pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

Electric Use at Pennsylvania Sewage Treatment Plants

March 2011

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Acknowledgements: Thanks to those who provided information for this report.

This report provides wastewater treatment plant (WWTP) operators and managers with the tools to evaluate and reduce electric consumption while improving operation and efficiency of treatment plants. Included are instructions to calculate and compare plant electric efficiency values as well as an overview of various attributes of Commonwealth WWTPs.

The Pennsylvania Department of Environmental Protection (Department) requested information from Pennsylvania WWTPs in conjunction with energy management training classes developed and presented by the Department. The *WWTP Energy Use Survey* form[1] (Survey) was used to collect specific information such as treatment type and unit processes, design and actual loadings, effluent limits and electric use and costs. The fundamental objective of the data collection effort was to establish electric use benchmarks for WWTPs in Pennsylvania. An energy use benchmark is a valuable tool to track energy performance, target specific energy efficiency upgrades and evaluate the success of energy efficiency projects.

Survey forms were received from 133 plants representing 12% of the approximate 1,123 municipal WWTPs in the state. WWTPs that returned the survey have a combined total of 635 MGD design flow and 445 MGD reported flow and total design organic loading of 1,004,448 lb/day BOD and reported total BOD loading of 512,344 lb/day. On average, the WWTPs operate at 70% of design flow and 51% of design organic loading. Annual electric costs for all 133 plants were $19,077,685. Refer to Appendix A for more survey data and information.

Figures 1, 2 and 3 below use data from the entire sample set of 133 survey forms. 108 plants use an activated sludge process. 12 plants use more than one treatment type, such as activated sludge and trickling filter or two different activated sludge processes.

[1] Appendix B

Figure 1 Plants by Treatment Type

Treatment Types	**# of WWTPs**
Extended Aeration (EA)	34
Conventional Activated Sludge (CAS)	26
Sequential Batch Reactor (SBR)	25
Oxidation Ditch (OD)	11
Contact Stabilization (CS)	5
Trickling Filter (TF)	12
Rotating Biological Contactor (RBC)	6
Lagoon (LG)	7
Other	7
Total	**133**

Figure 2 Treatment Types

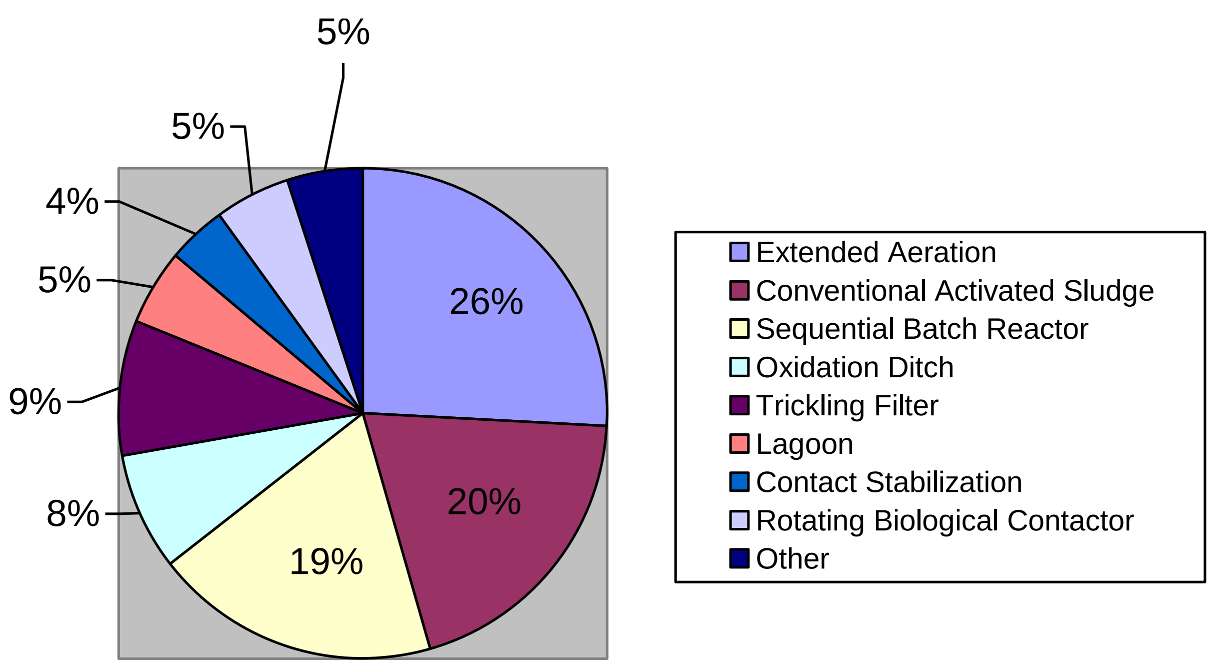


Figure 3 Specifics from the Survey (not used to calculate the WWTP Efficiency Baseline)

Disinfection	# WWTPs	% WWTPs
Chemical	102	77%
Ultraviolet	31	23%
Solids Handling		
Aerobic Digester	85	64%
Anaerobic Digester	17	13%
Anaerobic Digester/Gas Recovered	13	10%
Belt Press	47	35%
Reed Bed	13	10%
Drying bed	17	13%
Nutrient Limits		
Ammonia Nitrogen	53	70%
Phosphorous	37	30%
Ammonia Nitrogen & Phosphorous	29	23%

Figures 1 through 3 use information from the entire survey sample set of 133 plants. Of the 133 survey forms received, 117 were determined to be complete and accurate[2]. The remainder of the report uses information from this sample subset of 117 WWTPs.

For the 117 sample subset, total design flow is 618 MGD and total design loading is 987,915 lb/day BOD. Total reported flow is 433 MGD and total reported organic loading 504,955 lb/day BOD. The overall average percent of design flow and design organic loading is 70% and 51%, respectively, same as the full set of 133 plants. Annual electric costs for the 117 plants were $18,418,893.

As demonstrated in Figures 1 through 3 above, there are variations from plant to plant in flow rates, treatment type, discharge requirements and disinfection methods. These variations can be large and have a major impact on the amount of electricity consumed during treatment. This lack of standardization makes it difficult to establish a definitive WWTP energy efficiency baseline. The WWTP Efficiency Baseline calculator (WEB) is designed with this lack of standardization in mind. The electricity consumed by a plant in the treatment process is expressed in units of hydraulic loading (Megawatt-hours per million gallons or MWh/MG) and units of organic loading (kilowatt-hours per pound of treated BOD_5 or kWh/lb BOD). This value reveals how a WWTP uses electricity relative to other

[2] See Appendix A

plants and is the first step in evaluating plant efficiency. A high or large WEB means your plant is using more electricity when compared to other plants and indicates significant opportunities to improve efficiency and lower costs. Energy saving improvements are still possible even if your facility has a low WEB.

The instructions below will guide you in calculating the WEB. Following the calculations are tables (Figures 5 & 6) to compare your WEB with other treatment plants. Before you begin calculating the WEB, compile 12 concurrent months of electric bills and plant records (e.g. influent logs or Chapter 94 Report). Be sure the plant records coincide with the electric bills.

Calculating Your WWTP Efficiency Baseline

READ ALL INSTRUCTIONS BEFORE ENTERING DATA

Required Data:

1. You must use **12 consecutive months** of data for calculations
2. **kWh** - Monthly kWh use found on electric bill
3. **Plant flow** - Monthly average flow in MGD (million gallons/day) for the same 12 months
4. **Influent BOD** - Monthly average influent BOD lb/day (pounds per day) for the same 12 months
5. **Effluent BOD** - Monthly average effluent BOD lb/day for the same 12 months. Use cBOD if BOD data is not available

To calculate pounds per day use the following formula:

lb/day = mg/l x 24 hour flow in MGD during sampling period x 8.34

This is a separate calculation for each day samples are collected during the month. The average of these values is the number used for each monthly data entry.

