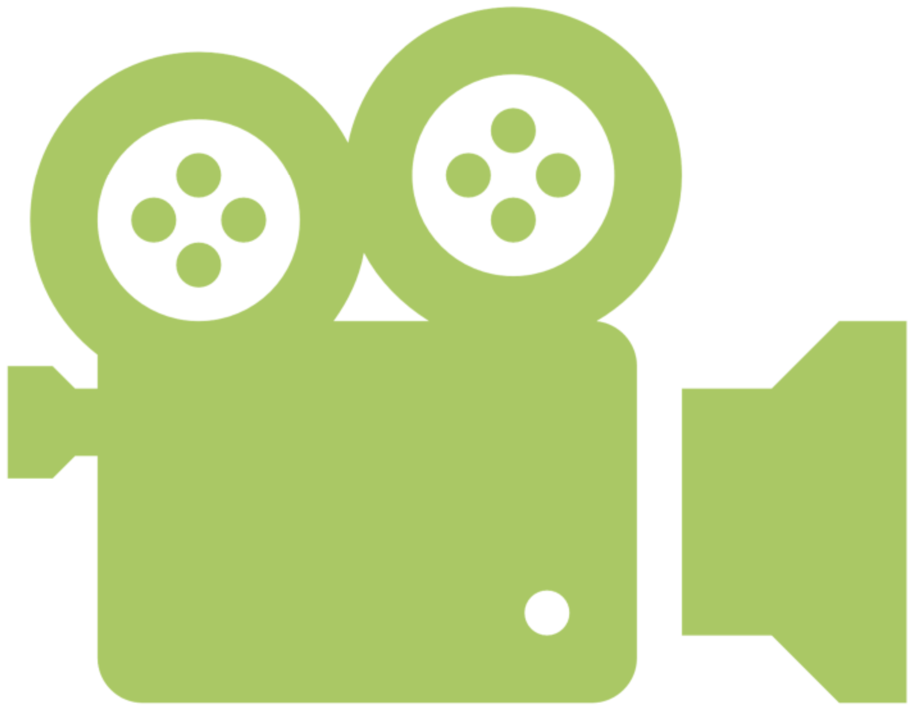
Recording



This meeting is being recorded (both audio and video)

If you do not consent to being recorded, please let the meeting moderator know ASAP and we will facilitate your participation in another way or adjust our procedure.

Thank You to Our Sponsor!

Better Plants
U.S. DEPARTMENT OF ENERGY

Today’s Trainers

Richard Jackson-Gistelli
SEM Coach

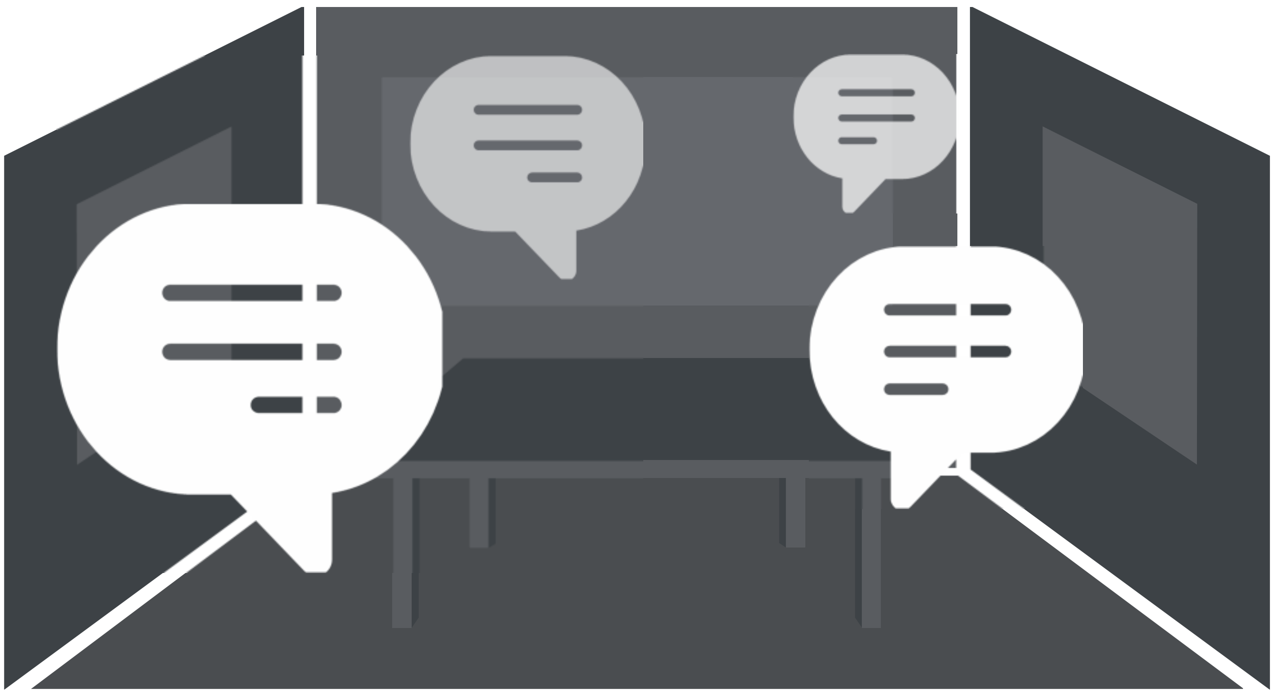
CascadeEnergy

Eric Wahlberg
(aka Eric Clapton)

WasteWater Technology TRAINERS

Thank You to Our Participants!

Introductions

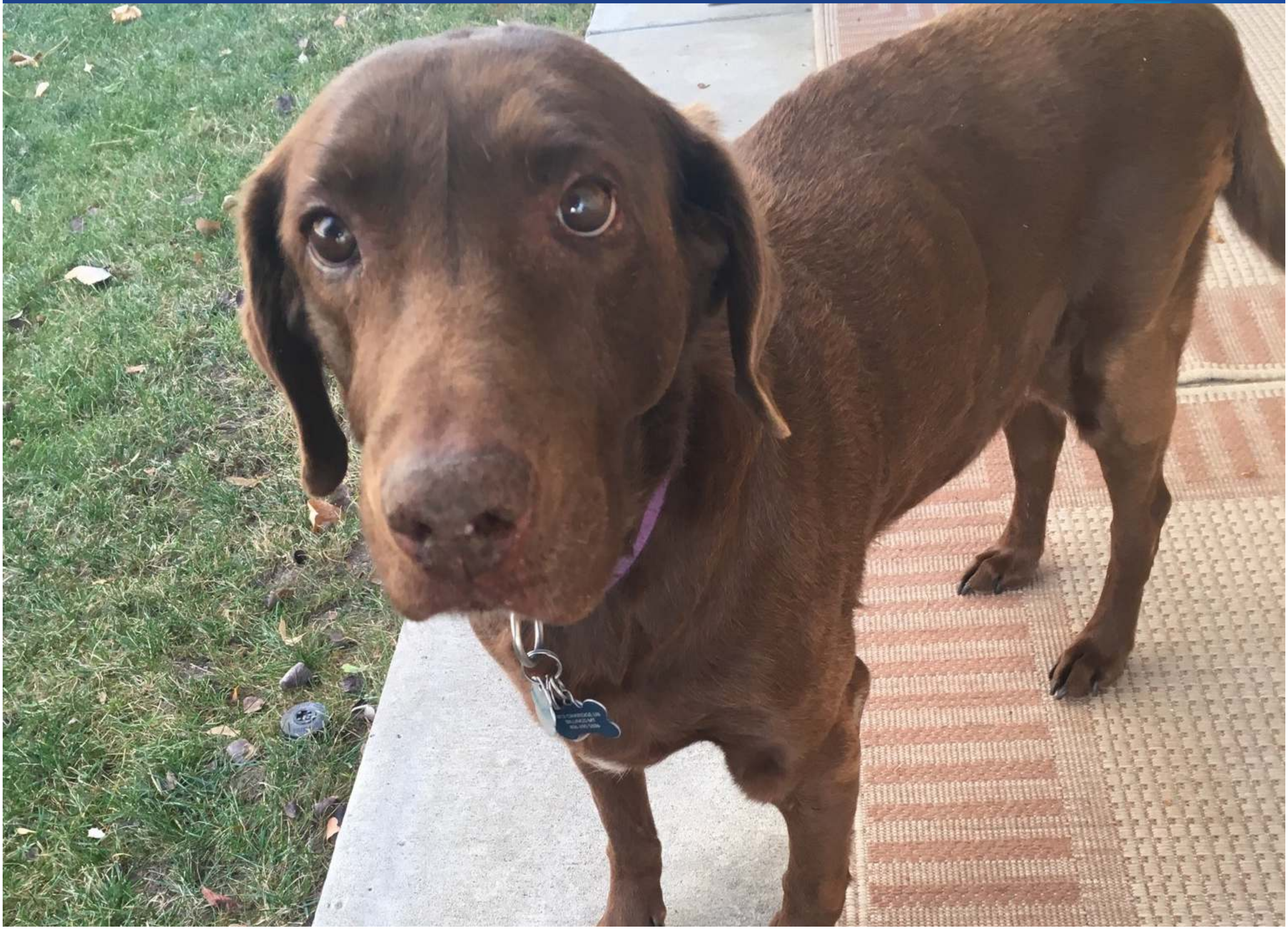


- We want to know you!!!
- 1. Please introduce yourself and tell us who is here from your site.
- 2. What is one thing you want to get out of this cohort today?

