Plant Optimization

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Plant Optimization

WWW 5650
7 contact hours
9 CC10 hours

In this time of increasing budget constraints, the operator or superintendent needs to have some tools available for cost cutting, process optimization, while still meeting all permit and treatment parameters. In this course, operators and superintendents will study some example budgets, learn about how to minimize energy use and costs, and develop methods to minimize chemical use and costs. They will also learn about how labor costs and other contract costs contribute to budget expenditures. Students should bring a process flow diagram from their facility or be prepared to draw one. If a line-item budget from the student's plant is available, students should also bring that to class.

Course Objectives

1. Identify the components of a water or wastewater treatment plant budget
2. Recognize the main categories of budget expenditures; labor, chemicals, energy, solids processing and disposal, and other costs
3. Explain how to do an energy audit, and identify possibilities for minimizing energy use
4. Explain how to do a chemical audit, and identify possibilities for minimizing chemical use and costs
5. Identify the implications of labor costs and how they can be optimized

Phase 1 – 8:00 AM to 10:00 AM

- Optimize to meet Permit requirements
    - How to optimize individual treatment processes in water and wastewater treatment
        - Secondary aeration
        - Sedimentation
        - Filtration
        - Disinfection
        - Dewatering
        - Drying beds
        - Land application

Phase 2 – 10:00 AM to 4:00 PM (includes one hour break for lunch)

- Optimize to reduce costs (after meeting permit)
    - Example plant budget (use theirs or present one)
    - Labor optimization – multi-skilling
    - Chemical optimization
    - Energy optimization

Class conducted in 7 hours with breaks as appropriate. Assessment (test) at the end.

Plant Optimization

Course Objectives

- By participating in this course, students will develop an understanding of:
- The components of a water or wastewater treatment plant budget
- The main categories of budget expenditures; labor, chemicals, energy, solids disposal, and other costs
- How to do an energy audit, and identify possibilities for minimizing energy use and costs
- How to do a chemical audit, and identify possibilities for minimizing chemical use and costs
- The implications of labor costs and how they can be optimized
- Developing a budget for their own facility, using connected horsepower, chemical usage, staff numbers and other contracts

Ground Rules

- We all have things to learn from each other
- It's OK to ask questions
- It's OK to provide comments.
- Raise your hand and I'll acknowledge you
- Emergencies
- Cell phones silenced
- Relax for the test. It's not difficult

Introductions

- Name
- Where you work, type of plant
- What you do, your responsibilities
- What you want to get from this class

Two Phases

- Optimize to meet the Permit
- Optimize to reduce costs

- We will discuss both in detail.
- Need to meet the Permit first

The Permit

- Issued by the State to match Federal mandates
- Based on the needs of the receiving stream
- For Water plants, the permit is set by drinking water standards
- Must be met or there are consequences
- The permit drives the cost

- Must be at least secondary treatment
- May also have to remove Phosphorus or Nitrogen or both
- May have limits on biosolids application to land

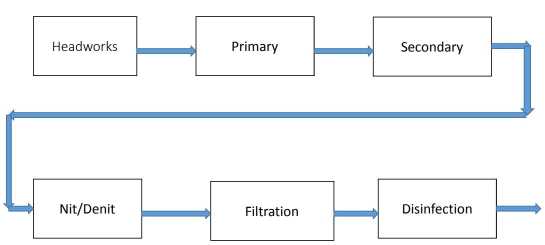
Facility

- Has the right equipment
- Process design is sufficient, i.e. if operated properly it will meet permit requirements
- If not, the municipality will be required to correct the situation
  - Could be a major or minor upgrade
  - They will have a deadline

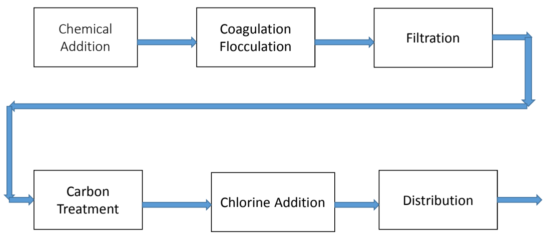
Assumption

- The following analysis assumes that the facility can do the job.

