Better Plants
U.S. DEPARTMENT OF ENERGY

SESSIONS 3, 4

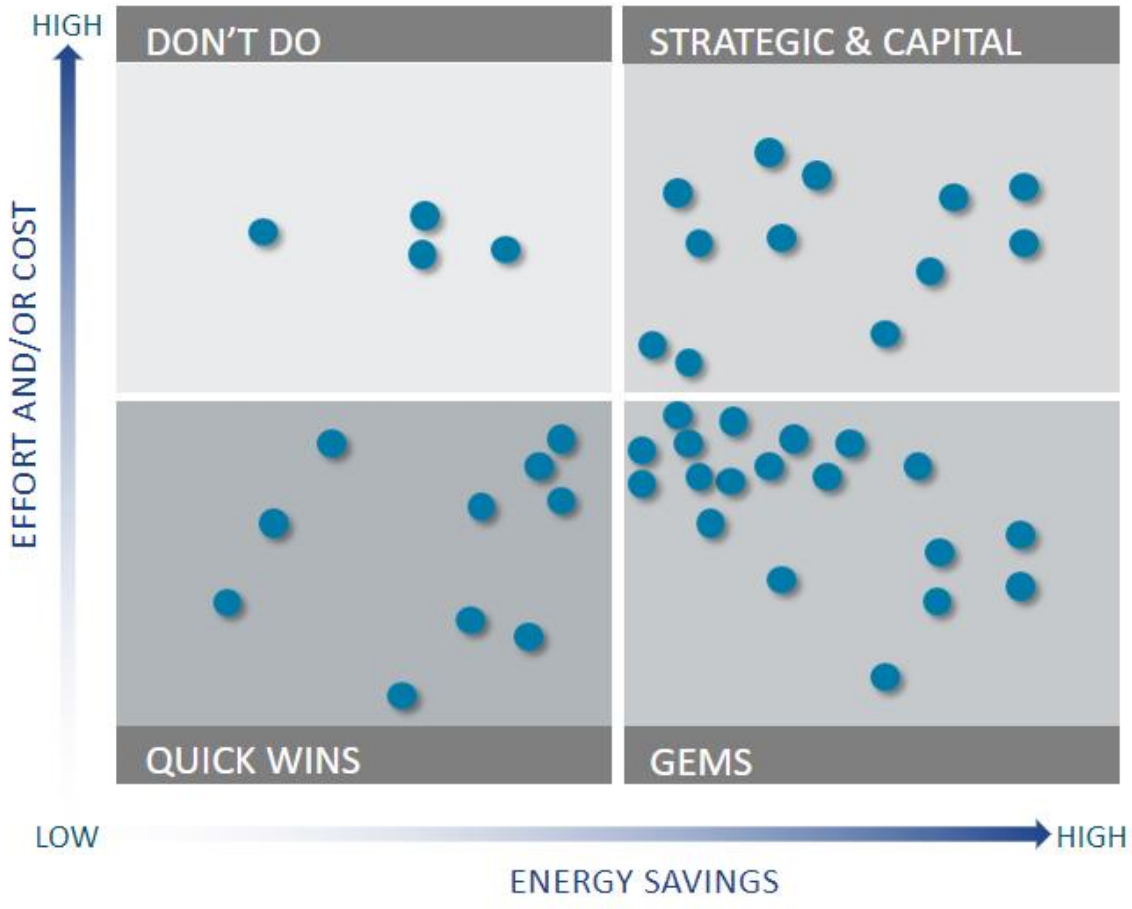
WORKBOOK

AGENDA

Welcome and Introductions
Headworks & Disinfection
Primary Solids & Clarification
Energy and the PD Blower
Energy and Demand
Aeration
Fans and Odor Control
Opportunity Register and Estimating Savings
Closing Remarks

OPPORTUNITY BRAINSTORMING AND PRIORITIZING

All energy projects can be placed in one of the four quadrants listed below.



Quick Wins – Quick and easy opportunities that should be implemented in the short term (~1 to 4 months).

Gems – Medium to High energy saving opportunities that the team should prioritize over all others, and complete as soon as possible.

Strategic – Opportunities that require additional effort and/or investment and should be considered for future implementation.

Don't Do – Not worth pursuing at this time given the high effort required and low energy savings.

