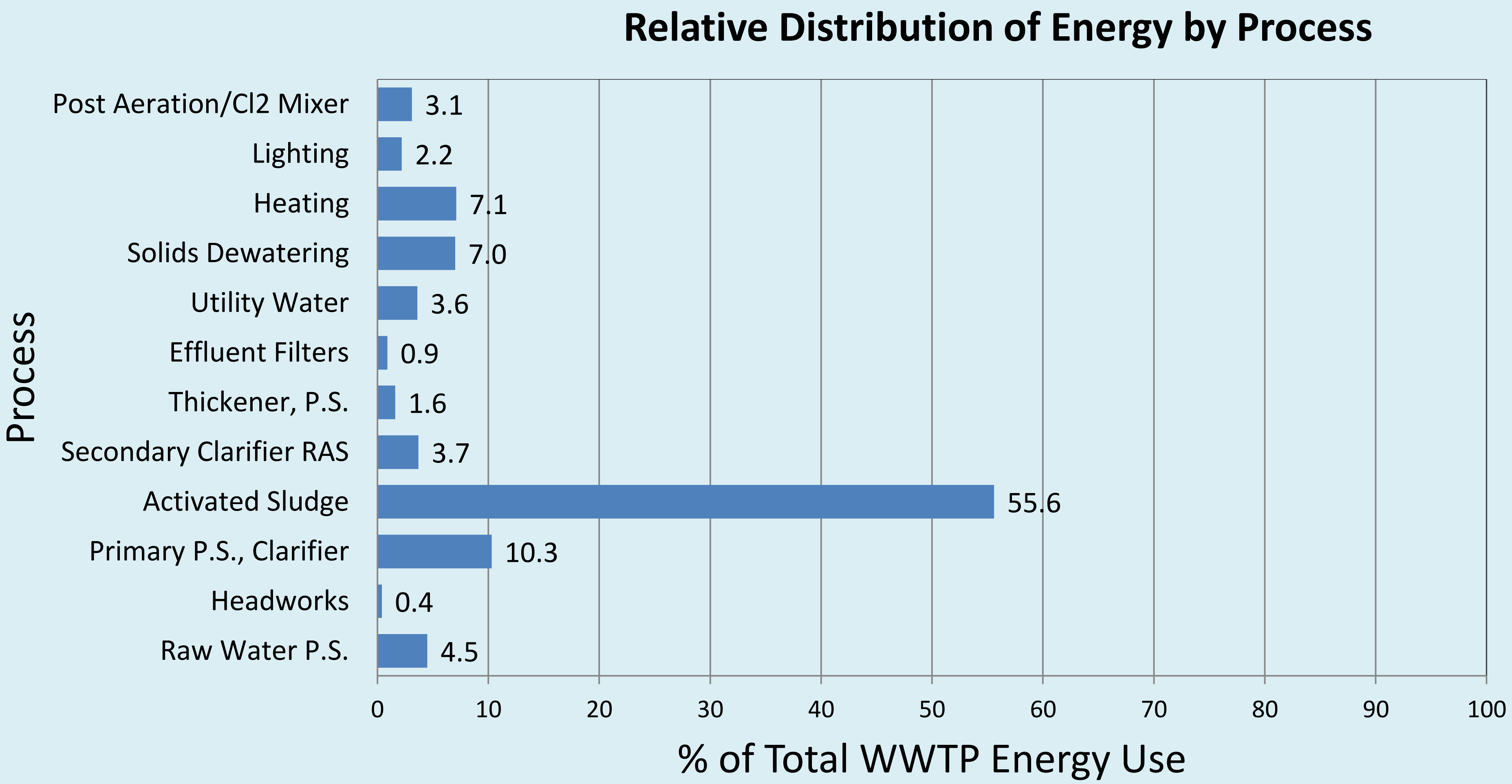
Saving Energy at WWTPs with the Bio-Tiger Model