Wastewater Treatment



Water Treatment



Chemical Addition

- Will discuss how to optimize later in the class

Coagulation/Flocculation

- Chemical addition must be optimized
- Requires good settling operation

Clarifier Video

- https://www.youtube.com/watch?v=rwiXby6j3Io

Activated Sludge Aeration*

- Converts BOD to CO2 and water
- Requires minimum of 2-3 hours detention time
- With longer aeration times (6 hours) can nitrify
- Requires good aeration control/DO control in various locations
- Can operate in different modes – plug flow, step feed, etc.
- Must observe biology to avoid problems (microscope)

Blower*

Optimize Aeration*

- Periodic examination of diffuser fouling
- Automatic DO control
- Match aeration to flows and loadings (day/night)
- Coarse vs. fine bubble diffusers
- Optimize grid pattern for diffusers
- Provide turndown on blowers (inlet vanes/vari-speed)
- If filamentous growth, add chlorine for a fixed time

Aeration Tank

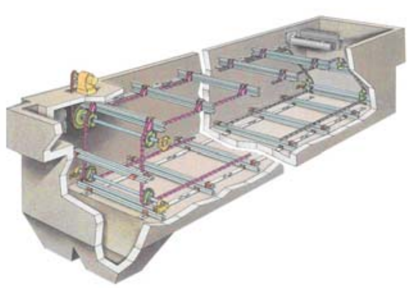
Coarse Bubble

Fine Bubble

Activated Sludge Sedimentation

- Takes mixed liquor from aeration and settles it
- Circular or rectangular clarifiers
- Usually a number of units
- Flow distribution among units and within the clarifier important
- Returns sludge to aeration
- Sludge wasting important to controlling biology
- Sludge blankets controlled to avoid decomposition

Rectangular Secondary Clarifier

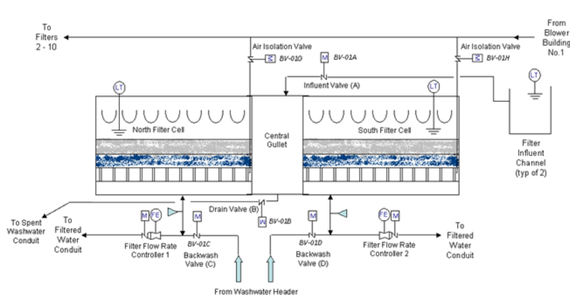


Optimize Sedimentation

- Use dye tests to evaluate flow distribution
- Monitor and control sludge blankets – various methods
- Take o/s annually to examine submerged equipment
- For bulking sludge change biology/DO, or chlorinate return sludge
- SVI (settling) tests
- Add polymer or ferric chloride to improve settling

Final Filtration

- Needed if > secondary treatment is required. Removes TSS, Phosphorus in wastewater
- Removes solids in water treatment
- Use single or dual media filters (sand/anthracite)
- Or moving bed, etc.
- Various means of control
- Chlorinate influent or backwash water
- Approx 10% of processed water used for backwash
- Backwash sometimes accompanied with air
- Media fouling requires attention



Optimizing Filtration*

- Optimize amount of backwash water. Backwash only when necessary
- Schedule backwashing to low energy cost times of day. Backwashing is the largest energy user in filtration
- Some plants chlorinate filter influent for both disinfection and for control of media fouling
- Equalize flow among available filters
- Examine underdrains annually for media loss, etc.
- Maintain all automatic valves – many associated with backwash
- Examine media for chemical buildup (mudballs)
- Automate backwash sequence (a batch process) to minimize damage to filters

Disinfection

- Either chlorination/dechlorination or UV (most used)
- Monitor effectiveness with fecal coliform test done daily
- Usually controlled to a chlorine residual within the plant for at least 30 minutes (Permit requirement)
- Reaction time slow
- UV controlled to an exposure level for a fixed time
- All residual chlorine must be removed before discharge – done with sodium bisulfite or SO2

Optimizing Disinfection

- Flow pace chemicals
- On-line analyzers for residual – for both hypochlorite and bisulfite feeds
- Do not store hypochlorite too long in warm weather – it loses strength
- Add chlorine ahead of filtration

Chlorination in Water Treatment

- Potable water requires a chlorine residual of approximately 0.2 to 1.0 mg/l at the far end of the system

Solids Processing

- Thickening - Gravity or Dissolved Air Flotation
- Blending (optional)
- Dewatering and lime addition
- Digestion (optional)
- Final dewatering
- Class A or B
- Hauling to land application sites/landfill
- Incineration
- Drying

