765,675	62,968,652	302,002		87,875			10,949	8,208	68,718		722	816	1,538	369,183
														Maintenance		5%	350,724

The packaged CHP system cost is estimated below.

Table J-3. Estimate of Packaged Costs for THS CHP System

Opinion of Probable Construction Cost						Date:	Thursday, November 8, 2018		
						Client:	Cape May County Municipal Authroity		
For	Cape May Technical School					Project:	Technical School CHP system		
Basis of Estimate		☐ No Design		☑ Conceptual Design		☐ Final Design		☐ Actual Cost	
Item #	Description	Quantity	Units	Material Cost per Unit	Total Material Cost	Labor Hour	Labor Cost per Hour	Total Labor Cost	Total Cost
	CHP System								
1	Division 01000 - General				$ 49,500			$ 10,800	$ 60,300
2	Division 23000 - Mechanical				$ 1,313,900			$ 232,500	$ 1,546,400
3	Division 25000 - Controls				$ 65,000			$ -	$ 65,000
4	Division 26000 - Electrical				$ 600,000			$ -	$ 600,000
5									
	Subtotal				**$ 2,028,400**	0		**$ 243,300**	**$ 2,271,700**
	HX and Miscellaneous								
1	Division 01000 - General				$ 12,700			$ -	$ 12,700
2	Division 23000 - Mechanical				$ 176,800			$ 80,700	$ 257,500
3	Division 25000 - Controls				$ -			$ -	$ -
4	Division 26000 - Electrical				$ -			$ -	$ -
5									
	Subtotal				**$ 189,500**	0		**$ 80,700**	**$ 270,200**
	Subtotal of All Items				**$ 2,217,900**	0		**$ 324,000**	**$ 2,541,900**
	Contingency			15%	$ 332,685		15%	$ 48,600	$ 381,285
	Subtotal				**$ 2,550,585**			**$ 372,600**	**$ 2,923,185**
	Construction Management Overhead			5%	$ 127,529		5%	$ 18,630	$ 146,159
	Profit			5%	$ 127,529		5%	$ 18,630	$ 146,159
	Subtotal Construction				**$ 2,805,644**			**$ 409,860**	**$ 3,215,504**
	Tax			0%	$ -		0%	$ -	$ -
	Mechanical Engineering			0%	$ -		10%	$ 321,600	$ 321,600
	Structural Engineering							$ -	$ -
	Architectural Design							$ 10,000	$ 10,000
	Filing/Expediting Consultant							$ 5,000	$ 5,000
	Construction Administration							$ 321,550	$ 321,550
	Commissioning							$ 35,000	$ 35,000
	Total Estimated Cost $								**3,908,654**

The packaged CHP system at the Waste water treatment plant (WWTP) includes a digester gas fired engine generator with heat recovery heat exchangers, digester gas storage tank, transfer pumps and related accessories, heating water piping to offices, controls and wiring.

The CHP system provides an overall efficiency of 60% and a cost saving of $345,200. The table below details the electrical and thermal energy savings for the proposed CHP system.

Table J-4. Electrical and Thermal Energy Savings for Proposed WWTP CHP System

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Electric Savings													
Electric Production (kWh)	290,160	262,080	290,160	280,800	290,160	280,800	290,160	290,160	280,800	290,160	280,800	290,160	3,416,400.00
Total Electric Savings	29,708.40	26,935.89	30,403.74	29,142.97	29,369.48	28,785.64	29,707.25	29,388.88	28,967.54	29,494.70	28,211.97	30,676.51	350,792.97
Natual Gas Savings													
Useful Thermal (MMBTU/Month)	751.4	731.7	728.9	270.2	362.9	589.9	1160.5	1160.5	717.8	740.9	707.7	804.1	8,726.65
Natural Gas Savings ($/Month)	9904.5	9645.4	9608.9	3561.5	4783.8	7776.3	15297.1	15297.1	9462.2	9766.9	9329.3	10600.0	115,033.09
Cost of CHP Operation													
Maintenance Cost ($/Month)	8,705	7,862	8,705	8,424	8,705	8,424	8,705	8,705	8,424	8,705	8,424	8,705	102492
Total Operational Savings	30,908.12	28,718.90	31,307.81	24,280.49	25,448.49	28,137.96	36,299.55	35,981.19	30,005.79	30,556.83	29,117.27	32,571.67	363,334.06
											5% down for	Maintenance	345,200.00

The estimated cost for the project is shown below.

Table J-5. Estimate of Packaged Costs for WWTP CHP System

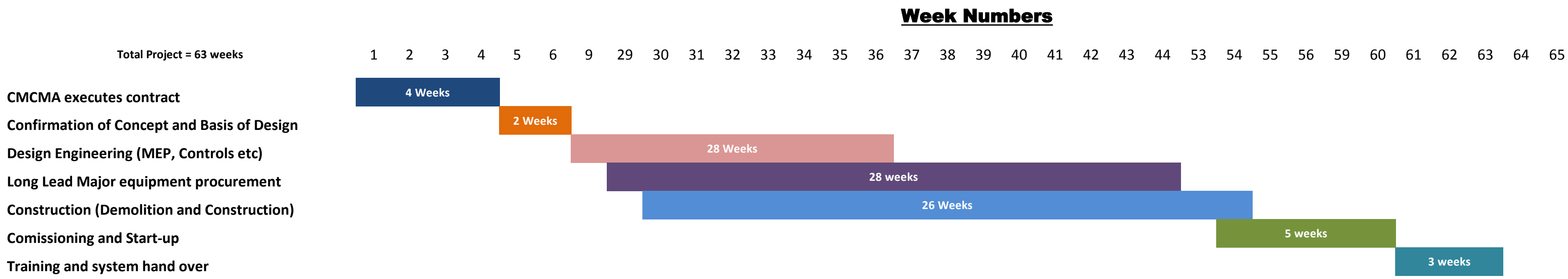
Opinion of Probable Construction Cost		Date:	Thursday, November 8, 2018
		Client:	Cape May County Municipal Authroity
For	Cape May Technical School	Project:	Technical School CHP system
Basis of Estimate	☐ No Design	☑ Conceptual Design	☐ Final Design ☐ Actual Cost

Item #	Description	Quantity	Units	Material Cost per Unit	Total Material Cost	Labor Hour	Labor Cost per Hour	Total Labor Cost	Total Cost
	CHP System								
1	Division 01000 - General				$ 163,500			$ 10,800	$ 174,300
2	Division 23000 - Mechanical				$ 1,004,000			$ 207,000	$ 1,211,000
3	Division 25000 - Controls				$ 55,000			$ -	$ 55,000
4	Division 26000 - Electrical				$ 275,000			$ -	$ 275,000
5									
	Subtotal				**$ 1,497,500**	0		**$ 217,800**	**$ 1,715,300**
	HX and Miscellaneous								
1	Division 01000 - General				$ 59,000			$ -	$ 59,000
2	Division 23000 - Mechanical				$ 122,800			$ 80,700	$ 203,500
3	Division 25000 - Controls				$ -			$ -	$ -
4	Division 26000 - Electrical				$ -			$ -	$ -
5									
	Subtotal				**$ 181,800**	0		**$ 80,700**	**$ 262,500**
	Subtotal of All Items				**$ 1,679,300**	0		**$ 298,500**	**$ 1,977,800**
	Contingency			15%	$ 251,895		15%	$ 44,775	$ 296,670
	Subtotal				**$ 1,931,195**			**$ 343,275**	**$ 2,274,470**
	Construction Management Overhead			5%	$ 96,560		5%	$ 17,164	$ 113,724
	Profit			5%	$ 96,560		5%	$ 17,164	$ 113,724
	Subtotal Construction				**$ 2,124,315**			**$ 377,603**	**$ 2,501,917**
	Tax			0%	$ -		0%	$ -	$ -
	Mechanical Engineering			0%	$ -		10%	$ 250,200	$ 250,200
	Structural Engineering							$ -	$ -
	Architectural Design							$ 10,000	$ 10,000
	Filing/Expediting Consultant							$ 5,000	$ 5,000
	Construction Administration							$ 250,192	$ 250,192
	Commissioning							$ 35,000	$ 35,000
	Total Estimated Cost	**$**							**3,052,309**

J.3 Project Schedule

The estimated schedule for the complete microgrid including controls, interconnects and installation of all equipment and systems is as indicated below. The schedule below begins after completion of the Stage 2 microgrid design studies, and after CMCMUA completes the procurement process to select the preferred contractor or developer for this project. It is expected that these tasks will take an additional 12-18 months in addition to the time shown on the schedule below.

Table J-6. Estimate of project Schedule for the Microgrid



K. DETAILED CASH FLOW EVALUATION

The financial analyses below present results for the publicly owned microgrid business model and the MESCO owned business model. The project would not be eligible for any for REC's or carbon credits. The analysis includes reductions in costs resulting from lower demand and ratchet charges, as explained in the CHP reports in the Appendices. These reductions are reflected in the lower future CMC electric costs shown below.

K.1 Publicly Owned Microgrid

An analysis of the savings and payback for this business model is presented below.

As shown, the gross savings before debt service would be approximately $695,000 per year, before debt service. However, the project would have a net annual cost of about $91,000 per year after debt service. The analysis assumes CMC would borrow the $6.55 million project cost at a 3.5% interest rate over a term of 10 years. In addition to these costs, the anaerobic digester would cost an additional $40.2 million to process peak summer sludge flows, or approximately $18.5 million based on off-peak flows.

Table K-1. CMC Savings Analysis for Publicly Owned Business Model

CMC Savings Analysis for Publicly Owned Business Model		
Current electric costs	$1,295,355	$/year
Current gas costs for Tech HS	$179,367	$/year
Total current energy costs	**$1,474,722**	$/year
Future ACE WWTP electric costs	$98,149	$/year
CHP Fuel	$440,400	$/year
CHP VOM	$183,538	$/year
Future ACE CMC electric costs	$19,157	$/year
Future gas costs at CMC facilities	$37,720	$/year
Total future energy costs	**$778,964**	**$/year**
Gross savings before debt service	**$695,758**	$/year
Debt service	$787,732	$/year
Net additional cost	($91,974)	$/year
Initial investment	$6,551,259	$
Payback	**9.4**	**years**

Note: VOM is variable operations and maintenance for the CHP units

K.2 Privately Owned Microgrid

The analysis below presents a simplified income statement for the MESCO that would own and operate the DER. This structure is referred to as a "tolling agreement," since CMCMUA would be responsible for procuring the natural gas for the CHP units, and the MESCO would be responsible for assuring the CHP units are available, and supply electricity and thermal energy to CMCMUA when required. Under the privately-owned business model, it is assumed that the County would be responsible for funding and constructing the new anaerobic digester.

Table K-2. MESCO Income Statement

Revenue			
County	$0.020	$/kWh	$124,830
WWTP	0.020	$/kWh	$58,708
Capacity payment	$24.16	$/kW-mo	$1,300,000
Total revenue			**$1,483,538**
COGS			
VOM	$0.02	$/kWh	$183,538
Fuel	$7.35	$/MMBTU	$0
Subtotal COGS			**$183,538**
Gross profit			**$1,300,000**
Gross margin			*87.6%*
SG&A			
Outside services			$25,000
Insurance			$25,000
Property taxes			$25,000
Management fee			$60,000
Other			$25,000
Subtotal SG&A			**$160,000**
EBITDA			**$1,140,000**
Debt service	*$17.34*	*$/kW-mo*	$932,752
Cash flow			$207,248
DSCR			*1.2*

Under this business model, CMCMUA would pay the MESCO a capacity payment of $1.3 million per year and pay energy payments dependent on the amount of energy supplied by the MESCO. The capacity payment is based on the amount required to achieve a debt service coverage ratio (DSCR) of 1.2, which is believed to be sufficient to satisfy a project finance lender. The energy payments would be passed on at cost to CMCMUA. The CMCMUA would also be responsible for purchasing natural gas for the CHP unit. The cost of the natural gas is estimated to be approximately $440,400 per year. This is based on a delivery charge of $2.35/MMBTU's and a commodity charge of $500/MMBTU's. The MESCO would also supply thermal energy from the CHP unit to the TSH, which would reduce gas costs by approximately $142,000 per year. Thus, the net annual cost to CMCMUA under this option would be as follows:

Table K-3. Revenue and Expenses for CMCMUA with MESCO Model

Revenue and Expenses for CMCMUA with MESCO Model		
Energy payment to MESCO-county	$124,830	$/year
Energy payment to MESCO-WWTP	$58,708	$/year
Capacity payment to MESCO	$1,200,000	$/year
Fuel purchases for CHP at Tech HS	$440,400	$/year
Additional electric purchases from ACE	$117,306	$/year
Fuel savings from CHP thermal supply	($141,648)	$/year
Net outlays	**$1,799,597**	**$/year**
Current CMCMUA energy costs	$1,474,722	$/year
Net additional costs to CMCMUA	**($324,875)**	**$/year**

Thus, the privately owned microgrid would cost nearly $300,000 more per year than if CMCMUA owns and operates the DER. However, CMCMUA would be able to avoid incurring approximately $6.55 million in debt under the MESCO business model.

L. POTENTIAL FINANCING

Because the capacity payment/tolling structure backed by CMCMUA's credit would assure cash flow for the MESCO, the project should be able to attract financing from a traditional lender at relatively low rates. We have assumed a rate of 7.0% for this analysis. The project could also likely be financed by a strategic investor, such as a vendor or contractor, or through an equipment lease.

The tolling structure would assure that the project company has no fuel cost risk, and the capacity payment would assure that the project would have enough income to cover fixed costs and debt service, even if for some reason the facilities did not require any energy from the CHP units. Finally, vendors and/or the Engineering, Procurement Construction (EPC) contractor would guarantee performance and availability of the DER.

We would not likely seek financing from a private equity firm, since their cost of capital would typically be higher than required based on the low project risk profile. However, it is possible that some private equity firms might be willing to accept a lower return than usual, given the projects low risk profile.

M. BENEFITS OF PROJECT

This section describes the benefits of the proposed TC DER Microgrid as well as the need for the proposed project. This includes an estimate of the value for reliability, resiliency, flexibility, and sustainability.

M.1 Reliability and Resiliency

Currently, the distribution system in the area is susceptible to infrastructure damage from flooding, wind and icing, as well as day-to-events ("blue sky") reliability events from vegetation, animals and weather. With upgrades to distribution infrastructure and addition of generation close to end loads, this project has the potential to improve both day-to-day reliability and performance during major storms.

Figure M-1 (from *Atlantic City Electric Company's Annual System Performance Report for 2016*[3]) shows the major reliability indices for the Cape May district for ten years from 2007 through 2016.

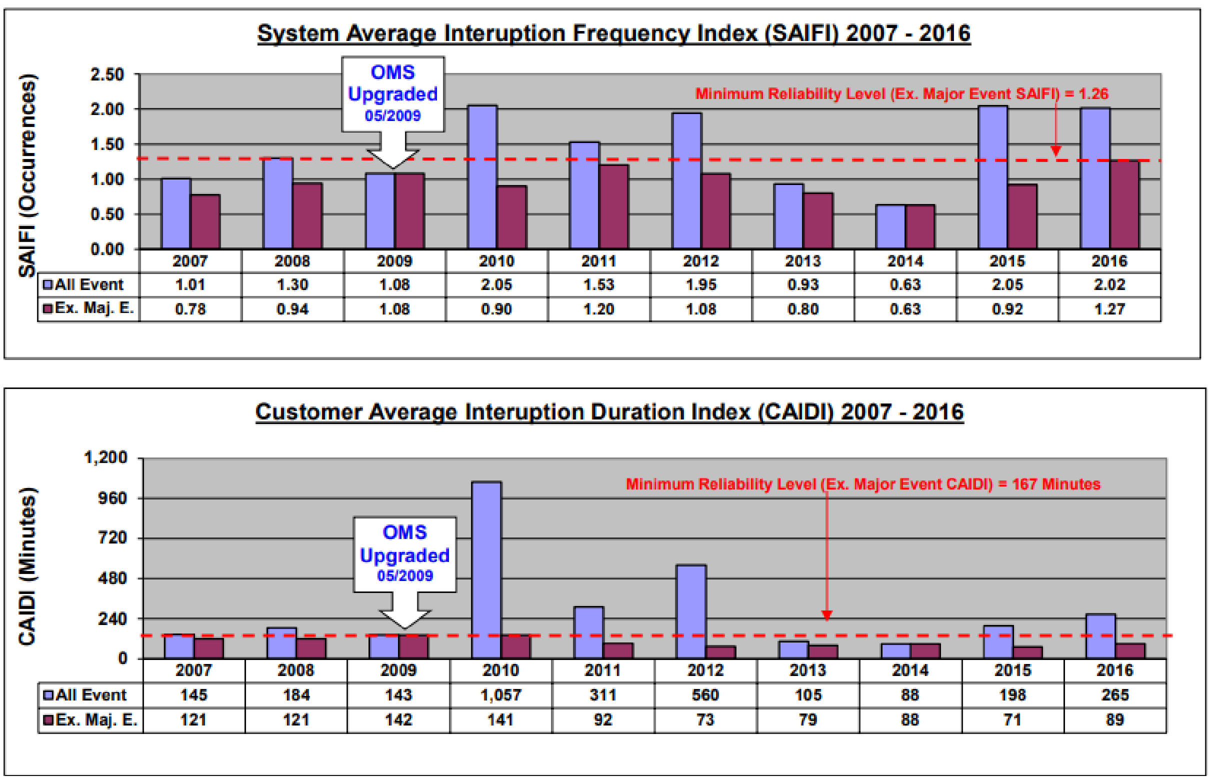


Figure M-1. Cape May District Major Reliability Indices 2007-2016

For 'blue-sky" events (purple bars), the district SAIDI (average hours of interruption per customer) in 2016 was 1.27 hours and the district CAIDI (average length of an event) was 89 minutes. This overall performance is below the average for all ACE districts but meets the minimum reliability level for the

[3] https://www.atlanticcityelectric.com/SiteCollectionDocuments/ACE%20-%202016%20NJ%20Annual%20Report%20-%20PUBLIC.pdf

company (for SAIDI and CAIDI, but not SAIFI). Nevertheless, ACE's performance puts it in the first quartile of utilities in the IEEE benchmark survey for 2016.[4]

However, if we drill down to the feeder level, the table below shows the performance for NJ0042 and NJ0381 over the past five years. Over the period, Feeder NJ0042 experienced 36 outages per year with an average of 95 minutes per interruption and NJ00381 averaged 29 outages per year with an average of 102 minutes per interruption. The average SAIFI and SAIDI for the circuits is slightly higher than for the Cape May District and ACE as a whole. A sampling of detailed outage records provided by ACE shows that many of the longer outages or the ones that affected a large number of customers were due to Equipment Failure, Wind, Lightning and Animals and Trees.

Table M-1 Reliability Performance for Feeders Serving Microgrid Loads

SAIFI						
	2014	**2015**	**2016**	**2017**	**2018**	**Avg**
NJ0042 Swainton Swainton	0.39	1.22	3.37	1.58	1.25	**1.56**
NJ0381 Court North	2.27	2.17	1.13	1.65	0.04	**1.45**
SAIDI (min)						
	2014	**2015**	**2016**	**2017**	**2018**	**Avg**
NJ0042 Swainton Swainton	27	98	506	149	103	**177**
NJ0381 Court North	215	201	40	255	5	**143**
Number of Outages						
	2014	**2015**	**2016**	**2017**	**2018**	**Avg**
NJ0042 Swainton Swainton	20	23	51	48	40	**36**
NJ0381 Court North	32	31	35	26	23	**29**
Average Outage Duration (min)						
	2014	**2015**	**2016**	**2017**	**2018**	**Avg**
NJ0042 Swainton Swainton	70	80	150	94	82	**95**
NJ0381 Court North	95	93	35	155	131	**102**

Many states, including New Jersey, permit utilities to exclude major events (those that affect a large percentage of a utility's customers for an extended period of time) from the standard reliability metrics reported to the regulating authority (SAIDI, SAIFI, CAIDI, etc.). This is reasonable since reliability metrics are meant to reflect the ability of the system (design and operation) to deliver power to customers under "normal" conditions. However, there are no commonly accepted metrics for performance during storms or major events (although some jurisdictions have proposed performance standards and scorecard-based assessment methods).

For the purposes of this discussion, the reliability metrics with major events *included* will serve as a proxy for resiliency performance.

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[4] http://grouper.ieee.org/groups/td/dist/sd/doc/Benchmarking-Results-2016.pdf

From a resiliency perspective, the blue bars in Figure M-1 above show the performance with major events included. With the outages from major storms included, the 2016 SAIDI jumps to 2.02 hours per customer and the CAIDI is 265 minutes per event (or almost 4.5 hours per event).

Figure M-2 and Figure M-3 below show the number of interruptions and the interruption causes from 2007 through 2016 excluding major events and including major events.

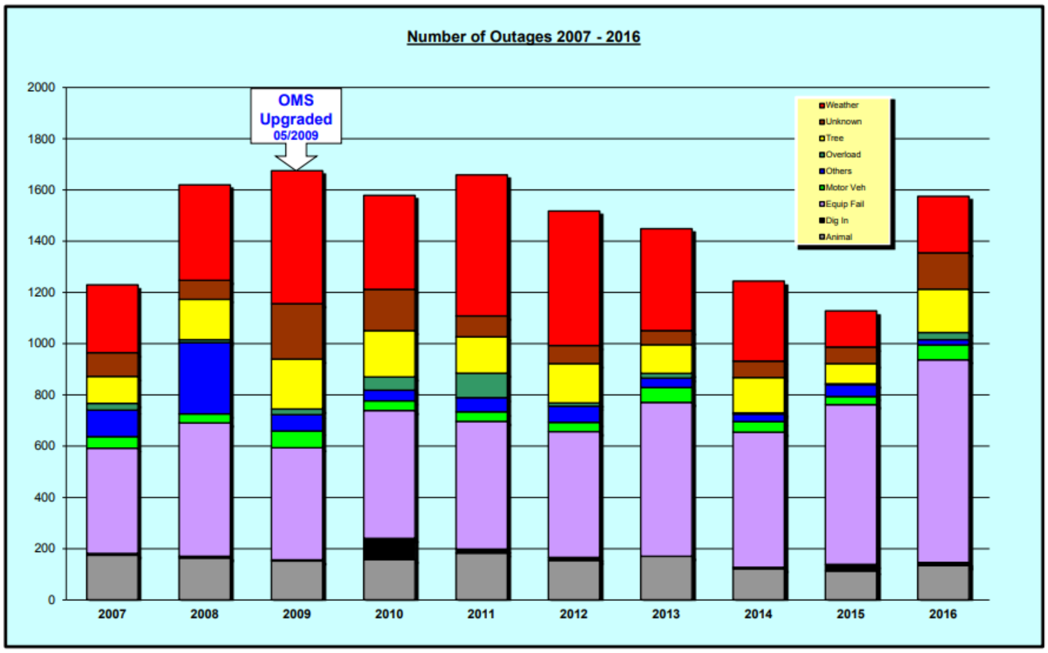

Figure M-2. Cape May Major Outages and Outage Causes 2007-2016 (Excluding Major Events)

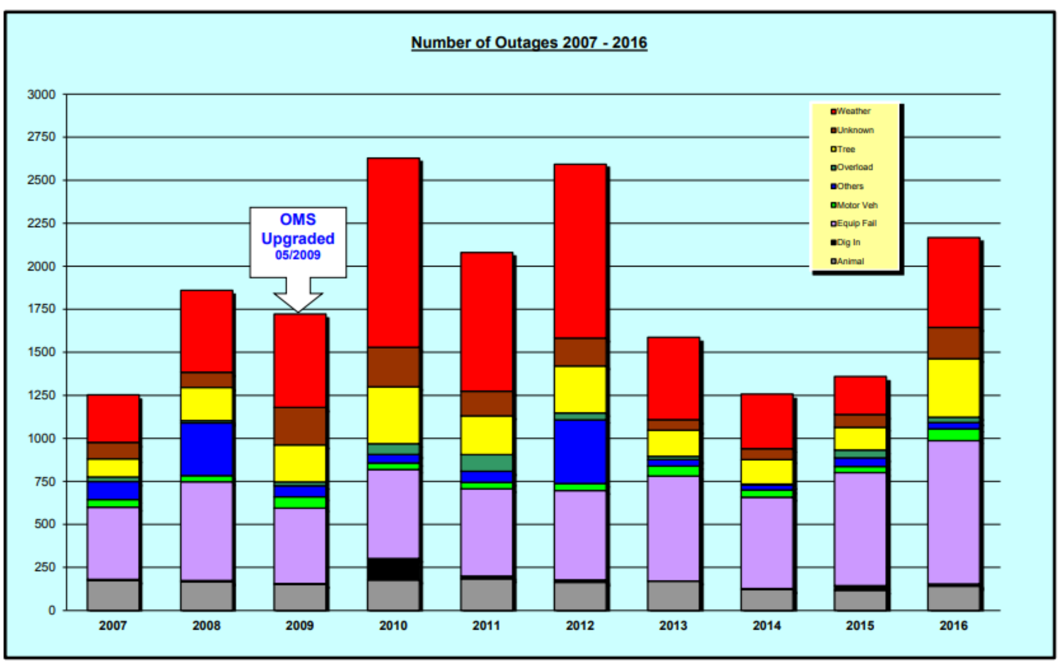

Figure M-3. Cape May Major Outages and Outage Causes 2007-2016 (Including Major Events)

In both cases, over the decade, the major causes are equipment failure (purple), weather (red), trees (yellow) and animals (grey). This is not surprising given that most of the infrastructure within the microgrid footprint is overhead and runs through some areas where there are trees along the right-of-way (ROW), particularly along Crest Haven Rd and north of the THS, around the WTTP.

As part of the microgrid design, some overhead sections in the microgrid area will be evaluated for distribution hardening measures to specifically improve reliability and resiliency. The goal is to insulate the critical infrastructure serving the microgrid facilities from events on the feeder system in the area. Potential hardening measures include:

- Aggressive tree trimming and removal of danger and hazard trees
- Application of covered wire lashed aerial cable or spacer cable
- Upgraded construction with stronger poles; compact construction with shorter cross-arms
- Strategic application of automated switches, sectionalizing and reclosing devices
- Where warranted, targeted undergrounding

In particular, the three-phase backbone between the DCF Regional School tap and the Safety Training Center (1,750 ft), and between the Technical High School and the WWTP (3,000 ft) is a candidate for upgrades. This is illustrated in Figure M-4 below.

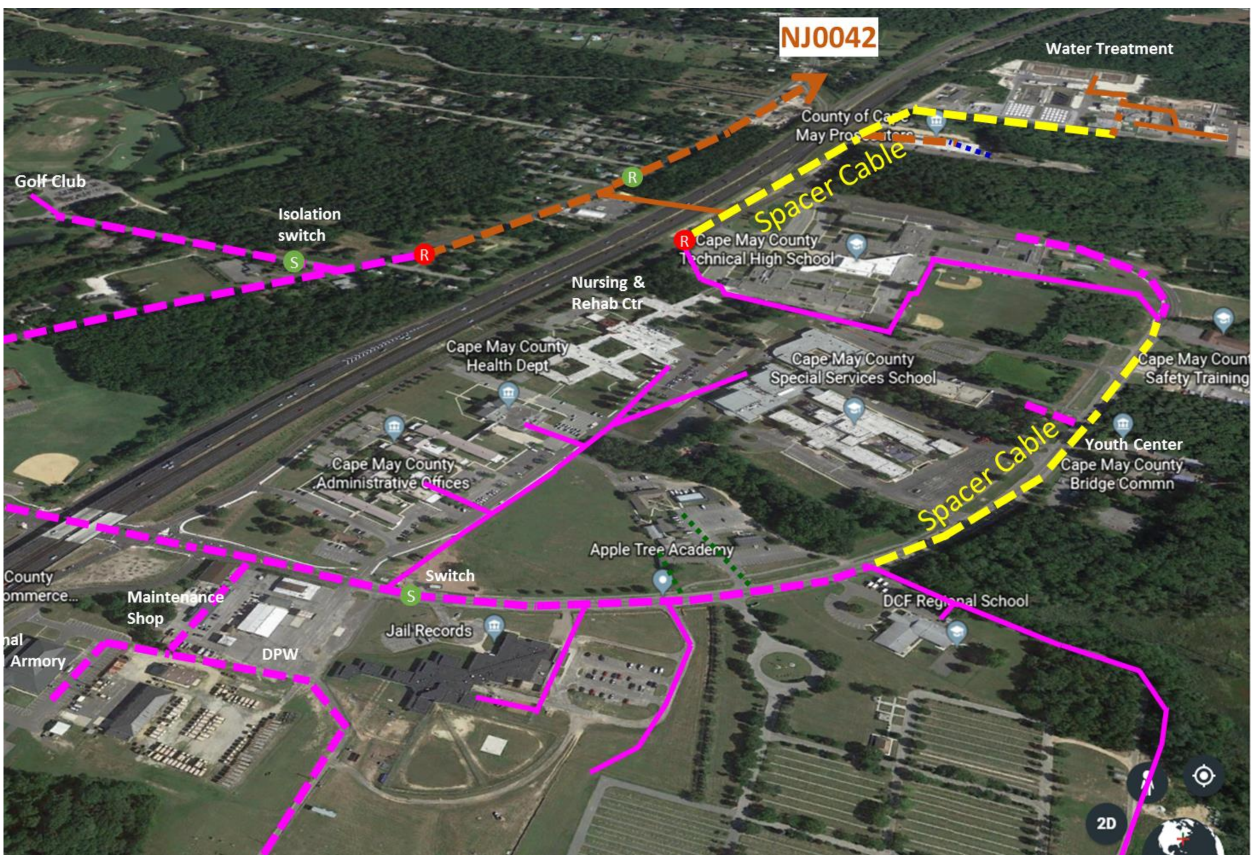

Figure M-4. Potential Spacer Cable Upgrades within the Microgrid Footprint

Distribution upgrades, such as spacer cable have the potential to significantly impact blue-sky reliability as well as performance during major storms (resiliency) because spacer cable can sustain higher wind, ice and snow loading, and being insulated, is impacted by vegetation and animal activity.

The microgrid design includes two new controller reclosers on NJ0042 and NJ0381 that ae capable of mitigating downstream faults and improving the reliability of customers on both feeders during blue-sky days. In addition, the two existing tie switches between NJ0042 and NJ0381 within the microgrid footprint will be automated (or replaced with reclosers) giving ACE the ability to quickly reconfigure the circuits to restore more customers faster for fault son either circuit. This would result in an observable improvement in SAIDI and CAIDI for both feeders.

M.1.1 Recent Major Events

The descriptions below are from two major storm events that impacted the Cape May area in 2016. Both are from the "Atlantic City Electric Company's Annual System Performance Report for 2016". [5]

> *On Friday, January 22, 2016, beginning at approximately 11:00 p.m., snow began falling in the southwestern areas of ACE's service territory. The snowfall, at times with blizzard conditions, became heavier into Saturday with high winds developing along the coastal areas that included wind gusts up to 70 miles per hour.*
>
> *The western area of the service territory experienced minimal customer outages and only minor structural damage. Due to the high sustained winds and flooding along the coast, however, ACE experienced significant damage to transmission and distribution lines and equipment, resulting in extensive power outages in the Cape May and Pleasantville Districts. There were no issues with any ACE substation in flood prone areas.*

Table M-2. Outages from Winter Storm Jonas

District	Date	Time	Number of Customers Out	Percent of Customer Base
Cape May	Jan. 23	5:00 a.m.	17,465	15.9%
Pleasantville	Jan. 22	6:00 a.m.	21,730	12.6%

> *On Tuesday, June 21, 2016, beginning at approximately 3:00 p.m., a severe summer storm with heavy straight line winds struck the Cape May County area, impacting Rio Grande, Wildwoods, and Cape May areas with wind speeds exceeding 70 miles per hour.*
>
> *The western and northern parts of the service territories were not significantly affected by the storm. Due to the high sustained and gusting winds, the southern reaches of Cape May County experienced severe and widespread damage to electric distribution lines and equipment, which resulted in extensive power outages.*

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[5] *"Atlantic City Electric Company's Annual System Performance Report for 2016"*, https://www.atlanticcityelectric.com/SiteCollectionDocuments/ACE%20-%202016%20NJ%20Annual%20Report%20-%20PUBLIC.pdf

Table M-3. Outages from Cape May Summer Storm

District	Date	Time	Number of Customers Out	Percent of Customer Base
Cape May	Jun. 21	5:00 p.m.	19,351	17.6%

In both cases, thousands of customers in cape May were interrupted, some for up to several days, due to distribution and transmission outages, the economy was impacted, and the safety and well-being of the public was affected, as is the case whenever power is lost.

The Cape May Microgrid, if it were operational, might have been able to mitigate some outages to critical facilities in the microgrid footprint, primarily because generation is close to or at the load locations, and ACE has more flexibility to reconfigure service.

M.1.2 Value of Improvements

According to Department of Energy (DOE) data, the total annual cost of power interruptions in the US is estimated to be $79 billion. The majority of this cost is attributed to commercial and industrial customers and is mostly caused by momentary interruptions.[6] The degree to which cost is incurred is entirely dependent on a number of factors, including customer/process type, customer size, length of interruption, time of day, day of week, month/season of year, and whether or not advance warning was given. Customer interruption cost data are typically estimated based on surveys which attempt to capture tangible, intangible and opportunity costs. In the absence of direct customer feedback, the Interruption Cost Estimate Calculator (ICE)[7] is a good proxy for estimating interruption costs and the value of reliability improvement.

Using the ICE Calculator, if implementation of the microgrid results in a 10% reduction in the average SAIFI and SAIDI on NJ0381 (from the average values in Table M-1), then the total benefit to the ten non-residential microgrid customers on the feeder is $24,583[8]. The result of this analysis is illustrated in the chart below. This is simplistic exercise with many assumptions, but it posits a way to place a value on the incremental benefit of reliability and resiliency improvements attributable to the microgrid.

[6] Kristina Hamachi LaCommare and Joseph H. Eto, "*Understanding the Cost of Power Interruptions to U.S. Electricity Consumers*," Ernest Orlando Lawrence Berkeley National Laboratory, September 2004, http://certs.lbl.gov/pdf/55718.pdf

[7] https://eaei.lbl.gov/tool/interruption-cost-estimate-calculator

[8] In 2018$ assuming 2% inflation, discount rate of 6% and 20-year life.

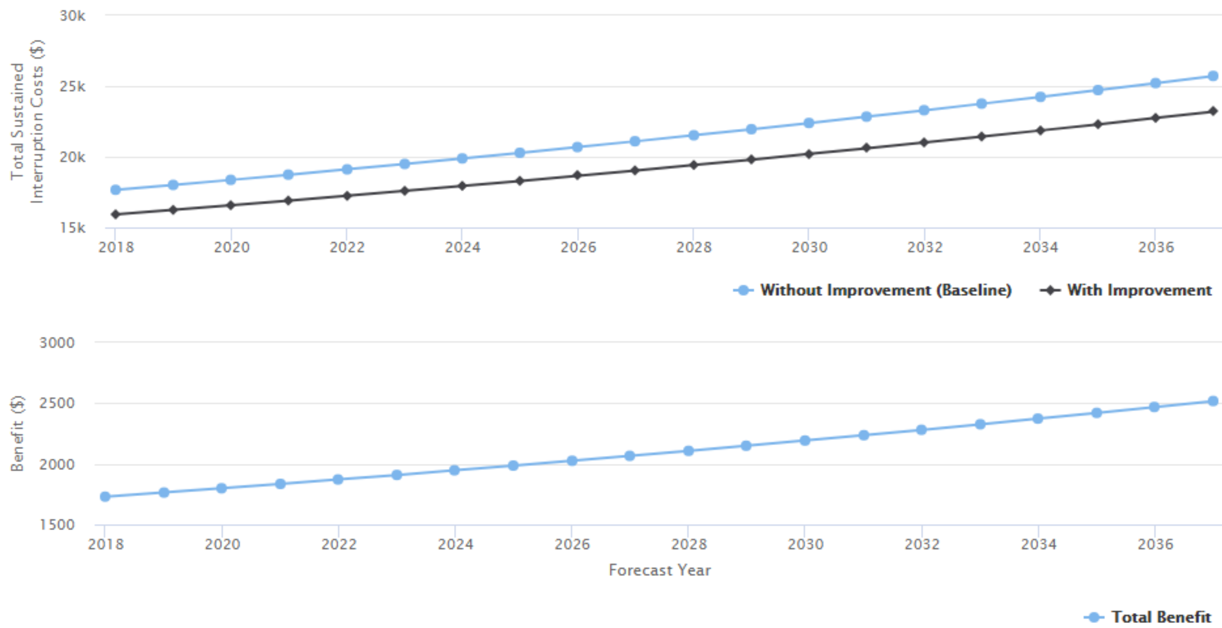


Figure M-5. Forecast of Total Sustained Interruption Cost from ICE Calculator

M.2 Flexibility

As discussed above, new controlled switches and recloses on NJ0042 and NJ0381 and between the two feeders within the microgrid footprint will be automated will give ACE the ability to reconfigure the circuits so that customers can be quickly moved from one feeder to the other to mitigate impacts from outages. In addition, the new microgrid DER creates an opportunity to reduce loading on the feeder during times of stress, increasing operational flexibility, reliability, and overall feeder performance.

M.3 Sustainability

The UN World Commission on Environment and Development defines sustainable development as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs.”

In the current design of the proposed microgrid, the sustainability objective is partially achieved by installing a CHP at the WWTP, which will be fueled by the biogas that will be produced by a new anaerobic digester (AD). The electricity from the CHP unit will significantly reduce use of electricity from the grid, most of which is produced by fossil fuels. In addition, the thermal energy from the AD will be used to increase the temperature of the influent to the AD, thus increasing the amount of biogas and renewable electricity. Finally, some of the electricity from the CHP unit will be used to power EV’s that will recharge at a new EV charging station at the WWTP.

The other CHP and RICE units to be installed in the microgrid will be fueled by natural gas. However, the CHP at the THS, by virtue of providing both electric power and useful thermal energy in a more efficient manner than the current combination of grid and boilers, contributes to the overall sustainability. Utilization of natural gas more efficiently for both electricity and thermal energy also implies production of less greenhouse gas emissions compared to business as usual.