6. Double click inside **Table 1** (below) to activate the Excel spreadsheet
   Note- if you have a hardcopy of this report and want an electronic copy with automated WEB calculator, contact your regional DEP Water Management program
7. Enter the required monthly data
   - Make certain values are in the specified units
   - Ensure all 12 months have values entered for all 4 columns
8. Benchmark will calculate as entries are made

Table 1 WWTP Efficiency Baseline Calculator

1	2	3	4
Electric use (kWh)	**Average daily flow (MGD)**	**Average daily influent BOD (lb/day)**	**Average daily effluent BOD or CBOD (lb/day)**

WWTP Efficiency Baseline	
#DIV/0! MWh/MG	#DIV/0! kWh/lb BOD

The WWTP Efficiency Baseline represents electric used per million gallons of flow (MWh/MG) through the plant and electric used per pound of BOD (kWh/lb BOD) removed by the plant. Figure 5 shows benchmarks for each treatment type[3]. Use the benchmark as a point of reference to measure your plant's electric consumption. Compare your calculated WEB to the benchmarks shown in the Figures below. If your WEB is higher than the values in Figure 5, start looking for ways to improve your energy efficiency. Even if your WEB is below the benchmark value there are still opportunities for savings.

Considerations when evaluating your WEB:

- If you are significantly over or under the benchmark, check your work and recalculate your values

[3] See Appendix A: Descriptions for Selected Terms

- Accurate flow measurements/records and representative organic loading values (good influent sampling/analyses) are crucial
- Unusual influent character, pre- or post-aeration, sludge processing and other variables could bias results
- WWTPs operating at significantly less than design hydraulic or design organic loading tend to be less efficient

Figure 5 **WWTP Efficiency Benchmarks**

Treatment Type	MWh/MG	kWh/lb BOD
Extended Air	< 3.8	< 2.9
Conventional Activated Sludge	< 1	< 0.7
Sequential Batch Reactor	< 1.8	< 1.6
Oxidation Ditch	< 2	< 1.6
Trickling Filter	< 0.5	< 0.4
Lagoon* (3 wwtp)	0.7 - 16.2*	2.1 - 12.1*
Contact Stabilization* (4 wwtp)	3.0 - 3.6*	2.3 - 6.5*
Rotating Biological Contactor* (2 wwtp)	0.6 - 8.4*	0.6 - 5.0*

* Entire range of values included due to small number of plants in category. More efficient plants have lower WEBs.

Figure 6 shows the WEBs for certain treatment types and flow ranges from the 117 plants. This offers another frame of reference for comparing your calculated value.

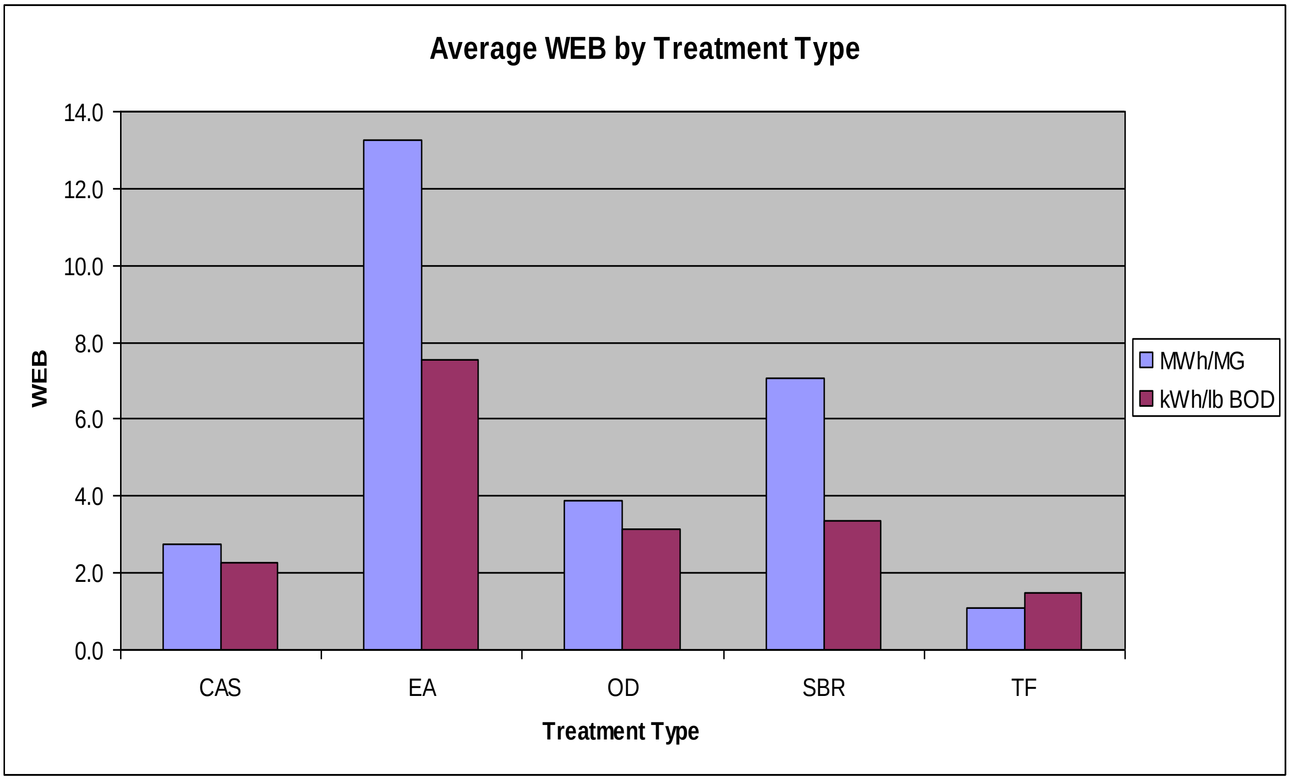
Remember, the most efficient plants will have low WEBs

Figure 6	WWTP Efficiency Baseline Ranges		
Treatment Type	Flow (MGD)	MWh/MG	kWh/lb BOD
Extended Air	<0.1	1.1 - 46.0	1.9 - 20.3
	0.1 - <0.5	3.3 - 6.9	2.5 - 4.9
Conventional Activated Sludge	0.1 - <0.5	2.5 - 5.3	2.8 - 6.3
	0.5 - <5	1.1 - 6.1	0.9 - 4.7
	>5	0.4 - 1.2	0.2 - 2.2
Sequential Batch Reactor	<0.1	8.7 - 25	3.2 - 7.1
	0.1 - <0.5	1.2 - 12.6	1.6 - 7.2
	0.5 - <5	1.8 - 6.6	1.4 - 4.5
Oxidation Ditch	0.1 - <0.5	2.2 - 6.6	2.1 - 6.4
	0.5 - <5	3.3 - 4.5	1.6 - 5.1

Graphs illustrating the WEBs for specific treatment types from the surveyed WWTPs are located in Appendix A.

Figure 7 shows the average WEB for each treatment type. Conventional Activated Sludge plants are the most efficient to operate when compared to the other activated sludge treatment types. It is also important to note, that the average WEBs (Figure 7) are much higher than the Benchmarks in Figure 5. This suggests the average treatment plant is inefficient and able to reduce costs and electric use considerably.

