CAMDEN MICROGRID SUSTAINABILITY LOOP

Microgrid Feasibility Study Report

December 2018

CONTENTS

I. Project Name: Camden Microgrid Sustainability Loop

II. Project Applicant: Camden County

The project applicant is Camden County in conjunction with Camden County Municipal Utilities Authority ("CCMUA") as the main lead and Covanta Camden Energy Recovery Center ("Covanta"). The New Jersey Board of Public Utilities ("NJBPU") granted an approval for the CCMUA to develop and implement a "Sustainability Loop" which involves transmission of green energy from Covanta's waste to steam facility to the CCMUA's wastewater treatment plant, and water reuse from the plant's effluent to Covanta.

III. Project Partners

CCMUA contracted D&B/Guarino Engineers and their subconsultant, Greener by Design (GbD), along with GridIntellect, BRS, and Compass as GbD's subconsultants, to develop a conceptual design of a "Sustainability Loop". The project team has also been working with PSE&G which services as the local utility for both gas and electric.

D&B/Guarino's role was to provide the conceptual design for treatment of up to 3 MGD portion of CCMUA's plant effluent to be utilized by Covanta as cooling water and other uses to be determined at a later date. D&B/Guarino also provided the conceptual design for the pump station, force main from the CCMUA plant to Covanta, electrical duct bank from Covanta to the CCMUA plant's main substation and electrical interconnect at the plant.

Greener by Design and its team of GridIntellect, BRS, and Compass, are the subconsultants providing the energy/electrical components of the conceptual design.

IV. Project Location

The project is located in the City of Camden, Camden County, New Jersey, connecting CCMUA and Covanta by approximately 7,600 feet of local roadways, shown in Figure 1.

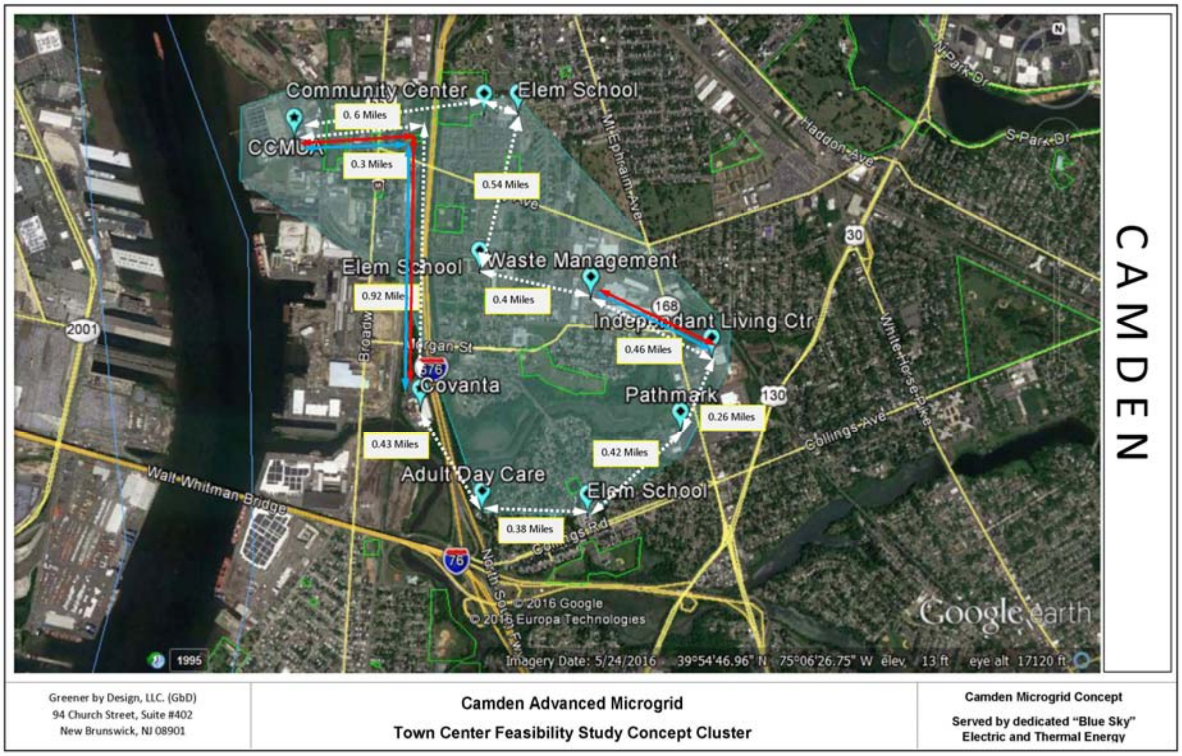
Figure 1: Map of Primary Participants in Sustainability Loop

Camden Microgrid

Figure 2: Preferred Alternative – Electric, Water Right of Way Mapping for Interconnection

Preferred Alternative

Figure 3: Camden MG Study Area



V. Project Description

In July 2017, At CCMUA's request, Greener by Design prepared the "Camden County Resiliency Energy Hub Microgrid Application", a proposal that was approved by CCMUA and NJBPU. The proposal examined the possibility of using the existing rights of ways to connect Covanta with the CCMUA and allow them to exchange electrical and thermal energy during emergency and non-emergency times based on the needs of the CCMUA and its connected microgrid community partners. The interconnection of the two facilities will allow Covanta to use treated wastewater for its power production operations, replacing its current use of ground/potable water. CCMUA along with its project team, D&B/Guarino Engineers and Greener by Design, developed a conceptual design of a "Sustainability Loop" which involves transmission of green energy from Covanta to the CCMUA's wastewater treatment plant, and water reuse from the plant's effluent to Covanta.

The Sustainability Loop is designed to have the CCMUA send Covanta its treated Treatment Works Effluent (TWE) to use as cooling water for Covanta's waste-to-steam on Holtec Blvd in

Camden, NJ (formally Morgan Blvd). In turn, Covanta would send the CCMUA electricity at a lower price than it pays now. With the completion of this project, the CCMUA would be 100% off the grid and 100% resilient in the face of power outages. The goal is to power the CCMUA with sludge, waste and the sun by the end of 2019. and Covanta would reduce or eliminate the use of ground/potable water for cooling operations. Once the system is operational, Covanta and CCMUA will have the capacity to use CCMUA right of ways to connect additional critical electric loads in the surrounding area. The connecting infrastructure could be owned and operated by CCMUA, provided a financial structure is approved by the NJBPU.

The conceptual design includes the development of:

1. A transformer at the waste to energy facility
2. A black-start system at the waste to energy facility
3. Energy transmission line from the waste to energy facility to the CCMUA's plant
4. TWE polishing treatment facility
5. TWE pumping station at the CCMUA plant
6. TWE force main from the CCMUA plant to the waste to energy facility

This report provides the technical and cost data for treatment alternative of CCMUA's plant effluent for water reuse at Covanta as well as the force main and electrical duct bank site location options and routes from the CCMUA plant to Covanta. The complete conceptual design will be submitted to NJBPU and NJDEP for review and approval as the project moves forward.

During initial investigations, Covanta provided acceptable limits for TWE meeting a requirement of 2-3 ppm of total suspended solids; however, Covanta updated their requirements to include ammonia and turbidity limits.

A treatment system that provides TWE to Covanta needs to include: pumps, water storage, and distribution pipeline. Based on those needs, the team performed a cost benefit analysis and the resulting analysis is outlined in this report.

The microgrid working team also conducted a cost benefit analysis of the benefits of constructing a thermal loop as part of the overall connecting infrastructure. This loop is designed to capture Covanta's waste thermal energy and recirculate that along the proposed Sustainability Loop right of way. An analysis is provided in this report (Addendum 3) but a brief overview shows that with investments in cogeneration at the CCMUA, and the recent investment of a variety of onsite generation assets at several of the large energy users, thermal energy consumption is not sufficient to warrant the expense of the connection and infrastructure necessary to maintain it.

Beyond the TWE system, the Sustainability Loop required design and modeling of its electrical system. The microgrid was modeled with HOMER Pro and Distributed Energy Resources Customer Adoption Model (DER-CAM) software, using an Energy First Portfolio Approach that optimizes asset-level operations for economic benefit. This includes operating combined heat and power (CHP) in continuous-duty full loading, instead of load-following operation, to minimize fuel cost, maintenance, and under-utilized capital assets. The photovoltaic (PV) generation supplements the system with available energy. The Sustainability Loop's two-turbine power generation meets any other load, while the energy storage operates to maximize economic and resiliency benefits. In very rare cases, when Covanta cannot meet the Sustainability Loop power and energy demands, the grid fulfills it in a load following mode. The connection to the grid will also be used to manage the voltage and frequency of the microgrid. The Energy First Approach relies on integrating energy storage to provide multiple functions, even at the same time, to the microgrid. These include basics like voltage support and frequency support. The system's conceptual design indicates that the load is met using onsite generation during hours of operation more than 80 percent of the time throughout a year while the rest of the hours are met with assistance from the utility grid. HOMER Pro is a microgrid software tool originally developed by the National Renewable Energy Laboratory (NREL) and enhanced and distributed by HOMER Energy. HOMER Pro uses simulations, optimization, and sensitivity analysis and nests three integrated tools in one software product, allowing microgrid design and economics to be evaluated concurrently. DER-CAM is a powerful and comprehensive decision support tool that helps to determine optimal distributed energy resource (DER) investments in the context of either buildings or multi-energy microgrids. DER-CAM uses advanced mathematical modeling techniques to formulate the optimal multi-energy microgrid design problem as a mixed-integer linear program (MILP). Unlike simulation-based models or optimization models based on heuristic and non-linear formulations, this allows DER-CAM to quickly find globally optimal solutions to a highly complex problem.

D&B/Guarino provided the technical and cost data for treatment of CCMUA's plant effluent for use by Covanta and the force main and electrical duct bank site location options and routes from the CCMUA plant to Covanta. GbD provided the technical and cost information for the electrical/thermal microgrid for the Feasibility Study (Addendum 1).

A. Critical Facility Electrical and Thermal Loads & Square Footage

The Covanta Camden Energy Recovery Center is a mass burn facility that serves Camden County. It is an 18-acre facility that began commercial operation in July 1991 and was acquired by Covanta in August 2013. The facility runs three boilers, processing approximately 1,050 tons of solid waste each day and producing a net output of 21 megawatts. Its Air Pollution Control Equipment includes semi-dry flue gas scrubbers injecting lime, fabric filter baghouses, nitrogen oxide control system, mercury control system, and a continuous emissions monitoring (CEM) system. The Energy-from-Waste System has three mass burn 350 ton per day boilers supplying steam to a common header spinning two 16.85MVA turbine generator sets and fed by two overhead P&H motorized grapple cranes. Combustion is controlled by an ABB S+ distributed control system and a Forney burner management system. The Energy Generation process includes two Franco-Tosi turbine generator sets coupled to ABB generators; the net output at full 3 boiler load is approximately 21 MW and has produced approximately 91% on an average daily basis over the last 3 years. Based on the economic models and the cost benefit analysis of an average rate of 0.07 cents per kwh, CCMUA will need to purchase approximately 2 MW of energy on a daily basis.

Currently, Covanta uses ground/potable water for its power production operations. Covanta's current facility's water usage is as follows:

- Cooling tower and Scrubber – 800,000 gallons per day.
- Boiler make-up – 65,000 gallons

Figure 4: Covanta Camden Energy Recover Center, Main Entrance

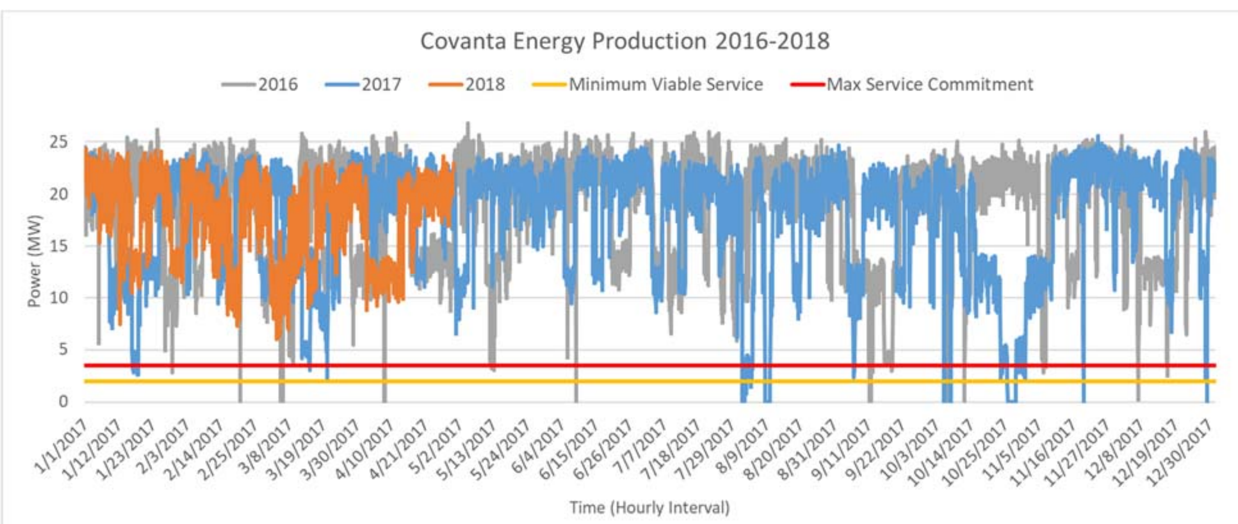
Covanta Camden Energy Recovery Center	
Address: 600 Morgan St, Camden, NJ 08104	
Facility Type: Recycling Center	FEMA Category: Risk Category III

Contact Information: Rick Sandner	
	RSandner@covanta.com

Hours of Operation: 24/7	Total Sq Footage: 120,000
Electric Load: 21 MW net output	Gas Load:
Energy Efficiency/Energy Conservation Measures: No	

The design team reviewed the energy production at the facility for the last three years (2016-present). Covanta's excess energy production capabilities need to be reliable and resilient for the microgrid operation to exceed utility grid reliability. The below graph, *Figure 5*: Covanta Energy Production 2016-2018, shows the total energy production onsite each hour. The data is not net production, which varies per operations and cannot be disclosed. Covanta can commit to the service range for CCMUA in the near term, shown between the yellow and red lines of 2.0MW and 3.5MW, respectively. Covanta has availability to provide approximately 11MW to the Sustainability Loop, with sufficient demand.

Figure 5: Covanta Energy Production 2016-2018



Historically, the production dropped below this maximum service level 21 times over three years for approximately 340 hours, and below the minimum viable service level for 231 hours. None of these reduced production hours occurred in 2018. See *Figure* and *Figure* for histograms of production output for Covanta for 2016 and 2017, with the green box highlighting hours below the maximum service commitment.