N. CONTROLS AND COMMUNICATIONS

The microgrid control design will utilize distributed utility grade controllers and Intelligent Electronic Devices (IEDs). These devices meet the requirements of NERC CIP-5 and will be shown to meet the requirements of NIST Risk Management Framework including:

- Microgrid controller is based on supervisory control architecture; controls assets by communicating with local controllers (IEDs/Relays, generator controls, local/load controllers, Building Management Systems, etc.)
- Controller gets information from assets through Supervisory Control and Data Acquisition (SCADA) protocols (Modbus, IEC 61850, DNP3, IEC 60870 etc.)
- Event latency is between 50 ms to 1500 ms and control latency is max.50 ms
- Bandwidth requirement is at least 10/100 mpbs

A key facet of the communication design is integration with ACE Distribution Management System (DMS), Outage Management System (OMS) and other utility enterprise systems. This will enable the utility to have visibility into the state of microgrid assets and exercise hierarchical control if appropriate.

- Microgrid controller could interact with DMS/SCADA or function as the DERMS when interacting with the DMS
- Controller interfaces and exchange messages with local (primary) DER controllers and protection IEDs
- Controller interfaces and exchange messages with DMS and utility enterprise bus using utility backbone communication system (WiMAX/copper/fiber)

The Team will evaluate the use of existing communications systems in two important areas:

Cost Savings and Interoperability: Reuse of existing communications systems can provide cost savings as the microgrid developer will not be required to deploy an entirely new communications fabric. Individual network segments or complete reuse of the communications system can be applied, and significant cost savings can be achieved. Additionally, where reuse is leveraged, protocols and data models can be selected to achieve maximum interoperability and performance.

Security and Resilience: There is a trade-off between cost savings acquired via reuse of existing communications systems and the reduced security and resilience attributes in older communications technology and design approaches. This will be analyzed, and cost and security considerations will be balanced to accommodate the site-specific functional requirements.

Maximum weather resilience and performance is achieved when underground fiber optic networks are deployed. Additional surety can be obtained by creating redundant fiber rings and including two-way communications. The use of fiber, redundant networks, and underground deployment makes this the most reliable and resilient method, but it is also costlier.

A plausible approach for the protection and controls architecture and the communications layout are shown in the schematics below.

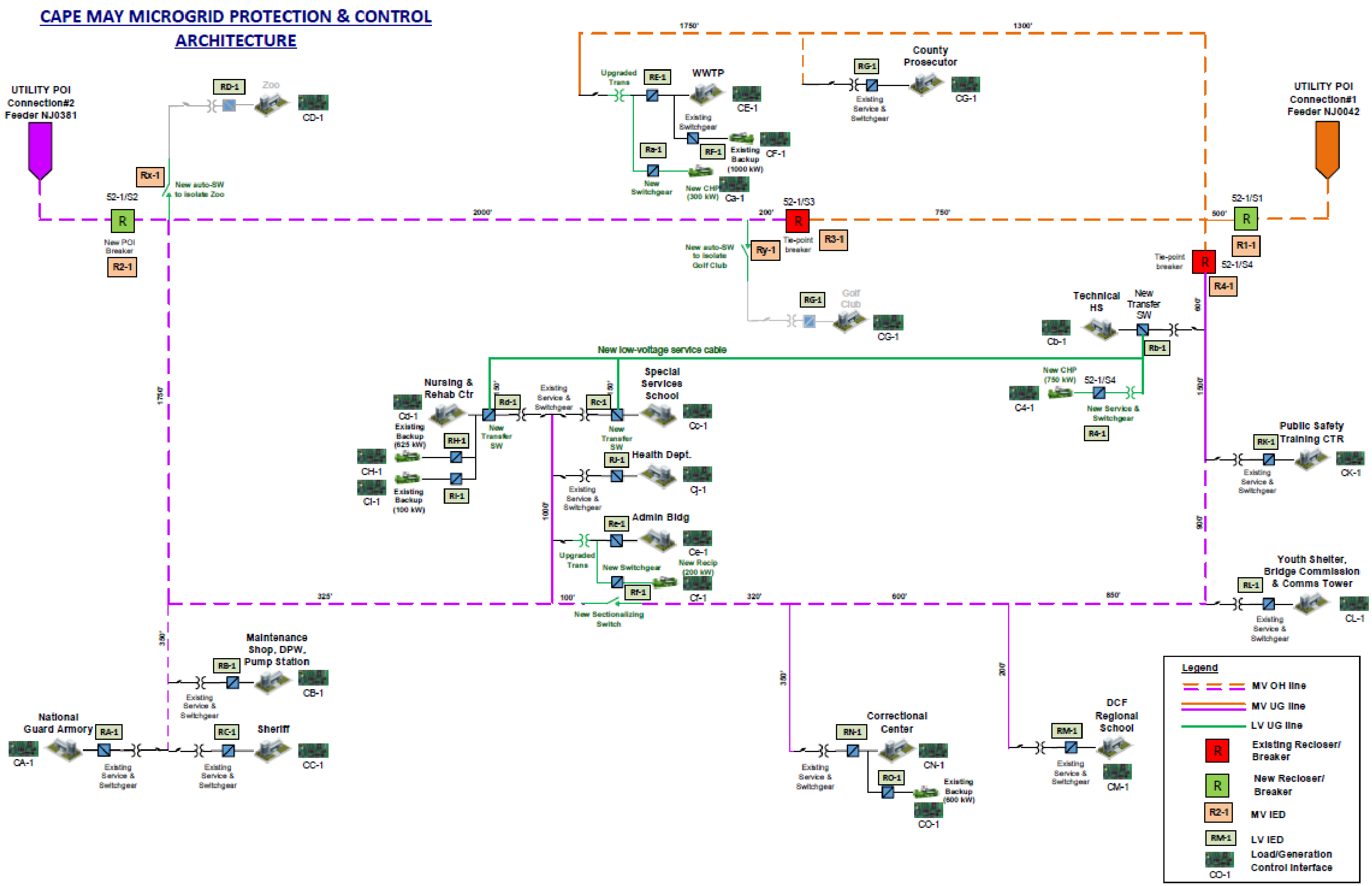


Figure N-1. Proposed Protection and Controls Architecture for the Microgrid

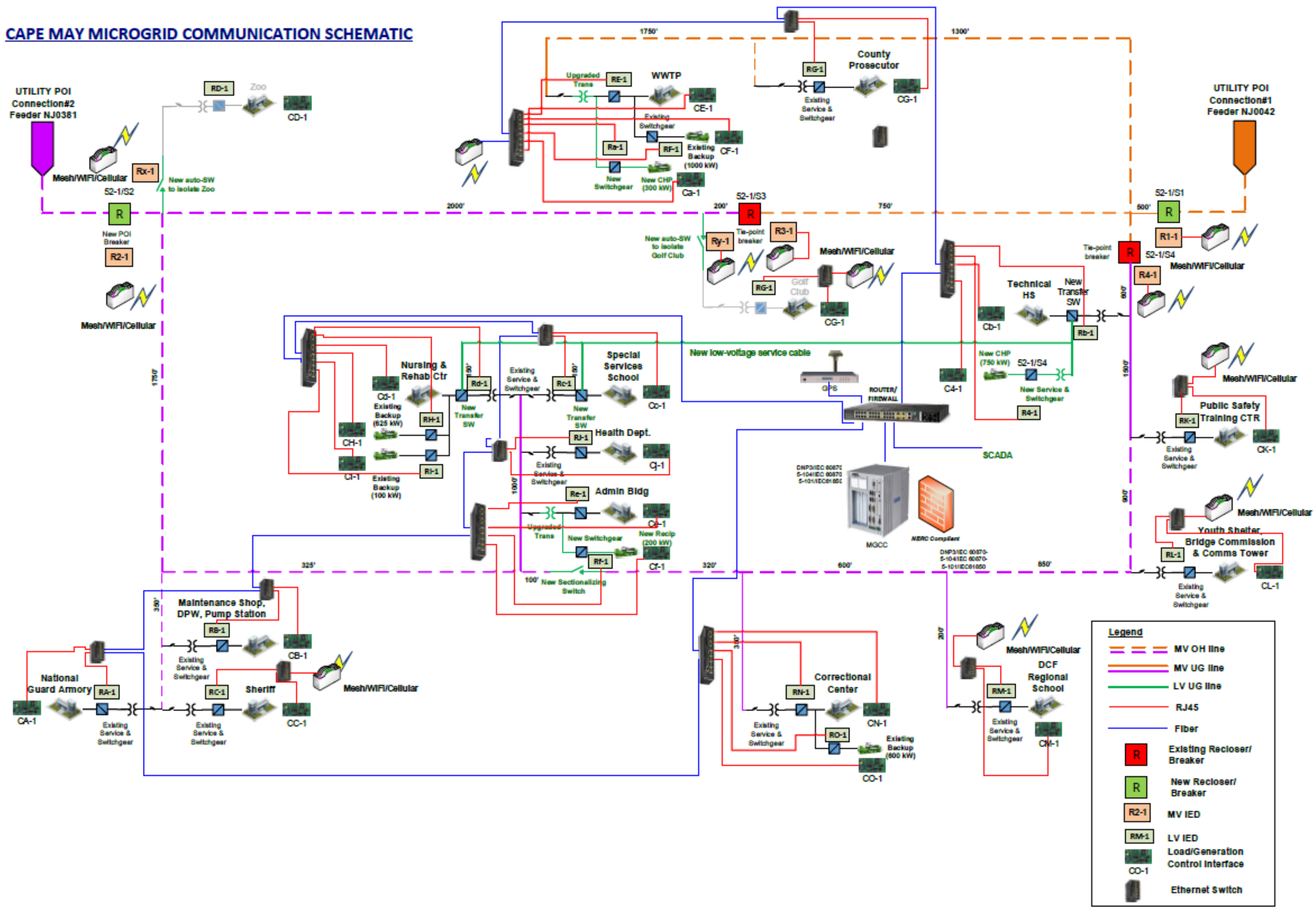
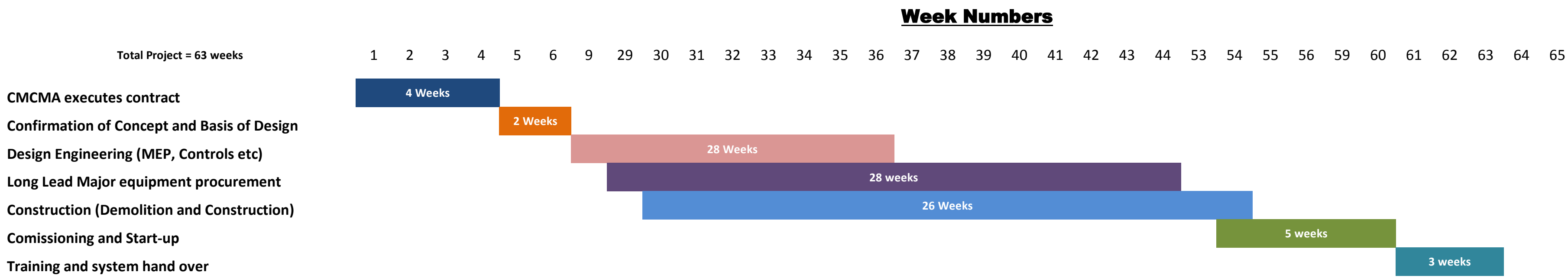


Figure N-2. Proposed Communications Layout for the Microgrid

O. CONSTRUCTION SCHEDULE

The estimated schedule for the complete microgrid including controls, interconnects and installation of all equipment and systems is as indicated below:

Estimated Project Schedule for the Microgrid



P. ON-GOING WORK WITH THE EDC AND GDC

The project team is in discussion with ACE about the distribution upgrades needed to implement the microgrid. Some specific items being discussed include:

1. Automation of the two existing tie switches between NJ 0042 and NJ0381 or replacement with high-speed reclosers to allow remote monitoring and control of the tie points
2. Installation of two new high-speed reclosers with controls a the microgrid boundaries of NJ0042 andNJ0381 to isolate the upstream portions of the two feeders
3. Installation automated (SCADA-controlled) isolation switches at (at least) two locations on laterals and taps to remove non-critical loads from the microgrid during islanding
4. Installation of one new auto-sectionalizing switch near the Correctional Center to improve operational flexibility in grid-connected and islanded mode
5. Acceleration of conversion of bare OH wire to spacer cable within the microgrid footprint, particularly along the three-phase backbone between the DCF regional School tap and the Safety Training Center (1,750 ft), and between the Technical High School and the WTP (3,000 ft).
6. Potential upgrade of a small segment of UG conductor between the Safety Training Center and Technical HS to improve voltage regulation in island mode

As noted earlier, ACE has indicated that although they support the goals of the microgrid program, there are many regulatory, engineering, and cost issues which must be addressed and resolved in the course of considering the program.

Q. CONCEPTUAL DESIGN

Q.1 Design Analysis

Please see the CHP Studies in Appendix 3 and 4.

Q.2 Schematic or one-line concept drawings

Please see discussion in Section I, schematics in Figure I-7 and Figure N-1, as well as the CHP Studies in Appendix 3 and 4.

Q.3 Conceptual cost estimate

Please see Section J as well as the CHP Studies in Appendix 3 and 4.

Q.4 Preliminary construction schedule

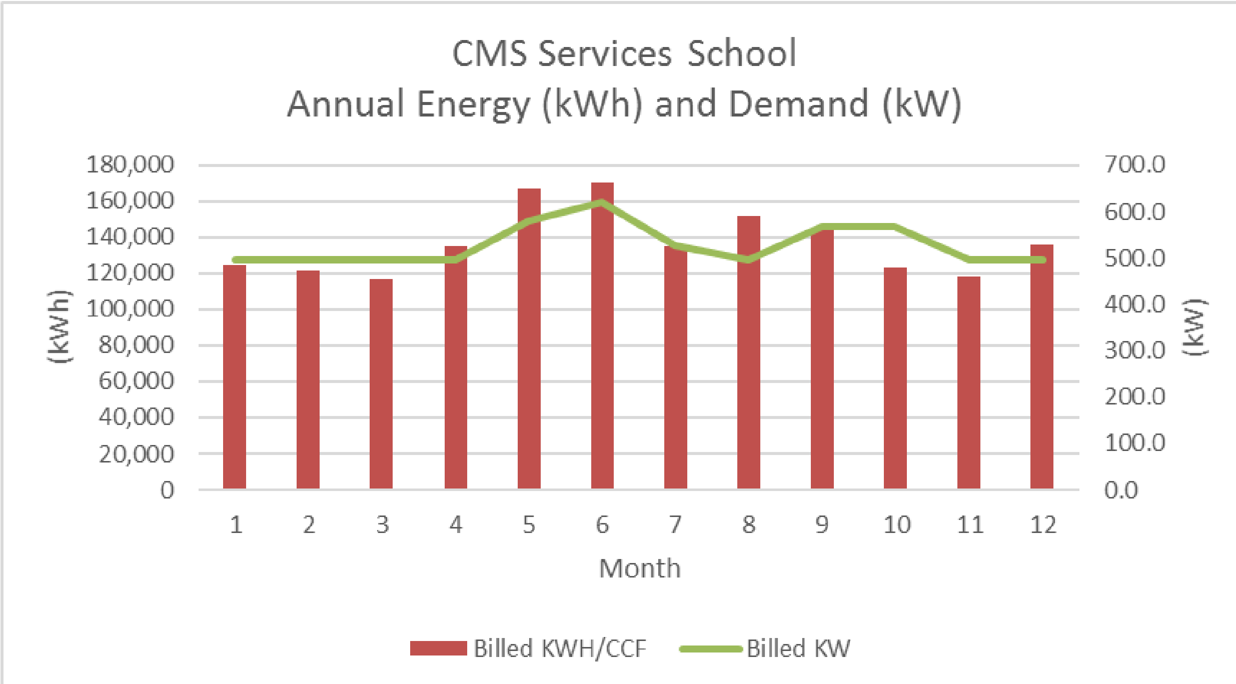
Please see Section O.

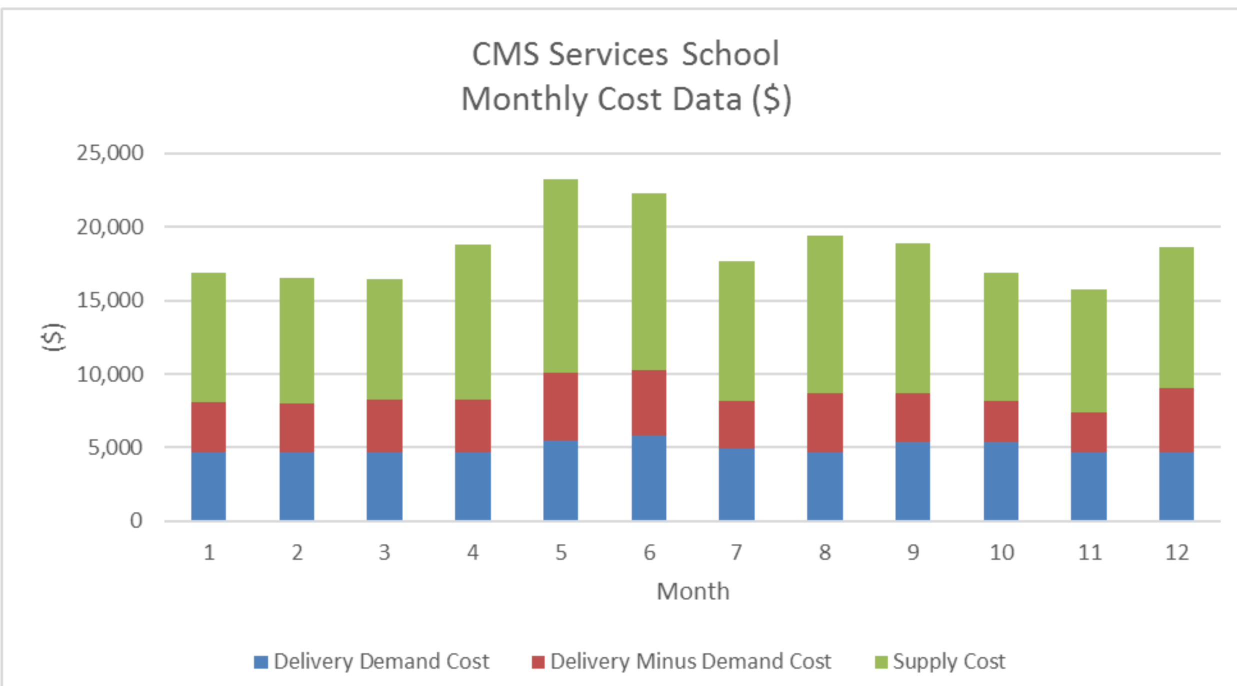
Q.5 Project definitions and special conditions

Please see Section G, and the CHP Studies in Appendix 3 and 4.

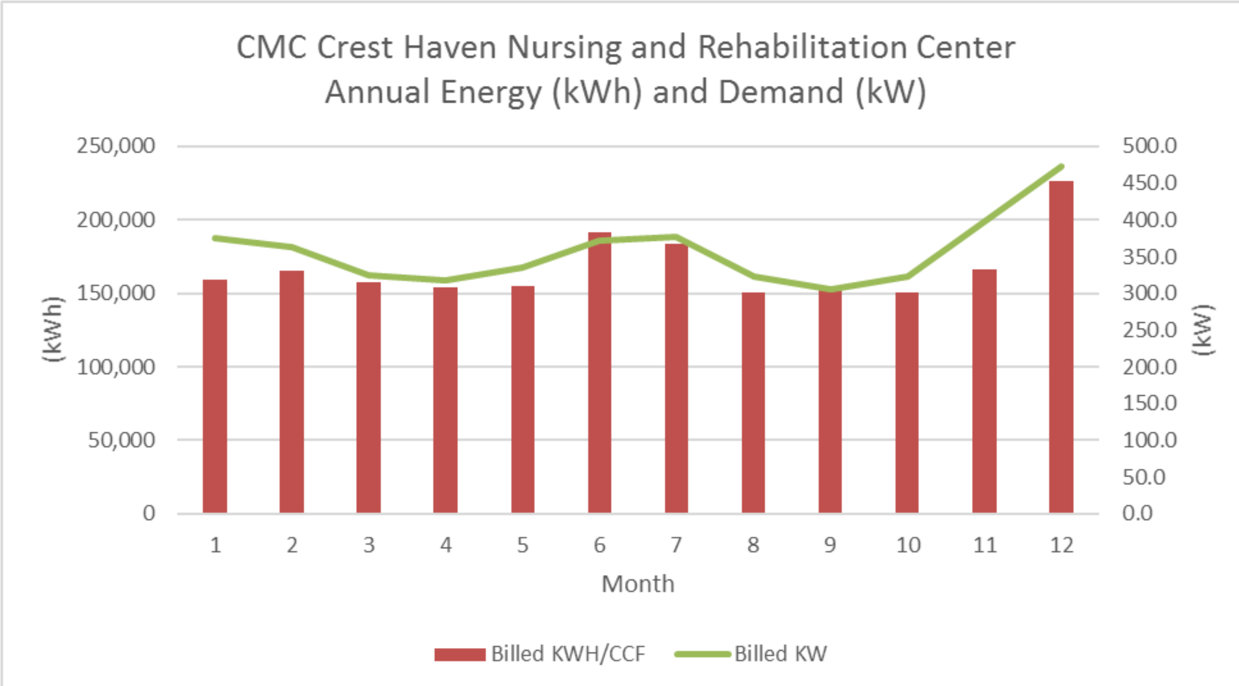
APPENDIX 1. MONTHLY ELECTRIC DATA

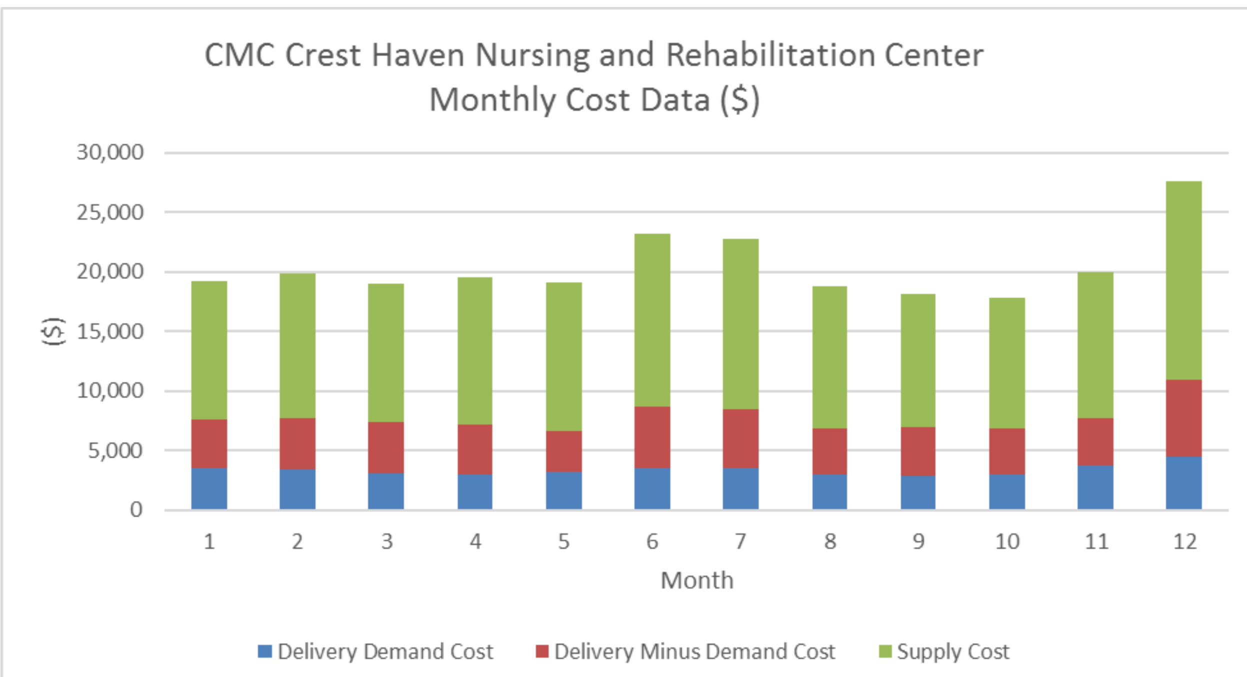
CMC Services School									
Month	Billed KWH/CCF (kWh)	Billed KW (kW)	Measured KW (kW)	Delta kW (kW)	Delivery Cost ($)	Delivery Demand Cost ($)	Delivery Minus Deman d Cost ($)	Supply Cost ($)	Total Cost ($)
1	124,800	496.8	435.0	61.8	8,097	4,690	3,407	8,772	16,869
2	121,800	496.8	342.0	154.8	8,009	4,690	3,319	8,561	16,569
3	116,700	496.8	360.0	136.8	8,261	4,690	3,571	8,202	16,464
4	135,000	496.8	489.0	7.8	8,219	4,690	3,529	10,602	18,821
5	167,400	579.0	579.0	0.0	10,071	5,466	4,605	13,147	23,217
6	170,700	621.0	621.0	0.0	10,282	5,862	4,420	12,026	22,308
7	135,000	528.0	528.0	0.0	8,196	4,984	3,212	9,511	17,707
8	151,800	496.8	489.0	7.8	8,714	4,690	4,024	10,694	19,408
9	144,600	567.0	567.0	0.0	8,689	5,352	3,337	10,187	18,876
10	123,300	567.0	567.0	0.0	8,162	5,352	2,810	8,686	16,849
11	118,500	496.8	387.0	109.8	7,419	4,690	2,729	8,348	15,767
12	135,900	496.8	351.0	145.8	9,037	4,690	4,347	9,552	18,589
	1,645,500	621.0	621.0	154.8	103,156	59,846	43,310	118,288	221,444


CMS Services School
Annual Energy (kWh) and Demand (kW)
(kWh)
180,000
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
700.0
600.0
500.0
400.0
300.0
200.0
100.0
0.0
(kW)
1 2 3 4 5 6 7 8 9 10 11 12
Month
Billed KWH/CCF
Billed KW

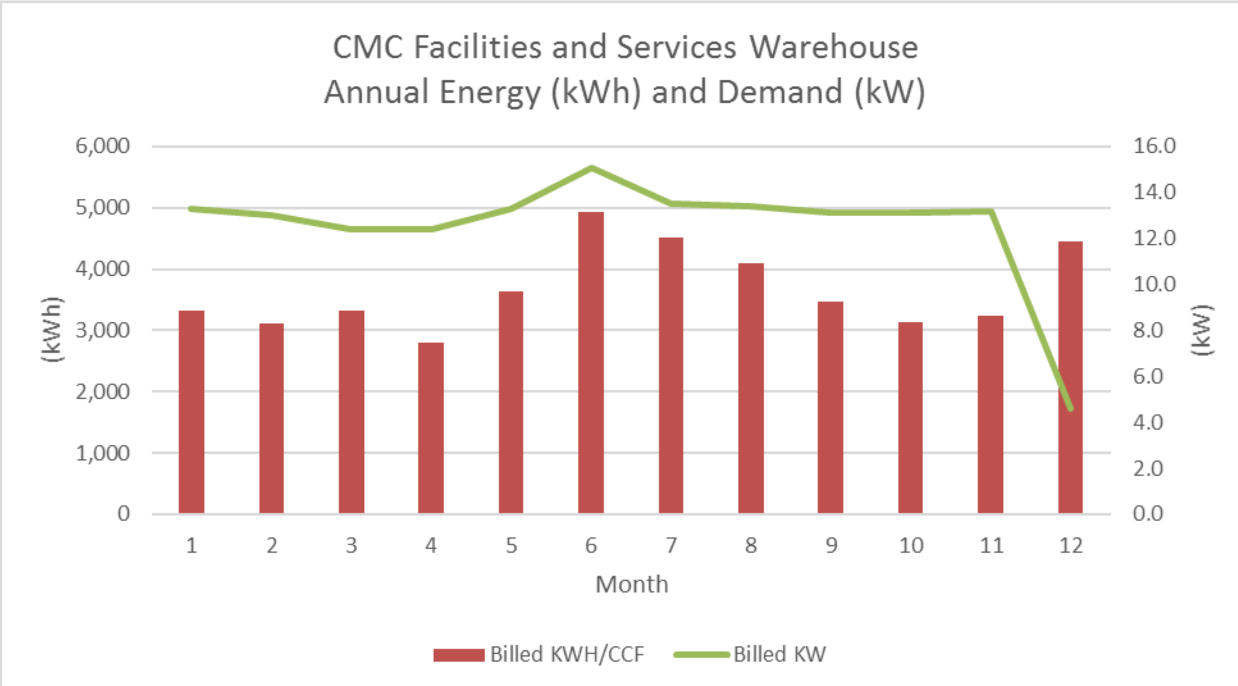

CMS Services School
Monthly Cost Data ($)
($)
25,000
20,000
15,000
10,000
5,000
0
1 2 3 4 5 6 7 8 9 10 11 12
Month
Delivery Demand Cost
Delivery Minus Demand Cost
Supply Cost

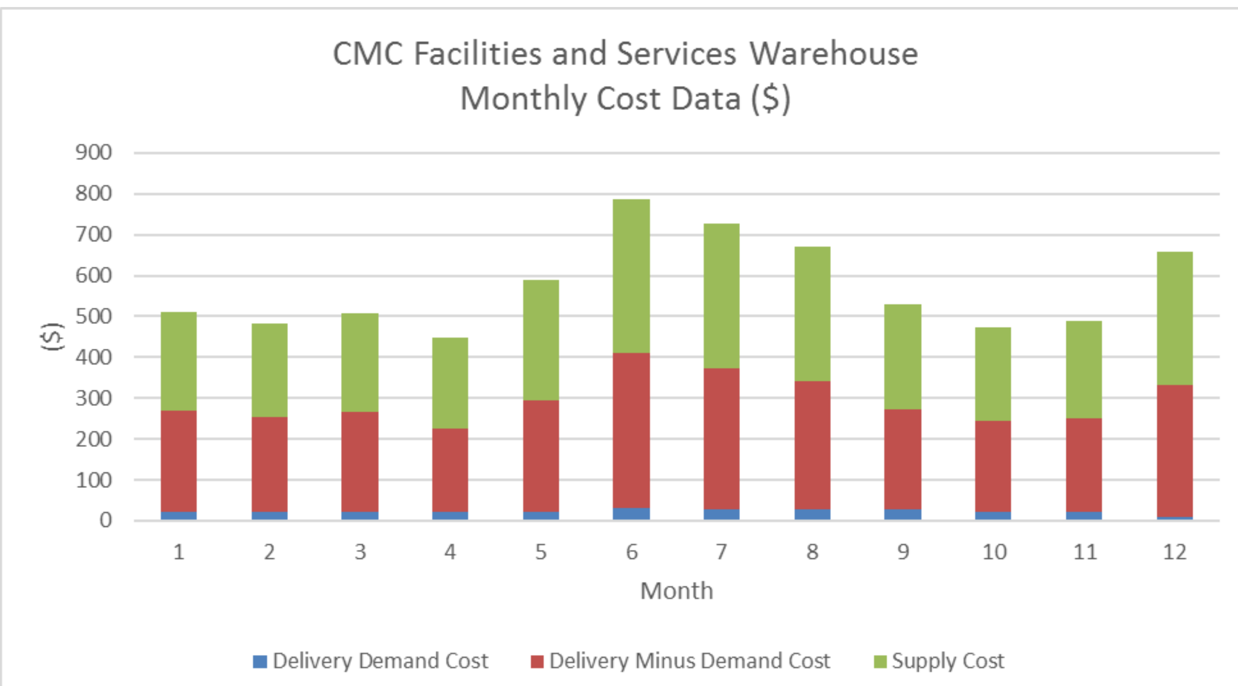
CMC Crest Haven Nursing and Rehabilitation Center									
Month	Billed KWH/CCF (kWh)	Billed KW (kW)	Measured KW (kW)	Delta kW (kW)	Delivery Cost ($)	Delivery Demand Cost ($)	Delivery Minus Demand Cost ($)	Supply Cost ($)	Total Cost ($)
1	159,080	375.3	375.3	0.0	7,608	3,543	4,065	11,671	19,279
2	165,567	362.3	362.3	0.0	7,778	3,420	4,357	12,147	19,925
3	157,844	324.4	324.4	0.0	7,455	3,062	4,393	11,581	19,035
4	153,886	317.2	317.2	0.0	7,198	2,994	4,204	12,408	19,606
5	155,089	335.7	335.7	0.0	6,619	3,169	3,450	12,505	19,124
6	191,572	372.4	372.4	0.0	8,647	3,516	5,131	14,574	23,221
7	183,830	376.7	376.7	0.0	8,462	3,556	4,906	14,275	22,738
8	150,896	322.7	322.7	0.0	6,915	3,047	3,868	11,891	18,806
9	152,052	305.6	305.6	0.0	6,928	2,885	4,043	11,182	18,110
10	150,221	322.7	322.7	0.0	6,819	3,047	3,772	11,047	17,866
11	166,219	398.2	398.2	0.0	7,731	3,759	3,972	12,224	19,954
12	226,804	472.0	472.0	0.0	10,952	4,455	6,496	16,640	27,592
	2,013,060	472.0	472.0	0.0	93,111	40,453	52,658	152,145	245,256


CMC Crest Haven Nursing and Rehabilitation Center
Annual Energy (kWh) and Demand (kW)
250,000
200,000
150,000
100,000
50,000
0
(kWh)
500.0
450.0
400.0
350.0
300.0
250.0
200.0
150.0
100.0
50.0
0.0
(kW)
1 2 3 4 5 6 7 8 9 10 11 12
Month
Billed KWH/CCF
Billed KW

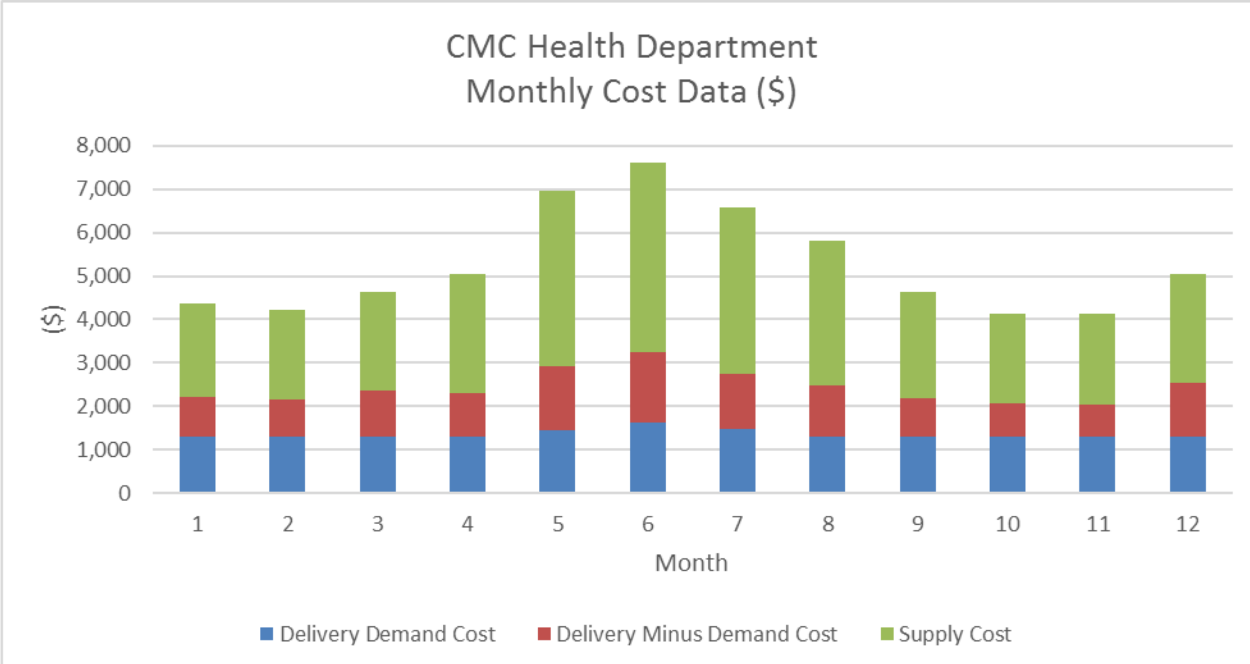

CMC Crest Haven Nursing and Rehabilitation Center
Monthly Cost Data ($)
30,000
25,000
20,000
15,000
10,000
5,000
0
($)
1 2 3 4 5 6 7 8 9 10 11 12
Month
Delivery Demand Cost
Delivery Minus Demand Cost
Supply Cost

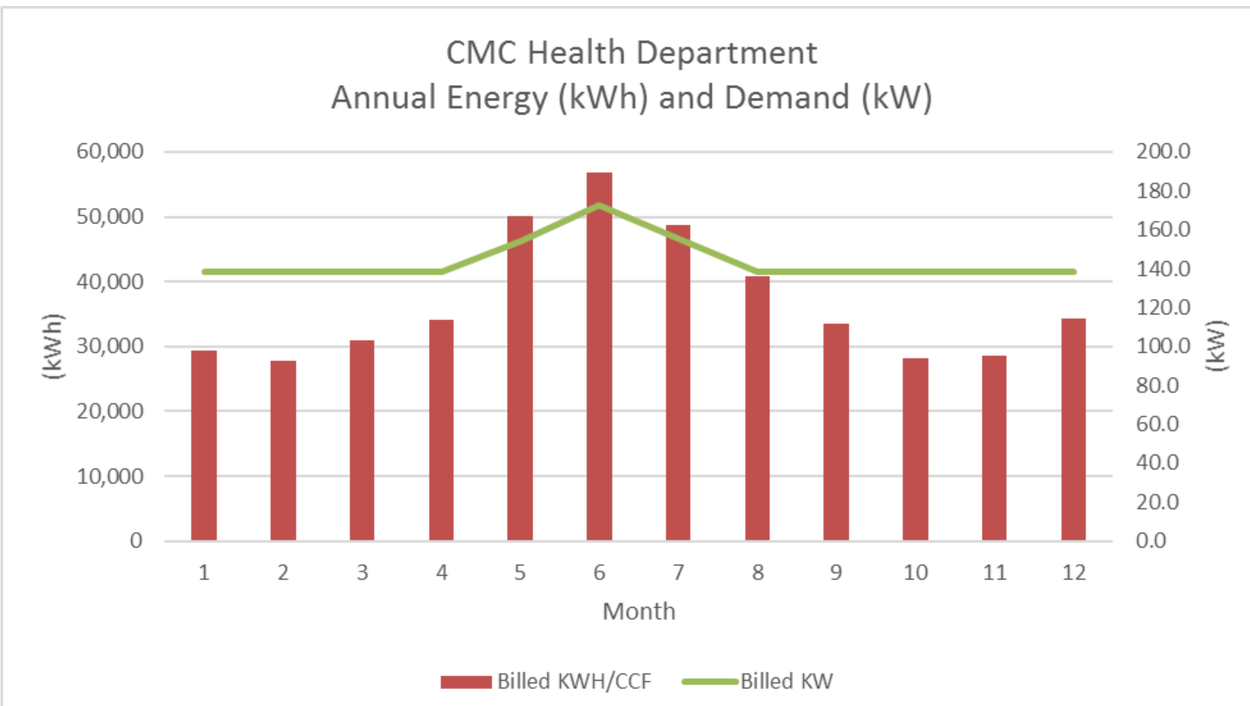
CMC Facilities and Services Warehouse									
Month	Billed KWH/CCF (kWh)	Billed KW (kW)	Measured KW (kW)	Delta kW (kW)	Delivery Cost ($)	Delivery Demand Cost ($)	Delivery Minus Demand Cost ($)	Supply Cost ($)	Total Cost ($)
1	3,322	13.3	13.3	0.0	268	23	246	244	512
2	3,118	13.0	13.0	0.0	253	22	231	229	482
3	3,312	12.4	12.4	0.0	265	21	244	243	508
4	2,794	12.4	12.4	0.0	224	21	203	225	449
5	3,636	13.3	13.3	0.0	295	23	273	293	588
6	4,928	15.1	15.1	0.0	409	31	378	378	788
7	4,509	13.5	13.5	0.0	372	28	344	353	726
8	4,093	13.4	13.4	0.0	343	28	315	328	671
9	3,475	13.1	13.1	0.0	273	27	246	256	528
10	3,124	13.1	13.1	0.0	245	22	222	230	474
11	3,227	13.2	13.2	0.0	252	22	229	237	489
12	4,447	4.6	4.6	0.0	333	8	325	326	659
	43,985	15.1	15.1	0.0	3,532	276	3,255	3,343	6,874