- Energy use for a given-size WWTP may vary significantly depending on:
  - Location
  - Strength of wastewater
  - Level of treatment
  - In-plant recovery
  - Type of treatment process
  - Mode of operation

- Relative distribution of energy use at a secondary wastewater treatment* plant:



* Sample 7.5 MGD WWTP

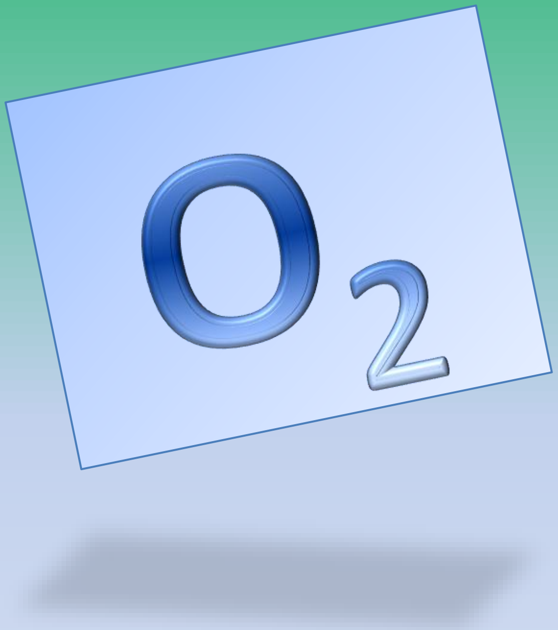
- Energy costs account for:
  - 15 to 30% of the operation and maintenance (O&M) budgets at a large WWTP, and
  - 30 to 40% of O&M costs at a small WWTP.

Secondary Treatment

- Overall, aeration devices used for the activated sludge system represent the most significant consumers of energy within a WWTP.

- Most aeration systems are classified as:
  - Diffused
  - Dispersed
  - Mechanical

- The ability of any type of equipment to dissolve oxygen within a wastewater treatment system depends on:
  - Diffuser device type
  - Basin geometry
  - Diffuser depth
  - Turbulence
  - Ambient air pressure
  - Temperature
  - Spacing and placement of the aeration devices
  - Diurnal variations in wastewater flow and organic load
  - DO concentration in aerobic reactors



- Having high DO (dissolved oxygen) concentrations within aeration tanks is a waste of energy

- If the system uses blowers, an operator should cut back on blowers or blower output.

- If the facility has coarse bubble diffusers, then a fine-bubble-diffuser system that is more efficient and uses less energy should be considered.

- If a facility has surface aerators, the submergence on the unit may be decreased, which results in:
  - Less DO concentration
  - Less amperage load on the motor (less electrical cost)

- If the liquid level of the basin cannot be adjusted, then:
  - VFDs should be installed on the aerators, or
  - Aerators should automatically start and stop based on time intervals.

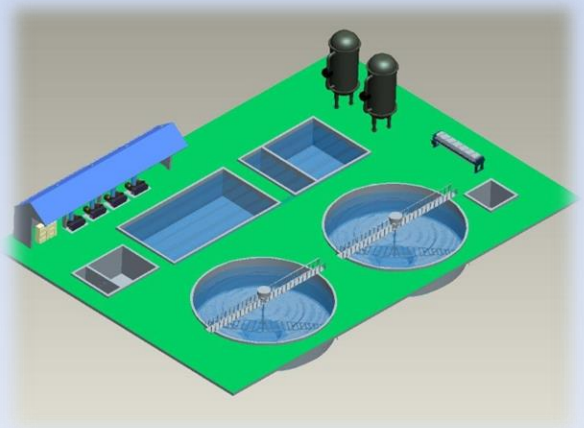
- Activated sludge aeration equipment uses large horsepower motors and multiple units such as:
  - Centrifugal-type blowers
  - Positive-displacement blowers
  - High-speed turbine (HST) blowers
  - Surface aerators

- Adding excessive air into the aeration tanks will only result in a waste of energy.