Figure 6: Covanta Production Histogram 2016

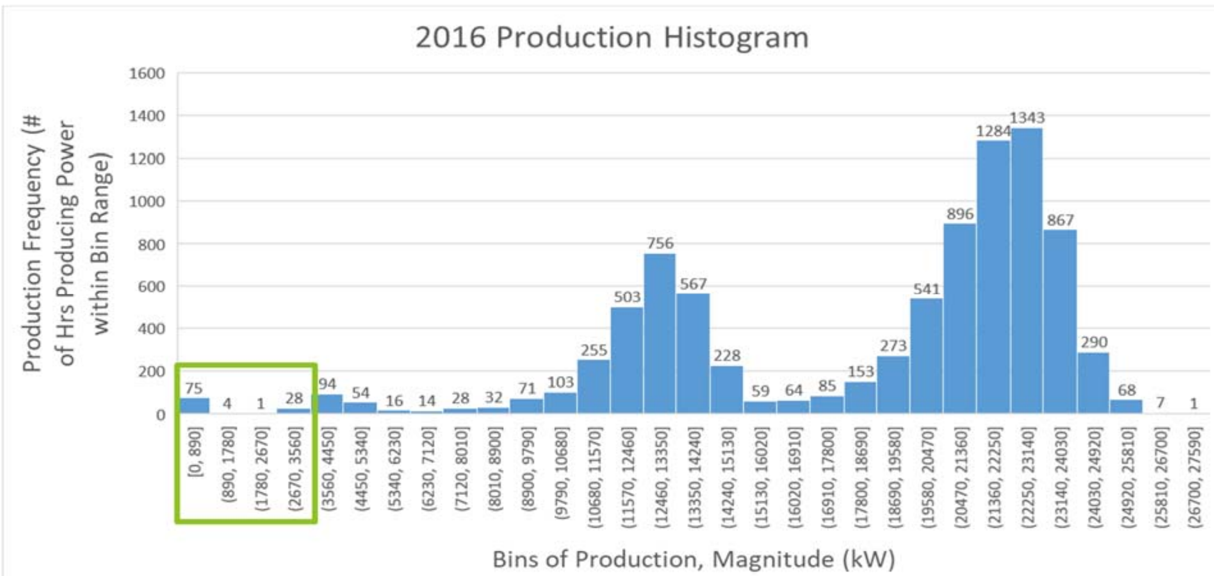


Figure 7: Covanta Production Histogram 2017

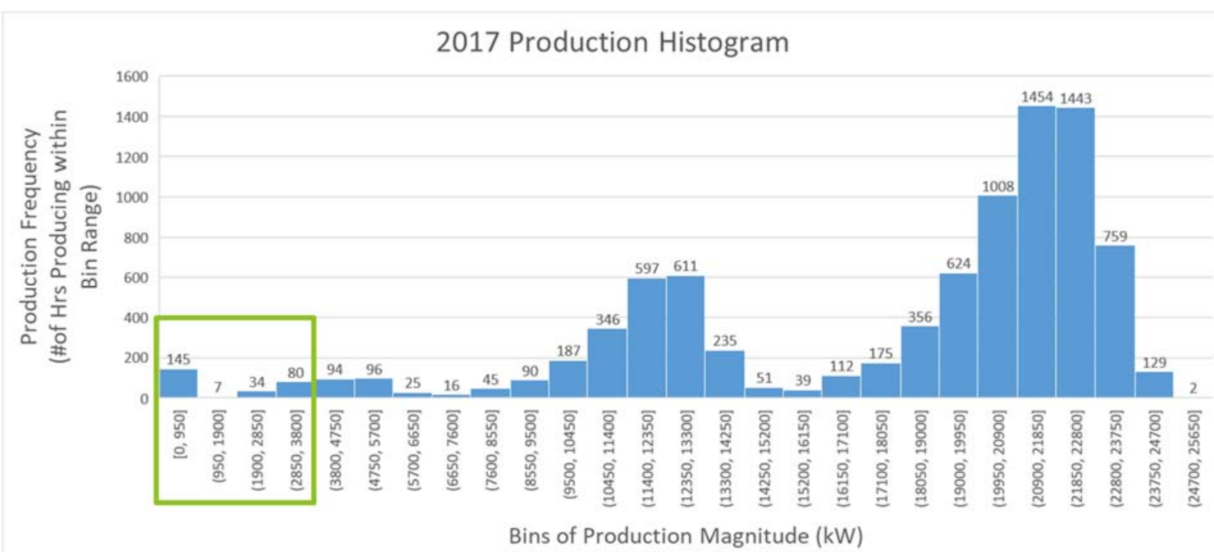
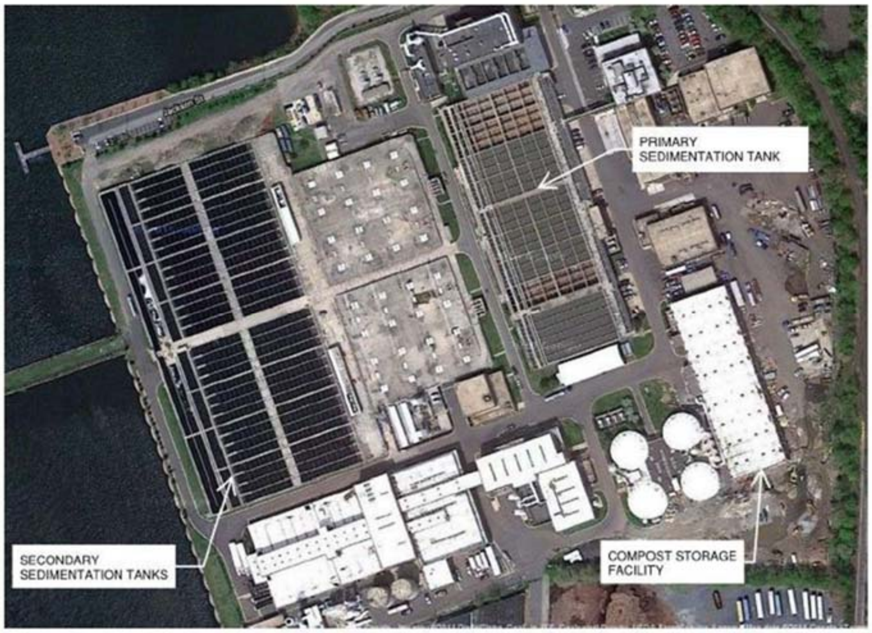


Figure 8: Camden County Municipal Utilities Authority, Bird's Eye View



Camden County Municipal Utility Authority	
Address: 1645 Ferry Ave, Camden, NJ 08104	
Facility Type: Water Pollution Control Plant	FEMA Category: Risk Category III

Contact Information: Andy Kricun	
(856) 583-1223	andy@ccmua.org

Hours of Operation: 24/7	Total Sq Footage: 300,000
Electric Load: 33,067,089 kWh, 4800 kW peak	Gas Load: 1,260,000 Therms Sludge Drying + 300,000 Therms Heating + 18,000 Therms miscellaneous = 1,578,000 Therms
Energy Efficiency/Energy Conservation Measures: Yes	

The wet and dry flow analysis of the facility shows a varying energy use between 1.25 MW and 4.14 MW based conditions. CCMUA owns and operates 25 pump stations located throughout Camden County. These stations have a combined load of approximately 1.1 MW during dry conditions and 2.5 MW during wet conditions. To provide a stable load profile sizable enough to facilitate the economic model, both the CCMUA facility and its various pump stations will need to be aggregated into a single procurement profile. One example is a main onsite account that can export and offset other accounts through virtual net metering (VNM), which will be referenced in this report

The CCMUA Delaware No. 1 Water Pollution Control Facility (WPCF) currently serves 37 communities and treats, on average, 55 million gallons a day of wastewater. Wastewater entering the facility undergoes pumping, preliminary treatment (screening and grit removal), followed by primary and secondary treatment (gravity sedimentation, oxygen activated sludge treatment and clarification) followed by disinfection by Sodium Hypochlorite. After disinfection, the final effluent is discharged to the Delaware River. CCMUA's New Jersey Pollution Discharge Elimination System Permit limits and average monthly values for 2017 are found in *Table 1* below.

TWE site treatment would require additional biological and physical treatment, disinfection and pumping facilities. The goal of this analysis is to site these facilities in areas available at the wastewater treatment plant and to lessen their impact on the wastewater treatment operations. The area available for the TWE site treatment facilities is approximately 17,500 SF (0.4 acres) located north of the existing secondary clarifiers (*Figure 15*.).

There are important DER existing (or in phases of installation and commissioning) at the CCMUA site. The three sections of solar arrays total 1,807 kW (STC rated DC) of Canadian Solar 250W modules, each section with a 500kW SMA Sunny Central inverter. The tilt angles vary from 12.5-15 degrees and the array azimuth is 160 degrees universally. The project was commissioned and began operating in 2011 through a Power Purchase Agreement over a 20-year term. The annual solar production provides approximately 2,529,000 kWh, or 9.75 percent, of the onsite electrical load, without export.

Another project underway includes adding DER in the form of 1,900kW (continuous electrical output) of combined heat and power (CHP). The General Electric Jenbacher 612 GS-F25 has flexible fuel inputs of biogas and natural gas and will use all recovered heat and electric onsite, without export. At full load, the electrical efficiency ranges from 43.7-44.4 percent, depending on fuel source. The permissible overspeed is 2,250 rpm vs. the operating 1,800 rpm. This overspeed function allows for short-term power balancing, ride-through provisions during islanding or grid-connection transitions, mandatory PV disconnection during loss of grid, and onsite critical load modulation to match available power.

Table 1: Summary of CCMUA Utility Load Data Provided and Used

Fuel Type	Electric	Natural Gas
Months of continuous usage	Sixteen (16) from PSE&G (kWh/kW)	Twenty-four (24) from PSE&G (therms)
Time Period of Data	July 2016 – November 2017	July 2016 – June 2018
Intervals of Data	15-min load profile, monthly for VNM accounts	Hourly load profile generated using proprietary 8760 hour Excel tool
Data Used in Model	Used May 2017-May 2018	May 2017-May 2018
Modifications Required	See table of Quality Assurance steps completed	Used local "Large Hospital" gas load profile from OpenEI, scaled for monthly bill amounts

The available load data for CCMUA is summarized in *Table 1*. The data for the onsite and VNM electric consumption, is represented in *Figure* and *Figure* , respectively. *Figure* shows the original PSE&G data from May 2017 through April 2018. VNM is the remote net metering credit system which allows power producers to offset electricity purchases by crediting meters located remotely off-site. The color chart shows each hour of the day (y-axis) versus each day of the year (x-axis). The color range on the right (purple is low consumption, red is high/peaking consumption) spans 6MW. Data anomalies, such as nearly three months of absent interval data, one power outage, and one demand surge required modification of the load curve. The consumption data also obfuscates the onsite solar production, which needed to be explicitly shown in modeling. The billed energy (kWh) and power (kW) amounts for the most recent 12 months are shown in *Table 2*, including the Main Plant and VNM accounts. These values were used to calibrate the given PSE&G load profile data, with its gaps and anomalies, to actual billed data from PSE&G. The resulting load profile, post-quality assurance controls and calibration, is shown in *Figure* .

Figure 9: CCMUA Site Energy Load, Original and Unedited

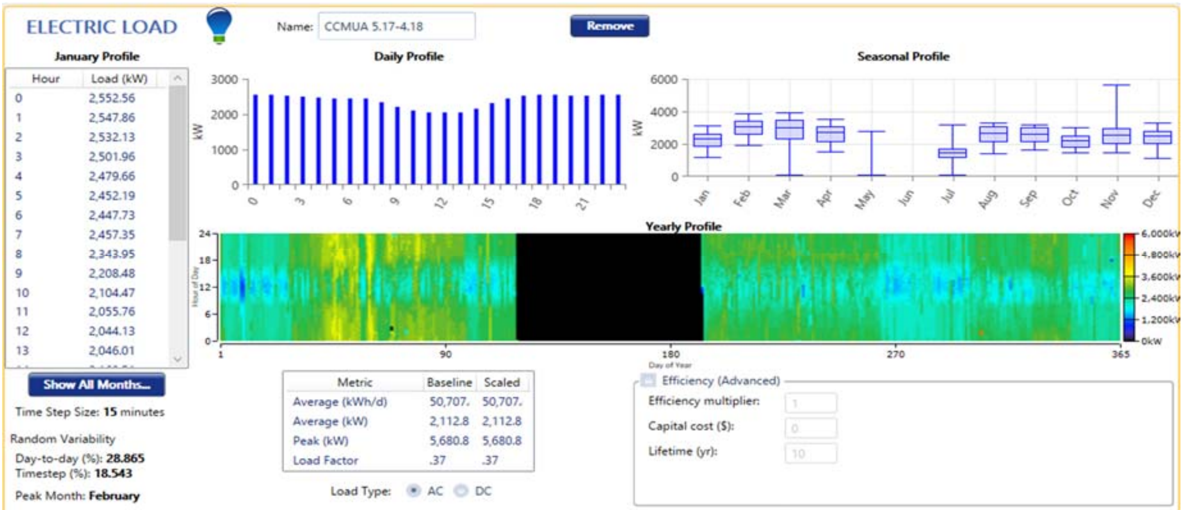
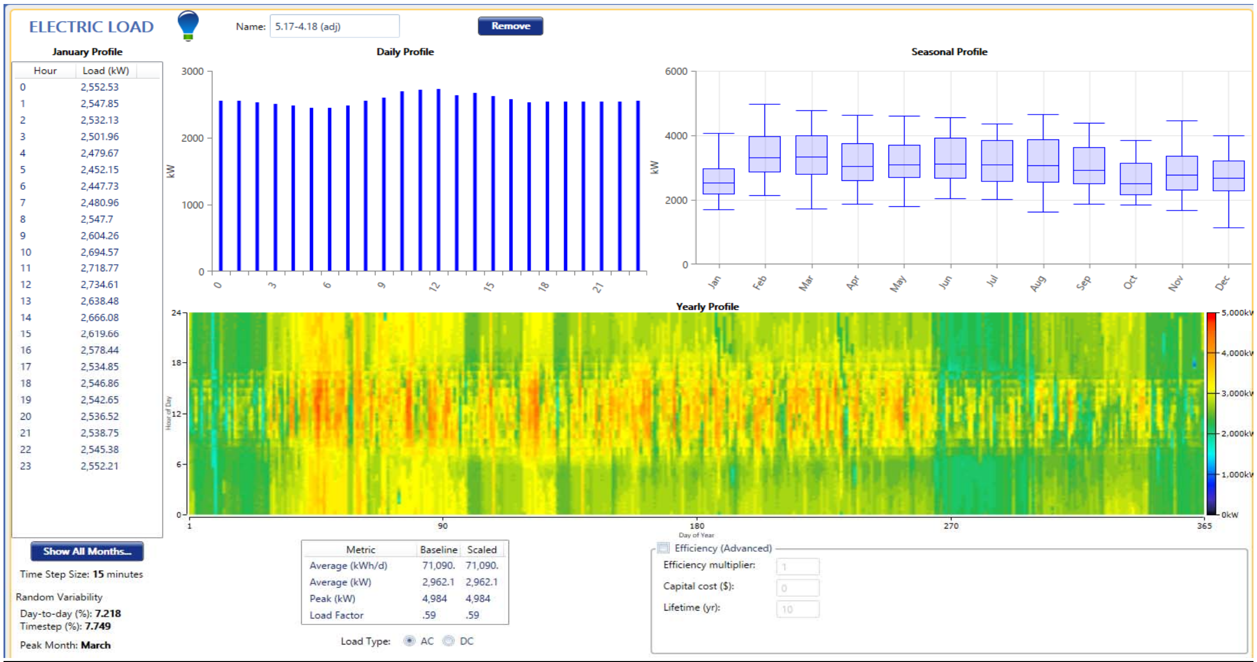


Table 2: CCMUA Onsite and Virtual Utility Data, Excluding DER

Month	CCMUA onsite data (Main Plant) – N2 (Excludes DER Production)				VNM Accounts – N3
	Electricity:Facility [kW](Hourly)		Gas:Facility [kW](Hourly)		Electricity [kW](Monthly)
	Usage (kWh)	Demand (kW)	Usage (Therms)	Usage (kWh)	Usage (kWh)
January	2,891,001	5,065.2	130,235	3,815,886	824,837
February	2,691,622	4,720.8	79,025	2,315,433	837,699
March	3,331,973	4,375.2	78,461	2,298,907	861,070
April	2,934,943	4,568.4	41,578	1,218,235	784,592
May	2,813,028	5,140.8	60,727	1,779,301	774,639
June	3,109,690	4,622.4	98,874	2,897,008	752,986
July	2,537,204	4,989.6	110,718	3,244,037	719,118
August	2,587,018	4,784.4	119,062	3,488,517	727,272
September	2,668,408	4,600.8	108,113	3,167,711	700,678
October	2,854,216	4,482.0	84,759	2,483,439	727,509
November	2,679,604	4,665.5	97,721	2,863,225	790,596
December	3,070,816	4,698.0	130,235	3,815,886	853,802
Totals/Peak kW	*34,169,523*	*5,065.2*	*1,139,508*	*33,387,584*	9,354,798

Figure 10: CCMUA Site Electric Load, Final and Calibrated



CCMUA has critical operations to maintain during all hours, and also has a large number of smaller, remote electrical loads in the local area, outside of the proposed Sustainability Loop microgrid. These accounts could benefit from VNM, instead of a time-of-use rate, through export production through Covanta during grid-connected, "blue sky" operations. The monthly consumption trends for each account and in aggregation is visualized in *Figure* and *Figure* , respectively. Since these meters and water pump stations are outside of the Sustainability Loop, production and consumption are not required to match, as resiliency and the related hourly fluctuations can be averaged over the month. If PSE&G required time-sensitive matching of Covanta production with CCMUA VNM water pumps, appropriate smart meters would be necessary for each of the accounts in *Figure* , which may not be present today, and the respective load profiles provided for the next stage of analysis. Estimates of water pump station consumption can be modeled for aggregated accounts using *Appendix Table* 1: of "Assessment of Electrical Load in Water Distribution Systems Using Representative Load Profiles-Based Method" **(**See Appendix**)**.

