Mid-Atlantic Industrial Assessment Center

Departments of Electrical/Computer Engineering and Mechanical Engineering
Center for Energy and Environmental Policy
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UNIVERSITY OF DELAWARE INDUSTRIAL ASSESSMENT CENTER

Report Number:	DL0216
Assessment Date:	December 2nd, 2022
Plant Location:	Wilmington, DE
Submitted Date:	December 19th, 2022
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PREFACE

The work described in this report was performed by the University of Delaware Mid-Atlantic Industrial Assessment Center (IAC) under contract with the Department of Energy (DOE). The objective of the IAC program is to identify and evaluate opportunities to conserve energy, minimize waste, and improve productivity. Analyses and recommendations are based upon observations and measurements made during a one-day site visit and are restricted in detail and completeness by limitations on available time at the site. In cases where assessment recommendations (ARs) involving engineering design and capital investment are deemed attractive, it is recommended that the services of an engineering consulting firm, in-house specialist, or equivalent expert be engaged to do detailed engineering design and to estimate implementation costs. Questions and comments regarding this audit report and details about specific assessment recommendations should be directed to the Director or Assistant Director of Mid-Atlantic Industrial Assessment Center at the University of Delaware.

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EXECUTIVE SUMMARY

Report No:	DL0216	Employees:	47
Assessment Date:	December 2nd, 2022	Operating Hrs:	8,760
		Facility Size:	650,000 ft^2

RECOMMENDATIONS AND RESULTS

Implementation of **all** the assessment recommendations in this report would:

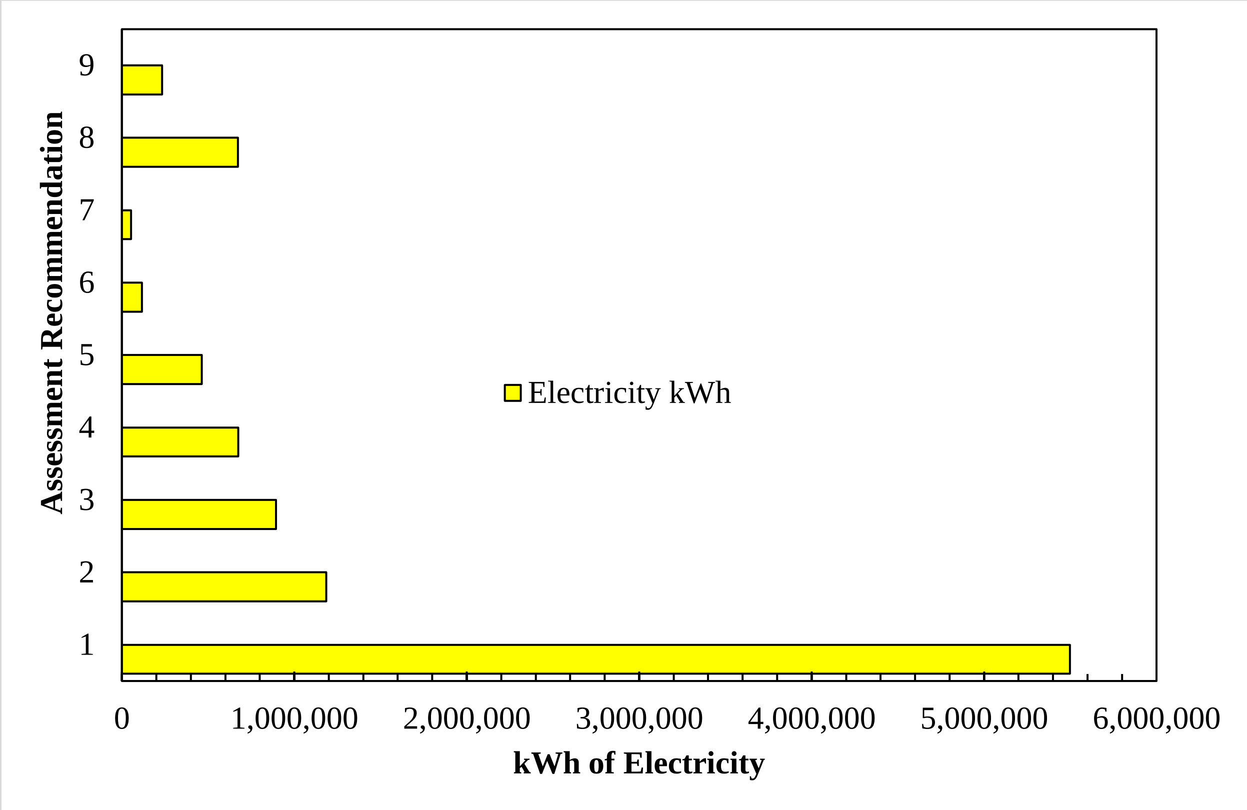
- Reduce electric energy consumption by **9,793,016 kWh** or **51.82%** per year.
- Reduce carbon dioxide emission from electricity generation and heating by **11,061,212 lbs** per year. This equates to a **51.82% reduction in the current facility's carbon footprint of 21,345,376 lbs/year**.
- Produce a total cost savings of **$1,028,242** per year, a reduction of **39.08%.**
- The total implementation cost of all recommendations is **$1,100,500** with an average payback of **1.07** years.

A summary of assessment recommendations is listed in **Table I** on the following page.

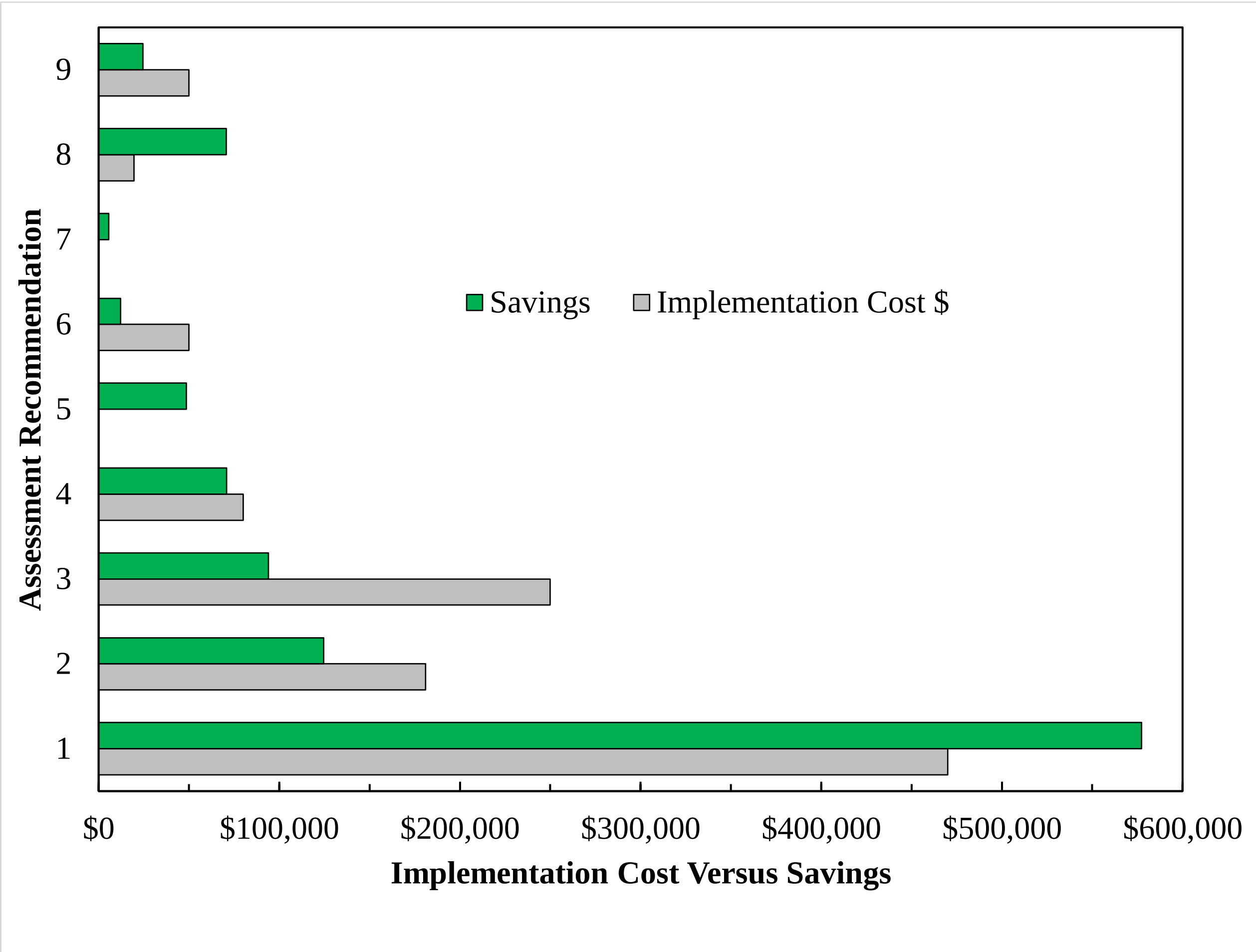
TABLE I: SUMMARY OF ASSESSMENT RECOMMENDATIONS
This table summarizes the energy savings of each assessment recommendation.

AR No.	Description	ARC Code	Electricity kWh	Cost Savings $	Implementation Cost $	Payback Period Years
1	Put Aeration Blowers on VFD Control	2.4146	5,498,000	$577,300	$470,000	0.81
2	Put RAS Pumps on VFD Control	2.4146	1,186,000	$124,500	$181,000	1.45
3	Replace Belt-Drive Centrifuge with Direct-Drive Unit	2.4322	894,900	$93,960	$250,000	2.66
4	Dedicate One Lift Pump as First Lag and Put on VFD Control	2.4146	675,000	$70,880	$80,000	1.13
5	Utilize Biogas in the Cogeneration Units	2.1331	463,000	$48,610	$0	0.00
6	Heat the Sludge with Cogeneration Waste Heat	2.2437	115,750	$12,154	$50,000	4.11
7	Run Admin Building Air Handler 'Fan-Auto'	2.6231	54,020	$5,672	$0	0.00
8	Upgrade Lighting to LED	2.7142	672,571	$70,620	$19,500	0.28
9	Replace Resistive Heaters with Ductless Heat Pumps	2.7234	233,775	$24,546	$50,000	2.04
	Total Savings		**9,793,016**	**$1,028,242**	**$1,100,500**	**1.07 Years**
	Current Consumption		**18,898,075**	**$2,631,207**		
	% Reduction		**51.82%**	**39.08%**		