VIRTUAL WASTEWATER INPLT SESSION 1

Day 1: Introduction to Wastewater Energy Optimization

A95



F
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199
MPH
MPG
100
50
0
PRIUS

Training Schedule Overview

Sessions 1 & 2

- Wastewater Energy Basics
- Intro to Wastewater Tools
- Process Energy Conservation
- Pumping Systems
- W3 Systems
- Follow the BOD

Sessions 3, 4, & 5

- More Energy Basics
- Headworks
- Primary Clarifiers
- Aeration Energy
- Sludge Quality & SRT

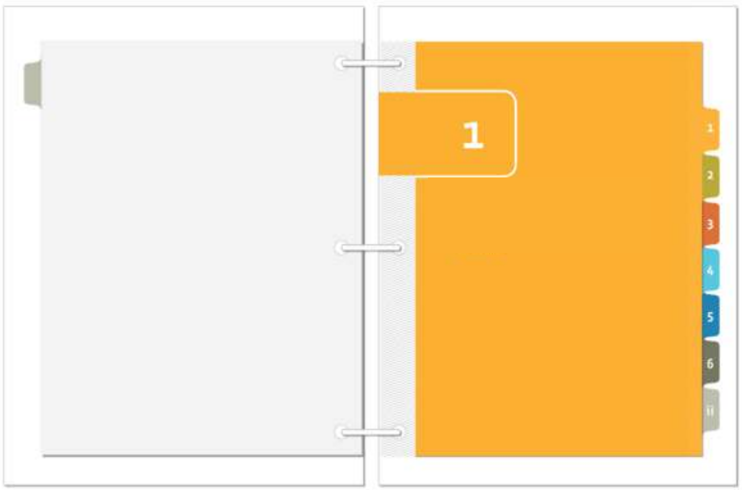
Sessions 6, 7, & 8

- Even More Energy Basics
- RAS Flow Optimization
- Thickening, Digestion, and Dewatering
- Ancillary Systems
- Fans and Odor Control
- Disinfection

Today's Agenda

	Welcome and Introductions
	Plant Process Energy Conservation
	Break
	Plant Energy Basics
	WW Efficiency – The Cheat Sheet
	W3 Systems & The DIY W3 Walkthrough
	Wrap-up
	Done

Supporting Materials



PARTICIPANT BINDER WORKBOOK

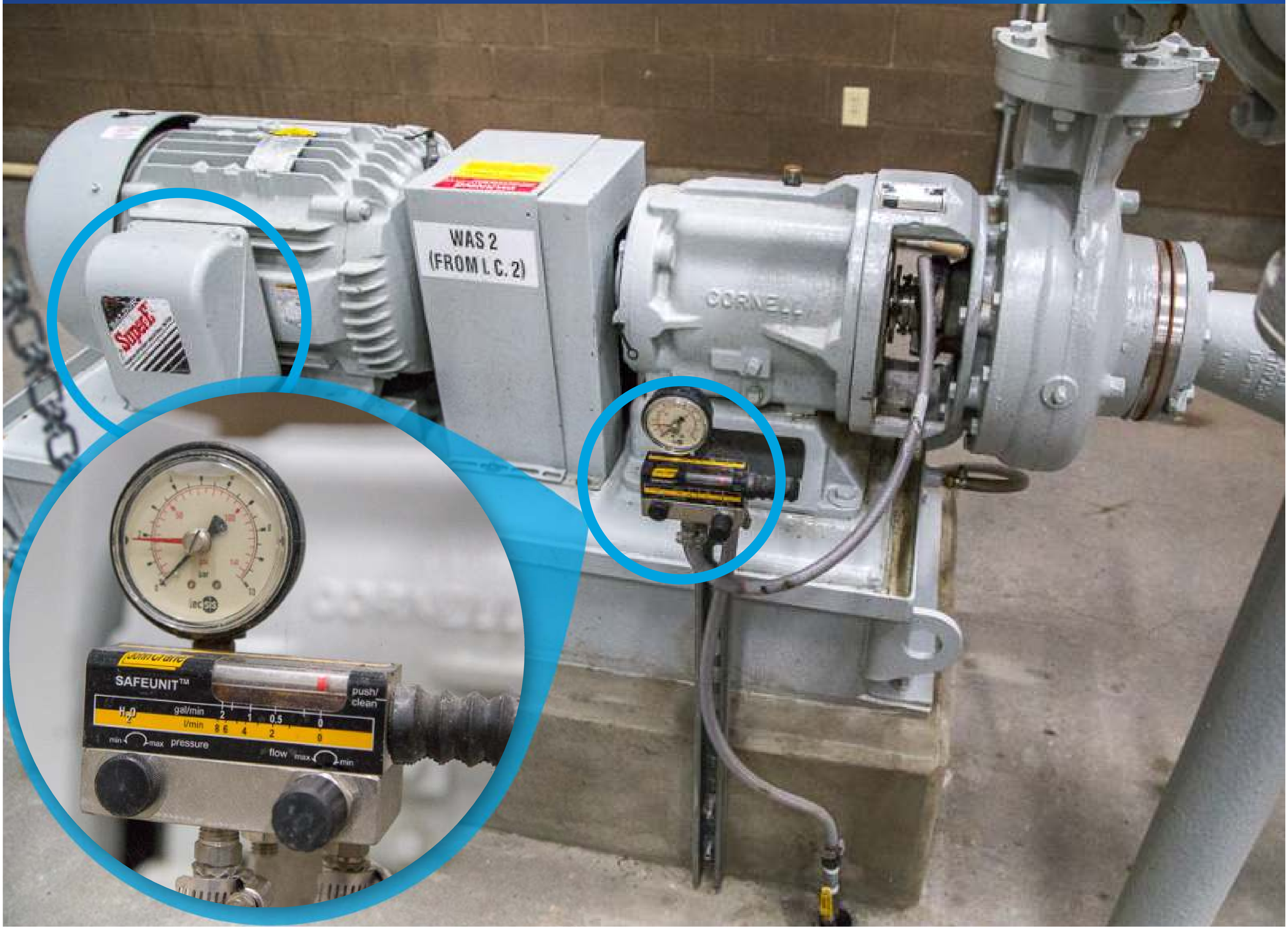
TOOLS

OPPORTUNITY REGISTER & THE TREASURE HUNT

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Treasure Hunts


TASKMASTER
ACTIVATED SLUDGE


WAS 2
(FROM L.C. 2)
CORNELL
SAFEUNIT™
push/
clean
H2O
gal/min
l/min
min
max
pressure
flow

Introduction to the Opportunity Register

2	Opportunity #	Opportunity Name	Description	Location	System*	Submitted By
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						

ERIC

Moving from **Stagnation** to **Continuous Improvement**

"It's only boring until you learn about it. Knowledge makes things interesting."