Figure 11: CCMUA Electricity Consumption for 24 Months - VNM Accounts

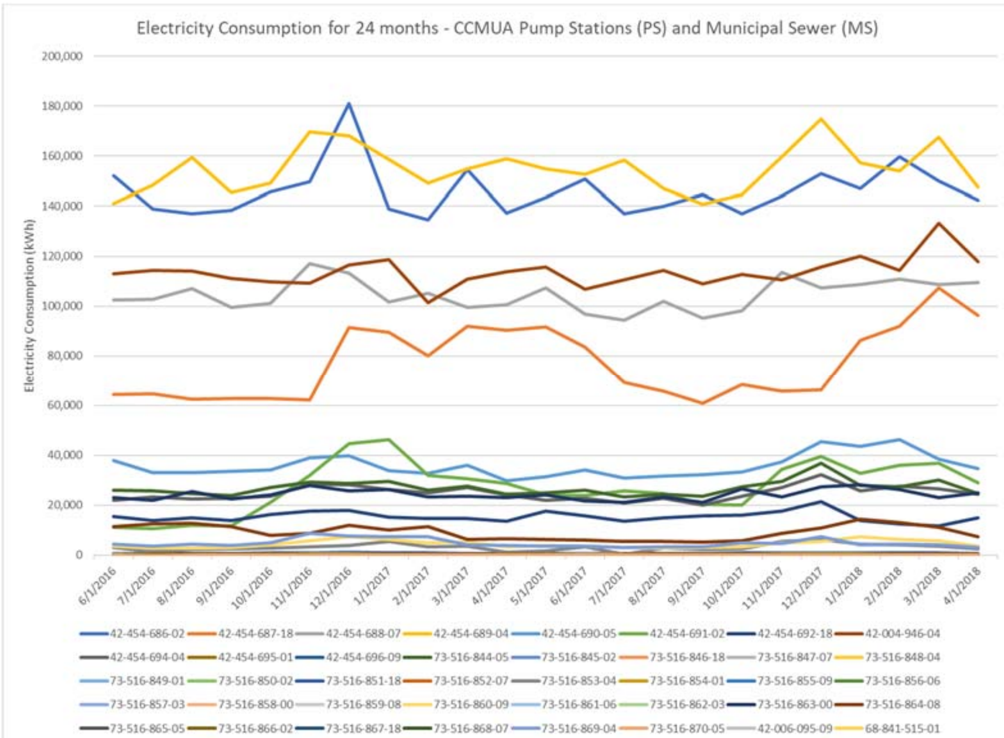
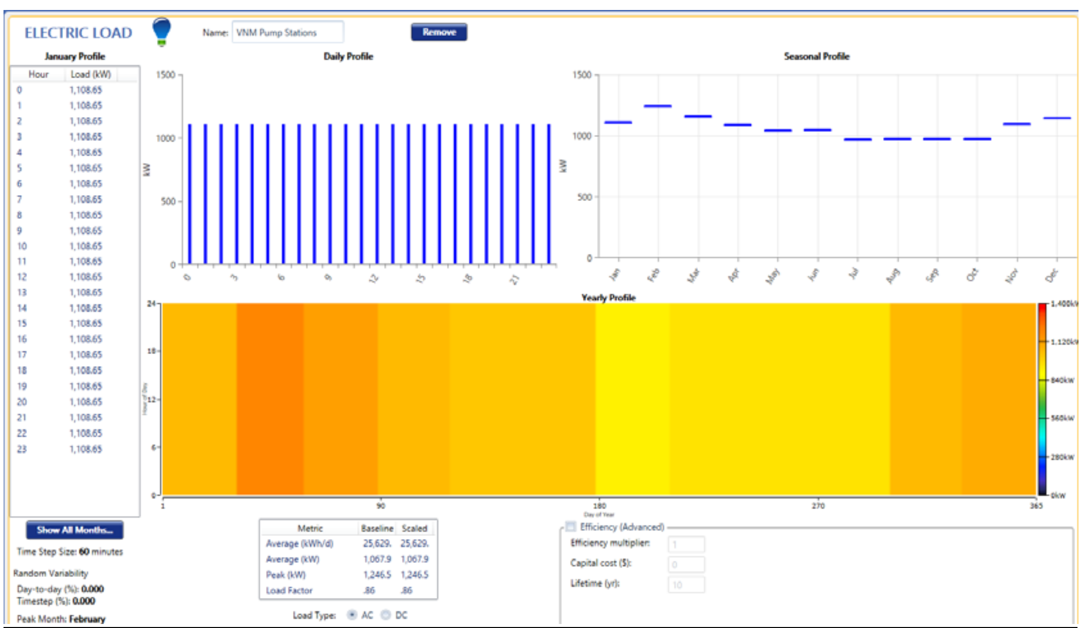


Figure 12: CCMUA Offsite Electric Load - VNM Accounts



B. Total Microgrid Project Electrical and Thermal Load

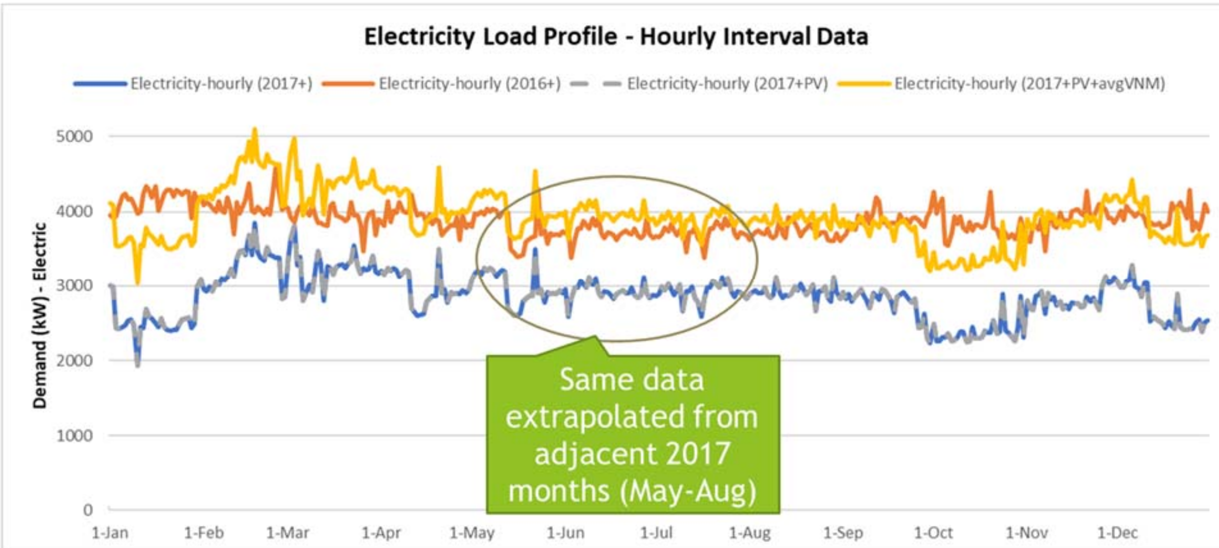
The total microgrid project loads for the first phase of the Sustainability Loop include the CCMUA onsite and VNM account loads. The consumption profiles for the aggregated onsite and VNM accounts are compared in *Figure 1*, showing progressive quality assurance steps for 2017-2018 data, with 2016-2017 data shown for context. The circled area was calibrated based on monthly-billed data and extrapolated electrical interval data, given the gaps existed for both 2016 and 2017 data. *Table 2*, shown previously, shows the total microgrid loads (excluding DER), separated by nodes/electrical buses. Node 1 (N1) is Covanta, Node 2 (N2) is CCMUA onsite, and Node 3 (N3) is the CCMUA VNM accounts. For the rest of the report, these naming conventions may be used interchangeably with the respective descriptions. N1 is treated as an export-only node, N2 includes both consumption and production (net-import), and N3 is a virtual load as only consumption. *Table 2* values for N2 do not reflect consumption of the existing and planned DER. *Table 3* shows the estimated values of N2, accounting for DER production.

Table 3: CCMUA Onsite and Virtual Utility Data, Including DER

Month	CCMUA (Main Plant) – N2 (Includes DER Production)				
	Electricity:Facility [kW](Hourly)			Gas:Facility [kW](Hourly)	
	Usage (kWh)	Generation (kWh) - CHP	Generation (kWh) - PV	Usage (kWh) – current equipment	Usage (kWh) - CHP
January	1,141,471	1,413,600	179,776	3,506,061	3,499,010
February	976,555	1,276,800	234,627	1,705,749	3,160,396
March	1,145,803	1,413,600	222,386	1,539,656	3,499,010
April	1,093,850	1,368,000	281,258	206,565	3,386,139
May	1,340,893	1,413,666	313,326	864,149	3,499,010
June	1,479,652	1,368,000	321,299	2,357,017	3,386,532
July	1,826,186	1,413,789	253,678	2,754,852	3,499,478
August	1,556,631	1,413,684	285,541	3,031,157	3,499,010
September	1,444,932	1,368,000	289,431	2,681,747	3,386,139
October	1,548,840	1,413,736	271,389	1,751,471	3,499,324
November	1,752,304	1,368,000	166,648	2,279,185	3,386,139
December	1,783,915	1,413,600	149,223	3,508,373	3,499,010
Totals/Peak kW	*17,091,033*	*16,644,475*	*2,968,582*	*26,185,982*	*41,199,196*

After these steps to qualify and validate the electrical data, the resulting loads were processed for use in both HOMER Pro and DER-CAM modeling software and are available upon request.

Figure 1: CCMUA Electricity Load Profile-Hourly Interval Data, Variation Due to Year, DER, and Offsite Loads Calibration



C. Critical Facility and Overall Project Energy Costs

As Camden's Electric Distribution Company (EDC), PSE&G serves CCMUA under the High-Tension Service tariff[1], which includes the follow components, as per the April 1, 2018 effective notice. *Table 4* shows these values including and excluding NJ Sales and Use Tax (SUT), below. Slight variations from these published values were present on available 2016-2017 CCMUA bills (PDF), and are noted in the final column. Slight variations are expected and demonstrate reasonably similar electric rates in 2018 as 2017.

Table 4: PSE&G High Tension Service (Sub transmission Voltage) Rate Tariff

High Tension Service (Sub transmission Voltages)	Published Value without SUT	Published Value with SUT	Billed Value (2017)
Service Charge ($ per month)	$1,911.39	$2,038.02	$2,044.90
Usage Charge ($ per kWh)	$0.0000	$0.0000	$0.0000
On-Peak ($ per kWh)	N/A	N/A	$0.001276002
Off-Peak ($ per kWh)	N/A	N/A	$0.001276002

[1] https://nj.PSE&G.com/aboutPSE&G/regulatorypage/-/media/A54279A4641A4FDC8BA14736B51CFE90.ashx (page 133 of 180)

Societal Benefits Charge ($ per kWh)	$0.007136	$0.007609	$0.007645902
Non-utility Generation Charge ($ per kWh)	$0.000089	$0.000095	N/A
Commercial and Industrial Energy Pricing (CIEP) Standby Fee ($ per kWh)	$0.000150	$0.000160	N/A
System Control Charge ($ per kWh)	$0.0	$0.0	N/A
Solar Pilot Recovery Charge ($ per kWh)	$0.000068	$0.000073	N/A
Green Programs Recovery Charge ($ per kWh)	$0.001006	$0.001073	N/A
Third Party Supplier ($ per kWh)	N/A	N/A	$0.07675
Solar PPA ($ per kWh) (20 years)	$0.0483		
Demand Charge ($ per kW per Annual Peak month)	$0.9701	$1.0344	$1.118030268
Generation/Transmission Demand (summer)	$3.5067	$3.7390	$ 3.7390
Generation/Transmission Demand (winter)	$0.0	$0.0	$0.0
Winter Season: Defined as October 1 to May 31 Summer Season: Defined as June 1 to September 30 On-Peak: 8am – 10pm weekdays Off-Peak: all other times			

Based on this rate structure, the energy costs for N2 are reported in *Table 5*.

Table 5: Simulated Electricity Costs (USD), based on HTS Rate Structure, when Applied to Modeled Load Profile from May 2017 - April 2018

Bill Component	Fixed Charges	Demand	Grid Purchases	Total w/ Tax	Average Rate USD/kWh
Month					
January	$2,077.11	$5,783.06	$240,544.81	$248,404.98	$0.0870
February	$1,876.10	$5,188.96	$221,544.35	$228,609.41	$0.0869
March	$2,077.11	$4,993.89	$248,021.46	$255,092.45	$0.0866
April	$2,010.10	$5,135.98	$241,390.23	$248,536.32	$0.0867
May	$2,077.11	$5,375.02	$234,944.43	$242,396.55	$0.0869
June	$2,010.10	$22,769.67	$257,549.80	$282,329.57	$0.0923
July	$2,077.11	$23,756.42	$215,153.26	$240,986.78	$0.0943
August	$2,077.11	$22,569.28	$218,653.27	$243,299.66	$0.0937
September	$2,010.10	$22,122.53	$224,865.98	$248,998.62	$0.0933
October	$2,077.11	$4,834.80	$237,866.62	$244,778.52	$0.0867
November	$2,010.10	$5,052.38	$230,786.78	$237,849.27	$0.0868
December	$2,077.11	$5,301.66	$263,168.24	$270,547.01	$0.0866
Total	$24,456.24	$132,883.65	$2,834,489.23	$2,991,829.12	$0.0889

The electrical costs for the VNM Accounts include supply charges, sometimes noted as the Price-to-Compare on billing records. *Table 6* shows the monthly, aggregated supply charge across 33 accounts, regardless of rate structure and potential demand charges. In a VNM approach, demand charges and other fees will not be avoidable and are not included in the economic optimization.

Table 6: CCMUA Electric Supply Charges, VNM Accounts

Month	VNM Accounts – N3
	Supply Charge/Price-to-Compare ($)
January	$ 71,231.21
February	$ 60,613.95
March	$ 57,393.52
April	$ 48,038.90
May	$ 58,120.81
June	$ 56,677.89
July	$ 56,570.78
August	$ 47,526.96
September	$ 48,536.57
October	$ 50,783.21
November	$ 66,277.17
December	$ 93,775.34
Totals	$ 715,546.31

Additional data was provided for previous time periods for supply charges (2016-2017), as shown in *Table 7*.

Table 7: CCMUA Electric Charges 2016-2017

CCMUA Electric Costs – N2		Total (kWh)	PSE&G ($)	PSE&G $/MWh	South Jersey ($)	SJ $/MWh	Total $/MWh	Price to Compare
2017	Jan	3,124,882	35,676	11.42	239,825	76.75	88.16	$ 189,312.73
2017	Feb	2,844,437	33,168	11.66	218,302	76.75	88.41	$ 173,006.54
2016	Mar	2,761,487	34,078	12.34	202,885	73.47	85.81	$ 152,306.01
2016	Apr	2,813,100	34,279	12.19	207,381	73.72	85.91	$ 140,104.45
2016	May	2,525,674	31,860	12.61	188,605	74.68	87.29	$ 152,364.64
2016	Jun	2,870,910	54,720	19.06	214,386	74.68	93.74	$ 158,533.89
2016	Jul	2,797,545	52,473	18.76	208,908	74.68	93.43	$ 153,518.89
2016	Aug	2,614,003	52,762	20.18	200,851	76.84	97.02	$ 169,339.54
2016	Sep	2,607,930	50,439	19.34	200,385	76.84	96.18	$ 178,610.39
2016	Oct	2,941,858	35,576	12.09	226,043	76.84	88.93	$ 163,637.01

2016	Nov	2,461,349	25,678	10.43	189,122	76.84	87.27	$ 136,048.81
2016	Dec	2,821,710	28,612	10.14	216,811	76.84	86.98	$ 118,831.71
	Totals	33,184,885	469,321	14.14	2,513,503	75.74	89.89	$ 1,885,614.61

D. Boundaries

The proposal examined the possibility of using the existing rights of ways to connect Covanta with the CCMUA. The proposed electrical duct bank can be installed following the water force main route up to the Covanta's driveway and then along the west side of the facility's driveway. At the top of the driveway, the duct bank would veer right and follow the inside of the facility's fence line up to the existing electrical transformer yard. D&B/Guarino proposes a route along the 7,600 feet area between CCMUA and Covanta for the Force Main and Electrical Duct Bank (*Figure 2: Force Main and Electrical Duct Bank Utility Locations Map*). The TWE pipeline is a 7,600 linear feet 12-inch distribution pipeline which will include 4 railroad crossings.

