“Energy Efficiency in Water & Wastewater Systems”

Edward J. Pietroski, PE

ENTECH ENGINEERING, INC.

685 South Mountain Blvd.

Mountaintop, PA 18707

570-868-0275

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ENTECH ENGINEERING, INC.

Understanding Energy Measurements and Charges

Read That Electric Bill !

- Smart Meters
  - Power Utility Website
  - Detailed Power Consumption
- What's it all mean
  - Demand
  - Transmission
  - Distribution
  - Generation Charge
- Your Rate Schedule

PPL Electric Utilities

Questions? Please call our Business Accounts help line by Mar 5.
1-888-220-9991
businessaccounts@pplweb.com

Visit us online at **pplelectric.com**

Bill Acct. No.	Due Date	Amount Due
XXXXXXXX	Mar 5, 2012	$1,485.66

Your Electric Usage Profile

Service to:
XXXXXXXXXXX
XXXXXXXXXXX

Your next meter reading is on or about Mar 5, 2012.

This section helps you understand your year-to-year electric use by month. Meter readings are actual unless otherwise noted.

Billing Summary (Billing details on back)

Balance as of Feb 2, 2012	**$0.00**
Charges:	
Total PPL Electric Utilities Charges	$1,485.66
Total Charges	$1,485.66
Amount Due By Mar 5, 2012	**$1,485.66**
Account Balance	$1,485.66

PPL Electric Utilities' price to compare for your rate is 6.775 cents per kWh effective 12/1/2011 to 2/29/2012. For a list of supplier offers, visit **papowerswitch.com** or **www.oca.state.pa.us.**

Your Message Center

- Peak Demand, 247.68 kW.
- With paperless billing, you can receive and pay your PPL Electric Utilities bills online. The process is free, quick, convenient and secure. To learn more or sign up, visit **pplelectric.com.**
- Before digging around your home or property, you should always call the state's One Call notification system to locate any underground utility lines. You can do this by simply dialing 811, which will connect you to the One Call system. Be safe and call 811 before you dig.
- Save postage and late charges - sign up for Automated Bill Payment.

Payment Methods

Online at:
pplelectric.com

By phone: **1-800-342-5775**
or call BillMatrix (service fee applies) at **1-800-672-2413** to pay using Visa, MasterCard, Discover or debit card.

By Mail:
2 North 9th Street
CPC-GENN1
Allentown, PA 18101-1175

Correspondence should be sent to:
Business Accounts
827 Hausman Road
Allentown, PA 18104-9392

Other important information on the back of this bill →

PPL Electric Utilities

Return this part in the envelope provided with a check payable to PPL Electric Utilities.

Bill Acct. No.	Due Date	Amount Due
XXXXXXXXXX	Mar 5, 2012	$1,485.66

Amount Enclosed:

XXXXXXXXXXX
XXXXXXXXXXX

PPL ELECTRIC UTILITIES
2 NORTH 9TH STREET CPC-GENN1
ALLENTOWN, PA 18101-1175

Your Supplier Contact Information

For questions regarding the generation and transmission portions of this bill, please contact your supplier at:

GDF SUEZ Energy Resources NA
Customer Services
P.O. Box 25225
Lehigh Valley, PA 18002-

Phone:
1-888-232-6206

Manage Your Account

Visit **pplelectric.com** for self-service options including:
- -View your bill, payment, and usage history.
- -Make a payment, set up a payment agreement.
- -Start/stop service.
- -Enroll in paperless billing, automatic bill pay, budget billing.
- -Report an outage, check outage status, and more.

View your rate schedule at **pplelectric.com/rates** or call **1-800-342-5775** to request a copy.

General Information

Generation prices and charges are set by the electric generation supplier you have chosen. The Public Utility Commission regulates distribution rates and services. The Federal Energy Regulatory Commission regulates transmission prices and services.

PPL Electric Utilities uses about $1.78 of this bill to pay state taxes and about $87.65 is used to pay the PA Gross Receipts Tax.

Billing Details

Previous Balance	$1,604.34	
Payment Received Jan 11, 2012 - Thank You!	-$1,604.34	
Balance as of Feb 2, 2012		$0.00
Charges for - PPL Electric Utilities		
General Service Rate: GS3 for Jan 4 - Feb 2		
Distribution Charge:		
Customer Charge	30.00	
248.0 kW at $4.51000000 per kW	1,118.48	
Smart Meter Rider	5.06	
Act 129 Compliance Rider	337.26	
PA Tax Adj Surcharge at -0.34500000%	-5.14	
Total PPL Electric Utilities Charges		$1,485.66
Amount Due By Mar 5, 2012		**$1,485.66**
Account Balance		$1,485.66

kWh Use By Meter

Reading Dates Previous/Present		Meter Number	Meter Constant	Meter Reading Previous/Present		Kilowatt Hours
Jan 4	Feb 2	93396833	480	08711	08922	101280
					Total	101280

Understanding Your Bill

Act 129 Compliance Rider - Charge to recover costs associated with Energy Efficiency and Conservation programs for customers as approved by the Public Utility Commission.

Customer Charge - Monthly basic distribution charge to cover costs for billing, meter reading, equipment, maintenance and advanced metering when in use.

Distribution Charge - Charge for the use of local wires, transformers, substations and other equipment used to deliver electricity to end-use consumers from the high voltage transmission lines.

kWh (Kilowatt-hour) - The basic unit of electric energy for which most customers are charged. The amount of electricity used by ten 100-watt lights left on for 1 hour. Consumers are usually charged for electricity in cents per kilowatt-hour.

Smart Meter Rider - Charge to recover costs associated with the Smart Meter Plan for customers as approved by the PUC.

State Tax Adjustment Surcharge - Charge or credit on electric rates to reflect changes in various state taxes included in your bill. The surcharge may vary by bill component.

Type(s) of Meter Readings:
Actual - Reading by distribution company.

***Federal I.D. 23-0959590**

$1,485.66

GDF SUEZ

SERVICE ADDRESS:

[redacted]

BILLING PERIOD
Feb 2, 2012 to Mar 05, 2012

Pay This Amount

AMOUNT DUE
$8,896.00
DUE DATE:
March 27, 2012

Questions about Your Bill?	Phone	Online Billing	Email Us
	1-888-232-6206	mygdfsuezenergybilling.com	custserv@gdfsuezna.com

For power outages and other electrical emergencies, call your electric distribution company:
PPL Electric Utilities
827 Hausman Rd
Allentown PA 18104-
1-800-342-5775
Utility Account Number:
0025162001

ACCOUNT BALANCE AS OF MAR 7, 2012	
Previous Balance	$7,667.56
Payment Received Feb 15 - THANK YOU	$7,667.56
Balance Remaining	$0.00
Current Charges	$8,896.00
Total Amount Due	**$8,896.00**

Charges for Billing Period for Feb 2, 2012 - Mar 5, 2012	
Energy Charges	
Energy 117600 kWh at $0.0701 per kWh	8,243.76
Trans Tariff Change	
198.08 kW @ $0.020096 /kW for 32 days	127.38
Subtotal Energy Charges	**8,371.14**
Taxes	
Gross Receipt Reimbursement	524.86
Subtotal Taxes	**524.86**
Total Energy Charges	**$8,896.00**
Total Charges for this Billing Period	**$8,896.00**

GENERAL INFORMATION

Thank you for being a GDF SUEZ Energy Resources customer, we value your business.

Your monthly charges from GDF SUEZ Energy Resources average 7.12¢ per kWh (Price to Compare).

If you are transferring service to another electricity provider at the end of your contract term with GDF SUEZ Energy Resources, please be aware that your service with GDF SUEZ Energy Resources doesn't expire until the regularly scheduled utility meter read date that follows the last day of April 2012.

Meter data on back.

GDF SUEZ Energy Resources reports status of accounts and payment history to credit bureaus.

Energy Efficiency in Water/Wastewater Systems

Pennsylvania Electric Utility Web-Links:

- (Allegheny Power): www.alleghenypower.com
  - Viewing your account information
  - Pick State (PA)
  - Products & Services
  - Energy Data Services
  - Log-In (Interval Metering Information)

- (Wellsboro Electric): www.wellsboro electric.com
  - E-Bill Account access

Energy Efficiency in Water/Wastewater Systems

Pennsylvania Electric Utility Web-Links:

- (Penn Power): www.firstenergycorp.com/pennpower.html
  - www.firstenergycorp.com/log-in.html
- (Duquesne Light): www.duquesnelight.com
  - www.duquesnelight.com/ssl/ForOurCustomers/login.cfm
- (Citizens Electric): www.citizenselectric.com
  - ebill.citizenselectric.com/css/
- (Pennelec): www.firstenergycorp.com/penelec.html
  - www.firstenergycorp.com/log-in.html

Energy Efficiency in Water/Wastewater Systems

Pennsylvania Electric Utility Web-Links:

- (Metropolitan Edison): www.firstenergycorp.com/met_edison.html
  - www.firstenergycorp.com/log-in.html
- (PECO (Exelon Com)): www.peco.com/Pages/Home.aspx
  - My Account
  - Usage (Log In)
  - E-Valuator Service (on line graphic and technical analysis/output)
- (Pike County Light & Power Co.): www.oru.com/index.html
  - My Account – Log in

Energy Efficiency in Water/Wastewater Systems

Pennsylvania Electric Utility Web-Links:

- (UGI Utilities Inc.): www.ugi.com/portal/page/portal/UGI/Home
  - www.ugi.com/portal/UGI/Customer_Services/Restrict_Account_Info_Electric

- (PPL Electric Utilities): www.pplelectric.com/Commercial+and+Industrial/#
  - www.pplelectric.com/Commercial+and+Industrial/Information+Center/
  - Requests for Customer Demand and Consumption History