Kang, Olmstead and Allbaugh, *WET*, (DEC/2010)

1. Commitment to saving energy throughout organization
2. Energy generation
3. Process energy conservation
4. Assess and refine

Four steps to energy self-sufficiency

A dual-vane control blower can increase turndown capability. Tetra Tech

A road map for U.S. wastewater treatment plants

S. Joh Kang, Kevin P. Olmstead, and Thomas A. Allbaugh

Very Different Than Energy Conservation

1. Commitment to saving energy throughout organization
2. Energy generation
3. **Process energy conservation**
4. Assess and refine

Four steps to energy self-sufficiency

A dual-vane control blower can increase turndown capability. Tetra Tech

A road map for U.S. wastewater treatment plants

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Process Energy Conservation—Seven Focal Points

1. Primary Clarifiers
2. Reduce SRT
3. Denitrify
4. Increase Equipment Turndown Capability
5. Create Swing-zones
6. Side-stream Treatment
7. Combined Heat and Power Cash-back Incentives

Four steps to energy self-sufficiency

A dual-vane control blower can increase turndown capability. Tetra Tech

A road map for U.S. wastewater treatment plants

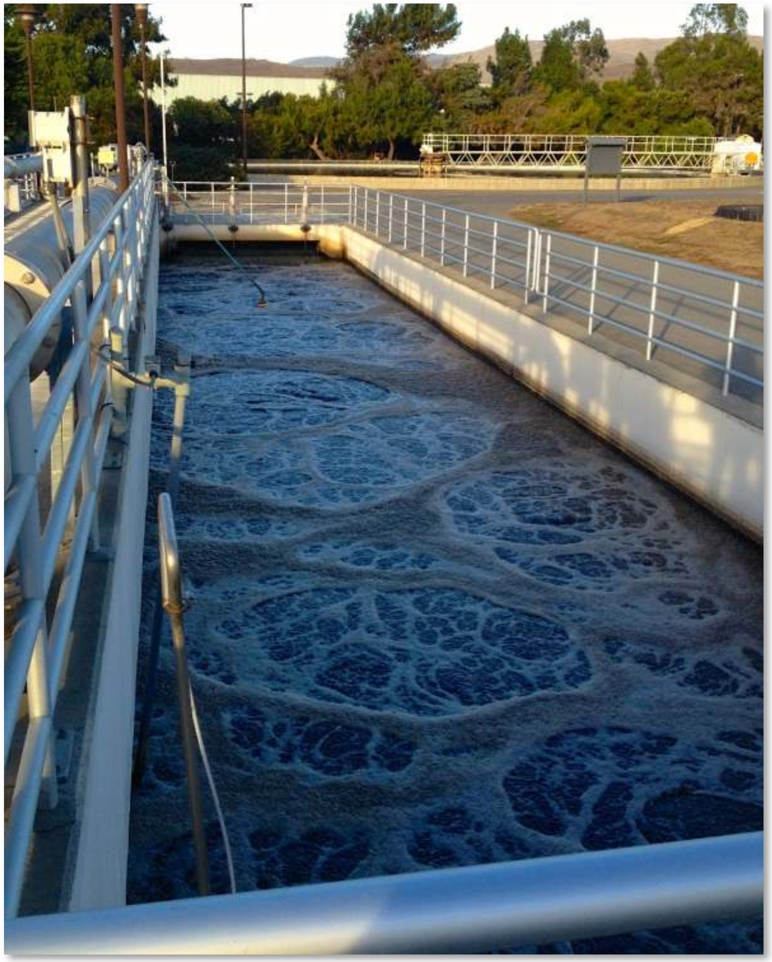
S. Joh Kang, Kevin P. Olmstead, and Thomas A. Allbaugh

Primary Clarifiers—On the Agenda

1. Add if not existing
2. Maintain and document maximum performance
3. Chemically enhanced primary treatment (CEPT)

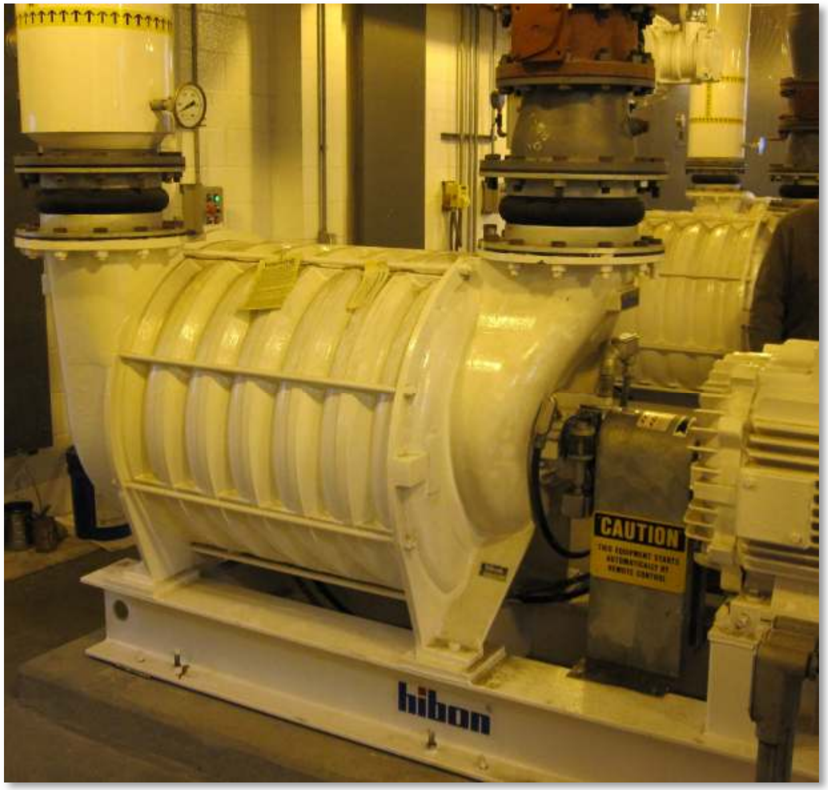
Reduce SRT—On the Agenda

1. Why SRT control is so important
2. Setting SRT_{TARGET}
   a. Meet effluent ammonia requirement or goal
   b. Maximize sludge quality
   c. Minimum that meets a. and b.



Equipment Turndown—On the Agenda

1. What's the right DO setpoint in aeration basins?
2. What's the right RAS flow rate?

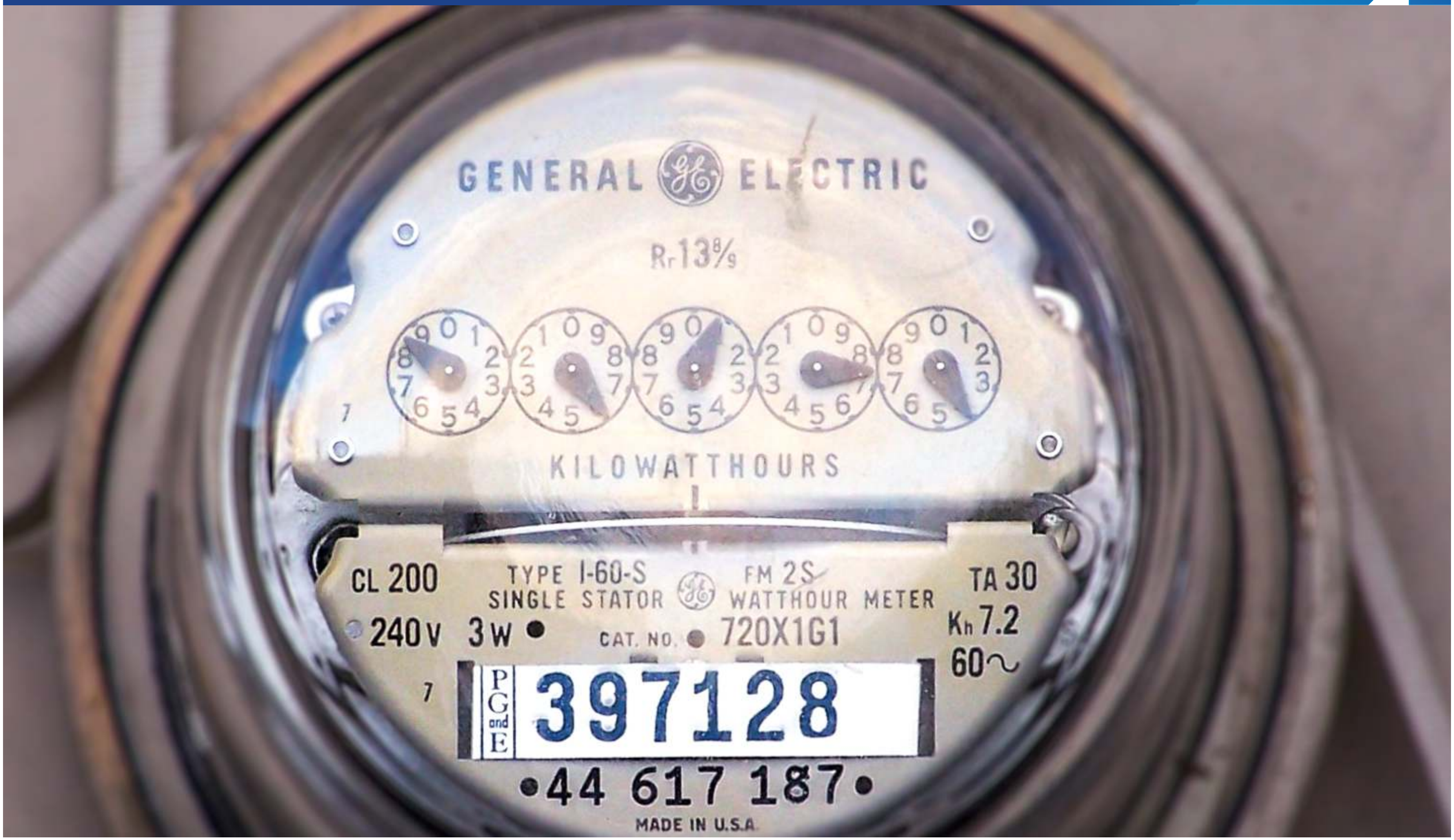


Next Session: Can't Generate Energy Without Anaerobic Digestion

1. Commitment to saving energy throughout organization
2. **Energy generation**
3. Process energy conservation
4. Assess and refine