Dewatering *

- Increases solids from 5% to 20 -30%
- Used in both water and wastewater treatment
- Conditioning with chemicals always required
- Necessary for trucking to land application sites, for incineration, for composting, and for landfilling
- Methods used are
  - Belt Filter Press
  - Centrifuge
  - Filter Press
  - Lagoons and Drying Beds

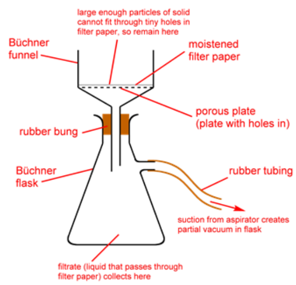
Centrifuge

Optimizing Dewatering

- All methods are dependent on proper conditioning
- Inorganic chemicals add weight to final product
- Organic chemicals (polymers) add no weight
- Chemical selection is done by lab tests, and confirmed in full scale
- Mixing of conditioning chemical very important to make the floc, but not breaking it down
- All dewatering does better if screenings and grit are removed

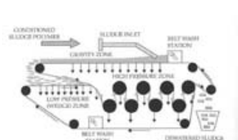
Polymer Demand Tank

Buchner Funnel



Jar testing

Belt Filter Press



Belt Press

Optimizing a Belt Filter Press

- Polymer can be neither under nor over-conditioned
- Use lab test to check drainage with different polymer feed rates
- Monitor belt condition – clean when plugged
- Find the best belt tension number
- Feed solids need to be low enough for good polymer incorporation

Optimizing a Centrifuge

- Maintaining a constant ratio of primary to secondary sludge is critical to stable operation
- Auto controls on centrifuge usually control torque
- Polymer addition point can be varied and there is an optimum location that can change
- High cake solids usually means dirty centrate – find the balance
- Monitor cake solids and centrate and adjust polymer rate
- Monitor SVI – lower is better
- Identify under -performing units

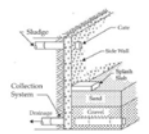
Centrifuge Video

- https://www.youtube.com/watch?v=Wnck3IJxCKU

Optimizing Drying Beds

- Need a lot of land area, with properly designed underdrain system
- Can add polymer to improve drainage
- Cover if affected by too much rain

Sand Drying Bed



Hauling to Land App Sites

- Usually pay by the wet ton hauled and applied
- Can minimize tonnage by getting a drier cake, using less inorganic chemicals
  - If lime stabilizing undigested solids need to meet pH of 12 without going too far over

Cost Reduction

- Assume that you are meeting permit

Reducing Costs

- Determine current costs and compare to standards/norms
- Compare to like facilities
- Look at how you do things and compare with others - You might find a better way

Reducing Costs

- Before you start this effort, be clear on the plant's overriding performance goals, e.g.
  - Permit – Zero violations
  - Safety – Zer0 lost time accidents
  - Budget targets - % reduction each year
  - Minimize downtime of equipment

What are your plant's performance goals?

Example Plant Budget

• Labor (direct salaries)	$577,000
• Overtime	60,000
• Benefits (35%)	202,000
• Training (~3.5% of direct salaries)	20,000
• Operating Supplies (mostly chemicals)	300,000
• Maintenance Supplies	50,000
• Lab supplies + Contract analysis	10,500
• Power	180,000
• BioSolids hauling & land app	170,000
• Miscellaneous	8,000

Budget Summary

- Total $1,757,500

- At 2.5 MGD average flow
  - $1,757,500 / 2.5 x 365 = $1925/MG
  - Staff = 10 members
  - AWT plant - Permit limits include N and P + low levels of BOD and TSS

Analysis*

• Labor	47%
• Oper supplies	19%
• Power	11%
• Biosolids	11%
• All other	12%

Benchmark

- $ per MG for total labor
- Find like plants with approx same effluent standards and approx same size

Labor

- Does every set of tasks fit into a 40 hour work week?
- Can people be trained to multi-task?
- Can lab staff , or maintenance staff fill in for operations?
- Employee availability = 85% (show calculation)
- Eliminate unnecessary tasks – perform task analysis
  - Define process standards
  - Look at each area and define a standard of care
  - Define needed tasks, time needed and who assigned

Calculation

- Determine % availability of a staff person
  - Assume 2080 hours per year (40 hours/week & 52 weeks/year)
  - Vacation time – 20 days/year
  - Sick leave – 5 days/year
  - Holidays – 9 days/year
  - Total = 34 days/year = 34 X 8 = 272
  - 272/2080 = 13.1% or 86.9% available

Management

- Old model – a person in charge of each section, e.g. operations, maintenance, lab, etc.
- New model – one person manages several functions; relies on technical experts in each area
- Can you consolidate O&M, E&I, Lab & Process Engineering
- Working managers?