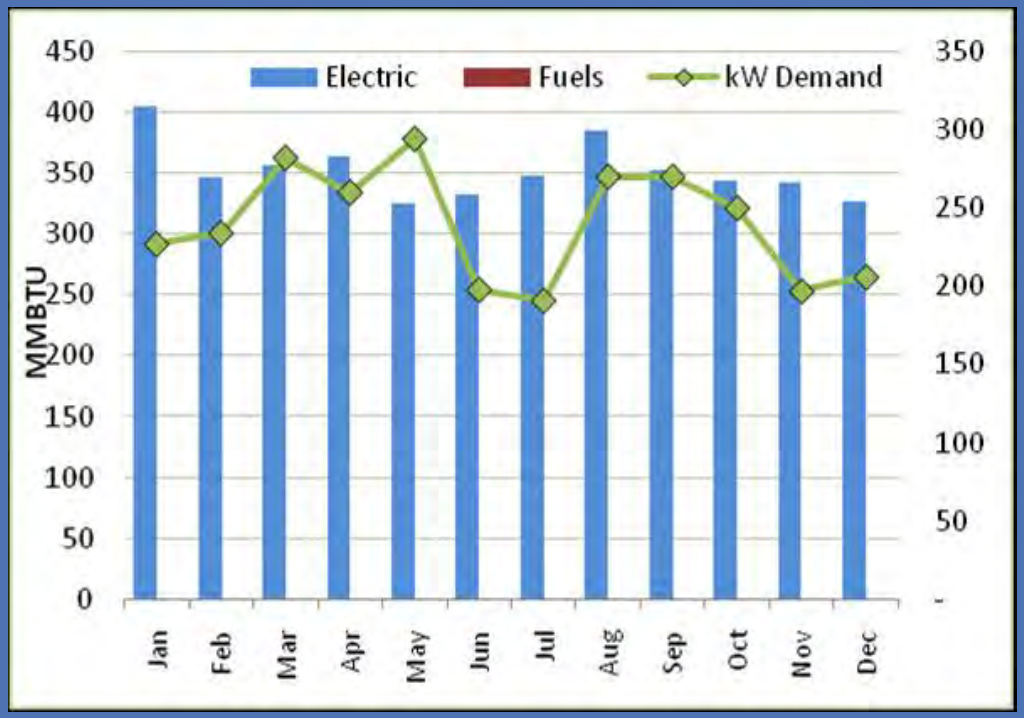
PPL Smart Meter Pilot Program

Electric Smart Meter Program - Potential Smart Meter Capabilities:

- Provide customers with direct access to price and consumption information.
- Provide customers with information on their hourly consumption (15 min. data).
- Ability to upgrade these minimum capabilities as technology advances and becomes economically feasible.
- Remote programming capability.
- Communicate outages and restorations.
- Ability to support net metering of customer generators (Demand Response Programs)

UTILITY BILL ANALYSIS

- Demand Charges & Peak Use Analysis
- Diurnal or Seasonal Differences



- Site Comparisons
  - Multiple Pump or Booster Stations in System
- Establish Metric – e.g. kWh-Month/rated HP or ¢/1000-gal.

PPL WEB PAGE INFORMATION

Home | myPPL | Contact Us | Outage Center | Log Out
Residential | Commercial and Industrial | Business Partners | Community Services
Quick Links

ppl

Commercial and Industrial Customers

myPPL

Welcome,
Edward Pietroski
ejp@entecheng.com
[Update your web profile]
[My Bank Information]

XXXXXXXXXXXXXX
XXXXXXXXXXXXXX

Rate Type:
GS-3 Distribution Only
[Select/Add a different account]

- > myPPL Energy Analyzer
- > View My Bill
- > Make a Payment
- > myPPL Alerts Enrollment
- > Phase-In Option
- > Deferral Option
- > Privacy Release
- > Enroll in Automatic Bill Payment
- > Enroll in Paperless Billing
- > Enroll in Budget Billing
- > Stop Service
- > Start Service
- > View Service Order(s)
- > View Payment History
- > Update Contact Info
- > Request Duplicate Bill
- > Report an Outage
- > My Outage Status
- > Take a Survey

WAYMART SEWER
XXXXXXXXXXXXX

XXXXXXXXXXXXXXXXXXXX

Bill Center

Bill History | Account Activity | Make a Payment

Business Bill Center

Welcome WAYMART SEWER !
Today is Friday, March 16, 2012.

Account Summary
0025162001

Account status as of 3/16/2012

Last Payment	$1,715.92
Received 3/14/2012 – Thank you!	
Account balance	**$0.00**

Bill Summary ending 3/5/2012

Previous balance	$0.00
Total current charges	$1,715.92
Amount Due 4/5/2012	**$1,715.92**

How does your usage compare?
SOUTH ST, SEWER

Electric

View Bill History
Review and compare up to 24 months of your billing history.

When does your business use energy?
SOUTH ST, SEWER

Choose meter: Electric – 93396833

View graphs of my daily or hourly energy use.

Title	Hourly Energy
Meter Number	
Selected Date	2/15/2012
Selected Period	Month
Primary Data Unit	-
Secondary Data Unit	kW
Tertiary Data Unit	-

	12:00 AM	12:15 AM	12:30 AM	12:45 AM	1:00 AM	1:15 AM
2/1/2012	160.51	175.87	139.01	154.94	173.38	158.21
2/2/2012	168.38	165.31	177.22	168.96	137.09	132.86
2/3/2012	166.27	152.26	161.28	181.82	168.19	164.35
2/4/2012	167.42	152.06	177.22	143.81	138.62	125.18
2/5/2012	155.9	156.1	156.1	150.53	174.91	154.94
2/6/2012	187.97	167.04	201.6	158.4	147.46	134.98
2/7/2012	152.83	154.94	150.72	152.45	167.23	156.29
2/8/2012	167.62	158.02	181.25	160.51	156.86	141.7
2/9/2012	84.67	96.96	86.4	105.22	132.29	122.69
2/10/2012	149.76	158.4	154.75	183.17	204.67	180.29
2/11/2012	170.11	150.34	143.81	148.61	186.43	189.89
2/12/2012	140.93	181.82	192.38	182.98	149.57	179.52
2/13/2012	161.28	187.39	196.8	168	155.71	145.54
2/14/2012	162.43	141.5	144	133.82	183.74	191.42
2/15/2012	148.42	132.67	124.42	187.39	188.74	175.68
2/16/2012	142.66	150.91	135.36	171.84	193.34	183.74
2/17/2012	156.86	136.13	124.99	128.06	182.98	176.83
2/18/2012	149.95	140.16	119.62	148.22	179.33	181.06
2/19/2012	140.74	183.17	191.42	178.37	145.15	144.96
2/20/2012	146.5	177.6	141.7	144	129.98	178.94
2/21/2012	161.47	191.62	193.73	151.68	167.62	182.4

Chart of 15 minute kw use for Peak Day

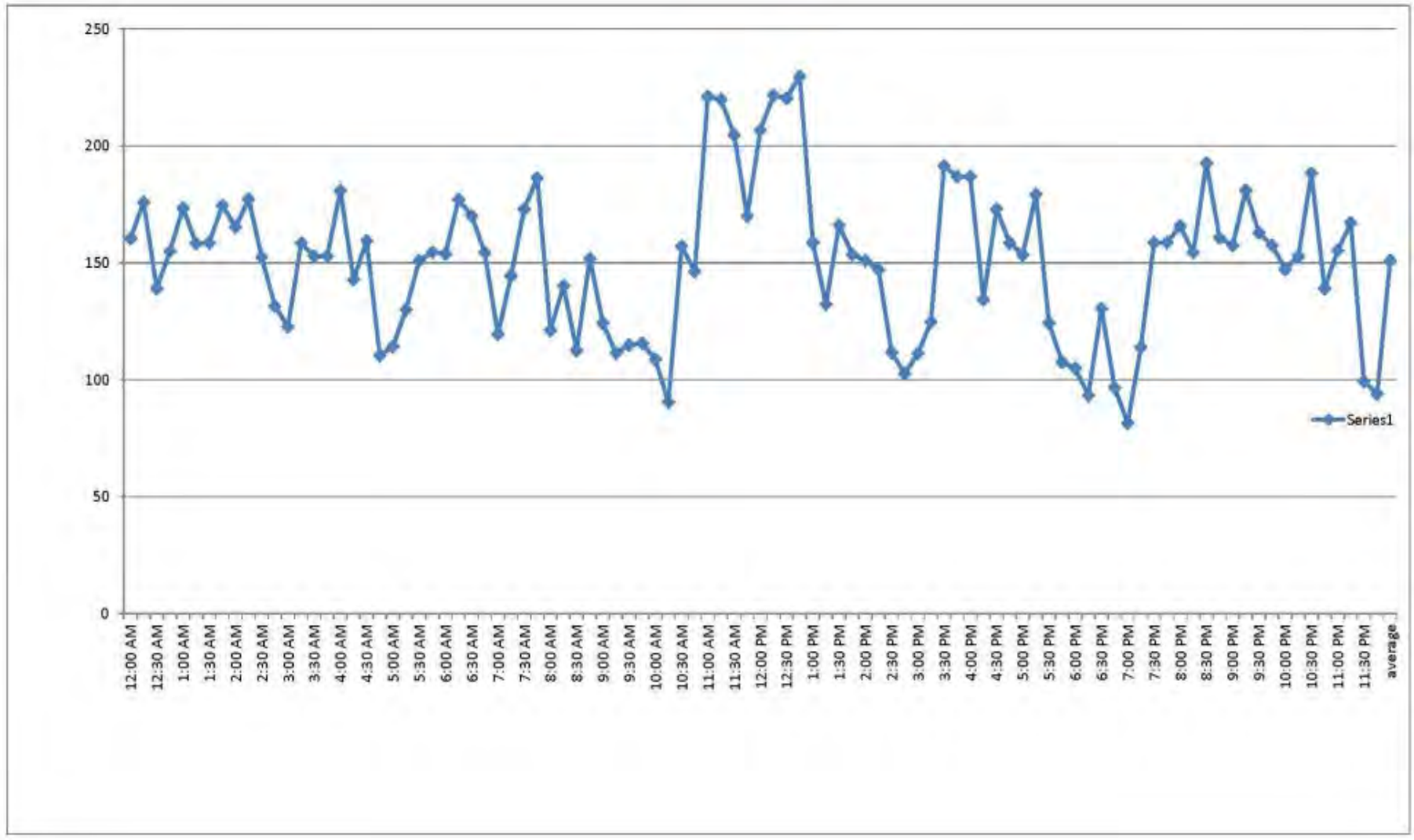
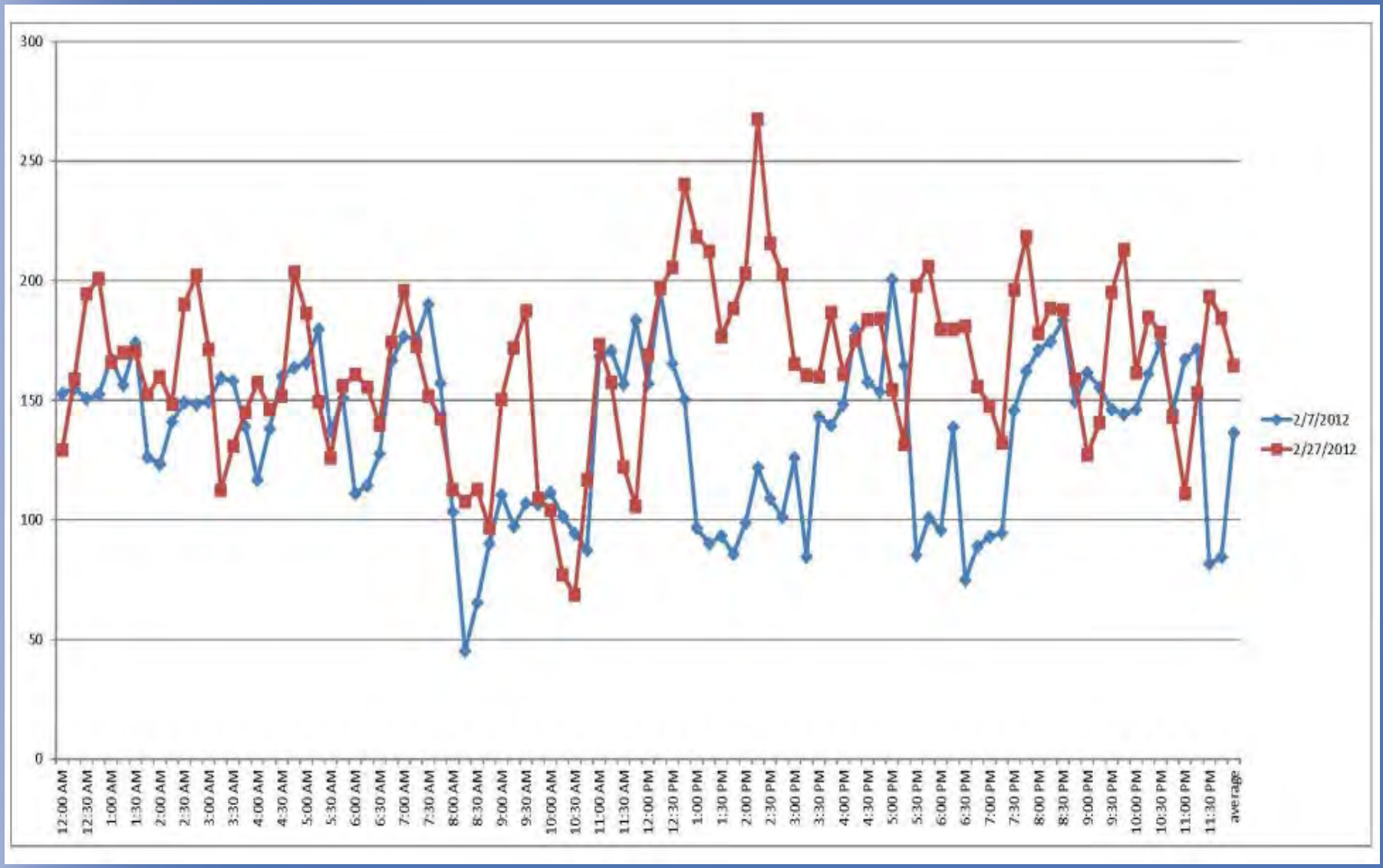


