City of Taunton

Wastewater Treatment Facility Energy Evaluation

December 2017

Conducted by:

JKMuir, LLC in coordination with **BETA Group, Inc.**

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Executive Summary

This report provides a summary description of the facilities and energy demands for the City of Taunton Wastewater Treatment Facility (WWTF) located in Taunton, Massachusetts. The facility descriptions are based on site visits, staff input and available drawings. Billing data was utilized to summarize the facility's current energy demands.

The objectives of the report include the following:

- Provide a summary description of the evaluated water pollution control facility;
- Summarize the energy usage and billing rates for the facility, and demonstrate how electrical energy is being used;
- Identify specific operational and capital improvements at the facility, and estimate the energy savings and cost for each project.

The projects have been categorized as Energy Conservation Measures (ECMs), for projects that require a capital investment, and Operational Measures (OMs) for projects that can be completed at a minimal cost.

Summary of Energy Use and Proposed Measures

The following tables present the annual electric energy use and a proposed estimate of potential energy conservation projects for this facility.

The energy usage summary shown below provides an overview of annual electrical (kWh) and costs based on billing information provided for 2016 and 2017 for the facility.

Table 1. Electric Energy Usage (Sept 2016 – Aug 2017)

Location	Annual Energy Use (kWh)	Avg. Monthly Demand (kW)	Annual Cost ($)	Unit Cost ($/kWh)
Taunton WWTF	3,306,600	537.9	$368,231	$0.11
Influent Pump Station	531,280	227.3	$97,003	$0.18

The following table presents the estimated annual energy saved based on recommendations, the monetary savings, estimated project cost, and the potential payback period.

The following report has been conducted in conjunction with the BETA Group Comprehensive Wastewater Management Plan (CWMP) for the Taunton WPCF. Estimated project costs have been developed with BETA Group, as noted.

Table 2. Recommended Cost Savings Projects

ENERGY CONSERVATION MEASURES		Annual Energy Savings (kWh)	First Year Annual Dollars Saved ($)	Initial Budgetary Project Cost ($)	Simple Payback (years)
OM 1	Plant Water System Pressure Reduction	129,259	$14,395	$0	0.0
OM 2	Surface Aerator Seasonal Operation	517,421	$57,621	$0	0.0
OM 3	Grit Blower Cycling	28,032	$3,122	$0	0.0
OM 4	Power Factor Correction	-	-	-	-
ECM 1	Primary Sludge Motor Replacement	17,345	$1,932	$10,700	5.5
ECM 2	Grit Blower Turndown	42,048	$4,683	$20,000	4.3
ECM 3	Aeration System Modifications	242,324	$26,986	-	-
ECM 4	Battery 2 RAS Pumps	115,176	$12,826	$56,500	4.4
ECM 5	Battery 1 RAS Pumps	33,022	$3,677	$36,000	9.8
ECM 6	Centrifuge Upgrades	-	-	-	-
ECM 7	UV System	-	-	-	-
Potential Energy Program Cost and Savings		**1,124,626**	**$125,241**	**$123,200**	**1.0**

Note: Savings based on current blended rate of $0.11/kWh

Energy Usage Data

Energy usage for September 2016 through August 2017 was evaluated using the facility's billing history data. The following figures provide monthly breakdowns of energy usage and peak demand at the plant and the influent pump station.

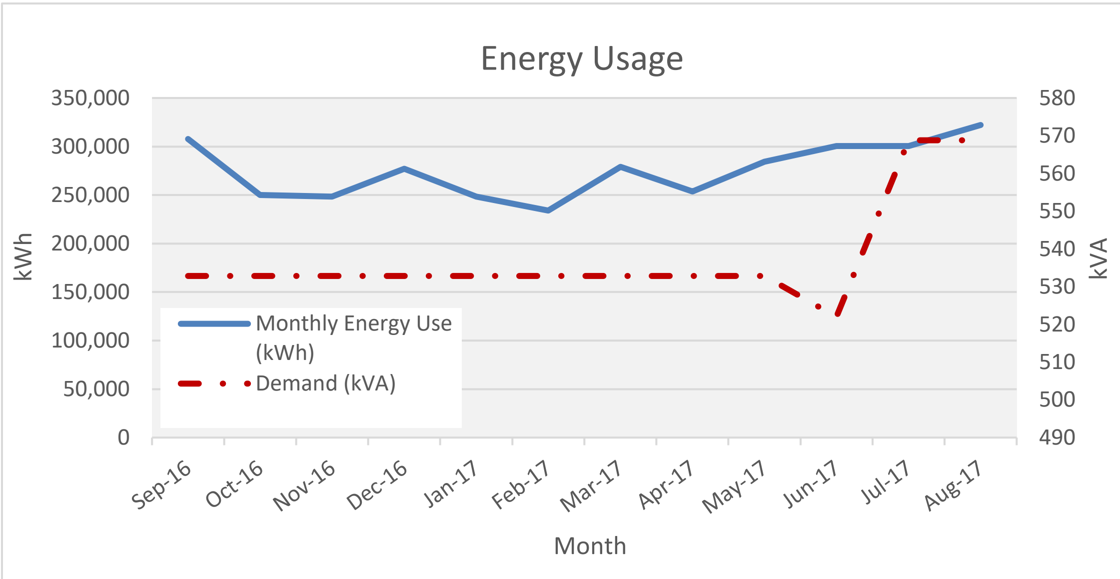


Figure 1. Annual Energy Usage and Electrical Demand – WWTF

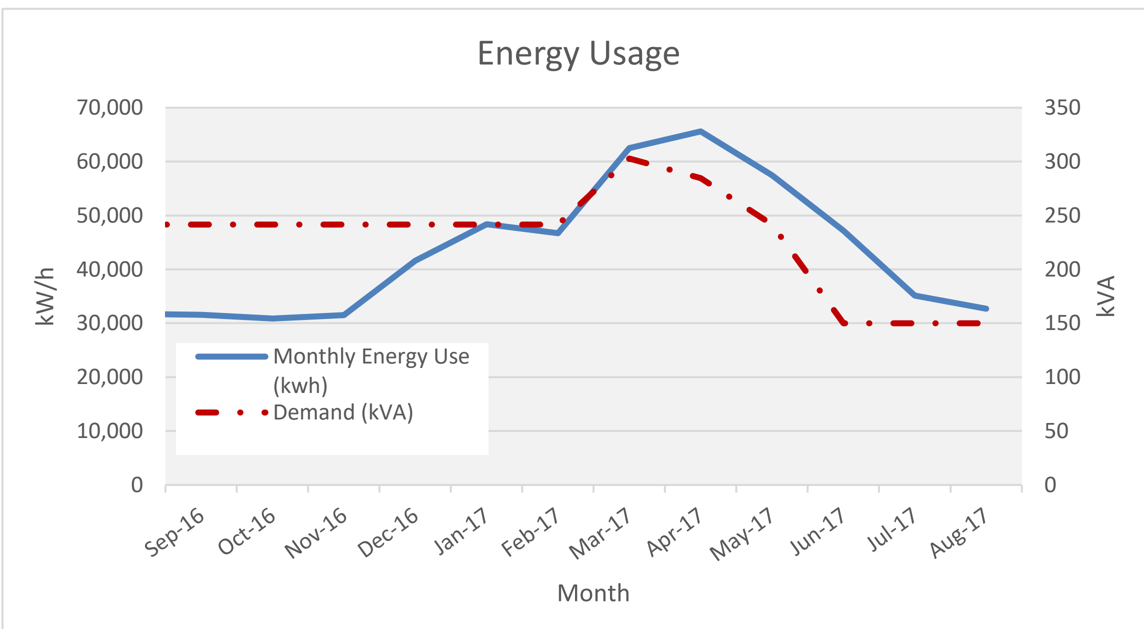


Figure 2. Annual Energy Usage and Electrical Demand – Influent Pump Station

Electrical Billing Rate Summary

The Taunton WWTF and influent pump station are billed for electricity under Taunton Municipal Light Plant under Rate 31 General Service - Primary. A copy of the rate tariff is included in Appendix A. This rate structure is applied to industrial or commercial customers with a monthly demand greater than 150 kilovolt-amperes (kVA). Under this rate, there is a monthly service charge of $959.90. There is a distribution demand charge of $4.81 per kVA, a Transmission Demand Charge of $5.04 per kVA, and a Transition Demand Charge of $4.94 per kVA. The demand charge is based on either the highest 15 minute kVA demand recorded in the current month or the highest 15 minute demand recorded in the previous June, July, or August; the customer is billed for the higher of these two demands. The Distribution and Generation charges change based on the usage under 300 hours and over 300 hours, the rate is greater for the first 300 hours in both cases. The Distribution charge for the first 300 hours is $0.01128 per kWh and $0.00376 per kWh over 300 hours. The Generation charge is $0.05823 per kWh for the first 300 hours and $0.05099 per kWh over 300 hours. Transition charge is $0.01624 per kWh. Currently, there is no charge for Transmission on a kWh basis.

It should be noted that this rate structure has billing for kVA, or apparent power. The power factor is the ratio between kW or true power to the apparent power (kVA). The kW is a measurement of the electricity being used by the equipment while the kVA is a measure of the total power drawn by the equipment. Therefore, the kVA demand is influenced by the power factor and may increase the billed demand and cost associated with operating this facility. Power factor correction may reduce the demand by correcting the kVA to most closely meet the kW demand, potentially reducing electricity charges.

Wastewater Energy Use Benchmark

Based on 2016 and 2017 facility data, the plant treats an average of 6.1 million gallons per day (MGD). Based on the electrical energy usage presented above, the plant consumes approximately 1,721 kWh per million gallons treated. The figure below shows the Taunton WWTF in red, compared to other municipal wastewater treatment plants in the Northeast. The energy use is average for facilities of a similar size (5 to 10 MGD).

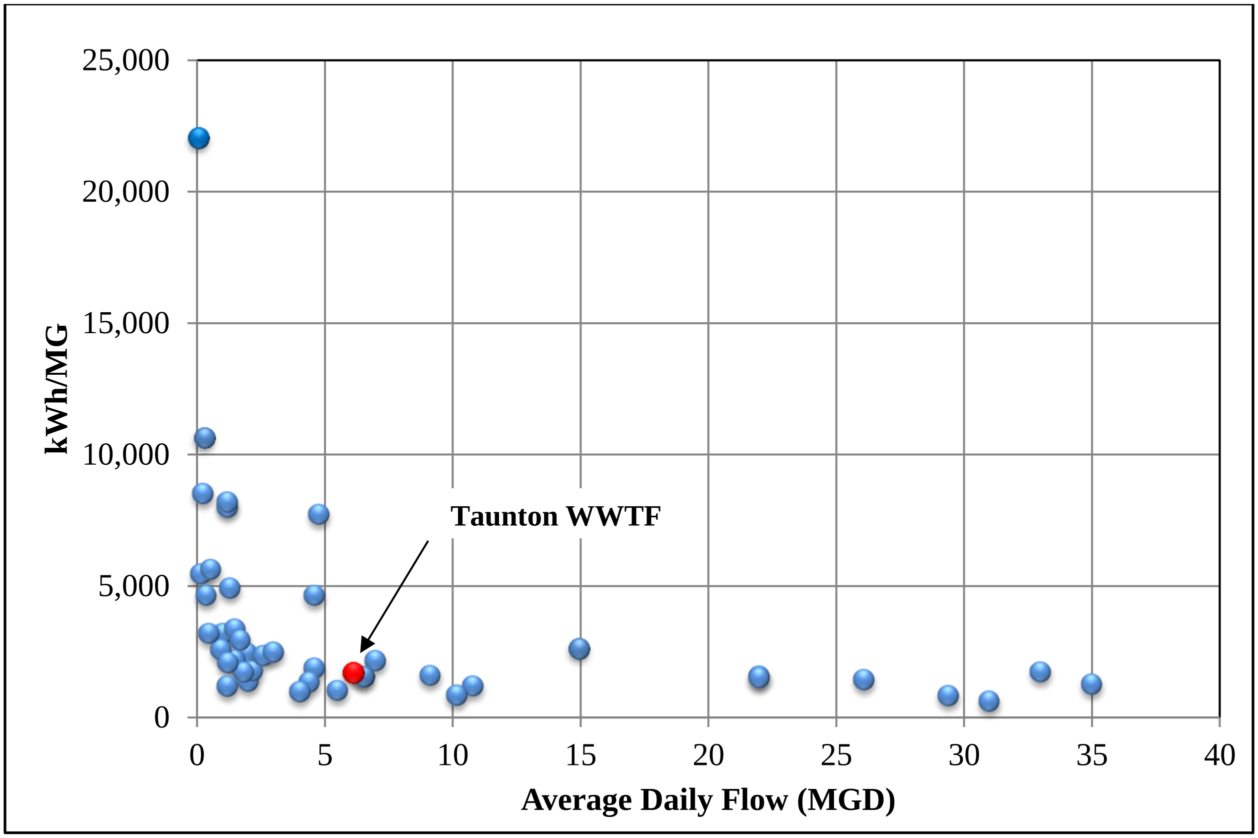


Figure 3. Energy Usage Per Million Gallons

Energy Balance & Use per Process

A breakdown of the electrical energy use for the facility is shown in the figure below. A detailed electrical energy end use reconciliation is provided in Appendix B.

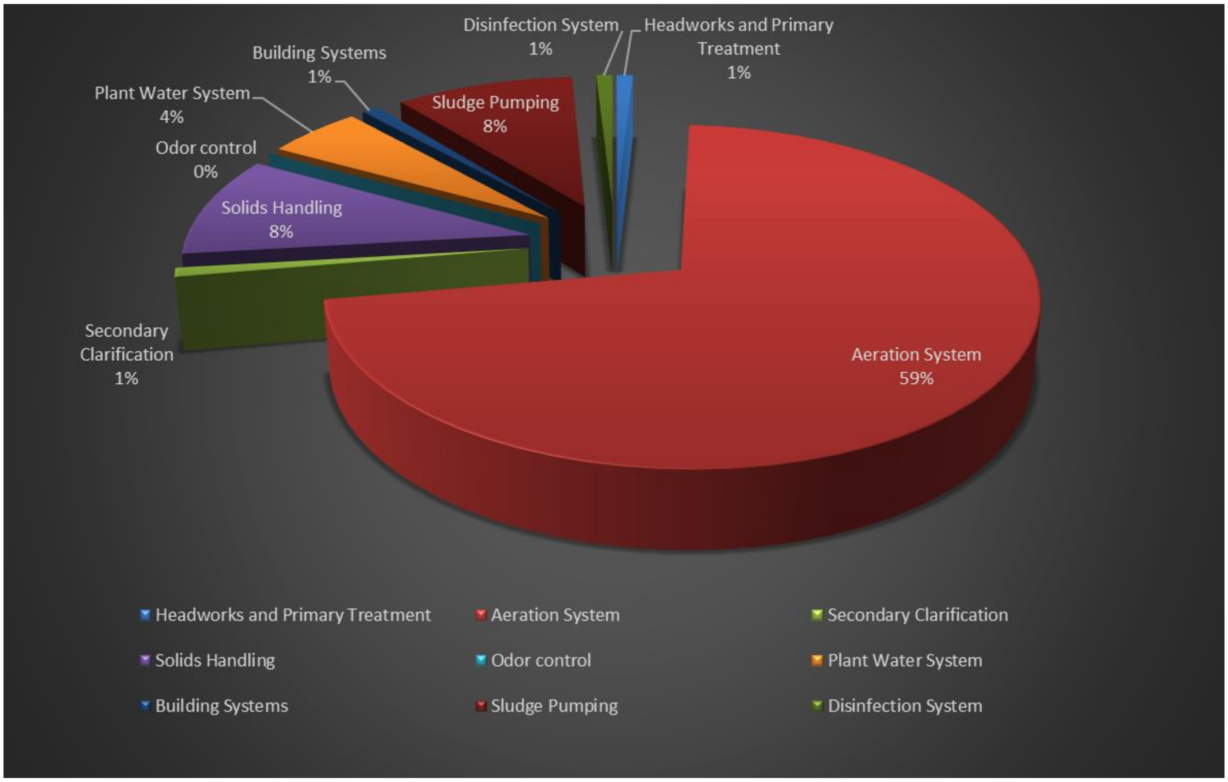


Figure 4. Electrical Usage Breakdown – 2017

As presented in the figure above, the aeration system consumes the majority of energy at the Taunton WWTF (58%). Other major users of energy at the Taunton WWTF include the solids handling and sludge pumping systems. Note that the odor control system is not operational at the facility and therefore is represented as using zero energy in the above figure.

Treatment Process & Building Systems

Wastewater Treatment Facility

The City of Taunton WWTF is located at 75 West Water Street in Taunton, Massachusetts. The plant has gone through major upgrades in the late 1970's to add secondary treatment and in 1999 for ammonia removal.

Flow enters the plant at the main lift station where it goes through an aerated grit chamber. The influent pumps lift the flow to the primary clarifiers. There are three primary clarifiers, all are typically online. Following the primary clarifiers, the flow is split between two batteries; 35% of the flow goes to Battery 1 and 65% goes to Battery 2. Each of the batteries contains three aeration basins. Half of the flow is evenly split between Basin 1 and 2. Basins 1 and 2 contain surface aerators that operate on VFDs at variable speeds based on maintaining a dissolved oxygen (DO) setpoint. The third basin in each battery is aerated through fine bubble diffusion and receives the other half of the flow. There are three multistage centrifugal blowers that feed the third basin in both batteries. The flow then continues to the secondary clarifiers. There are four secondary clarifiers, three are typically in operation. The flow from Battery 1 feeds one clarifier (Clarifier 1 or 2) and the flow from Battery 2 feeds two secondary clarifiers (Clarifier 3 and 4). Following secondary clarification, the flow is fed to the chlorine contact tank for disinfection by gravity.

Return activated sludge (RAS) is returned to the aeration basin with the RAS pumps. There are five RAS pumps, two for Battery 1 and three for Battery 2. Typically, one pump runs continuously on Battery 1 and two pumps run continuously on Battery 2. Primary sludge and waste activated sludge (WAS) is removed from the primary and secondary clarifiers with the primary sludge pumps and WAS pumps and sent to one of the two gravity thickeners. The thickened sludge is pumped from the gravity thickener to the two centrifuges. The dewatered sludge is then sent to the Taunton landfill for disposal.

The Plant Water System (PWS) consists of one, 25 HP pump and one, 40 HP pump on VFDs. Typically, the 40 hp pump operates continuously at full speed to maintain a pressure set point of 160 psi. The plant water system provides water to the gravity thickeners, plant hydrants, washdown water, spray water and polymer system.

The odor control system consists of a wet scrubber but it is not currently operated.

Pump Efficiency Analysis

During the site visit, electrical field measurements were taken to determine the hydraulic efficiency of selected process pumps. Spot readings of operating power to the motor and/or drive, flow rate, and suction and discharge pressure were recorded, where available, for the operating pump(s) at a number of the unit processes. Where pumps were operated by variable speed devices, readings were obtained at multiple operating speeds when possible.

To determine existing pump hydraulic efficiency, the spot readings were applied to the pump equation, as defined below. Please note the motor efficiency is based on nameplate data unless otherwise specified.

$$\text{Pump eff.}\,(\%) = \frac{\text{Flow (GPM)} \times \text{Head (Feet)} \times 0.746}{3{,}960 \times \text{kW} \times \text{Motor eff.} \times \text{Drive eff.}}$$

It was noted that the measured voltage at the raw sewage pump station was high. High voltage can cause issues with equipment, including VFDs, and it is recommended that the high voltage be further investigated.

Table 3. Pump Efficiency Analysis

Pump Name	Speed %	Leg	EMF (VAC)	Current (Amp)	Power (kW)	Power Factor	Flow (GPM)	Motor Eff. (%)	VFD Eff. (%)	Suction (psi)	Discharge (psi)	TDH (feet)	Efficiency (%)
Primary Sludge Pump 1	52%	A	284	7	1.1	0.51	514	70%	97%	1.0	10.0	-	**-**
		B	268	7	1.0	0.51							
		C	291	6	1.0	0.56							
		TOT/AVG	**486.1**	**7.0**	**3.1**	**0.53**							
Primary Sludge Pump 2	52%	A	284	7	1.0	0.53	476	70%	97%	6.6	11.3	10.9	**50%**
		B	268	6	0.9	0.52							
		C	290	6	1.0	0.58							
		TOT/AVG	**485.3**	**6.3**	**2.9**	**0.54**							
Primary Sludge Pump 3	68%	A	290	6	1.0	0.59	219	70%	97%	0.8	6.0	12.0	**25%**
		B	268	6	0.9	0.53							
		C	284	7	1.0	0.56							
		TOT/AVG	**485.1**	**6.3**	**3.0**	**0.56**							
Influent Pump 3	69%	A	289	49	11.8	0.83	3,395	96%	97%	-	-	-	**-**
		B	289	49	11.6	0.82							
		C	289	50	11.7	0.83							
		TOT/AVG	**499.7**	**49.3**	**35.1**	**0.83**							
Influent Pump 3	90%	A	289	95	24.6	0.90	6,111	96%	97%	-	-	-	**-**
		B	288	93	24.1	0.89							
		C	288	94	24.4	0.90							
		TOT/AVG	**498.9**	**94.0**	**73.1**	**0.90**							
Influent Pump 4	75%	A	289	62	15.6	0.87	4,312	96%	97%	-	-	-	**-**
		B	289	62	15.3	0.87							
		C	289	60	14.9	0.86							
		TOT/AVG	**499.9**	**61.4**	**45.8**	**0.87**							

Pump Name	Speed %	Leg	EMF (VAC)	Current (Amp)	Power (kW)	Power Factor	Flow (GPM)	Motor Eff. (%)	VFD Eff. (%)	Suction (psi)	Discharge (psi)	TDH (feet)	Efficiency (%)
Influent Pump 4	90%	A	288	93	24.1	0.90	6,145	96%	97%	-	-	-	**-**
		B	289	93	24.4	0.90							
		C	288	93	23.9	0.90							
		TOT/AVG	**498.6**	**92.8**	**72.4**	**0.90**							
RAS Pumps 2 & 3 (Battery 2)	52%	A	289	7	3.6	0.83	1,943	70%	97%	3.6	7.0	7.9	**44%**
		B	268	7	3.1	0.83							
		C	283	7	3.1	0.89							
		TOT/AVG	**484.6**	**7.1**	**9.7**	**0.85**							
RAS Pump 2 (Battery 2)	100%	A	288	45	12.2	0.94	2,049	93%	97%	0.7	7.0	14.6	**18%**
		B	266	44	11.1	0.93							
		C	282	45	11.5	0.91							
		TOT/AVG	**482.1**	**44.7**	**34.8**	**0.93**							
RAS Pump 2 (Battery 2)	83%	A	286	29	7.8	0.94	2,271	93%	97%	1.8	7.5	13.2	**28%**
		B	266	28	6.9	0.93							
		C	282	28	7.3	0.91							
		TOT/AVG	**480.5**	**28.0**	**22.0**	**0.93**							
RAS Pump 3 (Battery 2)	83%	A	288	22	5.9	0.93	2,396	93%	97%	1.5	7.1	13.1	**39%**
		B	266	22	5.3	0.92							
		C	282	22	5.5	0.90							
		TOT/AVG	**482.0**	**21.8**	**16.6**	**0.92**							
RAS Pump 3 (Battery 2)	100%	A	281	36	9.3	0.92	2,965	93%	97%	0.0	7.5	17.3	**38%**
		B	266	36	8.9	0.93							
		C	289	36	9.7	0.94							
		TOT/AVG	**482.2**	**35.9**	**27.9**	**0.93**							

Additional electrical field readings on other, non-pumping systems are included below.