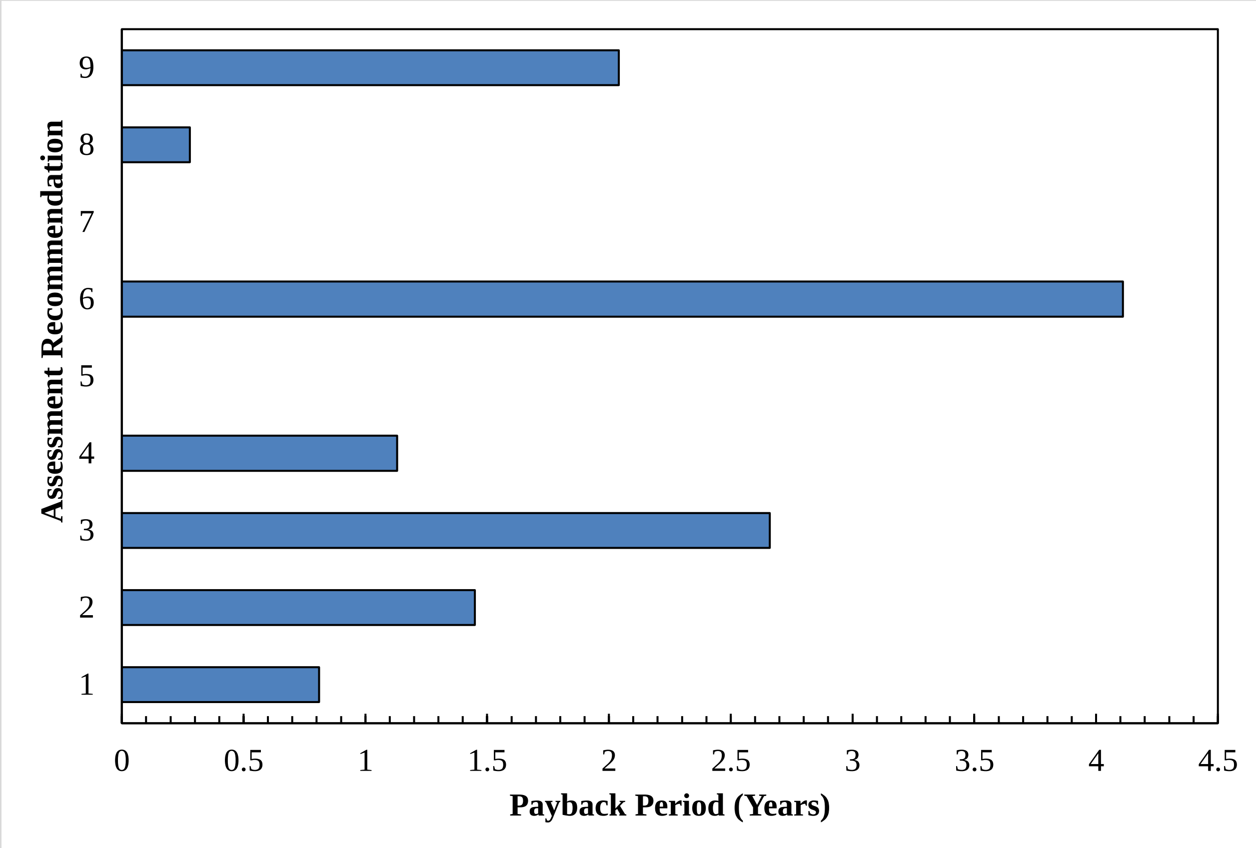
ANNUAL RESOURCE SAVINGS



COST SAVINGS AND IMPLEMENTATION COST



PAYBACK PERIOD



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CURRENT FACILITY OPERATIONS

SUMMARY OF BUILIDING STATISTICS

FACILITY DESCRIPTION

The average daily flow at the Wilmington WWTP is 68.7MGD (with a design capacity of 134MGD), so it processes 29,053MG/year. Plant personnel report that during dry weather the plant averages 60MGD, while during heavy rain 200MGD, indicating that heavy rain or "wet" mode of the plant is approximately given by 200f + 60(1-f) = 68.7, solving for f, the fraction of wet mode, is 6 % of the time.

Here is a facility overview including the main areas of the building:

The lift pumps are 250HP each. There are two intake wells, with five pumps that operate in stages governed by the well level (on-off control). During the assessment, which was a dry day, only one pump was operating for each well, when observed. Plant personnel informed the team that during dry weather, the first lag pump comes on 20% of the time. During wet weather, it is approximated that an average of four pumps operate. Thus, the lift pumps consume 250HP x0.746 (kW/HP) /0.93 (estimated efficiency) x (1.2 x 0.94 + 4 x 0.06) x 8766hrs/yr = 2,405,000kWh/year.

There are twelve total aeration blowers. During the assessment, which plant personnel inform was an average day, seven blowers were operating. The blowers each have a throttling valve that is controlled by a Dissolved Oxygen (DO) sensor, to maintain set point. Display readings for the blowers indicate that they have a roughly linear power vs. flow curve, with approximately 50% power at zero flow. Thus, this is the consumption of the blowers during the assessment, used as a snapshot average to calculate total blowers consumption per year:

blower	valve	HP	kW full load	kW at load
7	1	300	235.6	235.6
8	0.68	300	235.6	197.9
9	1	300	235.6	235.6
10	0.7	300	235.6	200.2
11	0.95	300	235.6	229.7
15	0.55	400	314.1	243.4
17	0.68	400	314.1	263.8
			total kW:	**1606.3**
			total kWh/year	**14080438**

There are a set of twelve Return Activated Sludge (RAS) 40HP pumps. They are on timer control, with approximately 70% average duty cycle according to plant personnel. Thus, they consume approximately 0.7x12x40x0.746/0.945 x8766 = 2,325,000kWh/year.

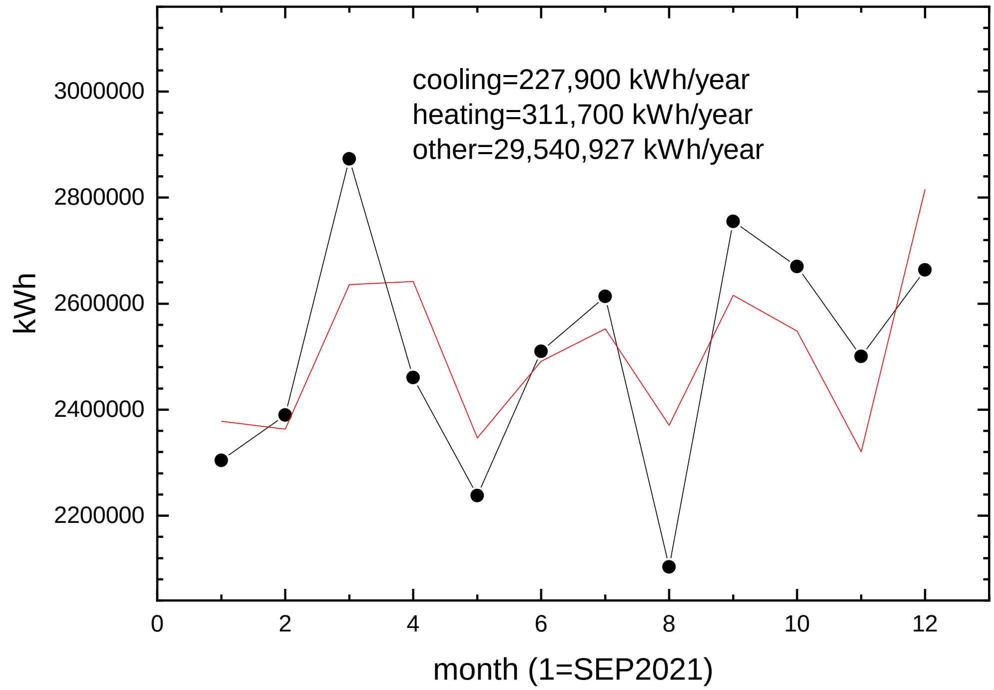
De-watering is performed by centrifuges. There are two, a 300HP belt-driven unit that can process 300GPM, and 125HP direct-drive unit that can process 220GPM. Thus they consume (300 + 125)x0.746/0.95 x 8766 = 2,926,000kWh/year.

Here is the plant lighting survey:

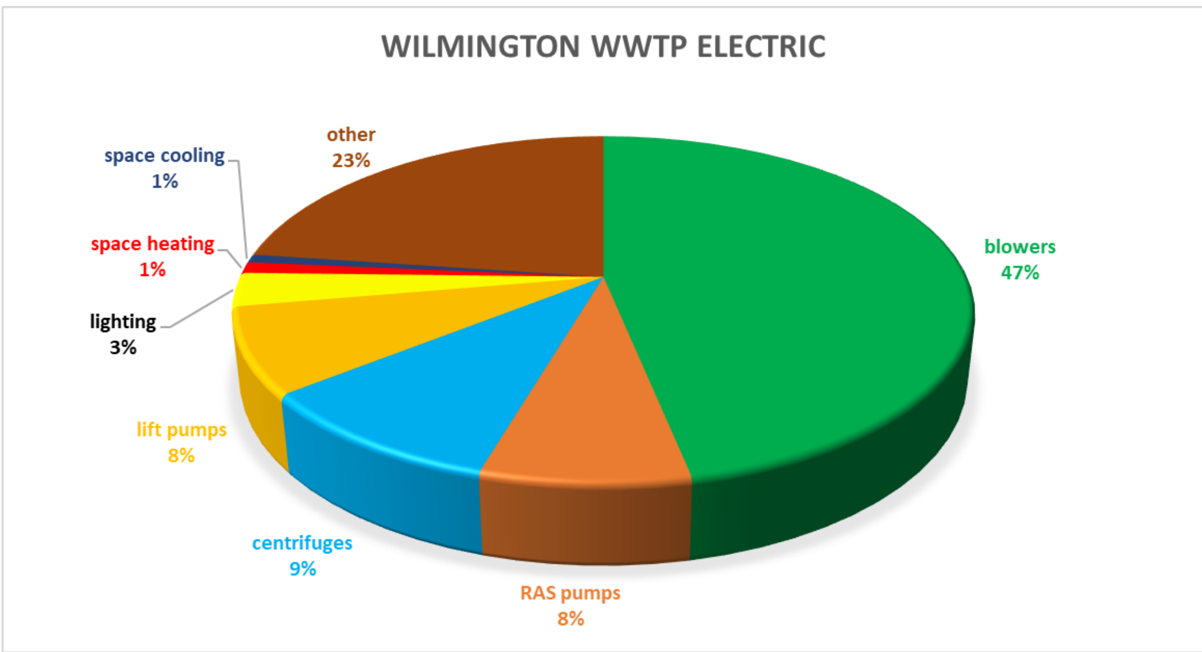
Building	Room	Hours/week	4ft T8 Tube (32 W)	2ft T8 U-Bend (31W)	8ft T8 Tube (86 W)	2-Pin CFL (13W)	Bulb (23W)	400W Metal Halide	600W Metal Halide	1000 W Metal Halide	High Pressure Sodium HID Bulb (150W	kWh/year
Admin	Entry	168				4						456
Admin	First Floor Hallway	50	16			4						1471
Admin	Engineers Room - 107	50	12									1002
Admin	Janitor Closet	50	1									83
Admin	Men's Bathroom	50	2			4						303
Admin	Women's Bathroom	50	2			4						303
Admin	Conference Room	50	35									2922
Admin	2nd Floor Lobby	50	16									1336
Admin	Kitchen	50		4		2						391
Admin	2nd Floor Hallway	50		14								1132
Admin	Men's Bathroom	50	2			4						303
Admin	Women's Bathroom	50	2			4						303
Admin	201	50	18									1503
Admin	208	50	12									1002
Admin	209	50	12									1002
Admin	210	50	12									1002
Admin	211	50	18									1503
Admin	212	50	12									1002
Admin	Stairway 1	50	4									334
Admin	Stairway 2	50		4								324
Admin	Stairway 3	168	8									2244
												0
Basement	Pipe Gallery	168	404				16	9	26	27	9	595916
												0
Tertiary Pond Building	Total Building	168	44									12343
												0
												0
Laboratory	Lobby	40	40									2672
Laboratory	Lab	40	35									2338
Laboratory	Storage	40	2									134
Laboratory	Side Room	40	24									1603
Laboratory	Bathroom	4	2			2						19
												0
Maintenance	Maintenance Shop	168	70									19636
Maintenance	Maintenance Office	168	8									2244
Maintenance	Control + Admin Office	168	6									1683
												0
Digestor #1 Building	Open Area	168	8					5				22407
Digestor #1 Building	Office	168	6									1683
												0
Digestor #2 Building	Open Area	168						9				36292
Digestor #2 Building	Upstairs	168							1	2		26211
Digestor #2 Building	Electrical	168	8									2244
Digestor #2 Building	Stairs	168	4									1122
												0
Parts Warehouse	Warehouse	50								15		45005
												0
Sludge Dewatering Plant	Entry	168	4									1122
Sludge Dewatering Plant	Hallway	168	30									8416
Sludge Dewatering Plant	Storage Bay #1	168			12							9047
Sludge Dewatering Plant	Truck Bay 2	168			8							6031
Sludge Dewatering Plant	Truck Bay 4	168			8							6031
Sludge Dewatering Plant	Polymer Feeder	168	4		10							8661
Sludge Dewatering Plant	Boiler	168	8									2244
Sludge Dewatering Plant	Plumbing	168	24									6732
Sludge Dewatering Plant	Shop	168	4									1122
Sludge Dewatering Plant	Bathroom	168	2									561
Sludge Dewatering Plant	Storage Room	168								2		20162
Sludge Dewatering Plant	Polymer Storage	168			4							3016
Sludge Dewatering Plant	Upstairs Break Room	168	14									3927
Sludge Dewatering Plant	Upstairs Bathroom	168	12									3366
Sludge Dewatering Plant	Upstairs Office	168	8									2244
Sludge Dewatering Plant	Upstairs Lunch	168	9									2525
Sludge Dewatering Plant	Upstairs Bell Press Open Area	168								5	2	53430
Sludge Dewatering Plant	Stairs #1	168	6									1683
Sludge Dewatering Plant	Stairs #2	168			12							9047
Sludge Dewatering Plant	Stairs #3	168			2							1508
												0
												944347

The plant has a co-generation engine plant that runs mostly off biogas from the digester, with some natural gas consumption. In the billing period analyzed, it produced 11,182,452kWh, for total of 30,080,527 kWh/year consumed by the plant (37 % from the co-gen).