Chart of 15 minute kw use Peak Day vs. Minimum Day



Power Use Compared To Operations

- **Charts can give accurate power use**
- **Document Your Operations !**
  - **Record what's running, the Big Ticket Items**
    - **Influent Pumps**
    - **Aeration Blowers**
    - **Digester Blowers**
    - **Time On - Time Off**
- **EVERY DAY ?**
  - **YES ! But just for a week or 2 weeks.**
  - **Compare spikes to what's on / what's off**
  - **What's the bare minimum**
  - **Do it in the summer dry period, winter cold, wet weather**

Power Use Compared To Operations

- **Charts can give accurate power use**
- **Experiment with varying operations**
  - **Run Blower 1 this week**
  - **Run Spare Blower 2 next week**
  - **Does Blower 1 use less power ?**
    - **Does Blower 2 need an overhaul ?**
    - **Does Blower 2 still have an old inefficient motor**
- **Water System has 5 wells, need 2 or 3 running**
  - **Measure Flow at each well, say for 1 week**
  - **Go to Chart for Exact Power Use**
  - **Determine kWh per 1,000 gallons pumped**
  - **Rely on Wells with lowest kWh per gallon**

Power Use Compared To Operations

- **Charts can give accurate power use**
- **Wire to Water Efficiency in a Well System**
  - **A water supply well has many components**
    - **Pump Efficiency ?**
    - **Motor Efficiency ?**
    - **Control: VFD, Timer, level, PRV, Throttling - Efficiency ?**
    - **Discharge Piping: Diameter & length. Head loss ?**
    - **Discharge Pressure. High or Low ?**
  - **Measuring Power in at meter and pump out put (gallons)**
    - **Determines bottom line efficiency in dollars across system.**

Power Use Compared To Operations

- **Charts can give accurate power use**
- **Wire to Water Efficiency in a Aeration System**
  - **An Aeration system has many components**
    - **Blower Efficiency ?**
    - **Motor Efficiency ?**
    - **Control: VFD, Timer, DO, Relief Valve. Efficiency ?**
    - **Inlet Filters & Silencers. Pressure loss.**
    - **Diffusers - Course or Fine Bubble. Efficiency?**
    - **Diffuser Depth. Deeper, greater efficiency. Backpressure.**
  - **Measuring Power in at meter and……?**
    - **Gallons treated ? Wastewater strength ?**
    - **BOD Lbs. removed ? Nitrogen Lbs. removed ?**
  - **In an Aerobic Digester measure ……**
    - **Volatile Solids Destroyed, pounds.**

Act 129

- The PUC is actively involved in the implementation process for Act 129 of 2008. On Oct. 15, 2008, Governor Rendell signed HB 2200 into law as Act 129 of 2008, with an effective date of Nov. 14, 2008.

- The Act expands the Commission's oversight responsibilities and imposes new requirements on electric distribution companies (EDCs), with the overall goal of reducing energy consumption and demand.

- The Act adds several new sections to, and amends several existing sections of the Public Utility Code. The Commission will implement the Act in phases. The first phase will deal with the Commission's obligation to adopt an energy efficiency and conservation (EE&C) program by Jan. 15, 2009.

Act 129 (cont)

- Act 129 requires each of the seven major Electric Distribution Companies (EDCs) in Pennsylvania to adopt a plan to reduce energy demand and consumption within its service territory.

- The Act requires a 1% reduction in consumption by May 31, 2011, a total of 3% reduction in consumption and a 4.5% reduction in peak demand by May 31, 2013.

Example of Act 129 EDC Implementation
PPL's 15 EE&C Programs

- *1. Efficient Equipment Incentive Program*
- 2. Residential Audit and Weatherization Program
- *3. Compact Fluorescent Lighting Campaign*
- 4. Appliance Recycling Program
- 5. ENERGY STAR® New Homes Program
- *6. Direct Load Control*
- *7. Time of Use Rates*
- 8. Low Income WRAP

Example of Act 129 EDC Implementation PPL's 15 EE&C Programs (cont)

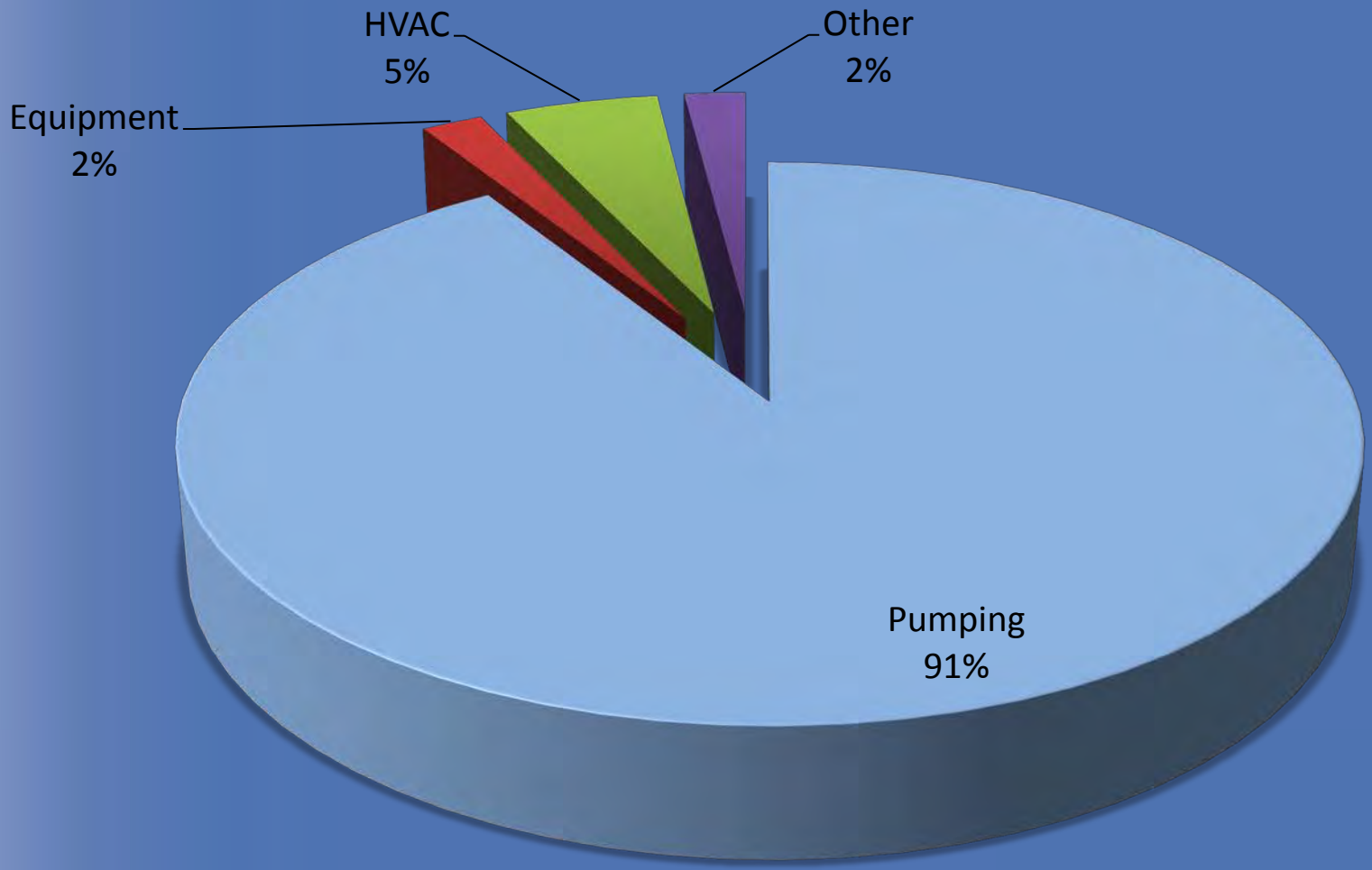
- 9. Low Income e-power Wise
- 10. PHFA Multifamily Housing Efficiency
- *11. Commercial and Industrial Custom Incentive Program*
- 12. HVAC Tune-Up Program
- *13. Curtailment*
- 14. Customer Awareness and Education
- *15. Customer sited renewable generation*

