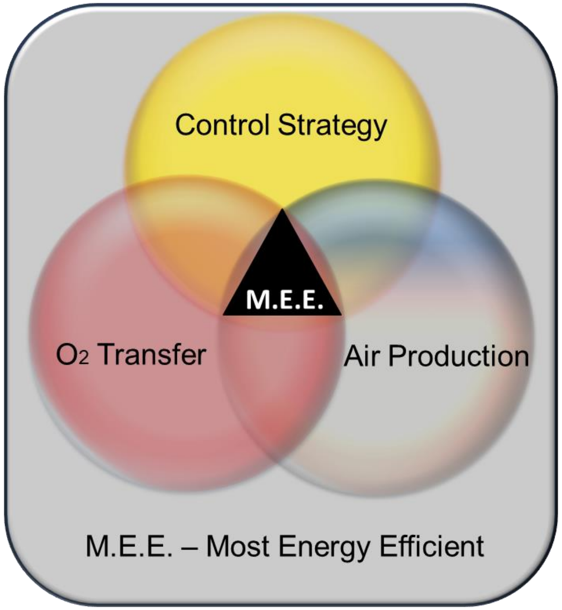
Hazen

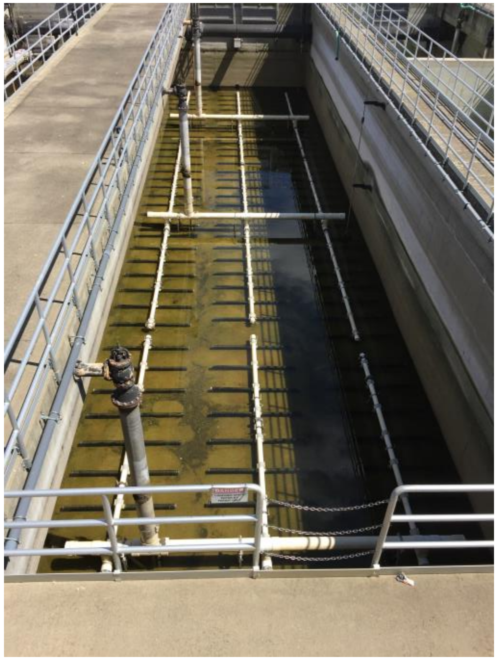


Aeration Systems & Efficiency

55th Annual Wastewater Workshop – OTCO, Inc.

Agenda

- Energy Management
- Evolution of the Biggest "Sink"
- Aeration System Efficiency Defined
- "I have a deal for you!!!"
- Case Study



Energy Management

"The Perfect Storm"

- Energy costs are rising
- More stringent treatment regulations
- Economy influence
- Social and environmental influences
  - CO_2 Emissions
  - Air Quality
- Federal and local government energy policies
  - Renewable energy portfolio standards
  - Grants and funding for "green" projects