Operations Staffing

- Can some operations tasks be automated?
  - Tradeoff with instrumentation staff
  - Investment in Process Control Systems
- Sampling – auto samplers
- Maintenance responsibilities – PM or CM
- Ownership
- Day vs. night staffing
- Standardize operations between shifts
- Shift handoffs

Maintenance Staffing

- Attempt to make majority of work planned
  - Maintenance Management System - CMMS - records
  - Predictive maintenance
  - Preventive maintenance – define work hours
  - Corrective maintenance
  - Capital Improvement
    - Concept of ROI

Qualified staff for automation and PCS maintenance

Consider contracting out specialty work, e.g. HVAC, cranes, centrifuge rebuilds

Maintenance (cont)

- Parts
  - Available and in a box handed to mechanic
  - What you keep on your shelf vs. vendor's shelf
  - Critical spare parts
    - For equipment with little installed redundancy
    - For equipment with long lead times

Addressing Overtime*

- Planned vs. unplanned OT
- Can multi skills offset some OT?
- How do you prioritize work and staffing?
- Minimum staffing on shifts
- Can others fill in?

Is OT an issue at your plant?

Operating Chemicals (WWT)

- Next largest expenses may include:
  - Polymers for settling, or for thickening/dewatering
  - Methanol for denitrification
  - Sodium hypochlorite for disinfection and odor control; also biology control in secondary
  - Sodium bisulfite for dechlorination
  - Ferric chloride or alum for phosphorus removal
  - Lime/magnesium hydroxide/ caustic for pH adjustment

Operating Chemicals (Water)

- Alum for coagulation
- Lime or caustic for pH control
- Sodium hypochlorite for safety in the delivery system
- Some chemicals to add fluoride to the water
- Some chemicals for taste and odor

Two Approaches

- Pay less for each chemical – via good purchasing techniques
- Use less to do each job – under operation's control

Pay Less

- Price often depends on quantity purchased
- Try to work with other agencies to do a group bid
- Getting competition is key to good pricing – search out suppliers
- Benchmark to learn what others are paying for that chemical
- Use chemical marketing firms to track pricing
- Use BLS PPI for some common chemicals

Feeding Chemicals

- Dry Product
  - Gravimetric
  - Volumetric
- Liquids
  - Pumping a liquid or slurry, w/wo carrier water
- Gas
  - Must be dissolved in water

Dry Feeders*

- Usually a silo or day tank to a volumetric feeder
  - Day tank can be on a scale
  - Can use a calibrated screw to feed. Requires periodic calibration
  - Other feeders – Belt, Revolving plate, Rotary, Shaker
  - Inspect to avoid buildup from moisture

Feed Controls - Solids

- Target a #/dry ton in solids streams
- Difficult to have an on-line analyzer that works
- Can run % solids or TSS in field
  - Need visual or grab sample of dewatered cake or centrate – to vary polymer dose

Feeding Liquids

- Positive displacement pumps
  - Gear pumps
  - Hose pumps (2000 hours life)
  - Diaphragm pump
  - Rotary lobe pump
  - Progressive Cavity pump

Pump Selection*

- Gear pumps – becoming more popular
- Hose pumps – Hose has a life span
  - No air binding
- Diaphragm pumps
  - Vari speed and vari stroke
  - Can air bind

  - View videos

Pump Selection (cont)*

- Rotary lobe pump – handles product without damaging, e.g. polymer
- Progressive cavity pump – Good general, all-purpose pump
- Drum pump – for small feed systems

- Pumps cannot be over or under sized
- Use graduated cylinder for calibrating pumps
- Carrier water advantages/disadvantages

Hose Pump for Hypo

Polymer Feed Pump

Calibration Chamber

Carrier Water

- Works to help disperse the chemical in the total flow, esp. if little mixing at point of application
- Some chemicals react with carrier water
  - Ferric chloride forms ferric hydroxide