Opportunities on Headworks & Disinfection

Notes on W3 Report Outs

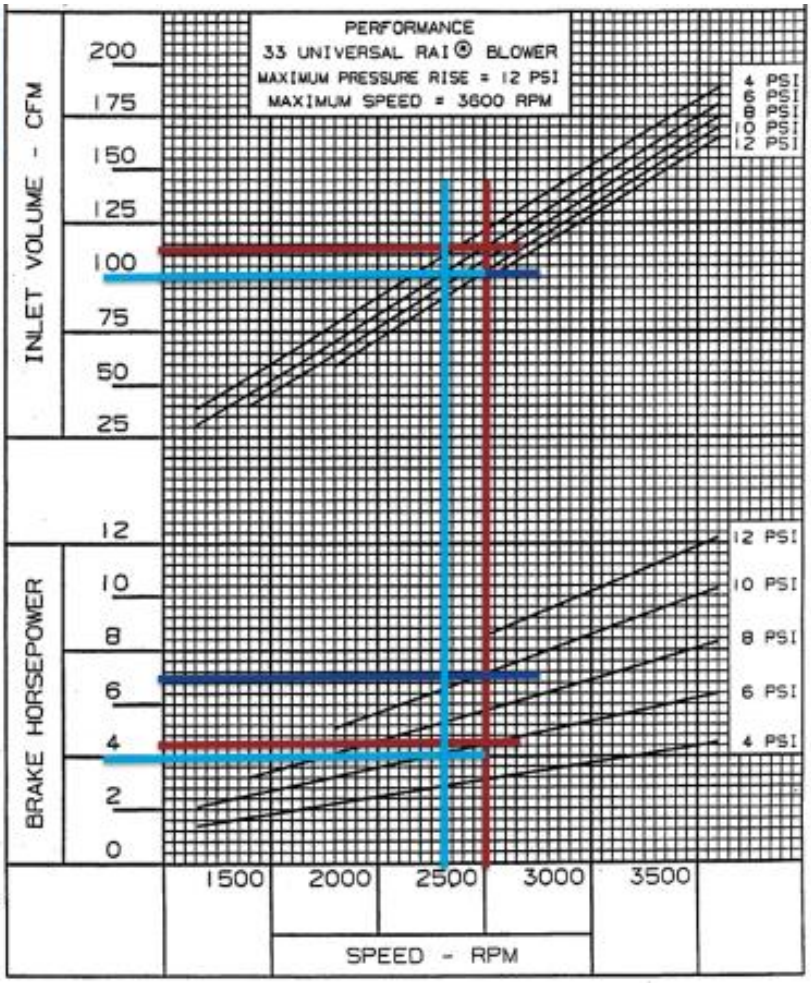
PD Blower Energy Example

@ 2500 RPM & 6 PSI:
4.8 BHP & 112 CFM.

@ 2500 RPM & 10 PSI:
7.1 BHP (UP 48%) & 102 CFM (DOWN 9%)

@ 2300 RPM & 6 PSI:
4.0 BHP (DOWN 16%) & 102 CFM.

CHANGE THE SHEAVE OR USE A VFD.



EXERCISE: ENERGY, DEMAND, AND READING A BILL

In the winter of 2014, Whatdrought, California's WWTP received the electric bill extracted and shown below. Whatdrought's plant is an activated sludge facility that processes wintertime flows averaging 2.7 MGD.

Instructions: Based upon the energy bill on the following page, answer the following questions.