Table 4. Equipment Electrical Readings

Equipment	Speed %	Leg	EMF (Volts)	Current (Amps)	Power (kW)	Power Factor
Mixer 1A	100%	A	287	20	4.8	0.86
		B	265	17	4.1	0.89
		C	280	22	5.4	0.87
		TOT/AVG	**479.6**	**19.8**	**14.3**	**0.87**
Mixer 1B	100%	A	280	12	2.9	0.87
		B	265	11	2.5	0.89
		C	286	11	3.0	0.91
		TOT/AVG	**479.6**	**11.3**	**8.4**	**0.89**
Mixer 1C	100%	A	280	14	3.4	0.91
		B	268	10	2.7	0.92
		C	289	11	2.9	0.93
		TOT/AVG	**482.6**	**11.8**	**9.0**	**0.92**
Mixer 2A	100%	A	283	17	4.5	0.90
		B	268	15	4.1	0.91
		C	289	16	4.4	0.93
		TOT/AVG	**483.8**	**16.0**	**12.9**	**0.91**
Mixer 2B	100%	A	283	13	2.9	0.86
		B	268	10	2.9	0.90
		C	289	11	2.9	0.87
		TOT/AVG	**484.1**	**11.4**	**8.6**	**0.88**
Mixer 2C	100%	A	282	13	3.0	0.90
		B	267	10	2.6	0.91
		C	300	11	2.8	0.93
		TOT/AVG	**489.9**	**11.4**	**8.3**	**0.91**
Mixer 4A	100%	A	281.1	29.9	8.0	0.91
		B	267	28.3	7.1	0.92
		C	287.6	29.5	7.9	0.93
		TOT/AVG	**481.9**	**29.2**	**23.0**	**0.92**
Mixer 4B	100%	A	281.0	31.0	7.5	0.91
		B	266.3	29.3	7.0	0.92
		C	287.4	28.8	7.8	0.93
		TOT/AVG	**481.3**	**29.7**	**22.3**	**0.92**
Mixer 4C	100%	A	281	22	5.9	0.93
		B	266	21	5.4	0.93
		C	287	21	5.8	0.94
		TOT/AVG	**481.2**	**21.3**	**17.1**	**0.93**

Equipment	Speed %	Leg	EMF (Volts)	Current (Amps)	Power (kW)	Power Factor
Mixer 5A	100%	A	281	32	7.7	0.91
		B	266	29	7.3	0.92
		C	287	29	7.9	0.93
		TOT/AVG	**480.6**	**30.0**	**22.9**	**0.92**
Mixer 5B	100%	A	280	27	6.8	0.90
		B	264	27	6.0	0.90
		C	286	27	7.3	0.92
		TOT/AVG	**478.9**	**26.8**	**20.1**	**0.91**
Mixer 5C	100%	A	280	20	4.9	0.88
		B	265	24	5.5	0.89
		C	286	18	4.8	0.90
		TOT/AVG	**479.4**	**20.6**	**15.2**	**0.89**
Aeration Blower 1	Constant Speed	A	267	107	25.1	0.88
		B	288	106	27.0	0.88
		C	283	106	25.4	0.85
		TOT/AVG	**483.5**	**106.3**	**77.5**	**0.87**
Aeration Blower 2	95%	A	282	91	23.2	0.90
		B	267	87	21.1	0.91
		C	289	92	24.5	0.93
		TOT/AVG	**483.1**	**89.7**	**68.8**	**0.91**
Grit Blower 1	Constant Speed	A	284	7	1.0	0.56
		B	270	6	1.0	0.60
		C	290	6	1.1	0.65
		TOT/AVG	**486.6**	**6.4**	**3.2**	**0.60**
Aeration Blower 2	100%	A	284	113	29.5	0.92
		B	269	109	26.9	0.92
		C	290	109	29.3	0.93
		TOT/AVG	**485.4**	**110.3**	**85.7**	**0.92**

Energy Conservation Measures

The purpose of this evaluation is to identify opportunities to reduce energy usage and costs at the WPCF. These opportunities may include the installation of more efficient equipment and modifications to control strategies that are currently using excess energy. The following summary of the plant wide energy evaluation identifies Operating Measures (OM) and Energy Conservation Measures (ECM) that can be implemented to achieve cost and energy savings. The following sections provide detailed calculations and discussion for various OMs and ECMs which could be implemented at the plant for energy savings.

OM #1 – Plant Water System Pressure Reduction

Description

The plant water pumping system consists of a 40 HP pump and a 25 HP pump. Currently the plant operates only the 40 HP pump constantly and at 100% speed to maintain a system pressure setpoint of 160 psi. The 25 HP pump is not used. The plant water system provides water to the polymer batching, lime slurry in the chemical building, the secondary clarifiers, the chemical carry water, the primary distribution box, the wash down water, the gravity thickener and the aeration effluent box. The specifications of the plant water pumps are presented below:

Table 5. Plant Water Pump Specifications

Specification	Pump 1	Pump 2
Manufacturer	Peerless	Peerless
Motor HP	25	40
Design Flow (gpm)	250	470
Design TDH (ft)	230	230
Speed (rpm)	3500	3500

The operation and maintenance manual indicates the plant water system was designed to maintain a system pressure of 100 psi. Reducing the plant water pressure to 100 psi as indicated in the O&M manual will reduce the energy usage of the system.

Calculations

Base Case

Under the base case, the 40 HP plant water pump operates continuously at 100% speed, maintaining a pressure of 160 psi. The plant water pumps were not tested at the site visit, however their energy usage was estimated based on their operating conditions.

Facility staff indicated the largest load on the plant water system is the gravity thickener dilution water. It was estimated that this system requires 100 to 150 gallons per minute (gpm) continuously. This flowrate was assumed to be the average flow condition for the plant water system. The manufacturer’s pump curve was obtained and a Variable Speed Analysis was performed using the affinity laws to determine the operating speed and efficiency of the pump under various flow conditions. Figure 5 shows the Variable Speed Analysis for the 40 HP plant water pump.

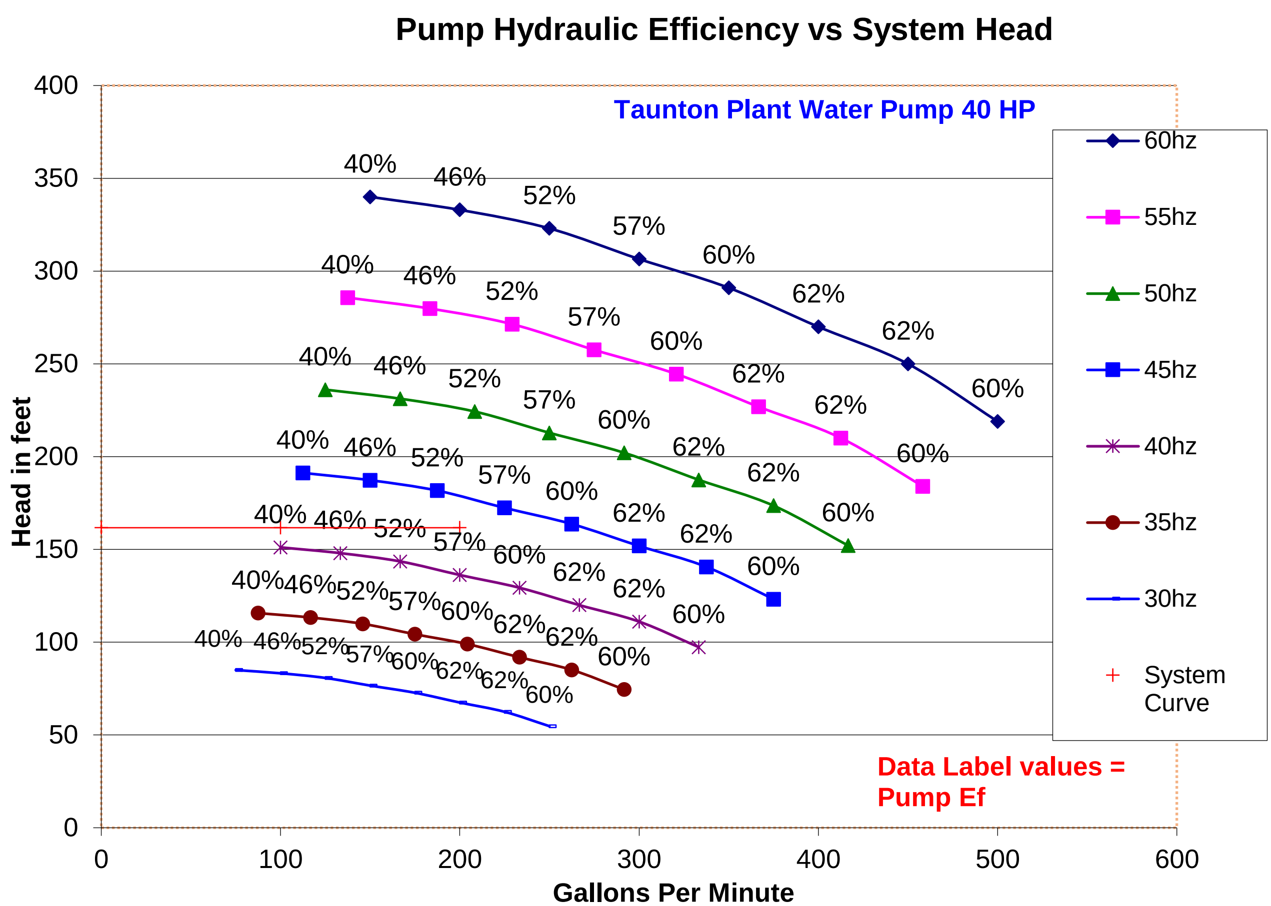


Figure 5. 40 HP Plant Water Pump Variable Speed Analysis

The base case energy usage is summarized in the following table:

Table 6. Plant Water Pumps – Existing Conditions

Condition	Flow (GPM)	TDH (FT)	Motor Eff.	VFD Eff.	Pump Eff.	kW Draw	Operating Hours	Annual Energy Use (kWh/Year)
Existing	150	370	93%	97%	40%	29	8,760	253,546

Notes:
1) Flow based on estimated average conditions
2) TDH based on maintaining a system pressure of 160 psi
3) Motor efficiency based on nameplate data
4) Pump efficiency based on MFG pump curve for 40 HP pump
5) kW draw calculated using pump efficiency equation

Proposed Case

Under the proposed case, the 25 HP plant water pump would operate continuously at 100% to maintain a pressure of 100 psi. The same average flowrate was used to determine the proposed case energy usage.

The manufacturer's pump curve was obtained and a Variable Speed Analysis was performed using the affinity laws to determine the operating speed and efficiency of the 25 HP pump under various flow conditions. Figure 6 shows the Variable Speed Analysis for the 25 HP plant water pump.

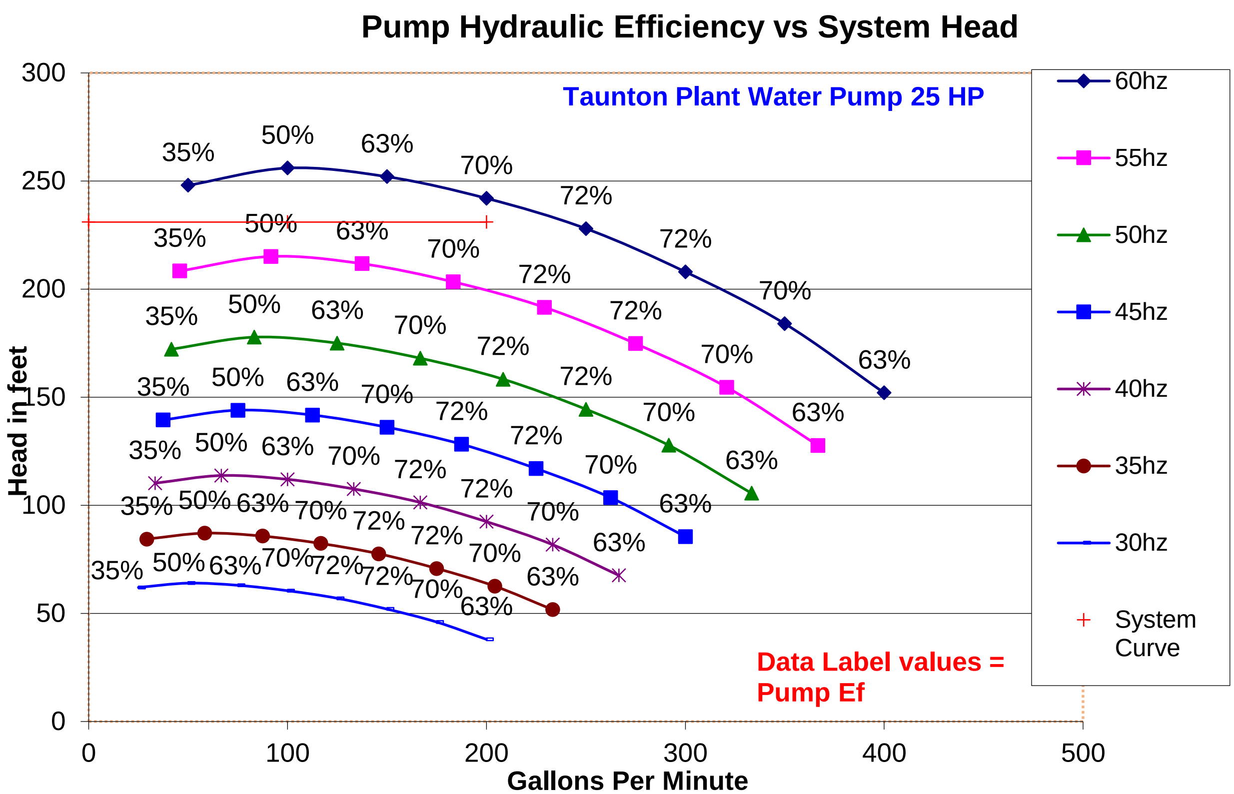


Figure 6. 25 HP Plant Water Pump Variable Speed Analysis

The proposed energy usage is summarized in the following table:

Table 7. Plant Water Pumps – Proposed Conditions

Condition	Flow (GPM)	TDH (FT)	Motor Eff.	VFD Eff.	Pump Eff.	kW Draw	Operating Hours	Annual Energy Use (kWh/Year)
Proposed	150	231	93%	97%	51%	14	8,760	124,287

Notes:
1) Flow based on estimated average conditions
2) TDH based on maintaining a reduced system pressure of 100 psi
3) Motor efficiency based on nameplate data
4) Pump efficiency based on MFG pump curve for 25 HP pump
5) kW draw calculated using pump efficiency equation

Summary of Cost and Savings

The estimated electrical and cost savings are presented in the table below:

Table 8. Plant Water Pumps – Energy Savings

Condition	Annual Energy Usage (kWh)	Annual Energy Cost ($)
Base	253,546	$28,235
Proposed	124,287	$13,841
Total Savings	**129,259**	**$14,395**

Note: Cost based on current blended rate of $0.11/kWh

It is assumed that this measure could be implemented by making manual control modifications. The project cost, savings and simple payback for implementing this measure is summarized in the table below.

Table 9. Plant Water Pumps – Cost Savings and Payback

Item	Cost
Annual Reduction (kWh)	129,259
Billing Rate	$0.11
Annual Savings	$14,395
Project Cost	$0
Simple Payback	**Immediate**

If a higher pressure is required at the headworks for the screens, there may be some cost associated with installing a booster pump at this location.

OM #2 – Surface Aerator Seasonal Operation

Description

The Taunton WWTF improvements include more efficient usage of the aerators within the aeration tanks. There are six aeration basins at the plant and four are constantly aerated by surface aerators. The aerators and their specifications are listed in the table below.

Table 10. Surface Aerator Specifications

Aerator	HP	Motor Manufacturer
1A	30	Reliance Electric
1B	20	Reliance Electric
1C	20	Reliance Electric
2A	30	Reliance Electric
2B	20	Reliance Electric
2C	20	Reliance Electric
4A	40	Reliance Electric
4B	40	Reliance Electric
4C	30	Reliance Electric
5A	40	Reliance Electric
5B	40	Reliance Electric
5C	30	Reliance Electric

In the winter months from October through May, the plant treats less flow than the rest of the year. The treatment requirements during these months can be met by two of the four aeration basins. Shutting off the aerators in the remaining two basins would result in energy savings for the plant.

Calculations

Base Case

Under the base case, all basins are used constantly throughout the year. The table below presents the estimated annual energy usage of the effluent pumps at typical flow and load conditions based on conditions observed during site visits and spot readings taken during the site visits.

Table 11. Surface Aerators – Base Case Energy Usage

Basin	Unit	HP	kW	kW/basin	Hours/year	kWh/year
	Aerator 1A	30	14.3			
	Aerator 1B	20	8.4			
1	Aerator 1C	20	9.0	31.7	8760	277,692
	Aerator 2A	30	12.9			
	Aerator 2B	20	8.6			
2	Aerator 2C	20	8.3	29.85	8760	261,486
	Aerator 4A	40	23.0			
	Aerator 4B	40	22.3			
4	Aerator 4C	30	17.1	62.39	8760	546,536
	Aerator 5A	40	22.9			
	Aerator 5B	40	20.1			
5	Aerator 5C	30	15.2	58.13	8760	509,219
					Total	**1,594,933**

Under the proposed case, Basins 1 and 5 would not be used during the months of October through May. Facility staff indicated this operation is done on a trial basis and that it would be helpful to understand the energy reduction associated with this operation. Under the proposed operation, the yearly operating hours of Basins 1 and 5 would be reduced to 3000, and the estimated energy usage under this condition is shown in the table below.

Table 12. Surface Aerators – Proposed Energy Usage

Basin		HP	kW	kW/basin	Hours	kWh
	Aerator 1A	30	14.3			
	Aerator 1B	20	8.4			
1	Aerator 1C	20	9.0	31.7	3000	95,100
	Aerator 2A	30	12.9			
	Aerator 2B	20	8.6			
2	Aerator 2C	20	8.3	29.85	8760	261,486
	Aerator 4A	40	23.0			
	Aerator 4B	40	22.3			
4	Aerator 4C	30	17.1	62.39	8760	546,536
	Aerator 5A	40	22.9			
	Aerator 5B	40	20.1			
5	Aerator 5C	30	15.2	58.13	3000	174,390
					Total	**1,077,512**

Summary of Cost and Savings

The cost and savings associated with this measure is summarized in the table below.

Table 13. Surface Aerator – Energy Savings

Condition	Annual Energy Usage (kWh)	Annual Energy Cost ($)
Existing	1,594,933	$177,616
Proposed	1,077,512	$119,995
Total Savings	**517,421**	**$57,621**

Note: Based on a blended rate of $0.11/kWh

The project cost, savings and simple payback for implementing this measure is summarized in the table below. Because there is no cost associated with turning off the aerators, there is no project cost and the payback is immediate.

Table 14. Surface Aerators – Cost Savings and Simple Payback

Item	Cost
Annual Reduction (kWh)	517,421
Billing Rate	$0.11
Annual Savings	$57,621
Project Cost	$0
Simple Payback	**Immediate**

There may be some cost associated with monitoring plant performance to ensure adequate aeration is maintained while aerators are off. In addition, some intermittent mixing in these tanks may be required to prevent settling.

OM #3 – Grit Blower Cycling

Description

The facility headworks includes an aerated grit chamber. Air is provided by two, 7.5 HP, constant speed blowers which are both operated continuously. The specifications of the grit blowers are outlined in Table 15. Other facilities have found that the operation of these blowers can be cycled, providing intermittent air to the tanks, without compromising the performance of the system. Adequate operation of these systems may be maintained with reduced air flow allowing for improved efficiency. Cycling the blowers on and off through the existing controls/SCADA system would reduce the energy usage of the aerated grit system.

Table 15. Grit Blower Specifications

Specification	Blower 1	Blower 2
Manufacturer	Roots Rotary Lab	Roots Rotary Lab
Model	32URA1	32URA1
Motor Manufacturer	WEG Motor	Baldor Motor
Motor HP	7.5	7.5
Motor Speed (rpm)	1725	1725

Calculations

Base Case

The base case includes continuous constant speed operation of both grit blowers. During the site visit, electrical readings of one blower was taken. This reading was used to calculate the annual energy usage of the two blowers, shown in the table below.

Table 16. Grit Blower Base Case Energy Usage

Equipment	Power Draw (kW)	Annual Operating Hours	Energy Usage (kWh/year)
Blower 1	3.2	8,760	28,032
Blower 2	3.2	8,760	28,032
		Total Energy Usage	**56,064**

Notes:
1) Power draw based on field testing of Blower 1.

Proposed Case

Under the proposed modifications the blowers would operate approximately 50% of the time, potentially cycling on and off every 30 minutes, or for longer cycles depending on operator preference and system performance. The following table presents the proposed energy usage:

Table 17. Grit Blower Proposed Case Energy Usage

Equipment	Power Draw (kW)	Annual Operating Hours	Energy Usage (kWh/year)
Blower 1	3.2	4,380	14,016
Blower 2	3.2	4,380	14,016
Total			**28,032**

Notes:
1) Power draw based on field data testing of Blower 1.

Summary of Costs & Savings

The savings associated with the two proposed cases are summarized in the table below.

Table 18. Grit Blower – Energy Savings

Condition	Annual Usage (kWh)	Annual Energy Cost (S)
Existing	56,064	$6,243
Proposed	28,032	$3,122
Savings	**28,032**	**$3,122**

It is assumed that this measure could be implemented utilizing the existing controls and SCADA system, resulting in no capitol cost for the facility. The savings and simple payback for implementing this measure is summarized in the table below.

Table 19. Proposed Case – Grit Blower Cycling

Item	Cost
Annual Reduction (kWh)	28,032
Billing Rate	$0.11
Annual Savings	$3,122
Project Cost	$0
Simple Payback	**Immediate**

OM #4 – Demand Monitoring/Power Factor Correction

Description

Under the current rate schedule, the Taunton WWTF is billed for demand based on peak kVA. The power factor is the ratio between kW, or true power, to the apparent power (kVA). The kW is a measurement of the electricity being used by the equipment while the kVA is a measure of the total power drawn by the equipment. Therefore, the kVA demand is influenced by the power factor and may increase the billed demand and cost associated with operating this facility. Power factor correction may reduce the demand by correcting the kVA to most closely meet the kW demand, potentially reducing electricity charges. The power factor of the total plant electrical demand is not indicated on the monthly electrical bills but could be determined through short term logging or monitoring of the power quality loggers on the main distribution panel (if available). This would provide an indication of the typical power factor. Power factor can be addressed through capacitors on the main system or at individual equipment. Lightly loaded equipment often has low power factors and therefore may be good candidates for power factor correction.

Calculations

The bill provided for the month of August 2017 was used as an example to show potential cost savings associated with power factor correction. These calculations are presented in the table below.

Table 20. Estimated Power Factor Correction Cost Savings

Billed Demand kVA	Assumed Existing PF	Existing Demand kW	Estimated Increased PF	New Demand kVA	Total Demand Charges	Monthly Cost Savings	Annual Cost Savings
568	0.9	511.2	0.95	538.1	$15	$442	$5,306

Notes:

1) Billed kVA based on most recent electrical bill (August 2017)

2) Estimated current power factor to be 0.9 based on measured PF during field testing

3) Conservatively estimated the power factor could be increased to 0.95

4) Calculated new kVA demand using the equation: kVA=kW/PF

5) Demand charges were estimated using provided electrical bills

The locations and equipment with low power factors would need to be identified and appropriate methods for increasing power factor and/or reducing demand would need to be evaluated. Additional savings could be achieved through both demand management and power factor correction.

ECM #1 – Primary Sludge Pump Motor Replacement

Description

There are three primary sludge pumps at the Taunton WWTF. Each pump is dedicated to one of three primary clarifiers and the flow is split evenly between all three of the pumps. The pumps operate continuously on belt drives and VFDs at a reduced speed setpoint. The pumps are operating under lightly loaded motor conditions at current speed setpoints. The light load on the motors decreases the motor efficiency and can cause operational and maintenance issues for the motors. Replacing the 25 HP motors with smaller motors that are sized for typical operating conditions would increase the motor efficiency and result in energy savings for the plant.

Calculations

Base Case

Under the base case, the primary sludge pumps operate continuously on belt drives and VFD's. Pumps 1 and 2 run at approximately 52% speed and pump 3 runs at approximately 68% speed. During the site visit, electrical readings, discharge pressures, wetwell levels and flows were taken. The table below outlines the estimated annual energy usage of the plant water pumps based on these readings.

Table 21. Primary Sludge Pumps – Base Case Energy Usage

Pump	Estimated Motor Efficiency	Motor Load	Power Draw (kW)	Operating Hours	Annual Energy Usage (kWh)
PSP 1	70%	16%	3.1	8,760	27,156
PSP 2	70%	14%	2.9	8,760	25,404
PSP 3	70%	15%	3.0	8,760	26,280
Total					**78,840**

Notes:

1. Motor efficiency reflects lightly loaded conditions.
2. Motor load = Power draw/(HP*0.746/Fully loaded motor efficiency).