Flushing Water

- All chemical piping should have a flushing connection
  - Never leave chemical sitting in a pipe. It attacks the piping/glue at fittings - hypo
  - Can have an auto solenoid to flush when feed stopped
  - Story about bisulfite flushing line
  - Protect from leaving it on

Feed Controls – Liquid

- Can be constant flow, but not optimum
- Best if flow-paced with main flow – metered flow rate determines pump speed or stroke
- Difficult to measure flow rates of chemical, often use a correlated speed
- Target a mg/l dosage into liquid flow
- Can use feedback from an on-line analyzer, e.g. NO_3 analyzer to set methanol flow

Feeding Gas

- Examples – Chlorine, Sulfur dioxide, Oxygen, Ozone
- Need an evaporator for Cl_2 and SO_2
- Water solution

Addition Points

- Get good mixing
- Reaction times
- Add at a point of natural turbulence or install a mixer
  - Chemical Injection Units
  - Ejectors
  - Static Mixers
  - Flocculation Tanks (mostly for solids streams)

Addition Points (cont)

- Difficult to get good mixing in raw sewage
- Most mechanical mixers require clean water
- CIUs are high speed machines that work well for Hypo, ferric chloride, and caustic
- Ejectors also work with these chemicals

Chemical Injection Unit (CIU)

For Mixing

- Ejectors - See video
- Floc tank - picture

Use Less*

- Collect data on usage
- Trend the data
- Compare with theoretical values
- Compare with literature
- Benchmark
- Look at addition point – good mixing?
- Flow pacing
- Online analyzers
- Jar testing to confirm dosages required
- Calibrate feed equipment

Example Chemical Dosages

- Ferric Chloride (P removal) – 5 mg/l of Fe and another 2.5 at second point
- Sodium Hypochlorite for Disinfection – 4 mg/l
- Sodium Bisulfite – 2.5 mg/l
- Methanol – 3 lbs/lb of NO_3-N
- Caustic – 0.81 lbs/lb of alkalinity
- Lime for solids stabilization – 15 to 20% of dry solids

Example Chemical dosages

- Polymer – in wastewater to aid settling- 0.2 mg/l
- Polymer for Thickening – 5 lbs/dry ton solids
- Polymer for Dewatering – 10 to 15 lbs/ton solids

Calculation (1)

- Given: Average flow = .075 MGD
- Fe dosage of 7.5 mg/l
- Calculate gpm of Ferric chloride feed

- 0.75 MGD X 8.34 #/MG/mg/l X 7.5 mg/l of Fe = 46.9 # Fe/day
- 46.9 #/day X (162.35/55.85) =
  136.4 # $FeCl_3$/day

Calculation (2)

- Given $FeCl_3$ as delivered is 34% solution; density of 11.67 # solution/gallon.
- 136.4 # $FeCl_3$/day /0.34 # $FeCl_3$/# solution = 401.2 # solution/day
- 401.2/ 11.67 #/gal = 34.4 gal/day of $FeCl_3$ solution
- 34.4/1440 min/day = 0.24 gal/min $FeCl_3$ solution

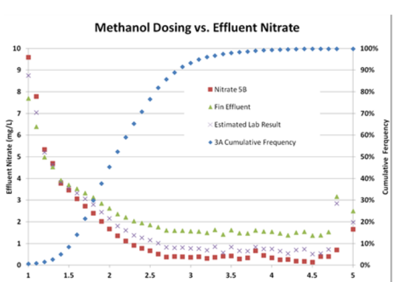
Optimizing Chemical Feed

- Trend data – know where you are
  - Measure flow or lbs of solids processed and lbs of chemical used per what is measured – Daily/Weekly/Monthly
  - Plot data
  - Look for ways to reduce consumption
  - Chemicals can be a large portion of total budget

Optimizing Chemical Feed

- Use flow pacing, on-line analyzers
- Give operators the data
- Set performance targets
- Calibrate pumps and dry feeders monthly/quarterly
  - Hose pumps and diaphragms wear
  - Volumetric screws get plugged

Trend Chart Example*



Resources

- Chlorine Institute – www.cl2.org
  - Chlorine, hypo, caustic, hydrochloric acid
- Methanol Institute – www.methanol.org
- National Lime Association – www.lime.org

Optimizing Polymer

- QA on deliveries – compare with original tested
- Jar tests for settling optimization
- Jar tests/Buchner funnel for solids
- Maybe add with Fe or Al
- Rise test in DAF
- Performance testing in field – Microwave or Sartorius