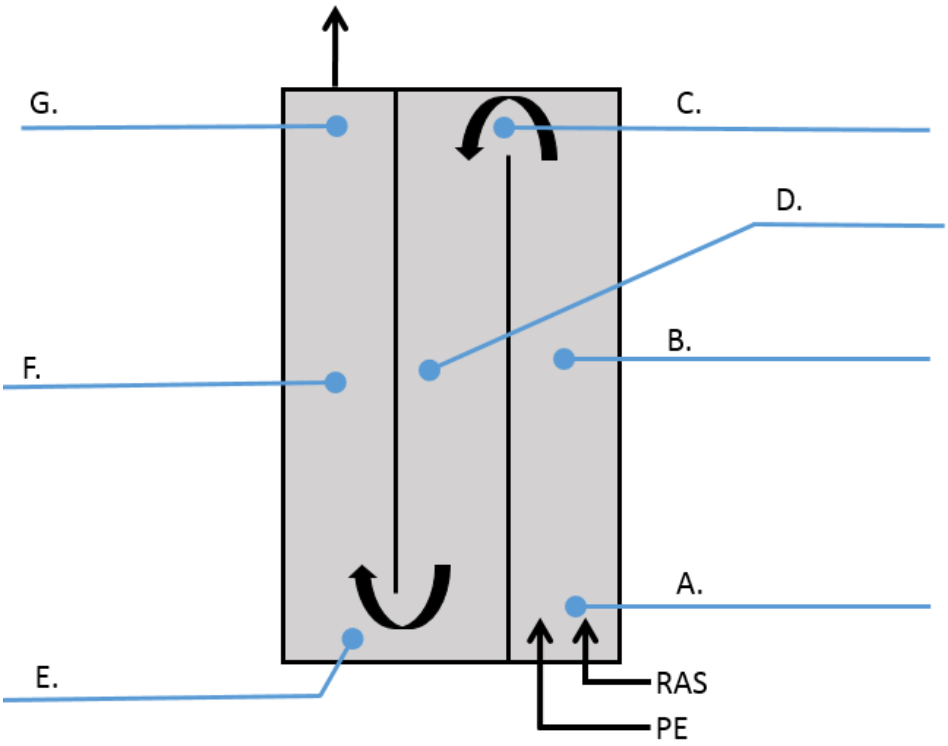
a. How many kilowatt-hours of electricity did this facility use during this billing cycle? (Dec 2013/Jan 2014)
b. How is the meter's multiplier used to calculate actual energy usage, on meter #3762043?
c. How much money did Whatdrought spend this month in demand charges? What percentage is this, of the total monthly electric bill for the facility?
d. Two 75 hp blowers run continuously to supply air to the aeration basin and also to mix the sludge storage tank. How many kW of power do the two blowers draw?
e. How many kWh do the two blowers use on average every day?
f. Based on the information above, what is the average whole-plant benchmark in kilowatt-hours per million gallon treated?

ACCOUNT NO	METER NO	PREVIOUS READING	PRESENT READING	MULT	HORSEPOWER CHARGE	KWH USAGE	CUSTOMER CHARGE	ENERGY CHARGE	ARREARS
SERVICE ADDRESS		SERVICE FROM	SERVICE TO	POWER FACTOR	SECURITY LIGHTS	CODE	MISC CHARGES	DEMAND CHARGE	TOTAL BILLED
3762031 901 WHARF ST-SWR PLANT	80918	27956 12-16-13	28479 01-14-14	120 23895.000		62760 0	$83.00	$3596.15 $906.34	$0.00 $4585.49
3762043 901 WHARF ST-SEWER PLANT	80916	58809 12-16-13	60150 01-14-14	80 36365.000		107280 0	$83.00	$6147.14 $2322.43	$0.00 $8552.57

EXERCISE: OUR – FINDING ENDOGENOUS

Materials needed: Laptop

Use the laptop to input the A-G data from 7 locations on the 3-pass aeration basin shown.



1. Where does endogenous respiration begin?

2. Where does this basin need the most air? The least?

3. What are some possible approaches to optimizing the air in this basin?

Location: A. Beginning Pass 1 (after PE and RAS)	
Time (seconds)	DO (mg/L)
0	7.45
10	7.02
20	6.59
30	6.18
40	5.72
50	5.29
60	4.88

Location: B. Mid-tank Pass 1	
Time (seconds)	DO (mg/L)
0	7.44
10	7.12
20	6.81
30	6.48
40	6.16
50	5.84
60	5.52

Location: C. End Pass 1 beginning Pass 2	
Time (seconds)	DO (mg/L)
0	7.48
10	7.21
20	6.93
30	6.68
40	6.40
50	6.14
60	5.89

Location: D. Mid-tank Pass 2	
Time (seconds)	DO (mg/L)
0	7.47
10	7.31
20	7.15
30	7.00
40	6.85
50	6.69
60	6.52

Location: E. End Pass 2 beginning Pass 3	
Time (seconds)	DO (mg/L)
0	7.17
10	7.02
20	6.86
30	6.70
40	6.57
50	6.43
60	6.27

Location: F. Mid-tank Pass 3	
Time (seconds)	DO (mg/L)
0	7.37
10	7.32
20	7.28
30	7.24
40	7.20
50	7.15
60	7.10

Location: G. End Pass 3, aeration basin effluent	
Time (seconds)	DO (mg/L)
0	7.42
10	7.39
20	7.33
30	7.30
40	7.25
50	7.22
60	7.18

EXERCISE – AERATION PRESSURE

Purpose: To develop knowledge, comfort and proficiency with the relationship between energy and aeration air discharge pressure.