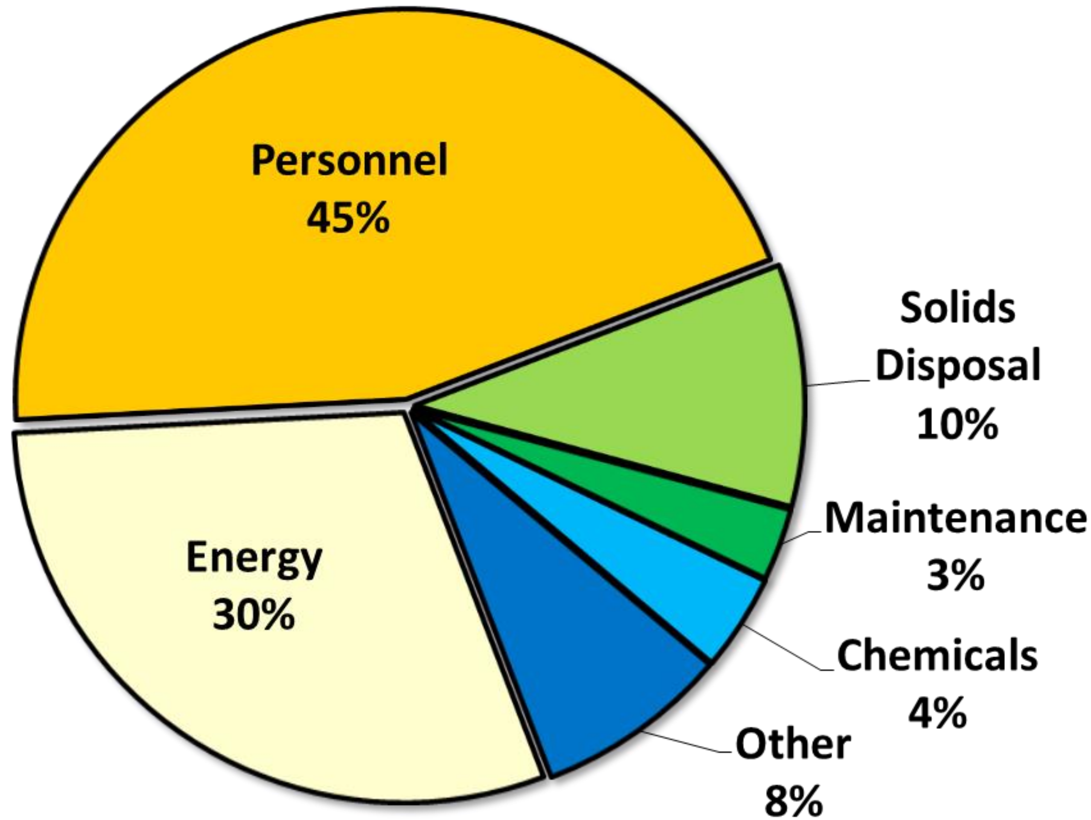
Energy Consumption in W/WW Industry

W/WW 3% of the nation's energy use (Source-EPA)