- A benefit of increased primary sludge is improvement in dewatering (using less chemical there)

Exercise

- Describe how you might optimize polymer

- Example on costs of polymer vs. hauling

Polymer Calculation

- Setting: Should Operations pay additional polymer costs to get higher cake solids in the dewatered cake?
- Assumptions: Polymer added at 10 lbs/dry ton to produce a 26% solids. If add 11 lbs/dry ton, can get 27% solids. Polymer cost is $1.75/pound.
- Hauling costs are $40.00/wet ton biosolids
- Average sludge production is 15 dry tons/day

- 15/0.26 = 57.7 wet tons/day ; 15/0.27 = 55.6 wet tons/day

Continued

- Cost/day to haul biosolids
  - At 26% solids 57.7 wet tons X $40.00 = $2308/day
  - At 27% solids 55.6 wet tons X $40.00 = $2224/day
  - Difference is $84/day

  Cost/day for extra polymer
  10lbs/dry ton X 15 dry tons/day = $150/day
  11 lbs/dry ton X 15 dry tons/day = $165/day
  Difference is $15/day
  Conclusion : **Add the extra polymer**

Polymer Flow Meters

Methanol

- Formula
- Try to use the carbon in wastewater first
- Flow pace addition
- Measure ammonia and add required amount
- Trim by measuring nitrate
- Insure good mixing
- Avoid overdosing as it drops DO and increases BOD
- Also vaporizes and may exceed air pollution limits

Sodium Hypochlorite *

- Disinfection and incoming odor control
- Run tests to see what chlorine residual meets fecal standard
- Flow pace or use a chlorine residual analyzer and trim feed
- Try to get double duty, e.g. disinfect and minimize growth on filter media

Sodium Bisulfite

- Dechlorination
- Instantaneous reaction
- Flow pace and trim with an on-line analyzer for chlorine residual

Ferric chloride or Alum

- Formula – Fe + PO4 = FePO4
- Jar tests to optimize
- Check for competing reactions, e.g. sulfides
- Can use ferrous to react with H2S
- Review mixing at addition point

pH Adjustment*

- Can use lime, magnesium hydroxide, or caustic
- Good mixing
- On-line analyzer for pH

pH Adjustment*

- Wastewater usually enters plant at a pH near 6.5, but can vary depending on industrial component
- Usually regulated to discharge at 6.0 to 9.0
- Some processes cause a drop in pH
  - Chemical (ferric chloride) for P removal
  - Nitrification

pH Adjustment (cont)

- Lime (quicklime) is the least costly, but comes with handling problems
  - Must be slaked
  - Lime must be kept away from moisture
  - Some large facilities have been shut down due to handling difficulties
    - Absorbs moisture in storage
    - White-outs
    - Scaling in lines after slaking

Raising Alkalinity (pH)

Chemical		Ca(OH)2	Mg(OH)2	NaOH
#chem/#alk		0.82	0.595	0.81
$/# chem.		$0.1445	$0.25	0.30
$/# alk added		0.1185	0.149	0.243
Cost/day (1,000#/day of alk)		$118.5	$149	$243

Chemical Optimization

- Most important
  - Give the performance data to Operations
  - And give them targets based on comparisons

Exercise

- What chemicals do you have and what have you done to optimize?

Reducing Costs

- Biosolids Reuse/Disposal

Biosolids

- Evaluate contracts for final reuse or disposal
- Do you have competition when it is bid?
- Benchmark with other plants
- Can you team up with another plant under one contract?
- Can you manage the hauling/land application with your staff and vehicles?
- Can you change your in-plant processes to make final disposal less expensive? This could be a long-term project

Reducing Costs

- Power Use

Typical Plant Use of Energy

• Pumping	12.0%
• Aeration	55.0%
• Clarifiers	3.0%
• Digestion	11.0%
• Solids Processing	8.0%
• Buildings, HVAC, Lighting	6.0%
• Other	5.0%

Aeration Tank

Primary Sludge Pump

Energy Use

- Typical activated sludge plant = 1200 to 2500 kwh/MG
- With advanced nutrient removal = increase another 30 to 50%

Optimizing Energy Use

- Two approaches
  - Use less
  - Pay less for what you do use

Energy Audit

- An audit helps you understand:
  - How much energy your plant uses
  - Helps you understand why you use it
  - Most of the time, this knowledge can lead you to defining saving opportunities

How to Begin to Optimize*

- Perform energy audit
  - List all motors over x hp (depends on plant size)
  - Estimate hours/day for each large user
  - Build a table by asset of kwh/day use
  - Estimate daily/annual cost of each asset
  - Calculate kwh/MG and compare to benchmark
- Examine rate structure
  - Based on usage above, is there a better rate structure
    - Demand Billing, e.g.