Materials needed: Laptop

C) Impact of Blower Pressure on Energy

Impact of Discharge Pressure Reduction on Blower Energy

Discharge Pressure	Reduction in pressure of ___ psig.				
	-0.5	-1	-1.5	-2	-4
12	3.3%	6.7%	10.1%	13.4%	26.9%
11	3.7%	7.4%	11.1%	14.8%	29.6%
10	4.1%	8.3%	12.4%	16.5%	32.9%
9	4.6%	9.3%	13.9%	18.5%	37.0%
8	5.2%	10.6%	15.8%	21.0%	42.1%
7	6.1%	12.2%	18.3%	24.3%	48.6%

Example: 12 psig discharge lowered by 2 psig saves 13.4% at blower. (Assumes 70% blower eff. & 92% drive eff.)

psig	inches of H_2O
0.1	2.8
0.5	13.8
1	27.7
1.5	41.5
2	55.4
2.5	69.2
3	83.0
3.5	96.9
4	110.7

1 psi = 2.31 feet of water; 1 foot of water = 0.43 psi

What is the savings potential from lowering blower discharge pressure?

250	hp, blower
10	psig, discharge pressure
-0.5	pressure reduction
4.1%	%, potential energy savings
50,974	kWh annual energy savings
$3,058	annual cost savings @ $0.06/kWh

Instructions: Using the calculator (shown above) on your laptop, input information as necessary into the yellow cells to answer the following activity questions.

ACTIVITY QUESTIONS

a. How much energy is saved if this 50 hp blower's discharge pressure is reduced from 7 psig to 5.5 psig?	kWh/year	
b. What if it's a 150 hp blower, and the pressure is lowered from 10 psig to 9.5 psig. What percentage of energy is saved?	%	
c. If a 75 hp blower is turned down from 11 psig to 9 psig, how much money is saved (if energy costs 6¢ per kWh)?	$ /year	
d. If a 40 hp blower is turned down from 8 psig to 7 psig, how much energy is saved, and what percentage does that represent?	kWh/year	%

EXERCISE – DO RESIDUAL

Purpose: To develop knowledge, comfort and proficiency with the relationship between energy and residual dissolved oxygen (DO).
Materials needed: Laptop

Oxygen is required by the organisms that carry out secondary treatment in the aeration basin. Installed DO meters read how much "residual" or leftover oxygen is present. While many plants control blower operation automatically to maintain 1 mg/L DO or lower, we also see that many aeration basins carry excess DO "just in case" a large load comes in unexpectedly. This extra DO has an energy cost. The cheat sheet table shows how much energy savings (as a percentage) is available if residual DO is reduced to 1 mg/L, at various mixed liquor temperatures.

The calculator allows you to explore different scenarios and determine the approximate actual savings associated with these scenarios.

B) Impact of DO Levels on Energy

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

Impact of Average DO Level on Blower Energy						
Mixed Liquor Temp		DO Sat	Energy Savings Potential if DO Reduced from ___ to 1.0 mg/l			
°C	°F	mg/l	2	3	4	5
0	32	14.6	7.4%	14.7%	22.1%	29.4%
2	36	13.8	7.8%	15.6%	23.4%	31.3%
5	41	12.8	8.5%	16.9%	25.4%	33.9%
10	50	11.3	9.7%	19.4%	29.1%	38.8%
15	59	10.1	11.0%	22.0%	33.0%	44.0%
20	68	9.1	12.3%	24.7%	37.0%	49.4%
25	77	8.2	13.9%	27.8%	41.7%	55.6%

Note: *Higher impact as elevation increases.*

How much could my plant benefit from reducing DO to 1.0 mg/l?

100	hp, blower
68	°F, mixed liquor temp
9.1	mg/l, DO Sat
4	current DO level
37.0%	%, potential energy savings
212,779	kWh annual energy savings
$12,767	annual cost savings @ $0.06/kWh

Instructions: Use the table and calculator above to answer the questions below. Adjust information in the yellow fields as needed to answer the questions.