The total electric from the utility and co-gen is plotted:



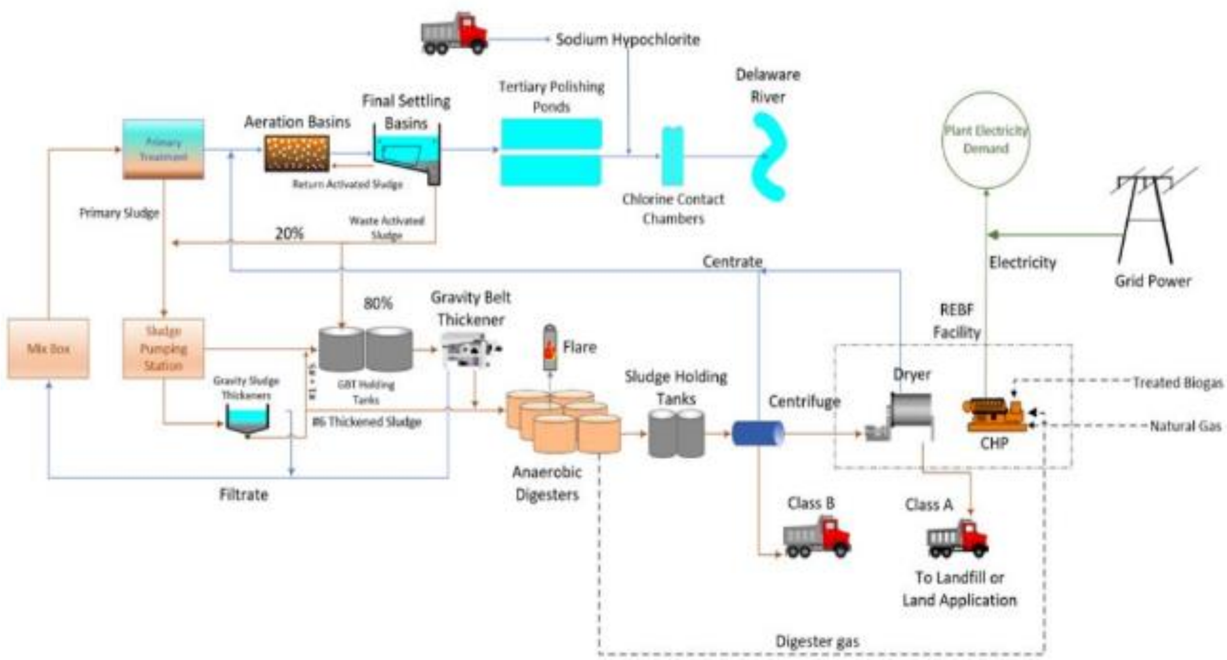
Here is the following plant electric use breakdown:



Natural gas is mostly used in a hot oil boiler for the dryer, and a lesser amount for partial fueling of the co-gen plant. From plant personnel, it is estimated that 15 % of co-gen production is by natural gas, or 0.15x11182452 = 1,677,368 kWh/year. Assuming a co-gen engine efficiency of 25%, the natural gas consumed by the co-gen is 1677368/293/0.25 = 22,899 MMBTU/year. Thus 0.85x11182452 = 9,505,084 kWh/year is via biogas.

Digester biogas production is 7,901MMBTU/year. Plant personnel report that currently 20% is used in the digester hot water boilers, and 80% is flared.

The plant roughly follows this process flow diagram:



Plant existing Best Practices are the digester, use of digester biogas for sludge heating and in the co-gen plant, the co-gen plant, variable speed drives on the Wastewater Activate Sludge (WAS) pumps, and preheating of hot oil boiler with a heat exchanger in the stack.

ENERGY AND WASTE ACCOUNTING

ENERGY MANAGEMENT

One of the most practical strategies to analyze and control costs is an effective energy management program. Keeping up-to-date records of monthly energy consumption and associated costs using spreadsheets and bar charts can help track energy usage and identify opportunities to increase production efficiency and reduce energy costs. Separate analyses should be carried out for each primary energy type and all units should be converted to a common basis for easy interpretation and comparison.

The primary electric unit used in this report is kilowatt-hours per year (kWh/yr); electric demand savings are reported in kilowatts per year (kW/yr). The primary gas energy unit used is therms of natural gas (thm). The energy unit used for liquid fuels (diesel, propane, gasoline) is British Thermal Units (Btu) per unit volume. All electric energy and gas energy savings are also reported in the common unit of Btu/yr), or million Btu's per year (MMBtu/yr). Some common conversion factors are listed below.

Energy Unit	**Equivalent Value**
GENERAL	
1 MMBtu	1,000,000 Btu
1 gallon of water	8.33 lbs
1 Kilojoule	0.94782 Btu
ELECTRICITY	
1 kWh	3,413 Btu or 0.003413 MMBtu
1 MMBtu	293.0 kWh
1 hp-h (electric)	2,545 Btu or 0.002545 MMBtu
1 hp (electric)	0.746 kW
1 kW	1.341 hp (electric)
NATURAL GAS	
1 therm (thm)	100,000 Btu
1 decatherm (Dth)	10 therms = 1,000,000 Btu = 1 MMBtu
100 cu. ft. natural gas (ccf)	~92.02 therms = 9.202 MMBtu*
1 hp-h (boiler)	33,500 BTU
OTHER	
1 gallon No. 2 Fuel Oil (Diesel)	140,000 Btu*
1 gallon No. 4 Fuel Oil	144,000 Btu*
1 gallon No. 6 Fuel Oil	152,000 Btu*
1 gallon gasoline	130,000 Btu*
1 gallon propane	92,000 Btu*
1 ton Coal	20,000,000 Btu*
1 Ton Refrigeration	12,000 Btu/hr

* Energy content varies with supplier

Energy Consumption Breakdown

DETAILED ELECTRICITY SUMMARY

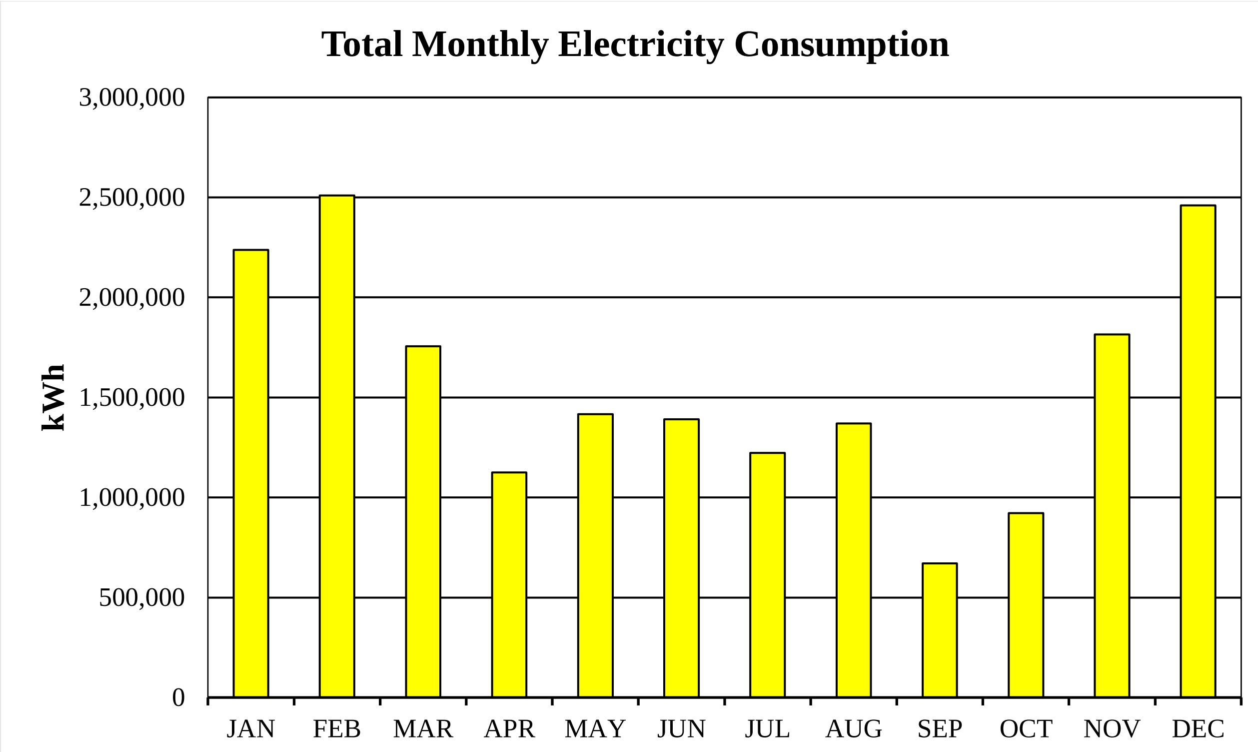
Plant annual electricity consumption is 18,898,075 kWh/year with an average blended billing rate of $0.105/kWh. The following is a monthly breakdown of facility usage and projected breakdown:

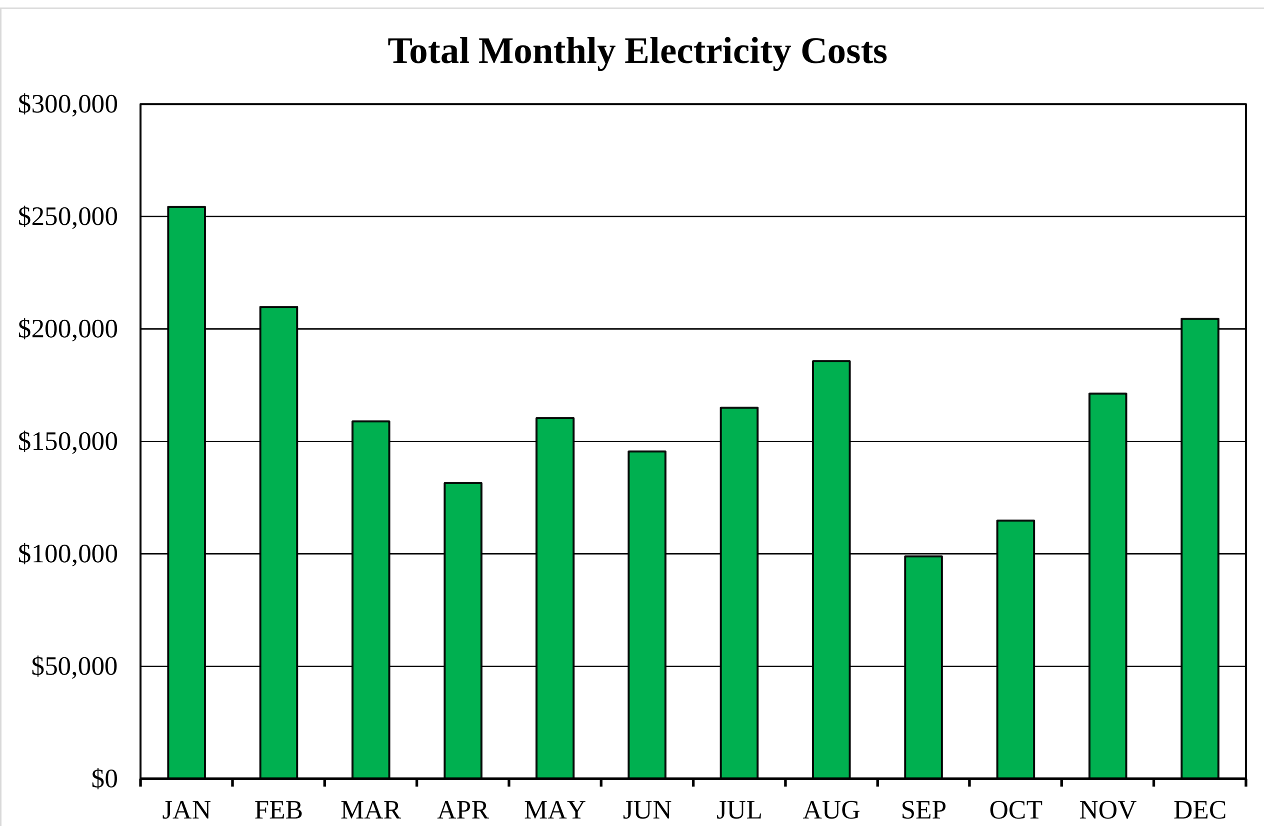
User	kWh/year	% Consumption
Aeration Blowers	14,080,000	46.8%
De-Watering Centrifuges	2,926,000	9.7%
Lift Pumps	2,405,000	8.0%
RAS Pumps	2,325,000	7.7%
Plant Lighting	944,347	3.1%
Space Heating	311,700	1.0%
Space Cooling	227,900	0.8%
Other	6,860,580	22.8%

Facility Electricity Consumption:

Month	kWh	$/kWh	kW	$/kW	Fees	Monthly Total ($)
JAN	2,237,825	$0.1036	3,998	$5.47	$658	$254,351
FEB	2,509,952	$0.0748	3,899	$5.53	$658	$209,837
MAR	1,755,430	$0.0772	3,987	$5.71	$658	$158,900
APR	1,124,422	$0.0946	4,077	$5.97	$658	$131,413
MAY	1,417,084	$0.0961	4,026	$5.81	$658	$160,310
JUN	1,391,472	$0.0849	4,608	$5.81	$658	$145,571
JUL	1,223,279	$0.1198	3,029	$5.90	$658	$165,044
AUG	1,369,887	$0.1198	3,562	$5.84	$658	$185,580
SEP	671,266	$0.1097	3,930	$6.25	$658	$98,876
OCT	922,446	$0.1004	3,645	$5.88	$658	$114,749
NOV	1,814,326	$0.0821	3,860	$5.62	$658	$171,260
DEC	2,460,686	$0.0734	3,904	$5.94	$658	$204,546
TOTALS:	**18,898,075**	**$0.0911**	**46,525**	**$5.81**	**$658**	**$2,000,437**

TOTAL ELECTRICITY COST AND CONSUMPTION SUMMARY GRAPHS





DETAILED NATURAL GAS SUMMARY

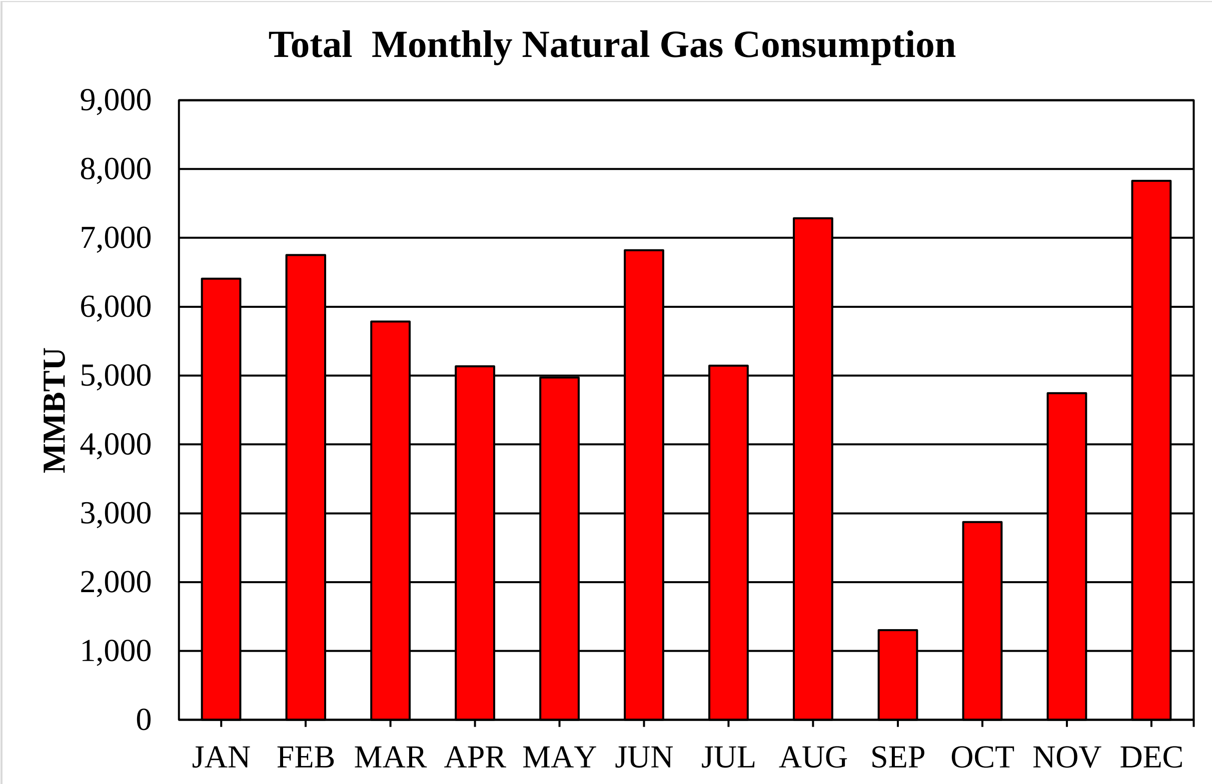
The facility's natural gas consumption is 65,502MMBTU/year at a cost of $9.69/MMBTU. The following is a monthly breakdown of facility usage and projected breakdown:

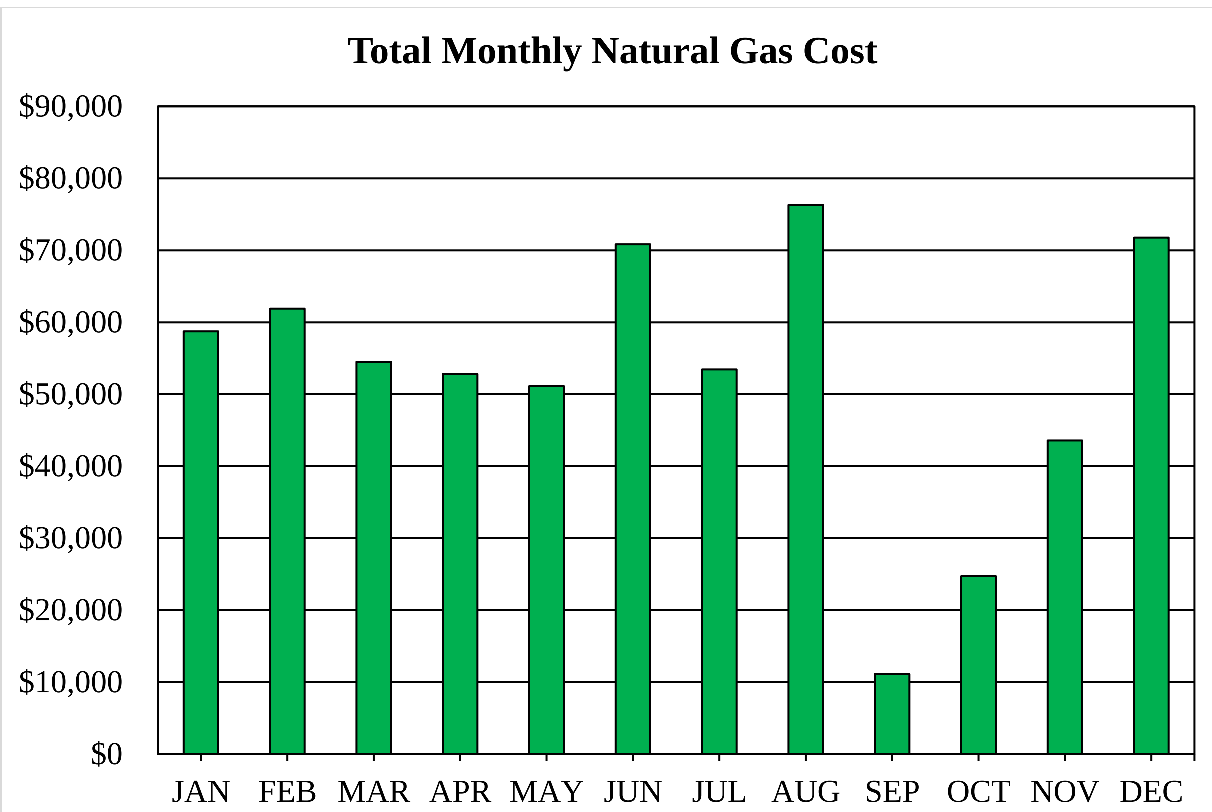
User	MMBtu/year	% Consumption
Cogeneration Units	22,899	35.0%
Dryers	42,603	65.0%

Facility Natural Gas Consumption:

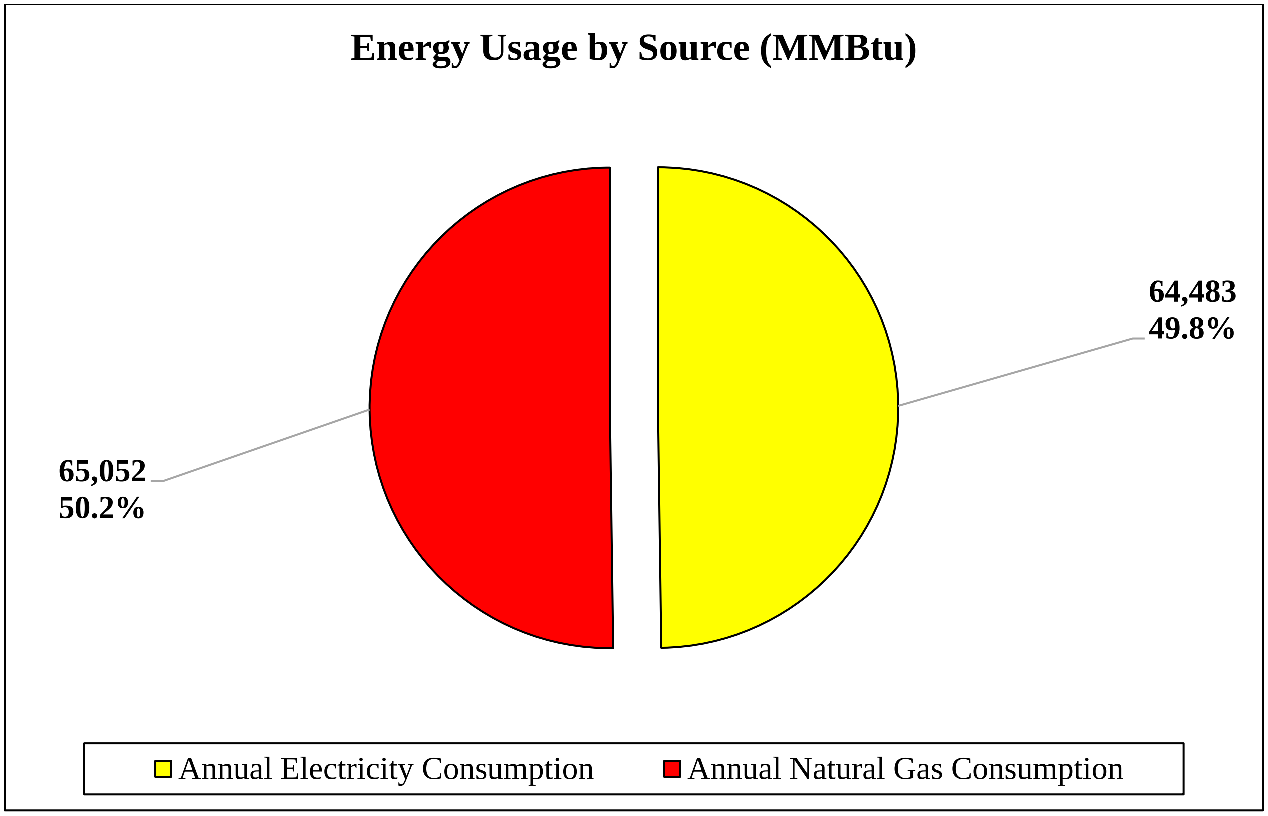
Month	MMBtu	$/MMBtu	Supply & Delivery Monthly Total ($)	Monthly Total with Other Fees ($)
JAN	6,405.5	$9.16	$58,672	$58,728
FEB	6,752.2	$9.16	$61,847	$61,903
MAR	5,785.8	$9.41	$54,453	$54,508
APR	5,137.1	$10.27	$52,779	$52,834
MAY	4,973.1	$10.27	$51,094	$51,149
JUN	6,821.7	$10.38	$70,783	$70,839
JUL	5,144.3	$10.38	$53,380	$53,436
AUG	7,283.6	$10.47	$76,263	$76,319
SEP	1,302.7	$8.47	$11,039	$11,095
OCT	2,871.1	$8.59	$24,668	$24,723
NOV	4,745.7	$9.17	$43,500	$43,556
DEC	7,829.6	$9.16	$71,715	$71,771
TOTALS:	**65,052**	**$9.69**	**$630,193**	**$630,860**

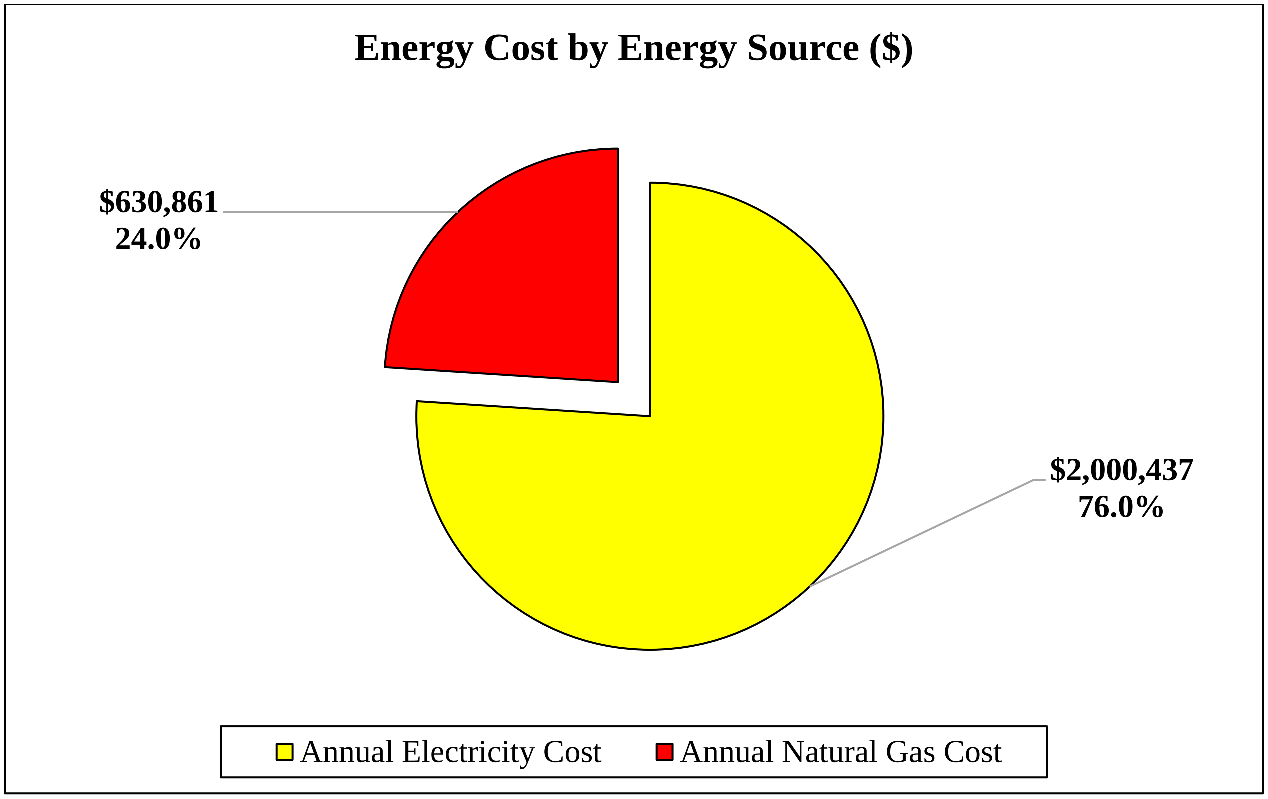
TOTAL NATURAL GAS COST AND CONSUMPTION SUMMARY GRAPHS





TOTAL ENERGY COST COMPARISON GRAPHS





ASSESSMENT RECOMMENDATIONS

ASSESSMENT RECOMMENDATION #1
ARC #2.4146: USE ADJUSTABLE FREQUENCY DRIVE ON EXISTING SYSTEM
PUT AERATION BLOWER ON VFD CONTROL

Annual Resource Savings			Annual Cost Savings	Implementation Costs	Simplified Payback Period
Electricity	**5,498,000**	**kWh**	**$577,300**	**$470,000**	**0.81 Years**

RECOMMENDATION:
It is recommended to replace the throttle control with variable speed drive control of the aeration blowers. This can be accomplished by opening the throttling valves to 100%, and then controlling the blower speed using DO control. The power consumption with VFD’s goes cubic with flow, so savings are greater than the linear trend that is seen with throttle control of the blowers.

ACTIONS:
Purchase and install VFD’s on the twelve aeration blowers used in the facility.

ANTICIPATED SAVINGS:
Using the assessment day as a normal average throughout the year, the following annual savings will be incurred which uses the blended electricity rate for monetary savings:

blower	valve	HP	kW full load	kW at load	kW VFD	savings/year	
7	1	300	235.6	235.6	235.6		
8	0.68	300	235.6	197.9	74.1		
9	1	300	235.6	235.6	235.6		
10	0.7	300	235.6	200.2	80.8		
11	0.95	300	235.6	229.7	202.0		
15	0.55	400	314.1	243.4	52.3		
17	0.68	400	314.1	263.8	98.8		
			total kW:	**1606.3**	**979.0**		
			total kWh/year	**14080438**	**8582252**	**5498186**	$577,310

Annual Reduction in Electricity Usage: 5,498,000 kWh
Annual Savings: $577,310

IMPLEMENTATION COSTS:

Item Description:	Quantity:	Unit Cost:	Total Cost:
Variable Speed Drive	12	$25,000	$300,000
Labor	12	$10,000/VFD	$120,000
Auxiliary Parts Estimate	-	-	$50,000
Total Implementation			$470,000

- The following are acceptable speed drives for this application:
    - https://www.wolfautomation.com/lslv2500h100-4cofd-plus-vfd-400hp-250kw-380/
    - https://www.wolfautomation.com/odp-2-84400-3hf4n-mn-vfd-400hp-250kw-480-amp/
    - https://www.wolfautomation.com/vfd-400hp-460v-3-phase-50x21-1x16-8/
- Labor is estimated to incur the plant ~$10,000 per VFD when installed by plant personnel (this accounts for a wage factor and lost productivity on other maintenance tasks).
- There is a range of VFD's available that will be satisfactory for this use, an estimate of $25,000 per VFD is reasonable based on the size of the system.

Total Implementation Cost: $470,000
Calculated Payback Period: 0.81 Years

ASSESSMENT RECOMMENDATION #2
ARC #2.4146: USE ADJUSTABLE FREQUENCY DRIVE ON EXISTING SYSTEM
PUT RAS PUMPS ON VFD CONTROL

Annual Resource Savings			Annual Cost Savings	Implementation Costs	Simplified Payback Period
Electricity	**1,186,000**	**kWh**	**$124,500**	**$181,000**	**1.45 Years**

RECOMMENDATION:
It is recommended to install VFD's rather than timer control for the RAS pumps. Instead of on/off control, variable operation will save energy as opposed to on/off operation as currently designed.

ACTIONS:
Purchase and install VFD's on the twelve RAS pumps used in the facility.

ANTICIPATED SAVINGS:
From plant personnel, the pumps average approximately a 70% duty cycle, thus the following annual savings will be incurred which uses the blended electricity rate for monetary savings:

a =	12	Number of RAS Pumps
b =	40	HP Rating per Pump
c =	0.746	Conversion Factor (HP to kW)
d =	0.945	Average Efficiency of Pump as Decimal
e =	0.7	Average Duty Cycle of Pumps as Decimal
f =	8,760	Hours in a Year

$$a * b * \frac{c}{d} * (e - e^3) * f = \mathbf{1,186,000}\boldsymbol{kWh/year}\ (\$\mathbf{124,500}/\boldsymbol{year})$$

Annual Reduction in Electricity Usage: 1,186,000 kWh
Annual Savings: $124,500

IMPLEMENTATION COSTS:

Item Description:	Quantity:	Unit Cost:	Total Cost:
Variable Speed Drive	12	$3,000	$36,000
Labor	12	$10,000/VFD	$120,000
Auxiliary Parts Estimate	-	-	$25,000
Total Implementation			$181,000

- The following are acceptable speed drives for this application:
  - https://www.wolfautomation.com/vfd-50hp-72a-380-480v-3-phase/
  - https://www.wolfautomation.com/vfd-50hp-460v-3-phase-ip20-nema-1/
  - https://www.automationdirect.com/adc/shopping/catalog/drives_-a-_soft_starters/ac_variable_frequency_drives_(vfd)/high-performance/gs4-4050
- Labor is estimated to incur the plant ~$10,000 per VFD when installed by plant personnel (this accounts for a wage factor and lost productivity on other maintenance tasks).
- There is a range of VFD's available that will be satisfactory for this use, an estimate of $3,000 per VFD is reasonable based on the size of the system.

Total Implementation Cost: $181,000
Calculated Payback Period: 1.45 Years

ASSESSMENT RECOMMENDATION #3
ARC #2.4322: USE OR REPLACE WITH ENERGY EFFICIENT SUBSTITUTES
REPLACE BELT-DRIVE CENTRIFUGE WITH DIRECT-DRIVE UNIT

Annual Resource Savings			Annual Cost Savings	Implementation Costs	Simplified Payback Period
Electricity	**894,900**	**kWh**	**$93,960**	**$250,000**	**2.66 Years**

RECOMMENDATION:
It is recommended to replace the belt-drive centrifuge with a direct-drive unit. Plant personnel report that the 300HP belt-drive unit can process 300GPM, while the existing 125HP direct-drive unit can process 220GPM. Thus, it is expected that a replacement unit for the belt-drive unit would only need to be approximately 170HP to process 300GPM.

ACTIONS:
Purchase a direct-drive centrifuge capable of processing 300GPM and incorporate it into the process. Decommission the belt-drive unit once integration is complete.