Understand Methods to Identify and Quantify Energy Use

ENERGY CONSUMPTION

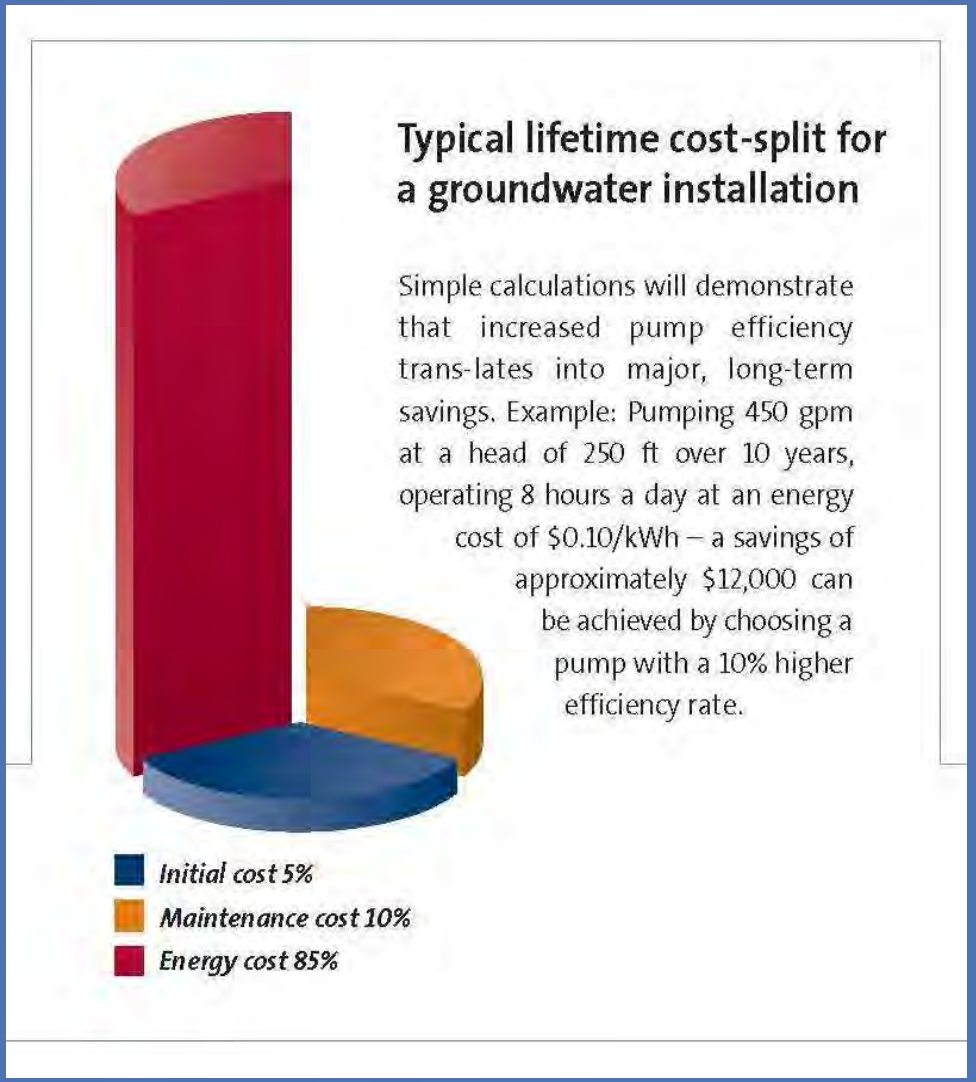
- Benchmarking
  - How do you compare
    - US EPA Energy Star Program
    - Versus other authorities, municipalities or counties
  - Comparisons are Valuable but……
    - Lots of variation from plant to plant
      - Facility Age
      - Flow
      - Treatment Type
      - Running near capacity (efficient) vs. 60% capacity
      - Treatment requirements
    - Take all Benchmarking with a grain of salt

Percent Total Energy in a Groundwater System



Power as a Life Cycle Cost

- Higher Efficiency Pump Costs More
- Higher Efficiency Motor Costs More
- It costs more to maintain ! DOUBLE?
- Energy is the biggest life cycle cost !



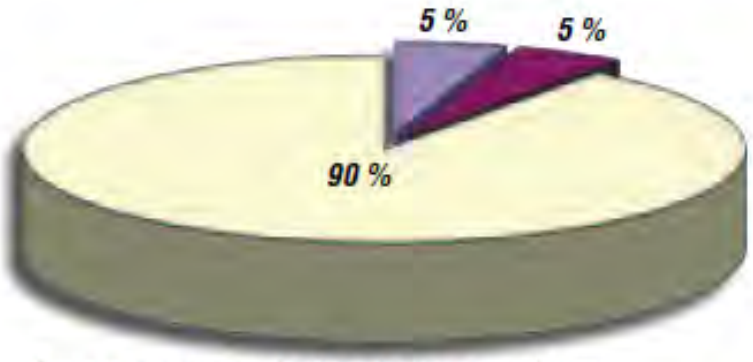
Power as a Life Cycle Cost

Rotary Lobe Compressor

The Rotary Lobe Compressor is the result of a synergy between the rotary lobe blower and the screw compressor technologies.

The Delta Hybrid was developed with the focus on increasing energy efficiency and achieving a significant reduction of energy costs and greenhouse gas emissions.

Wire-to-process energy usage reduction can exceed 30% over typical positive displacement blowers depending on operating conditions and turndown range.



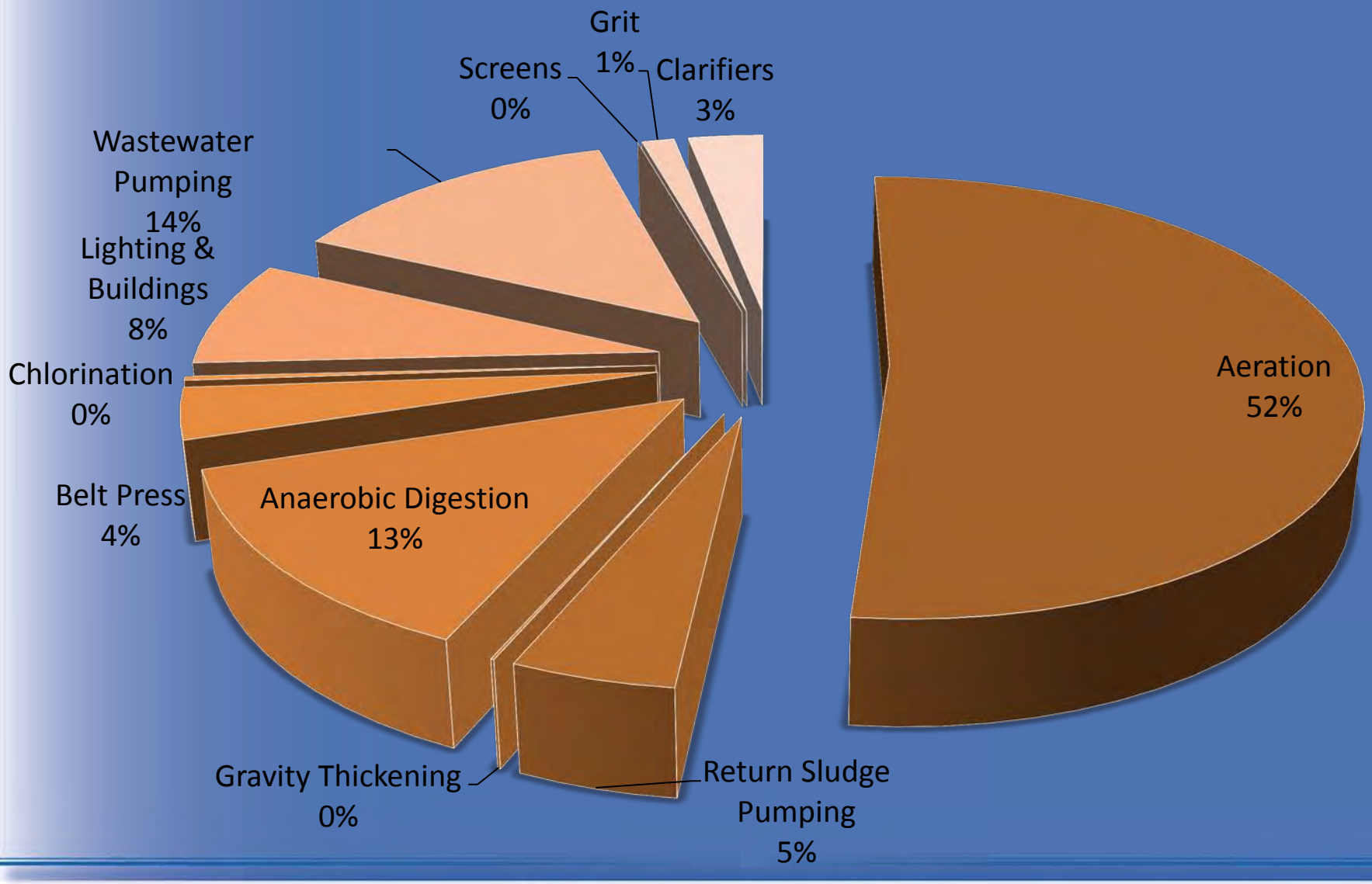
Optimized fluidic design of inlet and discharge ports provides for ideal flow conditions and reduced slippage. Moreover, the belt-driven Delta Hybrid offers the significant advantage of exact sizing: the greatest advantage comes from the energy that does not need to be used. A 5% excess in volume flow corresponds to a 5% higher energy use.

Hybrid Rotary Compressor Stage

3+4 rotor profile with internal compression for low pressure applications.

3+3 rotor profile with twisted rotors and patented pulse charging as well as low squeeze losses.

Percent Total Energy in an Activated Sludge System



ENERGY AUDITS

- Take a detailed look at all areas of your facility
- Make a List, Excel Spreadsheet
  - If its got a wire, list it !
- Record motor ratings, run times, Ultra Violet
  - Power Draw

Measure Power Use per Item

- Actual Use per Unit
  - Measure Operating Amps (current) and Volts
    - KIDS, DON'T TRY THIS AT HOME ! Use a Professional
  - Power = kW = Voltage X Current / 1,000
  - Estimate from Smart Meter Download
  - Kilowatt hour = kWh
    - 30 hp Motor = 50 kW X 24 hours / day = 1,200 kWh
    - 1,200 kWh X 30 days = 36,000 kWh
- Log Power Use in spread sheet
    - How does it compare to total plant
    - Whose the Big Power Hog?

Evaluate Effective Operating Scenarios

NO! I'm not repeating, remember this slide ?