E. Emergency Shelter Facilities

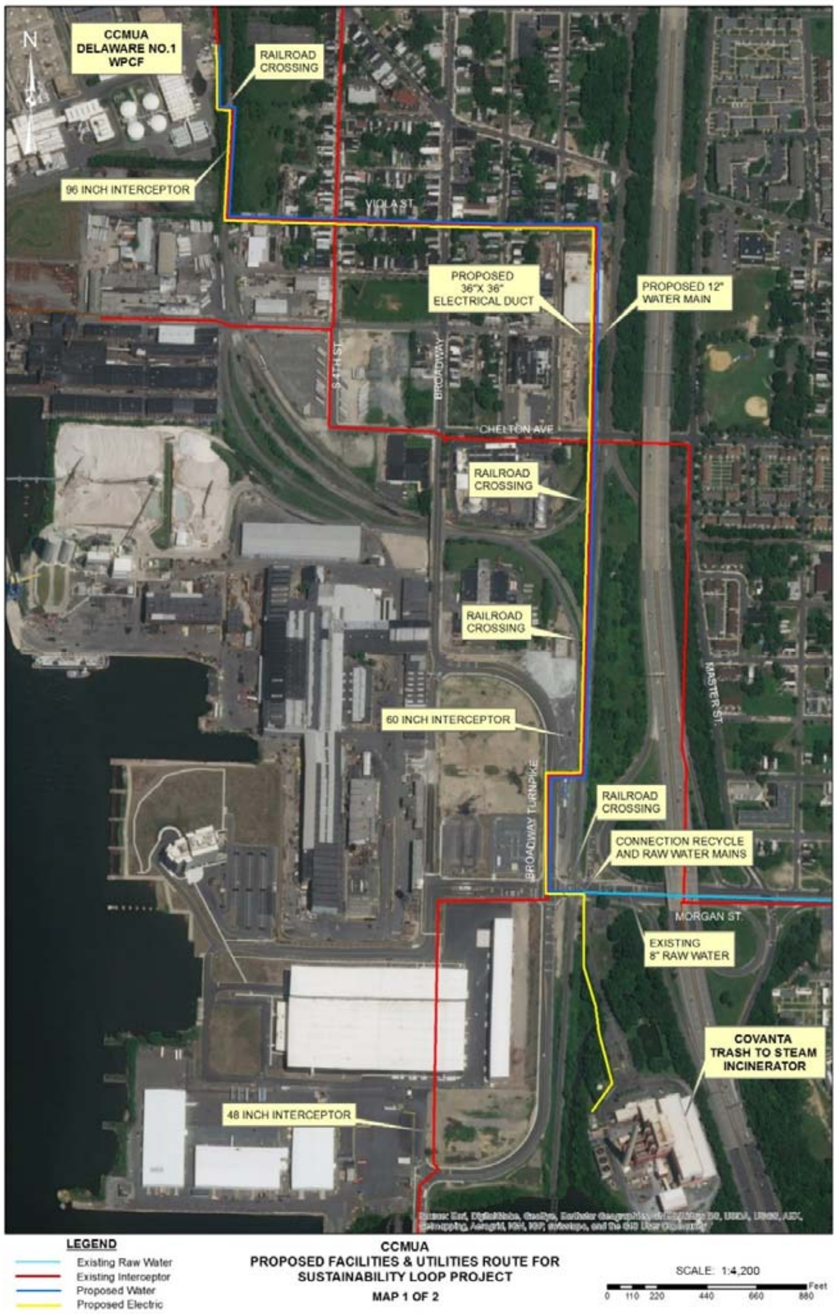
The CCMUA has office and emergency service capacity to host a variety of community and emergency service needs such as communication, charging and shelter of last resort. CCMUA has a conference room, bathroom and shower facilities and communication and specialty equipment that can be critical during times of emergency. CCMUA will have an ability to run continuously for 14 days and has several sources of onsite power in addition to the proposed connection to Covanta. In addition, CCMUA is proposing a phase 2 of this proposal that includes the connection of emergency power to several schools and shelter of last resort locations listed in the facility outlines below. Each of the facilities will have a hard-wired connection to CCMUA and Covanta and will have the capacity to be operational during black sky conditions.

(None at this time, will write up possible connections)

F. FEMA Category Classifications

- CCMUA – State and Federal Critical Facility
- New Village Supermarket – State Emergency
- Citgo Gas – State Emergency
- Camden Housing Authority – State Emergency
- Riletta Elementary School and H. B. Wilson Elementary School – State Emergency

Figure 2: Force Main and Electrical Duct Bank Utility Locations Map



G. Permits

The following permits have been outlined for the Sustainability Loop:

NJDEP – Division of Water Quality approval for diversion of treated effluent water. *Time Line: 120 Days*

NJDEP Site Remediation and NJDEP Division of Land Use – General Permit approvals for the trenching and piping necessary to facilitate the interconnection of the facilities. General soil samples have been complete and based on the categorization the project engineers are confident that this will be a standard process not requiring special consideration for contaminated soils. *Time Line: 200 Days*

NJBPU – Interconnection of Covanta to CCMUA. *Time Frame: Unknown*

Table 8: Current NJDEP capacity permits:

Parameter and Units	Averaging Period	Effluent Limitations	2017 Average Monthly Values
Flow (MGD)	Monthly Avg Daily Max	Monitor and report only + special conditions	54.9 mgd
cBOD5 (mg/l)	Monthly Avg Weekly Avg	20 30	12 mg/l
TSS (mg/l)	Monthly Avg Weekly Avg	30 45	13 mg/l
Fecal coliform (geometric mean) (# per 100 Ml)	Monthly Avg Weekly Avg	200 400	4.7 col/ 100 mL
Oil and Grease (mg/l)	Monthly Avg Instant Max	10 15	3.2 mg/l
Temperature (Deg. C)	Minimum Monthly Avg	Monitor and report only	18.8 Deg. C
Ammonia	Monthly	Monitor only	25 mg/l
pH (SU)	Minimum Maximum	6.0 9.0	5.9 6.8
Chlorine Produced Oxidants (CPO)	Monthly Avg Daily Max	Monitor and report only	0.7 mg/l
Copper, Total Recoverable (ug/L)	Monthly Avg Daily Max	100	24.4
Zinc, Total Recoverable (ug/L)	Monthly Avg Daily Max	226	37.8

[A listing of all potential permits, permit issuing agency, and general timeframe for issuance.]

H. Currently Installed and Implemented Measures

CCMUA has taken a variety of measures to reduce cost and consumption. In 2013, CCMUA completed an energy audit report, covering 15 facilities owned and operated by CCMUA, including its Camden facility. Following the completion of the audit, CCMUA installed several LED fixtures, but without any occupancy sensors. CCMUA is preparing a bid to upgrade their motors and variable frequency drives, which is estimates to be completed in 24 months, once construction begins. CCMUA has plans for a cogeneration system that will provide 1,900 kW_{el} to the Camden plant and will be fully operational in January 2020 with use of natural gas and digester gas. CCMUA has opted not to upgrade their HVAC system, implement wind energy, or UV disinfection at this time, which is mentioned in the audit. Finally, while CCMUA did not implement the solar array recommended in the audit, it has operated a solar array since 2011 totaling 1,807 kW (STC DC) and is in operation under a 20-year PPA.

VI. Ownership & Business Model

From a business model perspective, the Sustainability Loop is broken into three distinct businesses:

- Treatment and delivery of cooling water by CCMUA
- Generation of electricity by Covanta through waste incineration
- Microgrid (including its battery storage capacity) is potentially a third business, interwoven into Covanta and CCMUA operations while standing separately.

<u>Water</u>

The current study examines the feasibility of new water polishing capabilities, including a pump station and a force main that would allow CCMUA to provide cooling water to Covanta, so that the Covanta facility can move away from its current dependence on potable water. It is assumed that these water-related assets will be owned and operated by CCMUA. The CAPEX of these assets is estimated to be $18M.

CCMUA does not want to fund the development of these assets directly. The Authority hopes to make use of low-cost loan dollars -- specifically, financing from the New Jersey Environmental Infrastructure Trust (NJEIT), which provides funds “to qualified municipalities, counties, regional authorities and water purveyors in New Jersey for the purpose of financing water quality infrastructure projects." The NJEIT provides a 2.1% blended state and federal loan rate that is supported by the NJDEP and the USEPA revolving loan programs. Conceivably, NJEIT could provide all the financing needed for the construction of the water-related assets. CCMUA can also issue low cost bonds to cover the construction costs.

The open question is whether CCMUA's commercial model will support the costs associated with the repayment of these loans. (This question was not a part of this study. Presently, it is assumed that CCMUA can support these costs.) The answer to this question will depend on the payment terms in any eventual water agreement between CCMUA and Covanta. Additional details regarding CCMUA's cost of operations and their projected pricing to Covanta will be required to identify the favorable terms required.

To summarize, CCMUA's development of these assets depends on the availability of low-cost financing and on an acceptable agreement with Covanta.

Electricity

Covanta aims to sell the electricity generated by its waste incineration process to CCMUA and potentially to other off-take customers. It currently sells electricity at a rate of $0.02/kWh but would like to establish new power purchase agreements at a higher rate. There is plenty of capacity to do so — the company has availability to provide a maximum of 11 MW to the Sustainability Loop.

Covanta could choose to operate as a retailer, providing power directly to off-take customers, and/or it could operate as a wholesaler, selling to a third-party who would in turn act as a retail distributor. While retail price points might seem attractive to Covanta, operating as a retailer could require Covanta to own and operate the microgrid and its assets, including battery storage. With the aim of de-risking the project for all concerned, it makes sense to consider the microgrid as a separate business, financed, owned, and operated by a third party.

Microgrid

The proposed Sustainability Loop Microgrid would provide new shape to Covanta's onsite power generation, providing electricity that could be distributed back to Covanta, to CCMUA and, potentially, to a large universe of off-take partners in the vicinity. It would provide resiliency, offering black-start capability to Covanta in the event of an outage.

As the range of the microgrid grows – through the addition of more off-take customers – the case for this microgrid project becomes more compelling from an investment perspective. As this report makes clear, along with CCMUA, there are multiple critical facilities near the planned microgrid which could benefit from the resiliency and locally-generated power offered by the Camden microgrid. While more study needs to be done to understand the full commercial model of the expanded microgrid, experience indicates that this expansion would prove commercially viable. (It will also be important to specify initial assets so that they can be scaled up effectively as the system expands.)

Along with the standard microgrid components (transformers, switches, relays, wires, etc. and controller), the assets to be located at Covanta include a transformer, an interconnect, a duct bank, and an energy storage system as part of a black-start facility. Along with the basic microgrid assets, the inclusion of battery storage (as part of the black-start facility) in the microgrid increases revenue opportunities for the microgrid owner, as the battery can be used to sell excess power into the distribution and transmission markets, along with frequency regulation and other services.

Our preliminary analysis assumes third-party ownership of the microgrid and battery storage assets. Assuming an unlevered return of 10% to the project investor, our analysis suggests that the project scope, as currently envisioned, is not commercially viable or financeable. As indicated by the chart below, the project is only feasible at a small scale if the battery asset is removed entirely. Conversely, if the scale of the project increases significantly, a financially viable result can be achieved. The potential levers available to create a viable project include:

- Negotiation of a lower energy purchase price from Covanta (i.e., lower than $0.07/kWh)
- Higher off-taker energy sale price, or resiliency / black-start fees from off-takers
- Reevaluation of the size/type/cost of the battery (or potential removal from stage 1)

In summary, CCMUA is proposing to own and operate the proposed distribution system between CCMUA and Covanta Camden. CCMUA is proposing to pay a fee in addition to the cost of the purchase of the electrons from Covanta to provide a long-term maintenance of the interconnection. In addition, CCMUA is proposing to own, operate and maintain the extension of the proposed distribution system beyond the initial connection between Covanta and CCMUA. CCMUA is proposing to charge a nominal fee to operate and maintain the distribution system for those facilities connected to the Camden Microgrid. CCMUA is already an NJ BPU regulated entity and has authority to charge rate-payers various fees for the use of its systems. Given CCMUA's existing capacity to maintain linear infrastructure, they do not believe this will be a challenge and there is potential economy of scale benefits to multiple linear.

VII. Technology, Business, & Operational Protocol

A. Proposed Connections

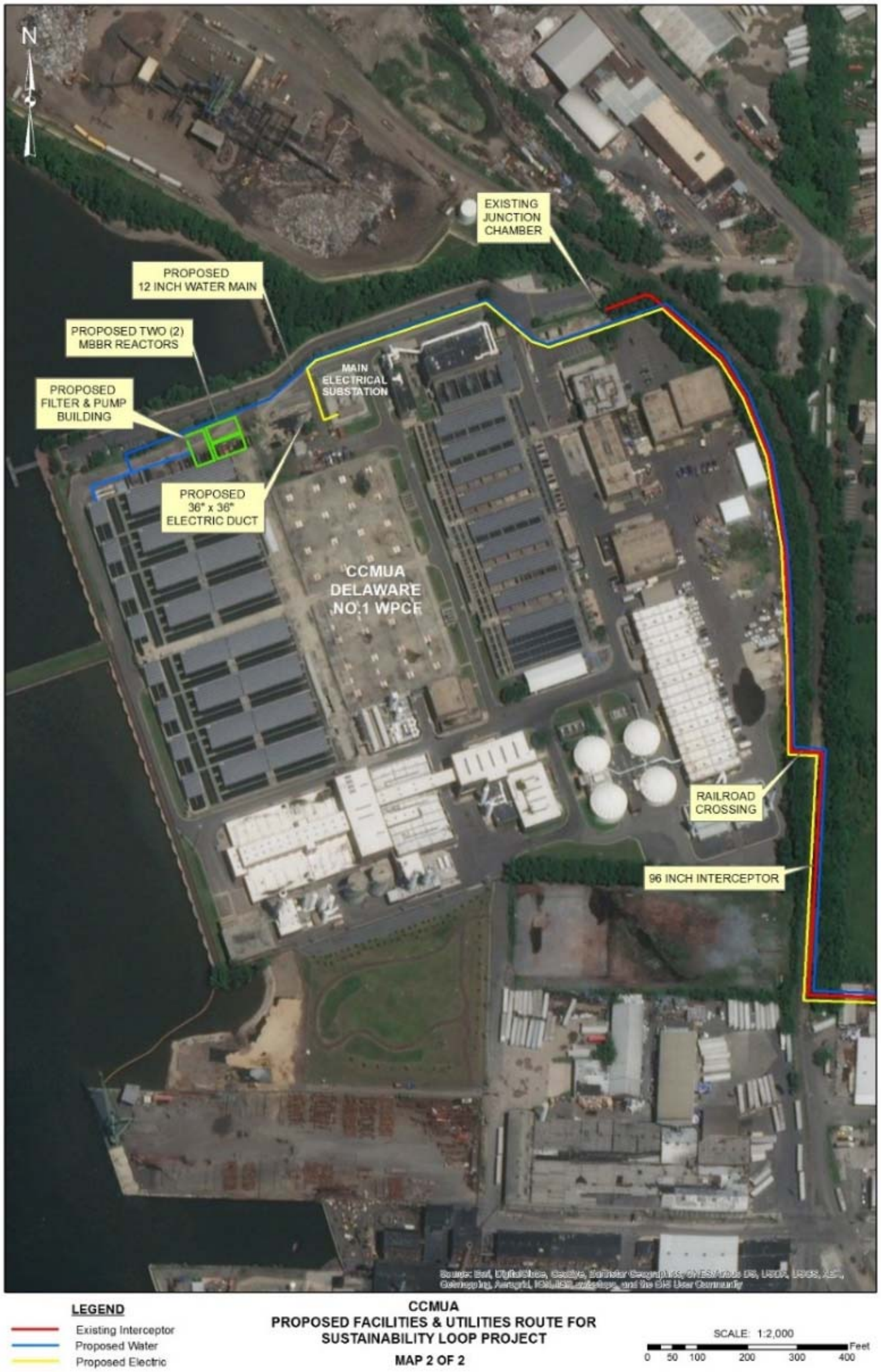
The Sustainability Loop extends between Covanta and CCMUA. Covanta has provided power to the PSE&G system with regularity. The current connection to the grid includes a substation at Covanta on feeder W-387, using transformers from Covanta's (13.8kV) buses to PSE&G's (26.4kV) distribution. Covanta also operates onsite buses at 4.16kV and 480V. Even though CCMUA also operates primarily on 4.16kV, the Sustainability Loop intends to serve many more customers than CCMUA. Since PSE&G operates at 26.4kV, maintaining the same voltage class allows more consistent, seamless, and supportive operation along PSE&G, as well as reducing the copper cabling required for lower voltage classes.