Figure 7



Did you compare your WEB with the appropriate treatment type? How do you compare with your peers? Is your WEB closer to the values in Figure 5 or Figure 7? Below are recommendations that will decrease your WEB:

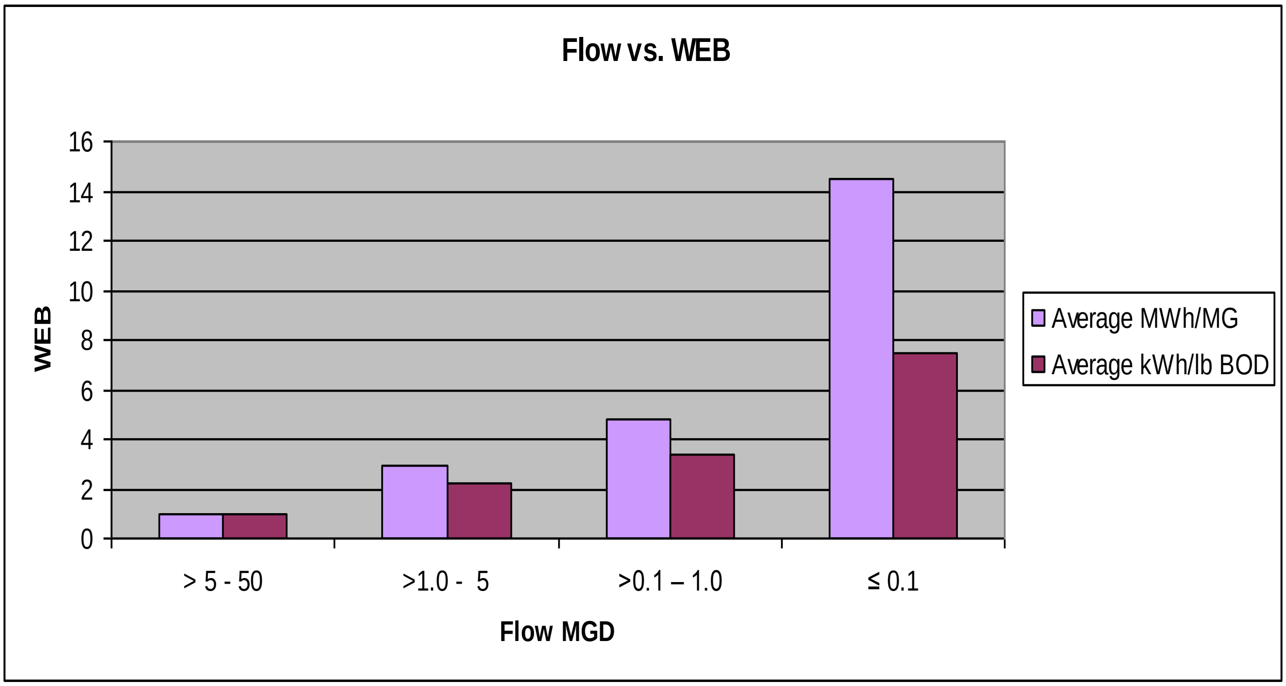
- ✓ Modify method of operation- consider on-off aeration vs. full time air, units in standby vs. all units in use, nitrate recycle
- ✓ Use automated controls such as dissolved oxygen (DO) sensors coupled with an adjustable speed blower motor drive (ASD)
- ✓ Replace old or rewound motors with Premium efficiency motors
- ✓ Install lower HP motors that can be staged to meet smaller load requirements
- ✓ Run pumps in parallel
- ✓ Reduce pressures where possible
- ✓ Downsize pumps where oversized
- ✓ Evaluate entire pump/motor/piping system- age, efficiency, replacement (design, permitting and installation) cost and salvage value
- ✓ Install ASDs when flows are large, highly variable, throttled or have bypasses
- ✓ **Even the most efficient plants can make improvements**

Hydraulic & Organic Loading

Electricity consumed per pound of treated BOD is not often used as an energy efficiency measure; many studies use only hydraulic (flow) based efficiencies. This report presents data for both hydraulic and organic efficiency. Figure 8 shows that there is less variability from plant-to-plant with electric used per lb BOD than in the electric used per million gallons. This is expected, as organic loading is more consistent than hydraulic loading due to the large influence of inflow/infiltration on the latter.

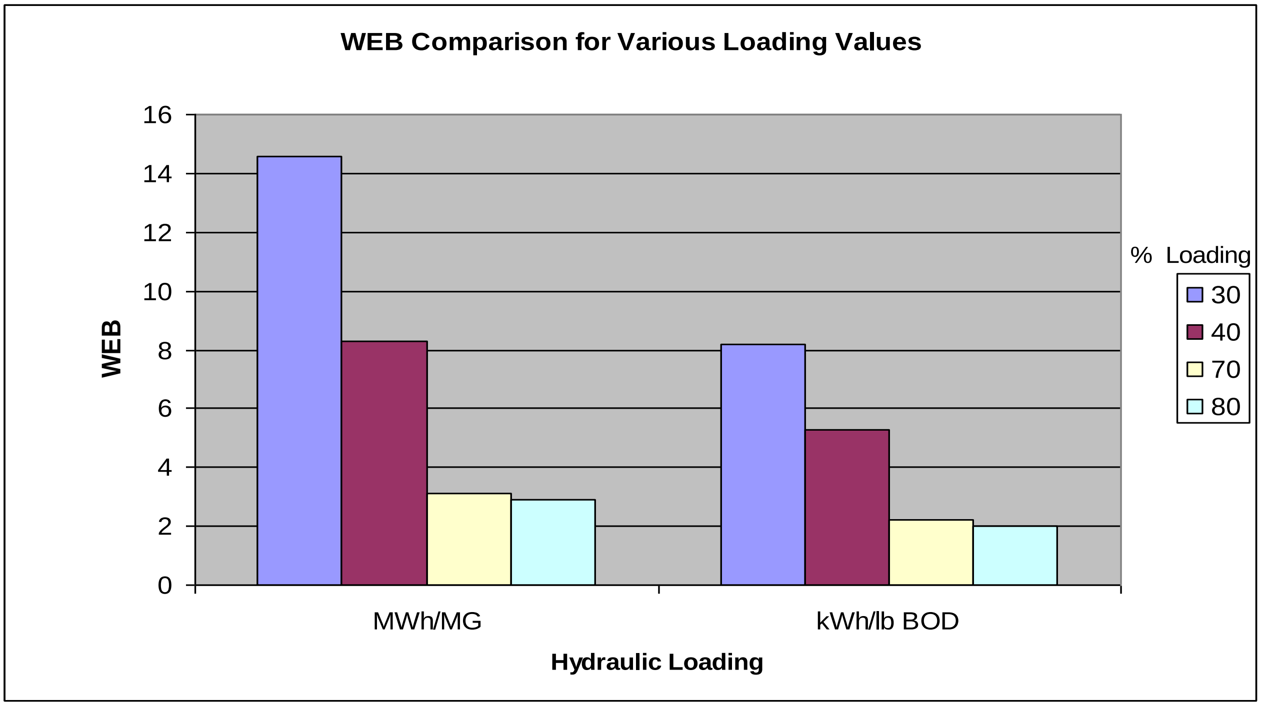
Figure 8 also suggests a strong relationship between size and efficiency. Large plants are much more efficient and are predominantly conventional activated sludge (most efficient activated sludge treatment type in this survey). Smaller plants often use less efficient treatment types, such as extended aeration.