EXERCISE – DO RESIDUAL CONTINUED

Questions

a. What percentage of energy could be saved if an aeration basin holding 25°C mixed liquor lowered its DO residual from 2 mg/L to 1 mg/L? _____%

b. If a plant is running 200 hp of blowers, and it has 59 °F mixed liquor, how many kWh/y of energy might it save by lowering its DO from 3 mg/L to 1 mg/L? _____kWh/year

c. In b) how much cost is saved (at $0.06/kWh)? $_____/year

d. How much total money can be saved if a plant running 100 hp of blowers in 20 °C mixed liquor reduces their DO residual from 5 mg/L to 1 mg/L? _____kWh/year

e. Your plant runs (on average) what total horsepower of blower? _____hp
What is the approximate temperature of your plant's mixed liquor? _____°F
What is the DO residual setpoint at your plant? _____mg/L

f. How much total money is saved if your plant reduces DO residual to 1 mg/L? $_____/year

ANSWER SHEETS

ANSWER SHEET – ENERGY BASICS DAY 2

In the winter of 2014, Podunk California's WWTP received the electric bill—extracted and shown below. Podunk's plant is an activated sludge facility that processes wintertime flows averaging 2.7 MGD.

ACCOUNT NO	METER NO	PREVIOUS READING	PRESENT READING	MULT	HORSEPOWER CHARGE	KWH USAGE	CUSTOMER CHARGE	ENERGY CHARGE	ARREARS
SERVICE ADDRESS		SERVICE FROM	SERVICE TO	POWER FACTOR	SECURITY LIGHTS	CODE	MISC CHARGES	DEMAND CHARGE	TOTAL BILLED
3762031	80918	27956	28479	120		62760	$83.00	$3596.15	$0.00
901 WHARF ST-SWR PLANT		12-16-13	01-14-14	23895.000		0		$906.34	$4585.49
3762043	80916	58809	60150	80		107280	$83.00	$6147.14	$0.00
901 WHARF ST-SEWER PLANT		12-16-13	01-14-14	36365.000		0		$2322.43	$8552.57

a. How many kilowatt-hours of electricity did this facility use during this billing cycle? (Dec 2013/Jan 2014) A = 62,760 + 107,280 = 170,040 kWh

b. How is the meter's multiplier used to calculate actual energy usage, on meter #3762043?
A: Present reading 60150 – previous reading 58809 = 1,341; 1,341 x multiplier 80 = 107,280 kWh used in the present billing period.

c. How much money did Podunk spend this month in demand charges? What percentage is this, of the total monthly electric bill for the facility? A: $906.34 + $2,322.43 = $3,228.77 demand charge; $3,228.77 ÷ ($4,585.49 + $8,552.57) = 24.6%

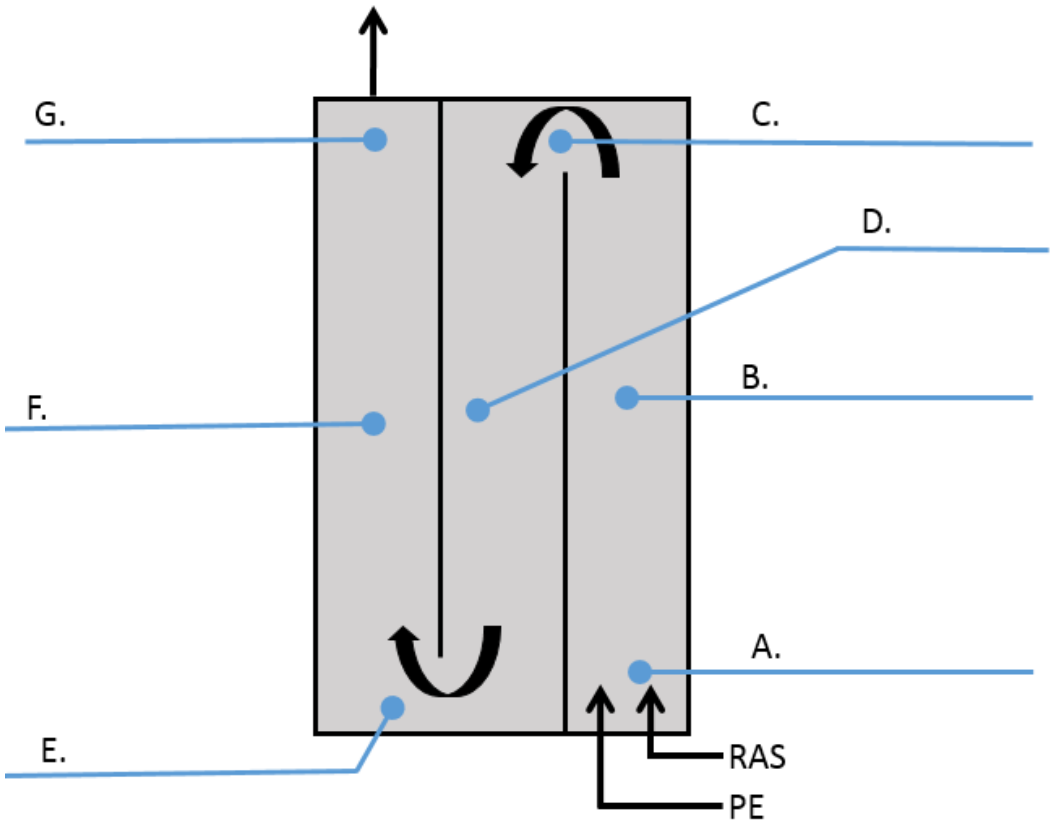
d. Two 75 hp blowers run continuously to supply air to the aeration basin and also to mix the sludge storage tank. How many kW of power do the two blowers draw?
A = 2 x 75 hp x 0.75 kW/hp = 112.5 kW