Inventory of Motors

Motor List by Area of the Plant					
Equipment	Rated hp	No. of units	Hrs/day	Year Installed	Efficiency
Raw Pump	150	5	16	2001	86.5%

Definitions*

- Watts (W) – Volts X Amps
- Kilowatts (kW) – 1000 watts
- Kilowatt Hours (kWH) – kW x Hours = the amount of power used
- 1.0 Horsepower – 0.746 kilowatts
- Duty cycle – number of hours a motor is running per day or per month
- Load factor – measured (or assumed) percentage of full load amps

Energy Management Plan

- Gather Data
- Analyze the data
- Develop a plan
- Implement the plan
- Evaluate results

Steps in conducting a Level 1 Audit

- Review your power bills (one to two years of data)
- Do an inventory of your largest motors
    - List horsepower rating, duty cycles, etc. of each
- With the above information look for opportunities to save
- Develop a number of Energy Conservation Measures (ECMs)

- The pitfall of a Level 1 audit is that it is not based on real data. It therefore assumes efficiencies that may not be realistic

Studying the Power Bill

Rate Structure

- Each company has a variety of rate structures
- Some for residential; some for commercial; some for industrial
- A plant and pump stations are considered industrial, because they have large motors that create more challenges for the power supplier
- You may have different rate structures for the plant vs. the pump stations, depending on maximum demand
- If you can generate power on-site, that puts you into another rate structure

Working with your power company

- Become friends with your account manager
- Ask them to help you understand your bill and how you can save
- This is one industry where helping you save money also benefits them. Why???
- Explore different rate structures
- They may even help you with an energy audit

Dissecting your Power Bill

- Basic charge - $ per month – the cost of having an account
- On peak usage - $ per kwh used during a day from 9 AM to 10 PM (could be tiered)
- Off peak usage - $ per kwh used during a day from 10 PM to 9 AM
- Demand - $ per kw – based on the maximum rate of electrical use in a 15, 30, or 60 minute period during that billing period
- Power factor – the ratio of real power to apparent power . You pay more if < 0.9

Explanation of bill components

- Basic charge
  - This is a monthly charge for the rate class that your facility is billed under
  - Not much that can be negotiated here

Explanation of bill components

- On peak and off peak
  - During certain times of the year, the power company bills at different rates for time of day.
  - On peak is usually higher and covers during the day
  - There may be one rate for the first 100 kwh and another for the remainder
  - Off peak can be lower and covers during the night
  - You can save money if you can move certain operations to the night time when the rate is lower
    - Does anyone have an example of an operation that can be moved to another time?

Explanation of bill components

- Demand rate
  - The power company also considers the total demand at any one time. They need to have the capacity to deliver your maximum demand. So they charge you for having to have capacity available.
  - Demand is often measured in increments of 15, 30, or 60 minutes.
  - Demand can be up to half the total bill
  - However, it can be managed to minimize demand and therefore this component of the bill
    - Anyone have an example?

Explanation of bill components

- Power factor (PF)
  - Can be an extra charge or a credit
  - An extra charge if PF is less than 0.9
  - A credit if PF is greater than 0.9
  - Most motors require more power than what is required to operate them
  - The ratio of what is used compared to what needs to be supplied is the PF
  - This can be corrected

Correcting power factor

- Installing capacitors (small investment that pays back quickly)
  - Can purchase for individual motors from electrical suppliers, such as GE, Schneider, Eaton, ABB, and many others
  - Correcting power factor always saves money
- Minimizing the operation of idling or lightly-loaded motors
- Avoid operation of equipment above the rated voltage
- Replace standard motors with high efficiency as the old ones wear out

Capacitors

Concept of ECMs *

- Recommend an Energy Conservation Measure
- Calculate cost of making the change, e.g. buy new equipment, build something new, etc.
- Calculate savings in annual budget
- Determine payback – if < 5 years, do it
- Do the highest payback projects first