Figure 8



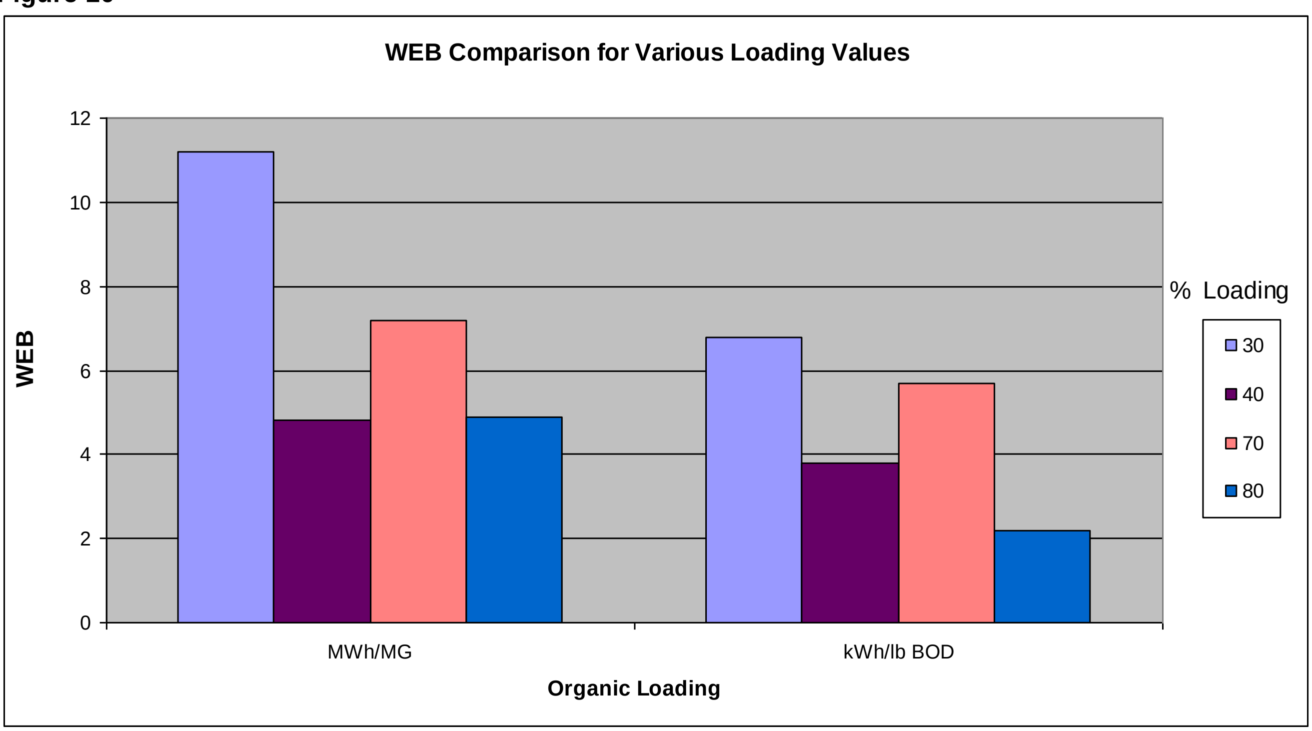
Figures 9 and 10 compare WEBs to percent of design load. The average WEB of a plant operating at 20% - 40% of its design flow is 11 MWh/MG & 6.3 kWh/lb BOD. This is about 2½ times higher than the average WEB of a plant operating at 60% - 80% of design flow (4 MWh/MG & 2.4 kWh/lb BOD).

Figure 9



A plant operating at 30% of its organic design load also uses more energy than a 70% loaded plant based on the average WEB - 8.2 MWh/MG & 5.3 kWh/lb BOD compared to 6.1 MWh/MG & 3.3 kWh/lb BOD, respectively.

Figure 10

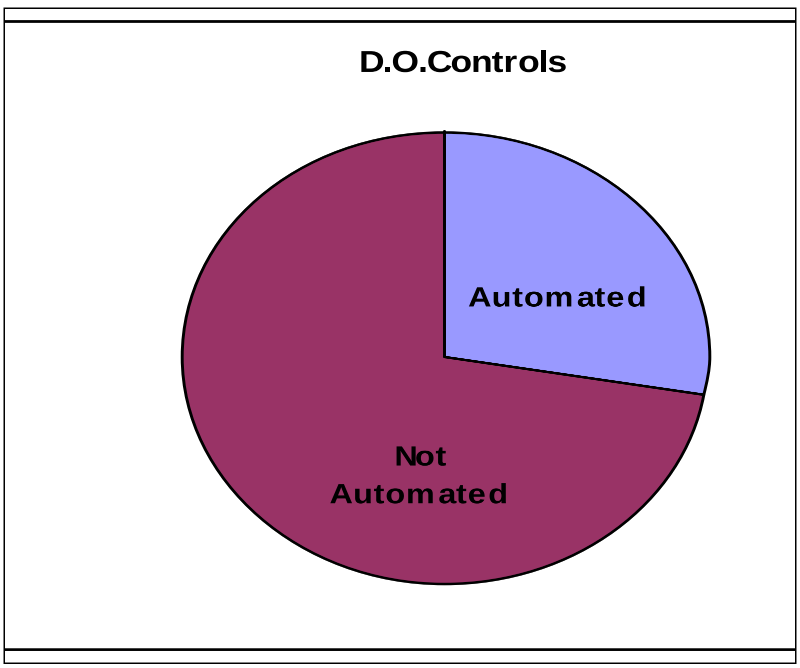


Systems must be properly sized to meet design standards and permit requirements along with the flexibility to minimize energy consumption under various operating conditions. For example, use a mix of small and large pumps equipped with ASDs and cascading controls instead of only large pumps sized for peak demand.

Aeration Systems

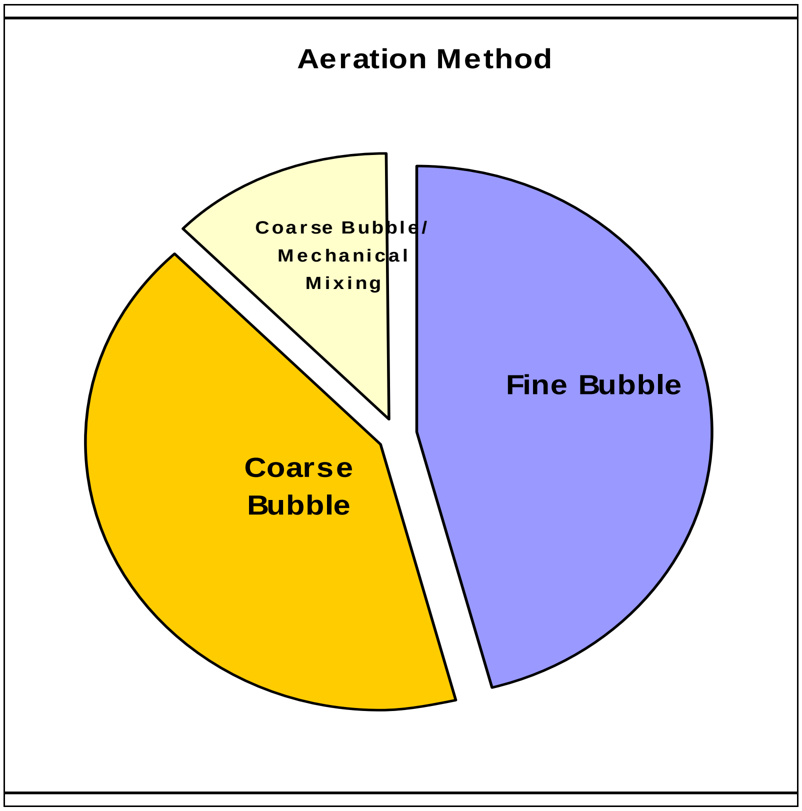
The aeration system accounts for over half of the total electric consumption at a typical activated sludge wastewater treatment plant. There are a number of opportunities to improve the energy performance of aeration systems, including automated DO controls, fine bubble diffusers, efficient blowers, and adjustable speed drives. These opportunities are not appropriate at every facility, but each should be evaluated for any project that includes an aeration system upgrade or expansion component.

Figure 11 Only 28% of surveyed WWTPs use automated dissolved oxygen controls



Plants that manually control DO should consider an automated system. WWTPs with manual control systems may experience upsets when flow variations or increases in BOD occur. For efficient operation and control, accurate DO measurements must be obtained frequently from wastewater in the aeration basins. It is almost always cost effective to install automated DO controls in aeration tanks. The same is also true for aerobic digestors. Automated controls maintain a selected DO range through varying diurnal and seasonal demand. These systems prevent under-aeration that may cause odors or upsets and over-aeration that wastes energy and increases equipment wear.

Figure 12 Aeration Methods for Surveyed Activated Sludge Plants



53% of activated sludge plants that submitted surveys use coarse bubble aeration. Typical oxygen transfer efficiency for coarse bubble diffusers is between 9% to 13%. Fine bubble aerators provide an oxygen transfer efficiency of 15% to 40%. Because fine bubble diffusers provide better oxygen transfer in wastewater; less air is required for biological treatment with no reduction in treatment performance. Less air means less power is required. Changing from inefficient coarse bubble diffusers to fine or ultra fine bubble systems will significantly reduce electric costs. Most retrofits from coarse bubble to fine bubble will produce aeration energy savings of 20% to 40% and simple paybacks of 2 to 4 years including the increased capital cost and the additional maintenance/cleaning costs.