CMC Facilities and Services Warehouse
Annual Energy (kWh) and Demand (kW)
6,000
5,000
4,000
3,000
2,000
1,000
0
(kWh)
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
(kW)
1 2 3 4 5 6 7 8 9 10 11 12
Month
Billed KWH/CCF
Billed KW

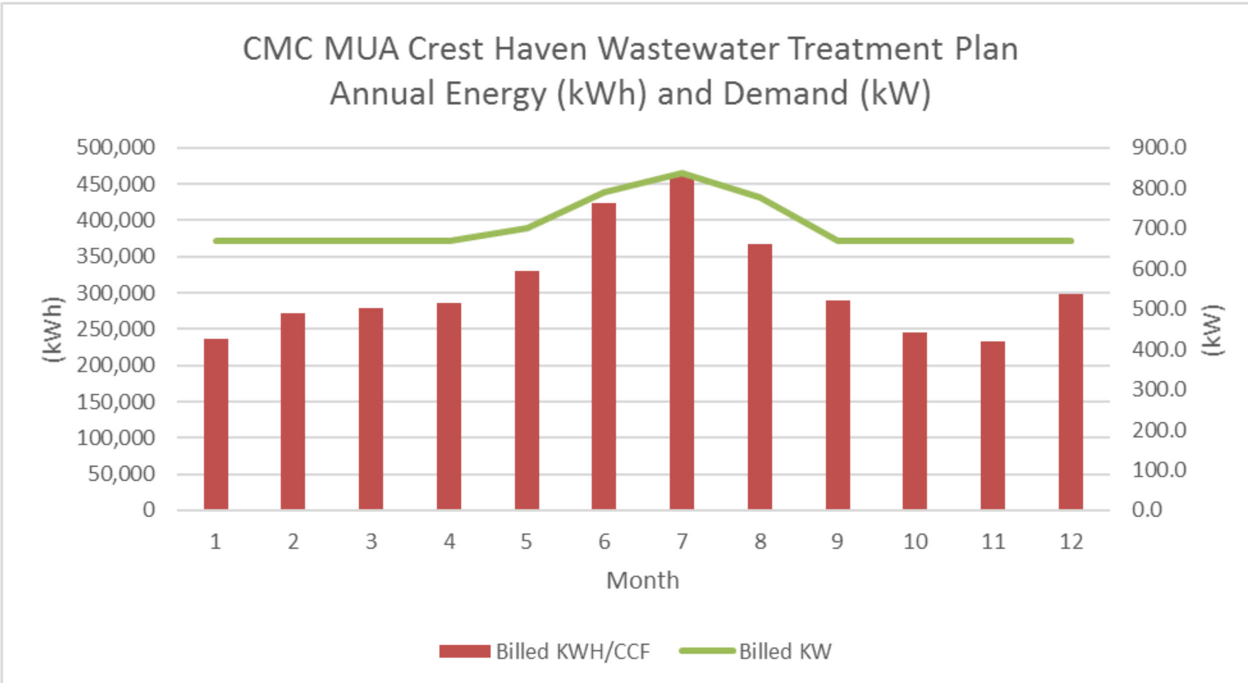

CMC Facilities and Services Warehouse
Monthly Cost Data ($)
900
800
700
600
500
400
300
200
100
0
($)
1 2 3 4 5 6 7 8 9 10 11 12
Month
Delivery Demand Cost
Delivery Minus Demand Cost
Supply Cost

CMC Health Department									
Month	Billed KWH/CCF (kWh)	Billed KW (kW)	Measured KW (kW)	Delta kW (kW)	Delivery Cost ($)	Delivery Demand Cost ($)	Delivery Minus Demand Cost ($)	Supply Cost ($)	Total Cost ($)
1	29,440	138.2	94.4	43.8	2,220	1,305	915	2,160	4,379
2	27,840	138.2	79.2	59.0	2,171	1,305	866	2,043	4,214
3	30,960	138.2	84.0	54.2	2,371	1,305	1,066	2,271	4,643
4	34,160	138.2	123.2	15.0	2,297	1,305	992	2,754	5,051
5	50,160	154.4	154.4	0.0	2,928	1,458	1,471	4,044	6,973
6	56,880	172.8	172.8	0.0	3,233	1,631	1,602	4,371	7,604
7	48,640	155.2	155.2	0.0	2,760	1,465	1,295	3,835	6,595
8	40,800	138.2	123.2	15.0	2,487	1,305	1,182	3,323	5,810
9	33,440	138.2	133.6	4.6	2,182	1,305	877	2,459	4,642
10	28,160	138.2	133.6	4.6	2,055	1,305	750	2,071	4,125
11	28,480	138.2	83.2	55.0	2,048	1,305	743	2,094	4,143
12	34,240	138.2	82.4	55.8	2,537	1,305	1,232	2,512	5,049
	443,200	172.8	172.8	59.0	29,289	16,299	12,991	33,938	63,228

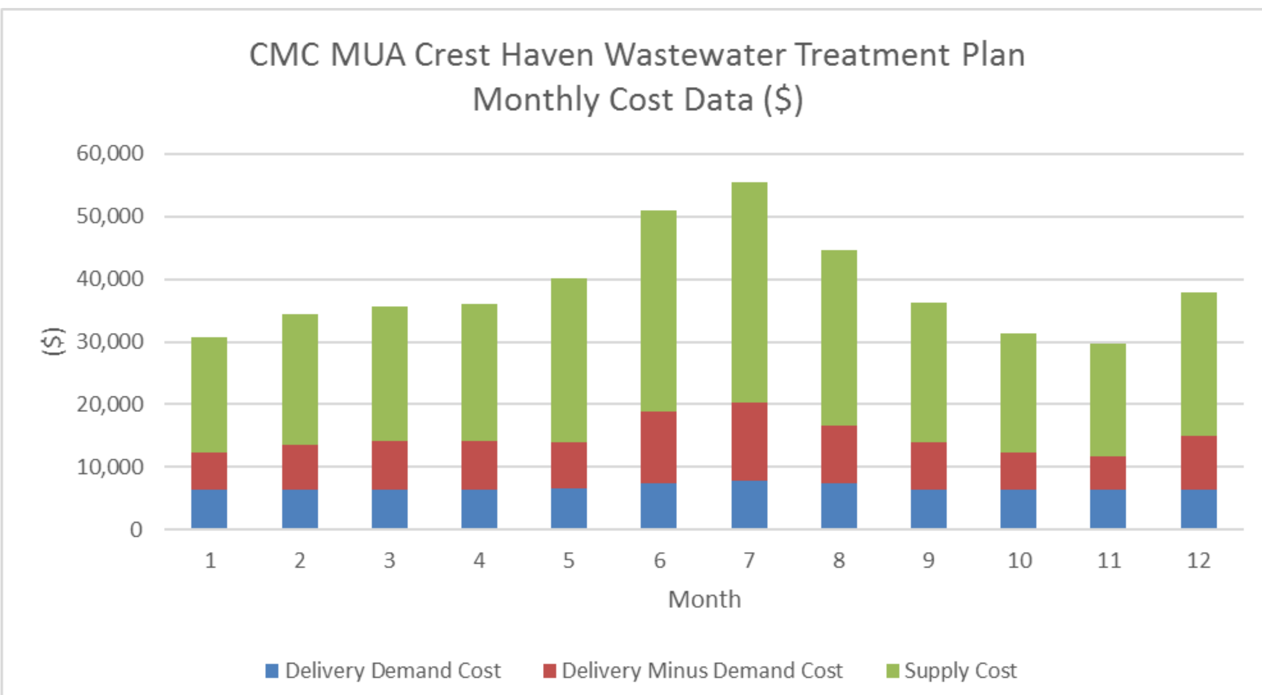

CMC Health Department
Monthly Cost Data ($)
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
($)
1 2 3 4 5 6 7 8 9 10 11 12
Month
Delivery Demand Cost
Delivery Minus Demand Cost
Supply Cost


CMC Health Department
Annual Energy (kWh) and Demand (kW)
60,000
50,000
40,000
30,000
20,000
10,000
0
(kWh)
200.0
180.0
160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
(kW)
1 2 3 4 5 6 7 8 9 10 11 12
Month
Billed KWH/CCF
Billed KW

CMC MUA Crest Haven Wastewater Treatment Plan									
Month	Billed KWH/CCF (kWh)	Billed KW (kW)	Measured KW (kW)	Delta kW (kW)	Delivery Cost ($)	Delivery Demand Cost ($)	Delivery Minus Demand Cost ($)	Supply Cost ($)	Total Cost ($)
1	237,084	670.6	581.8	88.8	12,395	6,331	6,065	18,281	30,676
2	272,061	670.6	656.3	14.3	13,510	6,331	7,179	20,874	34,384
3	278,839	670.6	567.4	103.2	14,171	6,331	7,841	21,461	35,632
4	285,604	670.6	667.1	3.5	14,133	6,331	7,803	21,928	36,062
5	330,610	701.1	701.1	0.0	13,969	6,618	7,351	26,213	40,182
6	424,162	788.4	788.4	0.0	18,833	7,442	11,391	32,224	51,057
7	463,785	838.3	838.3	0.0	20,381	7,913	12,468	35,156	55,537
8	368,153	777.4	777.4	0.0	16,708	7,339	9,370	28,030	44,739
9	289,097	670.6	562.0	108.6	13,988	6,331	7,657	22,257	36,245
10	244,515	670.6	532.6	138.0	12,352	6,331	6,021	18,908	31,260
11	232,142	670.6	580.7	89.9	11,808	6,331	5,477	17,919	29,726
12	298,069	670.6	644.6	26.0	15,005	6,331	8,674	22,929	37,934
	3,724,121	838.3	838.3	138.0	177,254	79,957	97,297	286,180	463,434

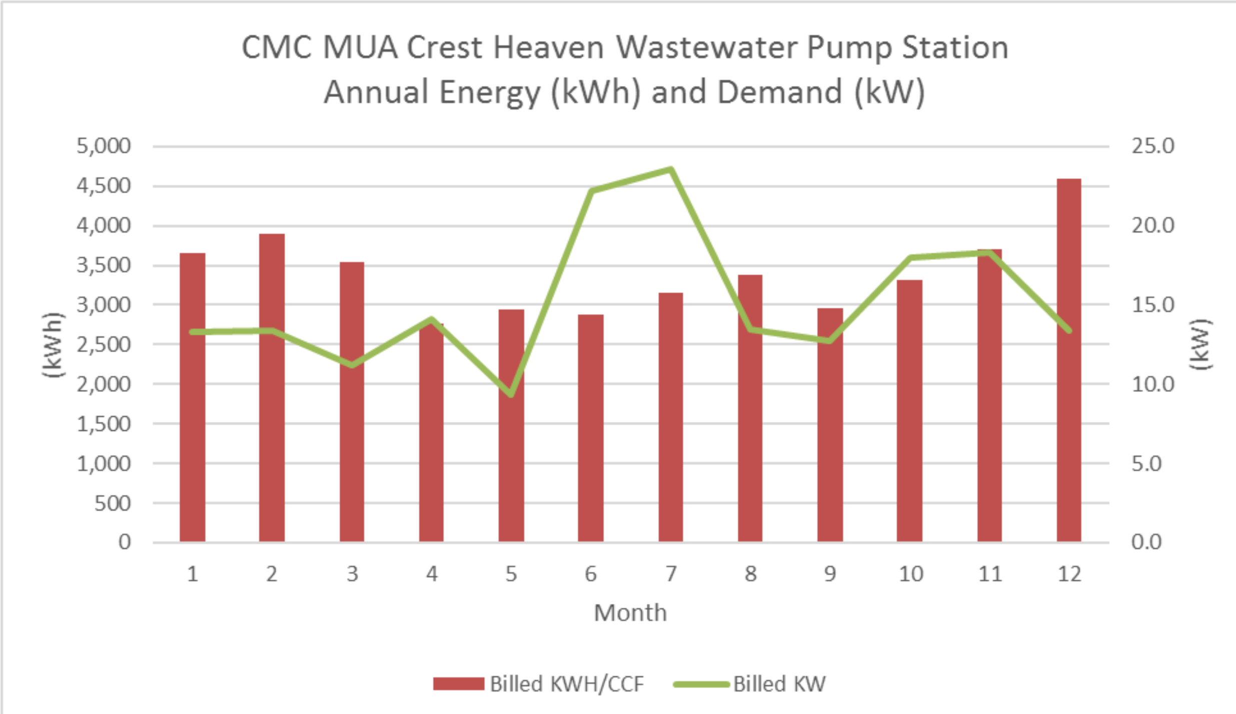


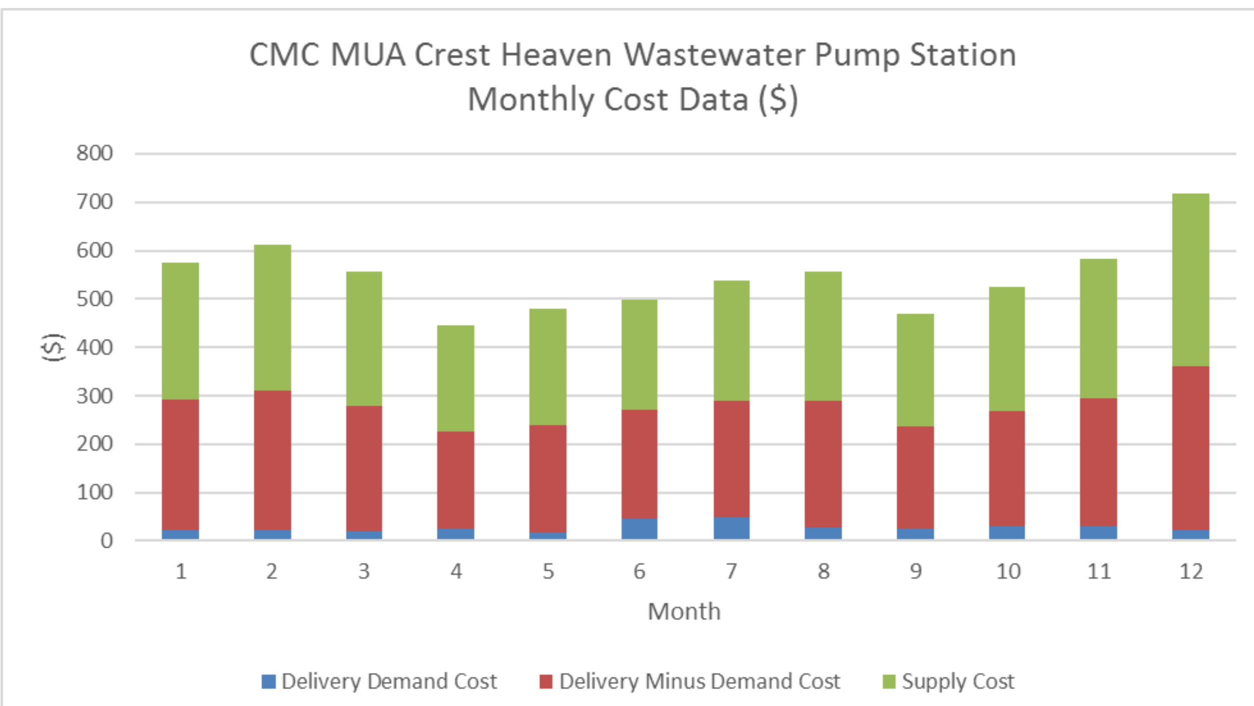
CMC MUA Crest Haven Wastewater Treatment Plan
Annual Energy (kWh) and Demand (kW)
(kWh)
(kW)
500,000
450,000
400,000
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0
900.0
800.0
700.0
600.0
500.0
400.0
300.0
200.0
100.0
0.0
1 2 3 4 5 6 7 8 9 10 11 12
Month
Billed KWH/CCF
Billed KW



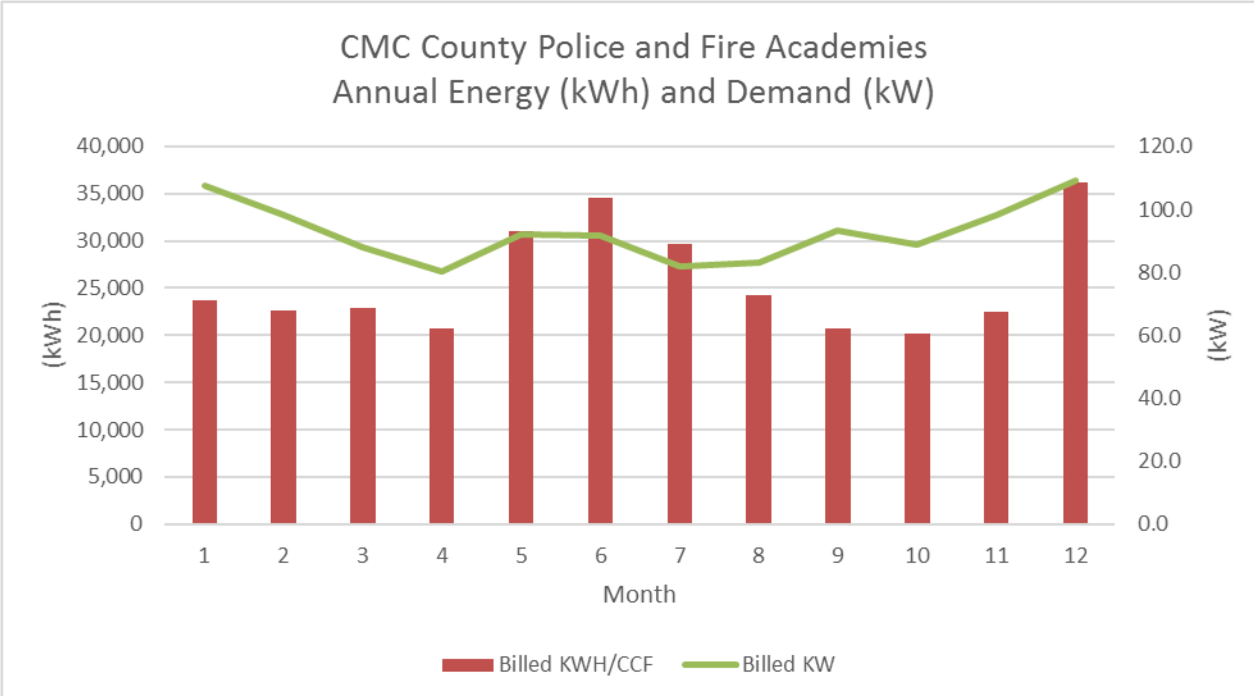
CMC MUA Crest Haven Wastewater Treatment Plan
Monthly Cost Data ($)
($)
60,000
50,000
40,000
30,000
20,000
10,000
0
1 2 3 4 5 6 7 8 9 10 11 12
Month
Delivery Demand Cost
Delivery Minus Demand Cost
Supply Cost

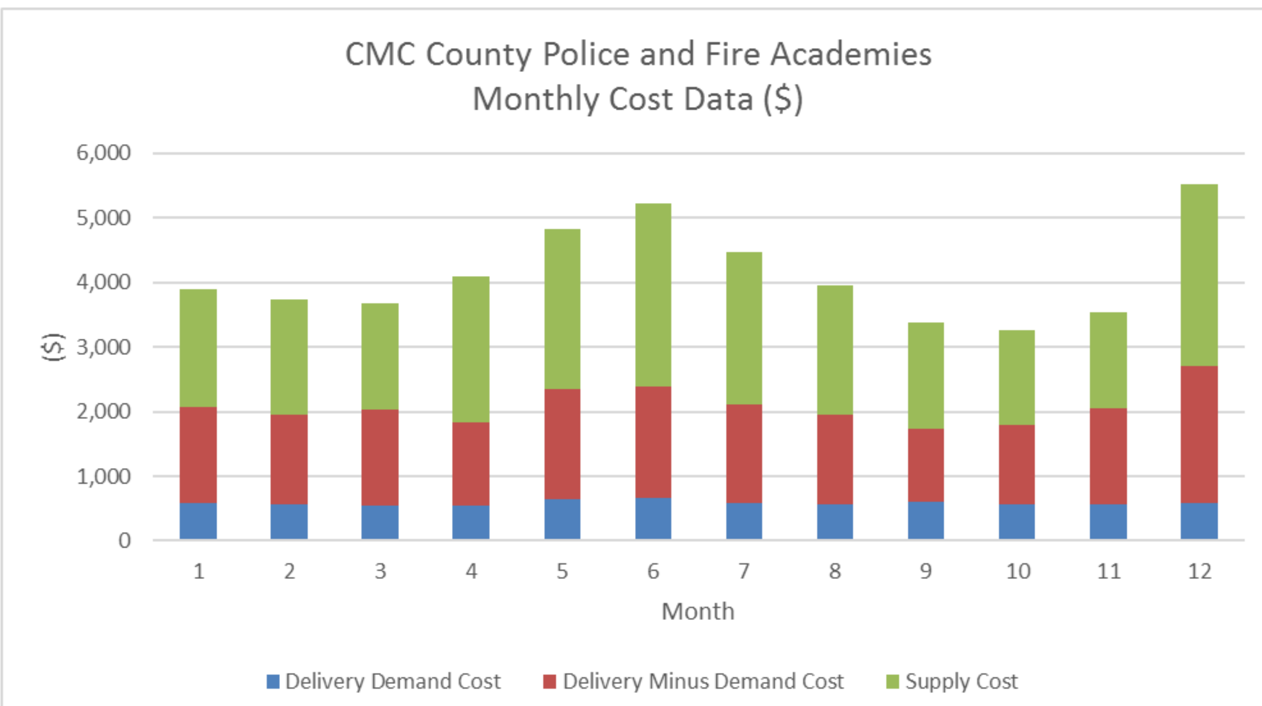
CMC MUA Crest Heaven Wastewater Pump Station									
Month	Billed KWH/CCF (kWh)	Billed KW (kW)	Measured KW (kW)	Delta kW (kW)	Delivery Cost ($)	Delivery Demand Cost ($)	Delivery Minus Demand Cost ($)	Supply Cost ($)	Total Cost ($)
1	3,648	13.3	13.3	0.0	293	23	270	283	576
2	3,898	13.4	13.4	0.0	311	23	288	302	612
3	3,535	11.2	11.2	0.0	280	19	261	276	556
4	2,772	14.1	14.1	0.0	227	24	203	218	445
5	2,940	9.3	9.3	0.0	239	16	223	241	480
6	2,880	22.2	22.2	0.0	270	46	224	228	499
7	3,149	23.6	23.6	0.0	290	49	241	247	537
8	3,377	13.5	13.5	0.0	290	28	262	265	555
9	2,955	12.7	12.7	0.0	237	26	211	232	469
10	3,312	18.0	18.0	0.0	267	31	237	259	526
11	3,711	18.3	18.3	0.0	295	31	264	288	583
12	4,592	13.4	13.4	0.0	362	23	339	355	718
	40,769	23.6	23.6	0.0	3,361	338	3,023	3,196	6,557


CMC MUA Crest Heaven Wastewater Pump Station
Annual Energy (kWh) and Demand (kW)
(kWh)
(kW)
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
25.0
20.0
15.0
10.0
5.0
0.0
1 2 3 4 5 6 7 8 9 10 11 12
Month
Billed KWH/CCF
Billed KW

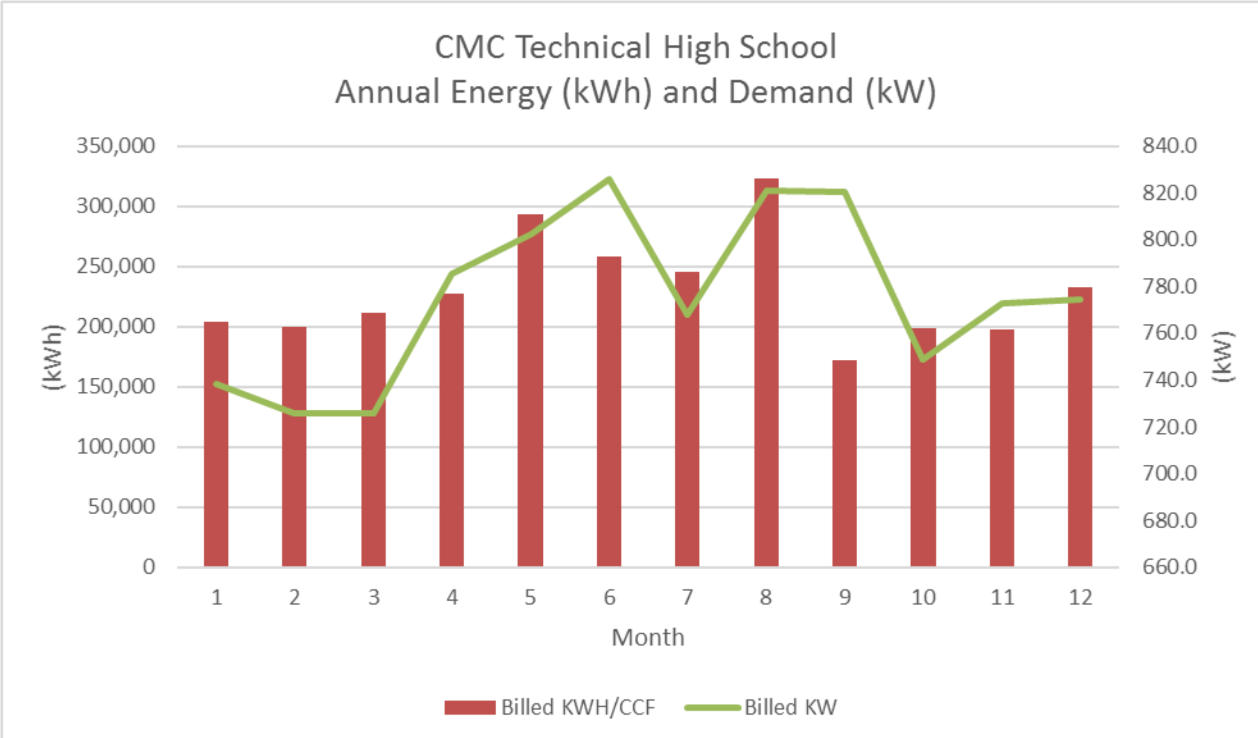

CMC MUA Crest Heaven Wastewater Pump Station
Monthly Cost Data ($)
($)
800
700
600
500
400
300
200
100
0
1 2 3 4 5 6 7 8 9 10 11 12
Month
Delivery Demand Cost
Delivery Minus Demand Cost
Supply Cost

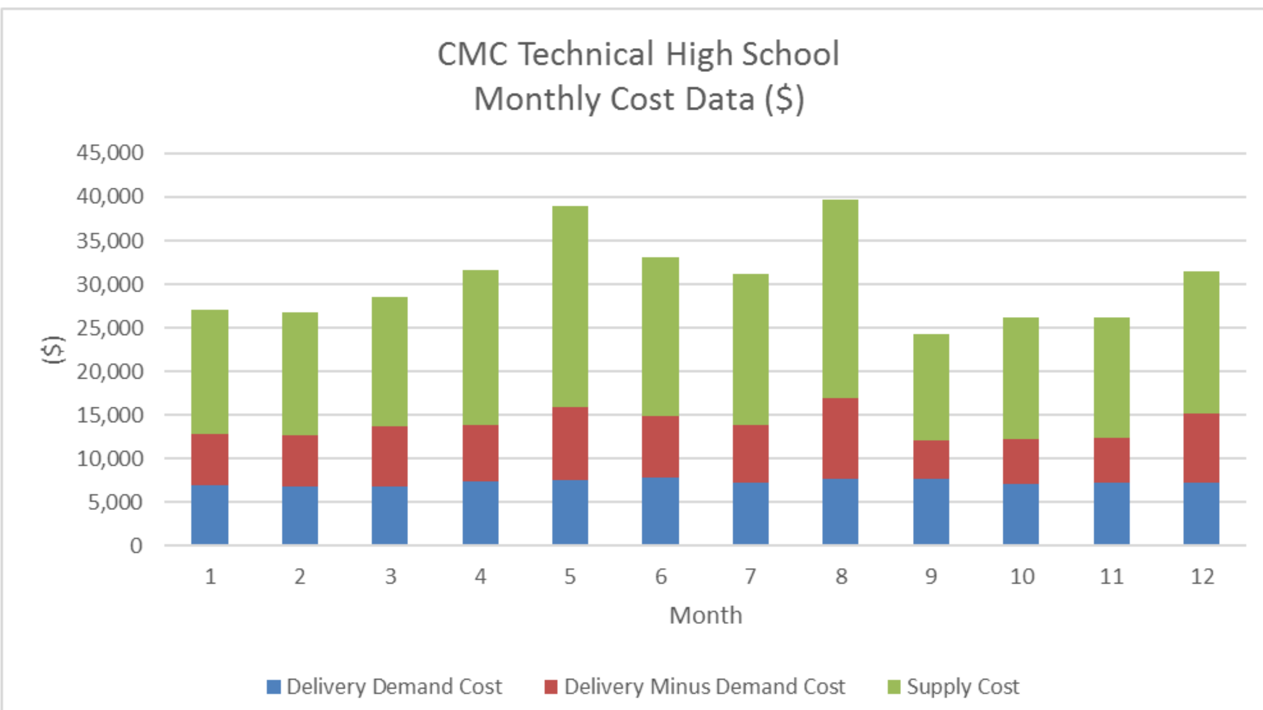
CMC County Police and Fire Academies									
Month	Billed KWH/CCF (kWh)	Billed KW (kW)	Measured KW (kW)	Delta kW (kW)	Delivery Cost ($)	Delivery Demand Cost ($)	Delivery Minus Demand Cost ($)	Supply Cost ($)	Total Cost ($)
1	23,724	107.4	96.9	10.5	2,073	587	1,486	1,815	3,888
2	22,627	98.3	83.3	15.0	1,944	572	1,372	1,793	3,737
3	22,918	87.9	77.6	10.4	2,033	554	1,479	1,642	3,675
4	20,710	80.3	77.3	3.1	1,831	541	1,290	2,266	4,097
5	31,044	92.2	92.2	0.0	2,341	641	1,700	2,488	4,829
6	34,620	91.8	91.8	0.0	2,393	671	1,722	2,826	5,219
7	29,716	81.9	81.9	0.0	2,114	589	1,525	2,353	4,467
8	24,181	83.3	83.3	0.0	1,960	567	1,393	1,994	3,954
9	20,689	93.2	93.2	0.0	1,737	606	1,131	1,634	3,371
10	20,218	88.6	79.0	9.6	1,787	555	1,232	1,475	3,262
11	22,438	98.3	84.2	14.2	2,045	572	1,473	1,497	3,542
12	36,128	109.0	108.0	1.0	2,706	590	2,116	2,808	5,514
	309,013	109.0	108.0	15.0	24,964	7,044	17,919	24,593	49,556


CMC County Police and Fire Academies
Annual Energy (kWh) and Demand (kW)
(kWh)
(kW)
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
1 2 3 4 5 6 7 8 9 10 11 12
Month
Billed KWH/CCF
Billed KW

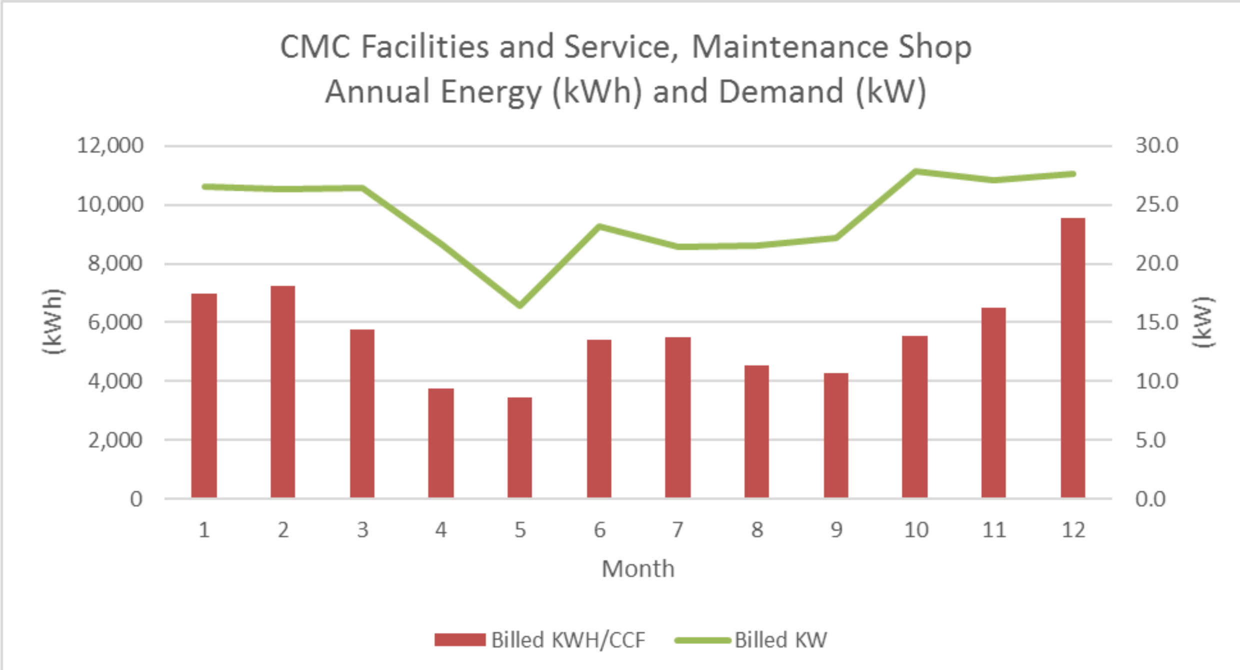

CMC County Police and Fire Academies
Monthly Cost Data ($)
($)
6,000
5,000
4,000
3,000
2,000
1,000
0
1 2 3 4 5 6 7 8 9 10 11 12
Month
Delivery Demand Cost
Delivery Minus Demand Cost
Supply Cost

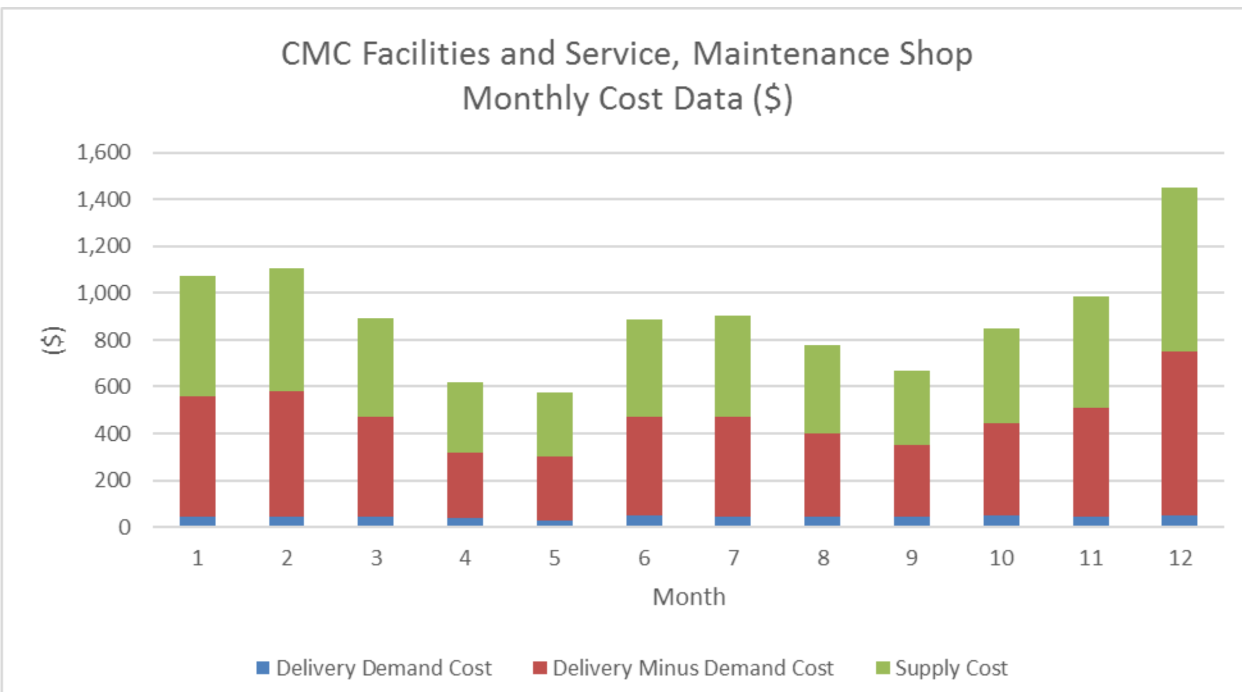
CMC Technical High School									
Month	Billed KWH/CCF (kWh)	Billed KW (kW)	Measured KW (kW)	Delta kW (kW)	Delivery Cost ($)	Delivery Demand Cost ($)	Delivery Minus Demand Cost ($)	Supply Cost ($)	Total Cost ($)
1	203,532	738.2	656.0	82.2	12,838	6,969	5,869	14,301	27,139
2	199,908	725.8	670.8	55.0	12,743	6,851	5,892	14,046	26,790
3	211,063	725.8	667.6	58.2	13,639	6,851	6,787	14,830	28,469
4	227,277	785.4	774.4	11.0	13,809	7,415	6,394	17,844	31,652
5	293,817	802.4	802.4	0.0	15,959	7,575	8,385	23,068	39,027
6	258,657	826.2	826.2	0.0	14,910	7,799	7,110	18,219	33,129
7	245,691	768.0	729.0	39.0	13,820	7,250	6,570	17,305	31,125
8	323,379	820.8	820.8	0.0	16,945	7,748	9,196	22,779	39,723
9	172,007	820.4	820.4	0.0	12,121	7,745	4,376	12,114	24,235
10	198,553	748.8	732.2	16.6	12,226	7,069	5,157	13,983	26,210
11	197,430	772.6	701.0	71.6	12,329	7,294	5,035	13,904	26,233
12	232,542	774.2	703.6	70.6	15,151	7,309	7,842	16,339	31,489
	2,763,856	826.2	826.2	82.2	166,490	87,874	78,616	198,731	365,221