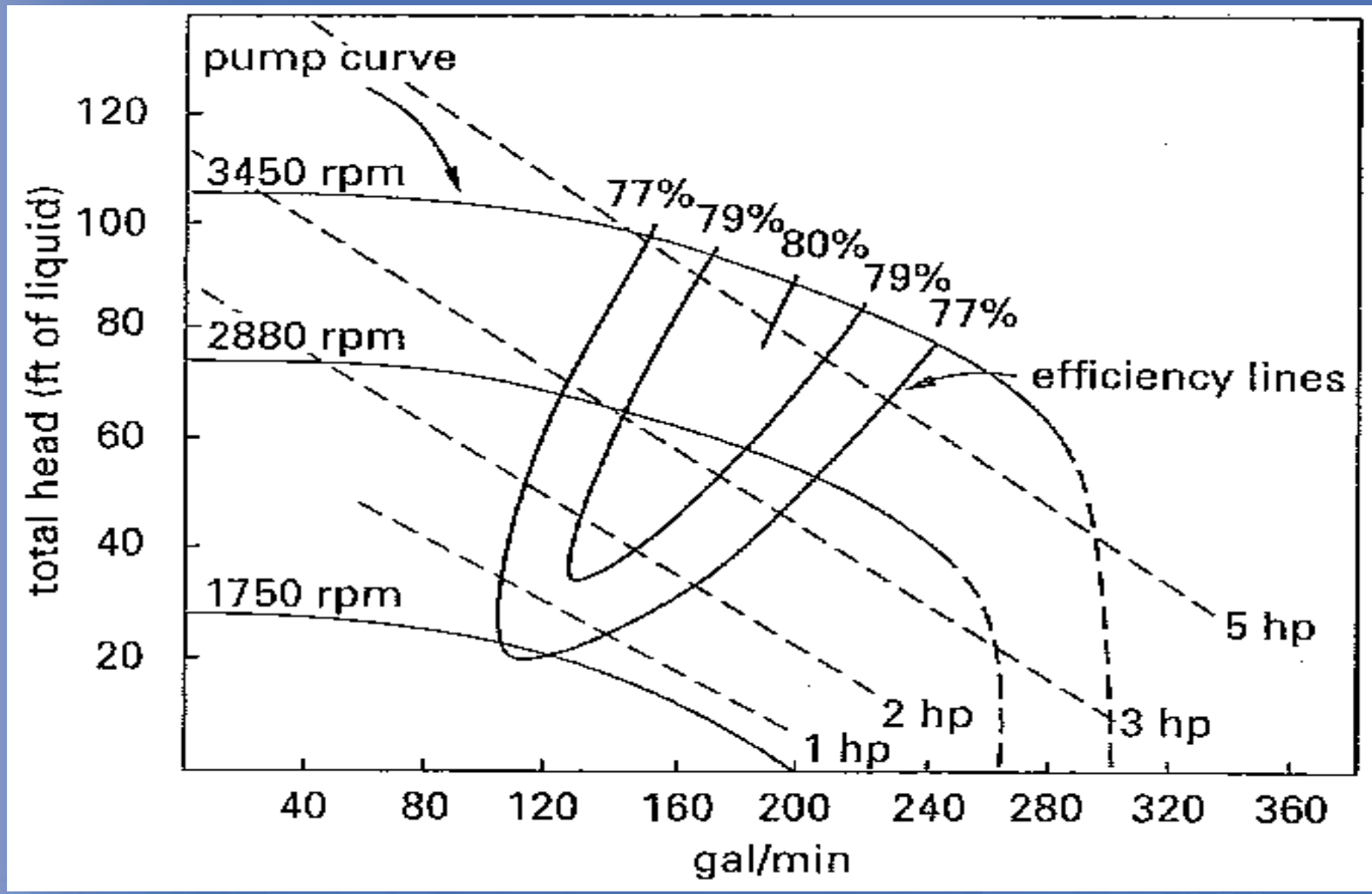
Power Use Compared To Operations

- Charts can give accurate power use
- Experiment with varying operations
  - Run Blower 1 this week
  - Run Spare Blower 2 next week
  - Does Blower 1 use less power ?
    - Does Blower 2 need an overhaul ?
    - Does Blower 2 still have an old inefficient motor
- Water System has 5 wells, need 2 or 3 running
  - Measure Flow at each well, say for 1 week
  - Go to Chart for Exact Power Use
  - Determine kWh per 1,000 gallons pumped
  - Rely on Wells with lowest kWh per gallon

PUMPING CONTROL STRATEGIES

- Constant Speed (CS) versus Variable Speed (VS)
  - Soft starts, longer run times, less cycling
  - For centrifugals, fan affinity laws
    - 80% Flow = 50% rated power
- Multiple Pumps versus Single
  - Use different on/off set points
- Variable Speed versus Multiple Pumps
  - Fewer yet larger pumps
- Combined versus CS Pumps

How That VFD Saves Pump Power



MOTOR EFFICIENCY

- All motors older than the 1970s are likely not high efficiency
  - 91% vs. 95% for 50-HP
- NEMA Premium Efficiency Standards
  - Paybacks in 3 years or less!!!!!!!
  - $554 savings per year for 50-HP Motor
- All older motors should be evaluated for cost of replacement and return on investment
  - Various incentives Federal/State/Utility
  - www.dsireusa.org
- e.g. PPL rebate
  - $25 - $1,595 per motor

PROCESS OPTIMIZATION

- Wastewater Dissolved Oxygen (DO) Control
- Mixing & Aeration Optimization
- Control Industrial Wastewater Dischargers
  - Organics, High BOD, FOG

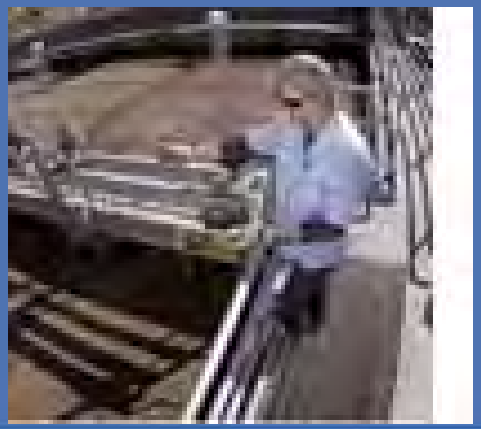
PROCESS OPTIMIZATION

Oxygen Needs

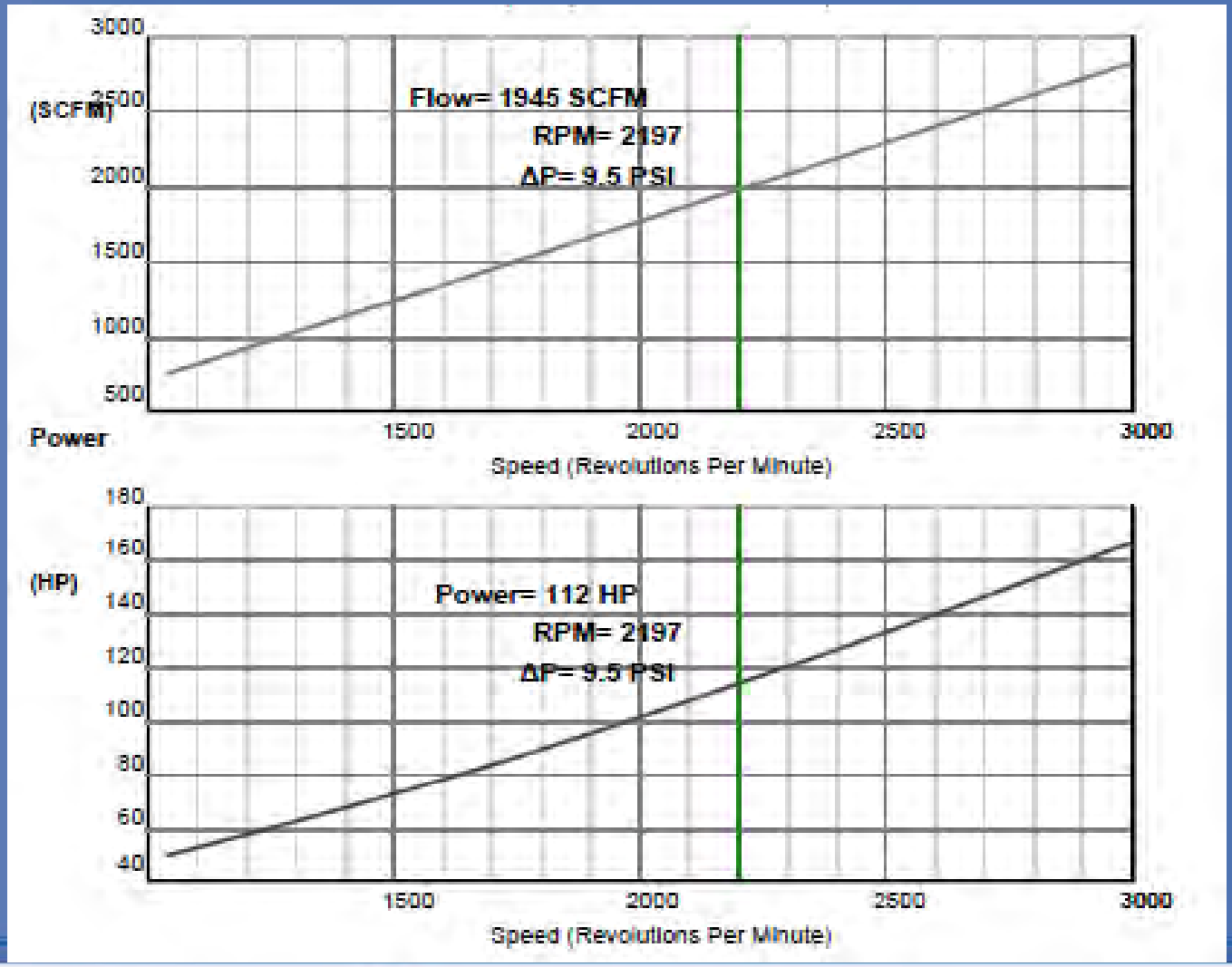
- **Depends on what you want to do**
  - **Eating 1 lb BOD uses ~1 lb O_2**
  - **Eating 1 lb NH_3-N uses ~4.6 lb O_2**
- **Depends on influent loading**
  - **Under, near, or over design loading?**
  - **When does it arrive?**

WASTEWATER DO CONTROL

- 25% Energy Reduction is Possible
- Handheld DO with Constant Speed
  - Simple Timer Control Blower On – Off
  - Many plants are over aerated due to lack of control
- Automated DO Control with VFDs
  - Ideal efficiency
  - Match DO to Load
- Incorporate with PLC or SCADA
  - SCADA will plot DO Trend
  - Operator adjusts to Trend
- Better nutrient treatment
  - Over aeration Limits Anoxic treatment



RPM vs. SCFM vs. Horsepower



RPM vs. SCFM vs. Horsepower

Hybrid Option

Performance Data:

		D 62S					
		Aeration Requirements			Minimum Flow Rates		
		Design	Summer	Winter	Design	Summer	Winter
flow at intake conditions	icfm	2,043	2,102	1,796	615	607	625
flow at standard conditions	scfm	1,945	1,830	1,895	536	529	660
intake pressure (absolute)	psia	14.00	14.00	14.00	14.00	14.00	14.00
differential pressure	psi	9.5	9.5	9.5	9.5	9.5	9.5
relative humidity	%	36	80	36	36	80	36
intake temperature	°F	68	95	20	68	95	20
discharge temperature	°F	192	225	138	199	234	140
blower speed	rpm	7,958	8,190	7,028	2,900	2,900	2,900
maximum speed	rpm	8,200	8,200	8,200	8,200	8,200	8,200
% of maximum		97%	100%	86%	35%	35%	35%
motor speed	rpm	3,570	3,674	3,153	1,301	1,301	1,301
power required at blower shaft	bHp	98.4	101.2	84.0	30.6	30.6	30.6
total power required to VFD	kW	81.3	83.6	69.3	25.3	25.2	25.3
motor rating	Hp	125					
Tolerance on flow & power	± 5 %						
Sound pressure level w/ enclosure measured in free field at 3ft. distance from the outline of the unit (tol. ± 2 dB(A)).	dB(A)	76	78	76	72	72	72

ON-OFF AERATION

Do we need 24/7 aeration?