Figures 13 & 14 show the WEBs for activated sludge plants that reported a single treatment type and aeration method. There are 34 fine bubble plants and 31 coarse bubble plants in the data set. Fine bubble is significantly more efficient as depicted in the figures below.

Figure 13

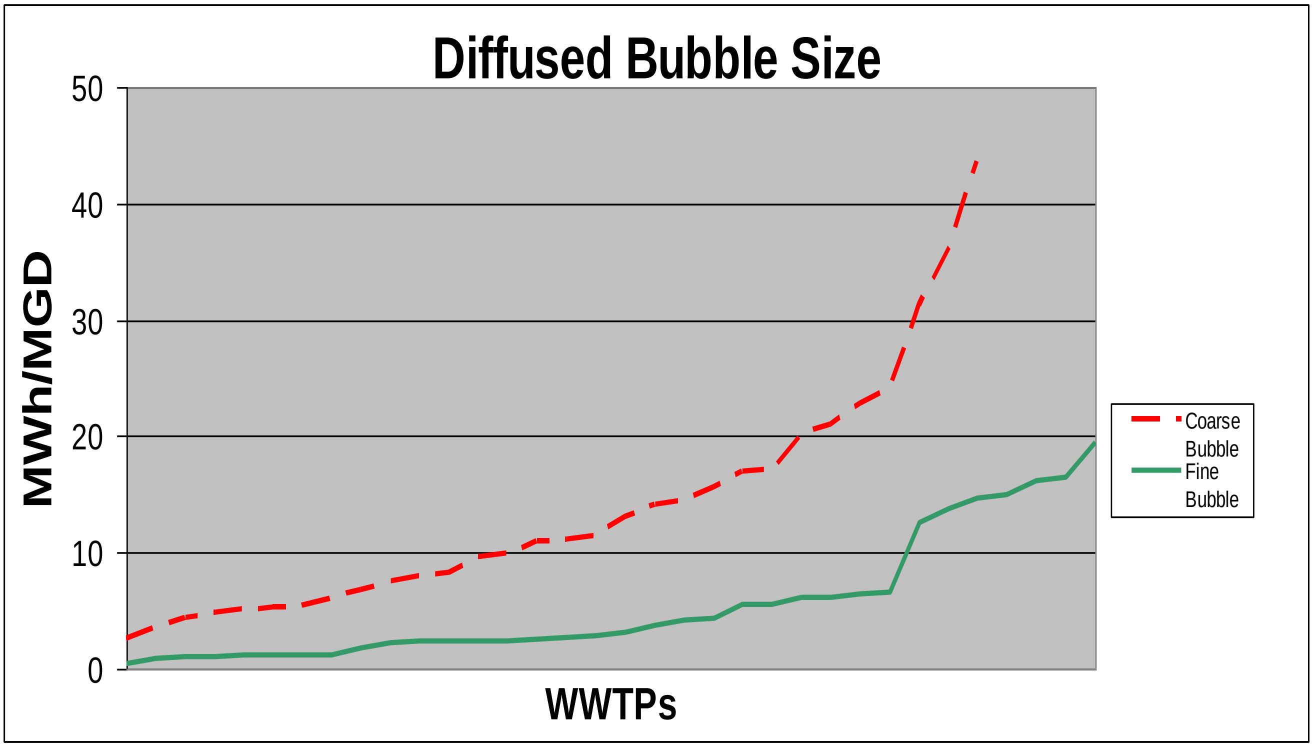
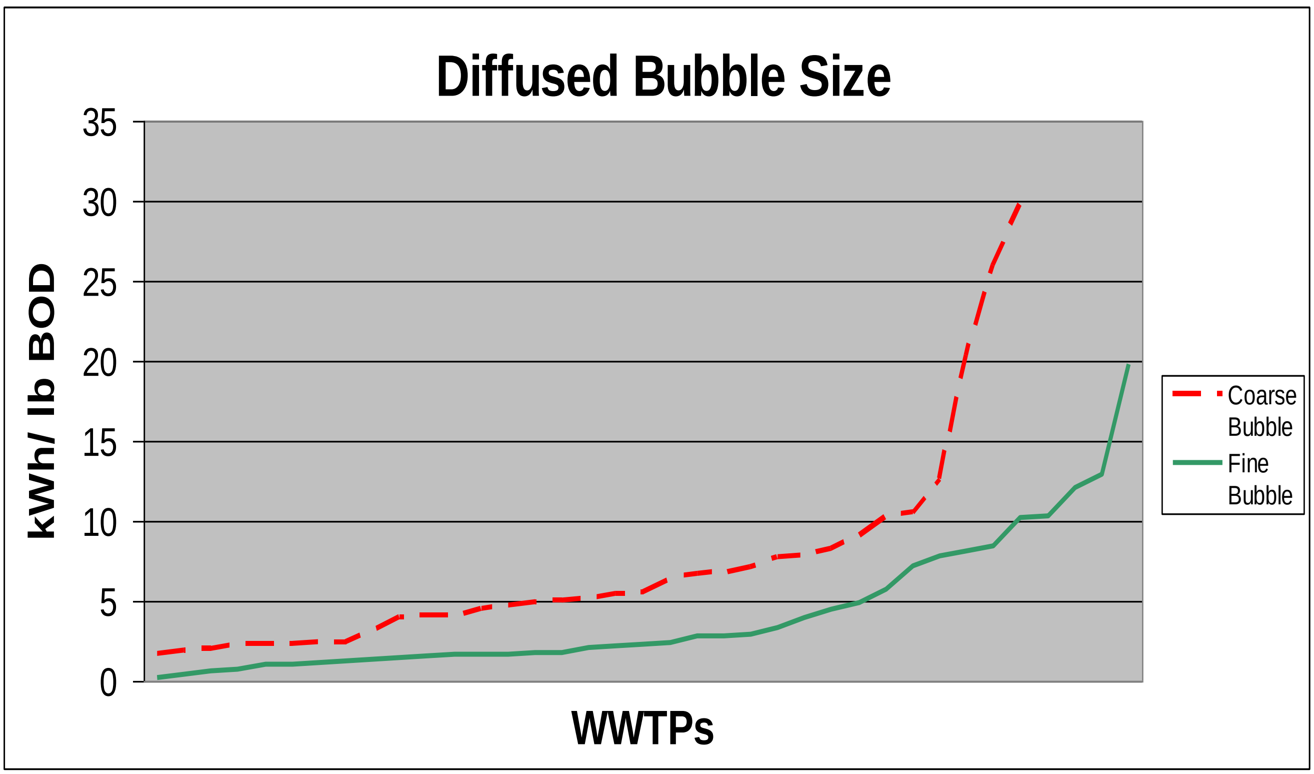


Figure 14



On-Off aeration is an operating mode that offers many advantages. SBRs, extended aeration and other processes incorporate extended periods of no aeration in the treatment cycle. Plants both with and without effluent nitrogen limits have cut energy, chemical, maintenance, and other costs by incorporating up to 12 hours of air off time into the daily cycle. Effluent quality can be improved due to better settleability and retention of solids during high flows. Energy savings of 15%- 45% are common for plants that have gone from full-time to on-off aeration (from *On/Off Aeration Saves Money and Improves Effluent Quality*, Ronald G. Schuyler, presented at 12th Annual National Operator Trainers' Conference, Kansas City, June 1995).

Activated sludge systems should:

- Evaluate opportunities for multi-blower or cascading blower operation and the latest fine bubble diffuser, blower technology and DO control strategies
- Consider "packaged" blower products that include blower, adjustable speed drive, DO sensor and PLC controls
- Annually test efficiency of blower motors (amperes, head loss, air flow, pressure, and other relevant system performance metrics)
- Convert from coarse bubble to fine bubble aeration
- Reduce air pressure when possible
- Repair leaks in the blower ductwork
- Maximize energy efficiency and system performance with operation and maintenance procedures
- Schedule equipment service, including diffuser maintenance (cleaning, replacement of broken units, etc.)
- Provide energy management training for operations staff regarding blower technology and DO management

Energy consumption at WWTPs can be reduced through conversion from standard to energy efficient equipment. Commonly installed energy efficient technologies include fine bubble diffusers, automated DO control systems (discussed above) as well as adjustable-speed drives (ASDs) and high or Premium efficiency motors. ASDs such as variable frequency and magnetic drives adjust motor or drive shaft speed in response to fluctuating demand. For example, an ASD on a blower motor can be linked to DO sensors, providing consistent DO concentrations over a wide range of flow and organic loading. Aside from the energy benefits, ASDs provide longer life cycles and less wear and tear on equipment. Payback periods for these drives range from a few months to less than three years for drives ranging in size from 25 to 250 HP. Programmable logic controls (PLCs) can automatically sequence and activate motors that drive pumps or aeration units to exploit off-peak electricity rates.