W/WW loads typically largest energy user for municipal utilities

Operating budgets stagnant or declining

- More automation (lower personnel $)
- Reduce energy



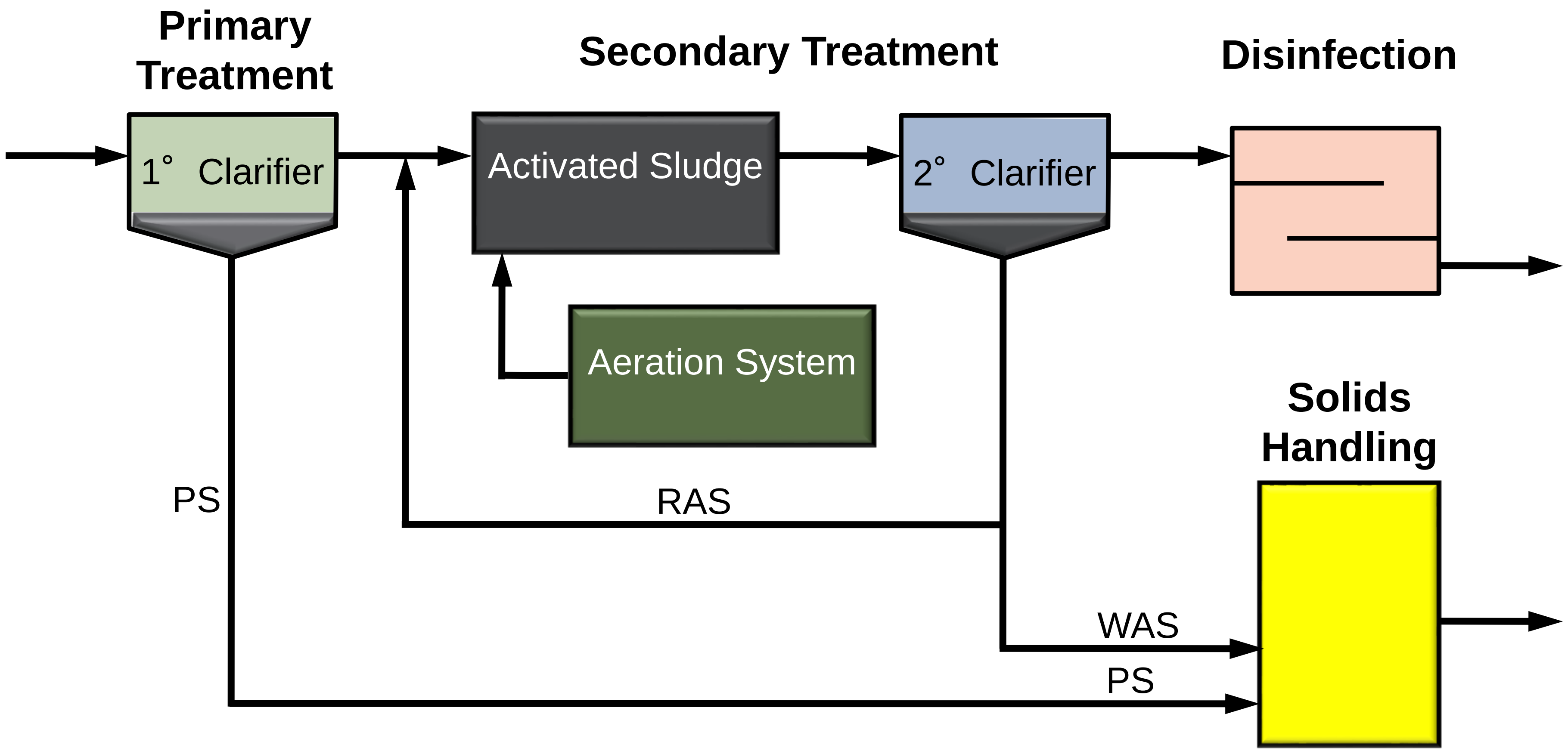
Wastewater Treatment

Different Thinking about "Energy"

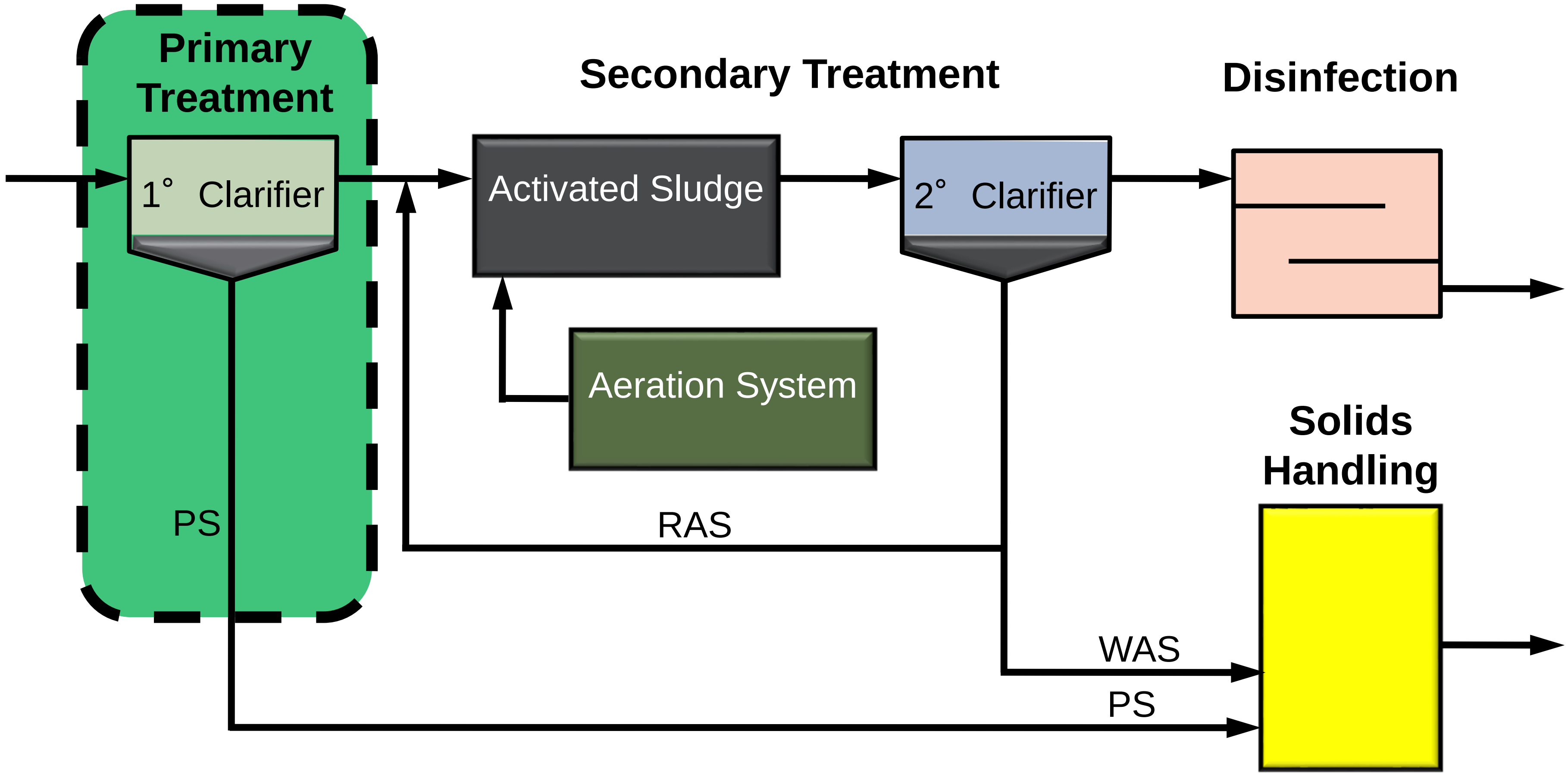
Yesterday's Thinking
Energy = Electrical Power