- Example

Return on Investment*

- If an improvement costs $10,000, is it worth it?
  - Based on this improvement, the savings are estimated at $500/year in less energy cost.
  - $10,000/500 = 20 years to get your money back
  - Would not be justified based on saving energy alone

Getting Data

- Best to measure while unit working using a watt meter
- Can estimate using nameplate data
  - {Hp X (0 .746)/motor efficiency (.90)} X annual hours X $/kwhr X load factor (0.65) = Annual costs
  - Using amps and volts
  - {(Load amps X volts X 1.732 X power factor)/1000} X annual hours X $/kwhr = Annual costs

Some energy saving measures

- Screening – very low energy use, haul to landfill
- Influent pumping – maximize wet well level
- Grit – Optimize blower use if aerated; change sheaves to reduce power use; pump only 15 minutes per hour
- Primary – Remove as many solids as possible as it reduces load on aeration; CEPT; sludge and scum pumping largest use in primary; optimize pumping
- Secondary – blower use high – use inlet vanes, vari-speed blowers, fine bubble diffusers; DO control; optimize DO level

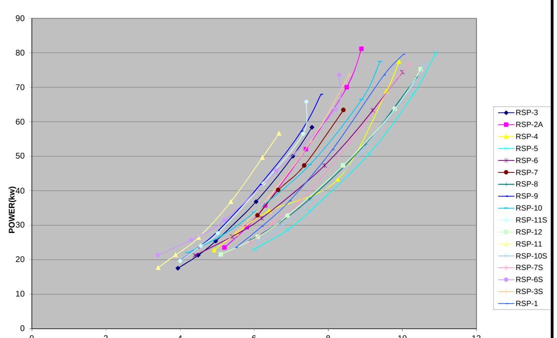
Energy saving measures (2)*

- RAS pumping can be significant since it is 40 to 100% of total forward flow
- WAS pumping only 1 to 3% of influent flow, but may have a high head
- Disinfection – low use, but high use of energy to produce hypo or UV
- Filtration – most energy use in backwashing, esp if air scour; if demand billing, may be able to backwash at off-peak power rates

Optimizing Pumps

- Pumps wear over time
- To check, take measurements and compare with original pump curve
- Can show which pumps are most worn
- Can develop a rebuild program with priorities
- Can install alternate impellers if flow changes made, vs. throttling
- Do you need a constant flow or variable flow

Pump Data



Causes of pump inefficiency*

- Wrong type of application
- Oversized
- Poor system design
- Cavitation – can lead to pump failure
- Wear ring clearance excessive
- Internal recirculation
- Poor flow control maybe pumping more than process needs
- Bearings worn
- Mechanical seal leakage – or improper packing adjustment

Routine pump evaluations

- Find a way to compare flow pumped vs. power consumed
  - Use drawdown in a tank
  - Or pump to a tank
  - Install a temporary meter on discharge line
  - Measure suction & discharge pressure (use new gages)
  - Measure power use
    - If a VFD, measure power into the VFD

VFD

Motors*

- Should generally purchase high efficiency motors for equipment with long run hours
- These cost 15 to 60% more than standard motors
- Calculate payback to determine if cost effective
- Example

Example Calculation on High-Efficiency Motors

- Question: Is it worth the money to purchase a high-efficiency motor?
- Assumptions: 10 hp motor; Normal efficiency = 86.5%; It costs $518.00; High efficiency = 91.2% and costs $781.00. Power costs $0.08/kwhr; Duty cycle 24 hours/day = 8760 hours/year.
- Hi-efficiency costs: (10 hp X 0.746 kw/hp / 0.912) X 8760 hours/year X $0.08/kwhr = $5732.00/year

Continued*

- Normal efficiency costs: (10 hp X 0.746 kw/hp / 0.865) X 8760 hours/year X $0.08/kwhr = $6044.00
- Difference in annual cost is $6044 - $5732 = $312.00
- Difference in purchase price is $781 - $518 = $263.00

- Payback is 263/312 = 84.3% or about 10 months.
- Any payback less than 3 to 4 years is worth doing.

Care of motors

- Keep vents clean – avoid overheating
- Keep belt tension optimized
- Do not over lubricate – a motor should last about 11 years or 100,000 hours

Summary

- There are many things you can do to optimize
- Focus on highest payback projects first
- Make one change at a time on a process
- Document your results - to sell to upper management
- Be patient – It can take years to finish – Or you may never finish…..