CMC Technical High School
Annual Energy (kWh) and Demand (kW)
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0
(kWh)
840.0
820.0
800.0
780.0
760.0
740.0
720.0
700.0
680.0
660.0
(kW)
1
2
3
4
5
6
7
8
9
10
11
12
Month
Billed KWH/CCF
Billed KW

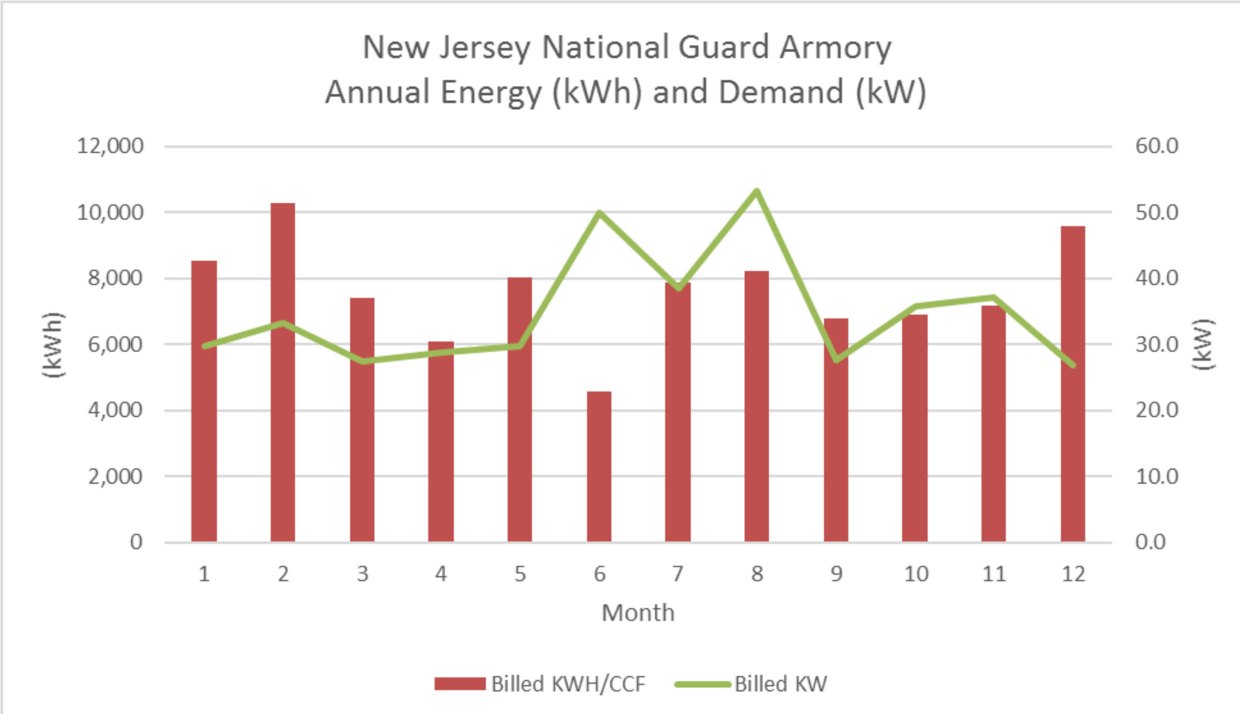

CMC Technical High School
Monthly Cost Data ($)
45,000
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
($)
1
2
3
4
5
6
7
8
9
10
11
12
Month
Delivery Demand Cost
Delivery Minus Demand Cost
Supply Cost

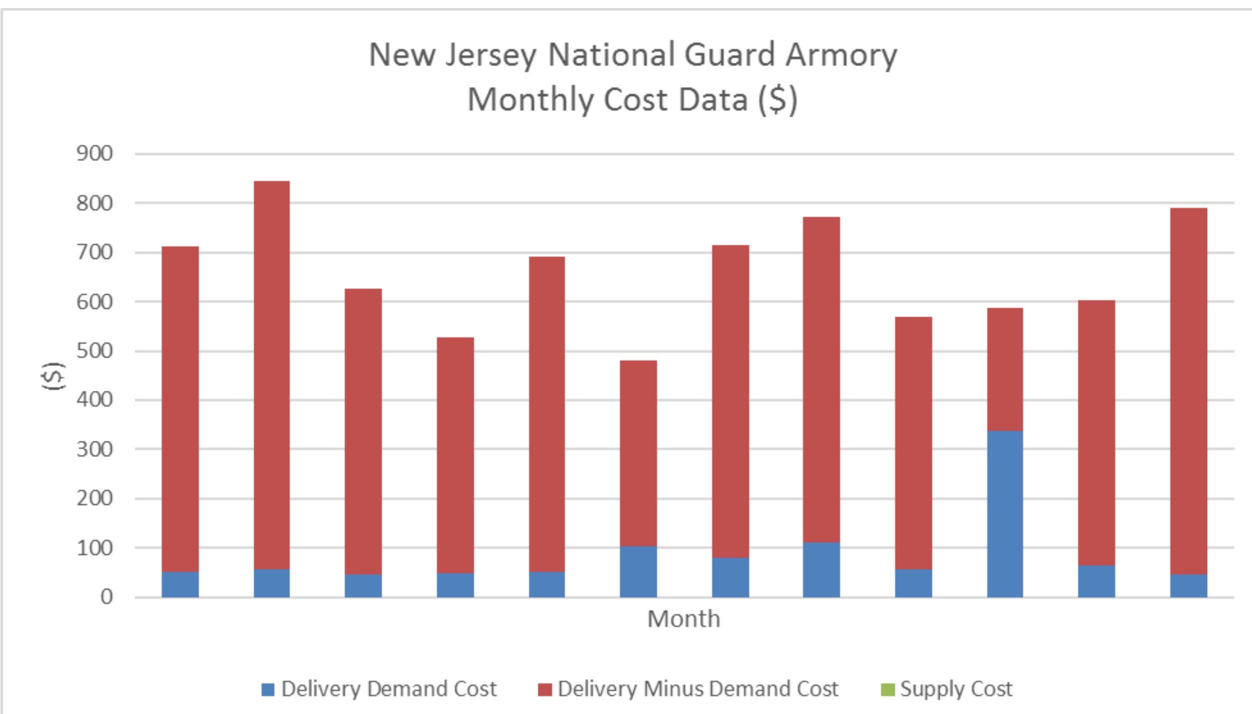
CMC Facilities and Service, Maintenance Shop									
Month	Billed KWH/CCF (kWh)	Billed KW (kW)	Measured KW (kW)	Delta kW (kW)	Delivery Cost ($)	Delivery Demand Cost ($)	Delivery Minus Demand Cost ($)	Supply Cost ($)	Total Cost ($)
1	6,974	26.6	26.6	0.0	561	45	516	512	1,073
2	7,227	26.3	26.3	0.0	579	45	534	530	1,109
3	5,759	26.4	26.4	0.0	473	45	428	423	895
4	3,774	21.6	21.6	0.0	317	37	280	304	621
5	3,451	16.4	16.4	0.0	300	28	272	278	578
6	5,401	23.2	23.2	0.0	469	48	421	420	889
7	5,493	21.4	21.4	0.0	469	44	425	436	905
8	4,551	21.5	21.5	0.0	401	45	357	374	776
9	4,272	22.2	22.2	0.0	353	46	307	314	667
10	5,536	27.9	27.9	0.0	445	47	397	407	852
11	6,484	27.1	27.1	0.0	508	46	462	477	985
12	9,571	27.6	27.6	0.0	751	47	705	702	1,454
	68,493	27.9	27.9	0.0	5,627	523	5,104	5,177	10,804


CMC Facilities and Service, Maintenance Shop
Annual Energy (kWh) and Demand (kW)
(kWh)
(kW)
12,000
10,000
8,000
6,000
4,000
2,000
0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
1 2 3 4 5 6 7 8 9 10 11 12
Month
Billed KWH/CCF
Billed KW


CMC Facilities and Service, Maintenance Shop
Monthly Cost Data ($)
($)
1,600
1,400
1,200
1,000
800
600
400
200
0
1 2 3 4 5 6 7 8 9 10 11 12
Month
Delivery Demand Cost
Delivery Minus Demand Cost
Supply Cost

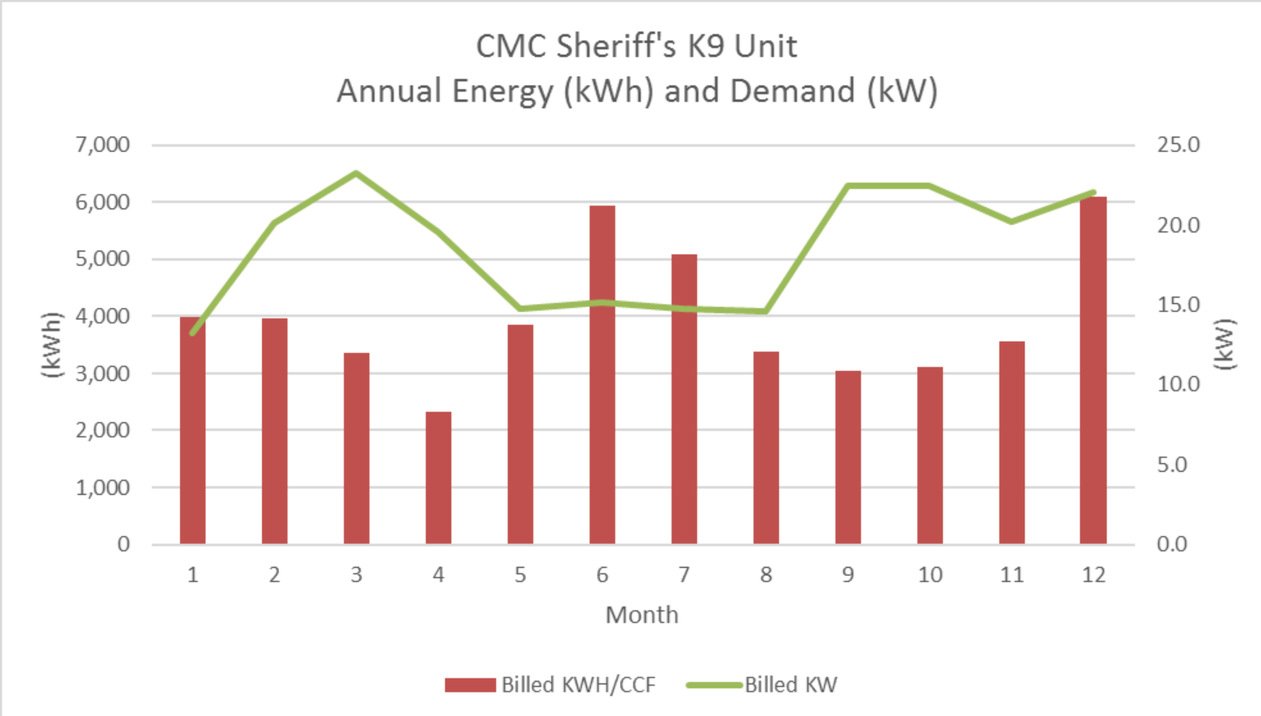
New Jersey National Guard Armory									
Month	Billed KWH/CCF (kWh)	Billed KW (kW)	Measured KW (kW)	Delta kW (kW)	Delivery Cost ($)	Delivery Demand Cost ($)	Delivery Minus Demand Cost ($)	Supply Cost ($)	Total Cost ($)
1	8,534	29.7	29.7	0.0	712	50	662	0	712
2	10,296	33.2	33.2	0.0	846	56	790	0	846
3	7,412	27.5	27.5	0.0	627	47	580	0	627
4	6,109	28.9	28.9	0.0	528	49	478	0	528
5	8,049	29.8	29.8	0.0	692	51	641	0	692
6	4,585	50.0	50.0	0.0	479	104	376	0	479
7	7,883	38.5	38.5	0.0	714	80	634	0	714
8	8,240	53.3	53.3	0.0	773	110	663	0	773
9	6,798	27.6	27.6	0.0	570	57	513	0	570
10	6,900	35.8	35.8	0.0	586	338	248	0	586
11	7,198	37.1	37.1	0.0	603	63	540	0	603
12	9,606	26.8	26.8	0.0	791	46	746	0	791
	91,610	53.3	53.3	0.0	7,921	1,051	6,871	0	7,921

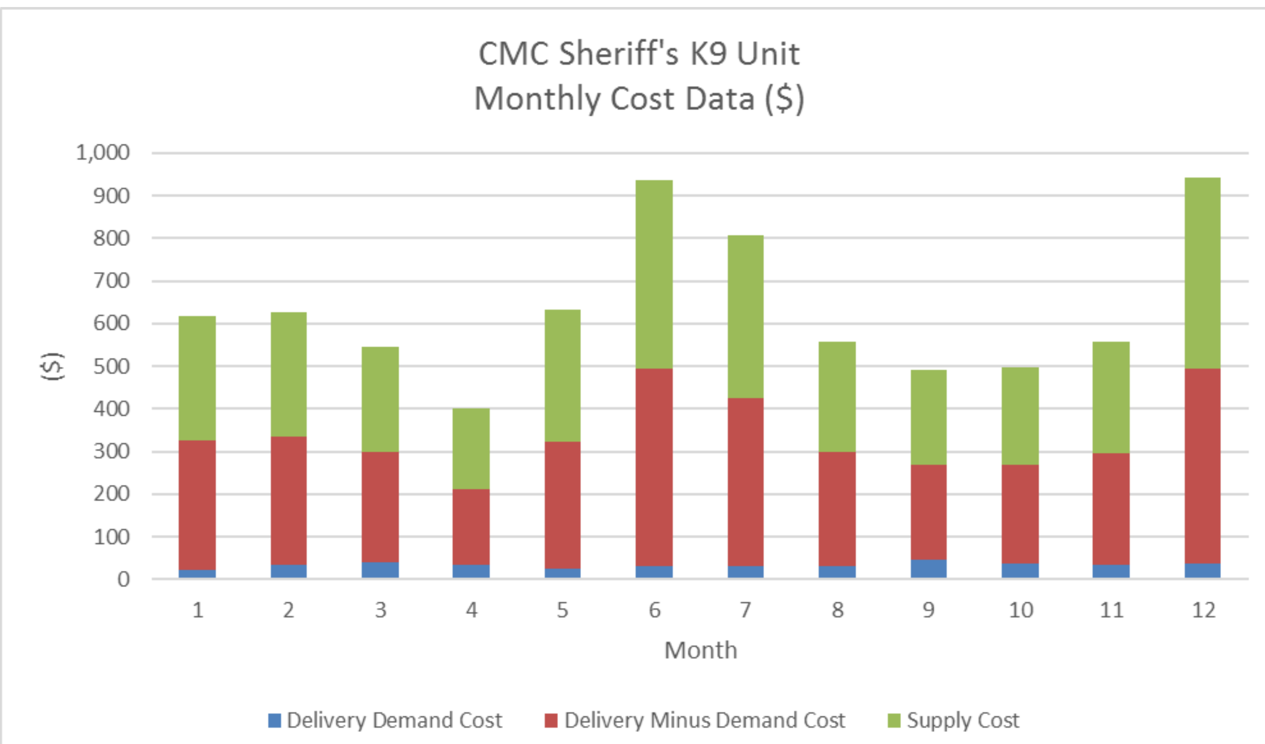

New Jersey National Guard Armory
Annual Energy (kWh) and Demand (kW)
12,000
10,000
8,000
6,000
4,000
2,000
0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
(kWh)
(kW)
1 2 3 4 5 6 7 8 9 10 11 12
Month
Billed KWH/CCF
Billed KW


New Jersey National Guard Armory
Monthly Cost Data ($)
900
800
700
600
500
400
300
200
100
0
($)
Month
Delivery Demand Cost
Delivery Minus Demand Cost
Supply Cost

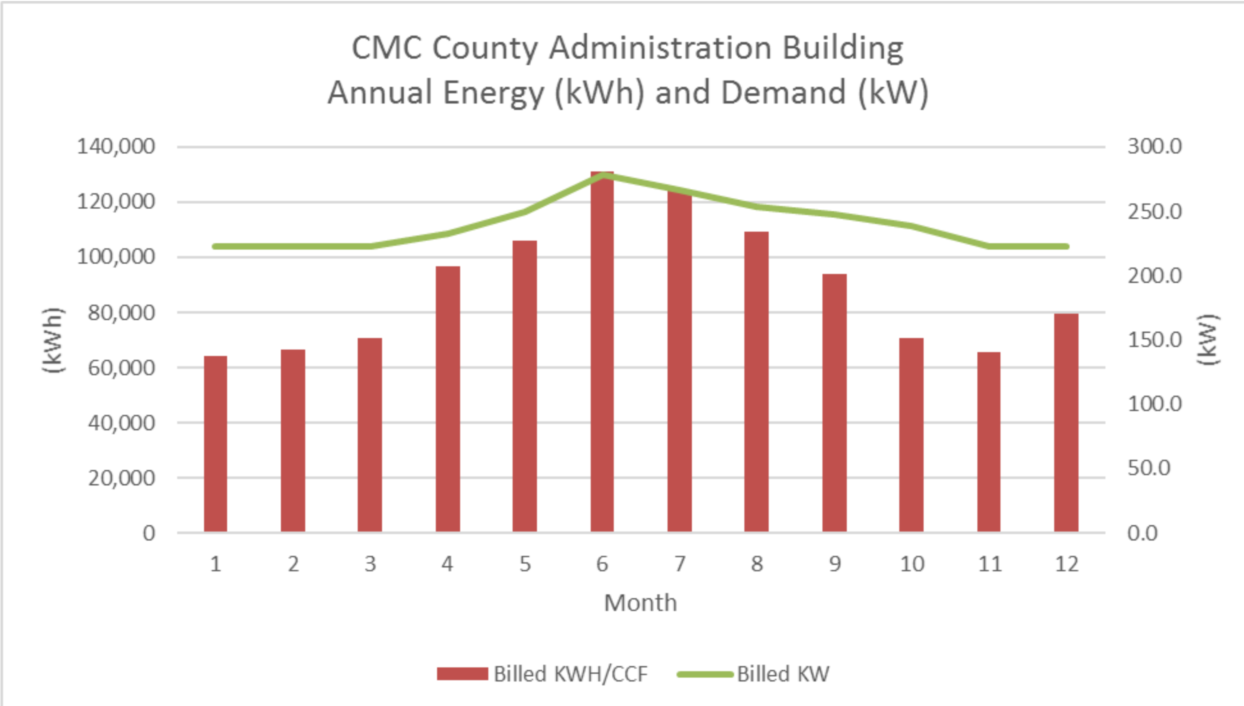
CMC Sheriff's K9 Unit

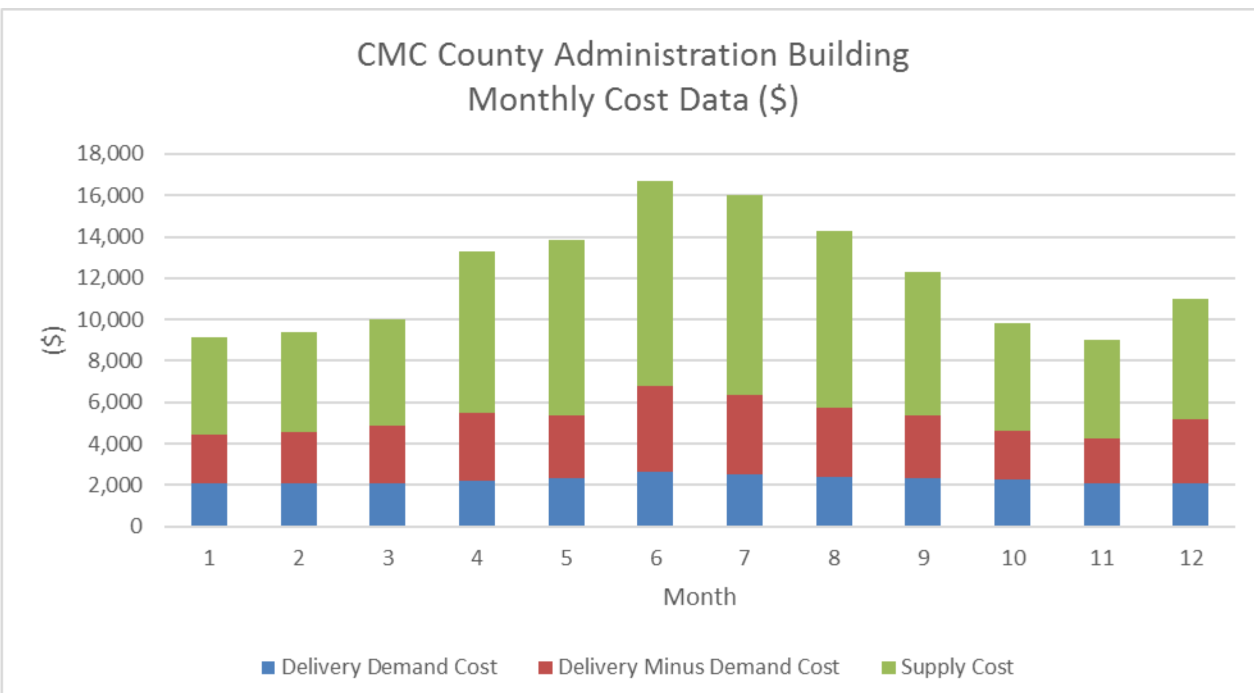
Month	Billed KWH/CCF (kWh)	Billed KW (kW)	Measured KW (kW)	Delta kW (kW)	Delivery Cost ($)	Delivery Demand Cost ($)	Delivery Minus Demand Cost ($)	Supply Cost ($)	Total Cost ($)
1	3,985	13.2	13.2	0.0	325	22	303	292	617
2	3,966	20.1	20.1	0.0	335	34	301	291	626
3	3,358	23.3	23.3	0.0	298	40	259	246	545
4	2,325	19.6	19.6	0.0	212	33	179	187	400
5	3,844	14.8	14.8	0.0	324	25	299	310	634
6	5,940	15.2	15.2	0.0	494	31	462	442	936
7	5,091	14.8	14.8	0.0	426	31	395	381	807
8	3,383	14.6	14.6	0.0	299	30	269	257	556
9	3,041	22.5	22.5	0.0	268	47	221	224	492
10	3,113	22.5	22.5	0.0	270	38	231	229	498
11	3,564	20.2	20.2	0.0	297	34	262	262	559
12	6,105	22.1	22.1	0.0	496	38	458	448	944
	47,715	23.3	23.3	0.0	4,044	404	3,640	3,570	7,614


CMC Sheriff's K9 Unit
Annual Energy (kWh) and Demand (kW)
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
(kWh)
25.0
20.0
15.0
10.0
5.0
0.0
(kW)
1
2
3
4
5
6
7
8
9
10
11
12
Month
Billed KWH/CCF
Billed KW

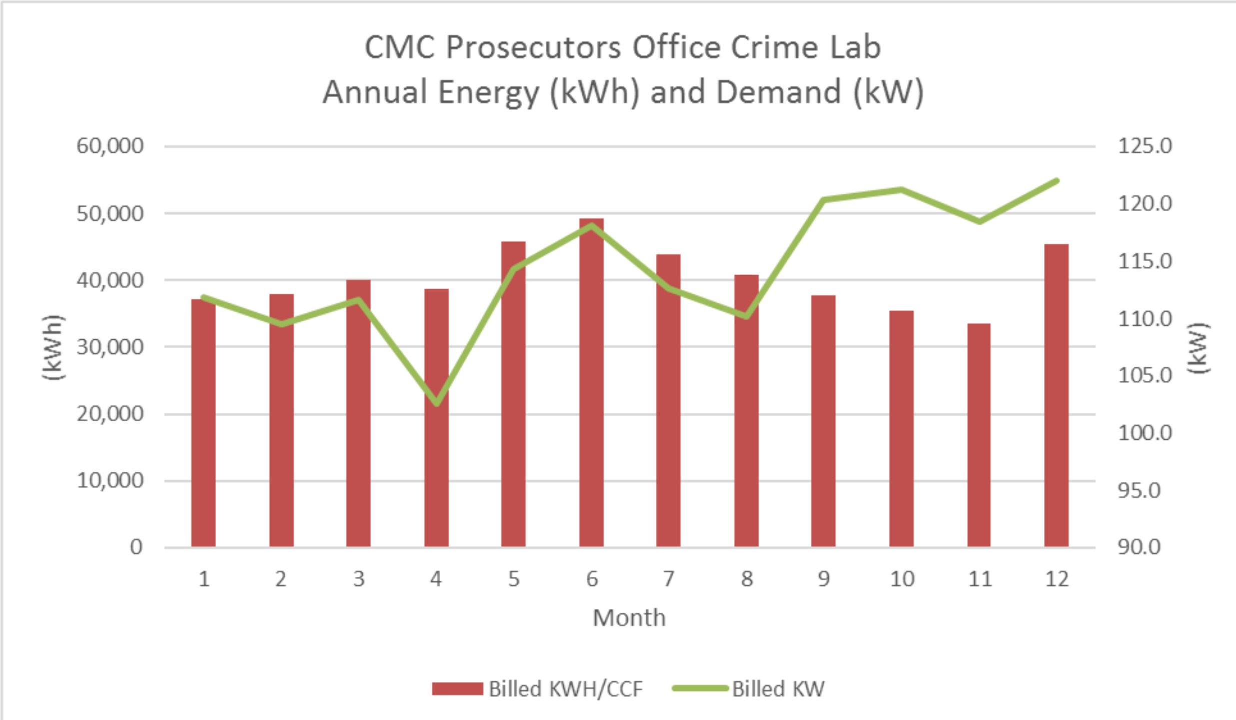

CMC Sheriff's K9 Unit
Monthly Cost Data ($)
1,000
900
800
700
600
500
400
300
200
100
0
($)
1
2
3
4
5
6
7
8
9
10
11
12
Month
Delivery Demand Cost
Delivery Minus Demand Cost
Supply Cost

CMC County Administration Building									
Month	Billed KWH/CCF (kWh)	Billed KW (kW)	Measured KW (kW)	Delta kW (kW)	Delivery Cost ($)	Delivery Demand Cost ($)	Delivery Minus Demand Cost ($)	Supply Cost ($)	Total Cost ($)
1	64,385	222.8	160.9	61.8	4,415	2,103	2,312	4,704	9,119
2	66,540	222.8	157.3	65.4	4,536	2,103	2,433	4,863	9,399
3	70,688	222.8	202.5	20.3	4,850	2,103	2,747	5,169	10,018
4	96,504	232.6	232.6	0.0	5,520	2,195	3,325	7,759	13,279
5	105,853	249.1	249.1	0.0	5,360	2,352	3,008	8,514	13,874
6	130,958	278.5	278.5	0.0	6,781	2,629	4,152	9,916	16,697
7	124,455	266.8	266.8	0.0	6,364	2,518	3,846	9,617	15,981
8	109,271	253.4	253.4	0.0	5,741	2,392	3,349	8,522	14,263
9	93,950	247.3	247.3	0.0	5,391	2,335	3,057	6,895	12,286
10	70,680	238.7	238.7	0.0	4,642	2,253	2,389	5,177	9,820
11	65,519	222.8	153.4	69.4	4,231	2,103	2,128	4,798	9,029
12	79,486	222.8	179.5	43.3	5,176	2,103	3,073	5,808	10,985
	1,078,289	278.5	278.5	69.4	63,008	27,189	35,819	81,742	144,750

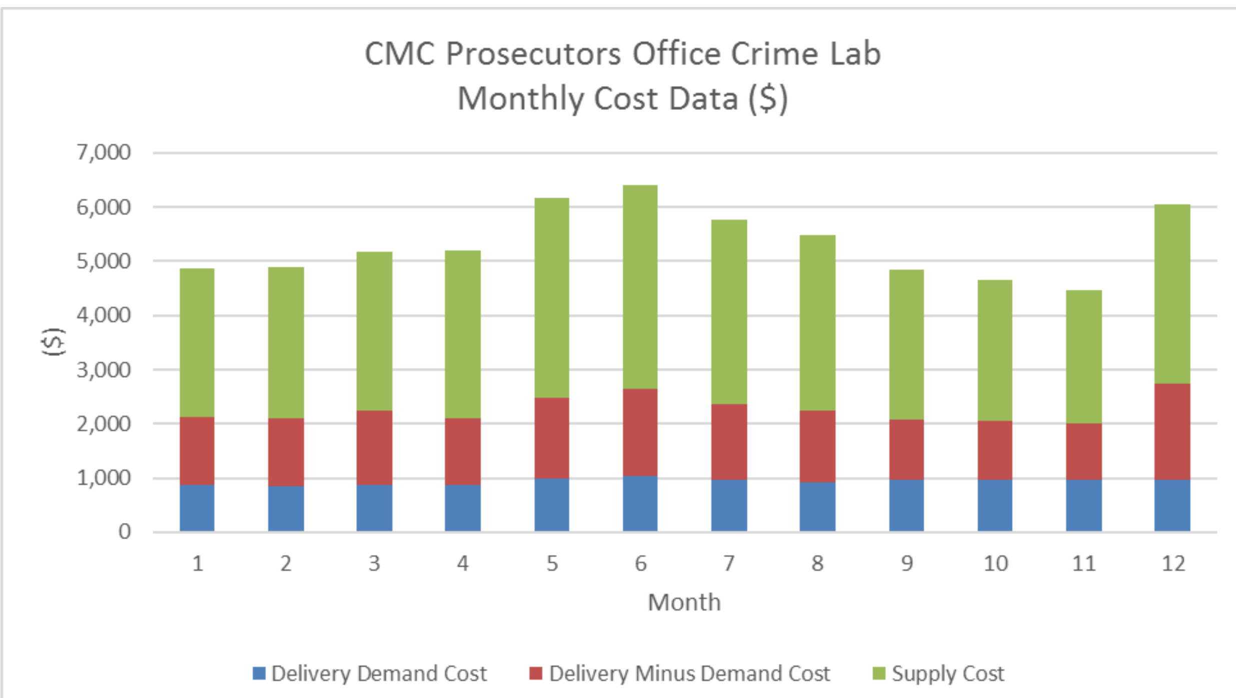

CMC County Administration Building
Annual Energy (kWh) and Demand (kW)
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
(kWh)
300.0
250.0
200.0
150.0
100.0
50.0
0.0
(kW)
1 2 3 4 5 6 7 8 9 10 11 12
Month
Billed KWH/CCF
Billed KW


CMC County Administration Building
Monthly Cost Data ($)
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
($)
1 2 3 4 5 6 7 8 9 10 11 12
Month
Delivery Demand Cost
Delivery Minus Demand Cost
Supply Cost

CMC Prosecutors Office Crime Lab									
Month	Billed KWH/CCF (kWh)	Billed KW (kW)	Measured KW (kW)	Delta kW (kW)	Delivery Cost ($)	Delivery Demand Cost ($)	Delivery Minus Demand Cost ($)	Supply Cost ($)	Total Cost ($)
1	37,232	111.9	111.9	0.0	2,131	884	1,248	2,732	4,863
2	37,891	109.5	106.0	3.5	2,114	845	1,269	2,780	4,894
3	39,990	111.6	111.6	0.0	2,238	871	1,367	2,934	5,172
4	38,604	102.6	102.6	0.0	2,093	880	1,213	3,113	5,206
5	45,867	114.3	114.3	0.0	2,479	987	1,492	3,698	6,178
6	49,170	118.1	118.1	0.0	2,648	1,029	1,620	3,748	6,396
7	43,896	112.6	112.6	0.0	2,361	976	1,385	3,409	5,771
8	40,739	110.2	110.2	0.0	2,252	912	1,340	3,223	5,475
9	37,728	120.3	120.3	0.0	2,073	968	1,104	2,775	4,847
10	35,396	121.2	121.2	0.0	2,052	961	1,090	2,603	4,655
11	33,596	118.5	118.5	0.0	2,007	957	1,050	2,471	4,477
12	45,323	122.0	122.0	0.0	2,737	963	1,774	3,325	6,062
	485,432	122.0	122.0	3.5	27,186	11,233	15,953	36,810	63,996

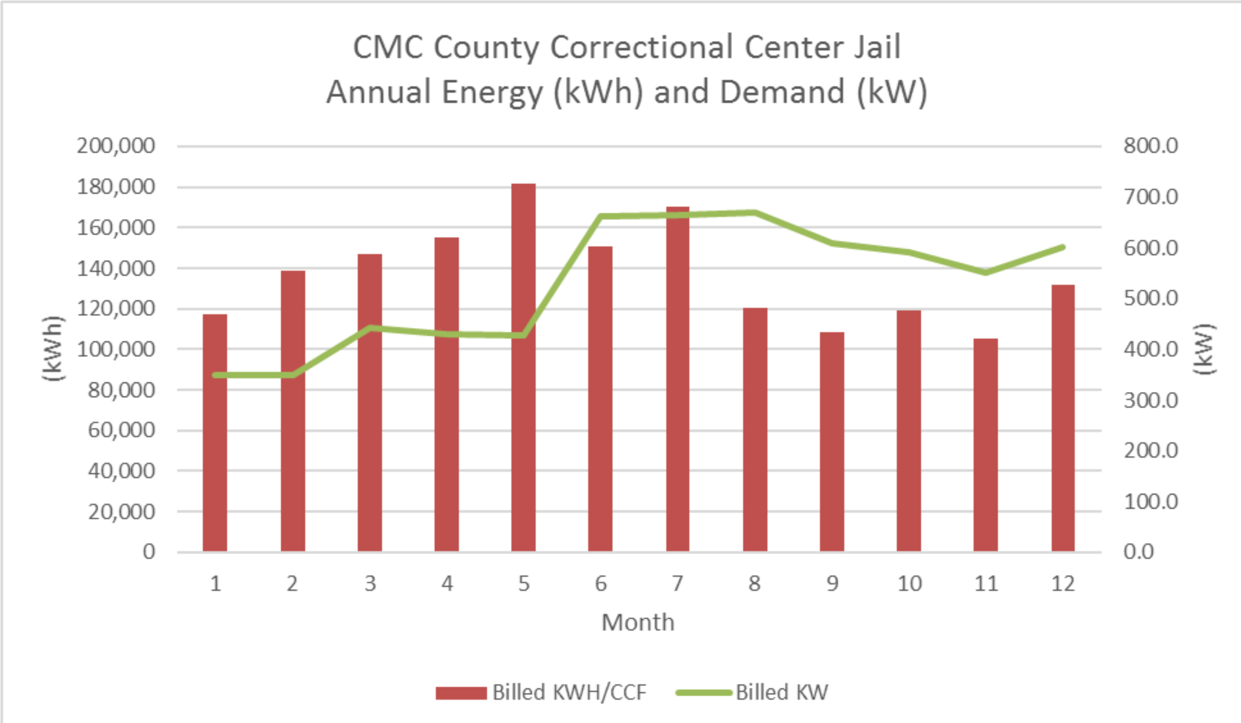


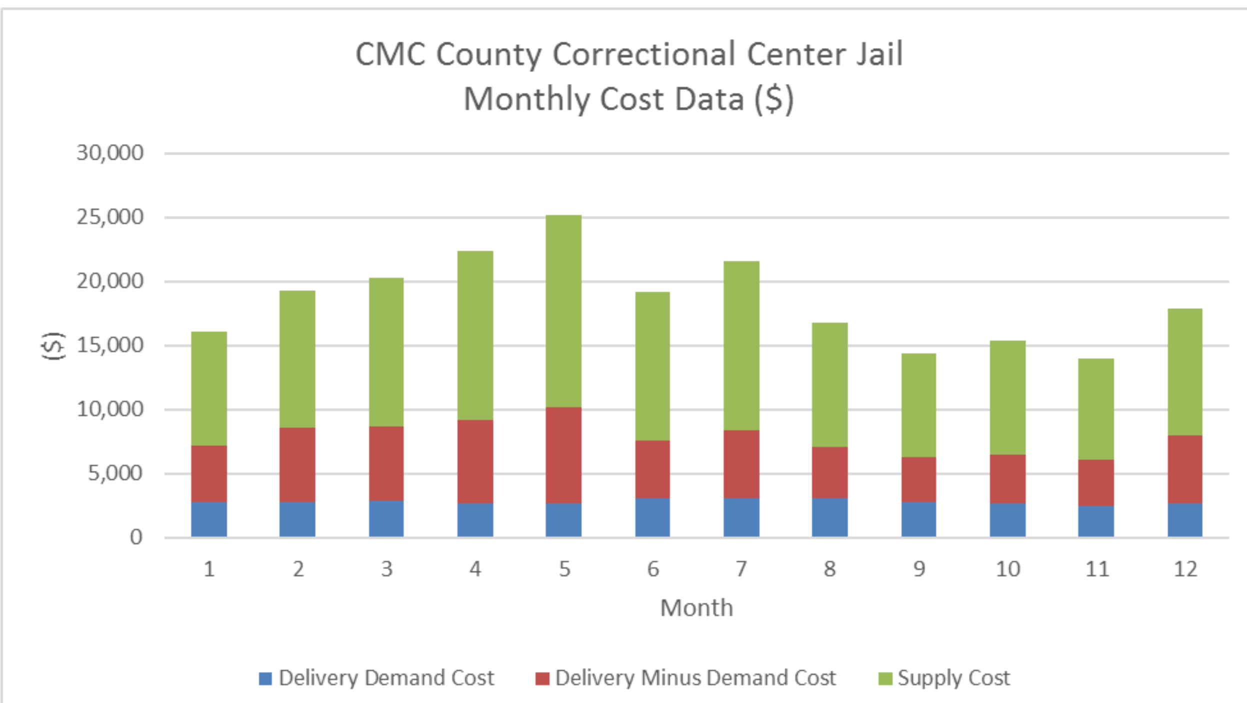
CMC Prosecutors Office Crime Lab
Annual Energy (kWh) and Demand (kW)
60,000
50,000
40,000
30,000
20,000
10,000
0
(kWh)
125.0
120.0
115.0
110.0
105.0
100.0
95.0
90.0
(kW)
1 2 3 4 5 6 7 8 9 10 11 12
Month
Billed KWH/CCF
Billed KW