Tomorrow's Thinking	
Potential Energy	Soluble COD
Energy Sinks	Aeration & Pumping Systems
Energy Extraction	Digester Gas

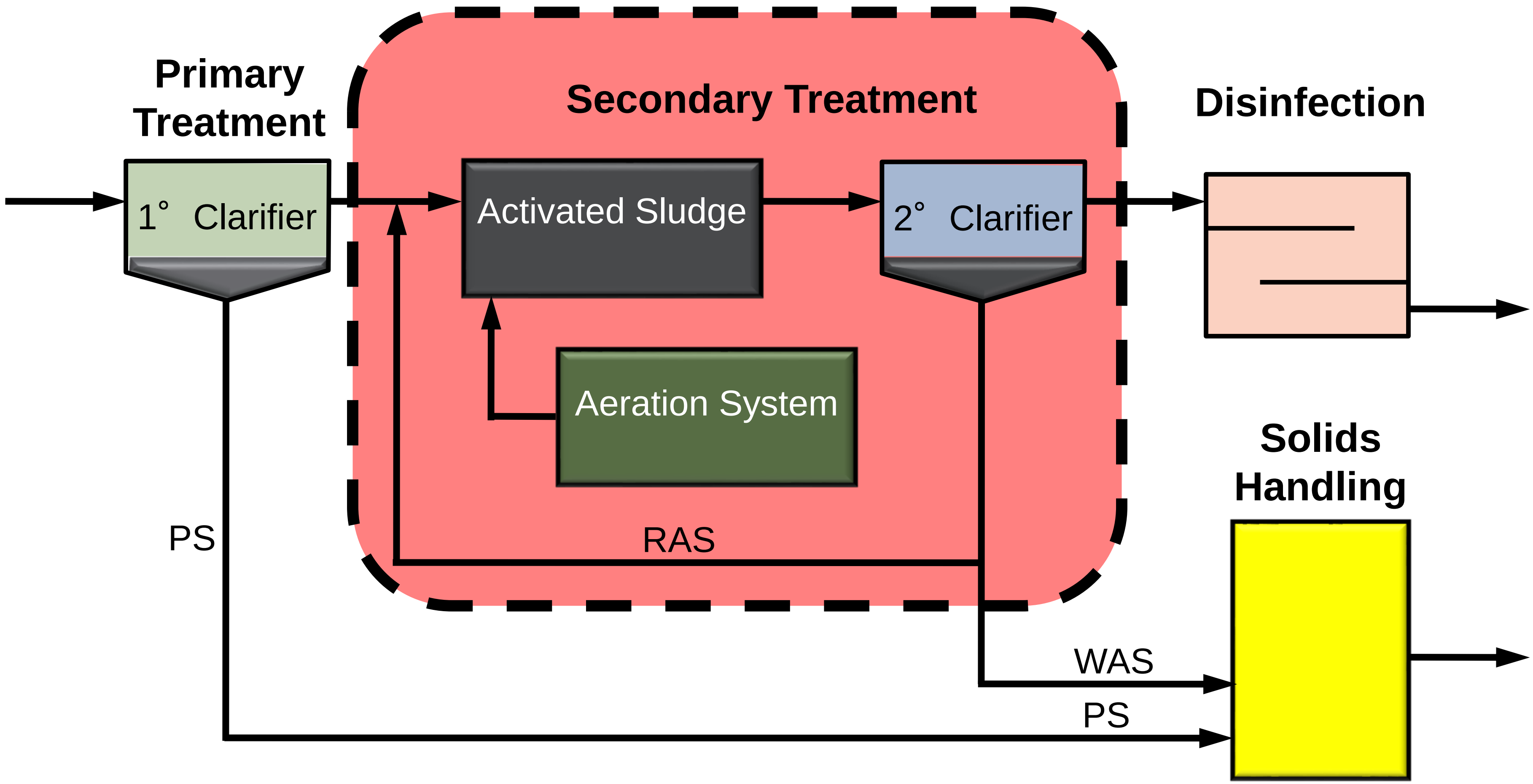