e. How many kWh do the two blowers use on average every day?
A = 112.5 kW x 24 h/d = 2,700 kWh

f. Based on the information above, what is the average whole-plant benchmark in kilowatt-hours per million gallon treated?
A: 170,040 kWh / 30 days = 5,668 kWh/d; 5,668 kWh/d ÷ 2.7 MGD = 2,099 kWh/MG

ANSWER SHEET - OUR – FINDING ENDOGENOUS

Use the laptop to input the A-G data from 7 locations on the 3-pass aeration basin shown.



A. 155 mg DO/L-h
B. 115 mg DO/L-h
C. 96 mg DO/L-h
D. 56 mg DO/L-h
E. 54 mg DO/L-h
F. 16 mg DO/L-h
G. 15 mg DO/L-h

ANSWER SHEET - OUR – FINDING ENDOGENOUS CONTINUED

1. Where does endogenous respiration begin?
   A: F

2. Where does this basin need the most air? The least?

   Most- First pass

   Least – F and G

3. What are some possible approaches to optimizing the air in this basin?

   A: Discuss.

ANSWER SHEET – EXERCISE – AERATION PRESSURE

a. How much energy is saved if this 50 hp blower's discharge pressure is reduced from 7 psig to 5.5 psig? _____ kWh/year A = 52,431 kWh/year

b. What if it's a 150 hp blower, and the pressure is lowered from 10 psig to 9.5 psig. What percentage of energy is saved? _____% A = 4.1%

c. If a 75 hp blower is turned down from 11 psig to 9 psig, how much money is saved (if energy costs 6¢ per kWh)? $_____/year A = $3,827/year

d. If a 40 hp blower is turned down from 8 psig to 7 psig, how much energy is saved, and what percentage does that represent? _____kWh/year, _____% A = 24,263 kWh/year, 10.6%

ANSWER SHEET: EXERCISE – DO RESIDUAL

a. What percentage of energy could be saved if an aeration basin holding 25°C mixed liquor lowered its DO residual from 2 mg/L to 1 mg/L? _____% A = 13.9%

b. If a plant is running 200 hp of blowers, and it has 59 °F mixed liquor, how many kWh/y of energy might it save by lowering its DO from 3 mg/L to 1 mg/L? _____kWh/year A = 252,528 kWh/year

c. In b) how much cost is saved (at $0.06/kWh)? $_____/year A = $15,152/year

d. How much total money can be saved if a plant running 100 hp of blowers in 20 °C mixed liquor reduces their DO residual from 5 mg/L to 1 mg/L? _____kWh/year A = $17,022/year

e. Your plant runs (on average) what total horsepower of blower? _____hp A = *plant-specific*
What is the approximate temperature of your plant's mixed liquor? _____ °F A = *plant-specific*
What is the DO residual setpoint at your plant? _____mg/L A = *plant-specific*

f. How much total money is saved if your plant reduces DO residual to 1 mg/L?
$_____/year A = *plant-specific*