CMC Prosecutors Office Crime Lab
Monthly Cost Data ($)
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
($)
1 2 3 4 5 6 7 8 9 10 11 12
Month
Delivery Demand Cost
Delivery Minus Demand Cost
Supply Cost

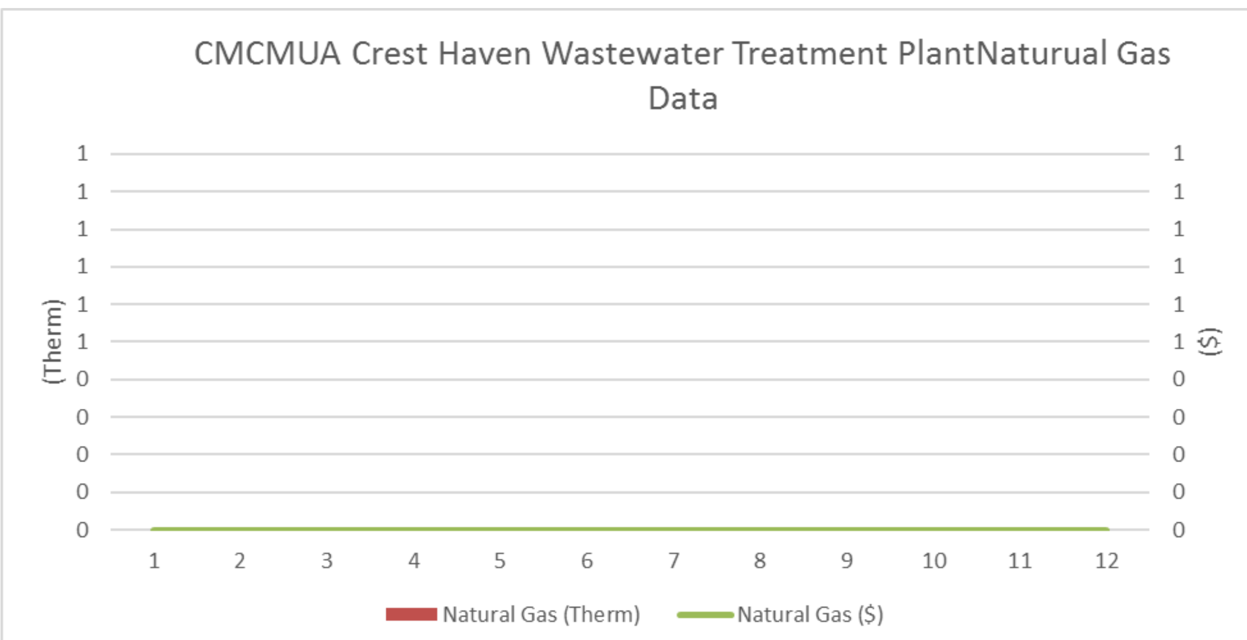
CMC County Correctional Center Jail									
Month	Billed KWH/CCF (kWh)	Billed KW (kW)	Measured KW (kW)	Delta kW (kW)	Delivery Cost ($)	Delivery Demand Cost ($)	Delivery Minus Demand Cost ($)	Supply Cost ($)	Total Cost ($)
1	117,015	349.4	349.4	0.0	7,152	2,755	4,397	8,910	16,062
2	138,968	349.4	349.4	0.0	8,561	2,755	5,806	10,747	19,309
3	147,214	443.4	443.4	0.0	8,729	2,915	5,814	11,544	20,272
4	155,194	429.0	424.2	4.8	9,227	2,711	6,517	13,170	22,397
5	181,615	427.0	426.2	0.8	10,138	2,707	7,431	15,032	25,170
6	150,926	661.0	341.0	0.0	7,587	3,064	4,523	11,554	19,140
7	170,490	663.4	343.4	0.0	8,408	3,069	5,338	13,207	21,614
8	120,142	670.2	350.2	0.0	7,115	3,083	4,032	9,698	16,813
9	108,562	610.2	319.8	0.0	6,300	2,802	3,498	8,133	14,433
10	119,184	591.0	311.8	0.0	6,512	2,691	3,821	8,924	15,436
11	104,990	551.8	289.4	6.4	6,045	2,484	3,560	7,919	13,964
12	131,813	601.8	322.6	0.0	7,967	2,709	5,257	9,947	17,914
	1,646,113	670.2	443.4	6.4	93,741	33,747	59,994	128,784	222,524


CMC County Correctional Center Jail
Annual Energy (kWh) and Demand (kW)
(kWh)
200,000
180,000
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
(kW)
800.0
700.0
600.0
500.0
400.0
300.0
200.0
100.0
0.0
1 2 3 4 5 6 7 8 9 10 11 12
Month
Billed KWH/CCF
Billed KW

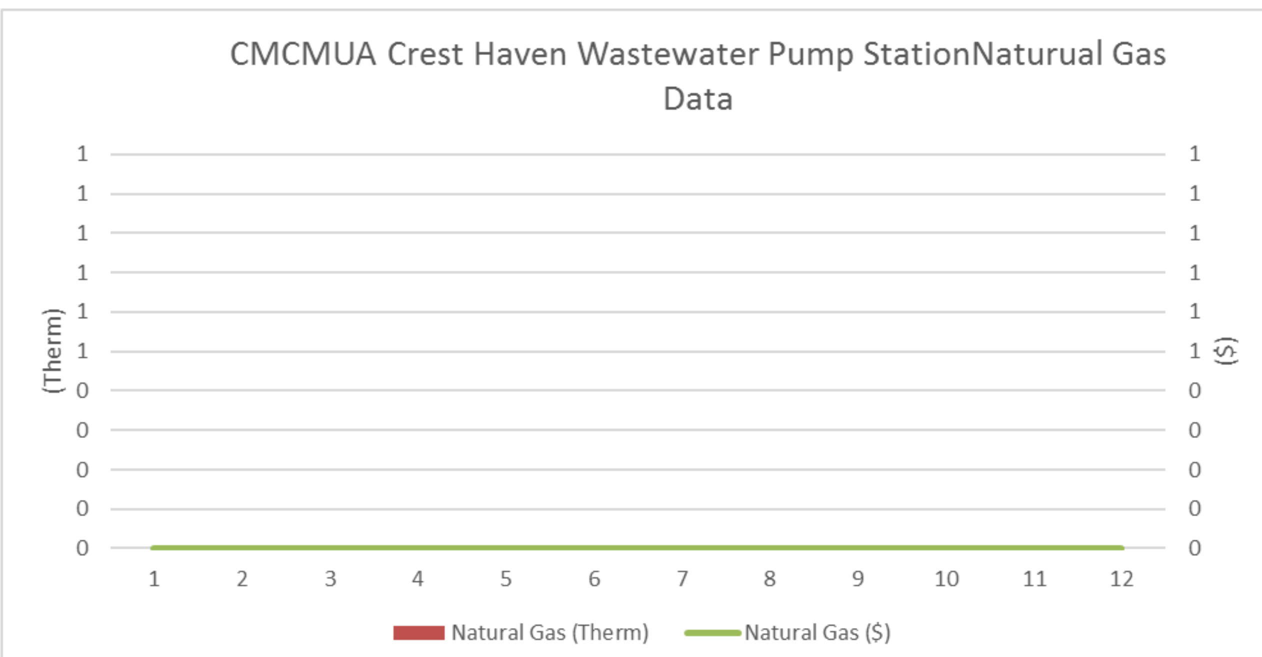

CMC County Correctional Center Jail
Monthly Cost Data ($)
($)
30,000
25,000
20,000
15,000
10,000
5,000
0
1 2 3 4 5 6 7 8 9 10 11 12
Month
Delivery Demand Cost
Delivery Minus Demand Cost
Supply Cost

APPENDIX 2. MONTHLY GAS USAGE DATA

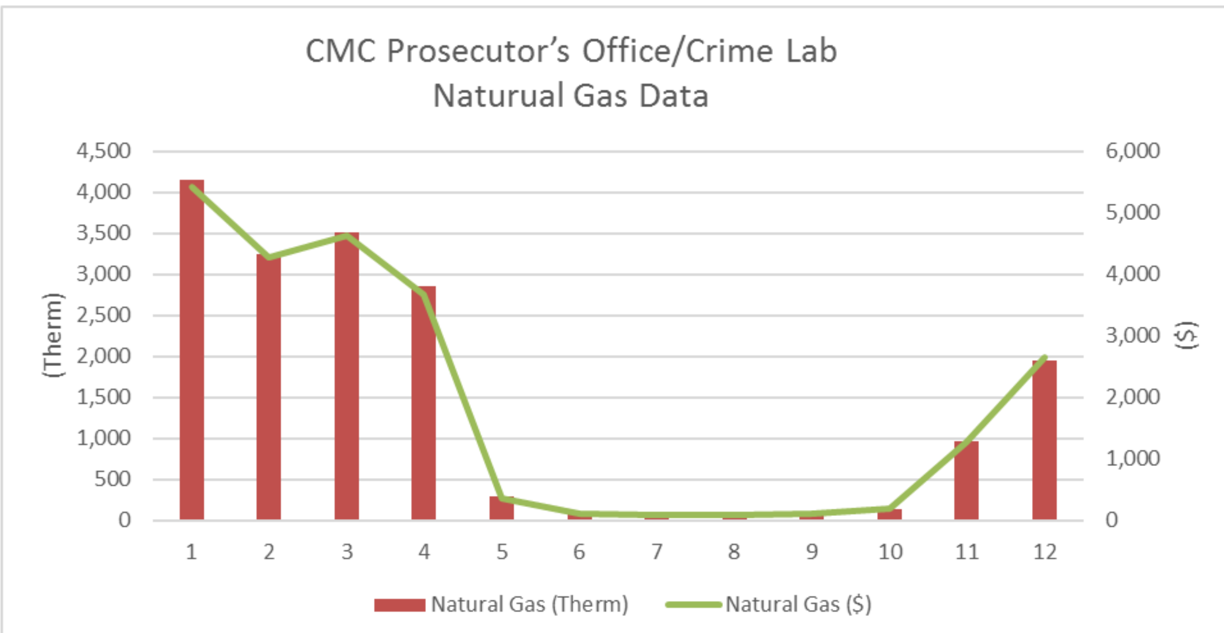
CMCMUA Crest Haven Wastewater Treatment Plant			
Month	Month	Natural Gas (Therm)	Natural Gas ($)
Jan	1	0	0
Feb	2	0	0
Mar	3	0	0
Apr	4	0	0
May	5	0	0
Jun	6	0	0
Jul	7	0	0
Aug	8	0	0
Sep	9	0	0
Oct	10	0	0
Nov	11	0	0
Dec	12	0	0
Total		0	0



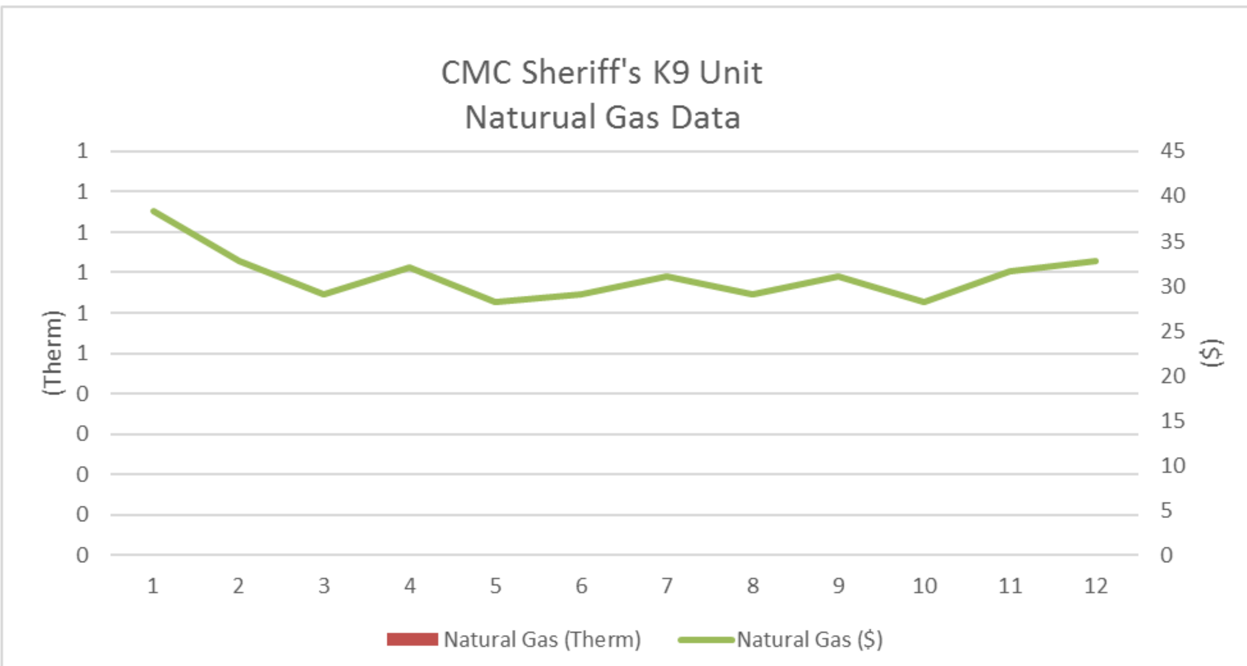
CMCMUA Crest Haven Wastewater Pump Station			
Month	Month	Natural Gas (Therm)	Natural Gas ($)
Jan	1	0	0
Feb	2	0	0
Mar	3	0	0
Apr	4	0	0
May	5	0	0
Jun	6	0	0
Jul	7	0	0
Aug	8	0	0
Sep	9	0	0
Oct	10	0	0
Nov	11	0	0
Dec	12	0	0
Total		0	0



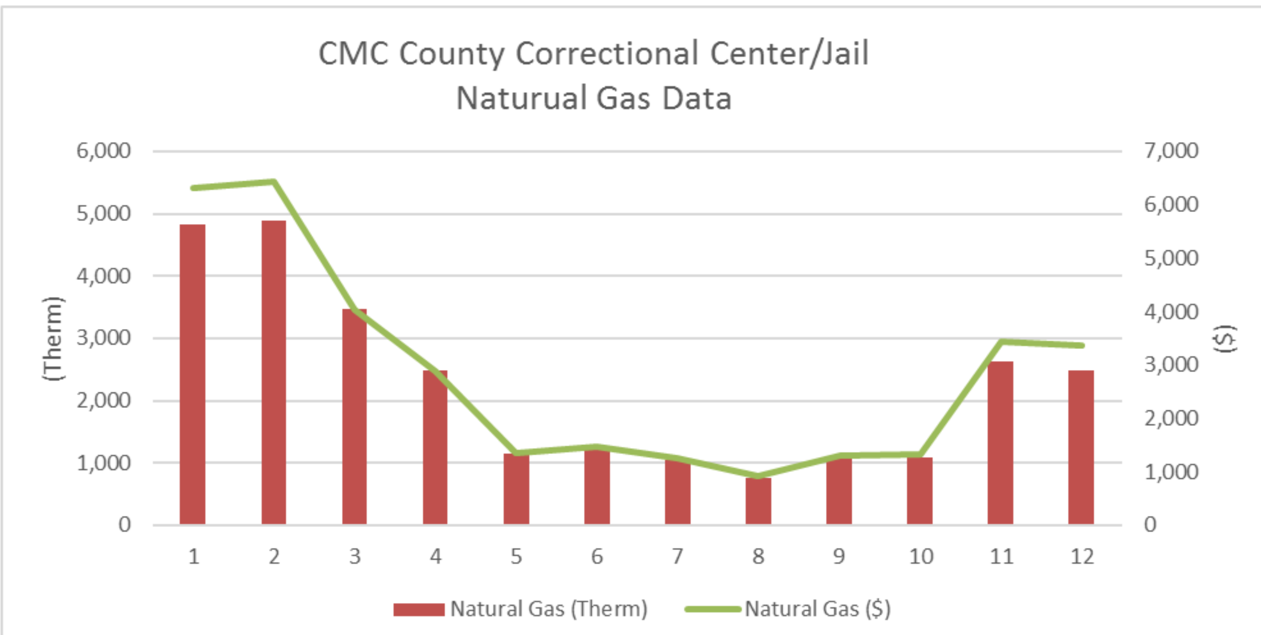
CMC Prosecutor's Office/Crime Lab			
Month	Month	Natural Gas (Therm)	Natural Gas ($)
Jan	1	4,147	5,423
Feb	2	3,246	4,282
Mar	3	3,510	4,638
Apr	4	2,865	3,683
May	5	298	371
Jun	6	82	121
Jul	7	50	89
Aug	8	51	88
Sep	9	66	110
Oct	10	138	191
Nov	11	965	1,285
Dec	12	1,958	2,656
Total		17,376	22,936



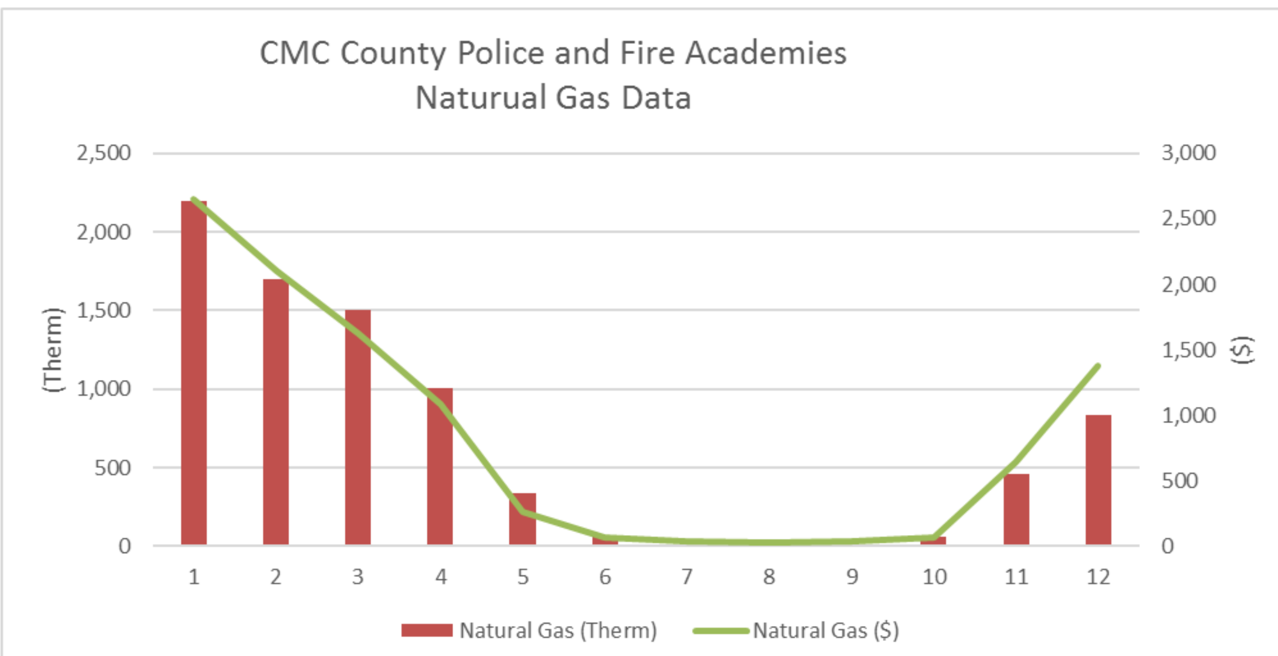
CMC Sheriff's K9 Unit			
Month	Month	Natural Gas (Therm)	Natural Gas ($)
Jan	1	0	38
Feb	2	0	33
Mar	3	0	29
Apr	4	0	32
May	5	0	28
Jun	6	0	29
Jul	7	0	31
Aug	8	0	29
Sep	9	0	31
Oct	10	0	28
Nov	11	0	32
Dec	12	0	33
Total		0	373



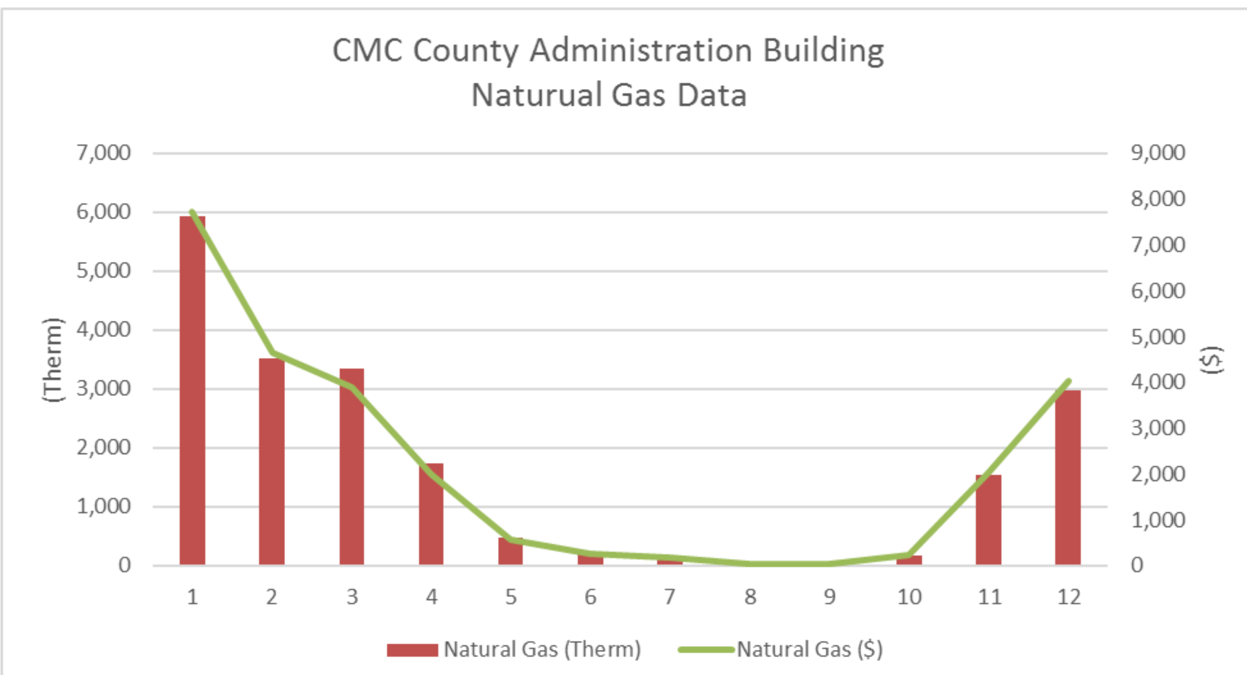
CMC County Correctional Center/Jail			
Month	Month	Natural Gas (Therm)	Natural Gas ($)
Jan	1	4,833	6,311
Feb	2	4,891	6,434
Mar	3	3,461	4,030
Apr	4	2,484	2,873
May	5	1,154	1,357
Jun	6	1,246	1,462
Jul	7	1,055	1,266
Aug	8	759	925
Sep	9	1,086	1,312
Oct	10	1,084	1,316
Nov	11	2,626	3,442
Dec	12	2,479	3,353
Total		27,158	34,081



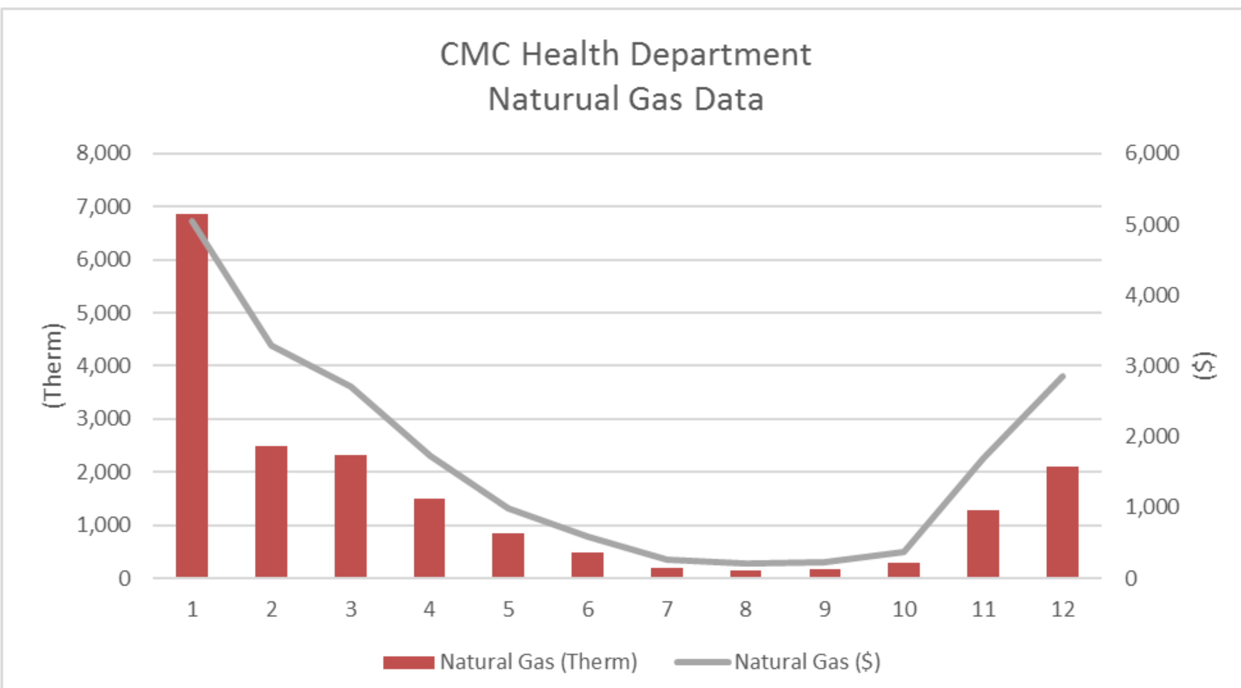
CMC County Police and Fire Academies			
Month	Month	Natural Gas (Therm)	Natural Gas ($)
Jan	1	2,197	2,652
Feb	2	1,701	2,106
Mar	3	1,504	1,625
Apr	4	1,008	1,088
May	5	334	265
Jun	6	63	69
Jul	7	2	32
Aug	8	1	30
Sep	9	4	34
Oct	10	63	71
Nov	11	460	646
Dec	12	838	1,374
Total		8,175	9,991



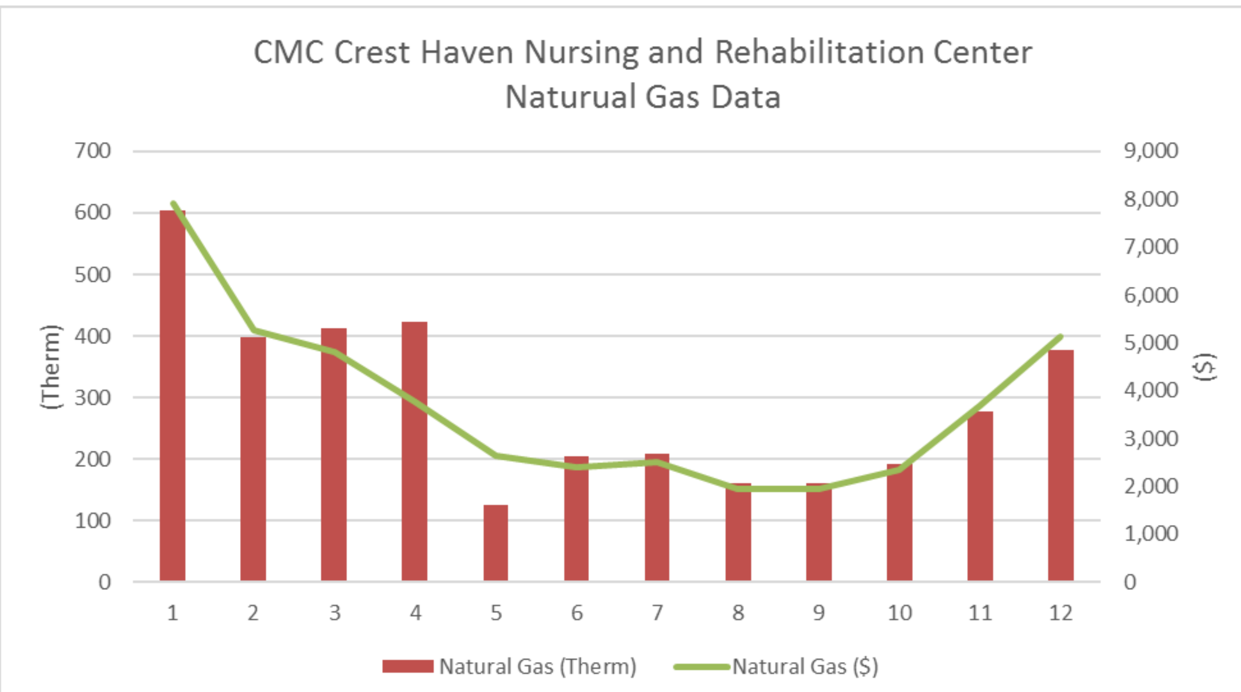
CMC County Administration Building			
Month	Month	Natural Gas (Therm)	Natural Gas ($)
Jan	1	5,924	7,729
Feb	2	3,529	4,650
Mar	3	3,350	3,900
Apr	4	1,735	2,008
May	5	479	581
Jun	6	206	264
Jul	7	117	168
Aug	8	3	31
Sep	9	4	34
Oct	10	165	224
Nov	11	1,542	2,036
Dec	12	2,981	4,026
Total		20,035	25,649



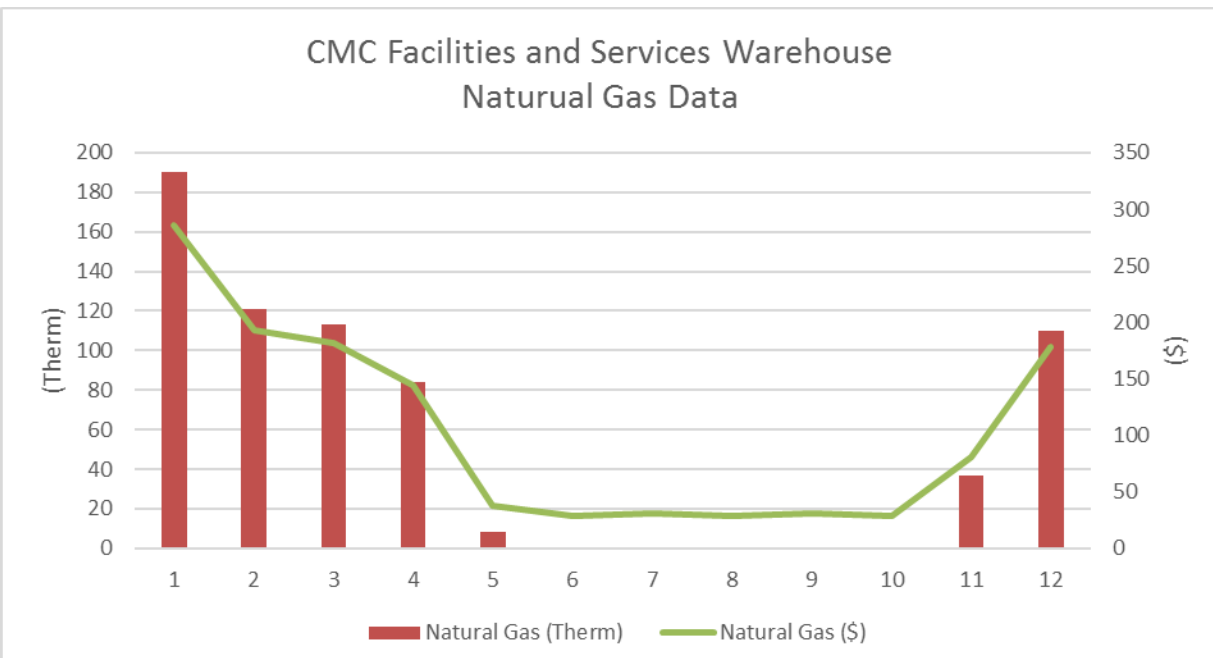
CMC Health Department			
Month	Month	Natural Gas (Therm)	Natural Gas ($)
Jan	1	6,864	5,054
Feb	2	2,490	3,291
Mar	3	2,318	2,710
Apr	4	1,507	1,734
May	5	840	994
Jun	6	489	592
Jul	7	191	256
Aug	8	146	200
Sep	9	159	221
Oct	10	288	371
Nov	11	1,274	1,686
Dec	12	2,098	2,846
Total		18,664	19,955



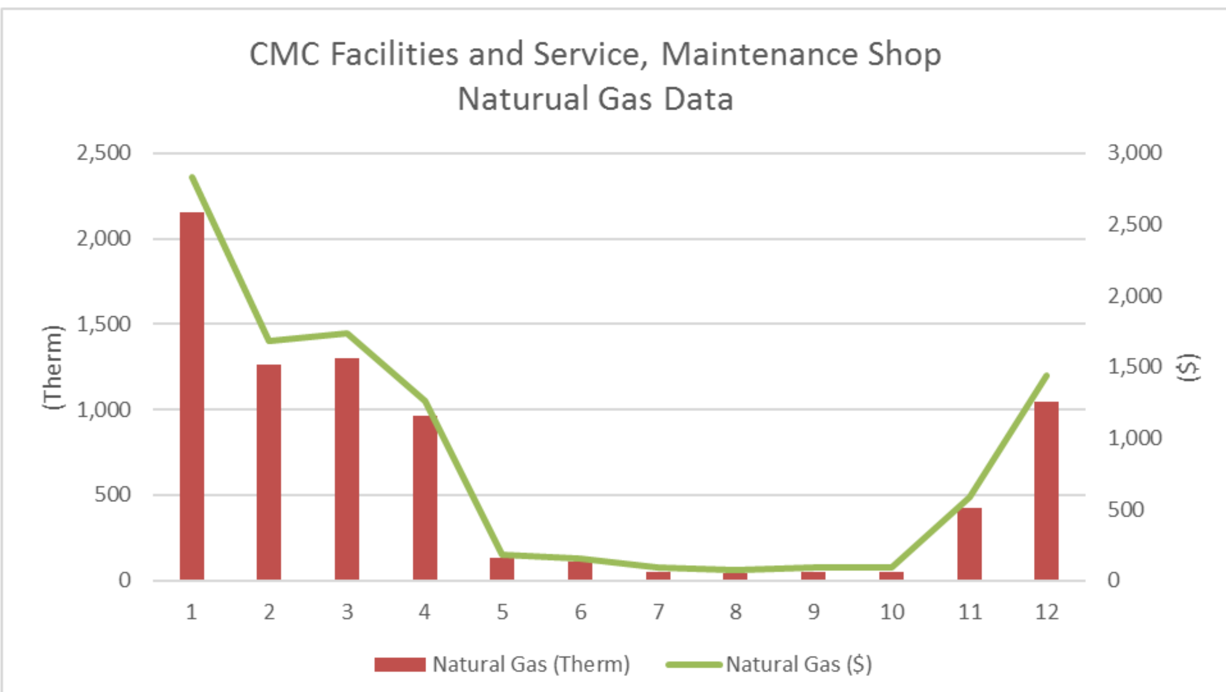
CMC Crest Haven Nursing and Rehabilitation Center			
Month	Month	Natural Gas (Therm)	Natural Gas ($)
Jan	1	604	7,917
Feb	2	397	5,261
Mar	3	412	4,817
Apr	4	423	3,754
May	5	125	2,642
Jun	6	205	2,409
Jul	7	208	2,499
Aug	8	161	1,954
Sep	9	160	1,948
Oct	10	192	2,340
Nov	11	278	3,674
Dec	12	378	5,130
Total		3,543	44,345



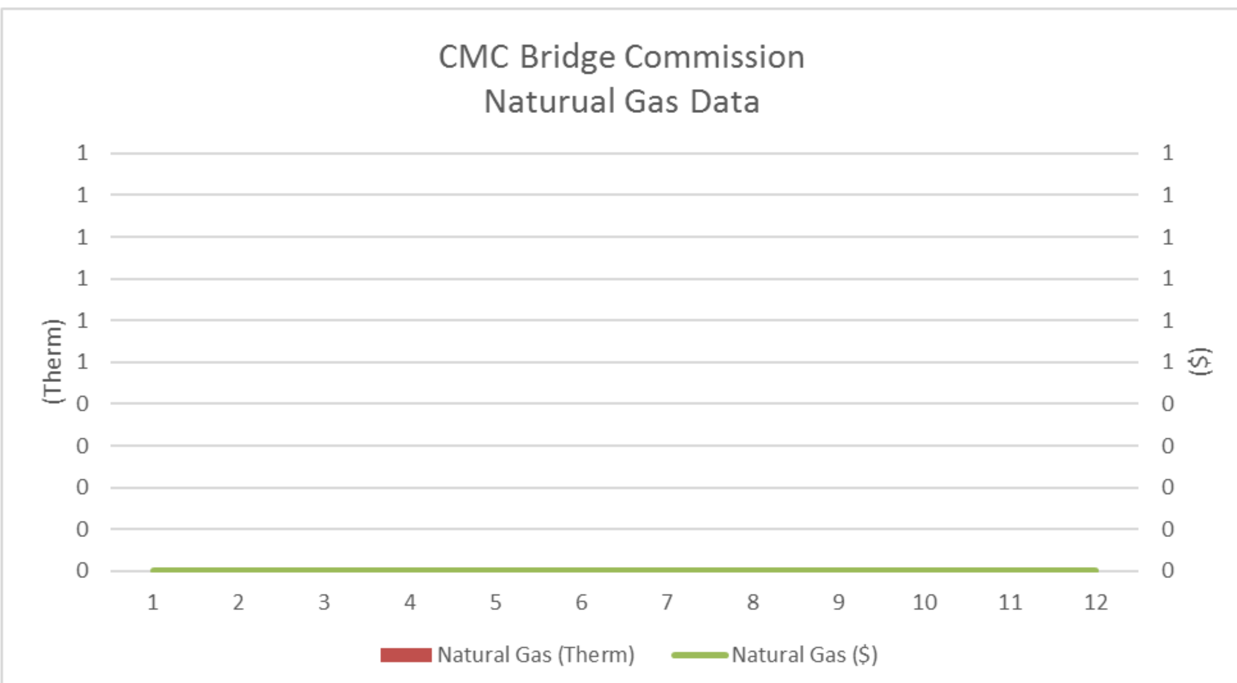
CMC Facilities and Services Warehouse			
Month	Month	Natural Gas (Therm)	Natural Gas ($)
Jan	1	190	286
Feb	2	121	193
Mar	3	113	182
Apr	4	84	144
May	5	8	38
Jun	6	0	29
Jul	7	0	31
Aug	8	0	29
Sep	9	0	31
Oct	10	0	28
Nov	11	37	81
Dec	12	110	178
Total		663	1,250