ANTICIPATED SAVINGS:
The following annual savings will be incurred which uses the blended electricity rate for monetary savings:

a =	300	Current HP of Centrifuge System
b =	170	Equivalent HP of a Direct-Drive Unit
c =	0.746	Conversion Factor (HP to kW)
d =	0.95	Average Efficiency of System as Decimal
e =	8,760	Hours in a Year

$$(a-b) * \frac{c}{d} * e = \mathbf{894,900 kWh/year}\ (\$\mathbf{93,960/year})$$

Annual Reduction in Electricity Usage: 894,900kWh
Annual Savings: $93,960

IMPLEMENTATION COSTS:

Material and Labor Costs			
Item Description:	**Quantity:**	**Unit Cost:**	**Total Cost:**
Direct Drive Centrifuge	1	$10,000	$20,000
Labor	-	-	$10,000
Total Implementation			$30,000

- The following vendors can be contacted for additional pricing information for direct-drive systems:
    - https://www.beckart.com/sludge-centrifuge
    - https://www.flottweg.com/
    - https://www.centrifugechicago.com/
- Specific pricing information for these systems is not readily available, therefore the auditing team and facility personnel have agreed that an initial estimate of $250,000 for integration of a system of this size.

Total Implementation Cost: $250,000
Calculated Payback Period: 2.66 Years

ASSESSMENT RECOMMENDATION #4
ARC #2.4146: USE ADJUSTABLE FREQUENCY DRIVE ON EXISTING SYSTEM
DEDICATE ONE LIFT PUMP AS FIRST LAG AND PUT ON VFD CONTROL

Annual Resource Savings			Annual Cost Savings	Implementation Costs	Simplified Payback Period
Electricity	**675,000**	**kWh**	**$70,880**	**$80,000**	**1.13 Years**

RECOMMENDATION:
It is recommended to dedicate one lift pump in each well (two total wells) to be the first lag pump, and then put that pump on VFD control. Plant personnel indicate the first lag pump, during effectively dry weather, which is 94% of the time, operates 20% of the time.

ACTIONS:
Purchase and install VFD’s on two first lag pumps (one in each well).

ANTICIPATED SAVINGS:
The following annual savings will be incurred which uses the blended electricity rate for monetary savings:

a =	2	Number of Lag Pumps to be Put on VFD
b =	250	HP Rating per Pump
c =	0.746	Conversion Factor (HP to kW)
d =	0.93	Average Efficiency of Pump as Decimal
e =	0.2	Average Duty Cycle of Pumps as Decimal
f =	8,760	Hours in a Year

$$a * b * \frac{c}{d} * (e - e^3) * f = \mathbf{675,000 kWh/year}\ (\$\mathbf{70,880/year})$$

Annual Reduction in Electricity Usage: 675,000 kWh
Annual Savings: $70,880

IMPLEMENTATION COSTS:

Item Description:	Quantity:	Unit Cost:	Total Cost:
Variable Speed Drive	2	$25,000	$50,000
Labor	2	$10,000/VFD	$20,000
Auxiliary Parts Estimate	-	-	$10,000
Total Implementation			$80,000

- The following are acceptable speed drives for this application:
    - https://www.wolfautomation.com/lslv2500h100-4cofd-plus-vfd-400hp-250kw-380/
    - https://www.wolfautomation.com/odp-2-84400-3hf4n-mn-vfd-400hp-250kw-480-amp/
    - https://www.wolfautomation.com/vfd-400hp-460v-3-phase-50x21-1x16-8/
- Labor is estimated to incur the plant ~$10,000 per VFD when installed by plant personnel (this accounts for a wage factor and lost productivity on other maintenance tasks).
- There is a range of VFD's available that will be satisfactory for this use, an estimate of $25,000 per VFD is reasonable based on the size of the system.

Total Implementation Cost: $80,000
Calculated Payback Period: 1.13 Years

ASSESSMENT RECOMMENDATION #5
ARC #2.1331: BURN A LESS EXPENSIVE GRADE OF FUEL
UTILIZE BIOGAS IN THE COGENERATION UNITS

Annual Resource Savings			Annual Cost Savings	Implementation Costs	Simplified Payback Period
Electricity	**463,000**	**kWh**	**$48,610**	**$0**	**Immediate**

RECOMMENDATION:
It is recommended to use the biogas from the digester in the cogeneration units, instead of flaring it. Currently, digester biogas production is 7,901MMBtu/year, and plant personnel report that approximately 80% of that is flared.

ACTIONS:
Divert biogas to the cogeneration units instead of flaring the excess biogas.

ANTICIPATED SAVINGS:
The annual savings will be as follows which uses the blended electricity rate for monetary savings:

a =	0.8	Percent of Biogas Flared as Decimal
b =	7,901	Yearly Production of Biogas (MMBtu)
c =	293	MMBtu to kWh Conversion Factor
d =	0.25	Efficiency of Cogeneration Units

$$a * b * c * d = \mathbf{463{,}000} \boldsymbol{kWh/year}\ (\$\mathbf{48{,}610}/\boldsymbol{year})$$

Annual Reduction in Electricity Usage: 463,000kWh
Annual Savings: $48,610

IMPLEMENTATION COSTS:
- Current facility infrastructure allows the cogeneration units to accept biogas, although much is currently not utilized and just flared. It is assumed that this proportion can be adjusted by facility personnel and will incur no implementation cost for performing this change.

Total Implementation Cost: $0
Calculated Payback Period: Immediate

ASSESSMENT RECOMMENDATION #6
ARC #2.2437: RECOVER WASTE HEAT FROM EQUIPMENT
HEAT THE SLUDGE WITH COGENERATION WASTE HEAT

Annual Resource Savings			Annual Cost Savings	Implementation Costs	Simplified Payback Period
Electricity	**115,750**	**kWh**	**$12,154**	**$50,000**	**4.11 Years**

RECOMMENDATION:
It is recommended to convert sludge heating in the digester from the biogas-heated hot water boiler to direct heating from the waste heat of the cogeneration plant. Digester biogas production is reported to be 7,901MMBtu/year. Plant personnel report that 20% of this is used for the digester hot water boilers. Converting sludge heating to direct heating will allow this biogas to be used in the cogeneration units to generate electricity.

ACTIONS:
Install piping of heat from cogeneration units to be diverted to be used for heating the process sludge. Then, divert excess biogas to the cogeneration units.

ANTICIPATED SAVINGS:
The annual savings will be as follows which uses the blended electricity rate for monetary savings:

a =	0.2	Percent of Biogas Used for Heating as Decimal
b =	7,901	Yearly Production of Biogas (MMBtu)
c =	293	MMBtu to kWh Conversion Factor
d =	0.25	Efficiency of Cogeneration Units

$$a * b * c * d = \mathbf{115,750\ \boldsymbol{kWh}}\ (\$\mathbf{12,154/\boldsymbol{year}})$$

Annual Reduction in Electricity Use: 115,750 kWh
Annual Savings: $12,154

IMPLEMENTATION COSTS:
- Diverting heat from the cogeneration units will require additional facility piping to directly heat the sludge with waste heat. No vendor estimate is possible for this quote, and for an initial estimate, it has been agreed upon with facility personnel that this implementation will cost approximately ~$50,000.

Total Implementation Cost: $50,000
Calculated Payback Period: 4.11 Years

ASSESSMENT RECOMMENDATION #7
ARC #2.6231: UTILIZE CONTROLS TO OPERATE EQUIPMENT ONLY WHEN NEEDED
RUN ADMIN BUILDING AIR HANDLER 'FAN-AUTO'

Annual Resource Savings			Annual Cost Savings	Implementation Costs	Simplified Payback Period
Electricity	**54,020**	**kWh**	**$5,672**	**$0**	**Immediate**

RECOMMENDATION:
It is recommended to switch the administration building's air handler to operate 'fan-auto'. The fan was measured to consume 7.25kW, and in 'fan-auto', for the plant's geography, our Center has determined that commercial HVAC units will come on average about 15% of the time on an annual basis.

ACTIONS:
Adjust the air handler to operate 'fan'auto'.

ANTICIPATED SAVINGS:
The annual savings will be as follows which uses the blended electricity rate for monetary savings:

a =	7.25	Fan Consumption (kW)
b =	0.85	Percent Savings as Decimal
c =	8,760	Hours per Year

$$a * b * c = \mathbf{54,020}\boldsymbol{kWh/year}\ (\$\mathbf{5,672}/\boldsymbol{year})$$

Annual Reduction in Electricity Use: 54,020 kWh
Annual Savings: $5,672

IMPLEMENTATION COSTS:
- There is no implementation cost associated with this recommendation.

Total Implementation Cost: $0
Calculated Payback Period: Immediate

ASSESSMENT RECOMMENDATION #8
ARC #2.7142: INSTALL HIGHER EFFICIENCY LAMPS AND/OR BALLASTS
UPGRADE LIGHTING TO LED

Annual Resource Savings			Annual Cost Savings	Implementation Costs	Simplified Payback Period
Electricity	**672,571**	**kWh**	**$70,620**	**$19,500**	**0.28 Years**

RECOMMENDATION:
It is recommended to replace all non-LED facility lighting with LED’s.

ACTIONS:
Replace 32W 4’ T8’s and 31W U-T8’s with 15W LED’s; 86W 8’ LED T8’s with 43W LED’s (these will require bypassing the ballasts of the fixtures); 2-pin CFL with 7W LED’s; 23W bulbs with 3W LED’s; 400W, 600W, and 1000W metal halide bulbs with 100W, 150W, and 250W LED’s (note this will require bypassing the ballasts of the fixtures); 150W sodium with a 36W LED.

ANTICIPATED SAVINGS:

Here is the current facility lighting survey:

Building	Room	Hours/week	4ft T8 Tube (32 W)	2ft T8 U-Bend (31W)	8ft T8 Tube (86 W)	2-Pin CFL (13W)	Bulb (23W)	400W Metal Halide	600W Metal Halide	1000 W Metal Halide	High Pressure Sodium HID Bulb (150W	kWh/year
Admin	Entry	168				4						456
Admin	First Floor Hallway	50	16			4						1471
Admin	Engineers Room - 107	50	12									1002
Admin	Janitor Closet	50	1									83
Admin	Men's Bathroom	50	2			4						303
Admin	Women's Bathroom	50	2			4						303
Admin	Conference Room	50	35									2922
Admin	2nd Floor Lobby	50	16									1336
Admin	Kitchen	50		4		2						391
Admin	2nd Floor Hallway	50		14								1132
Admin	Men's Bathroom	50	2			4						303
Admin	Women's Bathroom	50	2			4						303
Admin	201	50	18									1503
Admin	208	50	12									1002
Admin	209	50	12									1002
Admin	210	50	12									1002
Admin	211	50	18									1503
Admin	212	50	12									1002
Admin	Stairway 1	50	4									334
Admin	Stairway 2	50		4								324
Admin	Stairway 3	168	8									2244
												0
Basement	Pipe Gallery	168	404				16	9	26	27	9	595916
												0
Tertiary Pond Building	Total Building	168	44									12343
												0
												0
Laboratory	Lobby	40	40									2672
Laboratory	Lab	40	35									2338
Laboratory	Storage	40	2									134
Laboratory	Side Room	40	24									1603
Laboratory	Bathroom	4	2			2						19
												0
Maintenance	Maintenance Shop	168	70									19636
Maintenance	Maintenance Office	168	8									2244
Maintenance	Control + Admin Office	168	6									1683
												0
Digestor #1 Building	Open Area	168	8					5				22407
Digestor #1 Building	Office	168	6									1683
												0
Digestor #2 Building	Open Area	168						9				36292
Digestor #2 Building	Upstairs	168							1	2		26211
Digestor #2 Building	Electrical	168	8									2244
Digestor #2 Building	Stairs	168	4									1122
												0
Parts Warehouse	Warehouse	50								15		45005
												0
Sludge Dewatering Plant	Entry	168	4									1122
Sludge Dewatering Plant	Hallway	168	30									8416
Sludge Dewatering Plant	Storage Bay #1	168			12							9047
Sludge Dewatering Plant	Truck Bay 2	168			8							6031
Sludge Dewatering Plant	Truck Bay 4	168			8							6031
Sludge Dewatering Plant	Polymer Feeder	168	4		10							8661
Sludge Dewatering Plant	Boiler	168	8									2244
Sludge Dewatering Plant	Plumbing	168	24									6732
Sludge Dewatering Plant	Shop	168	4									1122
Sludge Dewatering Plant	Bathroom	168	2									561
Sludge Dewatering Plant	Storage Room	168								2		20162
Sludge Dewatering Plant	Polymer Storage	168			4							3016
Sludge Dewatering Plant	Upstairs Break Room	168	14									3927
Sludge Dewatering Plant	Upstairs Bathroom	168	12									3366
Sludge Dewatering Plant	Upstairs Office	168	8									2244
Sludge Dewatering Plant	Upstairs Lunch	168	9									2525
Sludge Dewatering Plant	Upstairs Bell Press Open Area	168								5	2	53430
Sludge Dewatering Plant	Stairs #1	168	6									1683
Sludge Dewatering Plant	Stairs #2	168			12							9047
Sludge Dewatering Plant	Stairs #3	168			2							1508
												0
												944347