Proposed Case

Under the proposed case, the existing 25 HP motors on the primary sludge pumps would be replaced with smaller motors sized for current conditions. The pumps would continue to operate at a reduced speed setpoint, but at a higher motor efficiency. The table below shows the estimated annual energy usage based on these upgrades.

Table 22. Primary Sludge Pumps – Proposed Case Energy Usage

Pump	Motor Efficiency	Power Draw (kW)	Operating Hours	Annual Energy Usage (kWh)
PSP 1	90%	2.4	8,760	21,182
PSP 2	90%	2.3	8,760	19,815
PSP 3	90%	2.3	8,760	20,498
Total				**61,495**

Notes:

1. Motor Efficiency based on fully loaded, smaller motor.
2. Typical operating speed, flow and head assumed to be same as base case.
3. Power draw based on new motor efficiency.

Summary of Cost and Savings

The estimated electrical and cost savings are presented in the table below.

Table 23. Primary Sludge Pumps – Energy Savings

Condition	Annual Energy Usage (kWh)	Annual Energy Cost ($)
Existing	78,840	$8,780
Proposed	61,495	$6,848
Savings	**17,345**	**$1,932**

Note: Based on current blended rate of $0.111/kWh

The budgetary project cost for 3 motor replacements is outlined in the table below.

Table 24. Primary Sludge Pumps – Project Cost

Item	Quantity	Unit Cost	Cost
3 Motors	3	$2,000	$6,000
Programing	LS		$2,200
Subtotal			$8,200
Contingency 30%			$2,500
Total			**$10,700**

The project cost, savings and simple payback for implementing this measure is summarized in the table below.

Table 25. Primary Sludge Pumps – Project Cost

Item	Cost
Annual Reduction (kWh)	17,345
Billing Rate	$0.11
Annual Savings	$1,932
Project Cost	$10,700
Simple Payback	**5.5**

In addition to motor replacements, to increase motor efficiency, it is recommended that the belt drives on the pumps be removed. It is recommended that the speed of the pumps be solely controlled with the existing VFDs to eliminate the added losses through the belt drives.

ECM #2 – Grit Blower Speed Turndown

Description

In addition to the operational measure of cycling the grit blowers, the blowers could be placed on VFDs and operated at reduced speeds. The standard for recommended cubic feet per minute of airflow per foot of channel length ranges from 3 to 8 (Metcalf & Eddy). It is likely feasible to reduce the airflow provided to the channel, assuming the system is sized for maximum design conditions. The reduced required airflow to the channel would allow for reduced speed operation of the blowers and reduce the energy usage of the system.

Calculations

Base Case

The base case is the same as the previous grit blower measure. The energy consumption is shown in the table below.

Table 26. Grit Blower Base Case Energy Usage

Equipment	Power Draw	Annual Operating Hours	Energy Usage (kWh/year)
Blower 1	3.2	8760	28,032
Blower 2	3.2	8760	28,032
		Total Energy Usage	**56,064**

Notes:

1) Power draw based on field testing of Blower 1.

Proposed Case

Under the proposed case, the speed of the blowers would be reduced with the addition of VFD’s. The Metcalf & Eddy Wastewater Engineering Treatment, Disposal and Reuse design manual (M&E) recommends 3-8 cubic feet per minute (cfm) aeration per foot of channel length. This represents a significant range in the potential required airflow of the system. Therefore, it is likely feasible to reduce the speed of the blowers, as the system is likely sized for maximum design conditions per the M&E design standards. (i.e. blowers are likely sized to provide 8 cfm per foot of channel length under maximum conditions, therefore, average/typical conditions likely require a reduced airflow.) In addition, adequate system performance is likely feasible at 5-6 cfm per foot of channel length. Airflow is not currently measured for the grit blowers, but it is recommended this be monitored permanently or for a short period of time should the facility choose to install VFD’s and reduce the air provided to the grit chamber. Under a more detailed study, the length of the channel and airflow of the blowers could be evaluated to determine the specific required airflow under various flow conditions. The energy usage of the blowers under the proposed condition is provided below.

Table 27. Grit Blower Proposed Case Energy Usage

Equipment	Estimated Power Draw (kW)	Annual Operating Hours	Energy Usage (kWh/year)
Blower 1	1.6	4,380	7,008
Blower 2	1.6	4,380	7,008
Total			**14,016**

Notes:
1) Reduced Speed is 50% speed; assuming linear reduction in BHP.

Summary of Costs & Savings

The savings associated with the proposed measure is summarized in the table below.

Table 28. Grit Blower – Energy Savings

Condition	Annual Energy Usage (kWh)	Annual Energy Cost ($)
Existing	56,064	$6,243
Proposed	14,016	$1,561
Savings	**42,048**	**$4,683**

The project cost of placing both blowers on VFD's and the addition of an airflow monitor is summarized in the table below.

Table 29. Grit Blower – Project Cost

Item	Quantity	Unit Cost	Cost
7.5 HP VFD	2	$2,000	$4,000
Airflow Monitor/Wiring/Install	1	$10,000	$10,000
Programing (10%)	LS		$1,400
Subtotal			$15,400
Contingency 30%			$4,600
Total			**$20,000**

The project cost, savings and simple payback for implementing this measure is summarized in the following table.

Table 30. Grit Blower – Simple Payback

Item	Cost
Annual Reduction (kWh)	42,048
Billing Rate	$0.11
Annual Savings	$4,683
Project Cost	$20,000
Simple Payback	**4.3**

As an alternative to placing both blowers on VFD’s, the plant could also operate one blower as opposed to two. It is still recommended that the plant monitor the airflow in the grit chamber, so the cost of the airflow meter would remain.

ECM #3 – Aeration System Modifications

Description

The Taunton WWTF currently uses a combination of surface aerators and fine bubble diffusers for aeration of the secondary treatment process. Aeration is provided to two batteries. Battery 1 receives 35% of the plant flow, and Battery 2 receives 65% of the plant flow. Each battery contains three basins, two of which are aerated with surface aerators and one of which is aerated using fine bubble diffusion. Half of the flow is sent to the fine bubble diffusion basin and half is split evenly between the two surface aerator basins for each battery. The CWMP includes plans to install new aeration blowers and convert all basins entirely to fine bubble aeration in the future. This upgrade will likely provide significant reduction in energy usage for the aeration system.

Calculations

Under the base case, aeration is provided to the six aeration basins using a combination of fine bubble diffusers and surface aerators. Electrical readings were taken during the site visit for each of the surface aerators. Based on discussions with plant staff, the speed of the aerators varies minimally so it was assumed for these calculations that the conditions observed during field testing are considered average annual conditions. Shown below is the annual energy usage of the surface aerators.

Table 31. Surface Aerator Energy Usage – Existing Conditions

Basin	Unit	HP	kW	kW/basin	Winter Hours	Summer Hours	kWh/year
1	Aerator 1A	30	14	32	0	3,000	95,100
	Aerator 1B	20	8				
	Aerator 1C	20	9				
2	Aerator 2A	30	13	30	5,760	3,000	261,486
	Aerator 2B	20	9				
	Aerator 2C	20	8				
4	Aerator 4A	40	23	62	5,760	3,000	546,536
	Aerator 4B	40	22				
	Aerator 4C	30	17				
5	Aerator 5A	40	23	58	0	3,000	174,390
	Aerator 5B	40	20				
	Aerator 5C	30	15				
Total Surface Aerator Annual Energy Usage							**1,077,512**

Notes:
1) kW draw based on field measured electrical readings
2) Hours of operation based on information from facility staff

There are three aeration blowers that provide air to the two fine bubble basins (Basin #3 and #6). One of the blowers (Blower #2) is operated at variable speeds on a VFD. The other two blowers (Blowers #1 and #3) are constant speed units. Based on discussions with facility staff, Blower #2 operates continuously year-round. The speed of Blower #2 is adjusted manually to meet oxygen demands. A second, constant speed blower is operated for approximately 20 hours per day during the summer months (June through September). The annual blower energy usage was estimated using this information and is presented in the following table.

Table 32. Aeration Blower Energy Usage – Existing Conditions

Condition	Blower	Speed (%)	Discharge Pressure (PSI)	Motor Eff. (%)	VFD Eff. (%)	Power Draw kW	Winter Hours (Hours/year)	Summer Hours (Hours/year)	Energy Usage (kWh/year)
Existing	Blower 2	95%	6.6	93%	97%	68.8	5,760	3,000	602,688
	Blower 1	Constant	6.6	93%	NA	77.5	0	3,000	232,500
Total Aeration Blower Energy Usage									**835,188**

Notes:

1) kW draw based on field measured electrical readings

2) Hours of operation based on information from facility staff

The total energy usage of the aeration system under current operation is shown below.

Table 33. Estimated Aeration System Annual Usage – Existing Conditions

Condition	Blower Usage (kWh)	Surface Aerator Usage (kWh)	Total Energy Usage (kWh)
Existing	835,188	1,077,512	1,912,700

Under the proposed case, all basins would be converted to fine bubble diffusion and air would be provided by new aeration blowers. During the preliminary design effort, the current and future flows and loads will be modeled to determine oxygen requirements of the revised secondary system. The modified secondary process will provide both nitrification and denitrification. Because the specifics of the process modifications and quantification of air requirements will be determined during the design phase, an estimation of the order of magnitude of savings that could potentially be achieved through conversion to fine bubble is presented in this ECM. Oxygen requirements and air flow variations, as well as diffuser layouts and blower sizing will be further defined during the design phase. Annual energy savings associated with converting entirely to fine bubble aeration was estimated by calculating the kW per million gallons treated using field measured values for each of the aeration basins. The kW per million gallons was calculated for each of the basins under summer and winter operation. These calculations are shown in the following tables.

Table 34. Surface Aerators – kW per Million Gallons

Summer					Winter				
Battery #	Basin #	Basin Flow (MGD)	Basin kW	kW/MG	Battery #	Basin #	Basin Flow (MGD)	Basin kW	kW/MG
1	1 & 2	1.1	62	60	1	1 & 2	1.1	30	30
2	4 & 5	2.0	121		2	4 & 5	2.0	62	

Notes:

1) Basin #1&2 flow equal to 17.5% of average daily flow (MGD)

2) Basin #4&5 flow equal to 32.5% of average daily flow (MGD)

3) Basin kW determined using field measurements

4) kW per million gallons determined by dividing total kW by total flow

Table 35. Aeration Blowers – kW per Million Gallons

Summer				Winter			
Basin #	Basin Flow	Basin kW	kW/MG	Basin #	Basin Flow	Basin kW	kW/MG
3 & 6	3.1	146	48	3 & 6	3.1	69	23

Notes:

1) Basins #3&6 flow equal to 50% of average daily flow (MGD)

2) Basin kW determined using field measurements

3) kW per million gallons determined by dividing basin kW by basin flow

As shown in the tables, in the summer season, the fine bubble aeration basins use approximately 12 kW per million gallons treated less than the surface aerator basins. In the winter season, the fine bubble aeration basins use approximately 7 kW less per million gallons treated less than the surface aerator basins. For the proposed case, the average daily flow and operating hours were applied to the calculated fine bubble aeration kW draw per million gallons treated. These calculations are shown in the following table.

Table 36. Aeration System Summer Energy Usage – Proposed Conditions

Average Influent Flow (MGD)	Basin 3&6 MGD	Basin 3&6 kW	Blower Summer kW per MG	Operating Hours	Blower Usage kWh per Year
6.1	3.1	146.3	48	3,000	877,800

Notes:

1) Average daily flow based on historical daily flows

2) Basin 3 & 6 flow equal to 50% of total flow

3) Basin kW determined using field measured values

Table 37. Aeration System Winer Energy Usage – Proposed Conditions

Average Influent Flow (MGD)	Basin 3&6 MGD	Basin 3&6 kW	Blower Winter kW per MG	Operating Hours	Blower Usage kWh per Year
6.1	3.1	68.8	23	5,760	792,576

Notes:

1) Average daily flow based on historical daily flows

2) Basin 3 & 6 flow equal to 50% of total flow

3) Basin kW determined using field measured values

Summary of Cost and Savings

The estimated electrical and cost savings are presented in the following table. This energy savings represents the savings under current average daily flow conditions. However, future flows are expected to increase to approximately 10 MGD which will increase the incremental savings. In addition, the upgraded aeration system is proposed to include both high efficiency blowers, diffuser selection to maximize oxygen transfer, and enhanced controls to optimize DO levels and nutrient removal. These features are expected to provide significant additional savings. It should also be noted that the relatively shallow tank depth limits the achievable oxygen transfer efficiency under fine bubble aeration. The design may consider low profile diffusers to maximize water surface elevation, and/or hyperbolic mixer-aerators as options for tank aeration and optimizing energy efficiency. Any incremental cost increases associated with these system features could be discussed with TMLP for potential energy efficiency incentives.

Table 38. Aeration System Upgrades – Energy Savings

Condition	Annual Energy Usage (kWh)	Annual Energy Cost ($)
Existing	1,912,700	$213,003
Proposed	1,670,376	$186,017
Total Savings	**242,324**	**$26,986**

The detailed project cost will be further developed during the design phase and will likely include diffusers, new blowers, air controls (including air flow control valves, air flow meters, DO and/or nitrogen probes), systems integration and programming, as well as start-up and commissioning.

ECM #4 – Battery 2 RAS Pump Rebuild/Replacement

Description

The Taunton WWTF currently operates five RAS pumps, two 25 HP pumps on Battery 1 and three 30 HP pumps on Battery 2. All pumps are on VFD's that adjust the RAS pump speeds based on a percent of the plant flow. The three pumps on Battery 2 pump to the same manifold and two pumps are typically in operation simultaneously. Based on field testing, Battery 2 pumps are running inefficiently and the rebuild or replacement the RAS pumps could result in energy savings for the plant. In addition, the motors are oversized and lightly loaded under average conditions. Replacing the motors with units sized for current operating conditions could increase load on the motor and the motor efficiency.

Calculations

Base Case

Under the base case, the two existing RAS pumps on Battery 2 are operated together to pump RAS to the manifold based on plant flows. The annual energy usage of these pumps based on historical plant flow data is shown in the table below.

Table 39. RAS Pumps – Base Case Energy Usage

% of Time	Total Flowrate (GPM)	No. of Pumps	Flowrate Per Pump (GPM)	TDH (ft)	Combined Pump and Motor Eff.	VFD Eff.	Power Draw Per Pump (kW)	Operating Hours	Energy Usage (kWh)
5%	1,691	2	846	7	24%	97%	5.0	438	4,378
20%	1,832	2	916	8	26%	97%	5.5	1752	19,137
50%	2,198	2	1,099	10	29%	97%	7.8	4380	67,891
20%	3,037	2	1,519	18	30%	97%	18.2	1752	63,631
5%	3,779	3	1,260	31	24%	97%	31.9	438	41,957
								Total	**196,944**

Notes:
1) Flowrates based on historical data provided by the plant
2) TDH based on system curve derived by field testing data
3) Combined Pump and Motor Efficiency from the motor and pump efficiencies from field testing
4) Power draw calculated using the pump efficiency equation

Proposed Case

Under the proposed case, the pumps would be replaced or rebuilt and the motors would also be replaced. The pumps would run under the same flow paced operating conditions. The manufacturer's pump curve was obtained and a Variable Speed Analysis was performed using the affinity laws to determine the operating speed and efficiency of the pump under various flow conditions. The figure below shows the Variable Speed Analysis for the Battery 2 RAS Pumps.

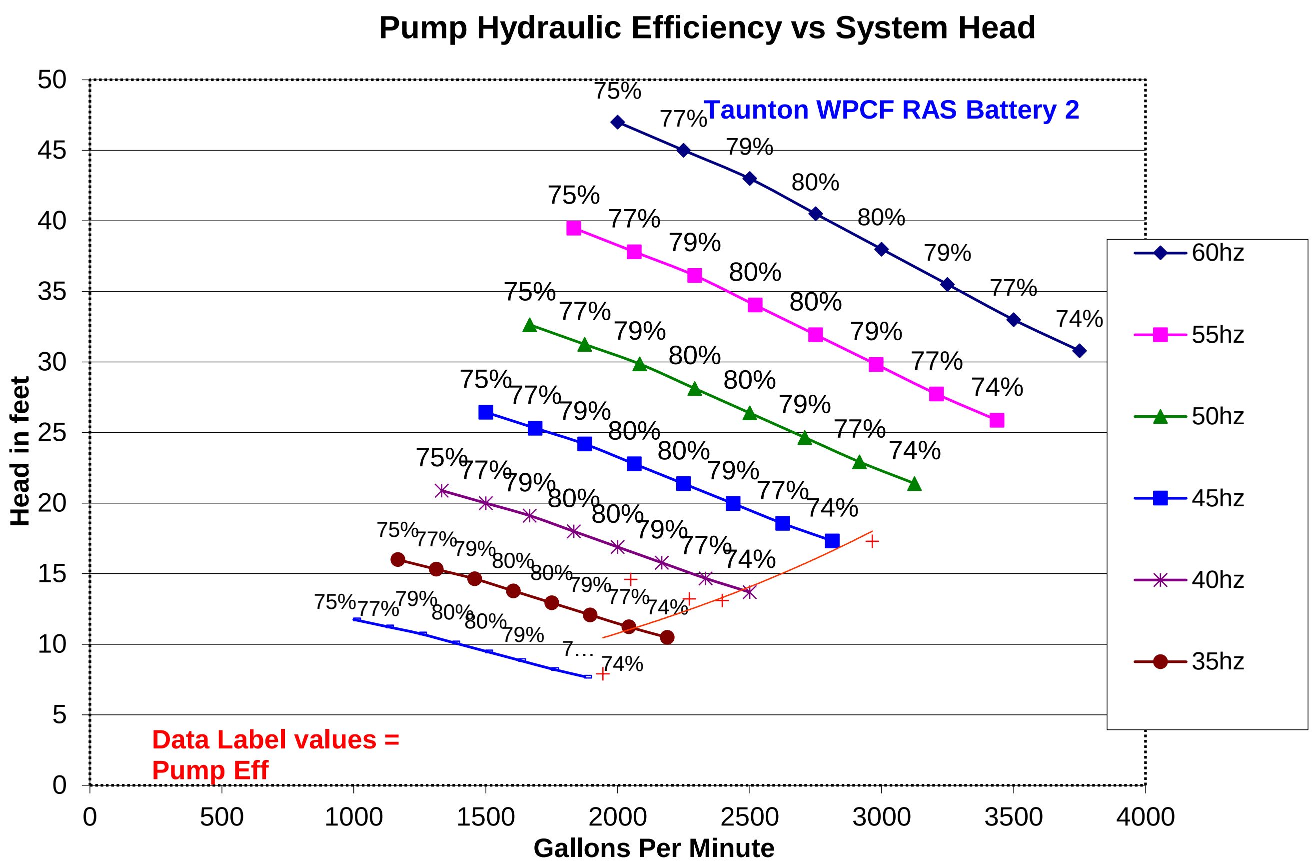


Figure 7. Battery 2 RAS Pump Variable Speed Analysis

The estimated energy usage under this condition is shown in the table below.

Table 40. RAS Pumps – Proposed Case Energy Usage

% of Time	Total Flowrate (GPM)	No. of Pumps	Flowrate Per Pump (GPM)	TDH (ft)	Combined Pump and Motor Eff.	VFD Eff.	Power Draw Per Pump (kW)	Operating Hours	Energy Usage (kWh)
5%	1,691	2	846	7	58%	97%	2.1	438	1,810
20%	1,832	2	916	8	62%	97%	2.3	1752	8,058
50%	2,198	2	1,099	10	67%	97%	3.3	4380	29,096
20%	3,037	2	1,519	18	70%	97%	7.8	1752	27,270
5%	3,779	3	1,260	31	64%	97%	11.9	438	15,584
								Total	**81,818**

Notes:
1) Flowrates based on historical data provided by the plant
2) TDH based on system curve derived by field testing data
3) Combined Pump and Motor Efficiency based on rebuilt/replaced equipment
4) Power draw determined using pump efficiency equation

Summary of Cost and Savings

The cost and savings associated with this measure is summarized in the table below.

Table 41. RAS Pump Rebuild/Replacement – Energy Savings

Condition	Annual Energy Usage (kWh)	Annual Energy Cost ($)
Existing	196,994	$21,938
Proposed	81,818	$9,111
Total Savings	**115,176**	**$12,826**

Note: Based on the billed rate of $0.111

The budgetary project cost for the rebuild/replacement of the pumps is outlined in the table below.

Table 42. RAS Pump Rebuild/Replacement – Budgetary Costs

Item	Unit Cost	Quantity	Total Cost
Pump Rebuild	$8,000	3	$24,000
$5,000	$5,000	3	$15,000
Installation	$1,500	3	$4,500
Subtotal			$43,500
Contingency 30%			$13,000
Total			**$56,500**

The project cost, savings and simple payback for implementing this measure is summarized in the table below.

Table 43. RAS Pump Rebuild/Replacement – Project Savings and Simple Payback

Item	Cost
Annual Reduction (kWh)	115,176
Billing Rate	$0.11
Annual Savings	$12,826
Project Cost	$56,500
Simple Payback	**4.4**

Although the Battery 1 pumps were not tested due to time restrictions, it is recommended that these pumps and motors are also replaced as they are most likely operating with similar inefficiency.

ECM #5 – Battery 1 RAS Pump Rebuild/Replacement

Description

The Taunton WWTF currently operates five RAS pumps, two 25 HP pumps on Battery 1 and three 30 HP pumps on Battery 2. All pumps are on VFD's that adjust the RAS pump speeds based on a percent of the plant flow. The two pumps on Battery 1 pump to the same manifold and one pump is typically in operation. Field testing was not performed on the Battery 1 RAS pumps, however the pumps are likely operating at a reduced efficiency similar to the Battery 2 RAS pumps. Replacing the Battery 1 pumps and motors will likely result in energy savings for the facility.

Calculations

Base Case

Under the base case, it was assumed the Battery 1 RAS pumps and motors were operating at a similar load and efficiency to the Battery 2 RAS pumps under average conditions. Field testing on the Battery 2 pumps showed an approximate motor loading of 40% under average conditions. These calculations are shown in the table below.

Table 44. RAS Pumps Motor Load

Pump No.	kW Draw	Motor HP	Load (%)
2	5.5	30	43.5%
3	4.2		

Notes:
1) kW Draw based on field measured values.
2) Motor load = (Total kW)/(Motor HP*0.746)

Shown below is the estimated energy usage of the Battery 1 RAS pumps under similar motor load and pump efficiency conditions.

Table 45. RAS Battery 1 – Existing Conditions

Motor HP	Load (%)	kW Draw	Hours/Year	kWh/Year
25	44%	8.1	8,760	71,102

Notes:
1) Motor load equal to Battery 2 motor load under average conditions
2) kW draw determined using equation: kW=HP*0.746*Load

Proposed Case

Under the proposed case, the Battery 1 RAS pumps would be replaced or rebuilt and the motors would be replaced with units sized for typical operating conditions. The pumps would continue to return a percent of influent flow. A similar percent reduction in power through the pump rebuild and motor replacement was assumed to calculate the proposed energy usage of the Battery 1 RAS pumps. The RAS Battery 2 pumps saw approximately 54% reduction in power based on pump rebuilds and motor replacement as shown below.

Table 46. Battery 2 Power Reduction – RAS Pump & Motor Replacement

Existing kW Draw	Proposed kW Draw	Reduction
9.7	4.5	54%

Notes:
1) Existing kW draw based on field measured values
2) Proposed kW draw calculated under average conditions

It was assumed the Battery 1 RAS pump power draw under average conditions could be reduced by 54%, as was estimated for the Battery 2 pumps. The proposed energy usage is calculated below based on this reduction.

Table 47. Battery 1 RAS Pumps – Proposed Conditions

Existing kW	% Reduction	Proposed kW	Hours/Year	kWh/Year
8.1	54%	4.3	8,760	38,080

Notes:
1) Existing kW calculated using estimated motor load of 44%
2) Proposed kW calculated based on 54% power reduction

Summary of Cost and Savings

The cost and savings associated with this measure is summarized in the table below.

Table 48. Battery 1 RAS Pumps – Estimated Savings

Condition	Annual Energy Usage (kWh)	Annual Energy Cost ($)
Existing	71,102	$7,918
Proposed	38,080	$4,241
Total Savings	**33,022**	**$3,677**

Note: Based on the billed rate of $0.111

The budgetary project cost for the rebuild/replacement of the pumps and replacement of motors is outlined in the table below.