Tomorrow's Thinking
Energy Management



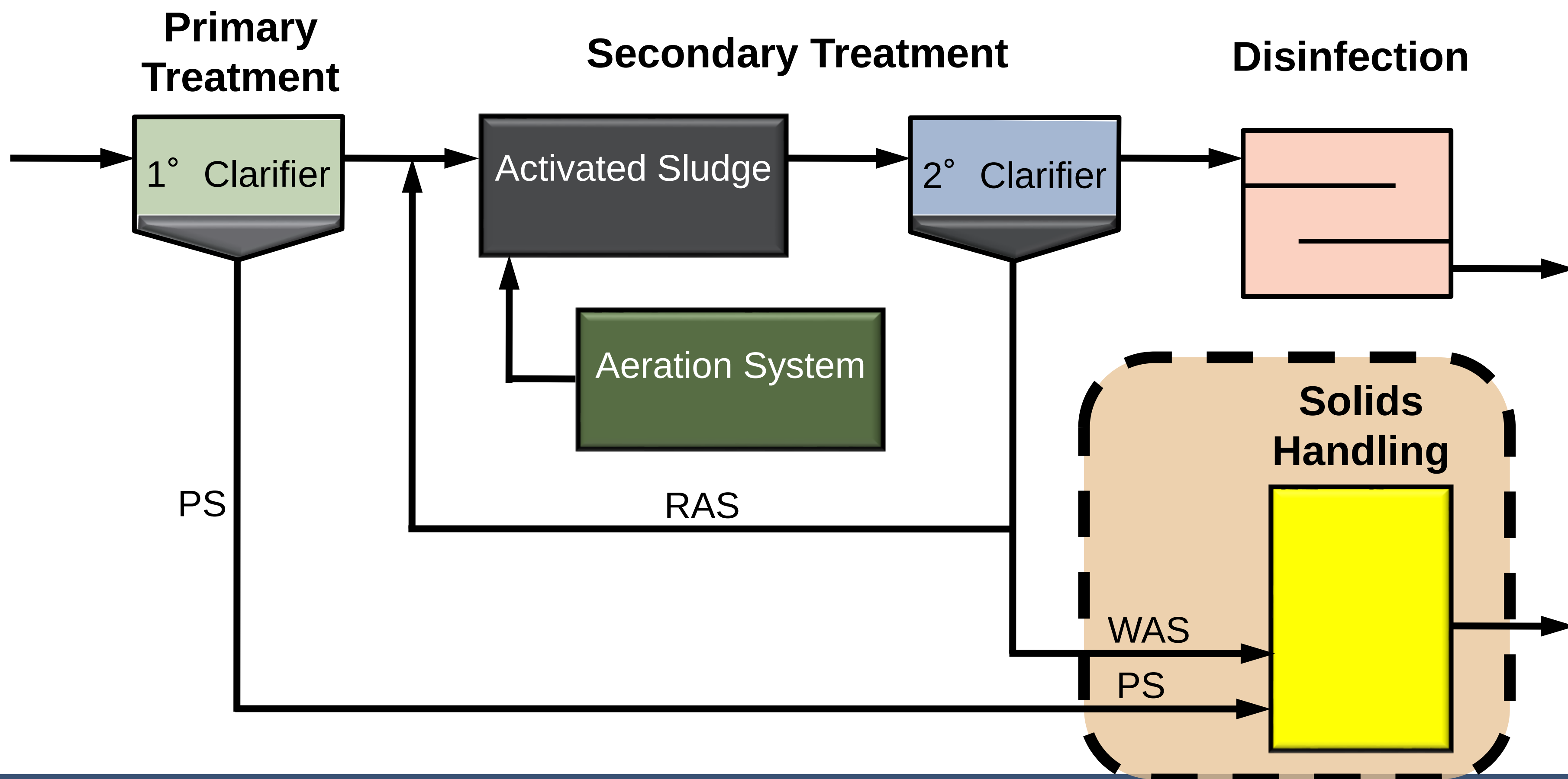
Available Influent Energy
Potential Energy – "It's Free"