Here is the updated lighting survey with LED's installed:

Building	Room	Hours/week	4ft LED Tube (15 W)	2ft LED U-Bend (15W)	8ft LED Tube (43 W)	2-Pin LED (7W)	LED Bulb (3W)	100W LED corn bulb	150W LED corn bulb	250W LED corn bulb	36W LED corn bulb	kWh/year
Admin	Entry	168				4						245
Admin	First Floor Hallway	50	16			4						699
Admin	Engineers Room - 107	50	12									470
Admin	Janitor Closet	50	1									39
Admin	Men's Bathroom	50	2			4						151
Admin	Women's Bathroom	50	2			4						151
Admin	Conference Room	50	35									1370
Admin	2nd Floor Lobby	50	16									626
Admin	Kitchen	50		4		2						193
Admin	2nd Floor Hallway	50		14								548
Admin	Men's Bathroom	50	2			4						151
Admin	Women's Bathroom	50	2			4						151
Admin	201	50	18									704
Admin	208	50	12									470
Admin	209	50	12									470
Admin	210	50	12									470
Admin	211	50	18									704
Admin	212	50	12									470
Admin	Stairway 1	50	4									157
Admin	Stairway 2	50		4								157
Admin	Stairway 3	168	8									1052
												0
Basement	Pipe Gallery	168	404				16	9	26	27	9	157635
												0
Tertiary Pond Building	Total Building	168	44									5786
												0
												0
Laboratory	Lobby	40	40									1252
Laboratory	Lab	40	35									1096
Laboratory	Storage	40	2									63
Laboratory	Side Room	40	24									751
Laboratory	Bathroom	4	2			2						9
												0
Maintenance	Maintenance Shop	168	70									9205
Maintenance	Maintenance Office	168	8									1052
Maintenance	Control + Admin Office	168	6									789
												0
Digestor #1 Building	Open Area	168	8					5				5435
Digestor #1 Building	Office	168	6									789
												0
Digestor #2 Building	Open Area	168						9				7890
Digestor #2 Building	Upstairs	168							1	2		5698
Digestor #2 Building	Electrical	168	8									1052
Digestor #2 Building	Stairs	168	4									526
												0
Parts Warehouse	Warehouse	50								15		9784
												0
Sludge Dewatering Plant	Entry	168	4									526
Sludge Dewatering Plant	Hallway	168	30									3945
Sludge Dewatering Plant	Storage Bay #1	168			12							4523
Sludge Dewatering Plant	Truck Bay 2	168			8							3016
Sludge Dewatering Plant	Truck Bay 4	168			8							3016
Sludge Dewatering Plant	Polymer Feeder	168	4		10							4295
Sludge Dewatering Plant	Boiler	168	8									1052
Sludge Dewatering Plant	Plumbing	168	24									3156
Sludge Dewatering Plant	Shop	168	4									526
Sludge Dewatering Plant	Bathroom	168	2									263
Sludge Dewatering Plant	Storage Room	168								2		4383
Sludge Dewatering Plant	Polymer Storage	168			4							1508
Sludge Dewatering Plant	Upstairs Break Room	168	14									1841
Sludge Dewatering Plant	Upstairs Bathroom	168	12									1578
Sludge Dewatering Plant	Upstairs Office	168	8									1052
Sludge Dewatering Plant	Upstairs Lunch	168	9									1183
Sludge Dewatering Plant	Upstairs Bell Press Open Area	168								5	2	11589
Sludge Dewatering Plant	Stairs #1	168	6									789
Sludge Dewatering Plant	Stairs #2	168			12							4523
Sludge Dewatering Plant	Stairs #3	168			2							754
												0
												271776

The annual savings will be as follows which uses the blended electricity rate for monetary savings:

$$944{,}347\frac{kWh}{yr} - 271{,}776\frac{kWh}{yr} = \boldsymbol{672{,}571 kWh/year}\ (\$\boldsymbol{70{,}620/year})$$

Annual Reduction in Electricity Use: 672,571 kWh
Annual Savings: $70,620

IMPLEMENTATION COSTS:

Item Description:	Quantity:	Unit Cost:	Total Cost:
15W T8 4’ LED Tubes	970	$4.69	$4,549.30
15W T8 U-Bend LED Tubes	22	$10.45	$229.90
43W T8 8’ LED Tubes	56	$22.18	$1,242.08
7W LED Bulb	28	$12.66	$354.48
3W LED Bulb	16	$1.65	$26.40
100W LED Bulb	23	$78.53	$1,806.19
150W LED Bulb	27	$40.14	$1,083.78
250W LED Bulb	51	$62.96	$3,210.96
36W LED Bulb	11	$57.13	$628.43
Ballast Bypass Labor	~129	$50/fixture	$6,300.00
Total Implementation:			$19,431.52

- The following can be used for lighting replacements:
  - 15W 4’ LED T8 Tube: https://www.1000bulbs.com/product/211678/TCP-10400.html?gclid=EAIaIQobChMIzdC0u6T1-wIVSVtyCh2vMA2fEAQYASABEgJ-xfD_BwE
  - 15W LED T8 U-Bend Tube: https://www.1000bulbs.com/product/220597/TCP-10313CS.html?gclid=EAIaIQobChMInPSY-qX1-wIVj6jICh3mxQ6GEAQYASABEgLAIPD_BwE
  - 43W 8’ LED T8 Tube: https://www.1000bulbs.com/product/225084/TCP-11223.html?gclid=EAIaIQobChMIhIGr1Kb1-wIVBoTICh1vGA3tEAQYASABEgKKEPD_BwE
  - 7W LED Bulb: https://www.1000bulbs.com/product/222410/LED-732240KG3.html?gclid=EAIaIQobChMI9rfx1KT1-wIVw97ICh2IiwnPEAQYASABEgIxlvD_BwE
  - 3W LED Bulb: https://www.sunco.com/products/a19-3w-led-bulb?currency=USD&variant=39622209601603&utm_medium=cpc&utm_source=google&utm_campaign=Google%20Shopping&gclid=EAIaIQobChMIrv275aT1-wIVCfjICh36PQPYEAQYASABEgI8c_D_BwE
  - 100W LED Bulb: https://www.1000bulbs.com/product/221977/PLTS-12061.html?gclid=EAIaIQobChMIvp2N_KT1-wIVFrjICh3kBQRyEAQYBiABEgL0EfD_BwE
  - 150W LED Bulb: https://www.1000bulbs.com/product/222087/PLTS-12051.html?gclid=EAIaIQobChMI3N-Mj6X1-wIVSuDICh119AaSEAQYASABEgKMdvD_BwE
  - 250W LED Bulb: https://www.1000bulbs.com/product/222727/TCP-11078.html?gclid=EAIaIQobChMIwOnsoaX1-wIVkrfICh2XFgZuEAQYASABEgKpZvD_BwE
  - 36W LED Bulb: https://www.1000bulbs.com/product/222751/TCP-11084.html?gclid=EAIaIQobChMI_4yQsaX1-wIVBfrICh1qKAe2EAQYASABEgIDJ_D_BwE

Total Implementation Cost: $19,500
Calculated Payback Period: 0.28 Years

ASSESSMENT RECOMMENDATION #9
ARC #2.7234: USE HEAT PUMP FOR SPACE CONDITIONING
REPLACE RESISTIVE HEATERS WITH DUCTLESS HEAT PUMPS

Annual Resource Savings			Annual Cost Savings	Implementation Costs	Simplified Payback Period
Electricity	**233,775**	**kWh**	**$24,546**	**$50,000**	**2.04 Years**

RECOMMENDATION:
It is recommended to replace all resistive electric heaters in the plant with ductless heat pump alternatives. From a seasonal profile of electricity consumption, the heaters consume 311,700kWh/year.

ACTIONS:
Purchase and install ductless heat pumps in necessary areas throughout the plant.

ANTICIPATED SAVINGS:
A heat pump has a coefficient of performance of 4, where the following annual savings will be incurred which uses the blended electricity rate for monetary savings:

a =	311,700	Annual Plant Electric Consumption for Heating (kWh)
b =	4	COP of Heat Pump[1]

$$a * (1 - \frac{1}{b}) = \mathbf{233,775}\boldsymbol{kWh/year}\ (\$\mathbf{24,546}/\boldsymbol{year})$$

Annual Reduction in Electricity Usage: 233,775 kWh
Annual Savings: $24,546

IMPLEMENTATION COSTS:

Item Description:	Quantity:	Unit Cost:	Total Cost:
Ductless Heat Pumps	5	$7,500	$37,500
Labor	5	$2,500/Heat Pump	$12,500
Total Implementation			$50,000

- The following is a standard heat pump that would be acceptable for plant use:
    - https://www.alpinehomeair.com/product/air-conditioning-cooling/ductless-mini-splits/five-zone-mini-split-systems/blueridge/bmm4821-12c-12c-12c-12c?linkfrom=froogle&utm_source=google&utm_medium=cpc&utm_campaign=Blueridge&utm_content=Blueridge_Products&utm_term=453085848&gclid=EAIaIQobChMI3Pyr-qn1-wIVlN7ICh2JAQLKEAQYAiABEgKKevD_BwE
    - https://hvacdirect.com/mrcool-olympus-48-000-btu-ductless-heat-pump-split-system-5-zone-wall-mounted-9-9-9-9-12-id15626.html
    - https://www.acwholesalers.com/LG-L5L48W0707091212/p117918.html

[1] https://www.attainablehome.com/ductless-mini-splits-is-it-worth-it/

- Quantity is estimated based on various areas that were seen during the audit. Each separate heat pump has a total estimated installed cost of ~$10,000.

Total Implementation Cost: $50,000
Calculated Payback Period: 2.04 Years

CYBERSECURITY

As part of our program, we also offer the attached industrial cybersecurity awareness self-survey. It offers some initial review of any potential cybersecurity issues at the plant. Furthermore, we have a cybersecurity audit group in our department, headed by Dr. Novocin, that potentially can offer a complete cybersecurity review. Please follow up if you'd like to access these additional services available from the university.

The following Cybersecurity information is provided from https://iac.university/cybersecurity

As systems to control energy-using manufacturing equipment become more connected to the internet, it is important for plant operations staff to have an understanding of cybersecurity risks and to coordinate risk management activities within their organization.

Small businesses may not consider themselves targets for cyber-attacks. However, they have valuable information cyber criminals seek, such as employee and customer records, bank account information, and access to larger networks. They can be at a higher risk for cybersecurity attack because they have fewer resources dedicated to cybersecurity.

By addressing risk areas, you can protect your business from damage to information or systems, intellectual property theft, regulatory fines/penalties, decreased productivity, or a loss of trust with customers.