Table 49. RAS Pump Rebuild/Replacement – Budgetary Costs

Item	Unit Cost	Quantity	Total Cost
Pump Rebuild	$8,000	2	$16,000
Motor Replacement	$4,000	2	$8,000
Installation/Rigging	$1,500	2	$3,000
Subtotal			$27,000
Contingency 30%			$9,000
Total			**$36,000**

The project cost, savings and simple payback for implementing this measure is summarized in the following table.

Table 50. Battery 1 RAS Replacement – Project Savings and Simple Payback

Item	Cost
Annual Reduction (kWh)	33,022
Billing Rate	$0.11
Annual Savings	$3,677
Project Cost	$36,000
Simple Payback	**9.8**

ECM #6 – Centrifuge Upgrades

Description

Primary and secondary sludge is dewatered at the Taunton WWTF using two centrifuges. Both centrifuges operate 7 hours per day, 7 days per week for the entire year. The specifications of the existing centrifuges are shown in the table below.

Table 51. Centrifuge Specifications

No. of Units	Manufacturer	Model No.	Capacity (gpm)	Max. Bowl Speed (RPM)	Motor HP	Motor RPM
2	Alfa Laval	DS-401	125	3250	100	3600

Other facilities with similar centrifuge equipment have achieved energy savings through control upgrades. The controls manufacturer was contacted to identify potential energy savings measures for the existing centrifuges at the Taunton facility. The existing centrifuges are already controlled with VFDs on the main drive and the back drive, so there is limited opportunity to reduce energy usage with enhanced controls. However, the existing control panel could be replaced with a modern model that has better control of the scroll drive. This upgrade would improve the performance of centrifuge and produce a better cake dryness. There would not be expected energy savings associated with this upgrade because the motors are already controlled by existing VFDs, but the potential cost savings associated with hauling less sludge volume to the Taunton landfill could offset the cost of the new control panel. The controls manufacturer estimated this upgrade would cost approximately $40,000 per panel.

ECM #7 – UV System

As part of the Comprehensive Management Planning process the Taunton WPCF is considering installation of an ultraviolet (UV) irradiation disinfection system to replace the existing chlorine disinfection. The available UV technologies now incorporate energy efficiency into the equipment and operation to reduce energy use as much as possible. UV disinfection can be an energy intensive process, there are various methods of reducing the energy use while still providing necessary disinfection. The efficiency alternatives may change based on manufacturer and flow rates (size of the system).

Most manufacturers offer efficiency controls which include flow pacing, where banks, rows, or individual UV bulbs shut down or turn on, or reduce intensity, based on flow rate, increasing as flow increases. Since increased flow does not necessarily increase the disinfection requirements, there are additional sensors that may determine the required disinfection. These sensors are typically called ultraviolet transmittance (UVT) meters. The transmittance basically measures how easily the UV light can pass through the wastewater based on the characteristics of the wastewater to determine how strong the UV dose needs to be for proper disinfection based on previously determined set points. The UVT can work with specific lamps and ballasts that increase and decrease power based on the existing UVT reading. A UV system controlled through these methods may have the ability to reduce energy use. The evaluation of UV systems may include investigation of the available controls and whether the controls require specific types of or proprietary lamps to operate most effectively.

Additional considerations when considering a UV system is the type of lamp. Currently, there are low pressure and medium pressure lamps typically used for water and wastewater applications. The pressure refers to the pressure of the gas inside the lamp and emit different ranges of visible light, where low pressure emits the specific 254 nanometers (nm) required for disinfection, medium pressure lamps emit a broader range of light (254-265 nm). Historically, medium pressure lamps were popular due to the ability to produce higher "kill" rates with less lamps, where the low pressure lamps required more lamps for the same disinfection. Newer low pressure lamps are able to produce an increased disinfection with the added benefit of less energy use due to the low pressure system. While medium pressure may still require less lamps, the energy consumption is typically higher. Medium pressure lamps also emit more heat than low pressure systems. The overall "efficiency" of low pressure lamps is higher because they are able to convert electrical energy into disinfecting energy more efficiently (18% for medium and 35% for low).

There is also a low pressure amalgam lamp, low pressure high output (LPHO), which is a specific type of low pressure lamp that requires less mercury and are not significantly effected by temperature fluctuations. These lamps are said to have a "higher power density" (watts per centimeter), as compared to traditional low pressure lamps, however, the energy draw also increases with the increased power density. The amalgam aspect is the mercury alloy used, as opposed to the traditional mercury low pressure lamps. Based on manufacturer provided data, amalgam UV lamps may provide a longer life span and run hours as compared to the alternative low pressure UV lamps. Amalgam lamps also have a higher operating temperature and a several minute "warm-up" period where the lamp must "warm up" to full strength to provide full disinfection. The greatest advantage of the amalgam lamp is the ability to use less lamps then traditional low pressure while still providing the most efficient energy conversion. When selecting a UV system, the type of lamp required to achieve the manufacturer provided energy production should be considered.

Besides the type of lamp, there are additional aspects of the lamp that differ between manufacturers that may reduce maintenance or replacement requirements. These include the material used for the sleeve, special coatings, available ballasts/drivers, longer hour running lamps, and available controls. The lamp cleaning system and ease of removal for maintenance may also be considered.

UV lamps ability to disinfect degrades over time of use. What initially provided sufficient disinfection may not provide the same disinfection after 10,000 run hours (over 1 year). The degradation is different for each type of lamp and should be considered when determining the potential efficiency of a UV system. Typically, medium pressure lamps have the lowest effective run hours, followed by traditional low pressure lamps, with amalgam low pressure lamps having the longest amount of run hours. The effective run hours are based on the ability to disinfect at the required disinfection dose over time. Manufacturers are able to provide conservative estimates of lamp run hours and effective disinfection.

Lamp configuration may also assist in energy efficiency. There are several popular methods of configuration; horizontal, vertical, and inclined or angled. The more recent inclined technology is intended to provide the maximum amount of cross sectional coverage with the least amount of lamps. Theses lamps may also be staggered to cover more cross section.

Light Emitting Diodes (LEDs) have gone through significant technological advancements in recent history. While LEDs are still being considered to eventually be used for disinfection at water and wastewater treatment facilities, the current research and development is limited and still very costly for equipment. It is possible that LEDs become a commonplace in municipal water and wastewater in the next 5 to 10 years. There have been successful demonstrations of this technology for use on a bench scale and is also going through the research and development phases with various manufacturers. If LEDs become a viable technology for the water and wastewater treatment industry, they may provide significantly longer effective run hours.

In conclusion, the potential energy reducing alternatives for UV systems depends on the design parameters and manufacturer available systems. Based on discussions with UV manufacturers, flow rates over 3.0 MGD typically have the most energy efficient options. For the Taunton WPCF this may include the available technologies and energy efficiency measures available based on the applications flows and available area for installation. It is recommended that control systems including UVT and dimming capabilities be considered for energy conservation. For the long term efficiency and maintenance of the system, the type of bulbs, installation type, and cleaning methodology may also be considered.

The additional cost associated with enhanced controls and/or advanced technologies may be offset by the additional energy savings over the life cycle of the equipment. In addition, potential incentives for these types of significant energy savings, custom conservations measures can be discussed with TMLP as the project progresses in order to offset the incremental cost increase and reduce the payback period associated with implementation.

Renewable Energy Evaluations

Solar Evaluation

Solar photovoltaic (PV) systems can be a reliable renewable energy source. There has been an increase in installation of PV technology in the northeast in recent years as public and private agencies and businesses look for opportunities to reduce their environmental impact and electrical costs. Solar cells (PV) convert sunlight directly into electricity and are typically combined into modules that are mounted in PV *arrays* that can be mounted at a fixed angle facing due south, or can be mounted on a tracking device that follows the sun, allowing them to capture the most sunlight over the course of a day.

According to the National Renewable Energy Laboratory (NREL) solar maps, the available solar energy in Connecticut is between 4.0 and 5.0 kilowatt hour per day per square meter (kWh/day/m^2) based on solar data collected from 1998 to 2009. The available energy may be reduced based on specific site and location conditions such as shading and obstructions and mounting method of PV such as ground or roof mount.

Three locations around the Taunton WPCF within the property lines were evaluated for installation of PV arrays. There is a large unused area at the plant, one open land location where a sludge drying field is no longer used and two building roofs were identified as potential PV installation locations. The following figure presents an aerial view of the WPCF.

Figure 8. Aerial of Taunton WPCF

The available area, as indicated on the map, is approximately 17,475 square meters (m^2) for the old sludge drying field site, 620 m^2 for the sludge handling building, and 480 m^2. All sites are relatively flat with no noticeable angle.

Solar Calculations – Potential Power Generation

As previously mentioned, the location and exposure to the sun effects the amount of energy produced through the array. The National Renewable Energy Laboratory (NREL), a division of the Department of Energy (DOE) provides a Photovoltaic calculator called PVWatts™, which estimates energy production and cost of energy for grid connected PV arrays throughout the world. This calculator was utilized to evaluate Sites #1, #2, and #3 at the Taunton WPCF.

Table 52. Land Area Specifications

Parameter	Specification
Land Area Site #1	17,475 square meters
Roof Area Sites #2 and #3	1,100 square meters (620 & 480)
Obstructions	Minimal Trees
Land Condition	Open field with a perimeter of trees. It should also be noted that the drainage of this area may also need to be modified for a solar installation.

NOTES:

- Total land area was calculated using Google Earth & PVWatts™.
- Obstructions determined through visual inspection.

The DC rating presented below was automatically generated by PVWatts™ based on the available land area. The size can also be calculated with the following equation.

$$DC\ Rating\ (kW) = Array\ Area\ (m^2) * 1\ \frac{1\ kW}{m^2} * PV\ Module\ Efficiency$$

Based on the existing conditions, the following parameters were established for evaluation through the calculator.

Table 53. Solar Location #1: Old Sludge Drying Field – Preliminary Evaluation

Location Identification	
Location:	875 West Water Street, Taunton, MA
Weather Data Source:	Providence, RI (TMY2)
Latitude:	41 ° N
Longitude:	72 ° W
PV System Specifications	
Site #1, 2, 3 DC Rating:	2,626.1 kW, 91.3 kW, 72.3 kW
System Losses:	20%
DC to AC Derate Factor:	1.1
Array Type:	1-Axis Tracking/Fixed (Open Rack)
Array Tilt:	20 °
Array Azimuth:	180 °
Energy Specifications	
Cost of Electricity:	11.1 ¢/kWh

NOTES:

- Weather Data source is the closest weather station utilized by the DOE.
- The latitude & longitude are for the Weather Data Source.
- Land area was calculated using PV Watts.
- The DC rating is the amount of energy that can be produced for the available area.
- System losses are based on soiling, shading, snow and wiring losses.
- The DC/AC Derate Factor is a size ratio between the inverter and arrays respective rated size. The larger the factor the more output is produced. A conservative 1.1 was selected.
- The array type is based on a fixed ground mount design.
- Array tilt is based on a typical ground mount tilt of 20°.
- Array Azimuth is based on true south (180°).
- Cost of electricity is based on previously calculated generation and delivery costs combined.

The calculator uses historical meteorological data recorded for a specific site and determines the solar radiation available. The kWh per month generated was calculated based on the solar radiation and the solar system specifications.

Table 54. Solar Energy Produced – Site #1: Old Sludge Drying Bed

Month	Solar Radiation ($kWh/m^2/day$)	Energy Production (kWh)	Energy Value ($)
January	2.73	195,665	$21,719
February	3.67	234,947	$26,079
March	4.58	315,951	$35,071
April	5.35	348,191	$38,649
May	5.78	375,715	$41,704
June	6.15	375,841	$41,718
July	6.39	395,234	$43,871
August	5.95	370,141	$41,086
September	4.55	279,992	$31,079
October	4	264,471	$29,356
November	2.74	181,247	$20,118
December	2.28	160,321	$17,796
Annual Value	**4.51**	3,497,716	**$388,247**

NOTE: Radiation and Energy values were calculated using PVWatts.

Table 55. Solar Energy Produced – Site #2: Sludge Building Roof

Month	Solar Radiation (kWh/m²/day)	Energy Production (kWh)	Energy Value ($)
January	2.73	6,803	$755
February	3.67	8,168	$907
March	4.58	10,984	$1,219
April	5.35	12,105	$1,344
May	5.78	13,062	$1,450
June	6.15	13,067	$1,450
July	6.39	13,741	$1,525
August	5.95	12,868	$1,428
September	4.55	9,734	$1,080
October	4	9,195	$1,021
November	2.74	6,301	$699
December	2.28	5,574	$619
Annual Value	**4.51**	121,602	**$13,498**

NOTE: Radiation and Energy values were calculated using PVWatts.

Table 56. Solar Energy Produced – Site #3: Administration Building Roof

Month	Solar Radiation ($kWh/m^2/day$)	Energy Production (kWh)	Energy Value ($)
January	2.73	5,387	$598
February	3.67	6,468	$718
March	4.58	8,699	$966
April	5.35	9,586	$1,064
May	5.78	10,344	$1,148
June	6.15	10,347	$1,149
July	6.39	10,881	$1,208
August	5.95	10,190	$1,131
September	4.55	7,709	$856
October	4	7,281	$808
November	2.74	4,990	$554
December	2.28	4,414	$490
Annual Value	**4.51**	96,296	**$10,689**

NOTE: Radiation and Energy values were calculated using PVWatts.

The following table presents the total energy production and energy summarized for all locations.

Table 57. Energy Production Summary

Location	Maximum Array Size (kW)	Annual Energy Production (kWh)	Annual Energy Value
Site #1: Old Sludge Drying Bed	2,626	3,497,716	$388,247
Site #2: Sludge Building Roof	91	121,602	$13,498
Site #3: Administration Building Roof	72	96,296	$10,689
Total	--	3,715,614	$412,434

The installation of solar panels on all of the available area as outlined above, could produce approximately 3,700,000 kWh per year. This represents approximately 112% of the total energy use of the facility, which means it would produce additional energy that could be sent back to the grid. It should be noted that the energy production identified above assumes all of the land and roof area would be utilized for solar panels. The true energy production would depend on the solar panel array size, which varies based on manufacturer, and access and fence requirements around the panels.

Based on the current interconnection requirements, the DC rating of the generation facility shall not exceed the peak demand experienced at the facility over the last 12 calendar months. The Taunton WPCF has an approximate peak demand of 557 kW, therefore, the maximum solar array shall not exceed this DC rating. The following table presents the potential energy production of a 557 kW solar array, based on the current maximum DC rating for the interconnection requirements.

Table 58. Solar Energy Produced – 557 kW Generator

Month	Solar Radiation ($kWh/m^2/day$)	Energy Production (kWh)	Energy Value ($)
January	2.73	38,255	$4,246
February	3.67	45,952	$5,101
March	4.58	61,807	$6,861
April	5.35	68,115	$7,561
May	5.78	73,494	$8,158
June	6.15	73,521	$8,161
July	6.39	77,318	$8,582
August	5.95	72,407	$8,037
September	4.55	54,756	$6,078
October	4	51,726	$5,742
November	2.74	35,430	$3,933
December	2.28	31,335	$3,478
Annual Value	**4.51**	684,116	**$75,937**

NOTE: Radiation and Energy values were calculated using PVWatts.

Based on this data, the largest possible solar array would produce approximately 684,000 kWh annually. This is approximately 21% of the plants overall annual energy use.

In further discussions with TMLP, they indicated they would consider the old sludge drying bed (Site #1) an independent electrical meter where power would need to be brought to this site, therefore, it would not be restricted to the peak demand requirements currently in the Interconnection agreements. TMLP also indicated they would be happy to work with the Taunton WPCF for installation of a solar system at Site #1.

Based on this preliminary analysis, installation of a solar PV array may be viable for the Taunton WPCF. However, prior to incorporating a solar PV array installation at the facility, a more thorough analysis of the costs, electrical energy production potential, payback period, and interconnection options of PV installations should be completed. As discussed in more detail below, the ability for the solar installation to be interconnected into the existing grid will need to be evaluated to determine the project cost. A thorough cost analysis of the installation and potential construction costs should also be performed to determine the payback period for such an installation. One particular challenge for site #1 is the condition of the land in the old sludge drying bed area. The condition of the roof and structural evaluation may also need to be further evaluated for sites #2 and 3.

Solar Conclusion

Based on the above analysis, further investigation should be conducted to determine the ability for the Taunton WPCF to interconnect a solar PV system into the grid. Taunton Municipal Lighting Plant (TMLP) requires an application and additional evaluation to determine if the existing electrical infrastructure and its components require modifications and upgrades prior to an interconnection. Interconnection requirements are further evaluated in the Interconnection section. TMLP also mentioned they would be happy to work with the Taunton WPCF to develop a solar installation at their facility.

The land and roof preparation and suitability should be determined for the overall project cost. In addition, the roof mounts will be located near three phase connections for inverter placement, however, the ground mount in the old sludge drying bed is not located near electrical connections and may require significant cost to install electrical lines to this location.

Battery storage is a potential alternative to be used with solar installations to reduce energy costs. Thirty minute interval demand data should be evaluated to further determine the potential for battery storage with a solar installation. Battery storage may be provided with lithium ion batteries in conjunction with solar installations. Currently, based on discussions with manufacturers, a batteries capability is most effective between 0.5 and 3 hours of storage, meaning, the demand may be reduced by the battery storage capabilities if the peak demand is over a period of 0.5 to 3 hours. If the demand significantly exceeds this duration, the battery is not able to reduce the demand, resulting in the peak demand costs. Alternatively, battery storage could be used for peak demand response. Peak demand response in New England is overseen by New England Demand Response Initiative (NEDRI), for the ISO New England regional power markets. Participating in a demand response program would allow the plant to operate off of the battery storage during peak times, which reduces the impact on the grid.

Incentives for Renewable Solar Energy – SREC & SMART Program

The funding options available for a solar array installation through state and federal funding agencies include the Solar Renewable Energy Certificates (SREC) program, and the Solar Massachusetts Renewable Target (SMART) program which is anticipated to be initiated on March 31st of 2018. The SREC program became the primary incentive funding source for solar technologies in 2012, in Massachusetts. Rooftop or ground-mounted projects greater than 25 kW with at least two thirds of annual output used onsite fall into the Market Sector B category and have an SREC factor of 0.9. Having a SREC factor of 0.9 provides the solar energy producer 9 SRECs for every 10 megawatt-hours produced by their array (90%). Since this program has reached its cap this SREC factor has been reduced to 0.6 for solar arrays which are mechanically complete or operational by March 31, 2018.

After this date, qualifying solar arrays will be eligible for the Massachusetts Department of Energy Resources (MA DOER) SMART program which will have a tariff-based incentive program. The SMART program is intending to develop 1,600 mega-watts (MW) of new solar generation. These incentives will vary upon size and location of the project and will be provided for 10 to 20 years (10-year contract for small, 20-year contract for large). The tariff will consist of eight-200 MW blocks, which are divided based on the overall available capacity in each Distribution Company's service territory. The compensation rates for each block will reduce by 4% from the base rate. Tariff based incentives will be determined by subtracting the volumetric distribution, plus transmission, plus three-year average basic service rate for each class, (base rate) from the contract price. Therefore, the incentives for the SMART program will vary by site. The SMART program is also not eligible for Municipal electrical customers, while the SREC program is available.

The SREC/SMART program is managed by the electric distribution companies (EDCs) such as Eversource and National Grid, and by the MA DOER. Under these regulations, the EDCs are required to allocate funding for the purchase of SREC credits from customers generating renewable energy. The customers, once deemed to be qualified bidders, will be able to sell their SRECs credits to the EDCs for a fifteen (10-20) year contract period. Under the new SMART program there will no longer be credits earned per MW that are to be sold back, instead there will be a tariff like incentive based on kWh that will be direct savings on energy bills.

Systems that qualify for SREC must be behind electric meters and in operation before March 31, 2018. Projects which are completed after this date will be eligible for enrollment in the SMART program.

The Taunton Municipal Light Plant (TMLP) will not be offering the SMART program, however, they are willing to offer a similar payback incentive based on energy production for solar installations. TMLP has requested that the Taunton WPCF contact them to discuss the potential incentives if they have determined to move forward with the potential solar installations.

Anaerobic Digestion Evaluation

The following description presents the preliminary design parameters for a Non-proprietary Dual Stage Mesophilic Anaerobic Digestion installation for sludge processing. Anaerobic Digestion is the decomposition of organic matter present in sewage solids into methane gas and carbon dioxide by microorganisms in the absence of oxygen. There are several reasons for considering advanced or high-performance anaerobic digestion at a wastewater treatment plant, including the reduction of pathogen concentrations, the desire to reduce energy costs by producing and using the digester gas as a fuel source and the potential reduction of greenhouse gas emissions. Methane produced in anaerobic digestion facilities can be utilized to reheat the digester and/or produce power thus replacing energy derived from fossil fuels, and hence reducing emissions of greenhouse gases. Mesophilic Anaerobic Digestion also results in Class B stabilized biosolids as an end-product, which would ultimately be land-filled.

Anaerobic digestion occurs as the result of a complicated set of chemical and biochemical reactions. These reactions occur as a result of the complex ecosystem involving many types of bacteria within the digester. The overall extent of sludge stabilization by anaerobic digestion is typically measured by the amount of volatile solids destruction that occurs within the digester.

There are two operational temperature levels for anaerobic digesters, which are determined by the species of methanogens in the digesters:

- Mesophilic digestion takes place optimally around 37°-41°C (98° to 105° F), where mesophiles are the primary microorganism present.

- Thermophilic digestion takes place optimally around 50°-52°C (122º to 126ºF) at elevated temperatures up to 70°C (158ºF), where thermophiles are the primary microorganisms present.

There are a greater number of species of mesophiles than thermophiles. These bacteria are also more tolerant to changes in environmental conditions than thermophiles. Mesophilic systems are therefore, considered to be more stable than thermophilic digestion systems.

In continuous digestion, organic matter is either added constantly or in stages to the reactor. The end products are removed continuously or periodically but there is a constant production of gas.

For this study, the Mesophilic Digestion process is further discussed below.

System Components

The following components should be evaluated for the Taunton WPCF in the Mesophilic Anaerobic Digestion System:

- Tank Volume (Volumetric Loading & Hydraulic Retention Time);
- Tank Covers;
- Tank Mixing System;
- Preliminary Footprint.

System Volume

The required volume for digesting sludge is a function of the volume of fresh sludge added daily, the volume of digested sludge produced daily, and the required digestion time in days. Additional volume is added for the supernatant liquid, gas storage and the storage of digested sludge. Anaerobic digesters are primarily sized based upon solids retention time (SRT) and hydraulic retention time (HRT). In this case, for a high-rate digestion system that will not include provisions for supernatant decant, SRT is interchangeable with HRT. The required design HRT value for Taunton should be determined based on the calculated volumetric loading criteria presented below.

The WEF MOP FD-9 recommends, for completely mixed and heated digesters a volumetric loading between 0.1 and 0.2 lbs VSS/1,000 ft^3 of volume per day. Based on the 72% VSS in the solids, it was determined that the minimum HRT to achieve this volumetric loading is 15 days.

There are two digester system styles that could be considered for installation, conventional and egg shaped. Conventional digesters are low vertical cylindrical reinforced concrete tanks, with vertical sidewalls. The 'egg' shape facilitates liquid mixing, reducing the buildup of scum, grit and dead zones within the reactor vessel. The egg-shaped digesters result in a smaller footprint, but greater visual impact. Egg shaped digesters are typically constructed of steel and are insulated with aluminum cladding on the exterior. The material cost of the egg digesters may be significant due to the material and construction requirements, based on this, the conventional digesters were further analyzed.

The design effort will include an evaluation of the required volume for digestion, and may include reutilizing the gravity thickener tanks (originally digestors) for digestion tanks. Capital costs for installation include of covers for gas storage, mixing systems, sludge heat exchangers, as well as gas and fire safety protection equipment.

Th advantages of anaerobic digestion include sludge volume reduction, production of biosolids that can be beneficially reused, potential reduction in hauling costs, and generation of renewable heat, power or both.