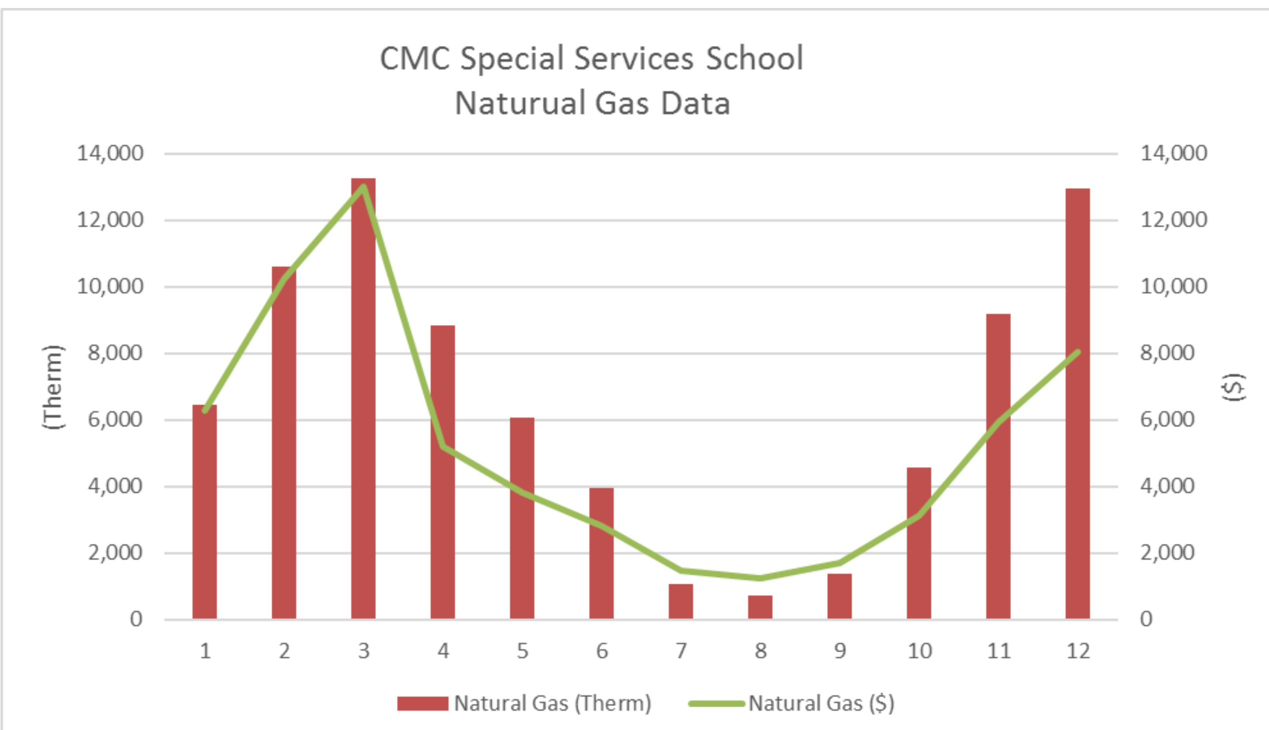
CMC Facilities and Service, Maintenance Shop			
Month	Month	Natural Gas (Therm)	Natural Gas ($)
Jan	1	2,155	2,837
Feb	2	1,261	1,682
Mar	3	1,302	1,739
Apr	4	964	1,261
May	5	132	181
Jun	6	108	152
Jul	7	48	87
Aug	8	40	75
Sep	9	48	88
Oct	10	51	87
Nov	11	423	582
Dec	12	1,046	1,437
Total		7,578	10,209



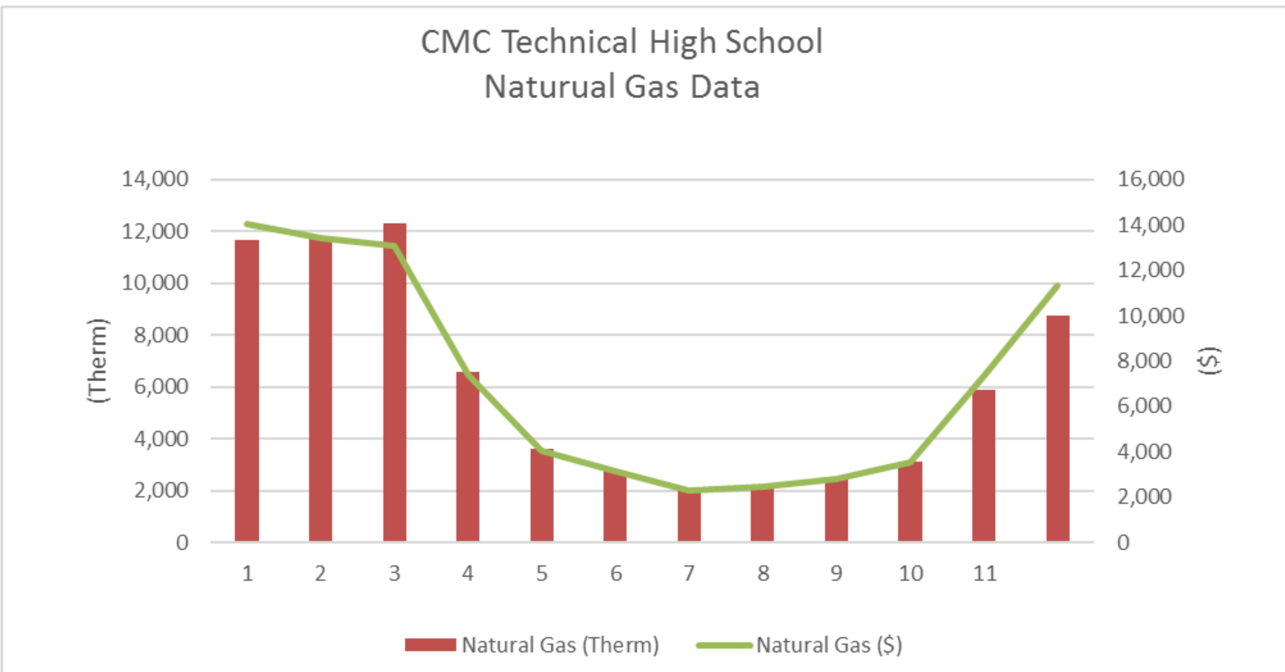
CMC Bridge Commission			
Month	Month	Natural Gas (Therm)	Natural Gas ($)
Jan	1	0	0
Feb	2	0	0
Mar	3	0	0
Apr	4	0	0
May	5	0	0
Jun	6	0	0
Jul	7	0	0
Aug	8	0	0
Sep	9	0	0
Oct	10	0	0
Nov	11	0	0
Dec	12	0	0
Total		0	0



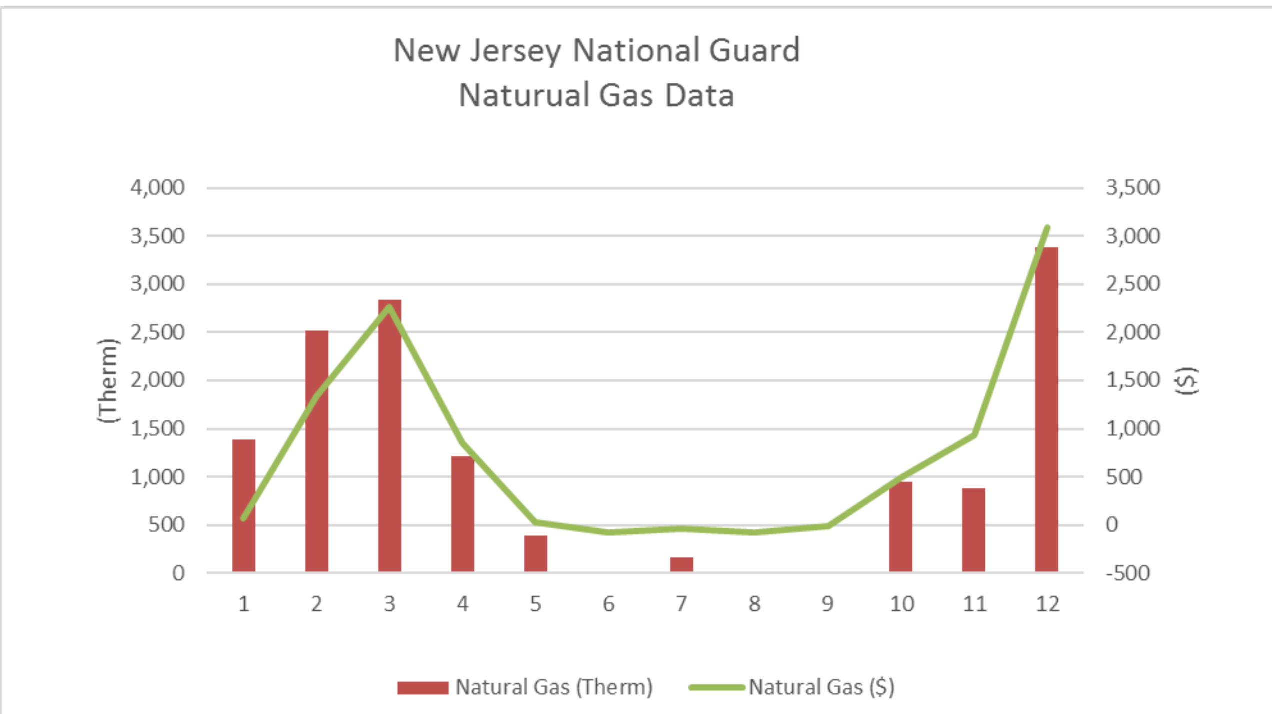
CMC Special Services School			
Month	Month	Natural Gas (Therm)	Natural Gas ($)
Jan	1	6,441	6,292
Feb	2	10,604	10,259
Mar	3	13,247	12,997
Apr	4	8,829	5,219
May	5	6,080	3,810
Jun	6	3,962	2,809
Jul	7	1,071	1,457
Aug	8	705	1,242
Sep	9	1,365	1,697
Oct	10	4,572	3,109
Nov	11	9,202	5,916
Dec	12	12,968	8,035
Total		79,046	62,844



CMC Technical High School			
Month	Month	Natural Gas (Therm)	Natural Gas ($)
Jan	1	11,671	14,055
Feb	2	11,721	13,414
Mar	3	12,306	13,067
Apr	4	6,585	7,399
May	5	3,588	4,030
Jun	6	2,761	3,120
Jul	7	2,012	2,303
Aug	8	2,167	2,463
Sep	9	2,481	2,815
Oct	10	3,111	3,560
Nov	11	5,900	7,362
Dec	12	8,761	11,334
Total		73,063	84,923



New Jersey National Guard			
Month	Month	Natural Gas (Therm)	Natural Gas ($)
Jan	1	1,388	62
Feb	2	2,517	1,329
Mar	3	2,834	2,261
Apr	4	1,210	849
May	5	391	25
Jun	6	22	-84
Jul	7	160	-42
Aug	8	0	-75
Sep	9	0	-6
Oct	10	950	499
Nov	11	884	930
Dec	12	3,380	3,093
Total		13,736	8,843



APPENDIX 3. THS CHP STUDY

SMITH ENGINEERING

FEASIBILITY STUDY REPORT

CLIENT: Cape May County Municipal Utilities Authority

PROJECT SITE: PO Box 610, Cape May Court House, NJ 08210

PROJECT: Evaluation of CHP System

SERVICES: System Modeling and Recommendations

REVISION: -

Report Issue: 12.07.2018

Report Signature Log

Nitin Pathakji — **Date:** **11.27.2018**

Report Author:

Nitin Pathakji — **Date:** **11.27.2018**

Report Analyst:

Nitin Pathakji — **Date:** **11.27.2018**

Technical Review:

Nitin Pathakji — **Date:** **11.27.2018**

Final Review: **Nitin Pathakji**

Report Issue Log

Issued for Client Review	**Date: 12.7.2018**

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Commonly-Used Abbreviations

%Sp	% Speed	**DG**	Door Grille	**HG**	Hot Gas	**PH**	Phase
°C	Degrees Celsius	**Dmd**	Demand	**HHW**	Heating Hot Water	**Po**	Position
°F	Degrees Fahrenheit	**DIA**	Diameter	**HHWP**	Heating Hot Water Pump	**Press**	Pressure
ΔT	Differential Pressure	**DP**	Differential Pressure	**HHWR**	Heating Hot Water Return	**PSI**	Pounds per Square Inch
ΔT	Differential Temperature	**Dp**	Dew Point	**HHWS**	Heating Hot Water Supply	**RA**	Return Air
A	Amps/Area	**Dpr**	Damper	**HP**	Heat Pump; Horsepower	**RAG**	Return Air Grille
AAV	Automatic Air Vent	**DTW**	Dual Temper Water	**HR**	Hour	**RAR**	Return Air Register
ABV CLG	Above Finished Ceiling	**DTWR**	Dual Temp Water Return	**HW**	Hot Water	**RD**	Round Diffuser
ACU	Air Conditioning Unit	**DTWS**	Dual Temp Water Supply	**HX**	Heat Exchanger	**ReH**	ReHeat
AFF	Above Finished Floor	**EA**	Each	**I.D.**	Inside Diameter	**RH**	Relative Humidity
AHU	Air Handling Unit	**EAT**	Entering Air Temperature	**IN.**	Inches	**RL**	Refrigerant Liquid
AP	Access Panel	**EC**	Evaporative Cooler	**IN. WG**	Inches of Water, Gauge	**RPM**	Revolutions per minute
BAS	Building Automation System	**EDH**	Electric Duct Heater	**kW**	Kilowatt	**RS**	Refrigerant Suction
BD	Balancing Damper	**EF**	Exhaust Fan	**kWh**	Kilowatt Hour	**RV**	Roof Vent
BFF	Below Finished Floor	**Eff**	Efficiency	**LAT**	Leaving Air Temperature	**SA**	Supply Air
BMS	Burner Management System	**EG**	Exhaust Grille	**LB**	Pound	**SAR**	Supply Air Register
BTU	British Thermal Units	**EH**	Exhaust Hood	**LD**	Linear Diffuser	**SD**	Smoke Damper
BTUH	BTU per hour	**EMCS**	Energy Management Control System	**LPS**	Low Pressure Steam	**SF**	Supply Fan; Square Feet
BYP	Bypass	**ER**	Exhaust Register	**LWT**	Leaving Water Temperature	**SG**	Soffit Grille
CAC	Control Air Compressor	**ESP**	External Static Pressure	**MA**	Mixed Air	**SIM**	Similar
CD	Ceiling Diffuser	**Evap**	Evaporator	**MAX**	Maximum	**SP**	Static Pressure
CF	Cubic Feet	**EWT**	Entering Water Temperature	**MBH**	Thousand BTUH	**SPEC**	Specification
CFH	Cubic Feet Per Hour	**F**	Flow	**MCF**	Thousands of Cubic Feet	**St**	Status
CFM	Cubic Feet Per Minute	**FCU**	Fan Coil Unit	**MD**	Motorized Damper	**STD**	Standard
CHW	Chilled Water	**FD**	Fire Damper	**MIN**	Minute; Minimum	**STL**	Steel
CHWP	Chilled Water Pump	**FG**	Fire Grille	**N.O.**	Normally Open	**Stm**	Steam
CHWR	Chilled Water Return	**FL DR**	Floor Drain	**NC**	Normally Closed	**TEMP**	Temperature
CHWS	Chilled Water Supply	**FPM**	Feet Per Minute	**NIC**	Not in Contract	**TG**	Transfer Grille
Cond	Condenser	**FT**	Feet	**NO.**	Number	**TSP**	Total Static Pressure
COND	Condensate	**FT WG**	Feet of Water, Gauge	**NPLV**	Nominal Part Load Value	**TYP**	Typical
CR	Cold Room	**FTU**	Fan Terminal Unit	**NPSHa**	Net Positive Suction Head Available	**UC**	Undercut Door - 3/4"
CU	Condensing Unit; Copper	**FW**	Feed Water	**NPSHr**	Net Positive Suction Head Required	**UH**	Unit Heater
CV	Coefficient of Valve	**G**	Glycol	**NTS**	Not to Scale	**V**	Valve; Volts
CW	Condenser Water	**GA**	Gauge	**OA**	Outside Air	**VAV**	Variable Air Volume
CWP	Condenser Water Pump	**GAL**	Gallons	**OAL**	Outdoor Air Louver	**VFD**	Variable Frequency Drive
CWR	Condenser Water Return	**GALV**	Galvanized	**OC**	On Center	**VFM**	Venturi Flow Meter
CWS	Condenser Water Supply	**GPH**	Gallons Per Hour	**OD**	Outside Diameter	**VVU**	Variable Volume Unit
DB	Dry-Bulb	**GPM**	Gallons Per Minute	**PF**	Power Factor	**WB**	Wet-Bulb
DDC	Direct Digital Controls	**H**	Enthalpy	**PG**	Process Glycol	**WPD**	Water Pressure Drop

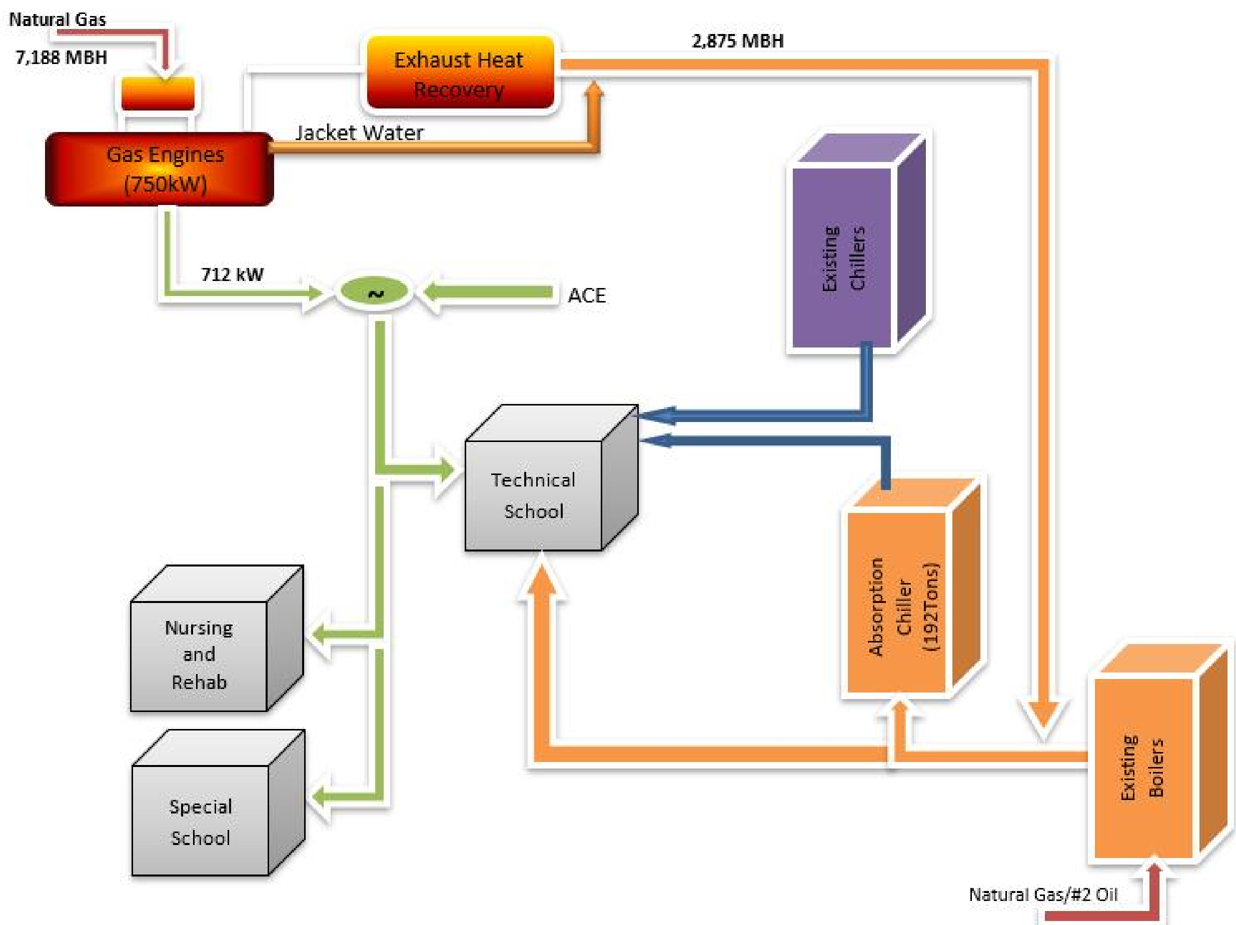
1. Executive Summary

A. Subject and Purpose

This report presents the findings of a Smith Engineering study for incorporating a CHP system, commissioned by Cape May County Municipal Authority under proposed Crest Haven Complex Microgrid feasibility study.

B. Option Analyzed

The option evaluated incorporating a 750kW CHP system at the Cape May County Technical School that captures waste heat and uses it in offsetting part of energy required for HVAC system at the school.



C. Financial Summary

Financial result for this analysis is summarized below in **Table 1Table 1**.

Table 1 – Financial Summary of Analyzed Options

CAPITAL COST	$ 3,908,654		
DISCOUNT RATE	5.0%	Assumed	
ESCALATION RATE			
Energy Escalation Rate	3.0%	Assumed	
Labor Cost Escalation Rate	2.5%	Assumed	
ANNUAL ENERGY COSTS			
Operation Cost Savings with Cogen	$ 350,724	$ 350,724	
SIMPLE PAYBACK (WITH ALL REBATE)	7.2	Years	
IRR WITH ALL REBATE	9.9%		

Year	Capital Cost	Accelerated Depreciation Savings	FITC Rebate	NJ Clean Energy Rebate	Cost Savings	PV Savings (With Rebate)	Cumulative Savings (With Rebate)
0	-$3,908,654		$0	$1,375,000			($2,533,654)
1		$0		$0	$350,724	$334,022	($2,199,631)
2		$0		$0	$361,245	$327,660	($1,871,971)
3		$0			$372,083	$321,419	($1,550,552)
4		$0			$383,245	$315,297	($1,235,256)
5		$0			$394,742	$309,291	($925,965)
6					$406,585	$303,400	($622,565)
7					$418,782	$297,621	($324,944)
8					$431,346	$291,952	($32,992)
9					$444,286	$286,391	$253,398
10					$457,615	$280,936	$534,334
11					$471,343	$275,585	$809,919
12					$485,483	$270,335	$1,080,254
13					$500,048	$265,186	$1,345,440
14					$515,049	$260,135	$1,605,575
15					$530,501	$255,180	$1,860,755
16					$546,416	$250,319	$2,111,074
17					$562,808	$245,551	$2,356,626
18					$579,693	$240,874	$2,597,500
19					$597,083	$236,286	$2,833,786
20					$614,996	$231,785	$3,065,572
						20 Year Cost Savings	$3,065,572

A. Recommendations

It is the recommendation of Smith Engineering to pursue the following.

- Implement a 750kW CHP system at the Technical High School which captures all the waste heat and utilizes it within the technical high school campus.
- Due to the operating hours of the school, excess electric that is produced can be utilized within the adjacent facilities in the same campus. Excess energy can be provided to the adjacent building of The Nursing and Rehabilitation Center and the Special School. It should be noted that the electrical energy to these facilities is during the off-peak hours and hence demand savings are restricted to the Technical School only.
- Rebates & Incentives – The NJ Clean Energy program provides a 35% capital cost incentive for implementation of the CHP system. The evaluation also considers the reduced natural gas rate under CHP system making the operation of CHP system attractive.
- The Technical School has sufficient space to incorporate a CHP system within their campus. The proposed CHP system is a outdoor packaged unit with sound attenuated panels.
- Environmental benefit – CHP provides a environmentally sustainable solution with saving 740 Acers of trees.

2. Introduction

A. Subject and Purpose

This report presents the preliminary findings of a Smith Engineering study commissioned by Cape May County Municipal Utilities Authority (CMCMUA) to perform an assessment and development of microgrid located at the Crest Haven Complex in Cape May, NJ.

As a part of the microgrid study, CHP technology is being evaluated to be part of generating asset that can be dispatched into the microgrid during emergency as well as being used within the campus to provide high efficiency cost effective energy resource to the campus. Based on the electric and thermal load profiles for various facilities within the microgrid, the Cape May Technical High School was selected for probable candidate for a CHP system

B. Scope of Work

The following tasks were completed in conducting this feasibility study:

- Survey and develop load profile for energy usage for the building
- Collect current energy costs and grade them with the building usage
- Evaluate reciprocating engine-based cogeneration systems that can be implemented to produce electricity, cooling and heating
- Perform physical, economical and subjective analysis for the cogeneration plant
- Evaluate the economics of equipment operations to determine the most cost-effective method of operation, considering load profiles, applicable utility tariffs, etc.
- Provide simple cost analysis of building, owning and operating a cogeneration facility.

3. Existing Infrastructure Summary

A. Building

The focus of this study is to evaluate feasibility of installing a CHP system at the Cape May Technical School (CMTS). CMTS is a 240,000 sqft technical school that comprises of classrooms, science labs, conference center, greenhouse and trade shops for automotive, masonry, carpentry etc. The building is a single-story construction with hydronic heating and roof top mounted packaged air conditioners. The school consisted of multiple buildings that were constructed in phases and recently interconnected.

Image 1 – Site Image

B. Central Plant

i. Generation

1. Heating Water

The building is heated with hot water being circulated throughout the campus. Part of the sections have condensing boilers that cater to the older building and were recently changed.

Table 2 – Boiler Data

BOILER ID	B-1	B-2	B-3	B-4	B-5	B-6	B-7	B-8	B-9
Location	Room 115	Room 115	Room 115	Room 182	Room 182	Room 213	Greenhouse	Room 328	Room 328
Service	Section100	Section100	Section100	Science Wing 100	Science Wing 100	Section 200	Greenhouse	Section 300	Section 300
Make	AERCO	AERCO	AERCO	AERCO	AERCO	Weil-McLain	Weil-McLain	Weil-McLain	Weil-McLain
Model	BMK-2.0 GWB	BMK-2.0 GWB	BMK-2.0 GWB	KC-1000 GWB	KC-1000 GWB	1494 Series	PL-584-W-F	AH-994 WF Series 2	AH-994 WF Series 2
Serial Number	G06-1887	G06-1888	G06-1889	NA	NA	NA	NA	460623	460628
Capacity (MBH)	2,000	2,000	2,000	1,000	1000	4,691	1,055	4,691	4,691
Rated Output (MBH)	1,720	1,720	1,720	860	860	3,770	633	3,770	3,770
Efficiency	86-92%	86-92%	86-92%	86-92%	86-92%	75%	60%	75%	75%
Fuel	N. Gas	N. Gas	N. Gas	N. Gas	N. Gas	N. Gas	#2 Fuel Oil	N. Gas	N. Gas
Approx Age	3	3	3	3	3	17	37	31	31
Comments	-	-	-	-	-	-	500 Gal Oil Tank	Makes DHW	Makes DHW

The boilers are in good condition and maintained well. The boilers predominantly use natural gas as their fuel source except for the greenhouse. The sections of building are not interconnected and operate as independent systems.

Based on the information provided by the facilities operations, during peak winter, all the boilers are used to meet the building HVAC demands.

2. Air Conditioning

The facility has multiple rooftop DX units that provide cooling to various sections of the building. Most of the DX units are modular in nature and cater to one or two class room or conditioned spaces. There are a number of split air conditioners at the site. The total installed cooling capacity is 465 TR out of which 162 TR is split air conditioning units. Most equipment is controlled manually and through a Johnson Controls Metasys DDC control system. There are still quite a few pneumatic controls on the existing units that are manually controlled.

The facility does do a night time/weekend temperature reset on the system to save energy.

3. Domestic Hot Water

The facility indicated that the domestic hot water load is quite large. Two boilers are dedicated to domestic hot water with individual capacity of 3,770 MBH. The major loads are cosmetology class and cafeteria.

ii. Utilization

1. Heating Hot Water

Heating hot water is utilized by the air handling units for space heating and is returned to the heat exchanger. Circulation pumps circulate the hot water through the air handling units.

2. Air Conditioning

The air conditioning system is a modular DX and split unit system. Each modular system caters to a single room or two rooms. The total load of 465 TR is provided by 233 TR of roof top units, 162 TR of split units and 70 TR of AHUs.

iii. Controls

1. Heating Hot Water Control

The boilers are operated to provide hot water directly into the facility. It was observed that the hot water pumps operate at constant speed to supply hot water at a fixed temperature.

2. Air Conditioning Control

The air conditioners are operated via a Johnson Metasys DDC control system. The facility personnel manage the space conditions based on each customer requirements with general space temperature maintained at 72F during normal operating hours.

3. Domestic Hot Water Control

The domestic hot water is controlled with a tank that stores the domestic water and provides it to the facility on as need basis. Circulation pumps circulate water though out the campus. Some sections of the facility have dedicated domestic hot water heaters. These include the gym section, the new science section and part of section 300 of the building.

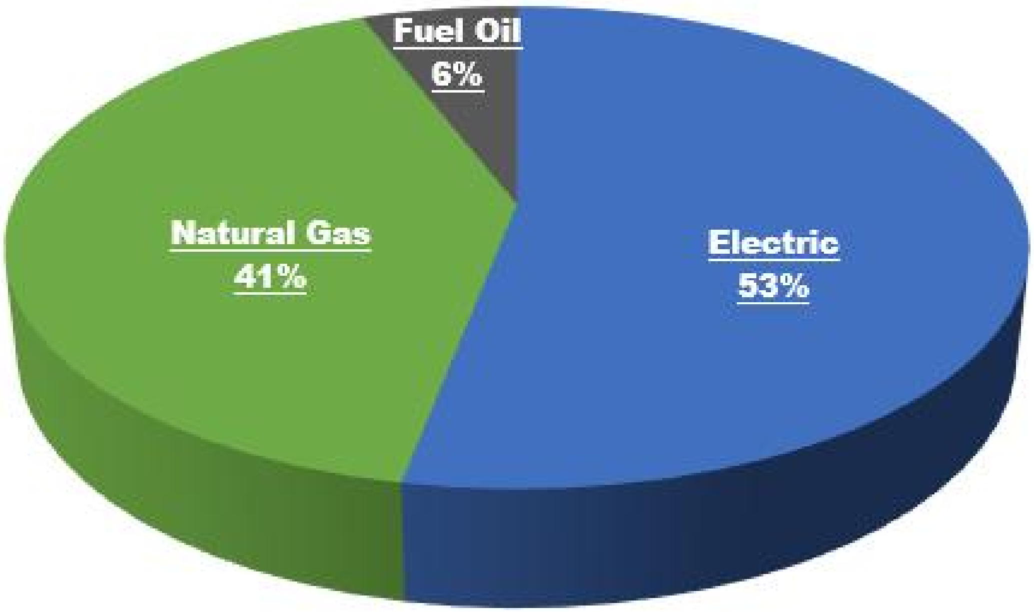
4. Utility Data Analysis

A. Utility Usage and Cost

Utility bill information was provided for the campus for one year. The usage data did not have hourly load profiles but monthly totals for electric and natural gas.

i. 2017 Utility Usage

Graph 1– 2017 Utility Usage



Electric	**2,763,856**	**kWh**
Natural Gas	73,064	Therms
Fuel Oil	7431	Gal

B. Rate Structure

The customer provided the following utilization information and details for electric and natural gas.

Monthly Electric Usage and Rates:

The electric service provided to the facility uses Annual General Service (AGS) under Atlantic Electric. The generation portion of the electric is secured from S.J Energy Company.

Table 3 – Electrical Utility

CMC Technical High School											
Month	Billed KWH/CCF (kWh)	Billed KW (kW)	Measured KW (kW)	Delivery Cost ($)	Delivery Demand Cost ($)	Delivery Minus Demand Cost ($)	Supply Cost ($)	Total Cost ($)	Rates $/kwh	Demand Cost $/kW	Supply and Delivery Charge $/kWh
1	203,532	738.2	656	12,838	6,969	5,869	14,301	27,139	0.133	9.4	0.10
2	199,908	725.8	670.8	12,743	6,851	5,892	14,046	26,790	0.134	9.4	0.10
3	211,063	725.8	667.6	13,639	6,851	6,787	14,830	28,469	0.135	9.4	0.10
4	227,277	785.4	774.4	13,809	7,415	6,394	17,844	31,652	0.139	9.4	0.11
5	293,817	802.4	802.4	15,959	7,575	8,385	23,068	39,027	0.133	9.4	0.11
6	258,657	826.2	826.2	14,910	7,799	7,110	18,219	33,129	0.128	9.4	0.10
7	245,691	768	729	13,820	7,250	6,570	17,305	31,125	0.127	9.4	0.10
8	323,379	820.8	820.8	16,945	7,748	9,196	22,779	39,723	0.123	9.4	0.10
9	172,007	820.4	820.4	12,121	7,745	4,376	12,114	24,235	0.141	9.4	0.10
10	198,553	748.8	732.2	12,226	7,069	5,157	13,983	26,210	0.132	9.4	0.10
11	197,430	772.6	701	12,329	7,294	5,035	13,904	26,233	0.133	9.4	0.10
12	232,542	774.2	703.6	15,151	7,309	7,842	16,339	31,489	0.135	9.4	0.10
	2,763,856	826.2	826.2	166,490	87,874	78,616	198,731	365,221	0.133	9.4	0.10

Monthly Natural Usage and Rates:

The facility received natural gas through South Jersey Gas Company under firm transportation rate. Woodruff Energy supplies gas to the facility. The data received from the facility indicates the natural gas requirement in Table 4. For a 240,000 sqft building, this gas consumptions seems too low. A recent energy assessment done for the Technical school indicates the gas consumption to be higher and in-line with the heating requirement of typical school of such size. Table 5 indicates the Natural Gas data from the energy assessment report. For the purpose of this analysis, the natural gas consumption is considered from the energy assessment report and gas rates taken from the facility report.

Table 4 – Natural Gas Utility

CMC Technical High School				
Month	Month	Natural Gas (Therm)	Natural Gas ($)	Gas Rate ($/Therm)
Jan	1	11,671	14,055	1.20
Feb	2	11,721	13,414	1.14
Mar	3	12,306	13,067	1.06
Apr	4	6,585	7,399	1.12
May	5	3,588	4,030	1.12
Jun	6	2,761	3,120	1.13
Jul	7	2,012	2,303	1.14
Aug	8	2,167	2,463	1.14
Sep	9	2,481	2,815	1.13
Oct	10	3,111	3,560	1.14
Nov	11	5,900	7,362	1.25
Dec	12	8,761	11,334	1.29
Total		73,063	84,923	1.16

Table 5– Natural Gas Utility

NATURAL GAS USAGE SUMMARY

Utility Provider: South Jersey Gas
Rate: Firm Transportation
Meter No: 197504, 4379388, 0455059, 0463306, 0341483, 0439871e, 0504592
Point of Delivery ID: -
Third Party Utility Provider: Woodruff Energy
TPS Meter No: -

MONTH OF USE	CONSUMPTION (THERMS)	TOTAL BILL
Jun-09	5,900.55	$9,818.32
Jul-09	1,233.23	$2,091.55
Aug-09	590.30	$1,075.62
Sep-09	2,095.10	$3,550.44
Oct-09	7,849.98	$13,095.80
Nov-09	11,231.96	$18,597.65
Dec-09	23,448.46	$38,723.16
Jan-10	31,171.50	$43,050.12
Feb-10	31,788.82	$44,051.09
Mar-10	19,486.82	$27,035.88
Apr-10	11,688.19	$16,266.58
May-10	8,143.08	$11,370.21
TOTALS	**154,627.99**	**$228,726.42**

AVERAGE RATE: $1.48 $/THERM

5. Load Analysis

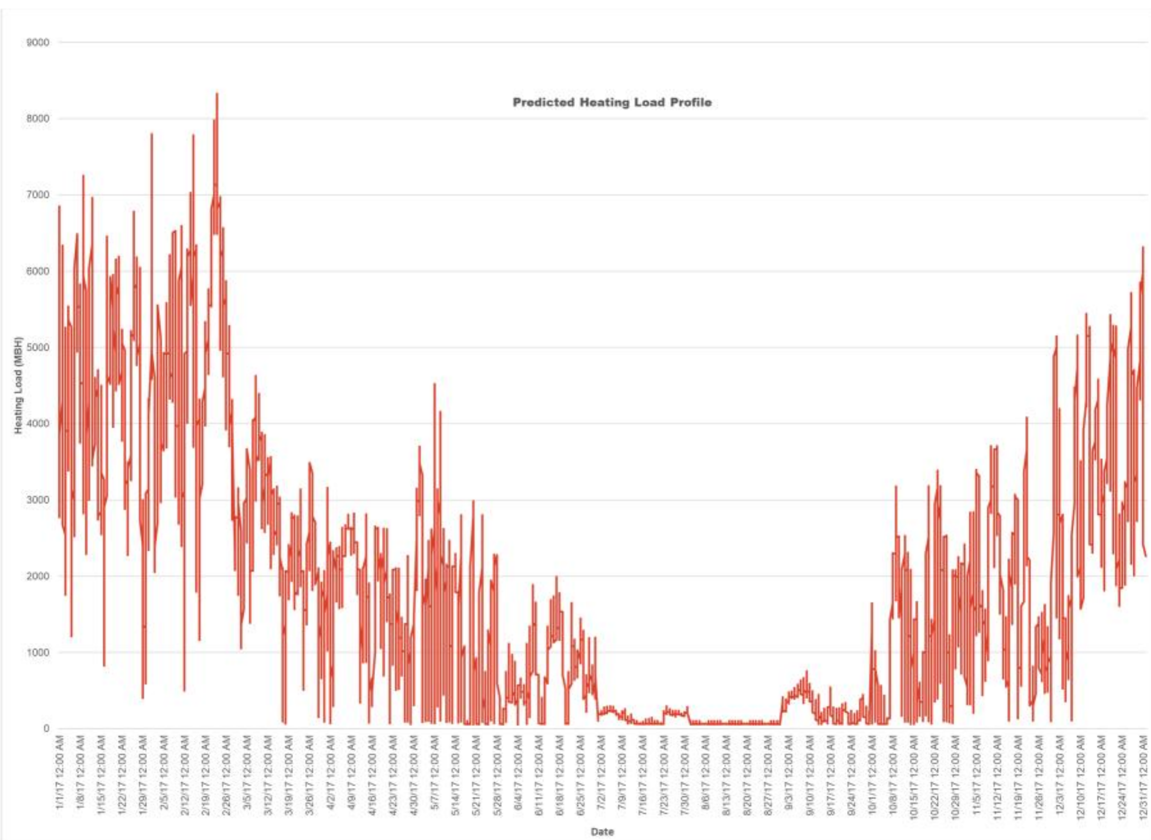
The first step in analyzing the plant is developing the existing operation model. The model is an hourly analysis model, meaning all important data is calculated once an hour for each of the 8,760 hours in a year. By calculating the plant operation every hour captures subtle changes in operation which affect the annual use. Examples of these subtle changes are weather conditions, load, and how the equipment efficiency changes as a result of these changing parameters. For these reasons, this method of analysis is far superior to other methods such as utilizing bin data or simplified efficiency metrics such as NPLV.