IAC Cybersecurity Assessments

Industrial Assessment Centers work with manufacturing clients to increase awareness of cybersecurity risks and potential mitigation activities. As part of facility site visits, IAC clients may elect to receive cybersecurity risk assessments to identify security and privacy deficiencies to the business infrastructure, with a focus on vulnerabilities associated with industrial controls systems.

The IAC Industrial Control Systems Cybersecurity Assessment Tool (the link to the tool is provided here and also included on the next page) includes 20 simple questions to characterize industrial controls systems and plant operations. The tool then provides a high-level assessment of risk (high, medium, or low). The companion User Guide (the link for which is provided here, and also on the next page) provides additional context for the questions included in the tool, to help clients understand how certain business practices lead to cybersecurity risk. Upon conclusion of the assessment, the tool generates a customized list of action items associated with the risks identified. For additional guidance, IACs refer clients to additional technical resource materials available through the NIST Manufacturing Extension Partnership (MEP) and other organizations.

IAC Industrial Control Systems Cybersecurity Assessment Tool:

Industrial Control Systems Cybersecurity Assesment Tool			
	People		
1	**Does your plant or facility provide basic cybersecurity awareness training to all employees?** *Yes*	Regular training of employees in proper conduct on company equipment can help prevent accidental downloads of viruses and other system vulnerabilities.	**Medium Risk**
2	**Are staff assigned and trained to take appropriate measures during a cybersecurity incident?** *No*	If a cybersecurity event were to occur, there could be issues with a safe and damage-free shutdown. Additionally, if roles are not properly articulated and no one knows who to contact regarding potential fixes for the system, the shutdown could be prolonged.	
	Process		
7	**Have you identified and inventoried critical equipment, data, or software in your plant or facility that would cause disruption to your operations if they were compromised?** *No*	Maintaining a list of your critical equipment, data, or software can help you prioritize actions during emergency shutdowns and other unplanned activities.	**High Risk**
8	**Does a plan exist to identify and isolate impacted assets, or shut down equipment as necessary in the event of a cybersecurity incident?** *No*	Without a plan to review IT and ICS assets, external consultants or IT staff may have difficulty working and may prolong the plant outage. Additionally, without an emergency shutdown plan, equipment could be accidentally damaged or destroyed.	
	Technology		
14	**Which of the following best describes the industrial controls in your plant or facility?** *Mainly using manual controls such as mechanical levers, pneumatic or electrical switches*	Manually operated machinery presents little risk in a cybersecurity environment due to its lack of connection with business systems and the broader internet.	**Low Risk**
15	**Are indicators or alerts set up on critical equipment to indicate unusual changes to operating parameters, multiple login attempts, or detect other anomalies in use?** *Yes*	These alarms will notify you if unauthorized users are changing equipment operating parameters or may be close to damaging equipment.	
	People: Medium Risk	**Overall Risk: Medium**	
	Process: High Risk		
	Technology: Low Risk		

***This form can be downloaded at the following link:*
https://iac.university/images/cybersecurity/Industrial%20Control%20Systems%20Cybersecurity%20Assessment%20Tool_2020-2-26.xlsx
And the user guide for this spreadsheet can be found here:
https://iac.university/images/cybersecurity/Industrial%20Control%20Systems%20Cybersecurity%20Assessment%20Tool_User%20Guide_2020-02-26.pdf

Cybersecurity Fundamentals for Small and Medium Sized Manufacturers

Most plant operations managers are not cybersecurity experts, but can benefit from a basic understanding of cybersecurity risks and mitigation activities. A guidance document provided by NIST, NIST Small Business Information Security: The Fundamentals, provides a thorough and easily readable overview of cybersecurity basics.

As a first step, organizations need to understand their cybersecurity risks, to determine where the organization is vulnerable and may be subject to disruption of systems and processes. Organizations can use helpful checklists from the NIST document, or other cybersecurity assessment tools, to conduct the following activities:

- Identify what information your business stores and uses
- Determine the value of your information
- Develop an inventory of technologies used to store and process information
- Understand your threats and vulnerabilities

Once risks are understood, organizations can determine appropriate mitigation activities. Example activities are shown below, grouped into the five broad categories of the NIST Cybersecurity Framework:

Source: N. Hanacek/NIST

IDENTIFY

- Identify and control who has access to your business information
- Conduct background checks
- Require individual user accounts for each employee
- Create policies and procedures for information security

PROTECT

- Limit employee access to data and information
- Install surge protectors and uninterruptible power supplies (UPS)
- Patch your operating systems and applications
- Install and activate software and hardware firewalls on all your business networks
- Secure your wireless access point and networks
- Set up web and email filters
- Use encryption for sensitive business information
- Dispose of old computers and media safely
- Train your employees

DETECT

- Install and update anti-virus, -spyware, and other –malware programs
- Maintain and monitor logs

RESPOND

- Develop a plan for disasters and information security incidents

RECOVER

- Make full backups of important business data/information
- Make incremental backups of important business data/information
- Consider cyber insurance
- Make improvements to processes/procedures/technologies

Additional Cybersecurity Assessment Tools

Once an organization has a basic understanding of cybersecurity risks and vulnerabilities, a more detailed assessment can be used to determine mitigation actions and security controls. Some of the common tools used to perform assessments are listed below. The CSET tool is one of the more comprehensive tools available for small and medium-sized manufacturers. Organizations can explore resources available to help conduct assessments (e.g., IACs, MEPs, third party vendors).

- Cyber Security Evaluation Tool (CSET): Comprehensive desktop software tool that guides users through a step-by-step process to assess their control system and information technology network security practices against recognized industry standards.
- NIST MEP Cybersecurity Assessment Tool: Online easy-to-use checklist that provides an assessment of business systems.
- Department of Energy C2M2 Model: Model used to measure the maturity of an organization's cybersecurity capabilities, developed by energy sector subject matter experts.

Department of Homeland Security Cyber Resilience Review: No-cost, non-technical assessment to evaluate an organization's operational resilience and cybersecurity practices.

Additional Resources

National Institutes for Standards and Technology Manufacturing Extension Partnership (MEP)

Provides cybersecurity resources for small manufacturers, based on the NIST Cybersecurity Framework

NIST MEP Cybersecurity Fact Sheet

Interactive Infographic: How Secure is Your Factory Floor?

NIST Small Business Information Security: The Fundamentals

NIST MEP Cybersecurity Assessment Tool

NIST Resources on DFARS Cybersecurity Requirement for suppliers to DOD

Department of Homeland Security National Cybersecurity and Communications Integration Center (NCIC)

Provides resources focused on industrial controls systems

Cybersecurity for the C Level

[Overview of Cyber Vulnerabilities of ICS]

- Recommended Practices technical resources to mitigate vulnerabilities of controls systems
- Cyber Threat Source Descriptions
- Critical Manufacturing Sector Cybersecurity Framework Implementation Guidance
- ICS-CERT Annual Assessment Report summary of Top Vulnerabilities

Department of Homeland Security Stop. Think. Connect. Campaign

- Toolkit for Small Businesses

Federal Communications Commission

- Cybersecurity for Small Business

Industry and University Cybersecurity Studies

- Information Trust Institute
- Cisco Systems Cybersecurity Reports
- Verizon Data Breach Investigations Report

**Please note that anything underlined and colored blue is a clickable link that will direct you to the specified resource

ADDENDUM

APPENDIX I: SECONDARY EFFECTS OF ENERGY EFFICIENCY ON AIR POLLUTION

Implementing the proposed energy efficiency recommendations will decrease the amount of electricity that must be generated and fuel that must be consumed and contribute directly to reductions in common air pollutants. Reducing energy consumption will decrease carbon dioxide (CO_2), sulfur dioxide (SO_2) and nitrogen oxides (NO_x) emissions directly from plant fuel consumption as well as indirectly at power generating stations. The table below shows the emission factors of each air pollutant based on each fuel source (see footnote references for emission factor sources).

Emissions Factors[2][3]	Electricity (lbs/kWh)	Natural gas (lbs/mmBTU)	No 2 Fuel Oil (lbs/mmBTU)	No 6 Fuel Oil (lbs/mmBTU)	Propane (lbs/mmBTU)
CO2 Factor	1.1295	117.6471	159.2857	166.6667	136.6120
SO2 Factor	0.0001	0.0006	1.0143	1.0467	0.0011
NOX factor	0.0006	0.0980	0.1714	0.3133	0.1421

If all the recommendations in this report were implemented, electricity consumption would be reduced by 9,793,016 kWh. Carbon dioxide emissions would decrease by 11,061,212 lbs/year, sulfur dioxide emissions by 979 lbs/year, and nitrogen oxide emissions by 5,876 lbs/year. Total carbon footprint reduction is 51.82% of the current footprint of 21,345,276 lbs/year. Total SO_2 reduction would be 51.82% of the current total of 1,890 lbs/year, while total NO_x reduction would be 51.82% of the current 11,339 lbs/year emissions. The table below provides a breakdown of how air emissions are reduced for each assessment recommendation:

[2] Source: Energy Information Agency (EIA) - State Electricity Profiles 2021: https://www.eia.gov/electricity/state/
[3] Source: Environmental Protection Agency (EPA) - AP-42 Compilation of Air Emissions Factors: https://www.epa.gov/air-emissions-factors-and-quantification/ap-42-compilation-air-emissions-factors

AR No.	Description	Energy Savings	CO_2 Reduction (lbs/yr)	SO_2 Reduction (lbs/yr)	Nox Reduction (lbs/yr)
1	Put Aeration Blowers on VFD Control	5,498,000 kWh	6,209,991	549.8	3,298.8
2	Put RAS Pumps on VFD Control	1,186,000 kWh	1,339,587	118.6	711.6
3	Replace Belt-Drive Centrifuge with Direct-Drive Unit	894,900 kWh	1,010,790	89.5	536.9
4	Dedicate One Lift Pump as First Lag and Put on VFD Control	675,000 kWh	762,413	67.5	405.0
5	Utilize Biogas in the Cogeneration Units	463,000 kWh	522,959	46.3	277.8
6	Heat the Sludge with Cogeneration Waste Heat	115,750 kWh	130,740	11.6	69.5
7	Run Admin Building Air Handler 'Fan-Auto'	54,020 kWh	61,016	5.4	32.4
8	Upgrade Lighting to LED	672,571 kWh	759,669	67.3	403.5
9	Replace Resistive Heaters with Ductless Heat Pumps	233,775 kWh	264,049	23.4	140.3
TOTALS			**11,061,212**	**979**	**5,876**
CURRENT EMISSIONS FOOTPRINT			**21,345,376**	**1,890**	**11,339**
TOTAL % REDUCTION OPPORTUNITY			**51.82%**	**51.82%**	**51.82%**

APPENDIX II: INFORMATION ABOUT ENERGY EFFICIENCY INCENTIVES IN DELAWARE

There are various incentives available from the federal government and State of Delaware that could help to defray the costs of implementing the energy efficiency recommendations provided in this report. Additionally, the facility can understand federal financial incentives for installation and use of renewable energy technologies. Although this assessment did not include a review of renewable energy technology opportunities, large environmental footprint reductions can be made through use of non-fossil fuel energy and there are excellent federal incentive opportunities to assist with costs of renewable energy. To understand the most current incentives, the facility should consult the following websites:

Federal Incentives:

- US DOE Office of Energy Efficiency and Renewable Energy:
  https://www.energy.gov/energy-economy/funding-financing
- Energy Star Tax Deductions for Commercial Buildings:
  https://www.energytaxincentives.org/resources/federal-tax-incentives

State of Delaware:

- Delaware Sustainable Energy Utility:
  https://www.energizedelaware.org/
- DNREC Renewable Energy Assistance:
  https://dnrec.alpha.delaware.gov/climate-coastal-energy/renewable/assistance/
- Database of State Incentives:
  https://programs.dsireusa.org/system/program

END OF REPORT