Typically, pump and blower motors account for 80% to 90% of energy costs at wastewater treatment plants. Premium efficiency motors are 28% more efficient than standard motors. In addition, efficient motors have lower failure rates as compared to standard motors. Selecting an appropriately sized motor is very important because motor efficiency drops rapidly when operation falls below 50% of full load capacity. Selecting an appropriately sized pump also improves energy efficiency. Use of oversized pumps often requires throttling to meet actual system needs. Energy losses due to throttling can be huge. Consider variable loads, fluid velocity, motor and pump types when choosing or modifying a pumping system to maximize energy efficiency.

Now What? Improving Your Plant's Efficiency

- All facilities have energy saving opportunities regardless of size
- Choose projects based on life cycle cost, not lowest first cost
- Simple modifications to equipment and/or operation can result in significant savings
- Aeration systems modifications provide the greatest savings opportunities
- Make a short list of things to do:
    - track motors and pumps efficiencies
    - evaluate operation mode (step feed vs. plug flow; on/off air vs. full time air)
    - unit-by-unit assessment of pump systems (over or under loaded)
- Invite someone knowledgeable but unfamiliar with your plant to do a walk-thru
- Consider using your electric utility, an ESCO (Energy Services Company) and/or other consultant to get more information, an energy audit and funding assistance
- Electric utilities offer financial incentives to install energy efficient measures such as, design and retrofit costs for ASDs/motors, HVAC upgrade (electric heat pump) and lighting until May 2013
- Use biogas to generate electricity or heat
- Install motion-detecting lights or lights on timer switches in infrequently-used stations
- Replace High Intensity Discharge, T12 lighting with T8, T5 or LED lighting
- Heat and cool with heat pumps using effluent
- Install heat exchangers to recapture heat from exhaust air
- Use a combined heat and power (CHP) system to capture the methane
- Outfalls with significant head may be good candidates for hydropower
- Check out resources in Appendix D
- **When operators are aware of energy, energy management & savings follow**

An energy management program is not a one time event but a continual process. Creating and implementing an energy management program will save money and energy, as well as enhance process control and water quality.

WWTPs are stretched between increasing demands and dwindling resources. Operator and managers are facing increasing costs for labor, chemicals, energy and regulatory compliance. As budgets tighten, operators/managers are looking for ways to operate more efficiently and control costs without cutting services or raising rates. Using energy more efficiently can be an effective strategy to reduce operating costs at your treatment plant.

Appendix A

Survey Data

133 WWTPs completed the *WWTP Energy Use Survey* form (Appendix B). Submissions were received via email and postal mail. Most were submitted via email thru a cooperative effort with the PA Rural Water Association. All calculations are based on a 12-month period, generally calendar year 2008. 117 of the survey forms were determined to be complete and accurate. Data from only these forms are used in the majority of the report. Criteria for a complete, accurate survey form are:

- Must treat sewage (some survey forms were from industrial WWTPs)
- All questions were answered and necessary values were included to calculate WEB
- The reported annual kWh use divided by cost must be $0.06 - $0.17 Calculated cost outside this range indicates a likely error in the reported values.
- Reported information must be reasonable, based on best professional judgment. For example, surveys reporting average flow = 5.0 MGD and average organic load = 100 lb/day or design flow = 5.0 MGD and design load = 20,000 lb/day, would not be used.
- WWTPs with % of design organic load (actual/design x 100) = 7% - 92% and % of design flow = 21% - 115% are included in the report