WASTEWATER PLANT ENERGY BASICS AND KPIS

Plant Energy 101



Reading Your Electricity Bill

ACME ELECTRIC

February 2019

Account ID	0004 1234-56789 8
Billing Dates	12/31/2018- 1/31/2019 32 days of service

Invoice Number	**123456789**
Current Charges	**$29,760.80**
Due By	**2/15/2019**

METER # ABC123456, Schedule 81 Secondary

Service Description	
Basic Charge	560.00
System Usage Charge	593.85
Off-Peak Usage of 195446.000 kWh x $0.0335	6,547.44
On-Peak Usage of 295347.000 kWh x $0.0504	14,885.49
Demand Charge of 932.000 kW x $1.9500	1,817.40
Transmission Charge of 932.000 kW x $0.910	848.12
Distribution Facility Capacity Charge of 1017.00 kW x $2.0600	2,095.00
	$27,347.32
Taxes and Adjustments	
City Tax (1.5%)	410.21
Public Purpose Charge (3%)	820.42
108 Regulatory Adjustments	29.47
115 Energy Efficiency Funding	1,153.38
	$2,413.48

Period Ending	Avg Daily Temp	Avg kWh per day	Avg Cost per day
1/31/2019	71.5	15338	930.03
1/31/2018	73.1	15021	889.25

kWh use

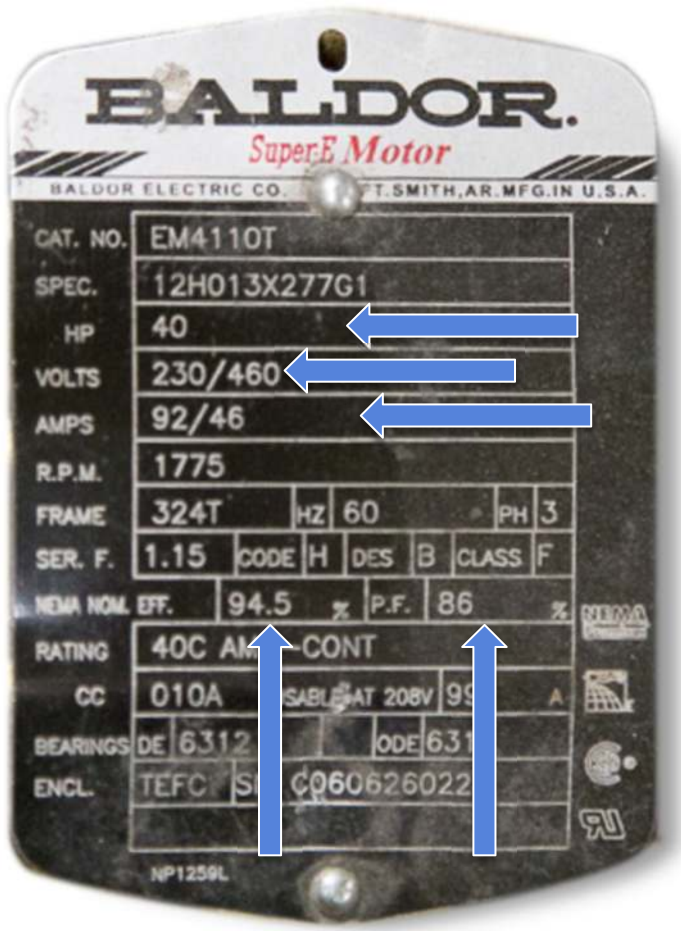
kW demand

Units of Measure

POWER
(demand)
kW

ENERGY
(consumption)
kWh

Motor Nameplates



Estimating Power

Estimating from Motor HP and Load Factor		
HP	=	Motor HP from the nameplate (Motor horsepower)
Load Factor	=	Estimated capacity/loading (0-100%)
Motor Efficiency	=	Motor efficiency rating from the nameplate

Estimating Power

Estimating from Motor HP and Load Factor

$$\textbf{Power (kW)} = \frac{0.746 * HP * \text{Load Factor}}{\text{Motor Efficiency }\%}$$

However, a simpler equation can be used for an estimate

$$\textbf{Power (kW)} = HP \times 0.75$$

Estimating Energy Cost

1

POWER
(kW)

2

HOURS
of operation

3

RATE
per kWh
(kilowatt-hour)

kWh = kW*Operating Hours

Cost ($) = kWh*$/kWh

Electricity Example

Power (kW)

= 0.746 * HP * Load Factor / Motor Efficiency %

= (0.746 * 40 * .80)/.945% = **25 kW**

Energy (kWh)

= kW * Annual Operating Hours

= 25 kW * 7,303 = **184,480 kWh**

Annual Energy Cost ($)

= kWh * $/kWh

= 184,480 kWh * $0.05 = **$9,224**

Sample Rates (cents/kWh) Across the US

Area	Industrial June 2016	All Sectors June 2016
New England	11.84	15.95
Middle Atlantic	7.18	12.92
East North Central	6.92	9.98
West North Central	7.77	10.47
South Atlantic	6.65	10.04
East South Central	6.06	9.19
West South Central	5.23	8.18
Mountain	6.79	9.90
Pacific Contiguous	10.12	13.59
Alaska & Hawaii	19.44	21.97
U.S. Total	**7.03**	**10.53**

July 2019

US Ind. Avg. 7.18

MA & RI Ind. 14.41

Idaho 6.69

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Period Ending	Avg Daily Temp	Avg kWh per day	Avg Cost per day
1/31/2019	71.5	15338	930.03
1/31/2018	73.1	15021	889.25

ACTIVITY SHEET – ENERGY BASICS EXERCISE DAY 1

a. How many kilowatt-hours of electricity did this facility use during this billing cycle? (January 2019)

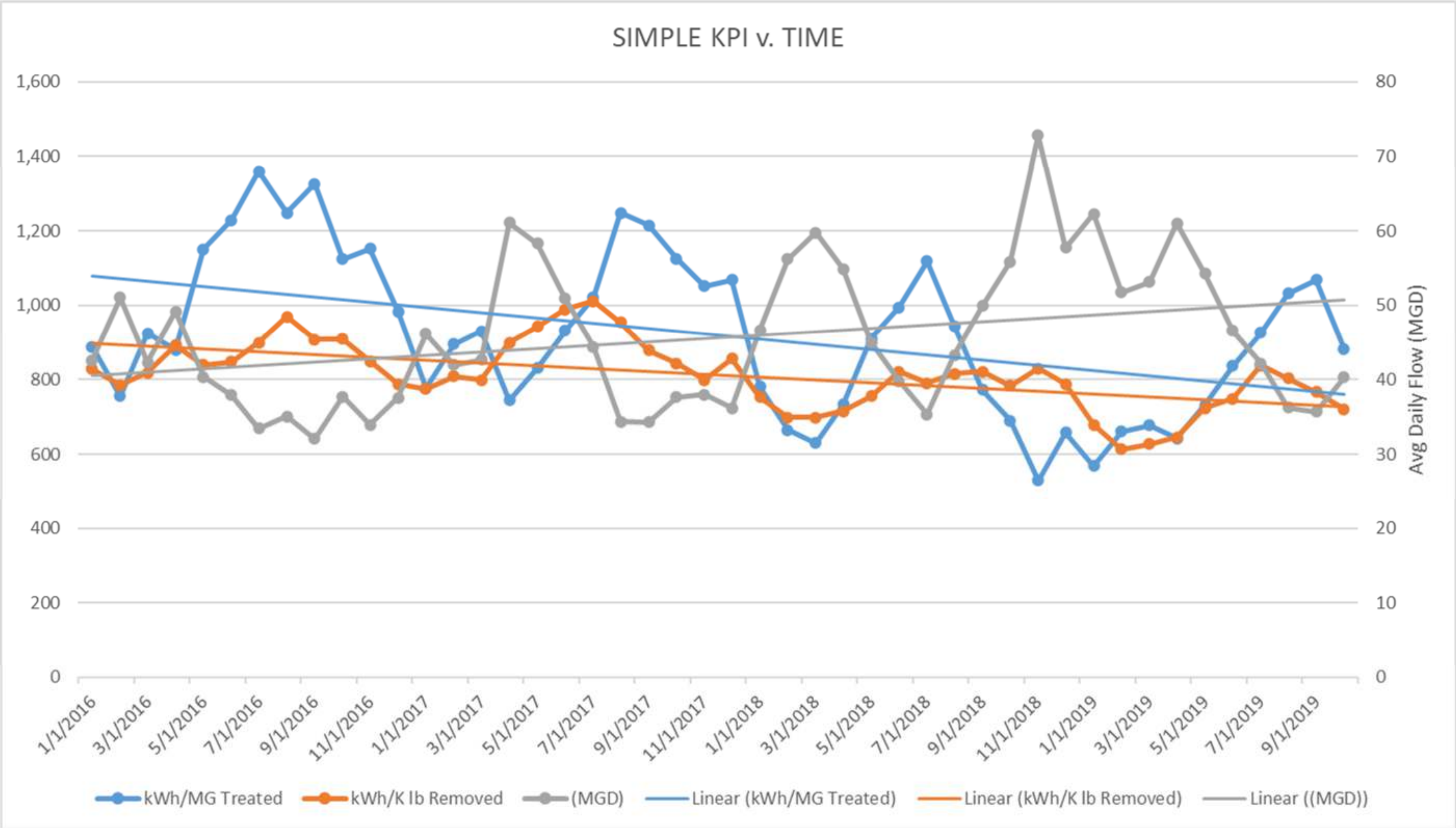
b. How much cheaper is their off-peak rate than their on-peak rate?