Cogeneration through Combined Heat and Power (CHP) utilizes the biogas created through Anaerobic Digestion to produce heat, which is exchanged to electricity production through a generator. The Mesophilic Anaerobic Digestion process has the ability to produce bio-gas for cogeneration.

Bio Gas Production

Gas produced during the anaerobic digestion of organic solids is an energy source that can be collected and used as an alternative fuel. As the gas is produced, it rises through the sludge and is collected above the digester tank liquid level and is either burned in a waste gas flare and/or collected and distributed to a dual-fuel boiler to heat the digester contents and/or to an electrical generation system such as a microturbine or engine generator.

The available biogas would then be used calculate the potential energy production using microturbines and internal combustion engines; and for calculating the heat recovery to heat the digesters for both technologies.

Microturbines and internal combustion engines are potential technologies to produce both electric and heat energy by utilizing excess digester gas as fuel. The following figure presents the typical design components included in a Co-generation system following Anaerobic Digestion.

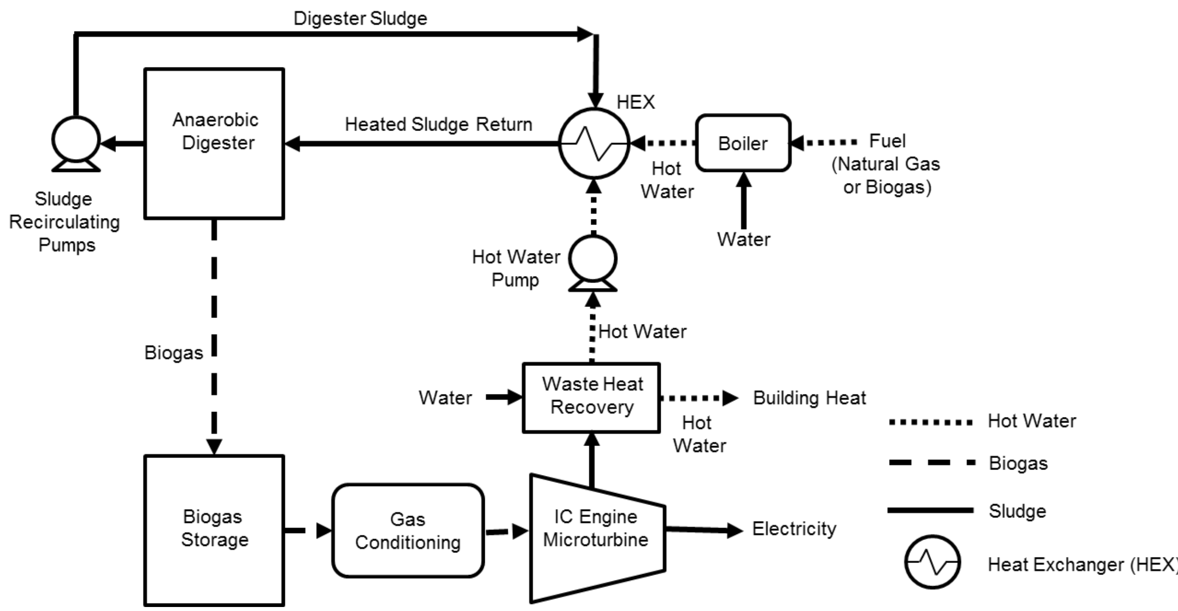


Figure 9. Digester & CHP Process Schematic

Engines and microturbines are sensitive to the quality of digester gas that is used for fuel and consequently requires the digester gas to be conditioned for the removal of moisture, particulates (especially siloxanes) and hydrogen sulfide. The removal of siloxane is critical as siloxane is converted to silica (ash) during the combustion process and can erode or damage engine and turbine parts. Therefore, conditioning the gas before use is a major factor in reliable microturbine operations.

The volume of gas that can be created by the digestion process varies with the sludge characteristics and conditions of the digestions (ph, temperature controls etc). The volume and btu content of the gas dictates the energy that can be recovered through heat or electricity. As part of the design phase effort the potential gas volume production, along with energy generation potential will be calculated along with the value of these renewable fuels versus the capital investment required for installing and maintaining the anaerobic digestion system.

The volume of organic content that is fed to the digestors can increase volatiles destruction capacity of the digestors, increasing gas and energy production. The recent state wide efforts to reduce the organic load to the solids waste stream of created an increased need for food waste processing and reuse locations. Source separated organics are continuing to provide an opportunity for the solids waste sector and wastewater industry to partner in organics recycling efforts that can create renewable energy, reduce greenhouse gases, and generate a revenue stream. This opportunity could be considered as part of the design efforts in coordination with input from Massachusetts state agencies and within the context of the current policies on organics recycling.

Installation & Interconnection of Renewable Energy Facilities

Financing of onsite generation systems can be accomplished through the following options:

- Municipal Ownership,
- Power Purchase Agreement.

These alternatives are discussed in more detail in the following sections.

Municipal Ownership

Under municipal ownership, the municipality would be responsible for acquiring the capital funding (i.e. issuance of bonds) necessary to purchase and install the proposed renewable energy system(s). The municipality would own the renewable energy system and the associated Renewable Energy Certificates (RECs) acquired through the generation of kW-hrs through New England Power Pool (NEPOOL). For solar installations in Massachusetts, the Solar Massachusetts Renewable Target (SMART) program will be utilized for solar generation incentives, further summarized below. Under this scenario, the municipality would be responsible for maintaining and operating the system and for acquiring the necessary permits to build and operate the generation unit.

By owning the system, the municipality would see a direct offset in electrical consumption and energy savings associated with the on-site generation of power. The system would be owned in perpetuity and would continue to provide power once the costs associated with the installation have been paid. However, a significant disadvantage involves the acquisition of funding for the project. In addition, the municipality would be responsible for operating and maintaining the system and for administering the sale of any acquired RECs for renewable energy besides solar. The solar incentives provided through the SMART program would be determined by Eversource and would be credited directly on your electric bill on a monthly basis based on the pre-determined credit per kWh generated, therefore, the municipality would not be responsibility for sale and tracking of RECs for solar installations.

Power Purchase Agreement / Third Party Ownership

A Power Purchase Agreement (PPA) is an alternative to municipal ownership in which the municipality becomes the host and the installer is the owner of the power system. In a PPA, the installing company owns the equipment and sells the electricity generated by the system to the municipality at a negotiated contract price. The installer is responsible for financing the project and for designing, installing, monitoring, operating and maintaining the system. The installer is also responsible for paying any property taxes associated with the system. Since installers are eligible to receive federal tax credit (30% for solar energy projects), they can benefit from an additional incentive that is not accessible by municipalities. The 30% solar investment tax credit (ITC) is currently available through the end of 2019, then drops to 26% for 2020 and 22% through 2021. In addition, any associated RECs or SMART incentives acquired through the operation of the system would be owned by the installer and not the host/municipality.

PPAs offer a number of advantages. The municipality would avoid acquiring any of the upfront costs necessary for the installation of the system. With the operation and maintenance of the system being the responsibility of the installer, the municipality would also avoid any of those costs. The municipality would see a savings based on the lower cost of electricity negotiated with the installer. At the end of the contract period, the host/installer would have the option to buy the system at a negotiated price.

Interconnection Requirements

Electricity for the Taunton WPCF is supplied through Taunton Municipal Lighting Plant (TMPL). Connection to the existing power grid requires an Interconnection Agreement between the generator (owner of the power system) and the energy distribution company (EDC).

Based on current TMPL requirements, the DC rating of a potential renewable energy source shall not exceed the maximum peak demand experienced at the plant over the last 12 month period. Based on the electrical data at the Taunton WPCF, the average demand is 537 kVA with a maximum demand of 569 kVA. Assuming the power factor is approximately 0.98, this is an average demand of 526.3 kW and a maximum demand of 557.4 kW. Based on discussion with TMPL, there is a potential to install a larger solar array adjacent to the plant. They are willing to work with the Taunton WPCF for this installation, the installation would require a separate electric line to be installed and may exceed the maximum peak demand at the plant.

The application process involves a number of screening steps to determine the project's feasibility, safety, reliance and overall compliance with the EDC's interconnection design and legal requirements. In addition, there are fees associated with an interconnection application, which vary based on the energy generation size of the proposed system. The following section provides the requirements for generation systems between 60 and 2,000 kW. TMLP recommends contacting them prior to the application to discuss the available alternatives.

Key requirements of the Interconnection Application process include the following.

- Initial Application fee of $500.
- Distribution System Impact Review Fee – the Customer will pay $3 per rated DC kW for this evaluation.
- Application shall be accompanied by three copies of the PE stamped one-line diagrams for the proposed facility, Distribution System Impact Review Fee, proof of insurance, and the application fee.
- The Customer is responsible for all costs to upgrade or modify the TMPL's distribution system to accommodate the proposed generation facility, if necessary.
- Customer is responsible for all costs associated with the design, installation, operation and maintenance for the generation facility on the Customer's side of the meter, including electrical use.

- If the Customer uses more electricity than the generation facility produces, the Customer will be billed at the regular applicable rate of electricity for the additional amount used as defined under their rate structure.

APPENDIX A

Rate Structure

M.D.P.U. No. 147
Cancels M.D.P.U. No. 141
Effective February 1, 2016

Taunton Municipal Lighting Plant
GENERAL SERVICE – PRIMARY
(Rate 31)

AVAILABILITY

This rate is available for service to any industrial or commercial use, where the load is in excess of 150 kilovolt-amperes. Service will be applied and measured at Primary voltage. The customer shall supply all transformer and regulating equipment. Service under this rate is subject to Taunton Municipal Lighting Plant's General Terms and Conditions for Retail Electric Service and its applicable requirements and specifications, as in effect from time to time.

MONTHLY CHARGE

Service charge $959.90

Delivery Services:			
Energy Charges:			
Distribution Charge		First 300 Hours	$0.01128 per kWh
		Excess 300 Hours	$0.00376 per kWh
Transmission Charge			$0.00000 per kWh
Transition Charge			$0.01624 per kWh
	Subtotal	First 300 Hours	$0.02752 per kWh
	Subtotal	Excess 300 Hours	$0.02000 per kWh
Demand Charges:			
Distribution Charge			$4.81 per kva
Transmission Charge			$5.04 per kva
Transition Charge			$4.94 per kva
		Subtotal	$14.79 per kva
Supplier Services:			
Generation Charge		Under 300 Hours	$0.05823 per kWh
		Over 300 Hours	$0.05099 per kWh
		Total Under 300 Hours	$0.08575 per kWh
		Total Over 300 Hours	$0.07099 per kWh
		Total Demand	$14.79 per kva

POWER COST ADJUSTMENT CLAUSE

The power cost adjustment, either a charge or a credit, will be applied to all kilowatt-hours used under this rate. Details of the power cost adjustment are provided in Service Classification No. 1.

BILLING DEMAND DETERMINATION

The Billing Demand shall be determined by comparing the highest fifteen minute kilovolt-ampere demand recorded or indicated in the current month by standard meter and the highest fifteen minute kilovolt-ampere demand recorded or indicated in the preceding months of June, July and August. The customer will be charged based on the higher of the two demands.

MINIMUM CHARGE

$ 3,178.40 per month including a minimum billing demand of 150 kilovolt-amperes.

TRANSFORMER RENTAL RIDER

Only when available and under special emergency conditions will the Taunton Municipal Lighting Plant install, for a temporary period, a transformer for customer requirements. The customer will be charged $0.20 per month per kilovolt-ampere of transformer capacity. Any new or additional transformer capacity will be provided by the customer.

TERM OF CONTRACT

Twelve months, and yearly thereafter. Interest will be charged at the rate of 1 ½% per month on any past-due balance over thirty days.

Taunton Municipal Lighting Plant
POWER COST ADJUSTMENT CLAUSE
SERVICE CLASSIFICATION NO. 1

The energy portion of the supplier services will be increased or decreased by the Power Cost Adjustment (PCA).

The PCA will be calculated for each quarter of the calendar year and updated on a monthly basis. The projected PCA for the next calendar year will be calculated by October 31 of the preceding year. The PCA will be calculated based on estimated power costs and kilowatt-hour sales for the quarter in which the PCA is to be applied. The actual PCA applied to billing may be levelized based on the annualized PCA projection and available rate stabilization funds. The cumulative PCA variance shall be controlled to maintain an adequate stabilization fund.

For the purpose of calculating the PCA, power costs will consist of all of TMLP's electric production resource energy costs. These costs may include certain capacity related costs, which are purchased bundled into the energy price. This cost of power, adjusted for over or under collections in the previous periods and rate stabilization fund requirements, will have subtracted from it the generation charge portion of the rate. The difference will be divided by the projected kilowatt-hour sales for the corresponding quarter less any sales to which the PCA is not applied, to arrive at the quarterly PCA.

APPENDIX B

Energy Balance

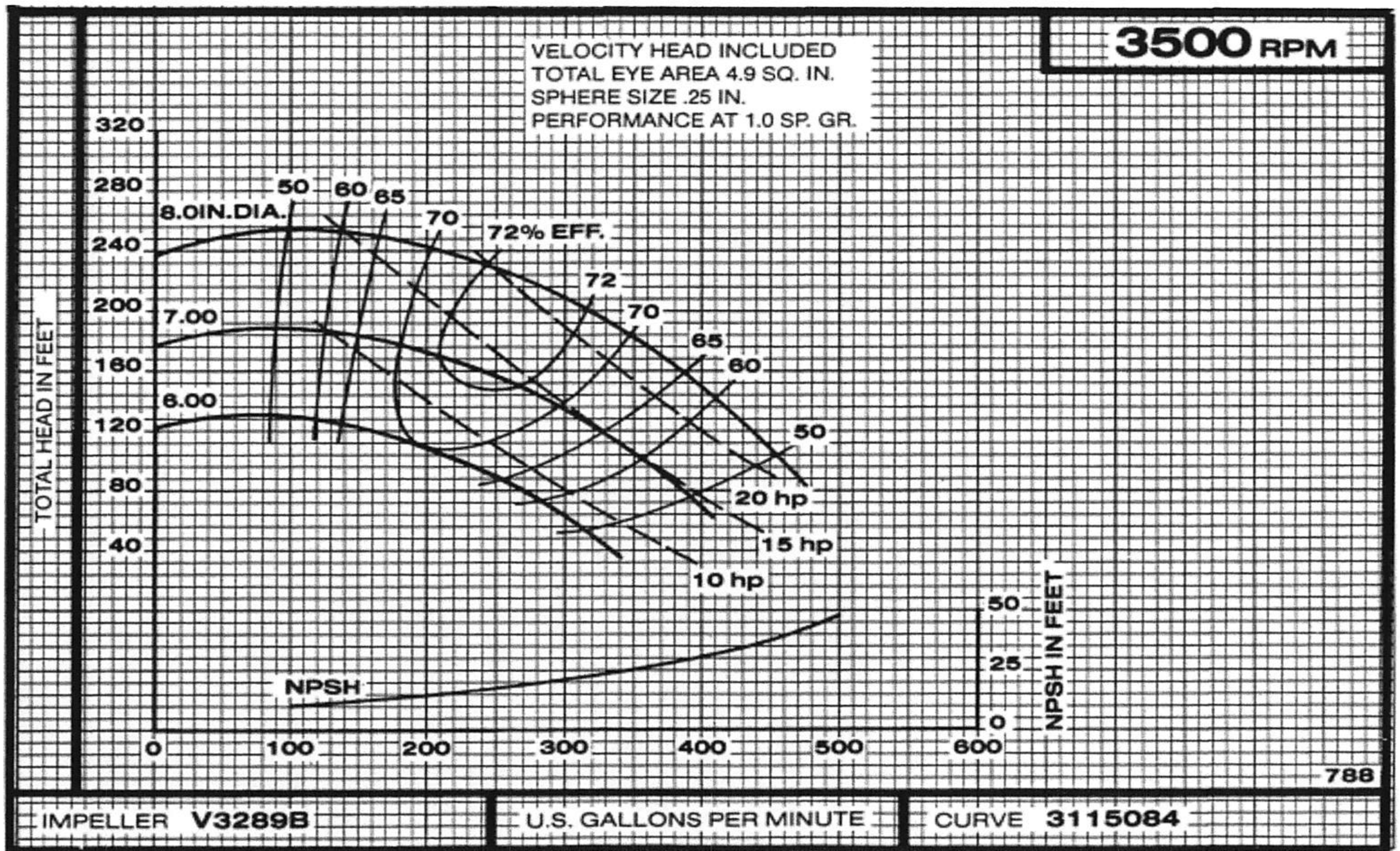
	A	B	C	D	E	F	G	H
3	**Facility:**	**Taunton WWTF**						
4		**Electric Energy Balance**						
5					**Measured or**	**Annual**		
6				**Estimated**	**Estimated**	**Estimated**		
7	**Equipment Description**		**HP**	**Load**	**kW**	**hours**	**kWhs**	**Notes**
8	**Influent Lift Station**							
9	Raw Wastewater Pump 1	VFD	130.0	--	73.1	8,700	635,970	Operating at 90%
10	Raw Wastewater Pump 2	VFD	130.0	--	72.4	870	62,988	Operating at 90%
11	Raw Wastewater Pump 3	Soft Start	130.0	--		24	0	Field Readings
12	Raw Wastewater Pump 4	Soft Start	130.0	--		0	0	Field Readings
13								
14							**698,958**	
15	**Headworks and Primary Treatment**							
16	Grit Blower 1		7.5	0.8	3.2	4,380	14,016	Field Readings
17	Grit Blower 2		7.5	0.8	3.2	4,380	14,016	Field Readings
18	Septage Pump		1.5	0.8	1.2	4	5	Runs twice a year, a couple hours each time
19	Bar Screen 1		1.5	0.8	1.2	146	175	20 seconds every 10 mins (both operate)
20	Bar Screen 2		1.5	0.8	1.2	146	175	
21	Screw Press		1	0.8	0.8	292	234	Bar screen is on both press and conveyor are on
22	Screw Conveyor		2	0.8	1.2	292	350	
23								
24					**12**		**28,971**	
25	**Aeration System**							
26	Aeration Mixer 1A		30	--	14.3	8,000	114,400	Field Readings
27	Aeration Mixer 1B		20	--	8.4	8,000	67,200	Field Readings
28	Aeration Mixer 1C		20	--	9.0	8,000	72,000	Field Readings
29	Aeration Mixer 2A		30	--	12.9	8,000	103,200	Field Readings
30	Aeration Mixer 2B		20	--	8.6	8,000	68,800	Field Readings
31	Aeration Mixer 2C		20	--	8.3	8,000	66,400	Field Readings
32	Aeration Mixer 4A		40	--	23.0	8,000	184,000	Field Readings
33	Aeration Mixer 4B		40	--	22.3	8,000	178,400	Field Readings
34	Aeration Mixer 4C		30	--	17.1	8,000	136,800	Field Readings
35	Aeration Mixer 5A		40	--	22.9	8,000	183,200	Field Readings
36	Aeration Mixer 5B		40	--	20.1	8,000	160,800	Field Readings
37	Aeration Mixer 5C		30	--	15.2	8,000	121,600	Field Readings
38	Aeration Blower 1		100	--	77.5	3,000	232,500	Field Readings
39	Aeration Blower 2	VFD	100	--	68.8	8,760	602,688	Field Readings
40	Aeration Blower 3		100	--	85.7	0	0	
41								
42					**414**		**2,291,988**	
43	**Secondary Clarification**							
44	Clarifier Drive 1		1.0	0.8	0.80	8,760	7,008	
45	Clarifier Drive 2		1.0	0.8	0.80	8,760	7,008	
46	Clarifier Drive 3		1.0	0.8	0.80	8,760	7,008	
47	Clarifier Drive 4		1.0	0.8	0.80	8,760	7,008	
48								
49					**3**		**28,032**	
50	**Chemical System**							
51	Lime Slurry Pump1			0.8	0.00	2,880	0	
52	Lime Slurry Pump 2			0.8	0.00	2,880	0	
53	Lime Slurry Pump 3			0.8	0.00	2,880	0	
54	Lime Slurry Pump 4			0.8	0.00	2,880	0	
55	Sample Pump		5.0	0.8	2.98	8,760	26,140	
56	Sodium Bisulfite Metering Pump 1		0.25	0.8	0.15	4,380	653	
57	Sodium Bisulfite Metering Pump 2		0.25	0.8	0.15	4,380	653	
58	Sodium Hypochlorite Metering Pump 1		0.25	0.8	0.15	4,380	653	
59	Sodium Hypochlorite Metering Pump 2		0.25	0.8	0.15	4,380	653	
60								
61					**4**		**28,754**	
62	**Sludge Pumping**							Field notes
63	Primary Sludge Pump 1		25	0.8	3.10	8,760	27,156	Constant speed
64	Primary Sludge Pump 2		25	0.8	2.90	8,760	25,404	Constant speed
65	Primary Sludge Pump 3		25	0.8	3.00	8,760	26,280	Constant speed
66	Scum Pump		5	0.8	2.98	1,000	2,984	
67	Primary Settling Tank Drive 1		1	0.8	0.60	8,760	5,228	
68	Primary Settling Tank Drive 1		1	0.8	0.60	8,760	5,228	
69	Primary Settling Tank Drive 1		1	0.8	0.60	8,760	5,228	
70	Return Sludge Pump 1 (Battery 1)	VFD	25	0.8	14.92	4,380	65,350	
71	Return Sludge Pump 2 (Battery 1)	VFD	25	0.8	14.92	4,380	65,350	
72	Return Sludge Pump 1 (Battery 2)	VFD	30	0.8	17.90	0	0	
73	Return Sludge Pump 2 (Battery 2)	VFD	30	0.8	5.50	8,760	48,180	52% speed
74	Return Sludge Pump 3 (Battery 2)	VFD	30	0.8	4.20	8,760	36,792	52% speed
75	WAS Pump 1 (Battery 1)		5.0	0.8	3	438	1,307	
76	WAS Pump 2 (Battery 1)		5.0	0.8	3	438	1,307	
77	WAS Pump 1 (Battery 2)	VFD		0.8	0	8,000	0	
78	WAS Pump 2 (Battery 2)	VFD		0.8	0	8,000	0	
79	WAS Pump 3 (Battery 2)	VFD		0.8	0	8,000	0	
80								
81								
82					**77.2**		**315,793**	