Questions?

- Improving the operation of aeration systems is one of the best ways to reduce the energy costs for wastewater treatment.

- The amount of oxygen required by the activated sludge process depends on:
  - Flow rate
  - Organic waste load
  - Oxidizable N load
  - SRT



- DO probes (sensors), in conjunction with online instrumentation systems perform the critical function of measuring DO levels in the aeration process.

- Typically, oxygen requirements vary throughout the day by a factor of 5 to 7 and can be regulated by automatically controlling systems.

- Air flowrates may be automatically adjusted by:
  - Changing blower speed
  - Adjusting blower inlet guide vanes
  - Operating control vanes

- A key to controlling the activated sludge process (and energy use) is matching oxygen supply to oxygen demand while maintaining a reasonable DO concentration.

- Typically, as wastewater flow and oxygen demand increase in the morning based on the diurnal flow of a WWTP, more aeration is needed.

- Conversely, as flow decreases during the night, the air supply should be reduced.

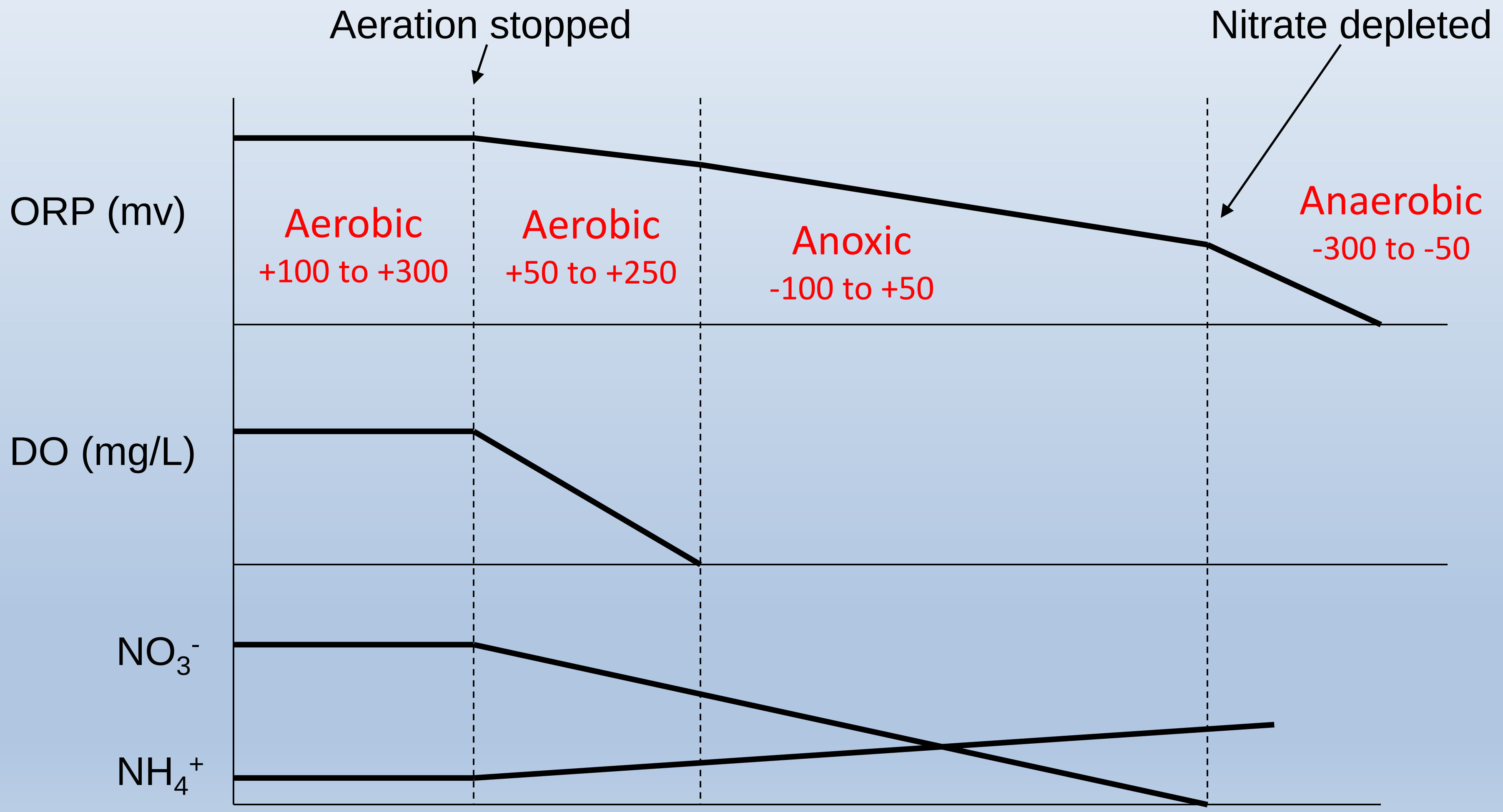
- A general rule has always been to maintain a DO concentration of 2mg/L in the aeration tanks.
- Once the carbonaceous and nitrogenous oxygen demand have been satisfied, maintaining any DO above 2 mg/L is excessive and a waste of energy.
- A number of treatment facilities maintain a DO concentration of 0.5 to 2.0 mg/L at the end of the aeration basin.