c. The plant runs two of its four 150 hp blowers all the time in the winter. How many kW of power do the two blowers draw?

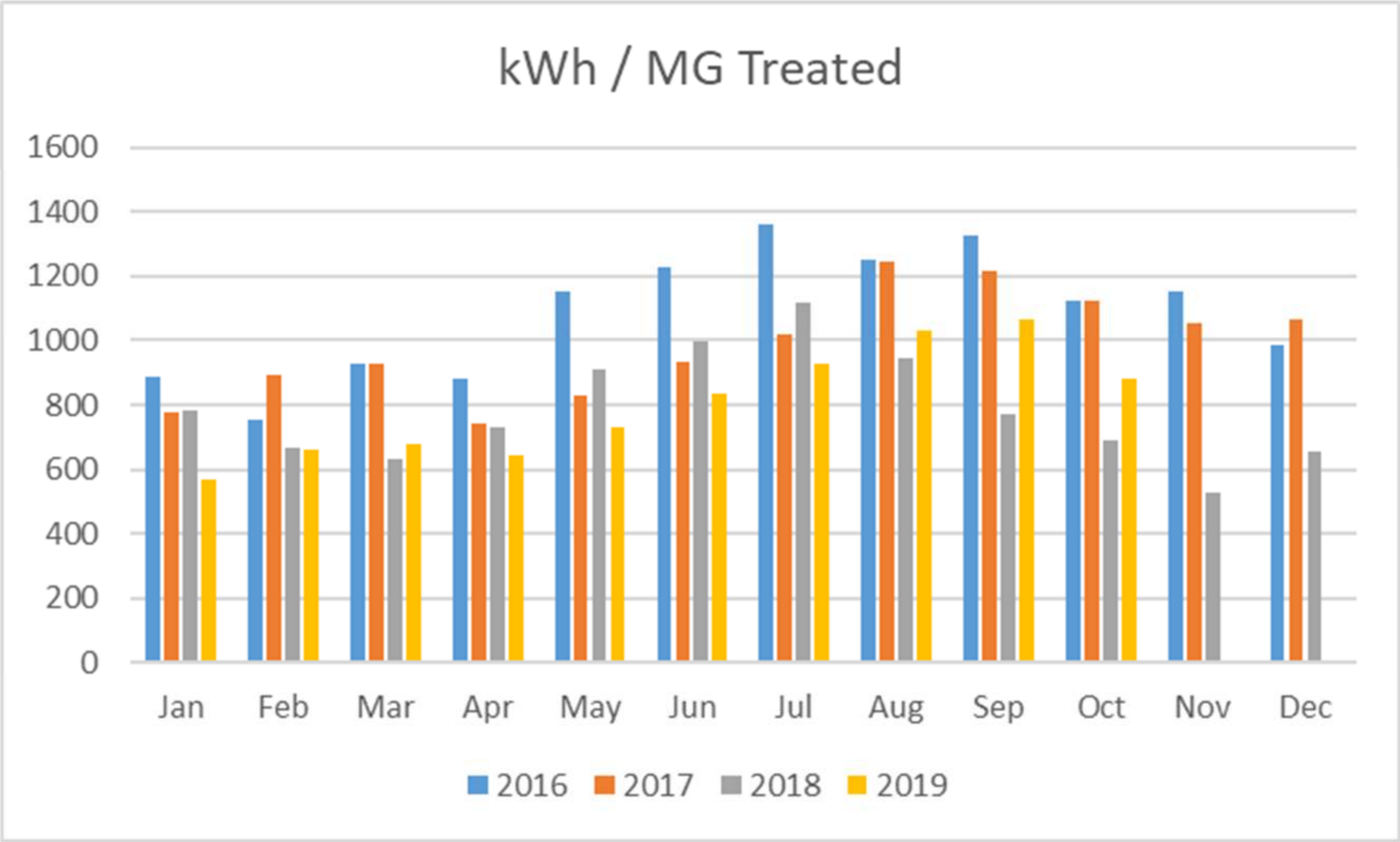
d. How many kWh do the two blowers consume on average every day?

e. From the info above, what is the average whole-plant benchmark in kilowatt-hours per million gallons treated?

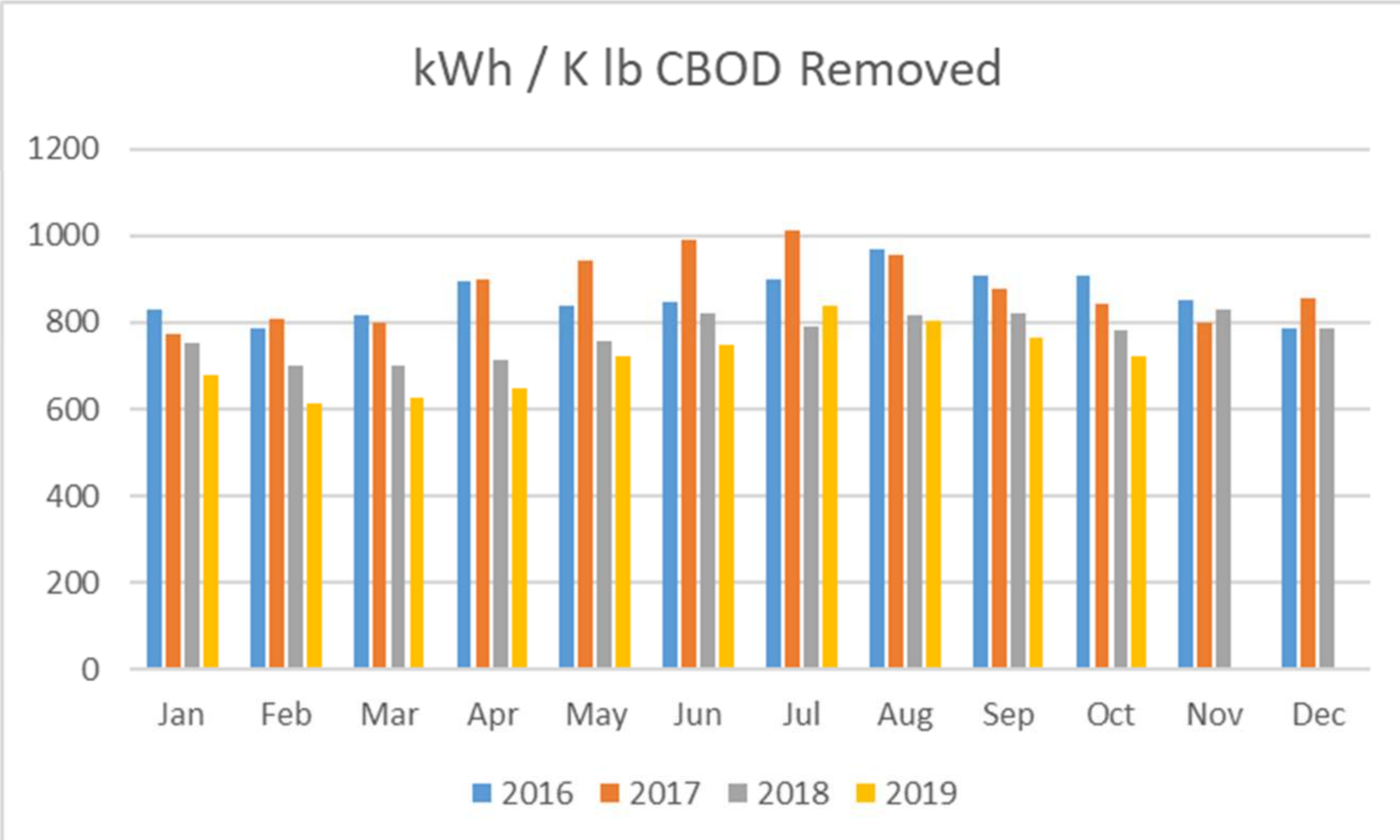
Simple KPIs


SIMPLE KPI v. TIME
1,600
1,400
1,200
1,000
800
600
400
200
0
80
70
60
50
40
30
20
10
0
Avg Daily Flow (MGD)
1/1/2016
3/1/2016
5/1/2016
7/1/2016
9/1/2016
11/1/2016
1/1/2017
3/1/2017
5/1/2017
7/1/2017
9/1/2017
11/1/2017
1/1/2018
3/1/2018
5/1/2018
7/1/2018
9/1/2018
11/1/2018
1/1/2019
3/1/2019
5/1/2019
7/1/2019
9/1/2019
kWh/MG Treated
kWh/K lb Removed
(MGD)
Linear (kWh/MG Treated)
Linear (kWh/K lb Removed)
Linear ((MGD))