Covanta considered three main options for its interconnection point. One option shifted the power bus outside of Covanta's 13.8kV system and created a direct connection from PSE&G to the Sustainability Loop at 26.4kV. The design was difficult to implement, due to its impact on Covanta's operations and uptime. A second option maximized redundancy, duplicating multiple switches and transformers in an adjacent substation. The design increased costs for maintenance and initial capital while changing the existing interconnection with PSE&G. The third option was a hybrid of the first two options, balancing transformer redundancy, space constraints, plant downtime due to switchyard construction and costs. The resulting one-line diagram for the microgrid utilized the third option in the Covanta connections as shown in *Figure 16*.

At CCMUA, PSE&G provides two feeders at 26.4kV. The preferred feeder, A, is B-444 (normally closed), and the non-preferred feeder, B, is W-387 (normally open and connected to Covanta). Both sets of transformers operating from 26.4kV to 4.16kV are 50 percent sized, or said differently, can handle a full switch of load from one feeder to the other. Currently, there are no automatic switches and no remote operability. While PSE&G controls the equipment, CCMUA owns it and replaced redundant lines A and B within the last five (5) years. The switchyard was large and seemed to include sufficient space to add some new equipment and replace items with limited functionality. The planned CHP at CCMUA will operate at 4.16kV, while the existing PV operates at 480V on both the A and B lines of the primary and secondary pumps, back-feeding to the main bus to 4.16kV.

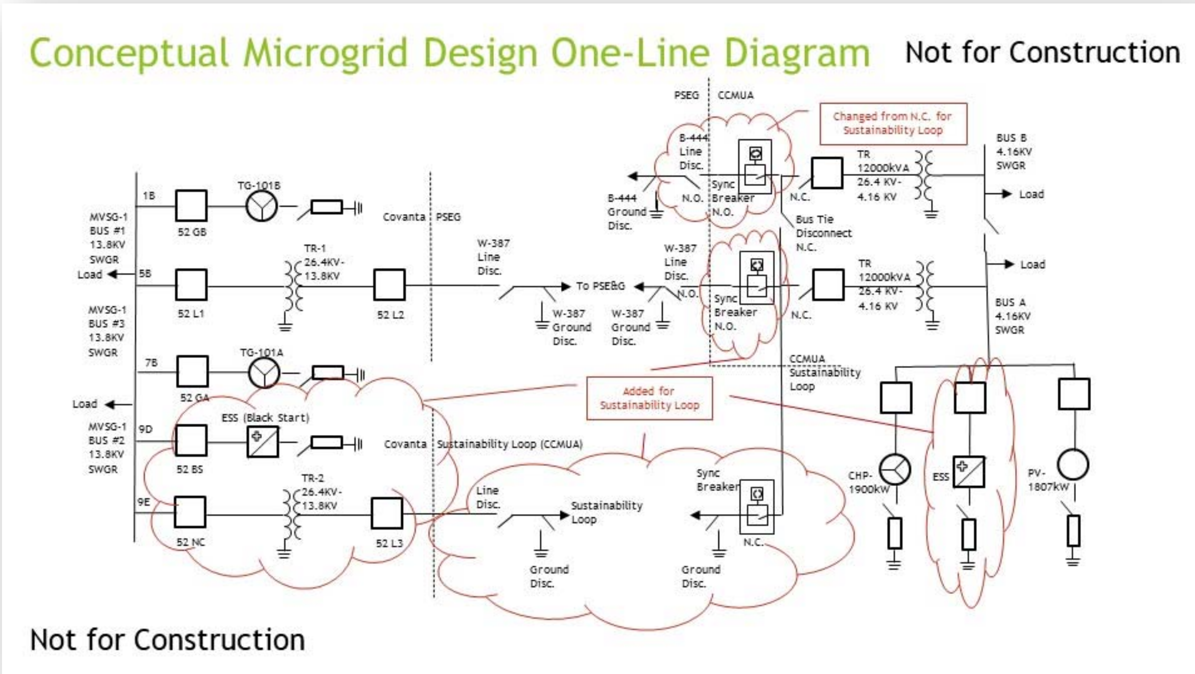
The Sustainability Loop operation will use three-phase, EPR-insulated copper line in the TWE ductwork, operating at 26.4kV. The interconnections at existing utility customer sites require introducing a Point of Common Coupling (PCC) to replace existing gear and to introduce automated, synchronizing switches. The PCC is discussed further in the following Distribution section. The utility routes near CCMUA are shown in *Figure 35*.

Figure 35: Proposed Facilities and Utilities Route at CCMUA



B. Connection Diagram

Figure 16: Conceptual Microgrid One-Line Diagram



C. Distribution System & Interconnections

The first item in considering the distribution system interconnection for the Sustainability Loop is the PCC. As shown in *Figure 16*, the PCC includes off-the-shelf components that either already exist in the system or are common in the utility system, plus a synchronizing breaker or switch. This structure, coupled with additional analysis compliant with IEEE 1547.4, enables the utility-controlled breaker or switch to immediately open (frequency = 59.3 Hz) on loss of the grid. The microgrid-managed synchronizing breaker will remain closed for a few more milliseconds until microgrid frequency reaches 57.0 Hz. Since the inverters and generator controls are operating based on the synchronizing breaker signals, these few additional milliseconds enable the energy storage and power electronics to better manage the transient as the microgrid resources pick up the portion of the load served by the utility grid just before the grid was lost. When, or if, the frequency dips to 57.0 Hz and the synchronizing breaker opens, the microgrid moves into island mode. The MGC will adjust all microgrid resources for island mode operational and performance objectives.

Both Covanta and CCMUA existing facilities and identifies available space at both facilities for the proposed Sustainability Loop facilities. In addition, this section focuses on the water component of the project, summarizing Covanta's requirements for acceptable TWE and CCMUA's current effluent quality.

To develop a conceptual design for a TWE side treatment system, some basic information is required. This includes design flows, constituencies to be removed and target effluent quality for those constituencies, and wastewater temperature.

Table 9: CCMUA NJPDES Permit Limits

Parameter and Units	Averaging Period	Effluent Limitations	2017 Average Monthly Values
Flow (MGD)	Monthly Avg Daily Max	Monitor and report only + special conditions	54.9 mgd
cBOD5 (mg/l)	Monthly Avg Weekly Avg	20 30	12 mg/l
TSS (mg/l)	Monthly Avg Weekly Avg	30 45	13 mg/l
Fecal coliform (geometric mean) (# per 100 Ml	Monthly Avg Weekly Avg	200 400	4.7 col/ 100 mL
Oil and Grease (mg/l)	Monthly Avg Instant Max	10 15	3.2 mg/l
Temperature (Deg. C)	Minimum Monthly Avg	Monitor and report only	18.8 Deg. C
Ammonia	Monthly	Monitor only	25 mg/l
pH (SU)	Minimum Maximum	6.0 9.0	5.9 6.8
Chlorine Produced Oxidants (CPO)	Monthly Avg Daily Max	Monitor and report only	0.7 mg/l
Copper, Total Recoverable (ug/L)	Monthly Avg Daily Max	100	24.4
Zinc, Total Recoverable (ug/L)	Monthly Avg Daily Max	226	37.8

Current Total Dissolved Solids (TDS) concentration in the CCMUA effluent are not monitored on the routine basis. However, several samples taken between February and March of 2017 averaged 477 mg/l.

In order for Covanta to replace its use of ground/potable water with CCMUA's treated wastewater, it would require the treated wastewater to meet the following requirements:

Table 10: Covanta's Acceptable TWE Treatment Levels

Parameter	**Concentration**
pH	6.0-8.0
Specific Conductivity	<500mmhos
Ammonia	<10 ppm
Chloride (ac Cl)	<50 ppm
Hardness (as $CaCO_3$)	<50 ppm
Manganese	<2 ppm
Zinc	<0.5 ppm
Iron	<1 ppm
Total Suspended Solids (TSS)	<10 ppm
Total Dissolved Solids (TDS)	<500 ppm
Turbidity (NTU)	<20
Flow	1.2 MGD
Pressure (min)	70 psi

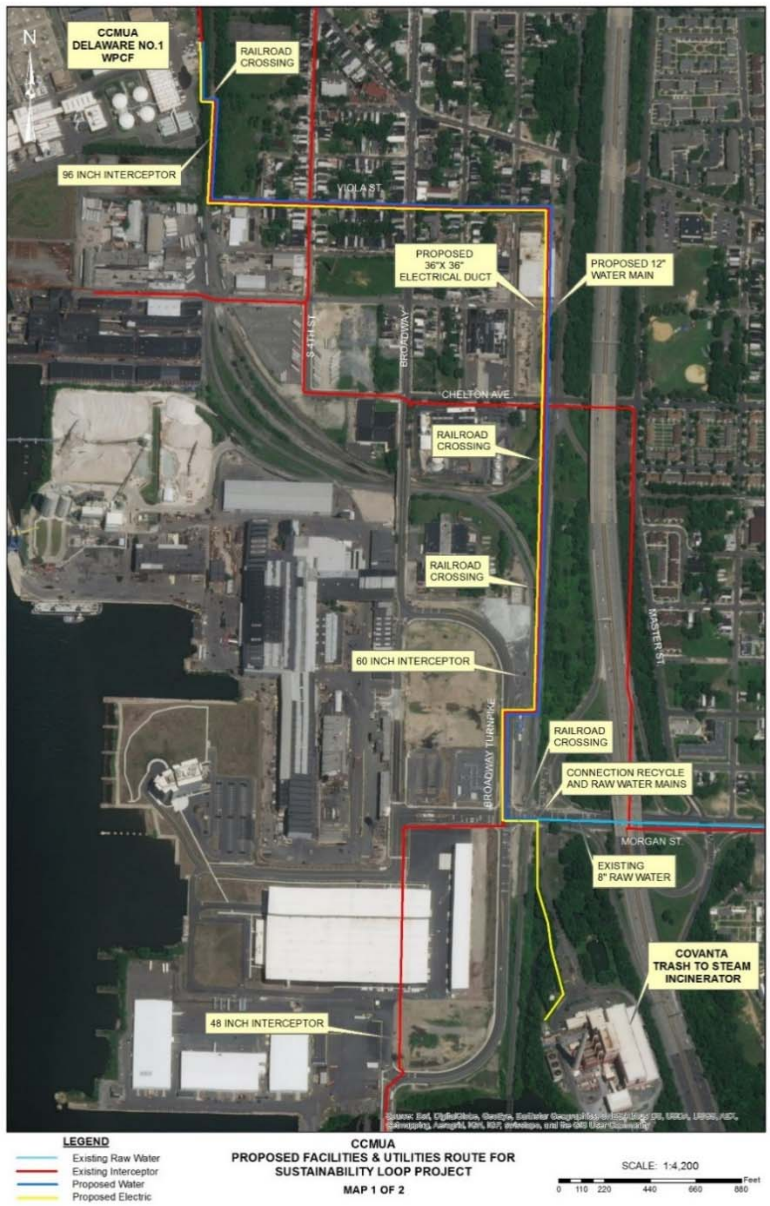
Proposed Force Main Location

The proposed connection points for the recycled water pipe line can be made at the beginning of Covanta's driveway, where the current 8" diameter well water main makes a 90-degree bend from Morgan Street, by installing a tee and two isolation valves, one on the existing well water main, and one on the new main, allowing the facility to use any of the lines. Another option is to bring a separate water line along the west side of the facility's driveway and make a similar connection described above in front of the service building.

Proposed Electrical Duct Bank Location

The proposed electrical duct bank can be installed following the water force main route up to the Covanta's driveway and then along the west side of the facility's driveway. At the top of the driveway, the duct bank would veer right and follow the inside of the facilities fence line up to the existing electrical transformer yard. A location map, *Figure 17*, provides proposed locations for utilities route.

Figure 17: Utilities locations



Design Flows

Based on the information presented in *Table 10*, Covanta requires a minimum flow of 1.2 MGD. However, CCMUA staff express their desire to evaluate a system capable of producing a peak flow of 3 MGD. As a result, a 3 MGD facility was evaluated.

Constituencies to Be Removed and Effluent Quality

The current plant effluent meets most of the Covanta's acceptable treatment levels. The constituencies for which levels were not acceptable and targeted effluent quality were identified as follows in *Table* .

Table 11: Undesirable Constituencies

Parameter	Current TWE Concentration	Acceptable Concentrations
Ammonia	25 ppm	<10 ppm
Chloride (ac Cl)	70 ppm	<50 ppm

Wastewater Temperature

Wastewater temperature is important for sizing biological systems for nitrification. As in most biochemical reactions, temperature greatly influences nitrification rates. Based on monitoring data and the possible requirement for year-round nitrification, the report uses a minimum wastewater temperature of 11°C (51.8°F).

Evaluation of Treatment Alternatives for Ammonia Removal

D&B/Guarino compared CCMUA's Delaware No. 1 WPCF effluent quality and Covanta's constituencies and their maximum concentration limits for their recycled water requirements. It was determined that the Delaware No. 1 WPCF's effluent requires treatment for Ammonia and Total Dissolved Solids in order for Covanta to replace its use of potable water with TWE.

Ammonia removal technologies fall into three basic alternatives:

1) physical/chemical, and 2) biological processes.

Physical/Chemical Processes

Physical/chemical processes rely on chemical reactions to remove ammonia and include: reverse osmosis, ammonia stripping, ion exchange and breakpoint chlorination. Reverse osmosis is expensive and requires a high degree of pretreatment. Ammonia stripping requires addition of lime to raise the pH of wastewater to about 11. At this pH, the ammonia is present as a gas, rather than as an ammonium ion. The limed wastewater is sprayed over a packing material, with air added counter current to the liquid flow to strip the ammonia gas. High power requirements and ammonia emissions present problems with this alternative, and the calcium carbonate scale that forms on the packing requires a high level of maintenance. In ion exchange, wastewater is passed through a bed of material that exchanges sodium or potassium in the exchange material for the ammonium ion in wastewater. When the ion-exchange material becomes exhausted, passing a caustic solution through the bed regenerates it. Regeneration releases the adsorbed ammonium ions, which are collected in the exhaust solution. Ammonia in the exhaust can be recovered for use as a fertilizer. High operation and maintenance costs and heat loss resulting from suspended solids build-up on the resin are all problems associated with ion exchange. With breakpoint chlorination, chlorine at high doses oxidizes ammonia nitrogen to nitrogen gas. Dichlorination is needed after breakpoint chlorination, and volatile organic compounds such as chloroform and other trihalomethanes are formed. Breakpoint chlorination must be preceded by treatment beyond secondary treatment, typically coagulation, settling and filtration, thus making it most effective on polished effluents. A problem with this alternative is that the chlorine demand will be too great to allow for cost-effective implementation. As result of the factors listed above, the physical/chemical processes were not evacuated further.

Biological Processes

Biological ammonia removal involves processes of nitrification in an aerobic environment by the life biomass. In nitrification, ammonia is oxidized to nitrite and then to nitrate. Processes available for biological nitrification include suspended-growth system, fixed film systems, and hybrid systems. In hybrid systems, fixed-film material is added to the aeration tank of suspended-growth systems.

Suspended Growth Systems

The activated sludge process at the CCMUA's Delaware No. 1 WPCF may be used for nitrogen removal and may include the following options:

- Sequencing batch reactors
- Membrane activated sludge system
- Single state activated sludge

Sequencing batch reactors

Sequencing batch reactors combine biological activity and settling in a single tank, rather than separating these functions in an aeration tank and a clarifier. They do not save space; however, and control and piping may become complicated for large facilities. They are not evaluated further in this report.