- **On-off aeration is common practice**
  - Extended air, SBR, Schreiber
  - Wet weather operations
- **Usually more air than we need**
  - Compare actual vs. design BOD loading
  - Look at process D.O.
  - Look at your effluent numbers

Why Does the D.O. Vary ?

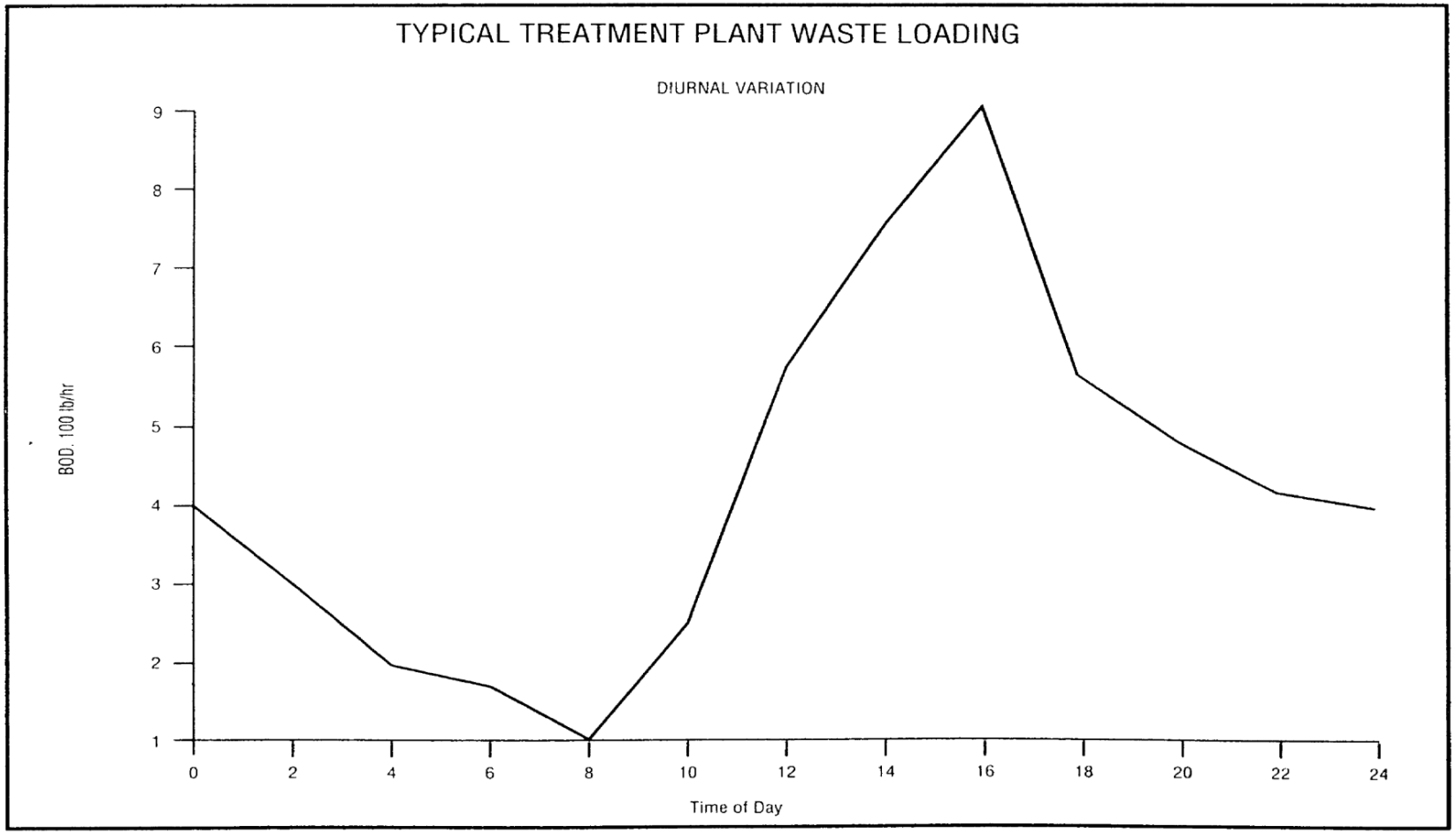


Figure 2. Variation in influent wastewater strength over 24 hours for a typical treatment plant.


SEQUENTIAL BATCH REACTORS HISTORICAL TREND
HISTORICAL
Jul 15
15:25:28
Jul 15
21:25:28
Jul 16
03:25:28
Jul 16
09:25:28
Jul 16
15:25:28
20
18
15
13
10
8
5
3
0
15:25:28
Tank Volumes: Green, Yellow, Blue
D.O. mg/l: Red, White, Purple

MIXING/AERATION OPTIMIZATION

- Factors to Consider
  - Aerator Type
    - Floating aerator – least efficient
    - Coarse bubble
    - Fine bubble – More bubble surface in contact with water
  - Aerator Depth – deep diffuser, longer time to rise, longer contact with water
  - Spacing – Too close bubbles coalesce, too far and poor mixing

Diffuser Type and Placement Oxygen Transfer Rate	Lb O2/hp-hr
Coarse Bubble Diffusers	2.0
Fine Bubble Diffusers	6.5
Jet Aerators Siemen's Jet Tech SBR	4.5
Surface Mechanical Aerators	3.0
Submerged Turbine Aerators	2.0

Aeration & Mixing Optimization

Activated Sludge Aeration Tanks

Aeration & Mixing Optimization

- Low Diffuser Efficiency
  - Atmosphere 20% Oxygen, Diffusers 15% efficient
  - Only 3% of the Air Volume Pumped enters water
  - 30 cfm of Oxygen requires 1,000 cfm blower
- High Diffuser Efficiency
  - Atmosphere 20% Oxygen, Diffusers 25% efficient
  - Now 5% of Air Volume Pumped enters water
  - 30 cfm of Oxygen requires 600 cfm blower
- Old Diffusers and Old Blowers ?
  - Retrofit all at same time

Aeration & Mixing Optimization

Aerobic Sludge Digesters

- Fine Bubble Diffusers
  - Limit solids concentration, 2% TSS
  - Limited mixing, may require Mechanical Mixers
- Shear Tube Diffusers
  - Good Oxygen Transfer Up to 4-5% TSS
  - Excellent Air Mixing, No Mechanical Mixing
  - Higher TSS means less Digester volume, less mixing air
- Covers for Heat Retention
  - Warmer Digester Contents, better digestion
    - More effective use of air
  - Air for mixing isn't wasted in cold weather

Aeration & Mixing Optimization

Aerobic Sludge Digesters

Shear Tube Diffuser

Aeration & Mixing Optimization

- Aerobic Sludge Digester Cover For Heat Retention

Aeration & Mixing Optimization

- Aerobic Sludge Digester Mixing Action under the Cover

Aeration & Mixing Optimization

Reduced Energy Use

$18,000 Annual Power Savings

$27,503 Energy Efficiency Rebate from PPL

Improved Sludge Reduction

2009 Disposed of 1,036 wet tons @ $26,000

2011 Disposed of 444 wet tons @ $11,000

57% reduction in sludge disposal

Annual Savings $15,000

Reduced Labor and Chemicals

Belt Press Operations 2009, 45+ hrs./week

Belt Press Operations 2011, <30 hrs./week

Less Polymer, Less Lime for Land Application

Eliminated Ferric Use for P removal

SLUDGETREATMENT

AN EXERCISE IN AEROBIC DIGESTION

By Bryen Woo & Douglas Cleary

Pennsylvania municipality improves sludge digestion & reduces energy use

ARTICLE SUMMARY

Challenge: The Frackville Area Municipal Authority sought to upgrade and improve its aerobic digestion system.

Solution: The engineering firm proposed retrofitting the two existing aerobic digestion tanks with a new aerobic digestion system to minimize operating and capital costs and provide maximum mixing and aeration efficiency of waste-activated sludge.

Conclusion: The new system has improved digestion performance and substantially reduced energy usage without creating a need for additional tank volume.

The Frackville Area Municipal Authority (FAMA) Wastewater Treatment Facility (WWTF) in Frackville, Pa., currently operates an Ovivo Airbeam cover aerobic digestion system that was commissioned in October 2010.

FAMA was seeking to upgrade and improve its aerobic digestion system, so it contacted Entech Eng. to design a new system that would reduce the amount of solids that needed to be disposed for land application.

Aerobic Digestion System Design

Previously, aerobic digestion at the FAMA WWTF was conducted through a floor-mounted coarse-bubble diffuser system in uncovered aerobic digester tanks. Entech proposed to retrofit the two existing aerobic digestion tanks with an Ovivo Airbeam cover aerobic digestion system. This would minimize operating and capital costs and provide maximum mixing and aeration efficiency of waste-activated sludge while using minimum energy requirements, reducing odors and providing optimum temperature control to improve digestion. Covering the aerobic digester tanks provided faster kinetic reactions in the system, resulting in shorter solids retention time in the existing tanks to obtain Class B stabilized sludge, which eliminated the need to construct new tanks.

Each aerobic digester tank was designed with an Airbeam cover integrating Ovivo's Mansel Smith diffusers and shear tubes. The shear tubes allow the diffusers to be submerged several feet above the bottom of the tank floor, reducing the blower discharge pressure, resulting in lowering energy requirements of the aerobic digestion operations.

Reduced Energy

In comparison with the prior floor-mounted diffuser system, the shear tube design is capable of lowering the discharge pressure of the blower system by nearly 1.5 psig, resulting in a reduction of more than a 15% in annual energy usage at the FAMA WWTF since its incorporation of the new aerobic digestion system. The reduced energy usage from this system saves FAMA $18,000 annually in energy costs.