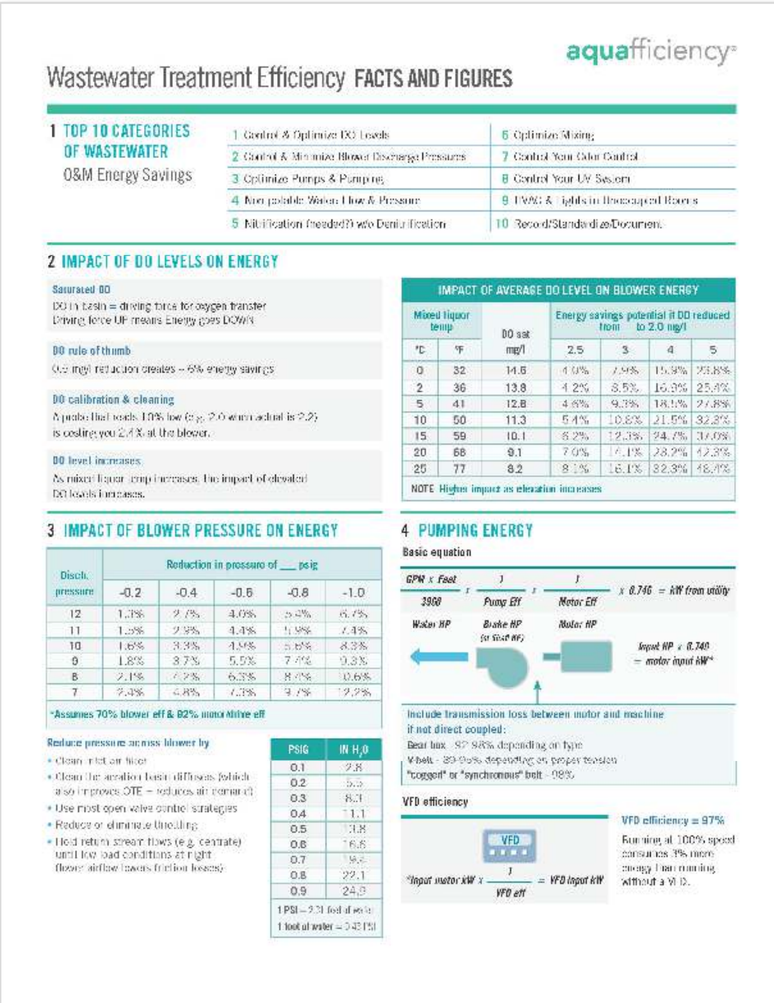
Year over Year KPIs



Year over Year KPIs



WW Energy Efficiency Cheat Sheet



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Wastewater Treatment Efficiency FACTS AND FIGURES

1 TOP 10 CATEGORIES OF WASTEWATER O&M Energy Savings

1 Control & Optimize DO Levels
2 Control & Minimize Blower Discharge Pressures
3 Optimize Pumps & Pumping
4 Non-potable Water Flow & Pressure
5 Nitrification (needed?) w/o Denitrification
6 Optimize Mixing
7 Control Your Odor Control
8 Control Your UV System
9 HVAC & Lights in Unoccupied Rooms
10 Record/Standardize/Document

2 IMPACT OF DO LEVELS ON ENERGY

Saturated DO
DO in basin = driving force for oxygen transfer
Driving force UP means Energy goes DOWN

DO rule of thumb
0.5 mg/l reduction creates ~ 6% energy savings

DO calibration & cleaning
A probe that reads 10% low (e.g. 2.0 when actual is 2.2) is costing you 2.4% at the blower.

DO level increases
As mixed liquor temp increases, the impact of elevated DO levels increases.

IMPACT OF AVERAGE DO LEVEL ON BLOWER ENERGY

Mixed liquor temp		DO sat	Energy savings potential if DO reduced from ___ to 2.0 mg/l			
°C	°F	mg/l	2.5	3	4	5
0	32	14.6	4.0%	7.9%	15.9%	23.8%
2	36	13.8	4.2%	8.5%	16.9%	25.4%
5	41	12.8	4.6%	9.3%	18.5%	27.8%
10	50	11.3	5.4%	10.8%	21.5%	32.3%
15	59	10.1	6.2%	12.3%	24.7%	37.0%
20	68	9.1	7.0%	14.1%	28.2%	42.3%
25	77	8.2	8.1%	16.1%	32.3%	48.4%

NOTE Higher impact as elevation increases

3 IMPACT OF BLOWER PRESSURE ON ENERGY

Disch. pressure	Reduction in pressure of ___ psig				
	-0.2	-0.4	-0.6	-0.8	-1.0
12	1.3%	2.7%	4.0%	5.4%	6.7%
11	1.5%	2.9%	4.4%	5.9%	7.4%
10	1.6%	3.3%	4.9%	6.6%	8.3%
9	1.8%	3.7%	5.5%	7.4%	9.3%
8	2.1%	4.2%	6.3%	8.4%	10.6%
7	2.4%	4.8%	7.3%	9.7%	12.2%

*Assumes 70% blower eff & 92% motor/drive eff

Reduce pressure across blower by
- Clean inlet air filter
- Clean the aeration basin diffusers (which also improves OTE – reduces air demand)
- Use most open valve control strategies
- Reduce or eliminate throttling
- Hold return stream flows (e.g. centrate) until low load conditions at night (lower airflow lowers friction losses)

PSIG	IN H_2O
0.1	2.8
0.2	5.5
0.3	8.3
0.4	11.1
0.5	13.8
0.6	16.6
0.7	19.4
0.8	22.1
0.9	24.9

1 PSI = 2.31 feet of water
1 foot of water = 0.43 PSI

4 PUMPING ENERGY

Basic equation

$$\frac{GPM \times Feet}{3960} \times \frac{1}{Pump\ Eff} \times \frac{1}{Motor\ Eff} \times 0.746 = kW\ from\ utility$$

Water HP — Brake HP (or Shaft HP) — Motor HP

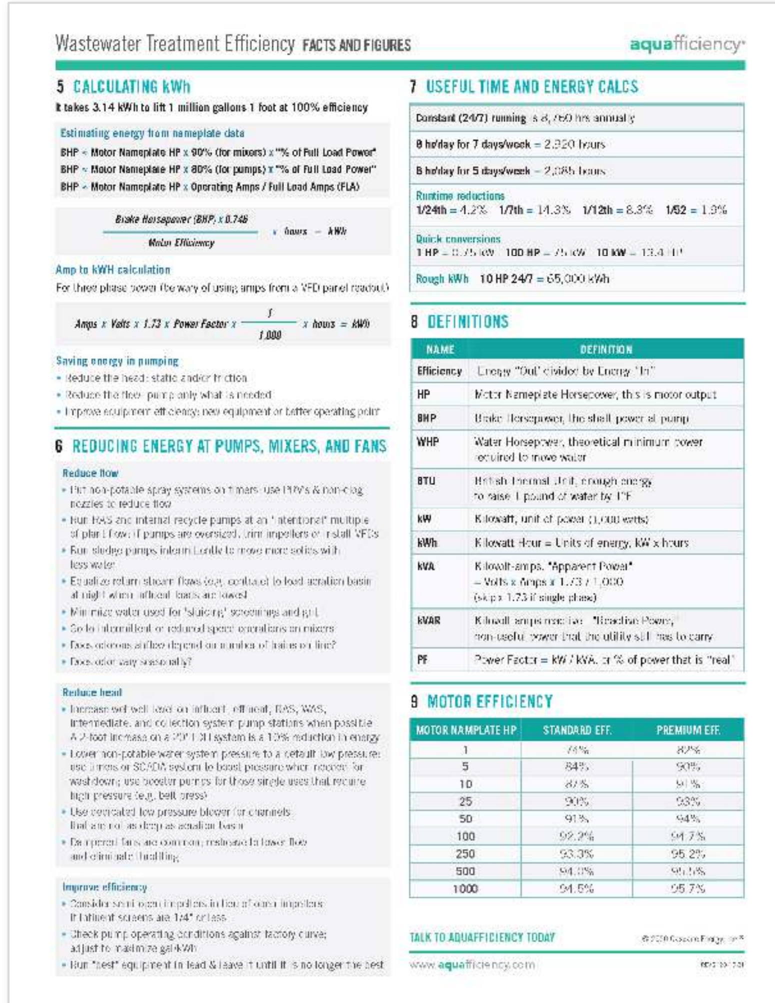
Input HP × 0.746 = motor input kW*

Include transmission loss between motor and machine if not direct coupled:
Gear box - 92-98% depending on type
V-belt - 89-95% depending on proper tension
"cogged" or "synchronous" belt - 98%