	A	B	C	D	E	F	G	H
83	**Solids Handling**							
84	Sludge Thickener Collector 1 (GT)		3	0.8	1.79	8,760	15,684	
85	Polymer Blender 2		3	0.8	1.79	100	179	
86	Polymer Pump 1		1	0.8	0.30	100	30	
87	Sludge Grinder 1		3	0.8	1.79	2,000	3,581	
88	Sludge Grinder 2		3	0.8	1.79	2,000	3,581	
89	Paddle Spreader		1	0.8	0.60	500	298	
90	Liquid Sludge Pump 1		20	0.8	11.94	2,000	23,872	
91	Liquid Sludge Pump 2		20	0.8	11.94	2,000	23,872	
92	Centrifuge 1		75	0.8	44.76	2,000	89,520	
93	Centrifuge Scraping Screw 1		15	0.8	8.95	2,000	17,904	
94	Centrifuge Feed Pump 1	VFD	10	0.8	5.97	2,000	11,936	
95	Centrifuge 2		75	0.8	44.76	2,000	89,520	
96	Centrifuge Scraping Screw 2		15	0.8	8.95	2,000	17,904	
97	Centrifuge Feed Pump 2	VFD	10	0.8	5.97	2,000	11,936	
98	Screw Conveyor 1		3	0.8	1.79	2,000	3,581	
99	Screw Conveyor 2		3	0.8	1.79	2,000	3,581	
100	Belt Conveyor		3	0.8	1.79	2,000	3,581	
101					**157**		**320,559**	
102	**Odor control**							
103	Odor Control Fan		30	0.80	17.90	0	0	
104	Odor Control Scrubber Pump 1			0.80	0.00	0	0	
105	Odor Control Scrubber Pump 2			0.80	0.00	0	0	
106	Scrubber Recycling Pump 1		7.5	0.8	4.48	0	0	
107	Scrubber Recycling Pump 2		7.5	0.8	4.48	0	0	
108								
109					**17.9**		**0**	
110	**Plant Water System**							
111	Plant Water Pump 1		25	0.80	21.00	0	0	
112	Plant Water Pump 2		40	0.80	21.00	8,000	168,000	
113								
114					**42.0**		**168,000**	
115	**Building Systems**							
116	Exaust Fan 1		3.0	0.8	1.79	1,450	2,596	
117	Exhaust Fan-2		0.3	0.8	0.18	1,450	260	
118	Exhaust Fan-3		0.25	0.8	0.15	1,450	216	
119	Exhaust Fan-4		0.25	0.8	0.15	1,450	216	
120	Exaust Fan 5		0.5	0.8	0.30	1,450	433	
121	Exhaust Fan-6		0.1	0.8	0.06	1,450	87	
122	Exhaust Fan-7		0.1	0.8	0.06	1,450	87	
123	Exaust Fan 8		1.0	0.8	0.60	1,450	865	
124	Exaust Fan 9		0.5	0.8	0.30	1,450	433	
125	Exaust Fan 10		0.5	0.8	0.30	1,450	433	
126	Exhaust Fan-11		0.25	0.8	0.15	1,450	216	
127	Exhaust Fan-12		0.25	0.8	0.15	1,450	216	
128	Exhaust Fan-B01		2.0	0.8	1.19	1,400	1,671	
129	Exhaust Fan-B02		0.25	0.8	0.15	1,400	209	
130	Air Handeling Unit 1		10	0.8	5.97	1,400	8,355	
131	Air Handeling Unit 2		5	0.8	2.98	1,400	4,178	
132	Hot Water Heater 1		0.05	0.8	0.03	1,400	42	
133	Hot Water Heater 2		0.05	0.8	0.03	1,400	42	
134	Hot Water Heater 3		0.05	0.8	0.03	1,400	42	
135	Hot Water Heater 4		0.05	0.8	0.03	1,400	42	
136	Hot Water Heater 5		0.05	0.8	0.03	1,400	42	
137	Hot Water Heater 6		0.05	0.8	0.03	1,400	42	
138	Hot Water Heater 7		0.05	0.8	0.03	1,400	42	
139	Hot Water Heater 8		0.05	0.8	0.03	1,400	42	
140	Indoor and Outdoor Lighting		0.05	0.8	15.00	500	7,500	
141	Bolier		3	0.8	1.79	1,000	1,790	
142	Misc		0.05	0.8	25.00		0	
143								
144					**57**		**30,095**	
146								
147			**Baseline**					
148			**Annual**	**% of**	**Average**			
149	**Plant Systems**		**kWh**	**Total**	**kW**			
150								
151	Raw Sewage Pumps		698,958	17.87%				
152	Headworks and Primary Treatment		28,971	0.74%	12			
153	Aeration System		2,291,988	58.60%	414			
154	Secondary Clarification		28,032	0.72%	3			
155	Solids Handling		320,559	8.20%	157			
156	Odor control		0	0.00%	18			
157	Plant Water System		168,000	4.30%	18			
158	Building Systems		30,095	0.77%	3			
159	Sludge Pumping		315,793	8.07%	77			
160	Disinfection System		28,754	0.74%	4			
161					**706**			
162								
163	**Annual Total**		**3,911,150**					
164	**Annual Electric Use 2016**		**3,904,200**	**100%**	**321**			

APPENDIX C

Pump Curves

Plant watere Pumps



Page 8 Rev. 7-88

Plant water pumps

Pump #1 25 HP - 250 GPM @ 230 TDH

Pump #2 40 HP – 470 GPM @ 231 TDH

Carlsen Systems, LLC

Craig Burmeister
Phone 203-427-3375

Customer :

Contact :

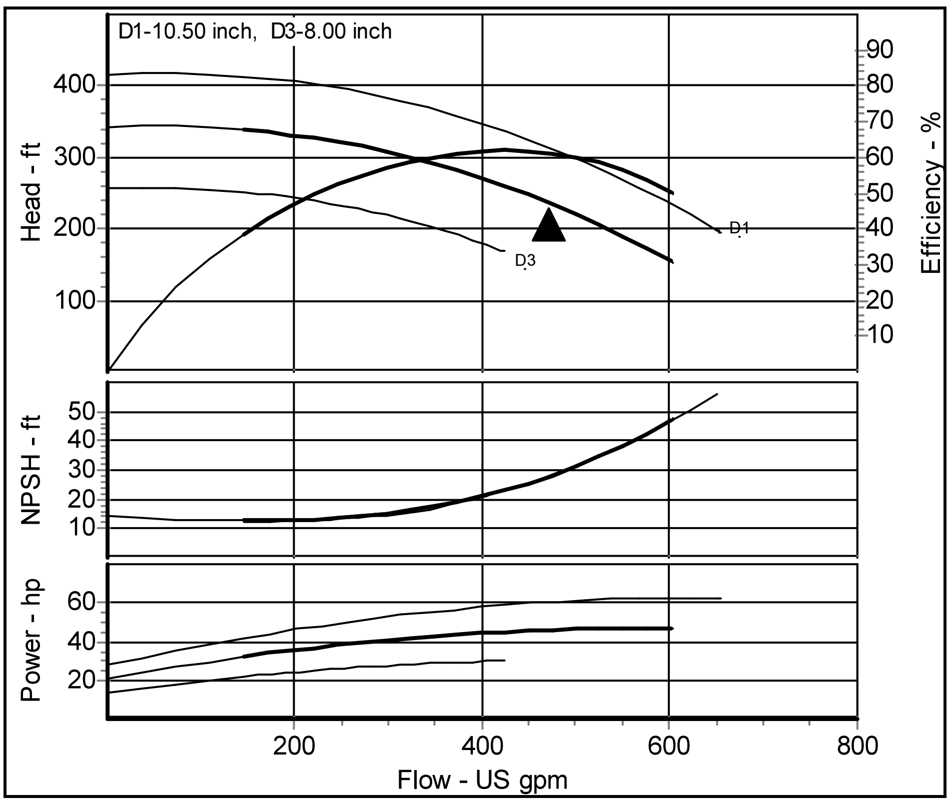
Project :

Phone : **Fax :**

Quote No. : US-1585-63 **Page No :** 1

Date : Tuesday, November 28, 2017

Type:	**C - End Suction Close Coupled General Purpose**	Item :	**1**
Pump Model:	**Peerless - C1125**	Impeller No.:	SeePtslist
Nom. Speed:	**3500 RPM, 60 Hz Electric**	Fluid:	**Water**
Impeller Dia.:	**9.54** inch	Temperature:	**68** °F
Curve No.:	**3110005/Rev 3**	Viscosity:	**1.007** cSt
Market :	**Water**	Sp. Gravity:	**1.000**
		Your Ref. :	



Duty Flow	**470**	US gpm
Duty Head	**230**	ft
Imp. Dia.	**9.54**	inch
Power Required	**45.9**	hp
NPSH Required	**27.7**	ft
Efficiency	**61.3**	%
Peak Power	**46.8**	hp
Closed Valve Head	**342.2**	ft
Tolerance	**Hyd Ins 14.6 Unilateral**	

Comments

Performance curve represents typical performance. See Hydraulic Performance document in RAPID for perfomance test acceptance grades/tolerances & contractual guarantees..

Flow (US gpm)	Head (ft)	Efficiency (%)	Power Required (hp)	NPSH Required (ft)
145.0	338.8	38.7	32.1	12.6
202.0	330.7	47.2	35.7	12.9
259.0	318.7	53.7	38.8	14.0
315.9	302.5	58.3	41.4	16.0
372.9	282.0	61.0	43.5	19.1
429.9	257.1	61.9	45.1	23.6
486.9	227.7	60.7	46.2	29.6
543.9	193.7	56.9	46.7	37.3
600.8	154.8	50.2	46.8	47.0

Grundfos - RAPID v8.25.9.1 (Windows 7) - 06th March 2012.

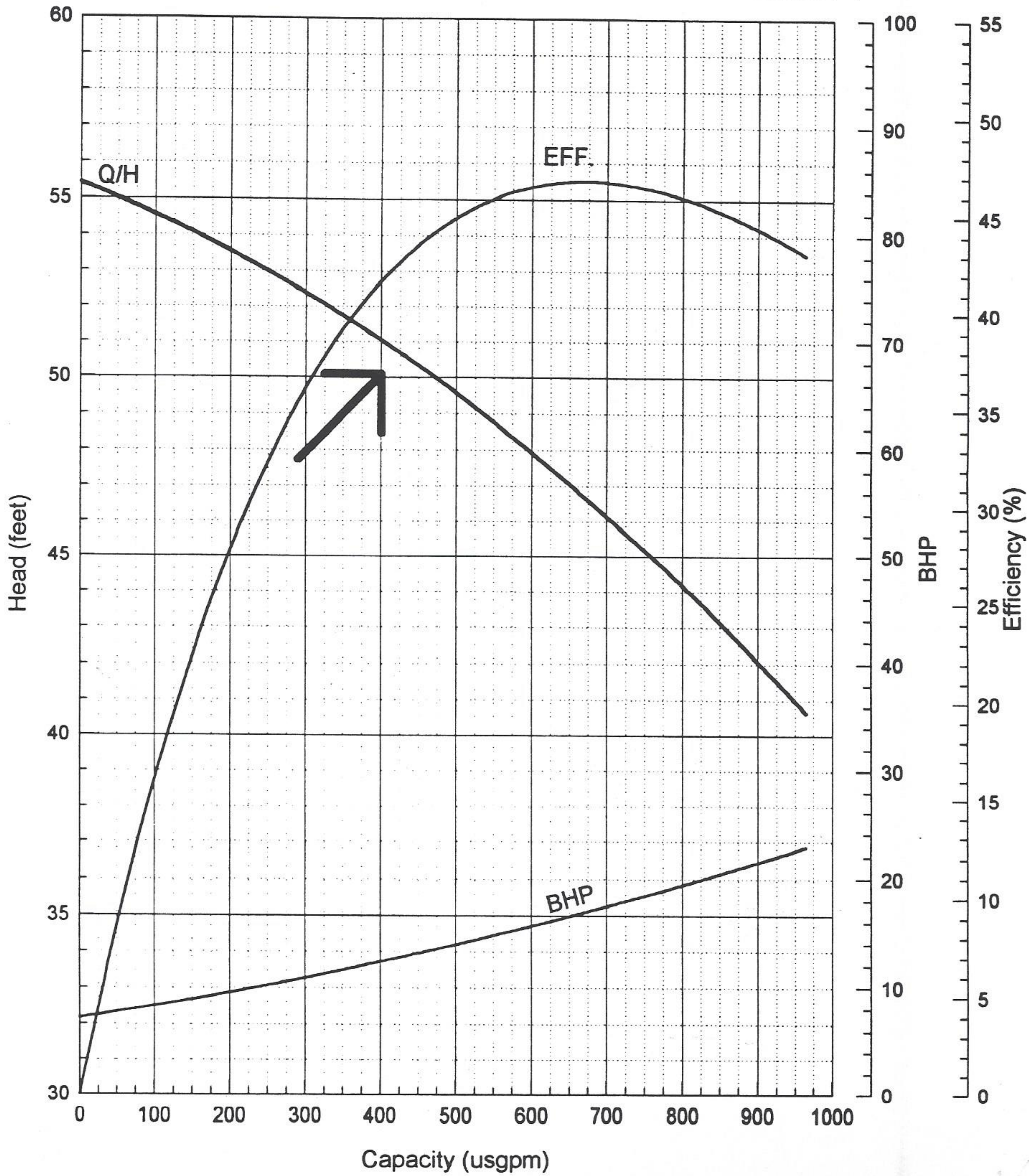
HAYWARD GORDON LTD.

Customer:	*Poole and Kent New England Inc.*	Model:	*XR4-12*
Project:	*City of Taunton WWTF*	Size:	*4 X 6 X 12*
Cust. P.O.:	*98905-1007*	Speed:	*1030 RPM*
Tag #:	*PRIMARY SLUDGE PUMP PSP-1*	Trim Dia.:	*Full*
Curve #:	*278997-1*	Rated Cap.:	*400 USGPM*
Test #:	*1*	Rated Head:	*50 Ft TDH*
Date:	*May 31, 1999*	Drawn:	*G.S.*

Certified Test by:

G.L. June 1/99

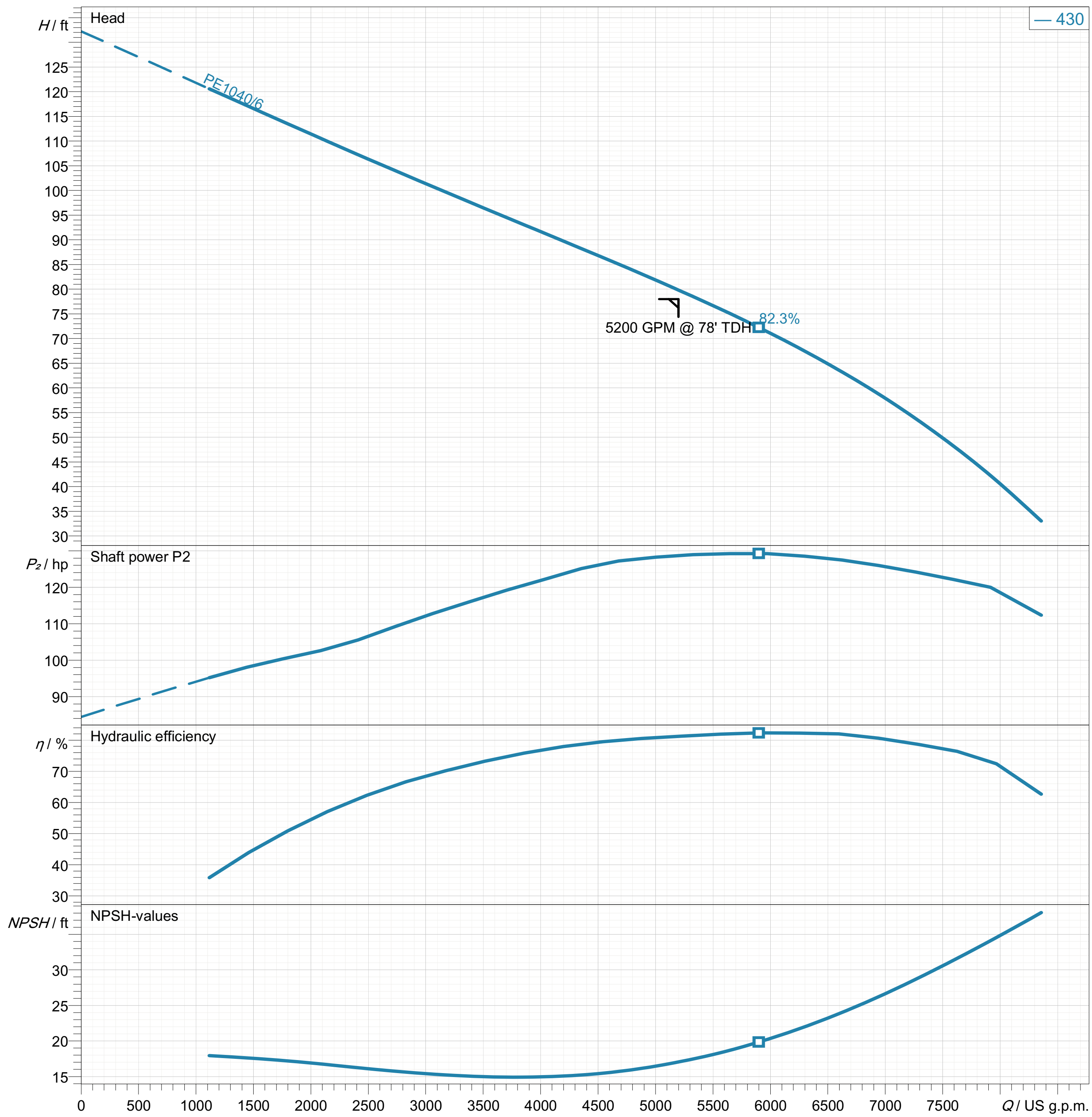
Initial Date



Curve number	Pump performance curves
Reference curve XFP 305M-CB2 60 HZ	XFP 305M-CB2 60 HZ

SULZER

			Discharge DN300	Frequency 60 Hz
Density 62.32 lb/ft³	Viscosity 1.001 mm²/s	Testnorm Hydraulic Institute	Rated speed 1189 rpm	Date 5/13/2015
Flow 5250 US g.p.m.	Head 79.4 ft	Rated power 129 hp	Hydraulic efficiency 81.3 %	NPSH 17.2 ft



Impeller size 430 mm	N° of vanes 2	Impeller Contrablock Plus impeller	Solid size 90 x 140 mm	Revision

Spaix® 4, Version 4.1.5 - 2015/03/27 (Build 932)
Data version Mar-2015

Item number	: Default	Size	: 10" 54X5
Service	:	Stages	: 1
Quantity	: 1	Based on curve number	: 10-54x5-1200-TALE5A
Quote number	:	Date last saved	: 10 Oct 2017 6:29 AM

Operating Conditions

Flow, rated	: 2,947.4 USgpm
Differential head / pressure, rated (requested)	: 38.78 ft
Differential head / pressure, rated (actual)	: 38.78 ft
Suction pressure, rated / max	: 0.00 / 0.00 psi.g
NPSH available, rated	: Ample
Frequency	: 60 Hz

Performance

Speed, rated	: 690 rpm
Impeller diameter, rated	: 19.12 in
Impeller diameter, maximum	: 21.00 in
Impeller diameter, minimum	: 18.00 in
Efficiency	: 80.18 %
NPSH required / margin required	: 7.82 / 0.00 ft
nq (imp. eye flow) / S (imp. eye flow)	: 43 / 159 Metric units
Minimum Continuous Stable Flow	: 2,002.4 USgpm
Head, maximum, rated diameter	: 63.13 ft
Head rise to shutoff	: 62.80 %
Flow, best eff. point	: 2,948.3 USgpm
Flow ratio, rated / BEP	: 99.97 %
Diameter ratio (rated / max)	: 91.05 %
Head ratio (rated dia / max dia)	: 74.72 %
Cq/Ch/Ce/Cn [ANSI/HI 9.6.7-2010]	: 1.00 / 1.00 / 1.00 / 1.00
Selection status	: Acceptable

Liquid

Liquid type	: Water
Additional liquid description	:
Solids diameter, max	: 0.00 in
Solids concentration, by volume	: 0.00 %
Temperature, max	: 68.00 deg F
Fluid density, rated / max	: 1.000 / 1.000 SG
Viscosity, rated	: 1.00 cP
Vapor pressure, rated	: 0.34 psi.a

Material

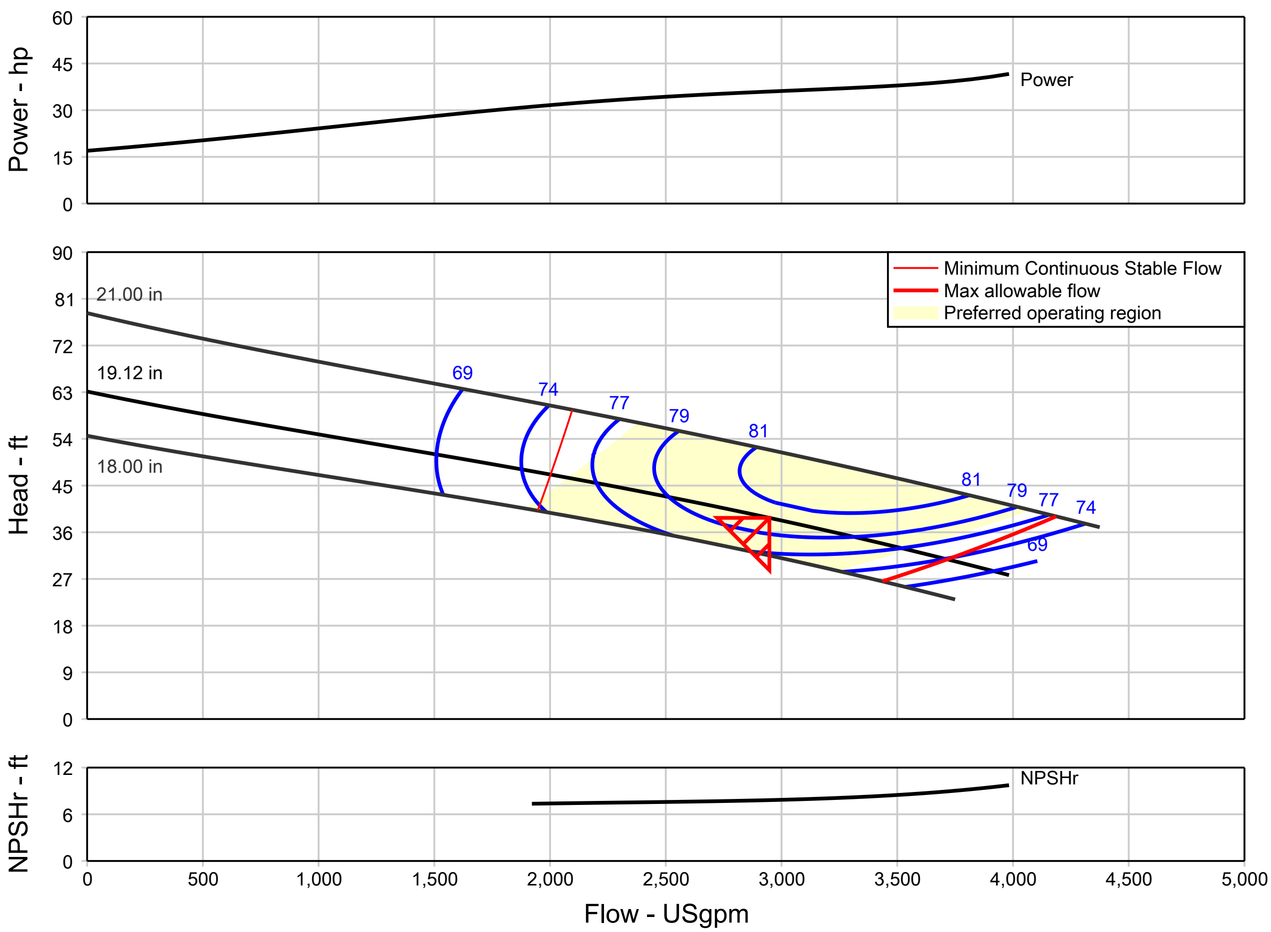
Material selected	: Cast Iron

Pressure Data

Maximum working pressure	: 27.32 psi.g
Maximum allowable working pressure	: 75.00 psi.g
Maximum allowable suction pressure	: N/A
Hydrostatic test pressure	: 115.0 psi.g

Driver & Power Data (@Max density)

Driver sizing specification	: Maximum power
Margin over specification	: 0.00 %
Service factor	: 1.00
Power, hydraulic	: 28.85 hp
Power, rated	: 35.99 hp
Power, maximum, rated diameter	: 41.64 hp
Minimum recommended motor rating	: 50.00 hp / 37.29 kW



Customer :
Project name :

Pump Performance Datasheet

Encompass 2.0 - 17.4.2.0

Item number	: Default	Size	: 10" 54X5
Service	:	Stages	: 1
Quantity	: 1	Based on curve number	: 10-54x5-1200-TALE5A
Quote number	:	Date last saved	: 10 Oct 2017 6:33 AM

Operating Conditions

Flow, rated	: 2,769.8 USgpm
Differential head / pressure, rated (requested)	: 35.16 ft
Differential head / pressure, rated (actual)	: 35.16 ft
Suction pressure, rated / max	: 0.00 / 0.00 psi.g
NPSH available, rated	: Ample
Frequency	: 60 Hz

Performance

Speed, rated	: 690 rpm
Impeller diameter, rated	: 18.31 in
Impeller diameter, maximum	: 21.00 in
Impeller diameter, minimum	: 18.00 in
Efficiency	: 78.16 %
NPSH required / margin required	: 7.71 / 0.00 ft
nq (imp. eye flow) / S (imp. eye flow)	: 43 / 159 Metric units
Minimum Continuous Stable Flow	: 1,962.0 USgpm
Head, maximum, rated diameter	: 56.92 ft
Head rise to shutoff	: 61.86 %
Flow, best eff. point	: 2,770.8 USgpm
Flow ratio, rated / BEP	: 99.96 %
Diameter ratio (rated / max)	: 87.19 %
Head ratio (rated dia / max dia)	: 65.63 %
Cq/Ch/Ce/Cn [ANSI/HI 9.6.7-2010]	: 1.00 / 1.00 / 1.00 / 1.00
Selection status	: Acceptable