Membrane Activated Sludge Systems

Membrane activated sludge systems use membranes to separate effluent from biomass, instead of clarifiers. Their advantage is that the concentration of mixed liquor in the aeration tanks can be much higher than with conventional activated sludge. With higher concentrations, the volume of aeration tanks can be decreased. Membrane activated sludge systems have not been used at plants larger that about 1 mgd, however. Membrane activated sludge systems are not further evaluated in this report.

Single-Stage Activated Sludge

Nitrification can be obtained in a single-sludge system, similar to the system currently used by the plant in their secondary treatment process. To provide nitrification in cold weather (the wastewater temperature can be 11 C or colder), the solids retention time (SRT) would have to be increased to about 11 days. Current design provides for an SRT of less than 3 days. This would require tank size much greater than the space available. Single-Stage Activated Sludge systems are not further evaluated in this report.

Fixed Growth Systems

In fixed-growth systems, the biological organisms grow on a supporting surface, in contrast to suspended-growth systems, where the organisms grow in liquid phase and then have to be separated from effluent in a clarifier. Fixed film systems include rotating biological contactors, nitrifying trickling filters, biological aerated filters and submerged packed-bed reactors, fluidized bed reactors, and moving bed biofilm reactors.

Rotating Biological Contactors

Rotating biological contactors (RBCs) consist of disks rotating on shafts arranged so that all or part of the disks are submerged. The excess biological growth sloughs from the disks and is captured in clarifiers. Mechanical reliability of RBCs can be a problem and RBCs are not often used at large treatment plants. Therefore, RBCs are not further evaluated in this report.

Trickling Filters

Trickling filters can be used for nitrification, sometimes without the need for settling tanks. However, trickling system would require a greater area than is currently available. In addition, odor control may be required for trickling filters. Nitrifying trickling filters are not further evaluated in this report.

Moving-Bed Biofilm Reactors (MBBR)

The moving-bed biofilm reactor (MBBR) process consists of a tank filled with small plastic elements. The hollow cylindrical elements are about 1 cm in all dimensions and have ridges on the exterior and a crosspiece on the inside. The primary purpose is to increase the amount of stabilized biomass within the reactor, thereby increasing treatment capacity. A clarifier is required to separate excess growth. ***This process is recommended and is used in our evaluation****.*

Evaluation of Alternatives for Solids Removal

This section addresses alternatives for removal of solids both present at the existing TWE and generated during ammonia removal process. It should be noted that only a Reverse Osmosis (RO) type of filter would guarantee the complete removal of all dissolved solids and minerals to the level required by Covanta. However, the exceedance level for those parameters versus their acceptable levels in the effluent does not justify a capital cost of 3 to 4 times greater than the other filtration options discussed below. As such, RO was not further evaluated in this report.

Sand Filters

Granular medium filtration involves passing the wastewater through a 10 to 36-inch-deep granular bed composed of small 0.014 to 0.059-inch particles. Wastewater passes down through the filter during its normal cycle of operation. Smaller particles penetrate into the filter and pass down until captured by the finer filter media located deeper in the filter. Conversely, larger particles are captured near the surface of the filter where the filter media is coarser. Eventually, the filter becomes plugged with material removed from the wastewater and must be cleaned by reversing the flow to backwash the filter. The filter's deep media bed allows it to handle high levels of suspended solids, however it requires a larger area for installation than both cloth and membrane filters and is more expensive than cloth filters. Sand Filters are not be further evaluated in this report.

Cloth Filters

Cloth media filtration involves the use of variable low speed rotating drum filters that are continually backwashed. Filtering is accomplished by the fabric (cloth) that is fitted on the drum periphery. The wastewater enters the tank. By gravity, liquid passes through the cloth. Solids collect on the outer surface of the media, forming a mat. Solids are backwashed off the cloth media by water spray nozzles.

The Disk Filter System:

1. Significantly smaller footprint compared to granular media filtration (sand/anthracite).
2. Does not require a clear well for backwash water.
3. Does not require an air scour system or <u>large</u> backwash pumps.
4. The filtration system remains in full service even during a backwash cycle.
5. Only a small portion of the filtration surface is backwashed at any one instance. This keeps the backwash flow rate low and the corresponding equipment at a low horsepower and easy to maintain.
6. Individual filtration disks can be removed from service for maintenance while the system remains in operation.

This system was recommended and further evaluated in this report.

Membrane Filters (Ultrafiltration/Microfiltration)

Membrane Filters consists of low-pressure, submerged membranes. An advanced aeration process combined with periodic backwashing removes particulate matter from the membrane surface. The membrane filter system consists of an array or skid of elements submerged inside a process tank. The membrane elements are attached to a manifold assembly, consisting of a central permeate header with an array of membrane permeate ports, which connect to individual membrane modules. Suspended solids, turbidity, viruses, bacteria and some organic compounds are removed by the membranes. The cost of construction of the membrane filters is higher than both sand and cloth filters. They also require a higher maintenance and more expensive to operate. Membrane Filters are not further evaluated in this report.

Proposed Treatment System and its Elements

The proposed plant effluent side treatment system schematic is presented on *Figure* and consist of:

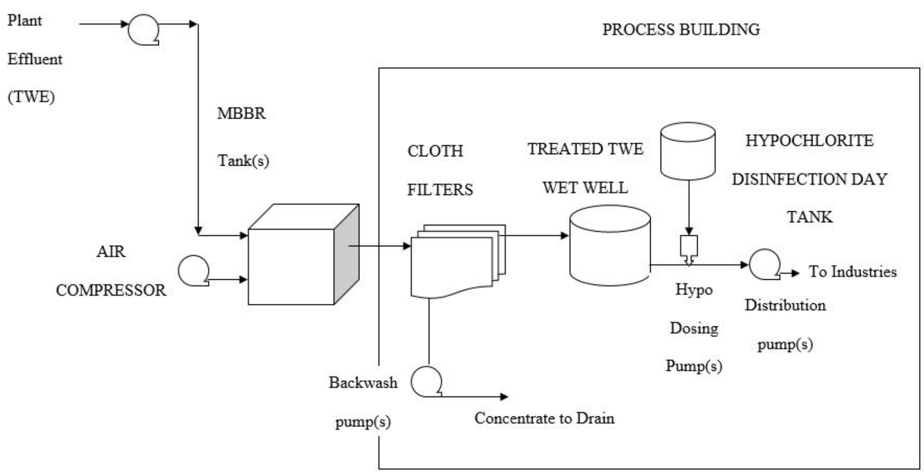
- **Plant Effluent Pumps**: Two pumps will be provided. One duty; one stand-by. Each pump will have 100 H.P. motor and will be capable of pumping up to 3 MGD of plant effluent at a TDH of 125 ft to the Ammonia removing process, MBBR. Pumps will be located at the effluent of the Secondary Sedimentation Tanks.
- **Ammonia and Suspended Solids Treatment**: A dual train two stage MBBR process housed in the two 35 ft by 30 ft by 18 ft deep tanks. The plant effluent will enter the tanks through a splitter box for even flow distribution. The process will require mixing and dissolved oxygen to remove ammonia. This will be provided by three 125 H.P. positive displacement blowers, two duty and one standby, and coarse bubble diffusers. MBBR effluent will be directed to two Cloth Disk Filters, which also will be housed in the 10 ft by 10 ft by 11 ft deep concrete tanks. The filter discharge will flow to the TWE wet well for distribution by TWE Pumps and the filtrate will be pumped to the head of the existing plant.
- **TWE Pumps**: Three 260 H.P. pumps will be provided to pump TWE to the Covanta, two duty and one stand-by. These pumps will be installed in the 30 ft by 10 ft by 10 ft deep

wet well. The pumps will be controlled by the line pressure and have a flow/pressure relief piping going back to the plant's disinfection contact tanks.

- **Process Building**: 60 ft x 40 ft process building will house MBBR air compressors, the disc filters, wet wells and pumps, chemical disinfection equipment, electrical and HVAC equipment.

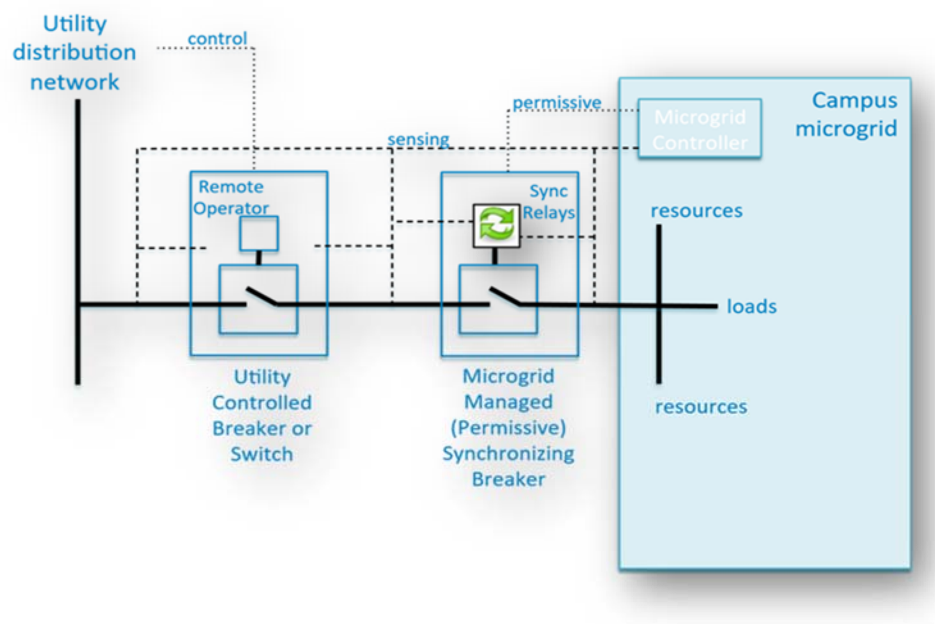
See *Figure* for the flow diagram for the entire proposed TWE Facility Schematic.

Figure 18: TWE Facility Schematic



D. TC DER Start & Operations

Figure 19: Point of Common Coupling Two Breaker Control Scheme for Interconnections



The microgrid design is focused on the development of an overall energy strategy that incorporates both demand-side management and new distributed generation resources to support the microgrid's operational objectives. Steady-state, normal "blue sky" operations for the Sustainability Loop and islanded, "dark sky" operations are managed, monitored, and controlled by a microgrid controller (MGC). The microgrid will take advantage of DER to remain in operation when the utility grid is not available. The MGC will monitor island mode frequency and voltage and adjust equipment operation accordingly to maintain circuit stability. The microgrid will also support the transition back to the grid when the utility service is restored. The design ensures that the return to the grid is a seamless transition and is coordinated with the utility through appropriate protocols, safety mechanisms, and switching plans (to be communicated to the MGC by the utility distribution management system and discussed later in the report). Given the excess power production available between Covanta, CCMUA, and any other Sustainability Loop customers, the time in islanded operation is infinite, assuming that CCMUA's natural gas is not interrupted and Covanta's waste-to-energy operation is not interrupted.

To support steady-state frequency requirements, as well as the ANSI 84.1-2006 standard voltage requirements and to support the customer power quality requirements at the Point of Common Coupling (PCC), the MGC will actively manage the dispatch of generation resources; actively manage the charge and discharge of energy storage; provide observability of microgrid-wide telemetry including frequency, power factor, voltage, currents and harmonics; provide active load management at CCMUA (in emergencies only) and its VNM Accounts (in all operations); and provide advance volt-VAR variability algorithms and other stability algorithms based on steady state telemetry of the system. Notable protections schemes are noted in *Table* . A Sequence of Operation, including Black Start, is included in *Table 13*.

Table 12: Microgrid Controller and PCC Protection Scheme

Underfrequency	Overvoltage
Undervoltage	Phase to phase fault
Overfrequency	Phase to ground fault
Protection Mitigation Controls	
Phase angle	Real-time droop

Both Covanta and CCMUA will need to undergo a power flow analysis study, after selecting a MGC, to quantify and clarify the sequence of operation during black-start, the starting currents, operating currents, and site SCADA interaction with the MGC to automate the process. After these studies, the MGC can operate accordingly to minimize large step changes in power draw, manage starting in-rush current vs running current, leverage the smaller CHP at CCMUA to extend the ESS support, and bring both facilities back online faster.

Table 13: Microgrid Sequence of Operation

Sequence of Operations
Normal (steady-state)
Enable/Disable MGC, Select Auto/Manual, Monitor Operations and Benefits
In Auto mode, MGC operates system for maximum economic benefits
In Manual mode, facility operator has direct control over assets
Grid failure (transition)
PCC senses loss of grid, transfers from grid-connected (export-only) to islanded (no export), PV trips offline, VNM account (N3) loads curtailed 100%
All loads supplied by Covanta (N1) generation, acting as voltage and frequency source, ESS switches to primary resiliency services (Peak Load Management, Frequency Regulation, Voltage Support, Reactive Power Support, Load Smoothing)
PV reconnects after IEEE 1547 programmed delay
ESS charges to near-maximum state of charge, MGC sends recommended output setpoints to Covanta (N1) to moderate generation to match demand
Grid recovery (transition)
PCC senses grid recovery and switches to grid-connected position
PV trips offline; PV comes online after set delay
MGC resumes using battery for economic optimization
Black Start (grid outage, Sustainability Loop outage, Covanta boilers hot or cold)
All utility switches open. Sustainability Loop synchronizing switches open.
ESS at Covanta (N1) provides voltage source, power/energy to start onsite loads (basic initial functions, like lighting) of approximately 1.25MW. Delay turning on additional loads until resistive and inductive loads reach steady-state running current.
*Alternative Supplement: Synchronizing switch to CCMUA closes. ESS (N1 or N2) starts CHP at CCMUA. Critical must-run loads at CCMUA turn on. PV reconnects after IEEE 1547 programmed delay. Reach steady-state running current. Excess power (~1MW) provided to Covanta for initial start-up sequence and voltage support.
ESS at Covanta (N1) provides voltage source, power/energy to start onsite loads (i.e. 800hp ID fans, combustion air fans, cooling tower fans, 4-6 combustion air fans, boiler grate hydraulic pumps, 2 APC pumps, fly ash handing equipment, condensate pumps, and 4-5 air

compressors) of approximately 1.0MW. Operators manually stage turning on equipment to balance starting current with running current.
Boilers startup (hot or cold sequence).
One turbine starts and switches to source voltage and frequency. ESS switches to constant charge, providing load to ramp turbine.
Energizes Sustainability Loop (non-CCMUA, non-DER sites). MGC determines onsite DER and electric bus operating status at CCMUA. Synchronizing switch at CCMUA matches voltage, frequency, phase angle, with zero power exchange. Energizes CCMUA buses. If DER not operating, MGC starts CHP to ramp to full load and ESS to resiliency services onsite.
PV reconnects after IEEE 1547 programmed delay
Second turbine starts. MGC monitors utility signal to provide power export and support to W-387 feeder. Second turbine ramps to charge all ESS.
MGC monitors utility signal to provide power export and support to B-444 feeder. *If signals of support for B-444 differ significantly from W-387, Sustainability Loop must wait until convergence.
PCC reconnects to utility and follows frequency. PV trips offline. Covanta switches to export-only and Sustainability Loop to economic optimization.
PV reconnects after IEEE 1547 programmed delay

E. NJBPU & EDC Tariff Requirements/FERC & PJM Tariff Requirements

F. FERC & PJM Tariff Requirements

Introduction

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

Regulatory Framework

In the United States, jurisdiction over energy industry operating standards and commodity prices are generally divided between the federal government and the states. The Federal Energy

Regulatory Commission (FERC) of the U.S. Department of Energy (DOE) regulates the interstate transmission of electricity, natural gas, and oil, while the states govern intra-state retail markets. In the 13-state area that includes all of New Jersey, FERC delegates administrative authority over the power transmission grid on a regional basis to the PJM Interconnection (PJM) Regional Transmission Organization subject to the Open Access Transmission Tariff (OATT). FERC sets natural gas and oil wholesale transportation rates directly through approved tariffs for interstate pipeline services.