VFD efficiency

$$*Input\ motor\ kW \times \frac{1}{VFD\ eff} = VFD\ input\ kW$$

VFD efficiency = 97%
Running at 100% speed consumes 3% more energy than running without a VFD.



Wastewater Treatment Efficiency FACTS AND FIGURES

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5 CALCULATING kWh

It takes 3.14 kWh to lift 1 million gallons 1 foot at 100% efficiency

Estimating energy from nameplate data
BHP ≈ Motor Nameplate HP x 90% (for mixers) x "% of Full Load Power"
BHP ≈ Motor Nameplate HP x 80% (for pumps) x "% of Full Load Power"
BHP ≈ Motor Nameplate HP x Operating Amps / Full Load Amps (FLA)

$$\frac{Brake\ Horsepower\ (BHP) \times 0.746}{Motor\ Efficiency} \times hours = kWh$$

Amp to kWH calculation
For three phase power (the way of using amps from a VFD panel readout)

$$Amps \times Volts \times 1.73 \times Power\ Factor \times \frac{1}{1{,}000} \times hours = kWh$$

Saving energy in pumping
- Reduce the head: static and/or friction
- Reduce the flow: pump only what is needed
- Improve equipment efficiency: new equipment or better operating point

6 REDUCING ENERGY AT PUMPS, MIXERS, AND FANS

Reduce flow
- Put non-potable spray systems on timers; use PRVs & non-clog nozzles to reduce flow
- Run RAS and internal recycle pumps at an "intentional" multiple of plant flow; if pumps are oversized, trim impellers or install VFDs
- Run sludge pumps intermittently to move more solids with less water
- Equalize return stream flows (e.g. centrate) to load aeration basin at night when influent loads are lowest
- Minimize water used for 'sluicing' screenings and grit
- Go to intermittent or reduced speed operations on mixers
- Does odorous airflow depend on number of trains on line?
- Does odor vary seasonally?

Reduce head
- Increase wet well level on influent, effluent, RAS, WAS, intermediate, and collection system pump stations when possible. A 2-foot increase on a 20' TDH system is a 10% reduction in energy
- Lower non-potable water system pressure to a default low pressure; use timers or SCADA system to boost pressure when needed for washdown; use booster pumps for those single uses that require high pressure (e.g. belt press)
- Use dedicated low pressure blower for channels that are not as deep as aeration basin
- Dampered fans are common; resheave to lower flow and eliminate throttling

Improve efficiency
- Consider semi-open impellers in lieu of open impellers if influent screens are 1/4" or less
- Check pump operating conditions against factory curve; adjust to maximize gal/kWh
- Run "best" equipment in lead & leave it until it is no longer the best

7 USEFUL TIME AND ENERGY CALCS

Constant (24/7) running is 8,760 hrs annually
8 hr/day for 7 days/week = 2,920 hours
8 hr/day for 5 days/week = 2,085 hours
Runtime reductions
1/24th = 4.2% 1/7th = 14.3% 1/12th = 8.3% 1/52 = 1.9%
Quick conversions
1 HP = 0.75 kW 100 HP = 75 kW 10 kW = 13.4 HP
Rough kWh 10 HP 24/7 = 65,000 kWh

8 DEFINITIONS

NAME	DEFINITION
Efficiency	Energy "Out" divided by Energy "In"
HP	Motor Nameplate Horsepower, this is motor output
BHP	Brake Horsepower, the shaft power at pump
WHP	Water Horsepower, theoretical minimum power required to move water
BTU	British Thermal Unit, enough energy to raise 1 pound of water by 1°F
kW	Kilowatt, unit of power (1,000 watts)
kWh	Kilowatt Hour = Units of energy, kW x hours
kVA	Kilovolt-amps, "Apparent Power" = Volts x Amps x 1.73 / 1,000 (skip x 1.73 if single phase)
kVAR	Kilovolt-amps reactive, "Reactive Power," non-useful power that the utility still has to carry
PF	Power Factor = kW / kVA, or % of power that is "real"

9 MOTOR EFFICIENCY

MOTOR NAMPLATE HP	STANDARD EFF.	PREMIUM EFF.
1	74%	82%
5	84%	90%
10	87%	91%
25	90%	93%
50	91%	94%
100	92.2%	94.7%
250	93.3%	95.2%
500	94.0%	95.5%
1000	94.5%	95.7%

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U.S. DEPARTMENT OF ENERGY

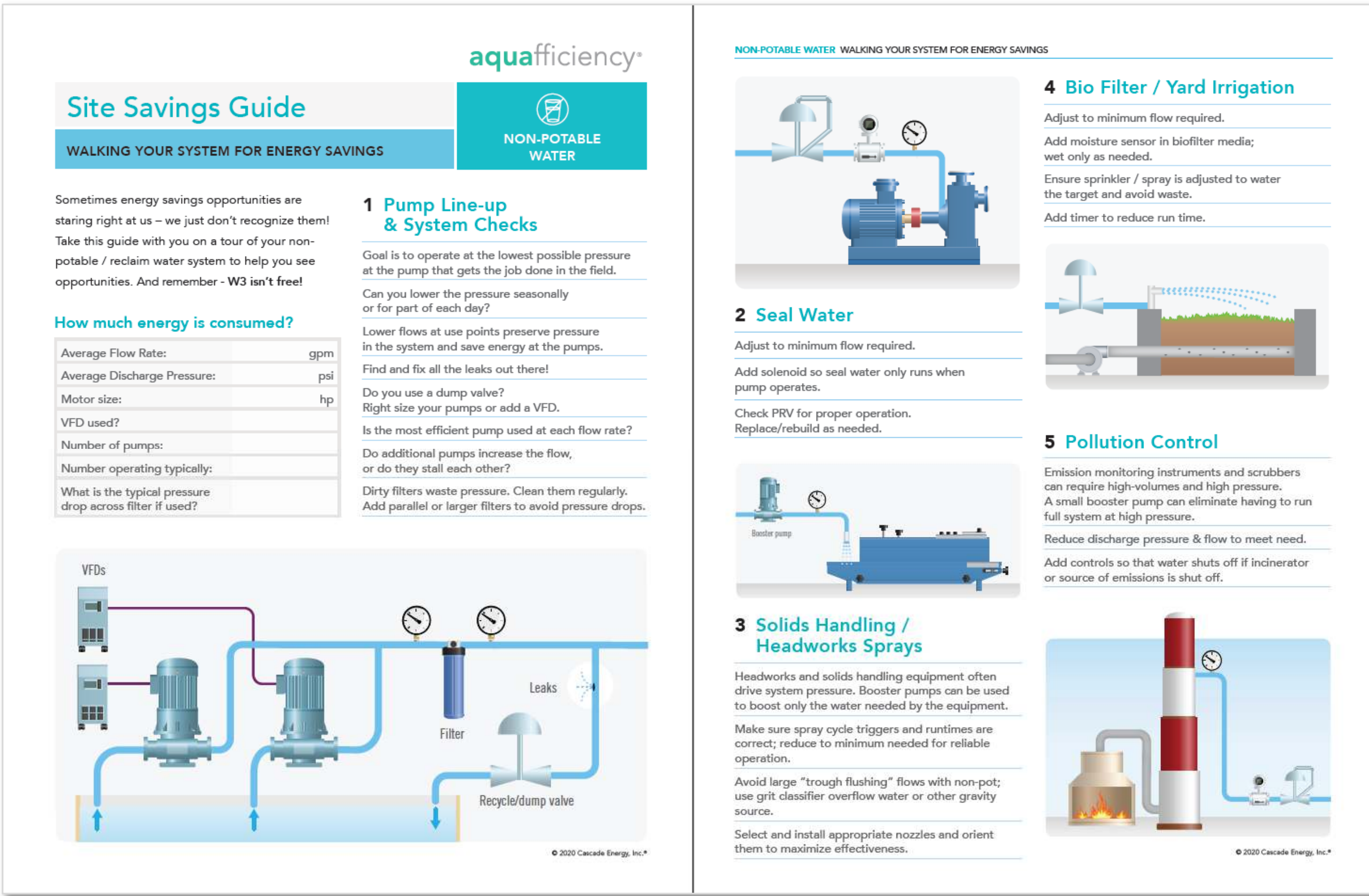
W3 SYSTEMS

W3 Systems

W3 Tour

W3 Tour Discussion

W3 systems



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Site Savings Guide

WALKING YOUR SYSTEM FOR ENERGY SAVINGS

NON-POTABLE WATER

Sometimes energy savings opportunities are staring right at us – we just don't recognize them! Take this guide with you on a tour of your non-potable / reclaim water system to help you see opportunities. And remember - **W3 isn't free!**

How much energy is consumed?