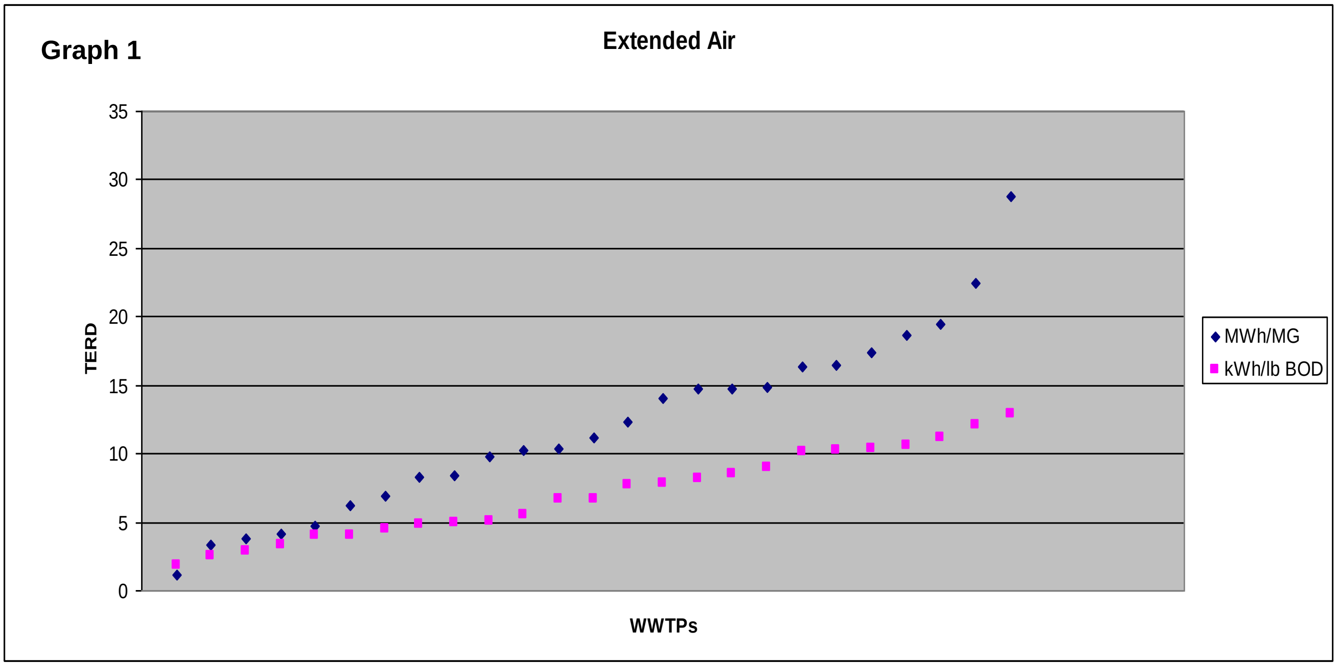
Table 2 Plants by Flow Class

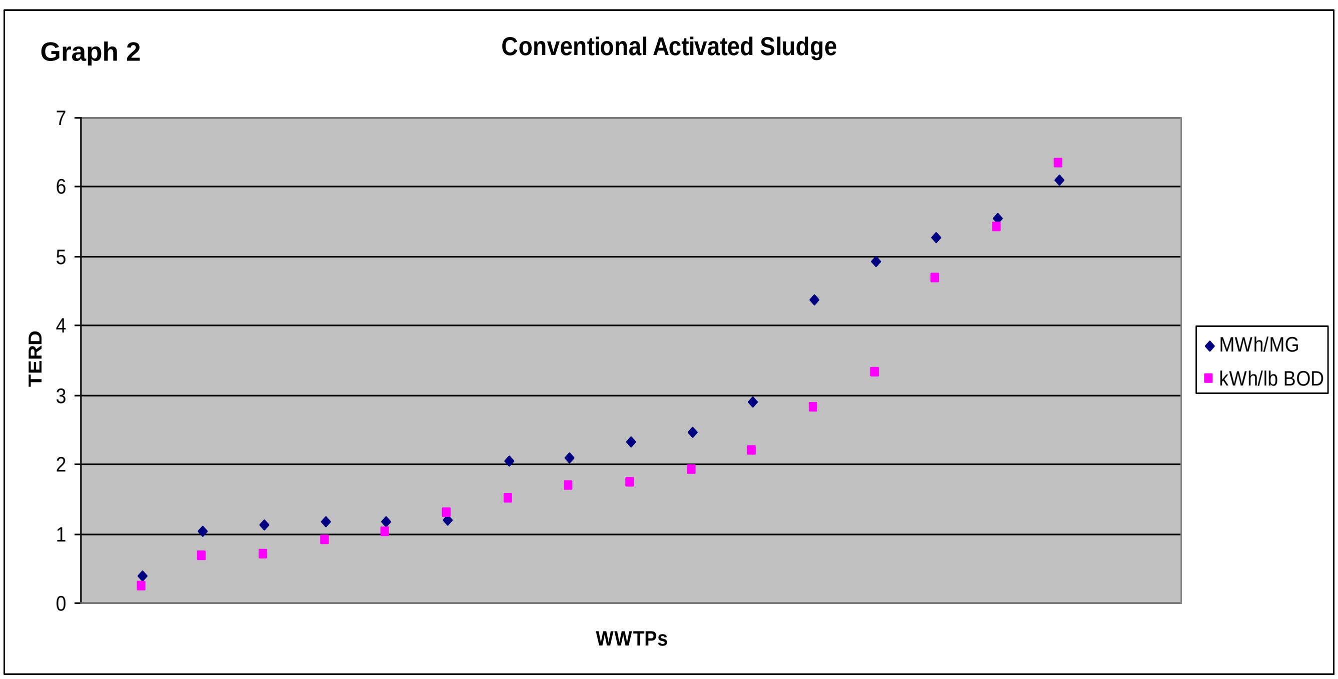
Design Flow (MGD)		# of WWTPs in survey	# of WWTPs PA-wide	Survey vs. PA-wide #
Class A	> 50	2	5	3.4
	> 5 - 50	12	72	1.4
Class B	>1.0 - 5	37	214	1.5
Class C	>0.1 – 1.0	57	490	1.0
Class D	≤ 0.1	25	342	0.6

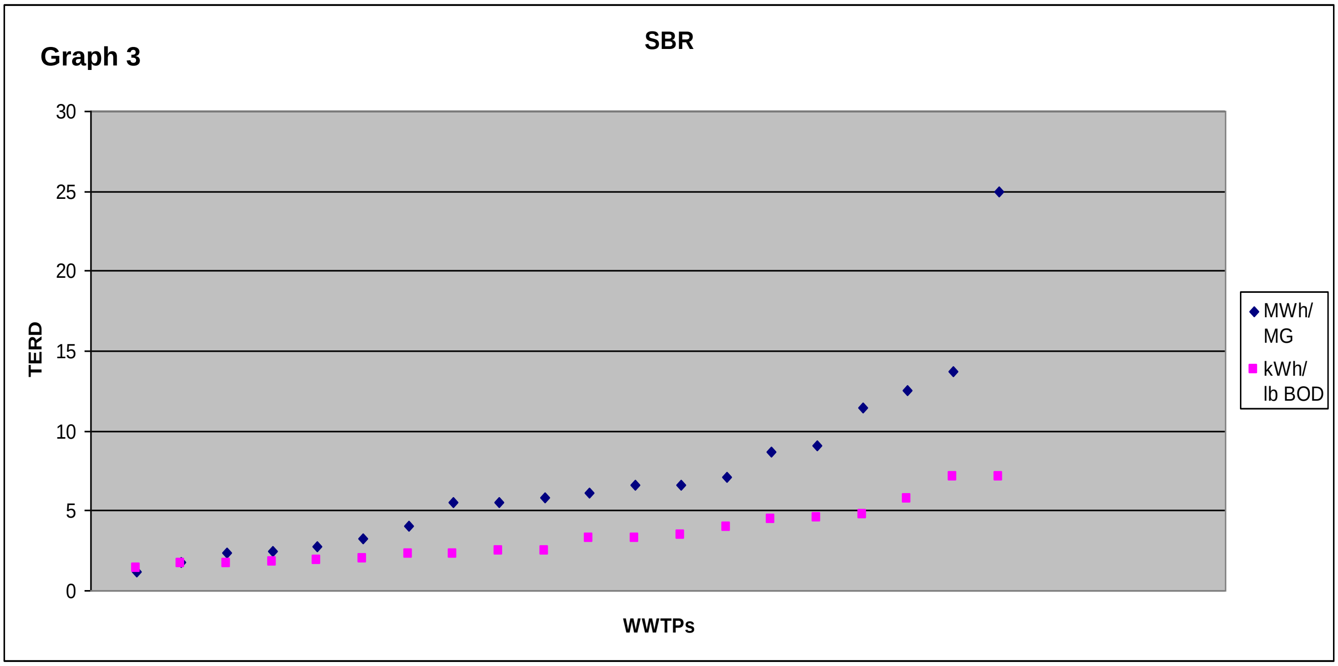
The Department defines design flow as Class A, B, C, or D for regulatory purposes. 89% of plants in the survey and 93% of plants statewide have design flows of 5.0 MGD or less. Nearly two thirds of the WWTPs in PA have design flows of 1.0 MGD or less. The Survey vs. PA-wide # column in the Table 2 above shows the proportion of plants in a particular class submitting surveys verses the proportion in the state-wide population. Class A and B are a higher proportion in the survey than statewide and Class D a lower proportion. For example, Class C plants are about the same proportion in the survey (57 / 133 → 43%) as state-wide (490 / 1123 → 44%). This yields the survey vs. state-wide proportion- 43 / 44 ≈ 1.0.

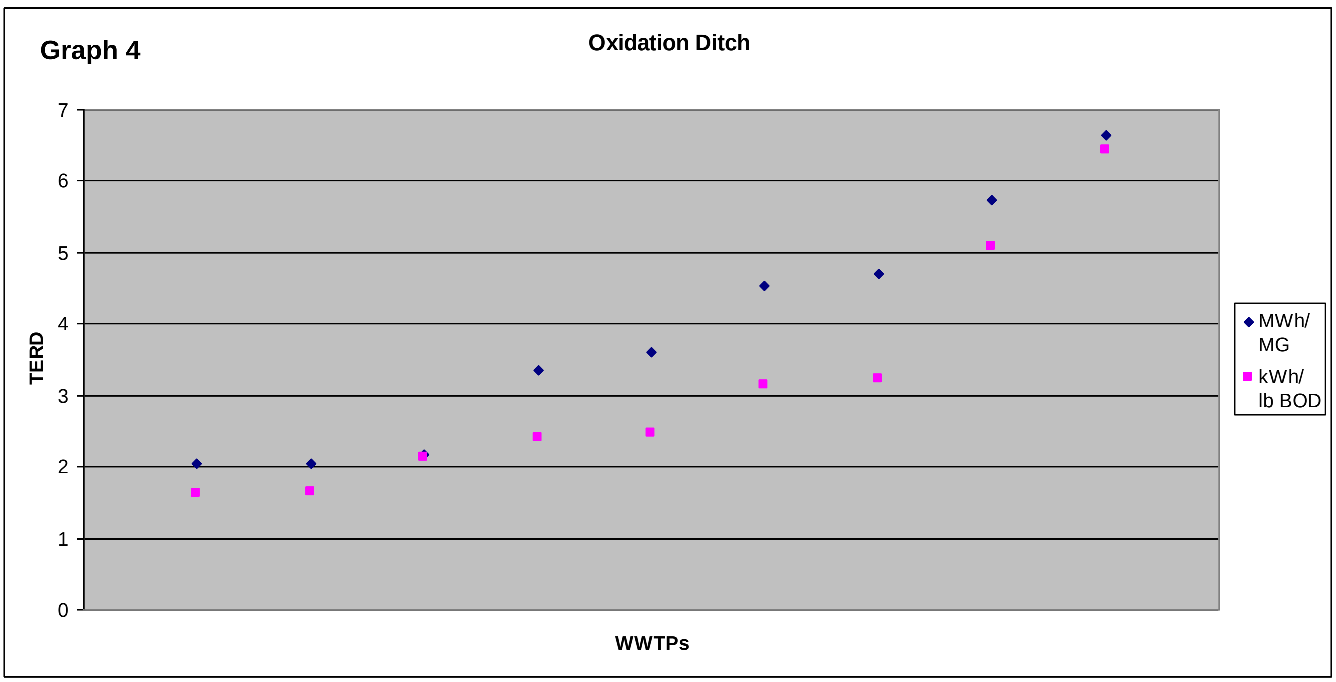
The statewide total design flow for all municipal WWTPs is approximately 2,300 MGD. The sample subset design flow total, 618 MGD, is 27% of this statewide total. As noted in Table 2, larger WWTPs had a proportionally greater response rate to the survey and as a result, the sample subset covers 27% of statewide design flows, while only 10% of the 1,123 plants in the state.