Pennsylvania Power & Light (PPL) Electric Utilities currently offers financial incentives under its E-power Program to facilitate the implementation of cost-effective, energy-efficient equipment for commercial, industrial, governmental, institutional and nonprofit customers. The E-power incentive program pays on a per-unit-of energy-saved (in kilowatt hours) basis. Due to the reduction in energy usage provided by its new aerobic digestion system, FAMA applied for this incentive. It was granted a $27,503 energy efficiency rebate from PPL in February 2012.

Reduced Sludge Disposal

Enhanced temperature control provided by the new aerobic digestion system greatly improved digestion performance at the FAMA WWTP. After the solids are digested by the aerobic digestion system, they are dewatered with a belt press; then the Class B solids are land applied. Prior to incorporation of the new system, 250 acres were used to land apply the solids. After installation, 172 acres are used, resulting in a reduction of more than 30%.

Prior to the new aerobic digestion system, FAMA disposed of 1,036 wet tons of solids in 2009, costing $26,000. After installation, it disposed of 444 wet tons of solids in 2011, costing $11,000. By substantially improving sludge digestion, the new system provides an almost two-and-a-half times reduction in sludge disposal, generating savings of $15,000 annually in disposal costs.

Improved Digestion Performance

The Airbeam Cover aerobic digestion system at the FAMA WWTF has improved digestion performance and substantially reduced energy usage without having the facility having to build additional tank volume. The improvements have resulted in a 57%-plus reduction in solids disposed and a 15% reduction in annual energy costs. FAMA is able to save a total of $33,000 annually through reduced energy and disposal costs alone.

Bryen Woo, P.E., is aeration/aerobic digestion product manager for Ovivo. Woo can be reached at bryen.woo@ovivoglobal.com. Douglas Cleary is plant operator for the Frackville Area Municipal Authority. Cleary can be reached at famaj2@verizon.net or 570.874.4421.

For more information, write in 1008 on this issue's reader service form on page 54.

ENTECH ENGINEERING, INC.

Control of WW Industrial Users

- Organics, High BOD, FOG
- Flow Rate Surges
- Equalization Tanks
  - Strength, large minimum volume of wastewater
    - Must have volume of water to dilute spike
  - Flow Surge, large empty volume to hold surge

Why Control a High BOD Discharger

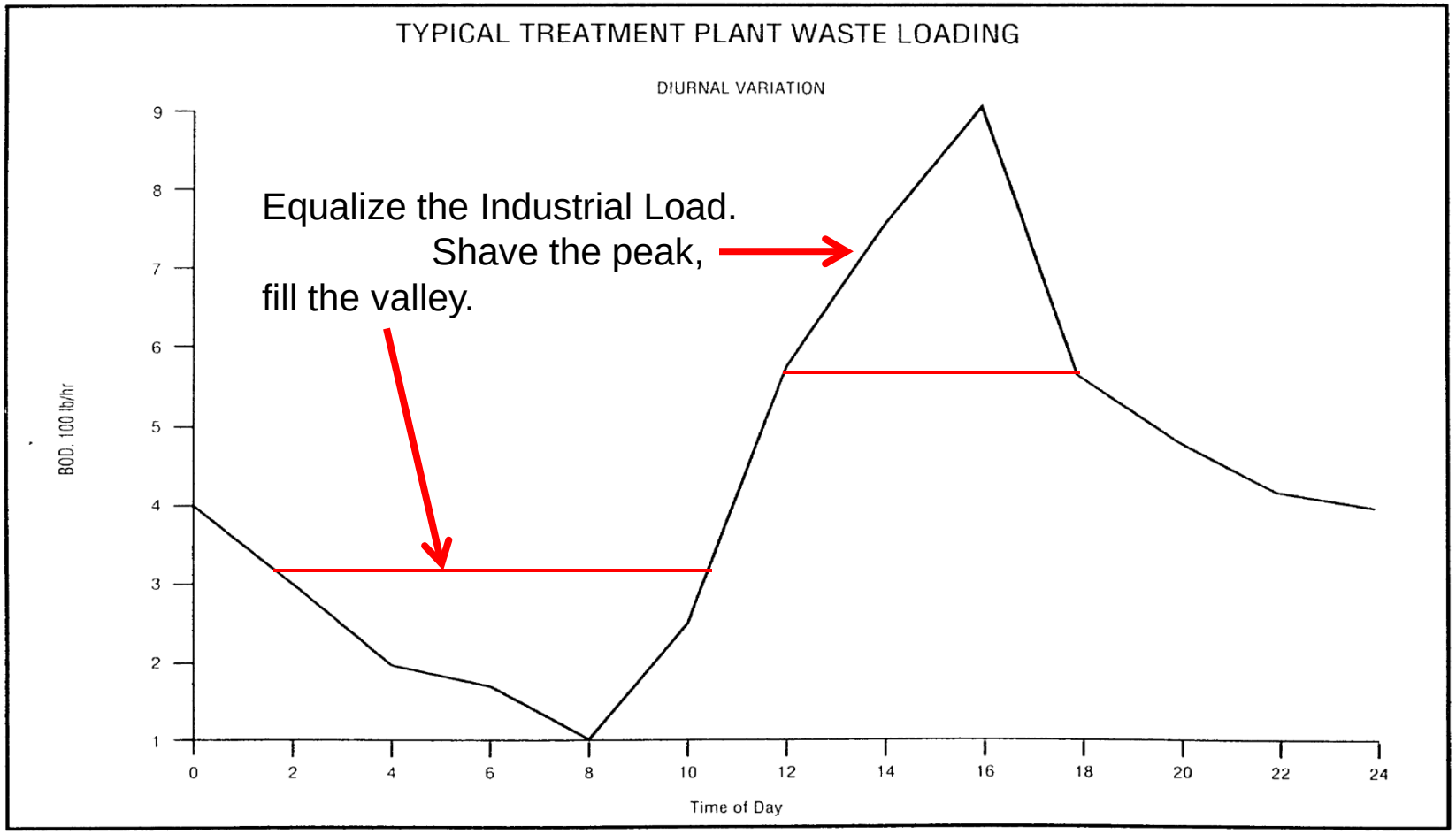


Figure 2. Variation in influent wastewater strength over 24 hours for a typical treatment plant.

Why Control a High BOD Discharger?

Internal Wastewater Sampling Report

Day	Initials	Flow Rate (GPM)	Equalization Tank Levels (Ft)	Diversion Tank Level (Ft)	Totalized Readings (gallons)	Daily Flow (gpd)
					9632846	
1	JH	16.54	14.57	0.29	9656711	23865
2	JH	16.55	16.07	0.61	9680558	23847
3	JH	16.53	14.82	0.59	9704406	23848
4	JH				9728260	23854
5	JH				9752114	23854
6	JH	16.53	13.90	0.50	9775968	23854
7	JH	15.15	13.45	0.35	9798673	22705
8*	JH	15.12	12.52	0.52	9820495	21822
9	JH	15.16	13.32	0.63	9842308	21813
10	JH	15.12	12.18	0.57	9864102	21794
11	JH				9885431	21329
12	JH				9906761	21329
13	JH	13.55	13.55	0.54	9928090	21329
14	JH	12.08	7.85	0.45	9946424	18334
15	JH	11.14	7.57	0.54	9962465	16041
16	JH	10.10	7.70	0.54	9977166	14701
17	JH	10.14	9.02	0.6	9991759	14593
18**	JH	8.00				11520
19**	JH	8.00				11520
20**	JH	8.10	12.01	0.42	30452	11664
21	JH	8.08	11.52	0.40	42100	11648

Learn Process Control Techniques to Reduce Energy Consumption

Process Control Techniques

More D.O…… IS NOT BETTER !

$$OTR = SOTR\left(\frac{B\,Cs - Cw}{Cs^{20}}\right)\theta^{T-20}$$

OTR = Oxygen Transfer Rate

Cs = Oxygen Saturation in Tank

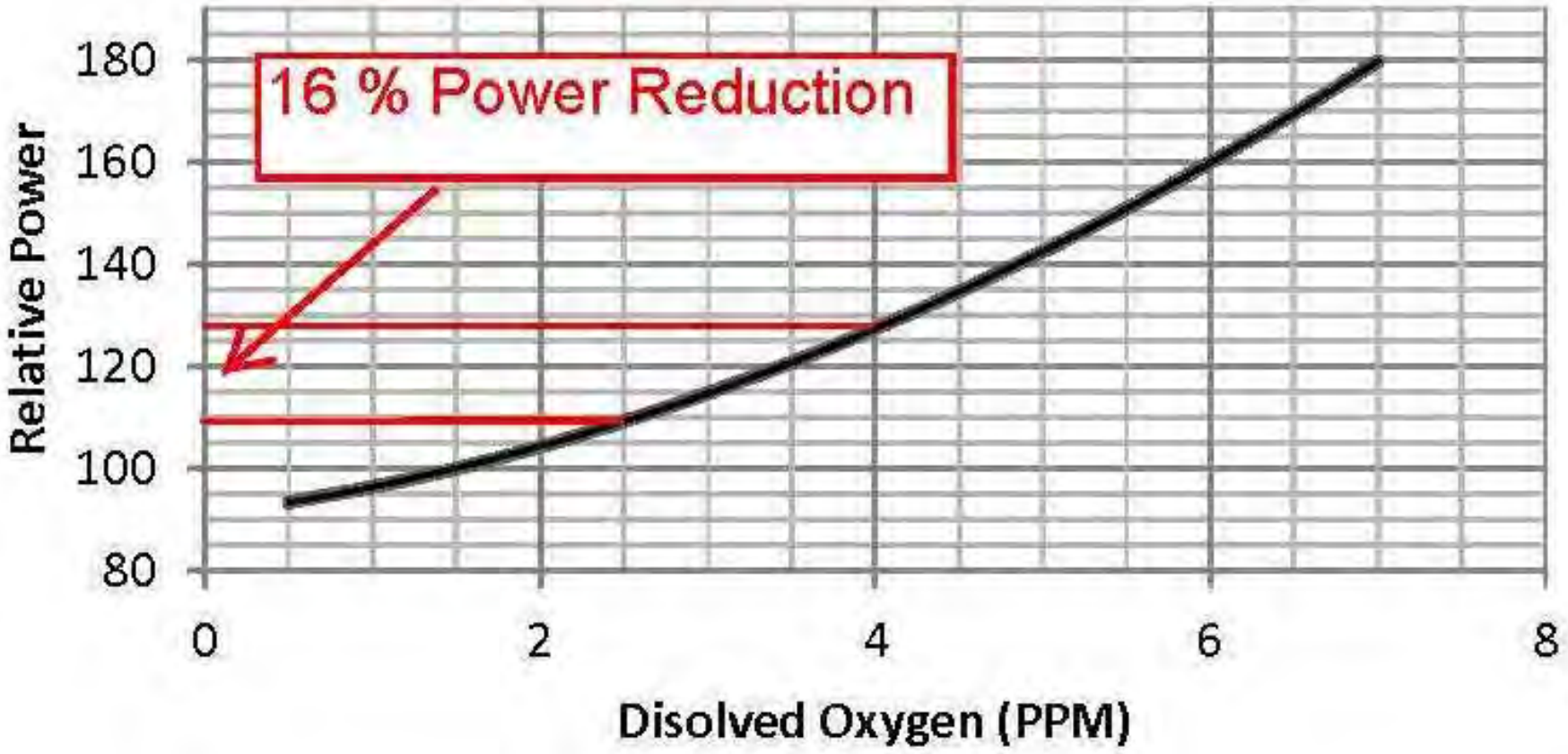
Cw = Oxygen Concentration in Tank

Bigger the difference between Cs & Cw, the higher the OTR

Nitrifiers are perfectly happy with a DO = 2 to 3 mg/l

Relative Energy Demand vs. DO set-point

Optimum 1.5 PPM



Process Control Techniques
Denitrification - Less is More ?