A. Heating & Domestic HW Load Analysis

i. Heating and Domestic HW Load

Since the BMS data is not available, the annual heating load profile is derived per load fluctuation along with weather for the given type of building and area of the building and past utility load profiles from the utility bills. With the absence of hourly natural gas consumption data, the heating load profile was developed to mimic a similar application considering the weather information for Cape May and monthly gas consumption.

Graph 2 – Heating & Domestic HW Load Profile



The load analysis indicates the peak heating and hot water requirement of 8,328 MBH which is inline with typical loads for similar applications in similar area. During the summer months, July and Aug, the heating and hot water demands reduce substantially since the school is off and there are minimal summer school activities in the campus. The installed boiler capacity is over 23,000 MBH with 9,300 dedicated to heating hot water.

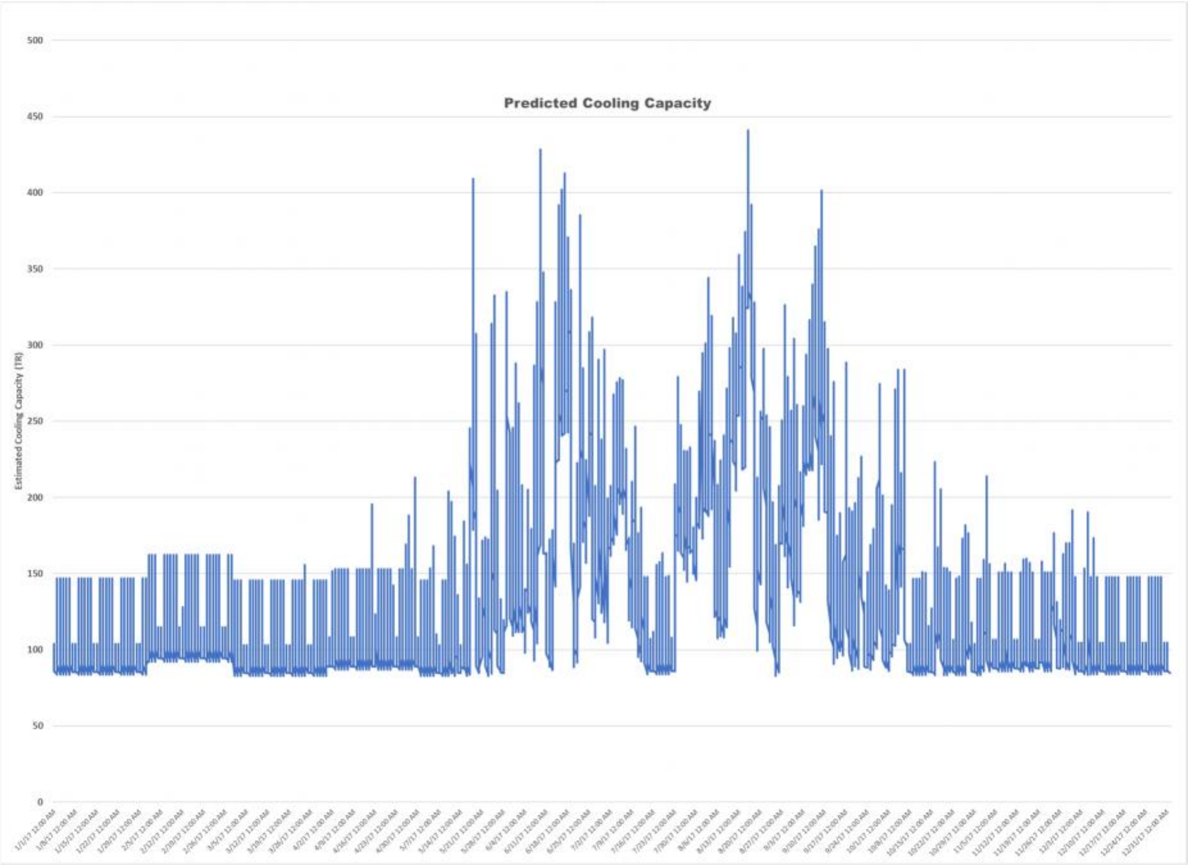
The heating hot water is divided into four major sections with each section having its own boiler plant. These sections include sections 100, section 200, section 300 and greenhouse. Although the buildings are interconnected with hall ways and passages, the heating systems are not interconnected.

B. Cooling Load Analysis

i. Cooling Load

Since the BMS data wasn't available, the annual cooling load profile is derived per load fluctuation along with weather for the given type of building and area of the building.

Graph 3– Cooling Load Profile

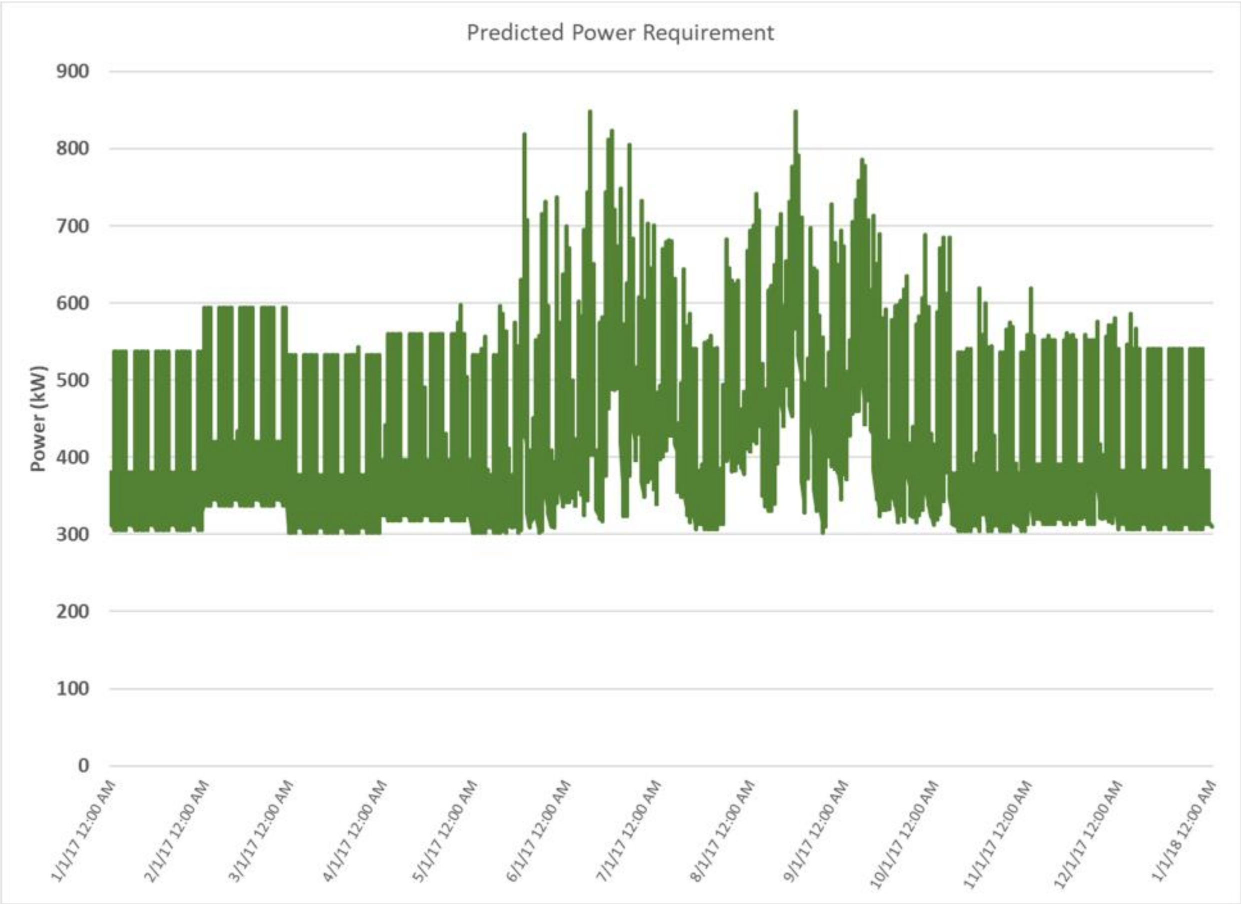


We estimate the peak cooling capacity to be 440 Tons, with a minimum core area cooling of approximately 80 Tons. All of the cooling systems are modular air cooled and split units. It was indicated that the facility operates the chillers during the off-school days.

C. Power Load Analysis

The campus needs for the power requirement are as indicated in Graph 4. The peak demand is 826 kW for the campus. The major electrical loads include HVAC, lighting, pumps and miscellaneous plug loads. Based on a typical application for the school, predicted load profile is created.

Graph 4 – Power Profile



In order to create better value for the proposed CHP system and to base load the electric generator, the intent is to provide the excess energy to the Nursing & Rehab center and Special school that are close to the Technical High School. The electrical requirements for these facilities are as shown below:

CMC Crest Haven Nursing and Rehabilitation Center									
Month	Billed KWH/CCF (kWh)	Billed KW (kW)	Measured KW (kW)	Delta kW (kW)	Delivery Cost ($)	Delivery Demand Cost ($)	Delivery Minus Demand Cost ($)	Supply Cost ($)	Total Cost ($)
1	159,080	375.3	375.3	0.0	7,608	3,543	4,065	11,671	19,279
2	165,567	362.3	362.3	0.0	7,778	3,420	4,357	12,147	19,925
3	157,844	324.4	324.4	0.0	7,455	3,062	4,393	11,581	19,035
4	153,886	317.2	317.2	0.0	7,198	2,994	4,204	12,408	19,606
5	155,089	335.7	335.7	0.0	6,619	3,169	3,450	12,505	19,124
6	191,572	372.4	372.4	0.0	8,647	3,516	5,131	14,574	23,221
7	183,830	376.7	376.7	0.0	8,462	3,556	4,906	14,275	22,738
8	150,896	322.7	322.7	0.0	6,915	3,047	3,868	11,891	18,806
9	152,052	305.6	305.6	0.0	6,928	2,885	4,043	11,182	18,110
10	150,221	322.7	322.7	0.0	6,819	3,047	3,772	11,047	17,866
11	166,219	398.2	398.2	0.0	7,731	3,759	3,972	12,224	19,954
12	226,804	472.0	472.0	0.0	10,952	4,455	6,496	16,640	27,592
	2,013,060	472.0	472.0	0.0	93,111	40,453	52,658	152,145	245,256

CMC Services School									
Month	Billed KWH/CCF (kWh)	Billed KW (kW)	Measured KW (kW)	Delta kW (kW)	Delivery Cost ($)	Delivery Demand Cost ($)	Delivery Minus Demand Cost ($)	Supply Cost ($)	Total Cost ($)
1	124,800	496.8	435.0	61.8	8,097	4,690	3,407	8,772	16,869
2	121,800	496.8	342.0	154.8	8,009	4,690	3,319	8,561	16,569
3	116,700	496.8	360.0	136.8	8,261	4,690	3,571	8,202	16,464
4	135,000	496.8	489.0	7.8	8,219	4,690	3,529	10,602	18,821
5	167,400	579.0	579.0	0.0	10,071	5,466	4,605	13,147	23,217
6	170,700	621.0	621.0	0.0	10,282	5,862	4,420	12,026	22,308
7	135,000	528.0	528.0	0.0	8,196	4,984	3,212	9,511	17,707
8	151,800	496.8	489.0	7.8	8,714	4,690	4,024	10,694	19,408
9	144,600	567.0	567.0	0.0	8,689	5,352	3,337	10,187	18,876
10	123,300	567.0	567.0	0.0	8,162	5,352	2,810	8,686	16,849
11	118,500	496.8	387.0	109.8	7,419	4,690	2,729	8,348	15,767
12	135,900	496.8	351.0	145.8	9,037	4,690	4,347	9,552	18,589
	1,645,500	621.0	621.0	154.8	103,156	59,846	43,310	118,288	221,444

6. Proposed CHP System

A. Proposed CHP Description

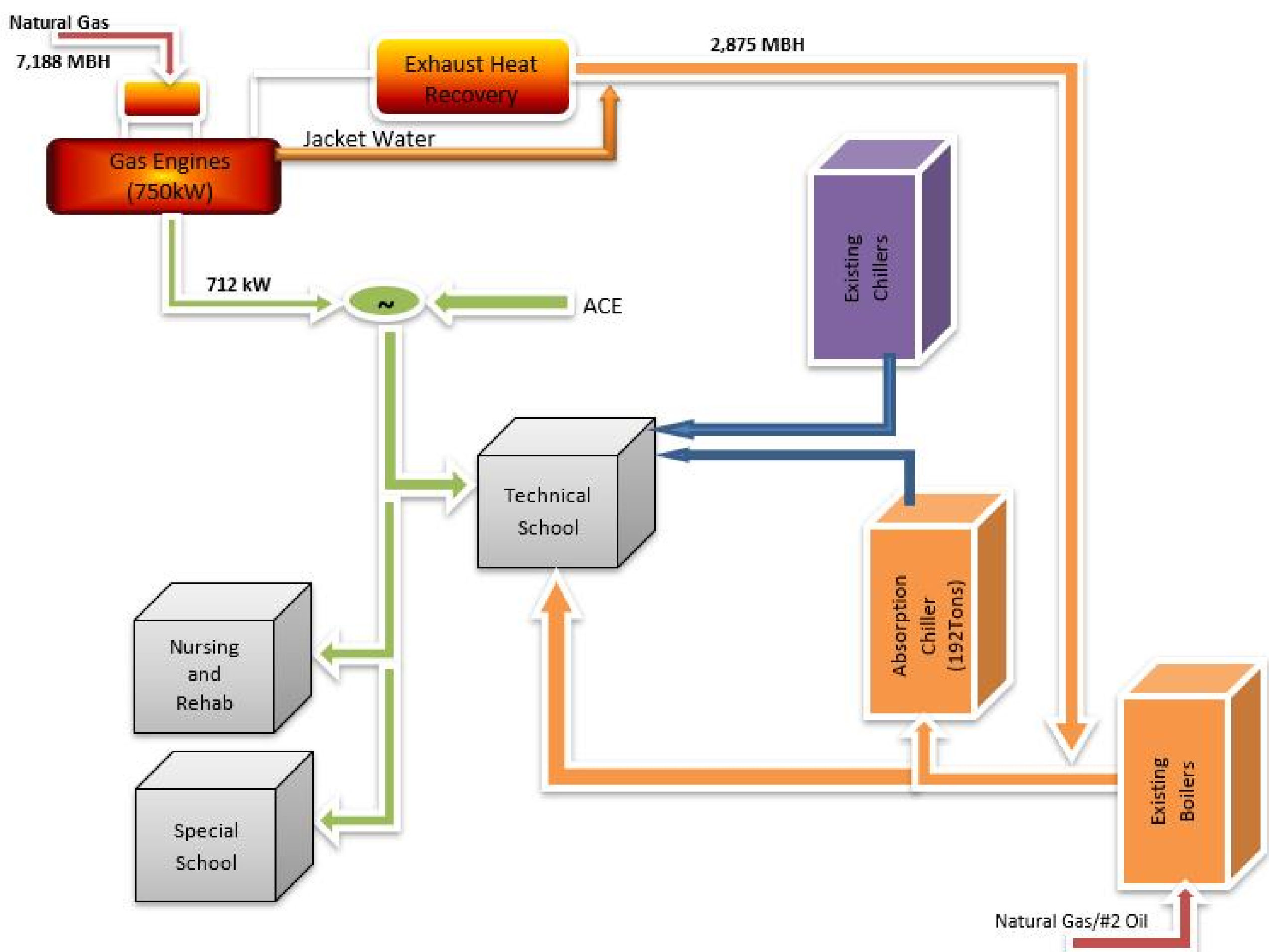
This measure proposes to install a 750kW CHP system at the Technical school. The 750 kW CHP system will recover waste heat in the form of hot water and chilled water for consumption within the technical school. Excess power produced by the CHP system will be provided to the adjacent facilities of Nursing and Rehab center and Special School.

i. Proposed System Description

CHP System:

The proposed CHP system comprises of 750kW reciprocating internal combustion engine (RICE) with heat recovered from the exhaust gases and jacket water to supplement the heating and domestic hot water needs for the Technical School. The waste heat in summer will be used in an absorption chiller to supplement part of the air conditioning needs for the technical school.

Image 2 – CHP Concept



External System:

Heating:

The recovered heat from the 750kW CHP system will be piped from the CHP module to the building heating system. The estimated peak heating available from the CHP system is 2,875 MBH. The connection will be such that the waste heat will act as supplement to the boilers and incase the CHP system is down for maintenance or for emergency, the existing boilers will automatically pick up the building heating load.

Cooling:

The recovered heat will provide source energy to a new proposed absorption chiller. The estimated peak cooling capacity available from waste heat is 192 TR. The chilled water generated from the absorption chiller will be circulated within the technical school. New fan coil units located in classrooms and common area will provide cooling to the building. The existing air conditioners will remain in place and will provide cooling needs for the rest of the campus and in case the CHP is not available for any reason.

Power:

The power generated by the CHP system will be connected to the main incoming to the technical high school, the nursing and rehab center and the special school. New common feeder from the main line will route the electrical connection to the three facilities. The Nursing and Rehabilitation facility and the special school are approximately 150 ft from the technical school. The proposed routing for the cable will be underground pre-buried cabling.

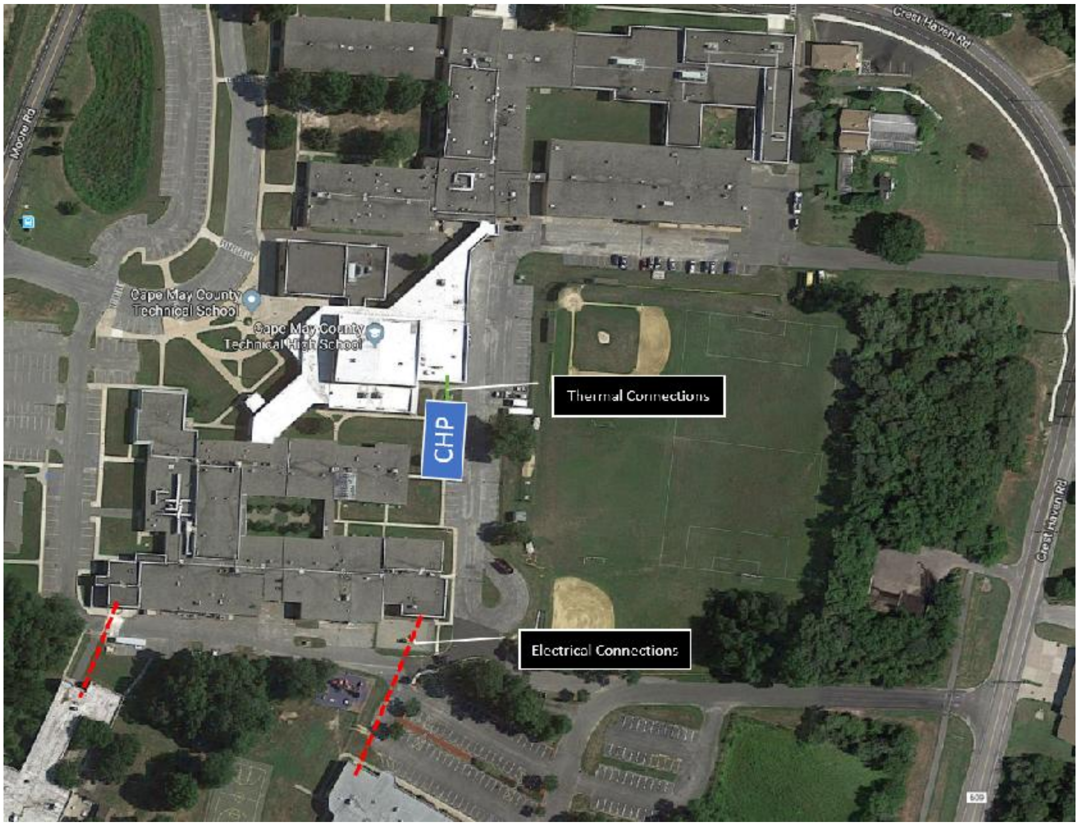
B. Physical Evaluation:

The proposed CHP system is a packaged outdoor unit with engine-generator and heat recovery system included in an outdoor rated enclosure. The proposed location for the CHP system is at the back of the building close to the existing mechanical room. There is ample space available in the mechanical room to include an absorption chiller and heat recovery heat exchanger.

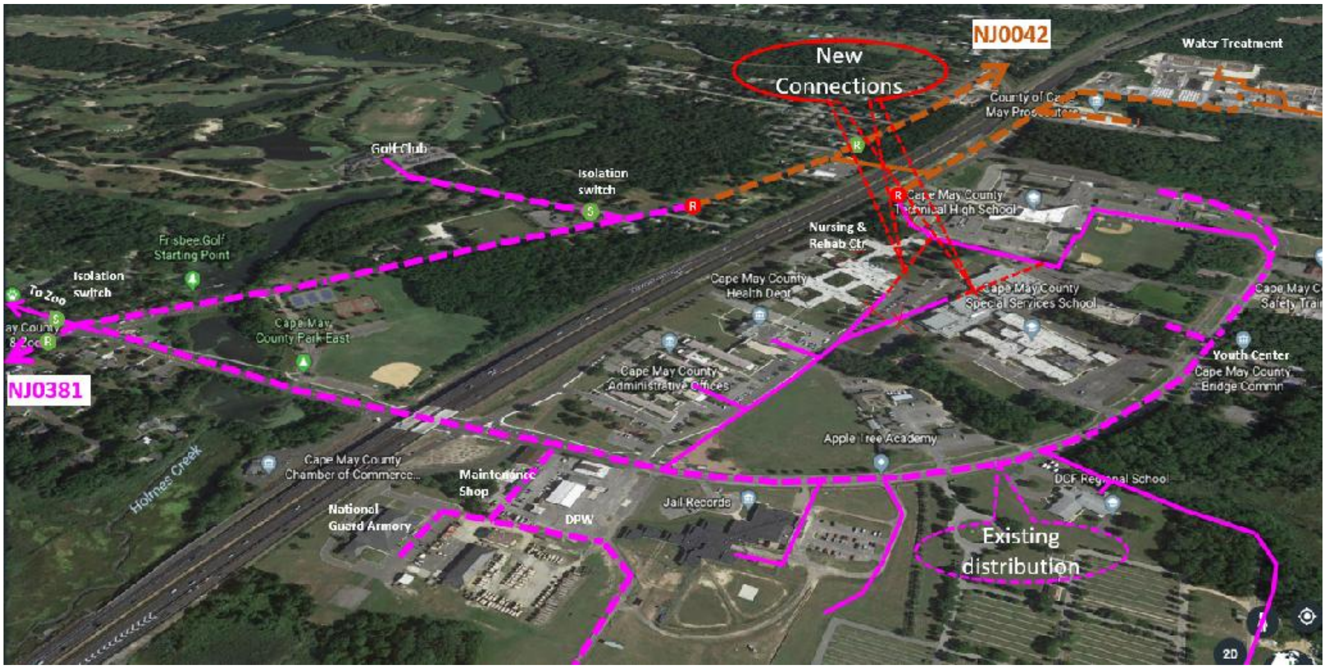
The cooling tower for the absorption chiller will be located near the boiler room and piped to the absorption chiller. The building is a single-story structure. The chilled water pipes can be routed in between the roof and false ceiling and along the passage way. The fan coil units can be ceiling mounted or on floor terminal units. The hot water can be connected to existing hot water circuit such that they operate in parallel with the existing boilers with base loading the CHP based waste heat.

A proposed location for the CHP module is indicated on Image 3.

Image 3 –Equipment Layout



The electrical connections for the proposed CHP are as shown below:



C. *Financial Evaluation*

The hourly model is created for the proposed implementation of a CHP system at the Technical School. The details of the analysis are shown below.

i. First Cost Analysis

The estimated initial investment of a 750kW CHP system along with power wiring and HVAC upgrades with the technical school is $3,908,700.

Table 6–Cost Estimate

SMITH ENGINEERING

212.671.2420 Office 888.224.3403 Fax
www.smith-eng.com

Opinion of Probable Construction Cost

For: Cape May Technical School

Date: Thursday, November 8, 2018
Client: Cape May County Municipal Authroity
Project: Technical School CHP system

Basis of Estimate: ☐ No Design ☑ Conceptual Design ☐ Final Design ☐ Actual Cost

Item #	Description	Quantity	Units	Material Cost per Unit	Total Material Cost	Labor Hour	Labor Cost per Hour	Total Labor Cost	Total Cost
	CHP System								
1	Division 01000 - General				$ 49,500			$ 10,800	$ 60,300
2	Division 23000 - Mechanical				$ 1,313,900			$ 232,500	$ 1,546,400
3	Division 25000 - Controls				$ 65,000			$ -	$ 65,000
4	Division 26000 - Electrical				$ 600,000			$ -	$ 600,000
5									
	Subtotal				**$ 2,028,400**	0		**$ 243,300**	**$ 2,271,700**
	HX and Miscellaneous								
1	Division 01000 - General				$ 12,700			$ -	$ 12,700
2	Division 23000 - Mechanical				$ 176,800			$ 80,700	$ 257,500
3	Division 25000 - Controls				$ -			$ -	$ -
4	Division 26000 - Electrical				$ -			$ -	$ -
5									
	Subtotal				**$ 189,500**	0		**$ 80,700**	**$ 270,200**
	Subtotal of All Items				**$ 2,217,900**	0		**$ 324,000**	**$ 2,541,900**
	Contingency			15%	$ 332,685		15%	$ 48,600	$ 381,285
	Subtotal				**$ 2,550,585**			**$ 372,600**	**$ 2,923,185**
	Construction Management Overhead			5%	$ 127,529		5%	$ 18,630	$ 146,159
	Profit			5%	$ 127,529		5%	$ 18,630	$ 146,159
	Subtotal Construction				**$ 2,805,644**			**$ 409,860**	**$ 3,215,504**
	Tax			0%	$ -		0%	$ -	$ -
	Mechanical Engineering			0%	$ -		10%	$ 321,600	$ 321,600
	Structural Engineering							$ -	$ -
	Architectural Design							$ 10,000	$ 10,000
	Filing/Expediting Consultant							$ 5,000	$ 5,000
	Construction Administration							$ 321,550	$ 321,550
	Commissioning							$ 35,000	$ 35,000
	Total Estimated Cost								**$ 3,908,654**

ii. Utility Cost Assumptions

The utility cost for evaluating the operating expenses for the CHP system are as below:

Power Cost:

The power cost considered for CHP evaluation is as follows:

The Generation and Transmission cost is $0.10009223/kWh

The demand cost is $9.44/kW

Due to the size of the generator, we assume standby charges at 0.96/kW/month based on the ACE tariff "Rider STB-Standby Service" applicable for AGS – Secondary Service.

Natural Gas Cost:

The natural gas cost considered for the CHP evaluation is as follows:

For CHP, South Jersey Gas Company (SJGC) has a tariff of EGS for natural gas consumption below 200MCF that we anticipate will be the CHP gas consumption.

The generation cost based on South Jersey Gas Company (SJGC) BGSS prices published for 2017 averaged $0.46307/therm. The CHP evaluation assumes the generation cost to be $0.5/therm.

The delivery charge of natural gas as per SJGC ESG rate is $0.219463/therm for summer months and $0.251451/therm for winter. The summer season is from April through October.

The demand charge is $8.362812/MCF per month.

Maintenance Cost

The maintenance cost for CHP is assumed at $0.02/kWh.

Equipment Efficiency

The existing boilers efficiency is assumed to be 80%.

The existing air-cooled chillers are assumed to have an energy consumption of 1.25 kW/Ton

iii. Rebates and Incentives

For the proposed CHP, we have considered the NJ Clean Energy Rebate for Combined Heat and Power Plant that provides up to $2.0 Million in incentives. The proposed CHP system will be a black start enabled unit and provides power to critical facility (school) and hence qualifies for additional 10% bonus.

Eligible Technologies	Size (Installed Rated Capacity)[1]	Incentive ($/kW)	% of Total Cost Cap per Project[3]	$ Cap per Project[3]
Powered by non-renewable or renewable fuel source[4]	≤500 kW	$2,000	30-40%[2]	$2 million
Gas Internal Combustion Engine	>500 kW - 1 MW	$1,000		
Gas Combustion Turbine	> 1 MW - 3 MW	$550	30%	$3 million
Microturbine	>3 MW	$350		
Fuel Cells with Heat Recovery				

The proposed CHP incentives are-

First 500kW	500	kW	$2,000	$/kw	$1,000,000
Next 500kW	250	kW	$1,000	$/kw	$250,000
				Sub Total	$1,250,000
				10% Bonus Incentive	$125,000
				Total Estimated Incentive	$1,375,000

iv. Operational and Economic Analysis

Table 7 – CHP Energy Economic Model

Month	Electrical Energy Saving (kWH)	Total Thermal Savings (MBH)	Total Cooling Savings (TR-Hours)	Total Natural Gas for CHP (MBH)	Total Energy Savings ($)	Electric Demand (kW)	Demand Charges ($)	New Electric Demand (kW)	Ratchet at 80% of peak (kW)	New Electric Demand Charge ($)	Electric Standby Charge ($)	Demand Savings ($)	Gas Demand (MCF)	Gas Demand Charge ($)	Monthly Charge ($)	Gas Charges ($)	Total Monthly Savings ($)
Jan	529,388	2,021,986	7,101	5,340,834	31394	738.2	6969	25.7	90.96	858.71	684	5426.29	7.19	60.15	68	128.15	36692.40
Feb	478,800	1,889,665	2,779	4,830,472	28819	725.8	6851	13.3	90.96	858.71	684	5308.29	7.19	60.15	68	128.15	33999.58
Mar	530,100	1,641,617	31,250	5,348,022	28914	725.8	6851	13.3	90.96	858.71	684	5308.29	7.19	60.15	68	128.15	34094.45
Apr	513,000	1,168,532	53,194	5,175,506	26845	785.4	7415	72.9	90.96	858.71	684	5872.29	7.19	60.15	68	128.15	32589.16
May	530,100	787,026	79,300	5,348,022	24701	802.4	7575	89.9	90.96	858.71	684	6032.29	7.19	60.15	68	128.15	30605.35
Jun	513,000	590,055	89,111	5,175,506	22970	826.2	7799	113.7	113.7	1073.39	684	6041.61	7.19	60.15	68	128.15	28883.00
Jul	530,100	123,323	110,804	5,348,022	19041	768	7250	55.5	90.96	858.71	684	5707.29	7.19	60.15	68	128.15	24619.69
Aug	530,100	59,030	129,626	5,348,022	20465	820.8	7748	108.3	113.7	1073.39	684	5990.61	7.19	60.15	68	128.15	26327.83
Sep	513,000	209,510	105,054	5,175,506	19459	820.4	7745	107.9	113.7	1073.39	684	5987.61	7.19	60.15	68	128.15	25318.16
Oct	530,100	778,833	78,605	5,348,022	24496	748.8	7069	36.3	90.96	858.71	684	5526.29	7.19	60.15	68	128.15	29893.86
Nov	513,000	1,092,410	59,928	5,175,506	24516	772.6	7294	60.1	90.96	858.71	684	5751.29	7.19	60.15	68	128.15	30139.20
Dec	530,813	1,849,528	18,925	5,355,211	30382	774.2	7309	61.7	90.96	858.71	684	5766.29	7.19	60.15	68	128.15	36020.00
Total	6,241,500	12,211,515	765,675	62,968,652	302,002		87,875			10,949	8,208	68,718		722	816	1,538	369,183
														Maintenance		5%	**350,724**

v. *Life Cycle Cost Evaluation*

Based on the energy evaluation, a life cycle cost of the proposed CHP is provided in the below table.

Table 8 – Life Cycle Cost

CAPITAL COST	$ 3,908,654	
DISCOUNT RATE	5.0%	Assumed
ESCALATION RATE		
Energy Escalation Rate	3.0%	Assumed
Labor Cost Escalation Rate	2.5%	Assumed
ANNUAL ENERGY COSTS		
Operation Cost Savings with Cogen	$ 350,724	$ 350,724
SIMPLE PAYBACK (WITH ALL REBATE)	7.2	Years
IRR WITH ALL REBATE	9.9%	

Year	Capital Cost	Accelerated Depreciation Savings	FITC Rebate	NJ Clean Energy Rebate	Cost Savings	PV Savings (With Rebate)	Cumulative Savings (With Rebate)
0	-$3,908,654		$0	$1,375,000			($2,533,654)
1		$0		$0	$350,724	$334,022	($2,199,631)
2		$0		$0	$361,245	$327,660	($1,871,971)
3		$0			$372,083	$321,419	($1,550,552)
4		$0			$383,245	$315,297	($1,235,256)
5		$0			$394,742	$309,291	($925,965)
6					$406,585	$303,400	($622,565)
7					$418,782	$297,621	($324,944)
8					$431,346	$291,952	($32,992)
9					$444,286	$286,391	$253,398
10					$457,615	$280,936	$534,334
11					$471,343	$275,585	$809,919
12					$485,483	$270,335	$1,080,254
13					$500,048	$265,186	$1,345,440
14					$515,049	$260,135	$1,605,575
15					$530,501	$255,180	$1,860,755
16					$546,416	$250,319	$2,111,074
17					$562,808	$245,551	$2,356,626
18					$579,693	$240,874	$2,597,500
19					$597,083	$236,286	$2,833,786
20					$614,996	$231,785	$3,065,572
						20 Year Cost Savings	$3,065,572

D. *Subjective Evaluation:*

Environmental Impact:

The proposed CHP system will provide a equivalent CO2 reduction of 740 acres of trees.

Flood Zone Consideration:

The technical school does not come under the FEMA flood area.

Image 4 –Flood Map

Annual System Efficiency:

The use of thermal at the Technical school allows the CHP to operate at an annual efficiency of over 72%. The absorption chiller provides the ideal thermal sink in terms of air-conditioning for the technical school and heating hot water for the winter operation.

Use as educational tool:

The technical school can use the CHP system to educate students in energy and environment and help them gain understanding of distributed generation, system efficiency, generating technologies and much more.

7. Conclusions and Recommendations

A. Conclusion:

The proposed CHP at Cape May Technical school provides over $3M in savings over the 20-year life span of such similar systems. It provides the resiliency required for the microgrid operation

B. Recommendations

It is the recommendation of Smith Engineering to incorporate a CHP system within the proposed microgrid at the Technical high School. A detailed study incorpotating actual hourly loads for the technical high school, nursing center and the special school should be considered.