Liquid

Liquid type	: Water
Additional liquid description	:
Solids diameter, max	: 0.00 in
Solids concentration, by volume	: 0.00 %
Temperature, max	: 68.00 deg F
Fluid density, rated / max	: 1.000 / 1.000 SG
Viscosity, rated	: 1.00 cP
Vapor pressure, rated	: 0.34 psi.a

Material

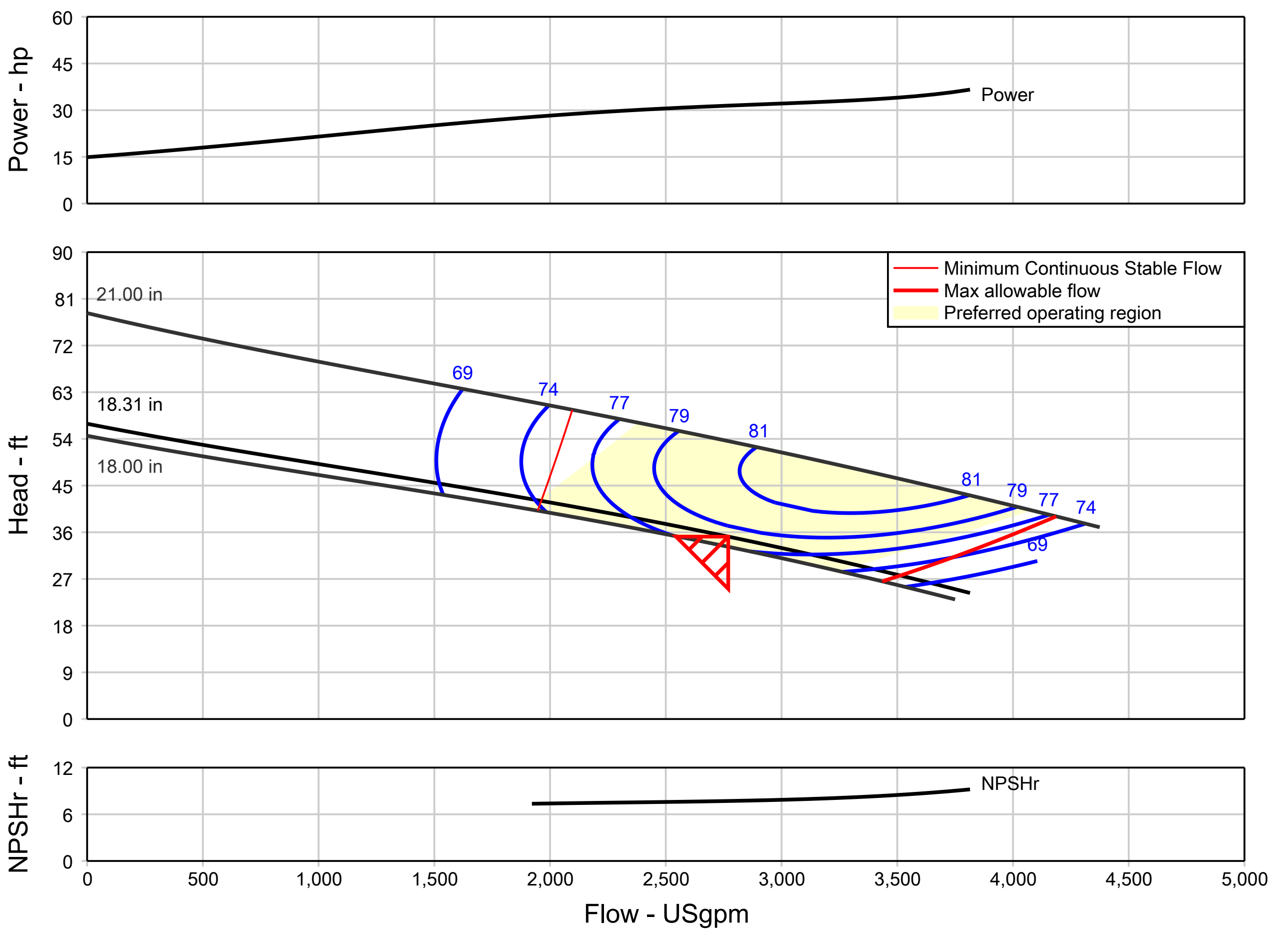
Material selected	: Cast Iron

Pressure Data

Maximum working pressure	: 24.63 psi.g
Maximum allowable working pressure	: 75.00 psi.g
Maximum allowable suction pressure	: N/A
Hydrostatic test pressure	: 115.0 psi.g

Driver & Power Data (@Max density)

Driver sizing specification	: Maximum power
Margin over specification	: 0.00 %
Service factor	: 1.00
Power, hydraulic	: 24.59 hp
Power, rated	: 31.46 hp
Power, maximum, rated diameter	: 36.60 hp
Minimum recommended motor rating	: 40.00 hp / 29.83 kW



FAIRBANKS NIJHUIS
3501 FAIRBANKS AVENUE ·
KANSAS CITY, KANSAS 66106
WWW.FAIRBANKSNIJHUIS.COM

PHONE: +1-913-371-5000 · FAX:

Item number	: Default	Size	: 4" 54X2
Service	:	Stages	: 1
Quantity	: 1	Based on curve number	: 4-54x2-1800-T4B1A
Quote number	:	Date last saved	: 10 Oct 2017 6:35 AM

Operating Conditions

Flow, rated	: 538.0 USgpm
Differential head / pressure, rated (requested)	: 30.80 ft
Differential head / pressure, rated (actual)	: 30.85 ft
Suction pressure, rated / max	: 0.00 / 0.00 psi.g
NPSH available, rated	: Ample
Frequency	: 60 Hz

Performance

Speed, rated	: 1165 rpm
Impeller diameter, rated	: 9.72 in
Impeller diameter, maximum	: 9.75 in
Impeller diameter, minimum	: 7.00 in
Efficiency	: 72.45 %
NPSH required / margin required	: 8.65 / 0.00 ft
nq (imp. eye flow) / S (imp. eye flow)	: 40 / 104 Metric units
Minimum Continuous Stable Flow	: 118.4 USgpm
Head, maximum, rated diameter	: 48.66 ft
Head rise to shutoff	: 57.96 %
Flow, best eff. point	: 535.5 USgpm
Flow ratio, rated / BEP	: 100.45 %
Diameter ratio (rated / max)	: 99.69 %
Head ratio (rated dia / max dia)	: 98.89 %
Cq/Ch/Ce/Cn [ANSI/HI 9.6.7-2010]	: 1.00 / 1.00 / 1.00 / 1.00
Selection status	: Acceptable

Liquid

Liquid type	: Water
Additional liquid description	:
Solids diameter, max	: 0.00 in
Solids concentration, by volume	: 0.00 %
Temperature, max	: 68.00 deg F
Fluid density, rated / max	: 1.000 / 1.000 SG
Viscosity, rated	: 1.00 cP
Vapor pressure, rated	: 0.34 psi.a

Material

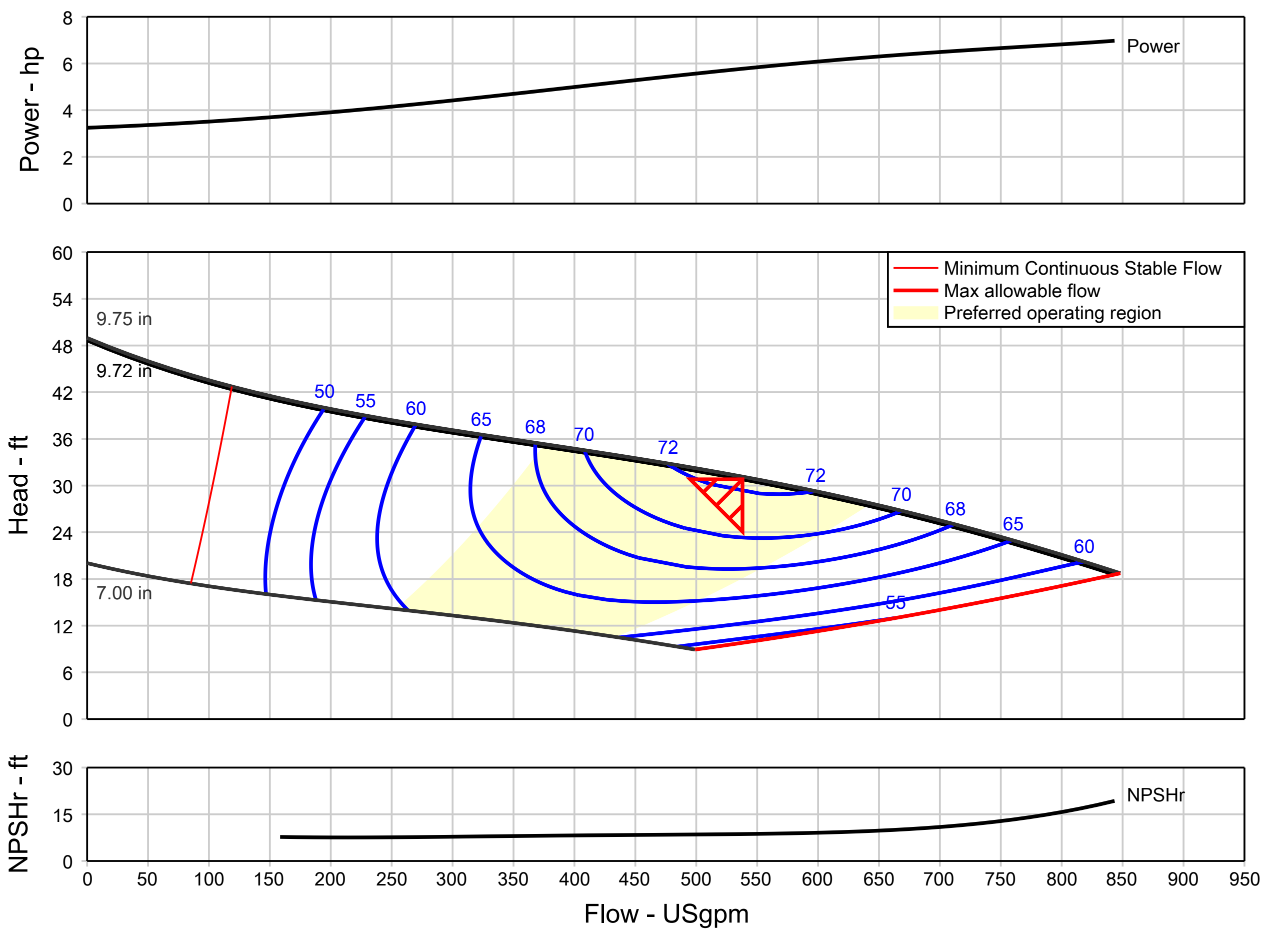
Material selected	: Cast Iron

Pressure Data

Maximum working pressure	: 21.06 psi.g
Maximum allowable working pressure	: 60.00 psi.g
Maximum allowable suction pressure	: N/A
Hydrostatic test pressure	: 90.00 psi.g

Driver & Power Data (@Max density)

Driver sizing specification	: Maximum power
Margin over specification	: 0.00 %
Service factor	: 1.00
Power, hydraulic	: 4.18 hp
Power, rated	: 5.77 hp
Power, maximum, rated diameter	: 6.97 hp
Minimum recommended motor rating	: 7.50 hp / 5.59 kW



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3501 FAIRBANKS AVENUE ·
KANSAS CITY, KANSAS 66106
WWW.FAIRBANKSNIJHUIS.COM

PHONE: +1-913-371-5000 · FAX:

Centrifuge Sludge Pumps

model - 40-6LTNS

seepex
Inc.
1834 Valley Street
Dayton, Ohio 45404
USA
Phone (513) 233-9904
Fax (513) 233-9024

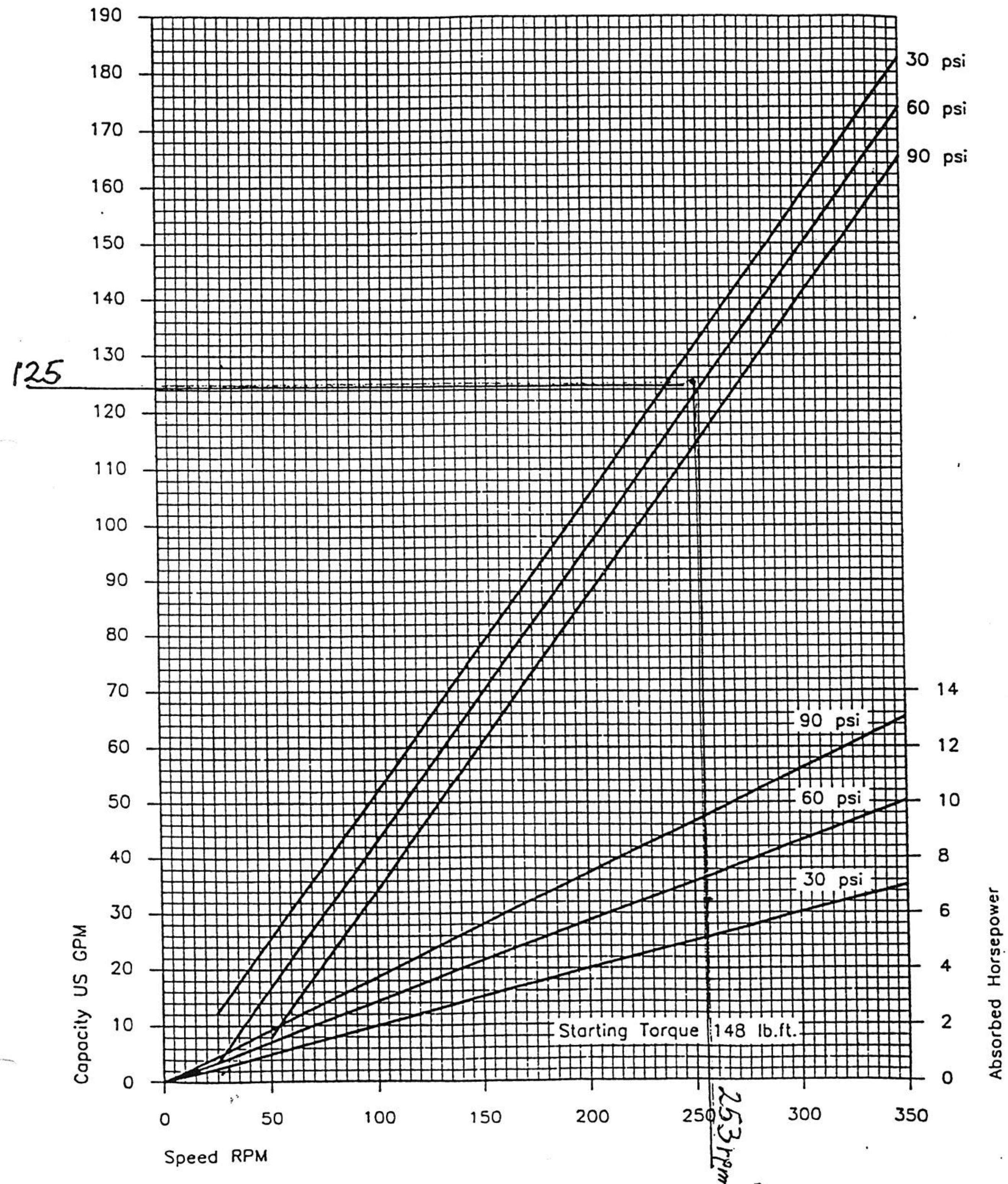
seepex Inc.

Performance Curve

CITY OF TAUNTON, MA.

125 GPM AT 43 PSI

40–6LT



Values based upon water 68°F ; For notes on drive selection refer to PER

APPENDIX D

Solar Data

Caution: Photovoltaic system performance predictions calculated by PVWatts® include many inherent assumptions and uncertainties and do not reflect variations between PV technologies nor site-specific characteristics except as represented by PVWatts® inputs. For example, PV modules with better performance are not differentiated within PVWatts® from lesser performing modules. Both NREL and private companies provide more sophisticated PV modeling tools (such as the System Advisor Model at http://sam.nrel.gov) that allow for more precise and complex modeling of PV systems.

The expected range is based on 30 years of actual weather data at the given location and is intended to provide an indication of the variation you might see. For more information, please refer to this NREL report: The Error Report.

The energy output range is based on analysis of 30 years of historical weather data for nearby , and is intended to provide an indication of the possible interannual variability in generation for a Fixed (open rack) PV system at this location.

RESULTS

684,116 kWh/Year*

System output may range from 631,302 to 701,629kWh per year near this location.

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)	Energy Value ($)
January	2.73	38,255	4,246
February	3.67	45,952	5,101
March	4.58	61,807	6,861
April	5.35	68,115	7,561
May	5.78	73,494	8,158
June	6.15	73,521	8,161
July	6.39	77,318	8,582
August	5.95	72,407	8,037
September	4.55	54,756	6,078
October	4.00	51,726	5,742
November	2.74	35,430	3,933
December	2.28	31,335	3,478
Annual	**4.51**	**684,116**	**$ 75,938**

Location and Station Identification

Requested Location	875 West Water Street, Taunton, MA
Weather Data Source	(TMY2) PROVIDENCE, RI 20 mi
Latitude	41.73° N
Longitude	71.43° W

PV System Specifications *(Commercial)*

DC System Size	552.6 kW
Module Type	Standard
Array Type	Fixed (open rack)
Array Tilt	20°
Array Azimuth	180°
System Losses	20%
Inverter Efficiency	96%
DC to AC Size Ratio	1.1

Economics

Average Cost of Electricity Purchased from Utility	0.11 $/kWh

Performance Metrics

Capacity Factor	14.1%

Caution: Photovoltaic system performance predictions calculated by PVWatts® include many inherent assumptions and uncertainties and do not reflect variations between PV technologies nor site-specific characteristics except as represented by PVWatts® inputs. For example, PV modules with better performance are not differentiated within PVWatts® from lesser performing modules. Both NREL and private companies provide more sophisticated PV modeling tools (such as the System Advisor Model at http://sam.nrel.gov) that allow for more precise and complex modeling of PV systems.

The expected range is based on 30 years of actual weather data at the given location and is intended to provide an indication of the variation you might see. For more information, please refer to this NREL report: The Error Report.

The energy output range is based on analysis of 30 years of historical weather data for nearby , and is intended to provide an indication of the possible interannual variability in generation for a Fixed (open rack) PV system at this location.

RESULTS

3,497,716 kWh/Year*

System output may range from 3,227,692 to 3,587,257kWh per year near this location.

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)	Energy Value ($)
January	2.73	195,665	27,863
February	3.67	234,947	33,456
March	4.58	315,951	44,991
April	5.35	348,191	49,582
May	5.78	375,715	53,502
June	6.15	375,841	53,520
July	6.39	395,234	56,281
August	5.95	370,141	52,708
September	4.55	279,992	39,871
October	4.00	264,471	37,661
November	2.74	181,247	25,810
December	2.28	160,321	22,830
Annual	**4.51**	**3,497,716**	**$ 498,075**

Location and Station Identification

Requested Location	875 West Water st, Taunton, MA
Weather Data Source	(TMY2) PROVIDENCE, RI 20 mi
Latitude	41.73° N
Longitude	71.43° W

PV System Specifications *(Residential)*

DC System Size	2626.1 kW
Module Type	Standard
Array Type	Fixed (open rack)
Array Tilt	20°
Array Azimuth	180°
System Losses	14%
Inverter Efficiency	96%
DC to AC Size Ratio	1.1

Economics

Average Cost of Electricity Purchased from Utility	0.14 $/kWh

Performance Metrics

Capacity Factor	15.2%

Caution: Photovoltaic system performance predictions calculated by PVWatts® include many inherent assumptions and uncertainties and do not reflect variations between PV technologies nor site-specific characteristics except as represented by PVWatts® inputs. For example, PV modules with better performance are not differentiated within PVWatts® from lesser performing modules. Both NREL and private companies provide more sophisticated PV modeling tools (such as the System Advisor Model at http://sam.nrel.gov) that allow for more precise and complex modeling of PV systems.

The expected range is based on 30 years of actual weather data at the given location and is intended to provide an indication of the variation you might see. For more information, please refer to this NREL report: The Error Report.

The energy output range is based on analysis of 30 years of historical weather data for nearby , and is intended to provide an indication of the possible interannual variability in generation for a Fixed (open rack) PV system at this location.

RESULTS

96,297 kWh/Year*

System output may range from 88,863 to 98,762kWh per year near this location.

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)	Energy Value ($)
January	2.73	5,387	767
February	3.67	6,468	921
March	4.58	8,699	1,239
April	5.35	9,586	1,365
May	5.78	10,344	1,473
June	6.15	10,347	1,473
July	6.39	10,881	1,549
August	5.95	10,190	1,451
September	4.55	7,709	1,098
October	4.00	7,281	1,037
November	2.74	4,990	711
December	2.28	4,414	629
Annual	**4.51**	**96,296**	**$ 13,713**

Location and Station Identification

Requested Location	875 West Water st, Taunton, MA
Weather Data Source	(TMY2) PROVIDENCE, RI 20 mi
Latitude	41.73° N
Longitude	71.43° W

PV System Specifications *(Residential)*

DC System Size	72.3 kW
Module Type	Standard
Array Type	Fixed (open rack)
Array Tilt	20°
Array Azimuth	180°
System Losses	14%
Inverter Efficiency	96%
DC to AC Size Ratio	1.1

Economics

Average Cost of Electricity Purchased from Utility	0.14 $/kWh

Performance Metrics

Capacity Factor	15.2%

APPENDIX E

Interconnection Data TMLP

TAUNTON MUNICIPAL LIGHTING PLANT

Terms and Conditions For Net Metering Service For Customer-Owned Electric Generating Systems Of Greater Than 60 Kilowatts Up To A Maximum Of 2000 Kilowatts

I. AVAILABILITY

Net metering service is available to generation facilities owned by an existing customer of the Taunton Municipal Lighting Plant ("TMLP") at the location at which such customer currently receives service from TMLP, for the purpose of offsetting all or part of that customer's own electric power requirements from solar, wind, fuel cell or hydroelectric sources ("Facility"). The use of a Facility for providing service to a third party is strictly prohibited. Under no circumstance shall output from the Facility be provided or credited to any third party. The availability of net metering to a customer that owns a Facility ("Customer") is subject to the terms and conditions contained in this tariff and to any General Terms and Conditions as may be adopted by TMLP and as they may be amended from time to time. In its sole discretion, TMLP may limit the cumulative generating capacity of all such Facilities in its service territory and the availability of this service. The DC size of the total system may not exceed Customer's highest demand peak for the twelve month period preceding the date on which Customer signs the Application set forth in Attachment 1 ("Initial Demand Period") or 2,000 kW, whichever is lower.

II. RATES AND CHARGES FOR SERVICE

2.1 Application Fee, Distribution System Impact Review, Billing and Energy Crediting.

2.1.1 Application Fee. Customer shall pay an application fee to TMLP of $500. Upon acceptance of a completed application by TMLP, the application will be placed in a queue of projects. If Customer fails to energize the Facility within 12 months of the Authorization Date the application will be removed from the queue of projects.

2.1.2 Distribution System Impact Review Fee. Customer shall pay an amount to TMLP equal to $3 per kW of nameplate dc capacity of the Facility for a distribution system impact study. If such study costs less than the deposit amount then TMLP shall refund the amount not spent within sixty (60) days of completing the study. If the study costs more than the deposit amount, then TMLP shall promptly bill Customer for the difference, which shall be due and payable upon receipt by Customer.

2.1.3 Costs of Distribution System Upgrades. Customer shall be responsible for the costs needed to modify and/or upgrade TMLP's distribution system to accommodate the Facility as set forth in the distribution system impact review performed by TMLP. TMLP shall bill Customer in advance, for the costs identified in the prior sentence. Customer shall pay the full amount due before construction is scheduled by TMLP. The invoice shall provide a reasonable breakdown of the costs. If Customer fails to pay the amount due within thirty (30) days of TMLP's invoice then the Facility shall be removed from the queue of projects.

2.1.4 Cost or Fee Adjustment Procedures. TMLP will, in writing, advise Customer in advance of any cost increase for work to be performed. Customer shall, within thirty (30) days of TMLP's notice of increase, authorize such increase and make payment in the amount, or TMLP will suspend the work and the Facility shall be removed from the queue of projects.