- Occurs when Blowers are OFF !
- Facultative Anaerobic Bacteria
  - Use the O3 in NO3 for Oxygen
  - Consume Soluble BOD in the Process
- Improves Process Control
  - Good sludge settling, reduces filamentous organisms
  - Reduces Sludge Production. Less Digestion, Less Dewatering

Denitrification

- Sludge production drops 5% or more in a system that denitrifies

Process Control Techniques

Aerobic Sludge Digesters

- DO Control
  - Automatic of limited value. Long Detention, low load
  - Measure with portable probe. 1 to 2 mg/l DO
- Blower Control
  - VFD
    - Limits Demand if Digester quickly goes above 2 mg/l.
    - Takes blower off “Efficiency Sweet Spot”
  - On – Off Timer
    - Lowest Capital Cost. Essential to good Digester Operation
    - Easy to use.
    - Set Air Off at 3:00 AM. Ready to Decant at 7:00 AM

Process Control Techniques

Aerobic Sludge Digesters

- On – Off Control benefits in Aerobic Digestion
  - Digestion reduces VSS to CO_2 and Ammonia
  - Aerobic conditions and bacteria convert NH_3 to NO_3
  - During Blower Off Cycle NO_3 is Denitrified
    - Reduces Nitrogen Load returned to Treatment System
    - Denitrification in Digester keeps pH higher
      - Returns Alkalinity to Digestion Process
  - Blower Off Cycling Reduces Phosphorous
    - Up to 50% reduction in P in recycled sludge filtrates.

Identify Energy Efficient Retrofits

Identify Energy Efficient Retrofits

- Lets Replace some inefficient Motors

Energy Efficiency in Water/Wastewater Systems

Present Monthly Electrical Profile

Month	kWh	kW	kWh Cost	kW Cost	Total Cost
January	63,266	202	$6,630	$913	$7,543
February	67,392	208	$7,063	$940	$8,002
March	80,190	225	$8,404	$1,016	$9,420
April	71,410	228	$7,484	$1,030	$8,514
May	76,140	235	$7,979	$1,062	$9,041
June	80,352	240	$8,421	$1,084	$9,505
July	79,380	245	$8,319	$1,107	$9,426
August	77,760	240	$8,149	$1,084	$9,233
September	78,797	228	$8,258	$1,030	$9,288
October	68,688	212	$7,199	$958	$8,156
November	64,519	206	$6,762	$931	$7,692
December	71,280	200	$7,470	$904	$8,374
Total	**879,174**		**$92,137**	**$12,057**	**$104,195**

High Efficiency Fan Motors -Energy Savings Calculation

- Assume the plant has two (2) existing 30 HP fan motors.
- Each existing fan motor has an efficiency of 86.2%.
- Demand of (2) fan motors equal to (2)*(30)*(.746) / (.862) = 52 kW.
- Replace the existing fan motors with high efficiency motors (93.6%).
- **Revised demand** of fan motors equal to (2)*(30)*(.746) / (.936) = 48 kW.
- Assume fan motors run 16 hours per day.
- **Reduction in consumption** equal to 4 kW times total operating hours per month.

Energy Efficiency in Water/Wastewater Systems

High Efficiency Fan Motors - Proposed Monthly Electrical Profile

Month	kWh	kW	kWh Cost	kW Cost	Total Cost
January	61,410	198	$6,436	$894	$7,330
February	65,472	204	$6,861	$922	$7,783
March	78,078	221	$8,183	$998	$9,181
April	69,554	224	$7,289	$1,012	$8,301
May	74,220	231	$7,778	$1,044	$8,822
June	78,368	236	$8,213	$1,066	$9,279
July	77,460	241	$8,118	$1,089	$9,207
August	75,840	236	$7,948	$1,066	$9,014
September	76,749	224	$8,043	$1,012	$9,055
October	66,768	208	$6,997	$940	$7,937
November	62,663	202	$6,567	$913	$7,480
December	69,168	196	$7,249	$885	$8,134
Total	**855,750**		**$89,683**	**$11,840**	**$101,523**

Energy Efficiency in Water/Wastewater Systems

High Efficiency Motors -Energy Savings Calculation

- Existing Plant Annual Electrical Operating Cost - $104,195
- Proposed Plant Annual Electrical Operating Cost - $101,523
- **Energy Savings (2) 30 HP High Efficiency Fan Motors - $2,672**
  - **(Demand and Consumption Savings)**
- **AND…….Your Power Company may offer a Rebate on Capital Cost !**

Identify Energy Efficient Retrofits

- Lets Replace some inefficient Motors
  - Saved $2,672 per year
- While we are at it, lets upgrade the controls
  - Simple On – Off Timer

Energy Efficiency in Water/Wastewater Systems

Fan Motors – Hours of Operation Energy Savings Calculation

- Assume the plant has two (2) existing 30 HP fan motors.
- Assume fan motors run 16 hours per day.
- The plant proposes to modify fan operation to only 12 hours per day.
- **Reduction in consumption is equal to the reduction in fan hours per day (4 hours) times the total demand of the fans (52 kW) times the number of days per month.**

Energy Efficiency in Water/Wastewater Systems

Reduced Fan Operating Hours - Proposed Monthly Electrical Profile

Month	kWh	kW	kWh Cost	kW Cost	Total Cost
January	57,234	202	$5,998	$913	$6,911
February	61,152	208	$6,409	$940	$7,348
March	73,326	225	$7,685	$1,016	$8,701
April	65,378	228	$6,852	$1,030	$7,882
May	69,900	235	$7,326	$1,062	$8,387
June	73,904	240	$7,745	$1,084	$8,829
July	73,140	245	$7,665	$1,107	$8,772
August	71,520	240	$7,495	$1,084	$8,579
September	72,141	228	$7,560	$1,030	$8,590
October	62,448	212	$6,545	$958	$7,502
November	58,487	206	$6,129	$931	$7,060
December	64,416	200	$6,751	$904	$7,654
Total	**803,046**		**$84,159**	**$12,057**	**$96,216**

Energy Efficiency in Water/Wastewater Systems

Fan Motors –Hours of Operation Energy Savings Calculation

- Existing Plant Annual Electrical Operating Cost - $104,195
- Proposed Plant Annual Electrical Operating Cost - $96,216
- **Energy Savings (2) 30 HP Fan Motors - $7,979**
  - **(Consumption Savings Only)**

Identify Energy Efficient Retrofits

- Lets Replace some inefficient Motors
  - Saved $2,672 per year
- While we are at it, lets upgrade the controls
  - Simple On – Off Timer
  - Saved $5,307
- DO Control with a VFD
  - Possible Larger Savings
  - Higher Capital Cost

ENERGY EFFICIENT DESIGN

- Energy efficiency
- Renewable energy
- Green design
- Increased efficiencies offset increased capital costs

LEED

- Green Building Certification
  - Energy efficiency
  - Water efficiency
  - CO2 emission reduction
  - Improved indoor environmental quality
  - Stewardship of resources

CASE HISTORY
LEED GOLD CERTIFIED BUILDING FINANCIAL SUMMARY

Base Project Cost :	$7,800,000
LEED Premium:	$ 700,000
Project Construction Cost:	$8,500,000

Total Cost per Square Foot without Incentives: $ 147 per sf

State Energy Administration Green Building Tax Credit:	$ 640,000
Local Municipal Green Building Tax Credit:	$1,100,000

Effective Project Cost:	$6,760,000

Total Building Area:	57,600 sf
Total Building Cost per Square Foot:	$ 117 per sf
Annual Operating Savings:	$100,000 per year

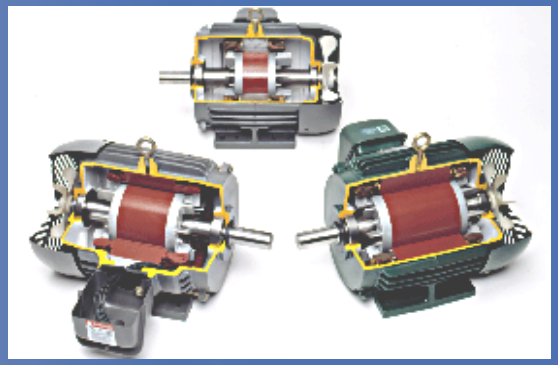
LIGHTING

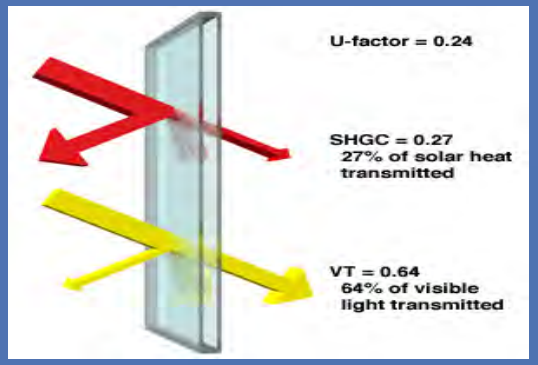
- Lighting Retrofit
  - Convert T12 TO T8
  - Convert Incandescent to CFL
  - Exit Signs to LED
  - Outdoor Green Lighting - LED & HID Lighting (MH or HPS)
- Daylight Dimmers versus Timers
- Occupancy Sensors

  - Solatubes and Day lighting Systems
  - Act 129 provides funding
    - e.g. PPL
      - $5 - $19 per T8 lamp
      - $15 LED per Exit sign

HVAC & BUILDING IMPROVEMENTS

- Insulation
- Windows – e.g. Low-E Glass
- Building materials
- Energy efficient motors on fans and motors





GEOTHERMAL & HEAT RECOVERY

- Conventional ground coupled (Closed Loop) systems
  - Energy for building heating & cooling demand
  - Heat Pump to Extract Heat from 55^{o} groundwater
- Wastewater Discharges
  - Effluent heat recovery
    - Influent has More heat, but may slow Nitrification
  - Post-Treat EQ
    - Lower 1 MGD by 2^{o} Recover 16,680,000 BTU
    - 695,000 BTU per Hour