APPENDIX 4. WTTP CHP STUDY

SMITH ENGINEERING

FEASIBILITY STUDY REPORT

CLIENT: Cape May County Municipal Utilities Authority

PROJECT SITE: PO Box 610, Cape May Court House, NJ 08210

PROJECT: Evaluation of CHP System for Waste Water Treatment Plant

SERVICES: System Modeling and Recommendations

REVISION: -

Report Issue: 12.10.2018

Report Signature Log

Nitin Pathakji	Date:	11.27.2018
Report Author:		
Nitin Pathakji	Date:	11.27.2018
Report Analyst:		
Nitin Pathakji	Date:	11.27.2018
Technical Review:		
Nitin Pathakji	Date:	11.27.2018
Final Review: Nitin Pathakji		

Report Issue Log

Issued for Client Review	Date:	12.10.2018

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Commonly-Used Abbreviations

%Sp	% Speed	**DG**	Door Grille	**HG**	Hot Gas	**PH**	Phase
°C	Degrees Celsius	**Dmd**	Demand	**HHW**	Heating Hot Water	**Po**	Position
°F	Degrees Fahrenheit	**DIA**	Diameter	**HHWP**	Heating Hot Water Pump	**Press**	Pressure
ΔT	Differential Pressure	**DP**	Differential Pressure	**HHWR**	Heating Hot Water Return	**PSI**	Pounds per Square Inch
ΔT	Differential Temperature	**Dp**	Dew Point	**HHWS**	Heating Hot Water Supply	**RA**	Return Air
A	Amps/Area	**Dpr**	Damper	**HP**	Heat Pump; Horsepower	**RAG**	Return Air Grille
AAV	Automatic Air Vent	**DTW**	Dual Temper Water	**HR**	Hour	**RAR**	Return Air Register
ABV CLG	Above Finished Ceiling	**DTWR**	Dual Temp Water Return	**HW**	Hot Water	**RD**	Round Diffuser
ACU	Air Conditioning Unit	**DTWS**	Dual Temp Water Supply	**HX**	Heat Exchanger	**ReH**	ReHeat
AFF	Above Finished Floor	**EA**	Each	**I.D.**	Inside Diameter	**RH**	Relative Humidity
AHU	Air Handling Unit	**EAT**	Entering Air Temperature	**IN.**	Inches	**RL**	Refrigerant Liquid
AP	Access Panel	**EC**	Evaporative Cooler	**IN. WG**	Inches of Water, Gauge	**RPM**	Revolutions per minute
BAS	Building Automation System	**EDH**	Electric Duct Heater	**kW**	Kilowatt	**RS**	Refrigerant Suction
BD	Balancing Damper	**EF**	Exhaust Fan	**kWh**	Kilowatt Hour	**RV**	Roof Vent
BFF	Below Finished Floor	**Eff**	Efficiency	**LAT**	Leaving Air Temperature	**SA**	Supply Air
BMS	Burner Management System	**EG**	Exhaust Grille	**LB**	Pound	**SAR**	Supply Air Register
BTU	British Thermal Units	**EH**	Exhaust Hood	**LD**	Linear Diffuser	**SD**	Smoke Damper
BTUH	BTU per hour	**EMCS**	Energy Management Control System	**LPS**	Low Pressure Steam	**SF**	Supply Fan; Square Feet
BYP	Bypass	**ER**	Exhaust Register	**LWT**	Leaving Water Temperature	**SG**	Soffit Grille
CAC	Control Air Compressor	**ESP**	External Static Pressure	**MA**	Mixed Air	**SIM**	Similar
CD	Ceiling Diffuser	**Evap**	Evaporator	**MAX**	Maximum	**SP**	Static Pressure
CF	Cubic Feet	**EWT**	Entering Water Temperature	**MBH**	Thousand BTUH	**SPEC**	Specification
CFH	Cubic Feet Per Hour	**F**	Flow	**MCF**	Thousands of Cubic Feet	**St**	Status
CFM	Cubic Feet Per Minute	**FCU**	Fan Coil Unit	**MD**	Motorized Damper	**STD**	Standard
CHW	Chilled Water	**FD**	Fire Damper	**MIN**	Minute; Minimum	**STL**	Steel
CHWP	Chilled Water Pump	**FG**	Fire Grille	**N.O.**	Normally Open	**Stm**	Steam
CHWR	Chilled Water Return	**FL DR**	Floor Drain	**NC**	Normally Closed	**TEMP**	Temperature
CHWS	Chilled Water Supply	**FPM**	Feet Per Minute	**NIC**	Not in Contract	**TG**	Transfer Grille
Cond	Condenser	**FT**	Feet	**NO.**	Number	**TSP**	Total Static Pressure
COND	Condensate	**FT WG**	Feet of Water, Gauge	**NPLV**	Nominal Part Load Value	**TYP**	Typical
CR	Cold Room	**FTU**	Fan Terminal Unit	**NPSHa**	Net Positive Suction Head Available	**UC**	Undercut Door - 3/4"
CU	Condensing Unit; Copper	**FW**	Feed Water	**NPSHr**	Net Positive Suction Head Required	**UH**	Unit Heater
CV	Coefficient of Valve	**G**	Glycol	**NTS**	Not to Scale	**V**	Valve; Volts
CW	Condenser Water	**GA**	Gauge	**OA**	Outside Air	**VAV**	Variable Air Volume
CWP	Condenser Water Pump	**GAL**	Gallons	**OAL**	Outdoor Air Louver	**VFD**	Variable Frequency Drive
CWR	Condenser Water Return	**GALV**	Galvanized	**OC**	On Center	**VFM**	Venturi Flow Meter
CWS	Condenser Water Supply	**GPH**	Gallons Per Hour	**OD**	Outside Diameter	**VVU**	Variable Volume Unit
DB	Dry-Bulb	**GPM**	Gallons Per Minute	**PF**	Power Factor	**WB**	Wet-Bulb
DDC	Direct Digital Controls	**H**	Enthalpy	**PG**	Process Glycol	**WPD**	Water Pressure Drop

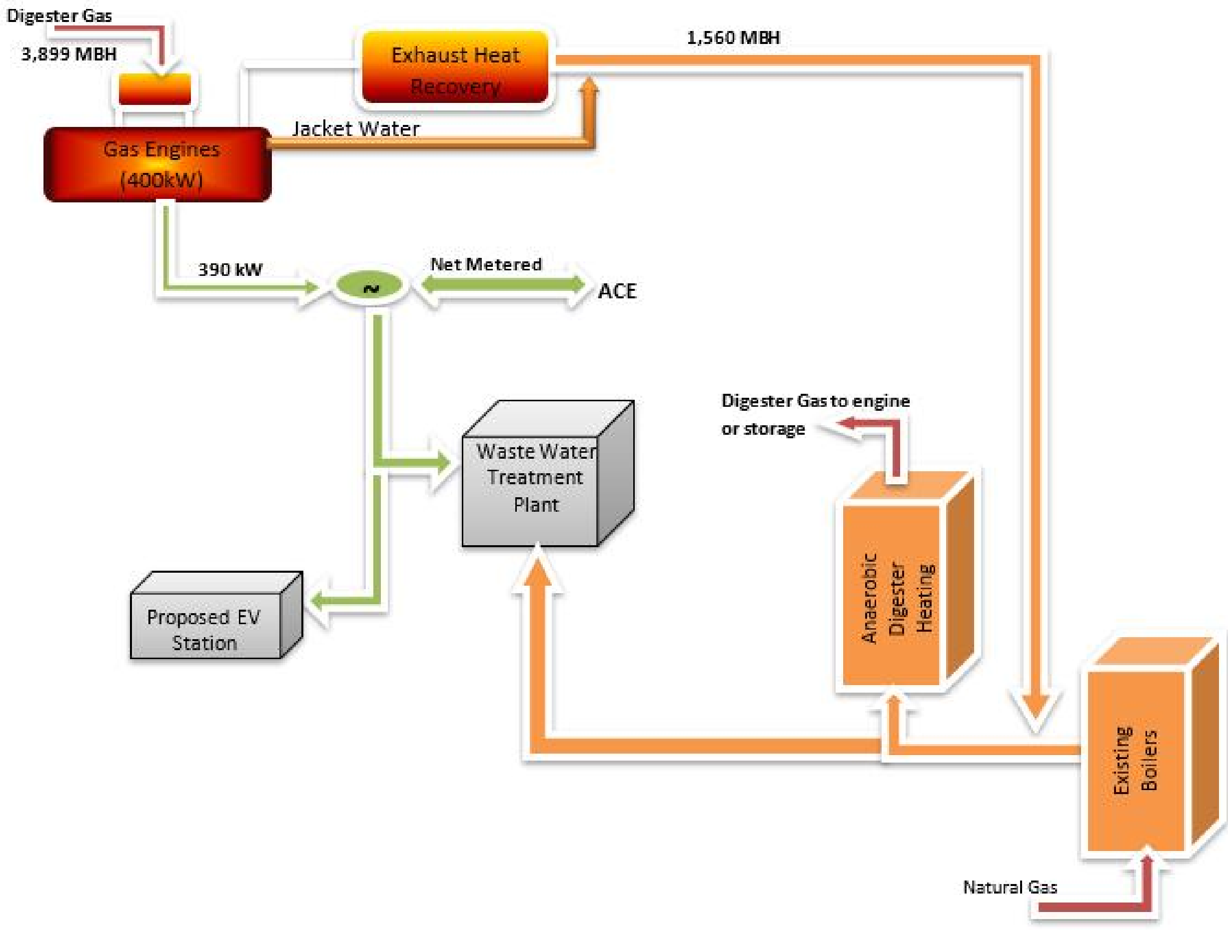
1. Executive Summary

A. Subject and Purpose

This report presents the findings of a Smith Engineering study for incorporating a CHP system at the waste water treatment plant (WWTP), commissioned by Cape May County Municipal Authority under proposed Crest Haven Complex Microgrid feasibility study.

B. Option Analyzed

The option evaluated incorporating a 400kW CHP system at the Cape May County WWTP that captures waste heat and uses it in heating the intake sludge for enhanced digester production and offsetting part of heating required for HVAC system at the office spaces within the WWTP.



C. Financial Summary

Financial result for this analysis is summarized below in **Table 1**.

Table 1 – Financial Summary of Analyzed Options

CAPITAL COST	$ 3,052,309	
DISCOUNT RATE	5.0%	Assumed
ESCALATION RATE		
Energy Escalation Rate	3.0%	Assumed
Labor Cost Escalation Rate	2.5%	Assumed
ANNUAL ENERGY COSTS		
Operation Cost Savings with Cogen	$ 349,500	$ 349,500
SIMPLE PAYBACK (WITH ALL REBATE)	6.1	Years
IRR WITH ALL REBATE	12.7%	

Year	Capital Cost	Accelerated Depreciation Savings	FITC Rebate	NJ Clean Energy Rebate	Cost Savings	PV Savings (With Rebate)	Cumulative Savings (With Rebate)
0	-$3,052,309		$0	$915,693			($2,136,616)
1		$0		$0	$349,500	$332,857	($1,803,759)
2		$0		$0	$359,985	$326,517	($1,477,242)
3		$0			$370,785	$320,298	($1,156,944)
4		$0			$381,908	$314,197	($842,748)
5		$0			$393,365	$308,212	($534,536)
6					$405,166	$302,341	($232,194)
7					$417,321	$296,582	$64,388
8					$429,841	$290,933	$355,321
9					$442,736	$285,392	$640,713
10					$456,018	$279,956	$920,669
11					$469,699	$274,623	$1,195,292
12					$483,790	$269,392	$1,464,684
13					$498,303	$264,261	$1,728,945
14					$513,253	$259,227	$1,988,172
15					$528,650	$254,290	$2,242,462
16					$544,510	$249,446	$2,491,908
17					$560,845	$244,695	$2,736,603
18					$577,670	$240,034	$2,976,637
19					$595,000	$235,462	$3,212,099
20					$612,850	$230,977	$3,443,076
						20 Year Cost Savings	$3,443,076

A. *Recommendations*

It is the recommendation of Smith Engineering to pursue the following.

- Implement a 400kW CHP system at the WWTP which operates using Digester gas and captures all the waste heat and utilizes it within the WWTP campus.
- Since this is a renewable energy, the electric generation can be net metered. The total energy produced by the engine generator is less than the total energy consumed by the WWTP and hence the net metered energy will remain within the WWTP.
- A detailed analysis is required with using the waste heat to additionally dry the sludge saving valuable transportation costs. The disposal transportation cost components that are related to wet sludge can be reduced by utilizing the waste heat and making the sludge drier. The factors to also consider are the terminal sludge disposal limits that may need to be evaluated with increase concentration of dry sludge.

- Rebates & Incentives – The NJ Clean Energy program provides a 30% capital cost incentive for implementation of the CHP system. The NJ Clean Energy Program provides a 30% enhanced incentive for use of renewable energy sources with total incentive of $1,040,000. However, due to the capital requirement, the project is capped at 30% of the capital and hence the incentive is limited to $915,693.
- The WWTP has sufficient space to incorporate a CHP system within their campus. The proposed CHP system is a outdoor packaged unit with sound attenuated panels.
- Environmental benefit – CHP provides an environmentally sustainable solution with saving 198 Acers of trees.

2. Introduction

A. Subject and Purpose

This report presents the preliminary findings of a Smith Engineering study commissioned by Cape May County Municipal Utilities Authority (CMCMUA) to perform an assessment and development of microgrid located at the Crest Haven Complex in Cape May, NJ.

As a part of the microgrid study, CHP technology is being evaluated to be part of generating asset that can be dispatched into the microgrid during emergency as well as being used within the campus to provide high efficiency cost effective energy resource to the campus. The WWTP that provides digester gas can be used to generate electrical energy and hence this application was selected for probable candidate for a CHP system

B. Scope of Work

The following tasks were completed in conducting this feasibility study:

- Survey and develop load profile for energy usage for the building
- Collect current energy costs and grade them with the building usage
- Evaluate reciprocating engine-based cogeneration systems that can be implemented to produce electricity, cooling and heating
- Perform physical, economical and subjective analysis for the cogeneration plant
- Evaluate the economics of equipment operations to determine the most cost-effective method of operation, considering load profiles, applicable utility tariffs, etc.
- Provide simple cost analysis of building, owning and operating a cogeneration facility.

3. Existing Infrastructure Summary

A. Building

The focus of this study is to evaluate feasibility of installing a CHP system at the Waste Water Treatment Plant (WWTP). The WWTP intends to implement anerobic digester at the facility and generate digester gas that can power an engine generator to provide electrical energy. The waste heat from the engine generator can be used to the heat the intake sludge and partial heating for the WWTP office spaces or alternatively, be used to offset the disposal cost of the sludge by drying it further using the waste heat.

Image 1 – Site Image

B. WWTP Plant

i. Generation

1. Sludge Gas

The amount of digester gas available was provided under by the customer. **Table 2** indicates the details of the sludge gas production on a monthly basis.

Table 2 – Sludge Gas Production

Sludge Gas Evaluation	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Notes
Sludge Feed (dry tons/month)	127	133	131	169	227	369	796	747	449	204	123	149	3,624	
Days Per Month	31	28	31	30	31	30	31	31	30	31	30	31	365	
Sludge Feed (dry lbs/month)	8194	9500	8452	11267	14645	24600	51355	48194	29933	13161	8200	9613		
Assumed VS:TS Fraction	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%		
Assumed VSR in Digestion	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%		
Calculated VSR (Lbs VSR/day)	3073	3563	3169	4225	5492	9225	19258	18073	11225	4935	3075	3605		
Unit Digester Gas Production (scf/lb VSR)	15	15	15	15	15	15	15	15	15	15	15	15		
Digester Gas Production (Scf/day)	46089	53438	47540	63375	82379	138375	288871	271089	168375	74032	46125	54073		Assumes 15 days SRT
Digester Gas Production (Scf/min)	32	37	33	44	57	96	201	188	117	51	32	38		
Digester Gas Production (Scf/month)	1,428,750	1,496,250	1,473,750	1,901,250	2,553,750	4,151,250	8,955,000	8,403,750	5,051,250	2,295,000	1,383,750	1,676,250	40,770,000	
Unit Energy in Digester Gas (BTU/scf)	600	600	600	600	600	600	600	600	600	600	600	600		
Energy in Digester Gas (MMBTU/day)	27.7	32.1	28.5	38.0	49.4	83.0	173.3	162.7	101.0	44.4	27.7	32.4		
Energy in Digester Gas (MMBTU/month)	857.3	897.8	884.3	1,140.8	1,532.3	2,490.8	5,373.0	5,042.3	3,030.8	1,377.0	830.3	1,005.8	24,462.00	MMBTU/year
Electrical Efficiency (%)	35%	35%	35%	35%	35%	35%	35%	35%	35%	35%	35%	35%		
Heat Efficiency (%)	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%		
Electrical Production (kW)	118	137	122	163	211	355	741	695	432	190	118	139	285	Generator Output Rating
CHP System Uptime (%)	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%		
Electrical Production (kWh/Month)	79142	82881	81635	105315	141459	229949	496042	465507	279803	127126	76650	92852	2,258,362	kWh/Year
Heat Output (MMBTU/Day)	10.0	11.5	10.3	13.7	17.8	29.9	62.4	58.6	36.4	16.0	10.0	11.7		Hot Water Available
Heat Output (MMBTU/Month)	308.61	323.19	318.33	410.67	551.61	896.67	1,934.28	1,815.21	1,091.07	495.72	298.89	362.07	8,806	MMBTU/year
Heat Output (Btu/hr)	414,798	480,938	427,863	570,375	741,411	1,245,375	2,599,839	2,439,798	1,515,375	666,290	415,125	486,653		

The seasonal changes in the intake sludge is quite large with the winter months having minimum intake and summer month peaking by over 600%.

2. Thermal Requirements

The potential use of the thermal energy can be in heating the intake sludge to enhance the digester gas production. Part of the thermal energy can also be used to dry the disposal sludge to reduce the transportation expenses.

3. Heating Hot Water

The facility has minimal natural gas usage for heating the office spaces. However, part of the energy can also be used to heating the office spaces in winter months.

4. Utility Data Analysis

A. Utility Usage and Cost

Utility bill information was provided for the campus for one year. The usage data did not have hourly load profiles but monthly totals for electric and natural gas.

The customer provided the following utilization information and details for electric and natural gas.

Monthly Electric Usage and Rates:

The electric service provided to the facility uses Annual General Service (AGS) under Atlantic Electric. The generation portion of the electric is secured from S.J Energy Company.

Table 3 – Electrical Utility

CMC MUA Crest Haven Wastewater Treatment Plan										
Month	Billed KWH/CCF (kWh)	Billed KW (kW)	Measured KW (kW)	Delivery Cost ($)	Delivery Demand Cost ($)	Delivery Minus Demand Cost ($)	Supply Cost ($)	Total Cost ($)	Supply + Delivery Charge	Demand Charge
1	237,084	670.6	581.8	12,395	6,331	6,065	18,281	30,676	0.103	9.441
2	272,061	670.6	656.3	13,510	6,331	7,179	20,874	34,384	0.103	9.441
3	278,839	670.6	567.4	14,171	6,331	7,841	21,461	35,632	0.105	9.441
4	285,604	670.6	667.1	14,133	6,331	7,803	21,928	36,062	0.104	9.441
5	330,610	701.1	701.1	13,969	6,618	7,351	26,213	40,182	0.102	9.439
6	424,162	788.4	788.4	18,833	7,442	11,391	32,224	51,057	0.103	9.439
7	463,785	838.3	838.3	20,381	7,913	12,468	35,156	55,537	0.103	9.439
8	368,153	777.4	777.4	16,708	7,339	9,370	28,030	44,739	0.102	9.440
9	289,097	670.6	562	13,988	6,331	7,657	22,257	36,245	0.103	9.441
10	244,515	670.6	532.6	12,352	6,331	6,021	18,908	31,260	0.102	9.441
11	232,142	670.6	580.7	11,808	6,331	5,477	17,919	29,726	0.101	9.441
12	298,069	670.6	644.6	15,005	6,331	8,674	22,929	37,934	0.106	9.441
	3,724,121	838.3	838.3	177,254	79,957	97,297	286,180	463,434	0.103	9.440

Monthly Natural Usage and Rates:

The facility received natural gas through South Jersey Gas Company under firm transportation rate.

The natural gas usage for the facility is minimal. The table below indicates the natural gas usage for the months the customer provided the gas bills.

Table 4 – Natural Gas Utility

CMCMUA WWTP				
Month	Building 1 Gas Requirements (Therms)	Building 1 Gas Requirements (Therms)	Building 1 Gas Requirements (Therms)	total therms (Therms)
1	1,386	1,527	1555.11	4,468
2	1,291	1,196	1641.12	4,128
3	1,277	1,146	1724.51	4,148
4	534	465	759	1,758
5	102	0	0	102
6	NA	NA	NA	NA
7	NA	NA	NA	NA
8	NA	NA	NA	NA
9	NA	NA	NA	NA
10	NA	NA	NA	NA
11	NA	NA	NA	NA
12	NA	NA	NA	NA

5. Load Analysis

The first step in analyzing the plant is developing the existing operation model. The model is a monthly analysis based on the sludge (digester) gas production. Since the digester gas is a renewable energy, we have assumed net metering for the electrical energy generated by the proposed CHP plant

A. Digester Gas Production

The use of thermal energy from the CHP system enhances the amount of digester gas that can be produced by the sludge. We estimated the enhancement to be 30%.

Table 5– Digester Gas Production

Sludge Gas Evaluation	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Notes
Sludge Feed (dry tons/month)	127	133	131	169	227	369	796	747	449	204	123	149	3,624	
Days Per Month	31	28	31	30	31	30	31	31	30	31	30	31	365	
Sludge Feed (dry lbs/month)	8194	9500	8452	11267	14645	24600	51355	48194	29933	13161	8200	9613		
Assumed VS:TS Fraction	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%		
Assumed VSR in Digestion	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%		
Calculated VSR (Lbs VSR/day)	3073	3563	3169	4225	5492	9225	19258	18073	11225	4935	3075	3605		
Unit Digester Gas Production (scf/lb VSR)	19.5	19.5	19.5	19.5	19.5	19.5	19.5	19.5	19.5	19.5	19.5	19.5		
Digester Gas Production (Scf/day)	59915	69469	61802	82388	107093	179888	375532	352415	218888	96242	59963	70294		Assumes 15 days SRT
Digester Gas Production (Scf/min)	42	48	43	57	74	125	261	245	152	67	42	49		
Digester Gas Production (Scf/month)	1,857,375	1,945,125	1,915,875	2,471,625	3,319,875	5,396,625	11,641,500	10,924,875	6,566,625	2,983,500	1,798,875	2,179,125	53,001,000	
Unit Energy in Digester Gas (BTU/scf)	600	600	600	600	600	600	600	600	600	600	600	600		
Energy in Digester Gas (MMBTU/day)	35.9	41.7	37.1	49.4	64.3	107.9	225.3	211.4	131.3	57.7	36.0	42.2		
Energy in Digester Gas (MMBTU/month)	1,114.4	1,167.1	1,149.5	1,483.0	1,991.9	3,238.0	6,984.9	6,554.9	3,940.0	1,790.1	1,079.3	1,307.5	31,800.60	MMBTU/year
Electrical Efficiency (%)	35%	35%	35%	35%	35%	35%	35%	35%	35%	35%	35%	35%		
Heat Efficiency (%)	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%		
Electrical Production (kW)	154	178	158	211	275	461	963	904	561	247	154	180		
CHP System Uptime (%)	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%		
Electrical Production (kWh/Month)	102885	107746	106126	136910	183897	298934	644854	605159	363743	165264	99645	120708	2,935,870	kWh/Year
Heat Output (MMBTU/Day)	12.9	15.0	13.3	17.8	23.1	38.9	81.1	76.1	47.3	20.8	13.0	15.2		Hot Water Available
Heat Output (MMBTU/Month)	401.19	420.15	413.83	533.87	717.09	1,165.67	2,514.56	2,359.77	1,418.39	644.44	388.56	470.69	11,448	MMBTU/year
Heat Output (Btu/hr)	539,238	625,219	556,222	741,488	963,835	1,618,988	3,379,790	3,171,738	1,969,988	866,177	539,663	632,649		

Based on a total digester gas production of 31,800 MMBTU/year, we estimate that a 400 kW unit can be operated year around as base loaded unit.

B. Heating Load Analysis

The intake sludge can be heated to provide additional digester gas production. In the winter months, due to the reduced sludge intake, there is excess energy available from the waste heat generated by the engine CHP. Part of this can be used to heat the existing buildings.

Alternatively, the excess heat can be used to dry the sludge to reduce the disposal transportation cost. The evaluation would need more detailed break up of the disposal transport cost and limiting environmental conditions at the incinerator.

C. Power Load Analysis

The campus needs for the power requirement are as indicated in Table 6. The peak demand is 838 kW for the campus.

Table 6 - Power Profile

CMC MUA Crest Haven Wastewater Treatment Plan										
Month	Billed KWH/CCF (kWh)	Billed KW (kW)	Measured KW (kW)	Delivery Cost ($)	Delivery Demand Cost ($)	Delivery Minus Demand Cost ($)	Supply Cost ($)	Total Cost ($)	Supply + Delivery Charge	Demand Charge
1	237,084	670.6	581.8	12,395	6,331	6,065	18,281	30,676	0.103	9.441
2	272,061	670.6	656.3	13,510	6,331	7,179	20,874	34,384	0.103	9.441
3	278,839	670.6	567.4	14,171	6,331	7,841	21,461	35,632	0.105	9.441
4	285,604	670.6	667.1	14,133	6,331	7,803	21,928	36,062	0.104	9.441
5	330,610	701.1	701.1	13,969	6,618	7,351	26,213	40,182	0.102	9.439
6	424,162	788.4	788.4	18,833	7,442	11,391	32,224	51,057	0.103	9.439
7	463,785	838.3	838.3	20,381	7,913	12,468	35,156	55,537	0.103	9.439
8	368,153	777.4	777.4	16,708	7,339	9,370	28,030	44,739	0.102	9.440
9	289,097	670.6	562	13,988	6,331	7,657	22,257	36,245	0.103	9.441
10	244,515	670.6	532.6	12,352	6,331	6,021	18,908	31,260	0.102	9.441
11	232,142	670.6	580.7	11,808	6,331	5,477	17,919	29,726	0.101	9.441
12	298,069	670.6	644.6	15,005	6,331	8,674	22,929	37,934	0.106	9.441
	3,724,121	838.3	838.3	177,254	79,957	97,297	286,180	463,434	0.103	9.440

The total power requirement for the campus is 3.725 Million kWh. Since the proposed CHP is a renewable energy source, the unit can net metered to meet the annual consumption of 3.725 Million kWh.

6. Proposed CHP System

A. Proposed CHP Description

This measure proposes to install a 400 kW CHP system at the WWTP. The 400 kW CHP system will recover waste heat in the form of hot water for consumption within the WWTP. Excess power produced by the CHP system will be net metered such that the total energy generated does not exceed the facility electrical needs of 3.725 Million kWh.

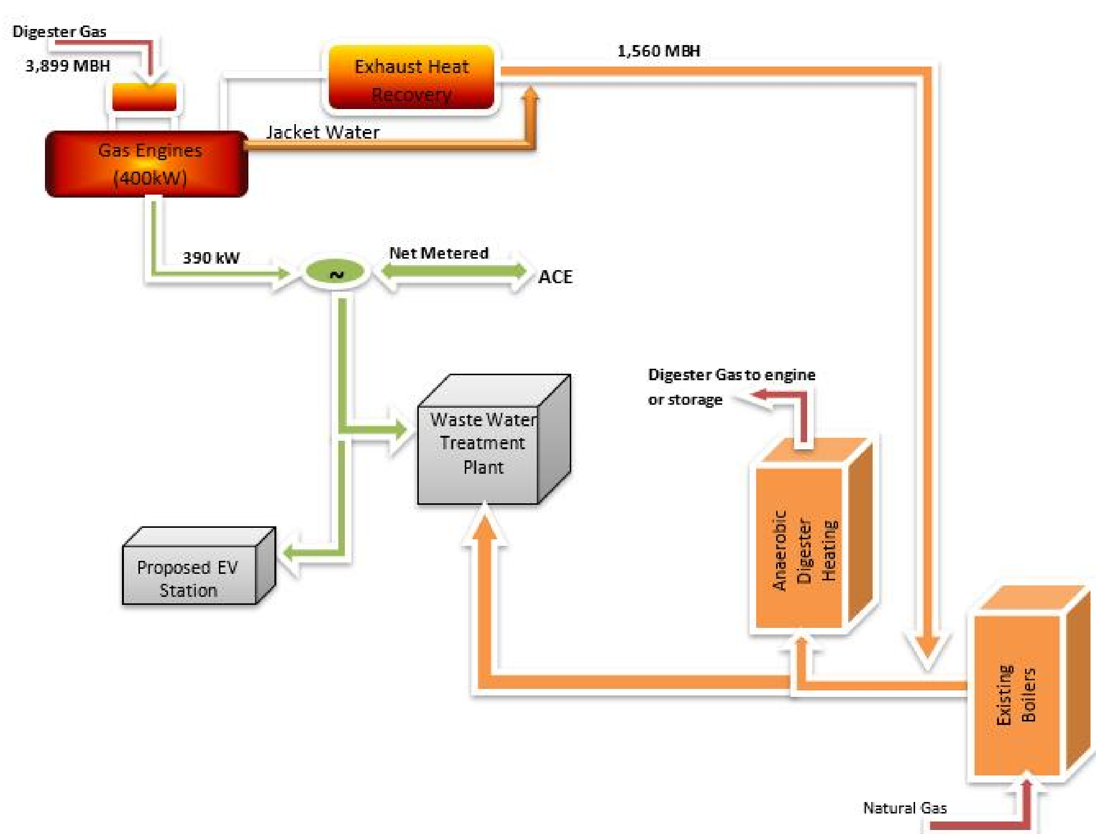
i. Proposed System Description

CHP System:

The proposed CHP system comprises of 400kW reciprocating internal combustion engine (RICE) with heat recovered from the exhaust gases and jacket water to heat the intake sludge and heating office spaces. The waste heat in summer will be used to heat the intake sludge since the sludge intake substantially increases in the summer months.

During the summer season, substantially higher quantity of digester gas is produced. The proposed configuration includes storage of the digester gas in tanks near the CHP system and utilization of the stored gas during the winter months. This provides an ideal base load operation for the CHP.

Image 2 – CHP Concept



External System:

Heating:

The recovered heat from the 400kW CHP system will be used to heat the intake sludge and space heating during winter months. The estimated peak heating available from the CHP system is 1,560 MBH. During the winter months, the sludge intake is substantially low. Part of the heating hot water will be used to heat the adjacent office buildings. During winter, it is estimated that the facility will not be able to consume all of the waste heat generated by the CHP system.

Alternatively, the waste heat that is available can be used to dry the disposal sludge to reduce the transportation cost. This evaluation requires more information on the transportation cost components with respect to wet sludge and dry sludge and the limitations of environmental impact on the incinerator at the delivery terminal.

Power:

The power generated by the CHP system will be connected to the main incoming to the WWTP with bi-directional meter. The power produced by the digester gas can be net metered for the facility such that the total consumption is equal to the power produced. The renewable energy that is provided by the CHP will be utilized within the facility with annual aggregation allowed under NJ AC 14:8-7.

B. *Physical Evaluation:*

The proposed CHP system is a packaged outdoor unit with engine-generator and heat recovery system included in an outdoor rated enclosure. The proposed location for the CHP system is at the back of the building close to the existing mechanical room.

The hot water can be connected to existing hot water circuit such that they operate in parallel with the existing boilers with base loading the CHP based waste heat.

A proposed location for the CHP module is indicated on Image 3.

Image 3 –Equipment Layout

C. Financial Evaluation

The monthly model is created for the proposed implementation of a CHP system at the WWTP. The details of the analysis are shown below.

i. First Cost Analysis

The estimated initial investment of a 400kW CHP system along with power wiring and HVAC upgrades with the technical school is $3,052,400.

Table 7–Cost Estimate

SMITH ENGINEERING

212.671.2420 Office 888.224.3403 Fax
www.smith-eng.com

Opinion of Probable Construction Cost		Date:	Thursday, November 8, 2018
		Client:	Cape May County Municipal Authroity
For	Cape May Technical School	Project:	Technical School CHP system

Basis of Estimate ☐ No Design ☑ Conceptual Design ☐ Final Design ☐ Actual Cost

Item #	Description	Quantity	Units	Material Cost per Unit	Total Material Cost	Labor Hour	Labor Cost per Hour	Total Labor Cost	Total Cost
	CHP System								
1	Division 01000 - General				$ 163,500			$ 10,800	$ 174,300
2	Division 23000 - Mechanical				$ 1,004,000			$ 207,000	$ 1,211,000
3	Division 25000 - Controls				$ 55,000			$ -	$ 55,000
4	Division 26000 - Electrical				$ 275,000			$ -	$ 275,000
5									
	Subtotal				**$ 1,497,500**	0		**$ 217,800**	**$ 1,715,300**
	HX and Miscellaneous								
1	Division 01000 - General				$ 59,000			$ -	$ 59,000
2	Division 23000 - Mechanical				$ 122,800			$ 80,700	$ 203,500
3	Division 25000 - Controls				$ -			$ -	$ -
4	Division 26000 - Electrical				$ -			$ -	$ -
5									
	Subtotal				**$ 181,800**	0		**$ 80,700**	**$ 262,500**
	Subtotal of All Items				**$ 1,679,300**	0		**$ 298,500**	**$ 1,977,800**
	Contingency			15%	$ 251,895		15%	$ 44,775	$ 296,670
	Subtotal				**$ 1,931,195**			**$ 343,275**	**$ 2,274,470**
	Construction Management Overhead			5%	$ 96,560		5%	$ 17,164	$ 113,724
	Profit			5%	$ 96,560		5%	$ 17,164	$ 113,724
	Subtotal Construction				**$ 2,124,315**			**$ 377,603**	**$ 2,501,917**
	Tax			0%	$ -		0%	$ -	$ -
	Mechanical Engineering			0%	$ -		10%	$ 250,200	$ 250,200
	Structural Engineering							$ -	$ -
	Architectural Design							$ 10,000	$ 10,000
	Filing/Expediting Consultant							$ 5,000	$ 5,000
	Construction Administration							$ 250,192	$ 250,192
	Commissioning							$ 35,000	$ 35,000
	Total Estimated Cost $								**3,052,309**

ii. Utility Cost Assumptions

The utility cost for evaluating the operating expenses for the CHP system are as below:

Power Cost:

The power cost considered for CHP evaluation is as follows:

The Generation and Transmission cost is $0.103/kWh

The demand cost is $9.44/kW

Due to the size of the generator, we assume standby charges at 0.96/kW/month based on the ACE tariff "Rider STB-Standby Service" applicable for AGS – Secondary Service.

Maintenance Cost

The maintenance cost for CHP is assumed at $0.03/kWh.

Equipment Efficiency

The existing boilers efficiency is assumed to be 88%.

iii. Rebates and Incentives

For the proposed CHP, we have considered the NJ Clean Energy Rebate for Combined Heat and Power Plant that provides up to $2.0 Million in incentives. The proposed CHP system will be a renewable energy and hence qualifies for additional 30% bonus.

Eligible Technologies	Size (Installed Rated Capacity)[1]	Incentive ($/kW)	% of Total Cost Cap per Project[3]	$ Cap per Project[3]
Powered by non-renewable or renewable fuel source[4]	≤500 kW	$2,000	30-40%[2]	$2 million
Gas Internal Combustion Engine	>500 kW - 1 MW	$1,000		
Gas Combustion Turbine	> 1 MW - 3 MW	$550	30%	$3 million
Microturbine	>3 MW	$350		
Fuel Cells with Heat Recovery				

The proposed CHP incentives are-

First 500kW	400	kW	$2,000	$/kw	$800,000
30% Bonus	30	%			$240,000
				Sub Total	$1,040,000
				Capped at 30% of Capital ($3.05M)	$915,693
				Total Estimated Incentive	$915,693

iv. Operational and Economic Analysis

Table 8 – CHP Energy Economic Model

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Electric Savings													
Electric Production (kWh)	290,160	262,080	290,160	280,800	290,160	280,800	290,160	290,160	280,800	290,160	280,800	290,160	3,416,400.00
Facility Demand (kW)	581.8	656.30	567.40	667.10	701.10	788.40	838.30	777.40	562.00	532.60	580.70	644.60	
Balance of Demand (kW)	191.8	266.3	177.4	277.1	311.1	398.4	448.3	387.4	172.0	142.6	190.7	254.6	
Ratchet at 80% (kW)	358.6	358.6	358.6	358.6	358.6	358.6	358.6	358.6	358.6	358.6	358.6	358.6	
Demand Charge Savings ($)	296.1	296.1	296.1	296.1	296.0	296.0	296.0	296.1	296.1	296.1	296.1	296.1	
Standby Charge	384.0	384.0	384.0	384.0	384.0	384.0	384.0	384.0	384.0	384.0	384.0	384.0	
Total Electric Savings	29,708.40	26,935.89	30,403.74	29,142.97	29,369.48	28,785.64	29,707.25	29,388.88	28,967.54	29,494.70	28,211.97	30,676.51	350,792.97
Sludge Temp (Deg F)	45	45	45	65	65	65	65	65	65	65	45	45	
Sludge Temp desired (Deg F)	105	105	105	105	105	105	105	105	105	105	105	105	
Sludge Flow (GPM)	13.6	15.8	14.1	18.8	24.4	41.0	85.5	80.3	49.8	21.9	13.7	16.0	
Thermal Required (MBH)	409.35	474.62	422.24	375.26	487.78	819.34	1710.46	1605.17	996.98	438.36	409.67	480.26	
Thermal Available (MBH)	1560	1560	1560	1560	1560	1560	1560	1560	1560	1560	1560	1560	
Leaving Sludge Temp	105	105	105	105	105	105	101.5	103.9	105.0	105	105	105	
Useful Thermal (MBH)	409.35	474.62	422.24	375.26	487.78	819.34	1559.77	1559.77	996.98	438.36	409.67	480.26	
Remaining Thermal (MBH)	1150.42	1085.15	1137.53	1184.52	1071.99	740.43	0.00	0.00	562.79	1121.41	1150.10	1079.51	
Building Heating Requirements (MMBTU/Month)	447	413	415	-	-	-	-	-	-	415	413	447	
Natual Gas Savings													
Cost of NG ($/MMBTU)	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	
Useful Thermal (MMBTU/Month)	751.4	731.7	728.9	270.2	362.9	589.9	1160.5	1160.5	717.8	740.9	707.7	804.1	8,726.65
Gas Boiler efficiency (%)	88%	88%	88%	88%	88%	88%	88%	88%	88%	88%	88%	88%	
Input Gas Savings (MMBTU/Month)	853.8	831.5	828.4	307.0	412.4	670.4	1318.7	1318.7	815.7	842.0	804.3	913.8	9,916.65
Natural Gas Savings ($/Month)	9904.5	9645.4	9608.9	3561.5	4783.8	7776.3	15297.1	15297.1	9462.2	9766.9	9329.3	10600.0	115,033.09
Cost of CHP Operation													
Maintenance Cost ($/kWh)	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	
Maintenance Cost ($/Month)	8,705	7,862	8,705	8,424	8,705	8,424	8,705	8,705	8,424	8,705	8,424	8,705	102492
Total Operational Savings	30,908.12	28,718.90	31,307.81	24,280.49	25,448.49	28,137.96	36,299.55	35,981.19	30,005.79	30,556.83	29,117.27	32,571.67	363,334.06
											5% down for	Maintenance	345,200.00

v. *Life Cycle Cost Evaluation*

Based on the energy evaluation, a life cycle cost of the proposed CHP is provided in the below table.

Table 9 – Life Cycle Cost

CAPITAL COST	$ 3,052,309		
DISCOUNT RATE	5.0%	Assumed	
ESCALATION RATE			
Energy Escalation Rate	3.0%	Assumed	
Labor Cost Escalation Rate	2.5%	Assumed	
ANNUAL ENERGY COSTS			
Operation Cost Savings with Cogen	$ 345,200	$ 345,200	
SIMPLE PAYBACK (WITH ALL REBATE)	6.2	Years	
IRR WITH ALL REBATE	12.5%		

Year	Capital Cost	Accelerated Depreciation Savings	FITC Rebate	NJ Clean Energy Rebate	Cost Savings	PV Savings (With Rebate)	Cumulative Savings (With Rebate)
0	-$3,052,309		$0	$915,693			($2,136,616)
1		$0		$0	$345,200	$328,762	($1,807,854)
2		$0		$0	$355,556	$322,500	($1,485,354)
3		$0			$366,223	$316,357	($1,168,997)
4		$0			$377,209	$310,331	($858,666)
5		$0			$388,526	$304,420	($554,246)
6					$400,181	$298,622	($255,625)
7					$412,187	$292,934	$37,309
8					$424,552	$287,354	$324,662
9					$437,289	$281,880	$606,543
10					$450,408	$276,511	$883,054
11					$463,920	$271,244	$1,154,298
12					$477,838	$266,078	$1,420,376
13					$492,173	$261,010	$1,681,386
14					$506,938	$256,038	$1,937,424
15					$522,146	$251,161	$2,188,585
16					$537,810	$246,377	$2,434,962
17					$553,945	$241,684	$2,676,647
18					$570,563	$237,081	$2,913,727
19					$587,680	$232,565	$3,146,292
20					$605,310	$228,135	$3,374,427
						20 Year Cost Savings	$3,374,427

D. *Subjective Evaluation:*

Environmental Impact:

The proposed CHP system will provide an equivalent CO_2 reduction of 198 acres of trees.

Flood Zone Consideration:

The WWTP does not come under the FEMA flood area.

Image 4 –Flood Map

Annual System Efficiency:

The use of thermal at the Technical school allows the CHP to operate at an annual efficiency of over 60%. If the waste heat is used for disposal sludge drying, the overall system efficiency can improve to over 70%.

7. Conclusions and Recommendations

A. Conclusion:

The proposed CHP at Cape May WWTP provides over $3M in savings over the 20-year life span of such similar systems. It provides the resiliency required for the microgrid operation

B. Recommendations

It is the recommendation of Smith Engineering to incorporate a CHP system within the proposed microgrid at the Technical high School. A detailed study incorpotating actual hourly loads for the WWTP should be considered. A detauled analysis of the use of waste heat to save on sludge disposal transportation should also be considered.