- Fine-bubble diffusers provide higher oxygen-transfer efficiencies as opposed to coarse-bubble diffusers.
- Installing fine-bubble diffusers into aeration basins will reduce the blower capacity needed to satisfy the process air demand.
- Less blower capacity will result in energy savings.

Intermittent Aeration for Energy Conservation in Oxidation Ditch

- Cycle time for on/off operation of aerators may vary
- Process control with DO and ORP monitoring
- When aerator is off, mixing is preferred
- During off period, oxidation ditch becomes anoxic reactor, and nitrate is consumed as bacteria degrade BOD
- ORP data are used to terminate off cycle and start aeration

Change in ORP and DO in On/Off Operation



Factors Affecting On/Off Operation

- Oxidation ditch HRT
- Influent flow rate
- TKN and BOD concentrations
- Number of on/off cycles per day
- Ditch MLSS concentration

Questions?

Bio-Tiger Model Training
March 4, 2021

Introduction to the Bio-Tiger Model

Providing Input Data to the Bio-Tiger Model for “Current Conditions”

Activated Sludge Input Data	
Temperature (°C)	**20**
S_o - Influent BOD_5 conc (mg/L)	**200**
V – volume of reactor (mil gal)	**1**
Q – influent flow rate (mgd)	**1**
Inert VSS (mg/L)	**40**
Oxidizable N (mg/L)	**35**
biomass (VSS/TSS)	**0.85**
Influent TSS (mg/L)	**200**
Inert Inorg TSS (mg/L)	**20**
Effluent TSS (mg/L)	**8**
RAS TSS (mg/L)	**10000**
MLSS (mg/L)	**3000**

f_d	0.1
Y	0.60
K_s (mg/L)	60
k_d at 20°C (1/day)	0.1
k at 20°C (1/day)	8

Aerator Performance Data	
Operating DO concentration (mg/L)	**4.5**
alpha	**0.84**
beta	**0.92**
SOTR, lb O2 / hp-hr	**2.7**
Temperature (°C)	**20**
Aeration (hp) being operated	**150**
Elevation (ft)	**200**
Aerators operating time (hr/day)	**24**
Type of aerators (1, 2, or 3)	**1**
Speed of aerators (%)	**100**
Energy cost unit ($/kWh)	**0.09**

SRT (day)
1
2
4
6
8
10
12
14
16
18
20
22

Analysis

Revert to default

Reviewing Output Data from the Bio-Tiger Model for "Current Conditions"