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

It should be noted that several of the energy flows in the microgrid are non-tariff, in that they are flows between generating resources and co-located loads on the same premises or inside the microgrid boundary, which for purposes of this discussion are assumed to operate free of the EDC franchise on the distribution of electric power. As Camden's EDC, PSE&G serves CCMUA under the High-Tension Service tariff[2].

Tariff Structure

Tariffs are complex. They do double duty of setting industry prices and terms & conditions for service and are necessarily detailed and multi-layered. Retail electricity tariffs generally offer single or "flat" rates (non-time-dependent), time-of-use rates (dependent on time of day to capture peak demand), and rates for controlled loads. Tariffs typically identify various service categories dependent on the customer type (i.e., residential, commercial, industrial, institutional,

[2] https://nj.PSE&G.com/aboutPSE&G/regulatorypage/-/media/A54279A4641A4FDC8BA14736B51CFE90.ashx (page 133 of 180)

etc.) and selected rate type. Tariffs also provide for rate riders for additional (sometimes temporary) charges or refunds separate from the basic monthly rates. These can include rate riders for generation services such as energy, transmission and capacity charges, which are a pass-through from the wholesale provider of electric power; societal benefits charges; and (of course) sales and use taxes. The final monthly bill will therefore be an aggregate of the many applicable charges, fees and possible refunds broken down into the basic separable categories of: generation, transmission, distribution, and retail services. The single bill is delivered by the local utility, which serves as an agent for others, such as PJM and third-party suppliers, who receive portions of the customer payment for their particular contribution to the metered energy flow.

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

Distributed Generation Interconnection Requirements

One tariff jurisdictional issue of particular importance to microgrid projects is the threshold question for a small generator project of whether the project falls under the PJM or the PSE&G interconnection process. PSE&G (governed by BPU) manages retail applications. PJM Interconnection (governed by FERC) is responsible for managing all wholesale interconnections to member EDC systems.

Three basic factors determine the jurisdiction of the small generator project: 1) the type of facility to which the project proposes to interconnect; 2) whether the output of the generator would only serve local load, and 3) whether all or some of the output of the generator may be available for wholesale sales under the OATT (the FERC-approved tariff). As the Sustainability Loop project anticipates connection only to the PSE&G retail distribution network (a non-FERC network) and the microgrid generation will not be selling into the wholesale market under a FERC tariff (but will only be consuming the power locally), no PJM interaction is anticipated. However, as potential export markets, including to the PJM wholesale markets for energy, capacity and ancillary services are attractive sources of future income for the project, this potential pathway is included in the detailed tariff structure analysis.

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

Customers that wish to sell power to PSE&G are restricted by the terms and conditions of Rider QFS of the PSE&G tariff for Cogeneration and Small Power Production Service. For generators larger than 1 MW, specific contract arrangements must be negotiated as part of the interconnection process to determine the price of delivered energy and capacity, which are controlled by the utility's ability to receive compensation for resale of the energy and capacity at PJM wholesale market prices. PSE&G may also put significant restrictions on delivery of energy based on local circuit conditions and may refuse to allow such an interconnection should it not be technically feasible for feed-in to the meshed network. All such contracts are subject to BPU approval.

Net metering is a type of feed-in tariff that can generate revenue for owners of Class 1 renewable behind-the-meter generation assets in the microgrid. In the case of the microgrid, net metering will apply to Level 1 & 2 interconnections (inverter-based facilities limited to 2 MW), which, as indicated, will be principally solar photovoltaic systems installed at the host facilities. Net metering provides for the billing or crediting, as applicable, of energy usage by measuring the difference between the amount of electricity delivered by PSE&G to a customer-generator. The amount of credit however is restricted to the amount of electricity supplied by PSE&G over an annualized period – therefore this cannot act as a positive revenue stream but only a potential offset against PSE&G charges.

<u>Smart Grid Distribution Automation</u>

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

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

Part 2: The Microgrid Tariff Structure

The following identifies six (6) principal metered energy flows that comprise the proposed system. Each is described in detail within this section.

Distribution Grid (PSE&G/PJM)

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

Metered flows include the following:

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

system to PJM. The owner of the microgrid assets deals with PJM directly for sales of services on the wholesale markets.

Microgrid Generation Bus (Non-Tariff)

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

Any excess energy from the distributed resources that is fed back into the grid through the captured PSE&G infrastructure will be sold to other microgrid customers sites, proportionate to their overall energy consumption. Since the microgrid assets will utilize existing utility distribution infrastructure, the host sites will continue to pay PSE&G via the delivery charge on the monthly bill. Host sites would amend their existing bi-lateral supply agreements to account for the fact that a portion of their supply would now come from the microgrid. Each microgrid generating asset will be paired with a dedicated meter that will measure the output for internal accounting

Captured PSE&G Distribution Grid (No-Tariff)

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

Natural Gas Distribution

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

Microgrid Thermal Energy Loop (Non-Tariff)

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

Virtual Microgrid (PSE&G)

The virtual microgrid refers to loads residing outside of the microgrid boundaries but connected by feeders to microgrid generation resources. Using the PSE&G Level 3 interconnection these microgrid DER should, in theory, be able to energize the feeder and brings these loads back on line in the case of contingencies lasting anywhere from a few minutes to several days or weeks (depending on the flow of natural gas and state of the PSE&G infrastructure). As indicated in Footnote 2, there are multiple technical challenges involved with making this potential revenue stream a reality, including access to the meshed network in a way that is safe and reliable. Primary critical loads are those that provide critical services and are the priority targets for service restoration in contingencies. Secondary loads are those loads on the feeder between the critical loads and the microgrid that will be energized incidentally as primary critical loads are brought back on line. These loads will continue to pay for their service under normal tariffs to the distribution company (PSE&G) however, a tariff rider that compensates the microgrid distributed resource asset owners for the reliability and resiliency services should be developed to service and avoided costs to the utility.

Part 3. Conclusions & Recommendations

Microgrid Tariff

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

The new tariffs should recognize the value imparted by the microgrid to the distribution grid, including avoided costs for maintenance and capacity expansion as well as increased reliability and resilience. This could be accomplished through approval of special microgrid rates for imported power and by eliminating (or mitigating) standby and demand charges. The new microgrid tariffs should also allow utilities to cede some of their franchise rights to a municipal authority and/or owner and operator of the advanced microgrid to allow for non-tariff distribution of microgrid generated energy.

Improved Interconnection Procedures

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

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

VIII. Overall Cost

Construction Cost Opinion for Tertiary Treatment and Pumping Equipment

D&B/Guarino provided a cost opinion for a 3 MGD treatment facility. The cost is based on the aeration, filtration, disinfection and pumping equipment as specified in in the proposed treatment system above, between the north fence line and Secondary Treatment System and shown in *Table 4*.

Table 14: Cost Opinion for a Treatment System and Associated Pumping Equipment

Process Elements	**Construction Cost (including Equipment, Installation and 20% Contingency)**
Effluent Pumps and Piping	
• Two (2) Plant Effluent Pumps	$250,000

Process Elements	Construction Cost (including Equipment, Installation and 20% Contingency)
• Effluent Piping	$100,000
Subtotal	**$350,000**
Ammonia Removal	
MBBR system	$3,000,000
MBBR tanks	$1,200,000
Subtotal	**$4,200,000**
Filtration	
Two (2) filters	$1,000,000
Subtotal	**$1,000,000**
Process Building	
Site preparation	$150,000
Foundation	$600,000
Building Structure	$1,000,000
Equipment and Systems	$1,500,000
Subtotal	**$3,250,000**
TOTAL	**$8,800,000**

Construction Cost Opinion for the TWE Pipeline

Table lists the pipeline construction cost opinion.

Table 15: Pipeline Construction Cost Opinion

Elements	Construction Cost (including Material, Installation and 20% Contingency)
12-inch distribution pipeline 7,600 L.F. of piping @$224/L.F. Including: trench excavation, piping, fittings and accessories, and trench paving restoration.	$1,700,000
Four (4) Rail Road Crossings @ $100,000 Ea.	$400,000
TOTAL	**$2,100,000**

Construction Cost Opinion for Electrical Duct bank

Table lists the Electrical Duct bank construction cost opinion.

Table 16: Electrical Duct bank Construction Cost Opinion

Elements	Construction Cost (including Material, Installation and 20% Contingency)
7,600 L.F. of piping @$592/L.F. Including: trench excavation, reinforced concrete duct bank, (6) 6" conduits, railroad crossings, and trench paving restoration.	$4,500,000
Thirty (30) Electrical Manholes @ $13,300 Ea.	$400,000
TOTAL	**$4,900,000**

Construction Cost Opinion for Electrical Interconnect at Plant's Main Electrical Substation

The construction cost of the Electrical Interconnect Work at the Plant's Main Electrical Substation was based on the cost of the similar work performed at the plant during recent construction project. This Cost was estimated at $600,000.

Cost Opinion for Operation and Maintenance of the Facilities

The cost to provide Covanta with TWE includes the operation and maintenance cost of the plant effluent pumps, TWE discharge pumps, air compressor, chemicals and personnel and materials is $850,000, shown in *Table* .

Table 17: Operation and Maintenance Cost Opinion

Elements	O&M Cost
Plant Effluent Pumps (100 H.P.)	$70,000/year
TWE Discharge Pumps (260 H.P.)	$200,000/year
Air Compressor (250 H.P.)	$174,000/year
Chemicals	$6,000/year
Operation & Maintenance (Personnel and Materials)	$400,000
TOTAL Annual O&M Cost ($)	**$850,000**

D&B/Guarino's Conclusion and Recommendations

D&B/Guarino developed a conceptual design for a Sustainability Loop for transmission of green energy from Covanta's facility to the CCMUA's wastewater treatment plant and water reuse from the plant's effluent to Covanta. D&B/Guarino recommends a Tertiary Treatment process to treat up to 3 MGD of CCMUA's plant effluent to be utilized by Covanta as cooling water. The recommended treatment system is a combination of a dual train two stage Moving-Bed Biofilm Reactors (MBBR) and Cloth Disk Filter to meet Covanta's proposed water quality criteria except for chlorides. The chloride exceedance is minimal and the removal to acceptable limits would require reverse osmosis treatment which is significantly more expensive than the treatment recommended herein. The chloride exceedance was discussed with Covanta, and it was agreed to proceed with the recommended treatment. The treatment process will also include disinfection. The proposed location of the treatment system is on the CCMUA WPCF plant north of the existing secondary clarifiers. The system will be capable of producing a peak flow of 3 MGD. The capital cost estimated for the Treatment Process is $10,500,000.

A pump station, force main from the CCMUA plant to Covanta, electrical duct bank from Covanta to the CCMUA plant's main substation and electrical interconnect at the plant are all necessary components. D&B/Guarino proposes a route along the 7,600 feet area between CCMUA and Covanta for the Force Main and Electrical Duct Bank (*Figure 24*). The TWE pipeline is a 7,600 linear feet 12-inch distribution pipeline which will include 4 railroad crossings at a capital cost of $2,500,000.

The electrical duct bank will consist of 36-inch by 36-inch concrete duct bank and (4) 6-inch embedded PVC conduits which includes four railroad crossings at a capital cost of $5,900,000.

The electrical interconnect at the plant's main substation will cost $700,000.

The total cost, including 20% contingency and 20% for design and construction administration will be $19,600,000, shown in *Table*.

D&B/Guarino also estimated the annual operation and maintenance costs at $850,000/year. The O&M cost includes equipment and chemical, and operation and maintenance for personnel and materials.

Table 18: Summary of Costs to Provides TWE to Covanta

Summary of Costs to Provide TWE to Covanta	
Proposed consumption (gpd)	3,000,000
Length of pipeline and duct bank (feet)	7,600
Cost of the pipeline ($)	$2,500,000
Cost of the treatment and pumping facilities ($)	$10,500,000
Electrical Duct Bank ($)	$5,900,000
Electrical Interconnect	$700,000
Total Capital Improvement ($)	$19,600,000
Annual O&M Cost ($)	**$850,000**

The cost opinion for the electrical components of the Sustainability Loop are specified in *Table* . The electrical ducts are included in the costs of the TWE plant and are excluded from the microgrid portion. The current design fully facilitates Covanta export to Sustainability Loop customers, as loading dictates. When possible, equipment sizing was made to match PSE&G to enable redundancy (N-1). If the existing connection to PSE&G fails (W-387), the Sustainability Loop can use the microgrid to send power to PSE&G via a different connection to the same feeder (W-387) or a different feeder (B-444). Assumptions of additional equipment follow below.

Table 19: Summary of Costs to Provide Sustainability Loop to CCMUA

Summary of Costs to Provide Sustainability Loop to CCMUA	
Proposed site consumption minimum (MW)	2.0
Future potential loop consumption (MW)	11 +
Length of pipeline and duct bank (feet)	7,600
High Voltage Cable ($)	$1,100,000
Switches ($)	$150,000
Yard Expansion and Transformer ($)	$730,000
Synchronizing and Interconnection Relays ($)	$35,000
Energy Storage for Black Start, part loading w/CHP ($)	$8,700,000
Additional control, monitoring, and protection ($)	$41,000

Microgrid Controller ($)	$200,000
Detailed Design and Construction Management ($)	$560,000
Total Capital Improvement ($)	$11,60,000

Assumptions for equipment and criteria

- TR-02 Size: New transformer to be sized the same as existing transformer 25/33.3MVA at 55C and 28/37.33MVA at 65C, 26.4kV-13.8kV.
- Cable between Camden County RRF and CCMUA will be 6 conductors (2 sets) 35kV cable. Cable type will be EPR/Copper Tape Shield, Shielded MV-105, 133% insulation. Cable size 750kcmil. (Note this is preliminary cable sizing without actual calculations that are to be performed during detailed design)
- 13.8kV cable between switchgear bus 2 and TR-02 will be 9 conductors (3 sets) 15kV cable. Cable type will be EPR/Copper Tape Shield, Shielded MV-105, 133% insulation. Cable size 750kcmil
- ESS is rated for outdoor use (NEMA enclosure) without HVAC system, including 3MW of power and 8 hours of energy at full load (12MWh). Depth of discharge is 90% to maintain sufficient voltage for operations. Includes approximately 1MW of CHP provision for 12 hours to enable 3MW of power and 12 hours of energy at full load.
- Annual O&M costs may be included in lease-back arrangement with PSE&G and are excluded in these estimates.

IX. Cash Flow Evaluation/Potential Financing

The model summarizes the detailed findings from our scenario analysis. Our model is based on the following key assumptions:

- $175/kW per year in PJM capacity ($40) & frequency regulation ($135) revenue for the battery
- $1M in grant funding available for battery CAPEX
- $1M in separate grant funding available for distribution infrastructure CAPEX
- Weighted Average Cost of Capital (WACC) from project private sector investor is 10%

To conservatively simplify this model, we have also assumed the following:

- There is no cost to Covanta for black-start capacity availability. (There likely will be a charge for this capacity.)
- Off-takers are not paying to dispatch the battery to avoid local demand charges. (There likely will be a charge for this dispatch.) However, in the case where we solve for project net income, we do add $10/MWh in demand charge avoidance credit to represent some willingness to pay for this avoided cost benefit (converted from capacity value to an annualized average energy equivalent value for ease of computation, and thus expressed in units of energy, not demand).

We devised five *technical* configuration scenarios that are shown in the rows of the *Table 20*. In addition, we devised three *financial* scenario groups to test against the technical scenarios:

- **Group A**: No grants, no storage revenue, 10% IRR target.
- **Group B**: Add grants and storage revenue, same IRR target as Group A.
- **Group C**: Keep grants and storage revenue, reduce IRR target by half to 5% (to approximate 100% public sector finance).

Within each financial scenario test group, we identify three financial variables to test:

- **Off-takers Sale Price:** Cost of energy to off-taker customers (either $80/MWh or solving based on other inputs).
- **Covanta Purchase Price:** Cost to purchase energy from Covanta (either $70/MWh or solving based on other inputs).
- **Project Net Income:** Surplus or shortfall (either exactly zero for breakeven or solving based on other inputs).

The results in the *Table 20* are coded green for the technical-financial scenario intersections in which all target conditions are met and the project is financially viable. **Group C** showed the greatest number of circumstances that were financially viable, particularly for scenarios with larger demand.