2.2 Net Metering Billing and Energy Crediting. TMLP shall determine the net electricity produced or consumed by Customer during each billing period, in accordance with TMLP's normal metering practices.

2.2.1. Customer shall pay all costs associated with the design, installation, operation, and maintenance of the Facility on Customer's side of the meter, as well as the meters that are necessary to register Customer's electric consumption, the Facility's electric generation and the net flow of electricity to and from Customer's premises.

2.2.2 If Customer uses more electricity during a billing period than its Facility generates, Customer will be billed for the net electricity supplied by TMLP based on the rate applicable to that Customer's class of service under the applicable TMLP tariff.

2.2.3 If Customer's Facility generates and delivers to TMLP's system more electricity than is consumed by Customer during a billing period, then Customer shall be billed for the same monthly charge(s) as applied to other customers in the same rate class; and shall be credited for the net excess kilowatt-hours generated as applied to the Generation and the Power Cost Adjustment (PCA). For Rate 31 customers the energy credit will be the excess of 300 hours rate and Power Cost Adjustment Clause in M.D.P.U. No. 123 will apply. This Generation and PCA cost credit will appear on the Customer's bill the following billing period.

2.2.4. Payment for Damage to TMLP System. If Customer's Facility causes damage to TMLP's electrical system and/or facilities, Customer shall be responsible for all costs associated with the repair and/or replacement of such facilities or equipment.

III. CONSTRUCTION OF THE FACILITY/TMLP APPROVAL

3.1 General Requirements. Customer may proceed to construct the Facility only after TMLP has received the completed Application for Customer Owned Generation Of Greater Than 60 kW Up To A Maximum Of 2000 kW appearing as Attachment 1 ("Application") and said application has been approved by TMLP. The Application shall be accompanied by three copies of the one-line diagram of the proposed Facility, the Distribution System Impact Review Fee, proof of insurance, and the application fee as specified herein. The one-line diagram submitted by Customer must be stamped by a registered professional engineer. TMLP will not approve any such application if it determines that the Facility could have an adverse impact on TMLP's system or does not or would not comply with the requirements of this tariff.

3.2 Interconnection Requirements. The Facility shall be designed, constructed, operated and maintained in a manner that causes it to meet or exceed all applicable safety and electrical standards, including but not limited to the Massachusetts Building Code, the Massachusetts Department of Public Utilities' regulations, the National Electric Code, the National Electrical Safety Code, IEEE and UL. Customer is responsible for all permits and regulatory approvals necessary for construction of the Facility.

3.3 Operational Requirements. Customer may operate Facility and interconnect with TMLP's system only after the following has occurred:

3.3.1 Municipal Inspection. Upon completing construction, Customer will cause the Facility to be inspected or otherwise certified and/or approved by the local wiring inspector.

3.3.2 Certificate of Completion. The Customer shall return the Certificate of Completion for Customer Owned Generation Of Greater Than 60 kW Up To A Maximum Of 2000 kW appearing as Attachment 2, to TMLP, 55 Weir Street, Taunton, MA 02780.

3.3.3 TMLP Right to Inspection. Within ten (10) business days after the receipt of the Certificate of Completion, TMLP shall, upon reasonable notice, and at a mutually convenient time, conduct an inspection of the Facility to ensure that all equipment has been properly installed, and that all electric connections have been made in accordance with TMLP's requirements including these Terms and Conditions. TMLP has the right to disconnect the Facility in the event of improper installation.

3.3.4 Interconnection Metering/Wiring. Customer shall furnish and have installed, if not already in place, the necessary meter socket and wiring in accordance with all applicable safety and electrical standards. Customer shall have installed a second meter socket and necessary wiring between the output of the Facility and Customer's main electrical service. The meter socket shall be located outside at a location approved by TMLP. Customer shall provide and install a safety disconnect switch **NO MORE THEN FOUR FEET** from TMLP's metering equipment that is accessible by TMLP at all times. An example one-line diagram is attached hereto as Attachment 3.

3.3.5. Safe Operation and Maintenance. Customer shall be solely responsible for constructing, operating, maintaining, and repairing the Facility in a safe manner as set forth in more detail in Section IV of this tariff. TMLP may temporarily disconnect the Facility to facilitate planned or emergency TMLP work. In addition, TMLP may disconnect the Facility from its system at any time that TMLP determines, in its sole discretion, that the safety and reliability of TMLP's system may be compromised by the operation of the Facility.

3.3.6 Meters. TMLP shall furnish, install and own the meters necessary to register Customer's electric consumption, the Facility's electric generation and the net flow of electricity to and from Customer's premises, if such meters are not in place, at Customer's expense.

3.3.7 No Unauthorized Changes to Equipment. Once in operation, Customer shall make no changes or modifications in the equipment, wiring, or the mode of operation without the prior written approval of TMLP and the local wiring inspector. Once in operation, TMLP shall have the right to disconnect the Facility from TMLP's system if at any time TMLP determines in its sole discretion that either (a) the Facility may endanger TMLP personnel, or (b) the continued operation of the Facility may endanger the property of or integrity of TMLP's electric system. The Facility shall remain disconnected until such time as TMLP is satisfied that the condition(s) that caused the problems have been corrected.

3.3.8 Inspection Requirements. Customer will remove the Facility from service and cause inspection of all function parts by a qualified person at least every two years. Customer shall retain all records pertaining such inspection and will make them available for TMLP's review upon request by TMLP.

3.3.9 TMLP Access. TMLP may enter Customer's premises or property (i) to inspect with prior notice at all reasonable hours Customer's protective devices and to read meter; and (ii) to disconnect the interconnection facilities at TMLP's meter or transformer pursuant to Article IV below.

IV. OPERATING REQUIREMENTS

4.1 General Operating Requirements. Customer shall operate and maintain the Facility in accordance with the applicable manufacturer's recommended maintenance schedule. Customer will continue to comply with all applicable laws and requirements after interconnection has occurred. In the event TMLP has reason to believe that Customer's installation may be the source of problems on TMLP's system, TMLP has the right to install monitoring equipment to determine the source of the problems. If the Facility is determined to be the source of the problems, TMLP may require disconnection of the Facility and terminate service under this tariff as set forth in Article VII. The cost of such testing will be paid by TMLP unless TMLP demonstrates that the problem or problems are caused by the Facility or if the test was performed at the request of Customer, in which case Customer shall pay for the cost of such testing.

4.2 No Adverse Effects; Non-interference. TMLP shall notify Customer if there is evidence that the operation of the Facility could cause disruption or deterioration of service to other Customers or if operation of the Facility could cause damage to TMLP's system. The deterioration of service could be, but is not limited to, harmonic injection in excess of IEEE Standard 1547-2003, as well as voltage fluctuations caused by large step changes in loading at the Facility. TMLP and Customer will notify the other of any emergency or hazardous condition or occurrence with its equipment or facilities which could affect safe operation of the other Party's equipment or facilities. Each Party shall use reasonable efforts to provide the other with advance notice of such conditions. Customer will protect itself from normal disturbances propagating through TMLP's system.

4.3 Safe Operations and Maintenance. Customer shall operate, maintain, repair, and inspect, and shall be fully responsible for, the Facility or facilities that it now or hereafter may own. Customer shall be responsible for the maintenance, repair and condition of the Facility on its side of the meter. Customer shall provide equipment on its respective side of the meter that adequately protects TMLP's system, personnel, and other persons from damage and injury.

4.4 Access. TMLP shall have access to the disconnect switch of the Facility at all times.

4.4.1 TMLP and Customer Representatives. TMLP and Customer shall provide and update as necessary the telephone number that can be used at all times to allow either Party to report an emergency.

4.4.2 TMLP Right to Access TMLP-Owned Facilities and Equipment. Customer shall allow TMLP access to TMLP's equipment and TMLP's facilities located on 's or Customer's premises. To the extent that Customer does not own all or any part of the property on which TMLP is required to locate its equipment or facilities to serve the Facility, Customer shall secure and provide in favor of TMLP the necessary rights to obtain access to such equipment or facilities, including easements if the circumstances so require.

4.4.3 Right to Review Information. TMLP shall have the right to review and obtain copies of Customer's operations and maintenance records, logs, or other information such as, unit availability, maintenance outages, circuit breaker operation requiring manual reset, relay targets and unusual events pertaining to the Facility or its interconnection with TMLP's system.

4.5. Disconnection

4.5.1 Temporary Disconnection

4.5.1.1 Emergency Conditions. TMLP shall have the right to immediately and temporarily disconnect the Facility without prior notification in cases where, in the reasonable judgment of TMLP, continuance of such service to Customer is imminently likely to (i) endanger persons or damage property or (ii) cause a material adverse effect on the integrity or security of, or damage to, TMLP's system or to the electric systems of others to which TMLP's system is directly connected. TMLP shall notify Customer promptly of the emergency condition. Customer shall notify TMLP promptly when it becomes aware of an emergency condition that affects the Facility that may reasonably be expected to affect TMLP's system. To the extent information is known, the notification shall describe the emergency condition, the extent of the damage or deficiency, or the expected effect on the operation of both TMLP's and Customer's facilities and operations, its anticipated duration and the necessary corrective action.

4.5.1.2 Routine Maintenance, Construction and Repair. TMLP shall have the right to disconnect the Facility from TMLP's system when necessary for routine maintenance, construction and repairs on TMLP's system. If Customer requests disconnection of the Facility by TMLP, Customer will provide a minimum of seven days notice to TMLP.

4.5.1.3 Forced Outages. During any forced outage, TMLP shall have the right to suspend interconnection service hereunder to effect immediate repairs on TMLP's system; provided, however, TMLP shall use reasonable efforts to provide Customer with prior notice. Where circumstances do not permit such prior notice to Customer, TMLP may interrupt interconnection service hereunder and disconnect the Facility from TMLP's system without such notice.

4.5.1.4 Non-Emergency Adverse Operating Effects. TMLP may disconnect the Facility if the Facility is having an adverse operating effect on TMLP's system or other customers that is not an emergency, and Customer fails to correct such adverse operating effect after written notice has been provided and a maximum of 45 days to correct such adverse operating effect has elapsed.

4.5.1.5 Modification of the Facility. TMLP shall notify Customer if there is evidence of a material modification to the Facility and shall have the right to immediately suspend interconnection service hereunder in cases where such material modification has been implemented without prior written authorization from TMLP.

4.5.1.6 Re-connection. Any curtailment, reduction or disconnection shall continue only for so long as reasonably necessary. Customer and TMLP shall cooperate with each other to restore the Facility and TMLP's system, respectively, to their normal operating state as soon as reasonably practicable following the cessation or remedy of the event that led to the temporary disconnection.

V. LIMITATION OF LIABILITY, INDEMNIFICATION AND INSURANCE

Customer shall indemnify and hold harmless TMLP and its elected officials, officers, employees and agents and each of the personal representatives, successors and assigns of any of the foregoing from and against any and all losses, claims, damages, costs, demands, fines, judgments, penalties, obligations, payments and liabilities, together with any costs and expenses (including without limitation attorneys' fees and out-of-pocket expenses and investigation expenses) incurred in connection with any of the foregoing, resulting from, relating to or arising out of or in connection with: (i) any failure or abnormality in the operation of the Facility or any related equipment; (ii) any failure of Customer to comply with the standards, specifications, or requirements referenced in these terms and conditions (including appendices hereto) which results in abnormal voltages or voltage fluctuations, abnormal changes in the harmonic content of the Facility output, single phasing, or any other abnormality related to the quantity or quality of the power produced by the Facility; (iii) any failure of Customer to duly perform or observe any term, provision, covenant, agreement or condition hereunder to be performed by or on behalf of Customer or (iv) any negligence or intentional misconduct of Customer related to operation of the generating system or any associated equipment or wiring.

TMLP shall not be liable to Customer or any other person for any loss, injury, damage, casualty, fees or penalties, asserted on the basis of any theory, arising from, related to or caused by the construction, installation, operation, maintenance or repair of the Facility, and associated equipment and wiring, except to the extent of its own gross negligence or willful misconduct, but only to the extent permitted by law. Neither by inspection nor non-rejection nor in any other way does TMLP give any warranty, expressed or implied as to the adequacy, safety or other characteristics of any equipment, wiring or devices, installed on Customer's premises, including the Facility. Customer shall maintain sufficient insurance to cover any damage to TMLP's system or its other customers caused by the Facility and shall name TMLP as additional insured. The Customer shall provide TMLP with proof of satisfactory insurance in accordance with Article VI below.

VI. INSURANCE REQUIREMENTS

6.1 General Liability.

6.1(a) In connection with Customer's performance of its duties and obligations hereunder, Customer shall maintain, during the term of the Agreement, commercial general liability insurance with a per occurrence limit of not less than: (i) five million dollars ($5,000,000) for each occurrence and in the aggregate.

6.1(b) Any combination of General Liability and Umbrella/Excess Liability policy limits can be used to satisfy the limit requirements stated above.

6.1(c) The general liability insurance required to be purchased in this Article VI may be purchased for the direct benefit of TMLP and shall respond to third party claims asserted against TMLP (hereinafter known as "Owners Protective Liability"). Should this option be chosen, the requirement of Section 6.2(a) will not apply but the Owners Protective Liability policy will be purchased for the direct benefit of TMLP and TMLP will be designated as the primary and "Named Insured" under the policy.

6.1(d) In the event the Commonwealth of Massachusetts, or any other governmental subdivision thereof subject to the claims limits of the Massachusetts Tort Claims Act, G.L. c. 258 (hereinafter referred to as the "Governmental Entity") is the Customer, any insurance maintained by the Governmental Entity shall contain an endorsement that strictly prohibits the applicable insurance from interposing the claims limits of G.L. c. 258 as a defense in either the adjustment of any claim, or in the defense of any lawsuit directly asserted against the insurer by TMLP. Nothing herein is intended to constitute a waiver or indication of an intent to waive the protections of G.L. c. 258 by the Governmental Entity.

6.2 Insurer Requirements and Endorsements. All required insurance shall be carried by reputable insurers qualified to underwrite insurance in Massachusetts having a Best Rating of "A-". In addition, all insurance shall, (a) include TMLP as an additional insured; (b) contain a severability of interest clause or cross-liability clause; and (c) provide that TMLP shall not incur liability to the insurance carrier for payment of premium for such insurance. In addition, Interconnecting Party shall either: (i) cause all policies of insurance obtained under this Article to require that the insurance carrier provide thirty (30) calendar days' prior written notice to TMLP before insurance provided under such policies may be reduced or cancelled or (ii) within two (2) Business Days of receipt by Interconnecting Party from its insurance carrier, transmit to Buyer by facsimile a copy of all changes in policy conditions.

6.3 Evidence of Insurance. Evidence of the insurance required shall state that coverage provided is primary and is not in excess to or contributing with any insurance or self-insurance maintained by Customer. Customer is responsible for providing TMLP with evidence of insurance on an annual basis.

Prior to TMLP commencing work on the system modifications identified in the distribution system impact review and annually thereafter, Customer shall have its insurer furnish to TMLP certificates of insurance evidencing the insurance coverage required above. Customer shall notify and send to TMLP a certificate of insurance for any policy written on a "claims-made" basis. Customer will maintain extended reporting coverage for three years on all policies written on a "claims-made" basis. In the event that an Owners Protective Liability policy is provided, the original policy shall be provided to TMLP.

6.4 All insurance certificates, statements of self insurance, endorsements, cancellations, terminations, alterations, and material changes of such insurance shall be issued and submitted to the following:

Taunton Municipal Lighting Plant
Attn: Customer Care Administrator
55 Weir Street
Taunton, MA 02780

VII. TERMINATION

Service under this tariff may be terminated under the following conditions.

7.1 By Customer. Customer may terminate service under this tariff by providing sixty (60) days written notice to TMLP. TMLP will provide a final bill for such service with the next bill for service to the location of Customer.

7.2 By TMLP. TMLP may terminate service under this tariff (1) if Customer fails to maintain an average electric demand over a rolling twelve (12) month period that is equal to or greater than eighty (80%) percent of Customer's average electric demand during the Initial Demand Period or (2) in the event that the Facility impairs the operation of TMLP's electric distribution system or service to other customers or materially impairs the local circuit and the Customer does not cure the impairment at its sole expense or (3) if there are any changes in applicable regulations or state law that have a material adverse effect on TMLP's ability to provide such service.

VIII. ASSIGNMENT/TRANSFER OF OWNERSHIP OF THE FACILITY

In the event that a transfer of ownership of the Facility to a new Customer occurs, the new Customer must file a new Application that must be approved by TMLP. Customer will remain the customer for all charges until service under this tariff has been terminated by Customer or TMLP.

IX. ADDITIONAL TERMS AND CONDITIONS

TMLP may amend these Terms and Conditions as it deems necessary or desirable, in its sole discretion.

Attachment 1

Taunton Municipal Lighting Plant
Application for Customer-Owned Generation Greater than 60 kW Up To A Maximum of 2000 kW

Contact Information Date Prepared: ________

Legal Name and address of Customer (or, Company name, if appropriate)

Customer or Company Name: ______________________________ Contact Person:
Mailing _ _ _ _ _ _ _ Address:
City: ____________________ State: __________ Zip Code: ____________________
Telephone (Daytime): ______________________ (Evening): ______________________
Fax Number: ______________ Email Address: ______________
Account Number: ______________ Rate: ______________

Alternative Contact Information (e.g. system installation contractor or coordinating company)

Name:
Mailing Address:
City:____________________State:___________Zip Code:
Telephone (Daytime):____________________(Evening):
Contact Person:______________Fax Number:___________Email Addess:

Net-Metering Facility Information

Address of Facility:
City:____________________State:___________Zip Code:
Type of Generating Unit: Synchronous_______Induction __________Inverter
Manufacturer:____________________Model:
Nameplate Rating: _____(kW) _____(kVAr) ____(Volts) Single ____or Three _____Phase
Prime Mover: Fuel Cell ____Turbine ____ Microturbine _____PV ____ Other ______________
Energy Source: Solar __ Wind __ Hydro __ Fuel Cell ___
For Solar PV provide system total nameplate (DC-STC) rating: ___________(kW)

Estimated Install Date: __________Estimated In-Service Date: ____________

Application Process

I hereby certify that, to the best of my knowledge, all of the information provided in this application is true:

Customer Signature: _________________Title:________Date:

The information provided in this application is complete:

Company Signature: _______________________________Title:________Date:

Net-Metering Facility Technical Detail

Information on components of the net-metering facility that are currently UL Listed:

	Equipment Type	Manufacturer Model	National Standard
1.			
2.			
3.			
4.			
5.			

Total number of generating units in net-metering facility?

Net-metering facility power factor rating:

Maximum adjustable leading power factor?

Maximum adjustable lagging power factor?

Generator Characteristic Data (for all inverter-based machines)

Maximum design fault contribution current? ___________________ Instantaneous _______or RMS?

Harmonics characteristics:

Start-up power requirements:

Generator Characteristic Data (for all rotating machines)

Rotating frequency: ________________________________(rpm) Neutral grounding resistor (If Applicable):

Additional Information for Synchronous Generating Units

Synchronous reactance, Xd: ___________(PU) Transient reactance, X'd: (PU)

Subtransient reactance, X''d: ___________(PU) Negative sequence reactance, X2: (PU)

Zero sequence reactance. Xo: ___________(PU) KVA Base:

Field voltage: ____________(Volts) Field current: __________(Amps)

Interconnection Equipment Technical Detail

Will a transformer be used between the generator and the point of interconnection? Yes No

If a transformer will be used, then Customer shall provide the necessary equipment.

Transformer Data (if applicable, for Customer-Owned Transformer):

Nameplate rating: ________________KVA Single ______or Three ________Phase

Transformer impedance: _____________(%) on a ____________kVA Base

If Three Phase:
Transformer primary: ___________Volts _________Delta _______Wye __________Wye Grounded
Other

Transformer secondary: _________Volts _________Delta _______Wye __________Wye Grounded
Other

Transformer Fuse Data (if applicable, for Customer-Owned Fuse):
Attach copy of fuse manufacture's Minimum Melt and Total Clearing-Current Curves

Manufacture: _________________Type: _____________Size: ______________Speed:

Interconnection Circuit Breaker (if applicable):
Manufacture: _________________Type: __________ Load rating: _________(Amps) Interrupting rating: ______(Amps)

Trip speed:___________(Cycles)

Interconnection Protective Relays (if applicable):

(If microprocessor-controlled)

List of Functions and Adjustable Setpoints for the protective equipment or software:

	Setpoint Function	Minimum	Maximum
1.			
2.			
3.			
4.			
5.			
6.			

(If discrete components)

(Enclose copy of any proposed Time-Overcurrent Coordination Curves)

Manufacturer: _______________Type: _____________Style/Catalog No.: ___________ Proposed Setting:

Manufacturer: _______________Type: _____________Style/Catalog No.: ___________ Proposed Setting:

Manufacturer: _______________Type: ______________Style/Catalog No.: ___________ Proposed Setting:

Manufacturer: _______________Type: _____________Style/Catalog No.: ____________Proposed Setting:

Manufacturer: ______________Type: ____________Style/Catalog No.: __________Proposed Setting:

Manufacturer: ______________Type: ____________Style/Catalog No.: __________Proposed Setting:

Current Transformer Data (if applicable):

(Enclose copy of Manufacturer's Excitation & Ratio Correction Curves)

Manufacturer: ______________Type: _____________Accuracy Class.: __________Ratio Connection:

Manufacturer: ______________Type: _____________Accuracy Class.: __________Ratio Connection:

Potential Transformer Data (if applicable):

Manufacturer: ______________Type: _____________Accuracy Class.: __________Ratio Connection:

Manufacturer: ______________Type: _____________Accuracy Class.: __________Ratio Connection:

General Technical Detail

Enclose 3 copies of site electrical One-Line Diagram showing the configuration of all generating facility equipment, current and potential circuits, and protection and control schemes with a Massachusetts registered professional engineer (PE) stamp.

Enclose 3 copies of any applicable site documentation that indicates the precise physical location of the Facility (e.g., USGS topographic map or other diagram or documentation).

Proposed Location of Protective Interface Equipment on
Property:

(Include Address if Different from Application Address)

____

____

Enclose copy of any applicable site documentation that describes and details the operation of the protection and control schemes.

Enclose copies of applicable schematic drawings for all protection and control circuits, relay current circuits, relay potential circuits, and alarm/monitoring circuits (if applicable).

Please enclose any other information pertinent to this installation.

Approval to Install Facility (For TMLP use only)

Highest demand during 12 month Initial Demand Period is _______________.
Average demand during Initial Demand Period is ________________.

Installation of the Facility is approved contingent upon the terms and conditions of this Agreement, and

agreement to any system modifications, if required

(Are system modifications required? Yes No To be Determined).

TMLP Signature:____
Title: Customer Care Department Manager
Date:______________________

TMLP Signature:____
Title: Transmission and Distribution Department Manager
Date:______________________

TMLP Signature:____
Title: General Manager
Date:______________________

Attachment 2
Taunton Municipal Lighting Plant
Certificate of Completion for Net Metering
For Customer-Owned Generation Of Greater than 60 kW
Up To A Maximum of 2000 kW
Certificate of Completion

Installation Information

Interconnecting Customer (Print):
Title:____
Mailing Address:
Location of Facility (if different from above):
City: ____State: ______________ Zip Code:
Telephone (Daytime):____(Evening):
Facsimile Number: ____E-Mail Address:
Account # (required - on bill) ________________Meter # (required – on bill)___________

Electrician or Electrical Installation Contractor:

Business Name: ____Contact Name (Print)
Mailing Address:
City: ____State: _________ Zip Code:
Telephone (Daytime):____(Evening):
Facsimile Number:____ E-Mail Address:
License number:____

TMLP Date of Installation Approval: _______________ Signature:__________________

Inspection:

TMLP must receive a completed inspection certificate from the local wiring inspector.

Attachment 2
Taunton Municipal Lighting Plant
Certificate of Completion for Net Metering For Customer-Owned Generation Of Greater than 60 kW Up To A Maximum of 2000 kW
Certificate of Completion
(Continued)

As a condition of interconnection you are required to send by USPS mail or Fax a copy of this form along with a copy of the signed electrical permit to:

TMLP
Attn: Administrator – Customer
Care & Communications
PO Box 870
Taunton, MA 02780

Received by TMLP__________________

Date & Initial ________________________

Attachment 3
Taunton Municipal Lighting Plant
Example One-Line Diagram