Approximate Operating Conditions	
Total average daily flow rate (mgd)	**1.00**
Aeration volume in service (mil gal)	**1.00**
Influent BOD5 concentration (mg/L)	**200**
Influent BOD5 mass loading (lb/day)	**1,668**
Sec ww Oxid N load (lb/day)	**292**
Sec ww TSS load (lb/day)	**1,668**
F/M ratio	**0.089**
Solids Retention Time (day)	**28.0**

MLSS (mg/L)	**3,000**
MLVSS (mg/L)	**2,242**
TSS Sludge Production (lb/day)	**827**
TSS in activated sludge effluent (lb/day)	**66.7**
Total Oxygen Requirements (lb/day)	**3,121**
Total Oxygen Req'd W/Denit. (lb/day)	**2,687**
Total oxygen supplied (lb/day)	**3,394**
Mixing intensity in the reactor (hp/mil gal)	**150**
RAS flow rate (mgd)	**0.43**
RAS recycle percentage (%)	**42.9**

WAS flow rate (mgd)	**0.010**
RAS TSS concentration (mg/L)	**10,000**
Total sludge production (lb/day)	**894**
Reactor Detention Time (hr)	**24.0**
VOLR (lb BOD/(thou cu ft-day))	**12.48**
Effluent CBOD5 (mg/L)	**4.0**
Effluent TSS (mg/L)	**8.0**
Effluent Ammonia-N (mg/L)	**0.38**
Effluent NO3-N (mg/L)	**26.0**
Effluent NO3-N W/denit (mg/L)	**7.8**

Actual Aerator Performance	
Field OTR (lb O2 / hp-hr)	**0.94**
Aerator energy use (kWh/month)	**70,200**
Energy cost ($/month)	**6,318**

Questions?

Providing Input Data for an "Alternate Scenario"

Activated Sludge Input Data for Alternate Scenario	
Temperature (°C)	**20**
S_o (mg/L)	**200**
V (mil gal)	**1**
Q (mgd)	**1**
Inert VSS (mg/L)	**40**
Oxidizable N (mg/L)	**35**
biomass (VSS/TSS)	**0.85**
Influent TSS (mg/L)	**200**
Inert Inorg TSS (mg/L)	**20**
Effluent TSS (mg/L)	**8**
RAS TSS (mg/L)	**10000**
MLSS (mg/L)	**3000**

f_d	0.1
Y	0.6
K_s (mg/L)	60
k_d at 20°C (1/day)	0.1
k at 20°C (1/day)	8

Aerator Performance Data	
Operating DO concentration (mg/L)	**2**
alpha	**0.84**
beta	**0.92**
SOTR, lb O2 / hp-hr	**2.7**
Temperature (°C)	**20**
Aeration (hp) being operated	**100**
Elevation (ft)	**200**
Aerators operating time (hr/day)	**24**
Type of aerators (1, 2, or 3)	**1**
Speed of aerators (%)	**85**
Energy cost unit ($/kWh)	**0.09**

Analysis

Revert to default

Reviewing Output Data for an "Alternate Scenario"

Approximate Operating Conditions for “Alternate Scenario”	
Total average daily flow rate (mgd)	**1.00**
Aeration volume in service (mil gal)	**1.00**
Influent BOD5 concentration (mg/L)	**200**
Influent BOD5 mass loading (lb/day)	**1,668**
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Effluent CBOD5 (mg/L)	**4.0**
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Effluent Ammonia-N (mg/L)	**0.38**
Effluent NO3-N (mg/L)	**26.0**
Effluent NO3-N W/denit (mg/L)	**7.8**

Actual Aerator Performance for “Alternate Scenario”	
Field OTR (lb O2 / hp-hr)	**1.56**
Aerator energy use (kWh/month)	**39,780**
Energy cost ($/month)	**3,580**
Cost savings vs. current conditions ($/month)	**2,738**

Questions?

Bio-Tiger Model
Case Study

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