The modeling results suggest that an even larger project has an even greater chance of success. Such a project would include more off-take customers, larger battery size, and additional revenue streams that a larger battery would allow, e.g., demand charge avoidance and participation in the arbitrage market, along with frequency regulation and capacity charges.

This expanded analysis is beyond the scope of this study. Future financial modeling should focus on the size and cost of the battery, as well as the opportunities the battery presents for diverse revenue streams, to better arrive at the optimal project scale.

Table 1: Summary of preliminary financial scenario modeling

Financial Scenario Group						A			B			C	
Financial Scenario					1	2	3	4	5	6	7	8	9
Backup Generation Resiliancy Availbility Fee Revenue ($/yr)					0	0	0	0	0	0	0	0	0
Demand Charge Avoided Cost Credit ($/MWh)					0	0	10	0	0	10	0	0	10
ESS Market Revenue ($/kW-yr)					0	0	0	175	175	175	175	175	175
ESS CapEx Grant Subsidy ($M)					0	0	0	1	1	1	1	1	1
Distribution Infrastructure CapEx Grant Subsidty ($M)					0	0	0	1	1	1	1	1	1
Unlevered Rate of Return to Investor (IRR %)					10%	10%	10%	10%	10%	10%	5%	5%	5%
Off-Taker Energy Only Sale Price ($/MWh)					{variable}	80	80	{variable}	80	80	{variable}	80	80
Covanta Energy Only Purchase Price ($/MWh)					70	{variable}	70	70	{variable}	70	70	{variable}	70
Project Net Income Surplus (Shortfall) ($/yr)					0	0	{variable}	0	0	{variable}	0	0	{variable}
Study Phase	**Technical Scenario ID**	**Technical Scenario Description**	**Annual Energy**	**Average Load**	**Off-Taker Sale Price**	**Covanta Purchase Price**	**Project Net Income Surplus (Shortfall)**	**Off-Taker Sale Price**	**Covanta Purchase Price**	**Project Net Income Surplus (Shortfall)**	**Off-Taker Sale Price**	**Covanta Purchase Price**	**Project Net Income Surplus (Shortfall)**
			MWh/yr	MW	$/MWh	$/MWh	$/yr	$/MWh	$/MWh	$/yr	$/MWh	$/MWh	$/yr
--	1	CCMUA (Water Production Only)	17,520	2.0	162	(12)	(1,256,659)	122	28	(471,830)	99	51	(133,896)
Phase 1	2	Scenario 1 + Other OffSite VNM Loads (1.1 MW)	27,156	3.1	129	21	(1,065,971)	98	52	(224,367)	86	64	111,184
--	3	Scenario 2 but with storage asset removed	27,156	3.1	84	66	170,340	78	72	327,945	76	74	369,903
Phase 2	4	Scenario 2 + 26 Additional Critical Loads (1.9 MW)	43,800	5.0	107	43	(733,304)	88	62	106,039	80	70	444,686
--	5	Scenario 4 + Unspecified Load (6.0 MW) to Reach Max Capacity	96,360	11.0	87	63	317,439	78	72	1,156,265	75	75	1,494,440

Investment Approaches

It seems clear that CCMUA will be able to fund the water portion of this project through low cost loans, and that it will be able to own and operate these components, as they are part of the Authority's core competency.

On the electric side, the initial development defined in this study – microgrid and a small amount of battery storage – is estimated at $11.6M CAPEX. Should a larger and more financeable project be pursued (as described above), this CAPEX number will be significantly larger.

This larger investment could prove challenging to Covanta's balance sheet. It should also be noted that microgrid operation and battery dispatch are not a part of Covanta's core competency. There is a strong argument to be made for a third-party to own and operate these assets, purchasing electricity directly from Covanta at a wholesale rate to distribute to various off-take customers.

By allowing third party financing and development, Covanta would distance itself from cost and schedule risk, along with other substantial commercial risks, including the negotiation of off-take agreements. The company would earn revenue through a PPA agreement with the project owner, and also, if desired, earn revenue as the contracted operator of the assets.

One regulatory issue that impacts this recommendation is that the third-party microgrid owner will need to obtain state authority to sell electricity. An alternative approach would be to establish a public/private partnership between the third-party owner and CCMUA, allowing the microgrid owner to dispatch electricity under CCMUA's authority. This third-party owner would likely need to be certified as a distributor by the New Jersey Board of Public Utilities.

More analysis – financial and regulatory – needs to be done to draw out the full commercial model for an expanded third-party microgrid serving multiple off-take customers, while proving services to the external grid. Based upon the results of this study, it is believed that a viable larger-scale microgrid development – one that provides customers with resiliency and cheaper electricity, and that offers market-rate returns to the third-party investor – is achievable.

X. Project Benefits

The need for microgrids is ever increasing with volatile weather conditions such as Hurricane Sandy and Polar Vortexes as well as constraints on our aging electrical distribution infrastructure and cyber-attacks on our electrical supply chain. Microgrids provide a reliable backbone to local resiliency, while also providing the opportunity for locally produced clean energy and a secure energy supply. A microgrid is an integrated energy system consisting of interconnected loads and distributed energy resources (DER) with the ability to connect and disconnect from the main utility grid. Simply put, microgrids are modern, small-scale versions of the traditional utility system. The advantages of a microgrid system include reliability, redundancy, fuel flexibility, energy efficiency, a cleaner environmental, locally and regionally, reductions of energy transmission loss, and improved grid security.

Microgrids incorporate locally produced energy sources such as solar photovoltaic arrays and combined heat and power generators, and connects this power to critical facilities within a defined region. This system is paired with current technology, which has the ability to send power back into the traditional grid during normal hours, but also can isolate itself during blackouts and times of emergency. Microgrids provide benefit by not relying on a fragile distribution system that moves powers across great distances, which not only allows for redundancies, but provides cost savings through efficiencies and clean energy. Finally, microgrids can provide ancillary services to the primary utility grid via load reduction during peak usage periods, as well as voltage and frequency regulation.

While this concept is not new and has been seen on military bases and single ownership campuses, the idea of community- and city-based microgrids is an emerging field. Cities and local communities are taking steps to improve their energy security and resiliency, which appeals to residents, business, and local government.

In particular, Camden's Sustainability Loop, provides a monetary benefit to CCMUA by lower energy costs, which can prevent future financial burdens on the tax base that CCMUA serves. As a critical facility, a microgrid would increase emergency preparedness benefits from continuous operation of information technology (IT), data servers, medical, public safety, and administrative facilities and isolating these services from external threats. Isolated services also provide flexibility for the facilities team to enhance building operations, equipment, and controls to achieve greater economics and value. Additionally, the environmental benefit from a system that incorporates renewable energy sources, energy storage, and high efficiency combined heat and power (CHP) provides a locally-sourced energy that reduces loss through transmission and distribution.

Based on Covanta's production history (*Figure* , *Figure* , and *Figure*), there is minor intermittency expected. There are 340 hours below the maximum service and 231 below the minimum service limit. These reduced hours of service output can occur for various reasons, some that are predictable and scheduled, including routine maintenance on turbines. Other reasons for reduced output are not predictable, like equipment failure or unscheduled grid outages when the utility requires/requests Covanta to curtail power export. In total, 231 hours below maximum service range equates to 1.134 percent of annual downtime, or 98.886 percent reliability. While the timing of the production is not critical to any VNM accounts, it is critical to emergency operations. Given the sufficient amount of other DER, the risk of CHP, PV, and ESS not operating or available is sufficiently small. Black start capability was only required in four events over the last 18 years. Covanta often can re-energize in less than 60 minutes, although cold start sequences require six to eight hours. Also, if the full amount of ESS is installed for the black-start capability at Covanta (separate from any CCMUA support), the load swing can be completely mitigated.

XI. Communication System

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

With any building operation assets, a suitable data and IT system to monitor, control, and protect assets is critical. Often times, industrial buildings may use a Supervisory Control and Data Acquisition (SCADA) or Building Automation System (BAS). Any viable MGC will need an active management and control architecture that supports the ten (10) EPRI/ORNL Use Cases, at minimum. These include frequency control, voltage control, intentional islanding, unintentional islanding, islanding to grid-connected transition, energy management, microgrid protection, ancillary services, black start, and user interface and data management. In addition to these core competencies, an MGC should include the following capabilities:

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

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

MGC software can be configured to serve as a facility microgrid control software and as DER management software that can connect to multiple sites for coordinated operations. The relationships between conventional grid management systems such as SCADA/DMS and DERMS, DER and microgrids are shown in *Figure 20.*

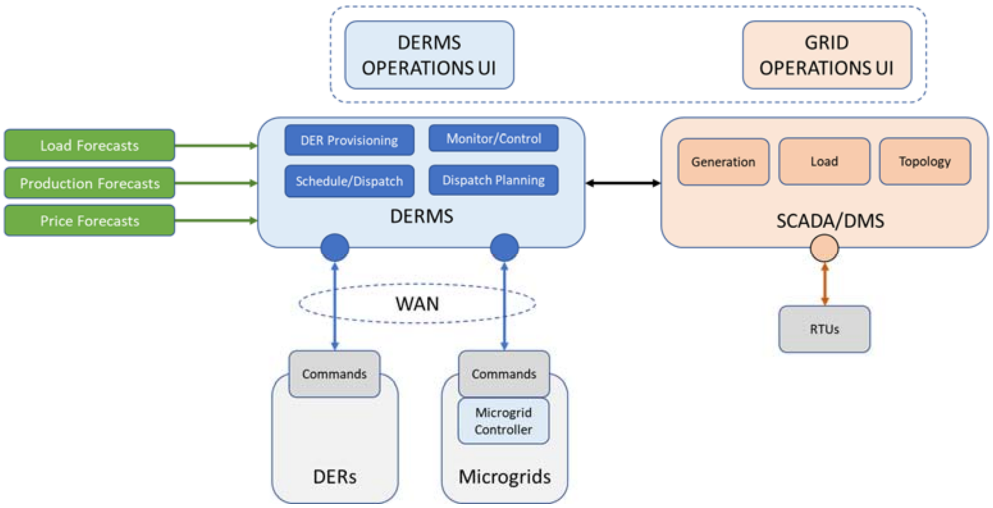
The microgrid proposed for this project will be set up to exchange information, including supervisory commands, to and from compatible distribution operations systems. Typical integration points are:

- Data exchange with SCADA/DMS system pertaining to generation, load and topology (networked switched state)

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

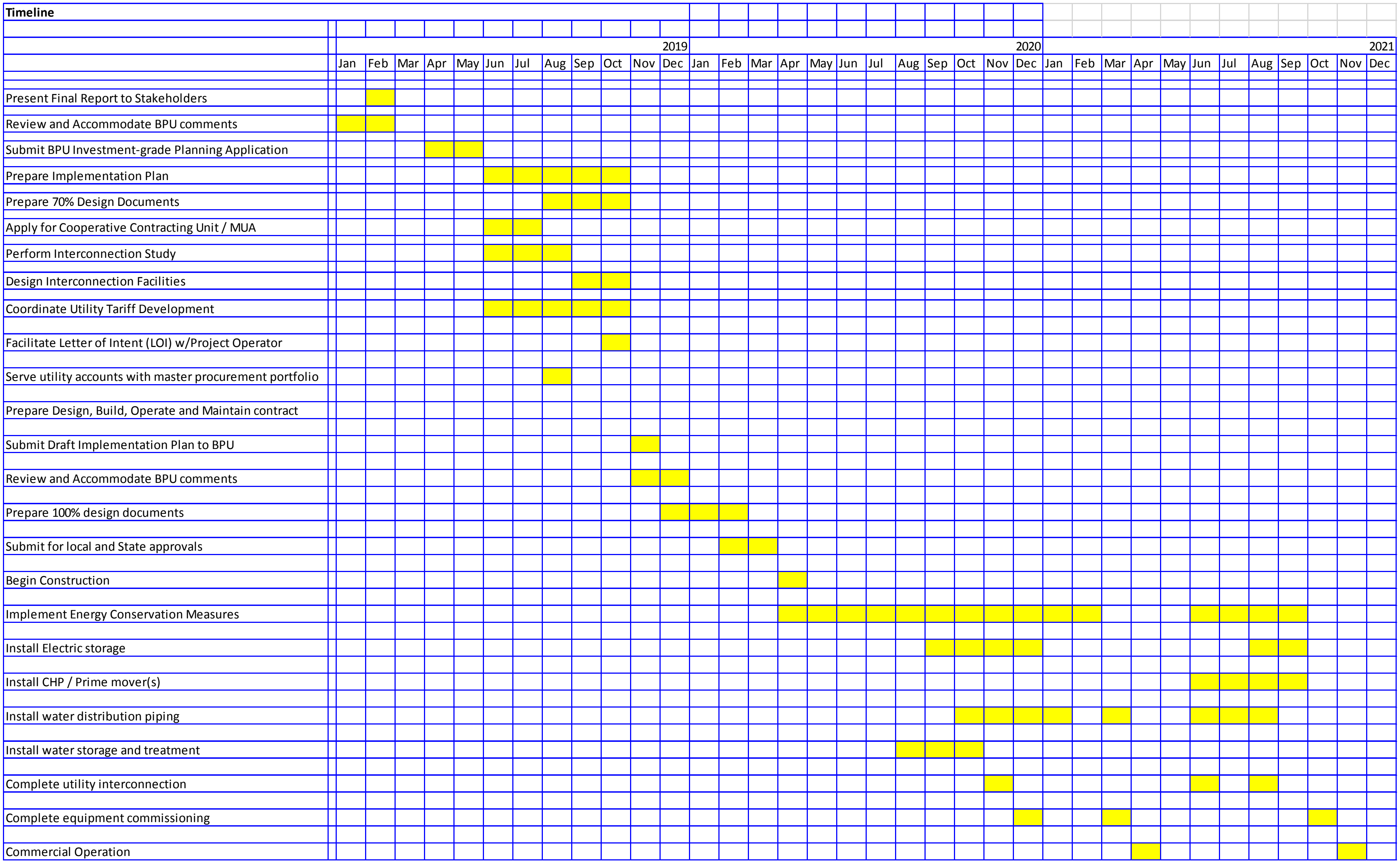
The proposed system will be operated from a control room with secure access provided to authorized stakeholders. Initial stakeholders are anticipated to be CCMUA, Covanta, PSE&G, and microgrid operator.

Figure 20: Relational Communication between Grid Operations, DERMS Operations, and the Sustainability Loop Microgrid



XII. Estimated Timeframe

The project team anticipates a 24 to 30-month process for the completion of the initial Sustainable Loop which includes procurement, design & engineering, and construction. This work will likely take place in conjunction with any future road and infrastructure work under CCMUA.


Timeline
2019
2020
2021
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Present Final Report to Stakeholders
Review and Accommodate BPU comments
Submit BPU Investment-grade Planning Application
Prepare Implementation Plan
Prepare 70% Design Documents
Apply for Cooperative Contracting Unit / MUA
Perform Interconnection Study
Design Interconnection Facilities
Coordinate Utility Tariff Development
Facilitate Letter of Intent (LOI) w/Project Operator
Serve utility accounts with master procurement portfolio
Prepare Design, Build, Operate and Maintain contract
Submit Draft Implementation Plan to BPU
Review and Accommodate BPU comments
Prepare 100% design documents
Submit for local and State approvals
Begin Construction
Implement Energy Conservation Measures
Install Electric storage
Install CHP / Prime mover(s)
Install water distribution piping
Install water storage and treatment
Complete utility interconnection
Complete equipment commissioning
Commercial Operation

XIII. Ongoing Work

The City of Camden is served by PSE&G for both electric and gas. PSE&G is represented by Addie Colon, Regional Public Affairs Manager for Camden County. The consultant team has worked with extensively with PSE&G engineer, Mike Henry and other PSE&G representatives who provided utility data. Although PSE&G role as a user and/or possible ownership role has not been solidified, the utilities along with PSE&G remain active stakeholders in the project.

I. Appendix: Technical Tables and References

Appendix Table 1: Assessment of Electrical Load in Water Distribution Systems

Hour	Usage (kWh)
0	72.95
1	66.95
2	65.34
3	65.19
4	67.27
5	78.61
6	105.16
7	130.96
8	122.11
9	123.57
10	119.09
11	113.26
12	109.95
13	110.44
14	108.64
15	113.11
16	119.76
17	130.13
18	140.12
19	145.00
20	160.36
21	136.24
22	115.69
23	87.94