Average Flow Rate:	gpm
Average Discharge Pressure:	psi
Motor size:	hp
VFD used?	
Number of pumps:	
Number operating typically:	
What is the typical pressure drop across filter if used?	

1 Pump Line-up & System Checks

Goal is to operate at the lowest possible pressure at the pump that gets the job done in the field.

Can you lower the pressure seasonally or for part of each day?

Lower flows at use points preserve pressure in the system and save energy at the pumps.

Find and fix all the leaks out there!

Do you use a dump valve? Right size your pumps or add a VFD.

Is the most efficient pump used at each flow rate?

Do additional pumps increase the flow, or do they stall each other?

Dirty filters waste pressure. Clean them regularly. Add parallel or larger filters to avoid pressure drops.

2 Seal Water

Adjust to minimum flow required.

Add solenoid so seal water only runs when pump operates.

Check PRV for proper operation. Replace/rebuild as needed.

3 Solids Handling / Headworks Sprays

Headworks and solids handling equipment often drive system pressure. Booster pumps can be used to boost only the water needed by the equipment.

Make sure spray cycle triggers and runtimes are correct; reduce to minimum needed for reliable operation.

Avoid large "trough flushing" flows with non-pot; use grit classifier overflow water or other gravity source.

Select and install appropriate nozzles and orient them to maximize effectiveness.

4 Bio Filter / Yard Irrigation

Adjust to minimum flow required.

Add moisture sensor in biofilter media; wet only as needed.

Ensure sprinkler / spray is adjusted to water the target and avoid waste.

Add timer to reduce run time.

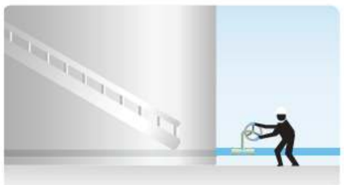
5 Pollution Control

Emission monitoring instruments and scrubbers can require high-volumes and high pressure. A small booster pump can eliminate having to run full system at high pressure.

Reduce discharge pressure & flow to meet need.

Add controls so that water shuts off if incinerator or source of emissions is shut off.

W3 systems



6 Tank Fill

A portable, low-head, high-flow pump can be used in lieu of non-pot system water to fill tanks.

Fill tanks when other uses of non-pot are low.

Utilize temporary pressure boost controls to compensate for fill; return system to lower pressure when fill is complete.

Consider equalizing tanks first through drains, then top with non-pot.

7 Hose Bibs / Washdown

Avoid "just running" hoses. If there is a constant area of concern, set up spray system or fix the problem.

All washdown hoses need nozzles and hand valves to be effective.

Add pressure boost controls to boost pressure during washdown activities and return to low pressure automatically.

If plant is not staffed at night, then no washdown will happen, and high pressure is not needed. Turn pressure up during day shift, turn down at end of day.

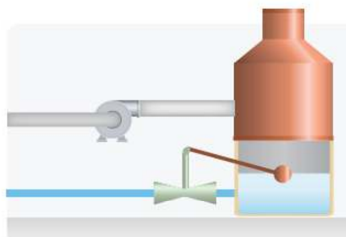
Disable/disconnect heat trace systems after winter.

8 Odor Control

Install float valve or other level control device rather than constant overflow for odor scrubber make up water.

No reason for high pressure water here; upsize pipe if the top-off time is not fast enough or reduce depth between high and low level setpoints.

While you're here: are the scrubber pumps throttled? Consider resizing or adding VFD.
Is the scrubber fan dampered?
Resheave to reduce flow and open damper.

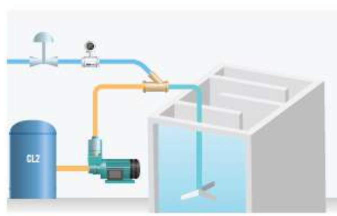


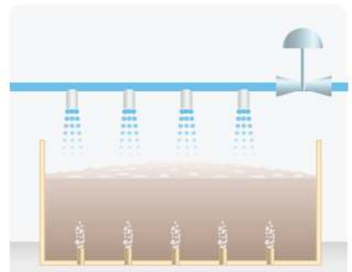
9 Carry Water

Carry water can be low, low pressure. Consider a separate, low-head pump.

Monitor flowrate and adjust to match the CL2 solution concentration used.

Would discharge manifold eliminate need for flash mixer?





10 Foam Suppression (at channels, tanks, etc.)

Foam suppression can be effective with very little water if the right nozzles are used.

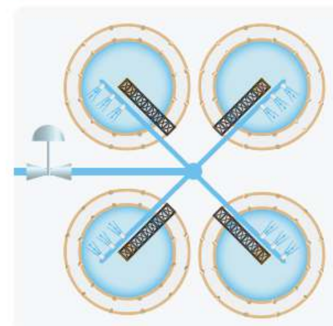
Consider running foam suppression on solenoids or auto cycle valves, half of the system at a time (e.g. north side of channel, then south side).

Blank off nozzles that aren't doing any useful work. Lower flow = lower energy!

11 Clarifier Scum Sprays

Clarifier sprays can run a few minutes every hour and do the job. Add solenoid valves and stagger the cycles so only one clarifier spray bar runs at a time.

Put spray bar control valves where operators can easily reach and adjust.
Reduce flows to minimum needed.



What did you find?

1 write down what you find

2 take a photo with your phone

3 send to your coach

FACILITY

YOUR NAME

SAVINGS OPPORTUNITIES:

W3 System Exercise

B) Energy Savings Calculator for Pumping W3 Water

Assumes static head of: 92.4 ft. of head

Approach 1 - No VFDs and pumps run year-round

	motor hp	VFD?	Days per year?	Hours per Day?	Hours per Year	kWh
Pump 1	100	No	365	24	8760	572,000
Pump 2	100	No	100	24	2400	157,000
						729,000

85 psig, system pressure
289 ft. of head
650 gpm

729,000 kWh, baseline annual energy consumption

Approach 2 - VFD on 1 pump, lower pressure, lower flow

	motor hp	VFD?	Days per year?	Hours per Day?	Hours per Year	kWh
Pump 1	100	Yes	365	24	8760	458,000
Pump 2	100	No	100	24	2400	122,000
						580,000

75 psig, system pressure
266 ft. of head
600 gpm

149,000 kWh, energy savings compared to Approach 1

C) Energy Savings Calculator for Treating W3 Water

What is your site's energy intensity for wastewater treatment? 2000 kWh/MG

	MG/year	kWh	kWh Savings
Approach 1	435	870,480	
Approach 2	402	803,520	66,960

66,960 kWh, energy savings from water treatment

D) Total Energy Savings

What is the total energy savings from lower system pressure? Both at the pump but also in reduced W3 water treatment?

215,960 kWh, total energy savings

W3 System Inventory Exercise

A) Inventory of Equipment

What equipment serves your W3 Water?

	hp	VFD?
Pump 1		No
Pump 2		No
Pump 3		No
Pump 4		No
Pump 5		No

What is the current pressure setpoint?

	psig

What is annual plant flow?

	MGD, average daily flow
0	millions of gallons/year

Alternate Names for W3

Plant Water
Non-Potable Water
Process Water
3W
2W
W2

What are your current uses for W3 Water?

Flow Required	*Pressure Required*	*Run Hours*	*Name*	*Notes*
			Grit washing	Grit washing
			Screen sprays	Screen sprays
			Screenings sluice	Screenings sluice
			Screenings washer/compactor	Screenings washer/compactor
			Clarifier sprays	Clarifier sprays
			Belt press washwater	Belt press washwater
			Housekeeping hosebibs	Housekeeping hosebibs
			Seal water	Seal water
			Odor control towers	Odor control towers

An actual picture…

Closing

SEE YOU THURSDAY!