Graphs 1 through 4 illustrate individual plant WEBs for each treatment type. Treatment plants in the lower left of the graphs are the most energy efficient (low WEB).






Graph 3
SBR
30
25
20
15
10
5
0
TERD
WWTPs
MWh/ MG
kWh/ lb BOD


Graph 4
Oxidation Ditch
7
6
5
4
3
2
1
0
TERD
WWTPs
MWh/ MG
kWh/ lb BOD

Descriptions for selected terms

Aeration: Data for Figures 12-14 use survey forms reporting coarse bubble, coarse bubble/mechanical mixing, or fine bubble only. 29 survey forms from activated sludge WWTPs reported a combination of methods or did not report aeration method.

Benchmark: Derived by selecting the lowest value of the top 10% most efficient plants in each treatment type.

DO control: Data for Figure 11 includes only activated sludge WWTPs (Conventional Activated Sludge, Contact Stabilization, Extended Aeration, Oxidation Ditch and Sequential Batch Reactor). Aerated lagoons are not included.

Disinfection, Solids Handling, and Nutrients: Some bias is expected in energy use within size classes based on these parameters. The report does not quantify such impacts.

kWh: kilowatt hour = 1,000 watt-hours. Commonly used by electrical distribution companies for billing. The monthly energy consumption of a typical residential customer ranges from a few hundred to a few thousand kilowatt-hours.

MWh: Megawatt hours = 1,000,000 watt-hours. Used for metering large amounts of electricity to industrial customers and in power generation.

Statewide WWTPs: Totals (1,123 plant name and design flow) taken from The Department's databases in June 2009.

Treatment Type: Primary treatment type was used for plants reporting more than one type.

WWTP: Plants treating primarily domestic wastewater - mostly publicly owned, municipal plants. Plants with design flow ≤0.01 MGD are not included.

Appendix B

WWTP Energy Use Survey

NPDES Permit Number: _____
Facility Name: _____
Contact: _____
Email: _____

Please check all boxes that apply or enter the answer on the blank line. Note that #4, 5 & 6 are **lb/day** and #7 is **mg/l**.

1. A. Type of treatment:

   ☐ Conventional Activated Sludge ☐ SBR ☐ Extended Aeration

   ☐ Oxidation Ditch ☐ Contact Stabilization ☐ RBC ☐ Trickling Filter

   ☐ Lagoon ☐ Other _____

   B. Do you have advanced treatment such as sand filtration or multi-staged biological treatment? ☐ Y or ☐ N

2. Design daily flow: _____ MGD
   In the Water Quality Management permit (monthly average value for flow) or the Chapter 94 Report

3. Annual average daily flow: _____ MGD
   From plant records or the Chapter 94 Report

4. Design influent BOD loading: _____ lb/day
   In the Water Quality Management permit (organic design capacity) or the Chapter 94 Report

5. Annual average daily influent BOD: _____ lb/day
   From plant records or the Chapter 94 Report

6. Annual average daily effluent BOD _____ lb/day or cBOD: _____ lb/day

7. NPDES permit discharge limits

   a. Effluent NH3-N (ammonia nitrogen) limit:
      Winter _____ mg/l
      Summer _____ mg/l
      No limit _____

b. Effluent TP (total phosphorus) limit:
   Winter ______ mg/l
   Summer ______ mg/l
   No limit ______

c. Effluent TN (total nitrogen) limit:
   Winter ______ mg/l
   Summer ______ mg/l
   No limit ______

8. Solids handling/dewatering:
   ☐ Aerobic Digestor ☐ Anaerobic Digestor

   ☐ Drying Bed ☐ Belt Press ☐ Reed Bed ☐ Thickener

   ☐ Centrifuge ☐ Other______

9. Please mark [yes] or [no] if used at your plant

Activated Sludge - Aeration Method

	Yes	No
Mechanical Mixer/Sparge Ring	☐	☐
Coarse Bubble	☐	☐
Fine Bubble	☐	☐
Pure Oxygen	☐	☐

Is automated DO monitoring used to control DO levels in the aeration process? ☐ ☐

Disinfection

Chemical	☐	☐
Ultraviolet (UV)	☐	☐

10. Is digester gas recovered? ☐ Yes ☐ No
    How much biogas is used? ______ (ccf)

11. Is electricity generated on-site? ☐ Yes ☐ No
    What is the fuel source? ☐ Biogas ☐ Natural Gas ☐ Other: ______

12. Annual electric costs: ______
    Compile <u>12 months</u> (one year) of electric bills or call your electric utility for information
    Add together <u>12 months</u> (one year) of your electricity charges/costs

13. Annual electric consumption: ______ (kWh)
    Total kWh or consumption (use) is usually summarized at the end of your bill
    Add together <u>12 months</u> (one year) of total kWh (kilowatt-hour) usage

Appendix C

Manual WWTP Efficiency Baseline Calculation

Column	1	2	3	4
	Electric use (kWh)	Average daily flow (MGD)	Average daily influent BOD (lb/day)	Average daily effluent BOD or cBOD (lb/day)
January				
February				
March				
April				
May				
June				
July				
August				
September				
October				
November				
December				
Totals				

1. Fill out the information in the table above.

2. Total each Column 1: (kWh), 2: (MGD), 3: (INBOD) and 4: (EFFBOD).

3. Calculate **MWh/MG** (Megawatt-hour per million gallons):

$$\textbf{MWh/MG} = \frac{\text{Column 1 total kWh}}{(\text{Column 2 total MGD})\ (30400)}$$

4. Calculate **kWh/lb BOD** (kilowatt-hour per pound treated BOD):

$$\textbf{kWh/lb BOD} = \frac{\text{Column 1 total kWh}}{(\text{Column 3 total INBOD} - \text{Column 4 total EFFBOD})\ (30.4)}$$

Appendix D

Resources

Consortium for Energy Efficiency:
http://www.cee1.org/ind/mot-sys/ww/cr.php3

Department of Energy, Pump Systems Matter, Hydraulic Institute:
http://www.pumpsystemsmatter.org/

Department of Energy, Pumping System Assessment Tool:
http://www1.eere.energy.gov/industry/bestpractices/software_psat.html

Department of Energy, MotorMaster:
http://www1.eere.energy.gov/industry/bestpractices/software_motormaster.html

Electric Utility Rebate Programs:
http://www.pennfuture.org/content.aspx?MenuID=1&SubSubSectionID=296&SubSectionID=293&SectionID=6

EPA ENERGY STAR for Wastewater Plants and Drinking Water Systems:
http://www.energystar.gov/index.cfm?c=water.wastewater_drinking_water

EPA Ensuring a Sustainable Future: An Energy Management Guidebook for Wastewater and Water Utilities:
http://www.epa.gov/waterinfrastructure/pdfs/guidebook_si_energymanagement.pdf

EPA Evaluation of Energy Conservation Measures for Wastewater Treatment Facilities:
http://water.epa.gov/scitech/wastetech/upload/ecm_report.pdf