Energy "Sinks"
Minimize Energy to Reduce Operating Costs



Energy "Harvesting"
Energy Produced > Energy Required



Tomorrow's Thinking
"Energy ≠ Electrical Power"

Potential Energy
- Denitrification
- Primary clarifier enhancement
- Primary sludge fermentation

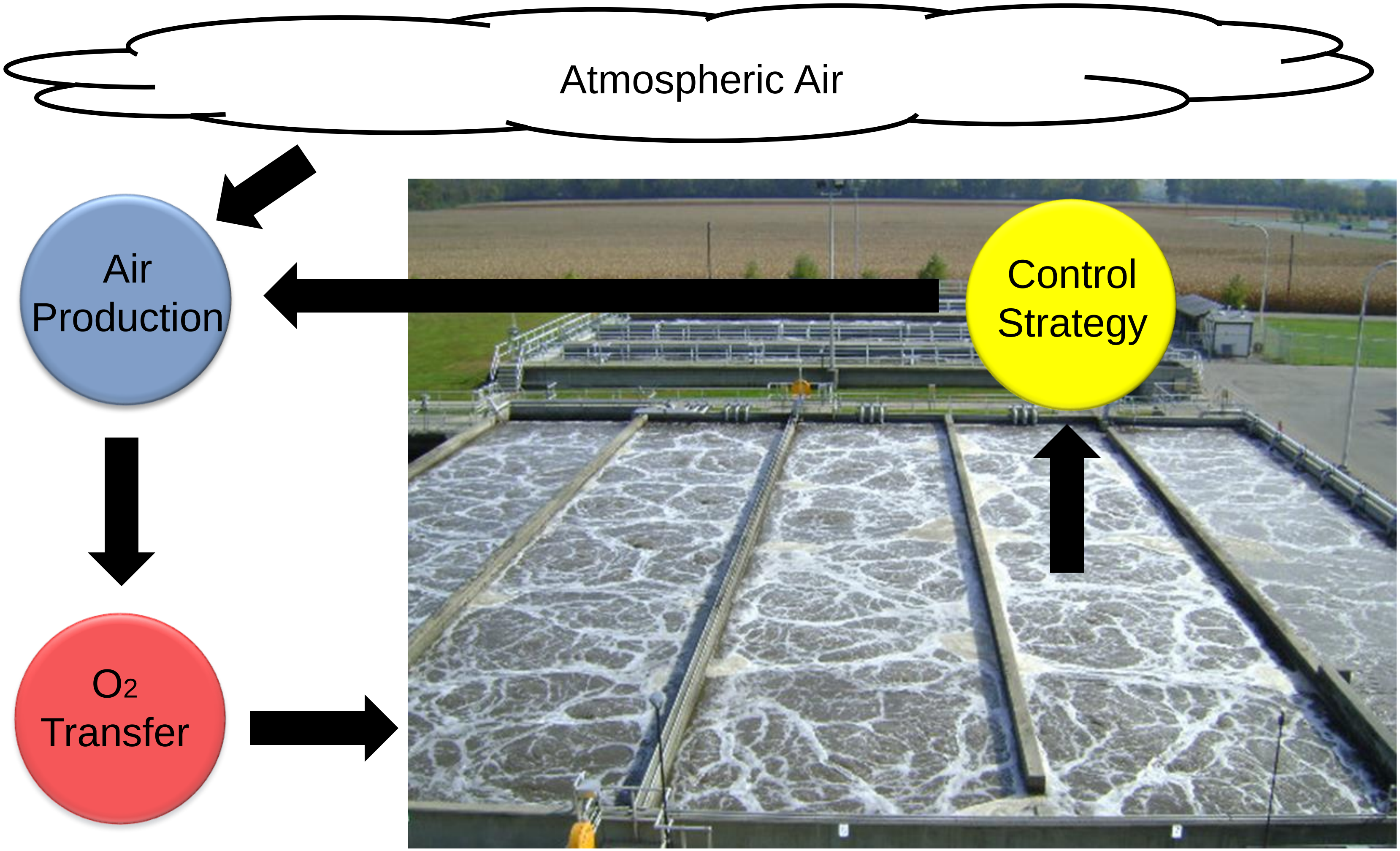
Energy Sinks
- Aeration improvements
- High efficiency motors
- Pump VFD
- Reduce chemical use

Energy Harvesting
- Anaerobic digestion
- Gas recovery
- Nutrient recovery
- Co-gen
- Heat recovery

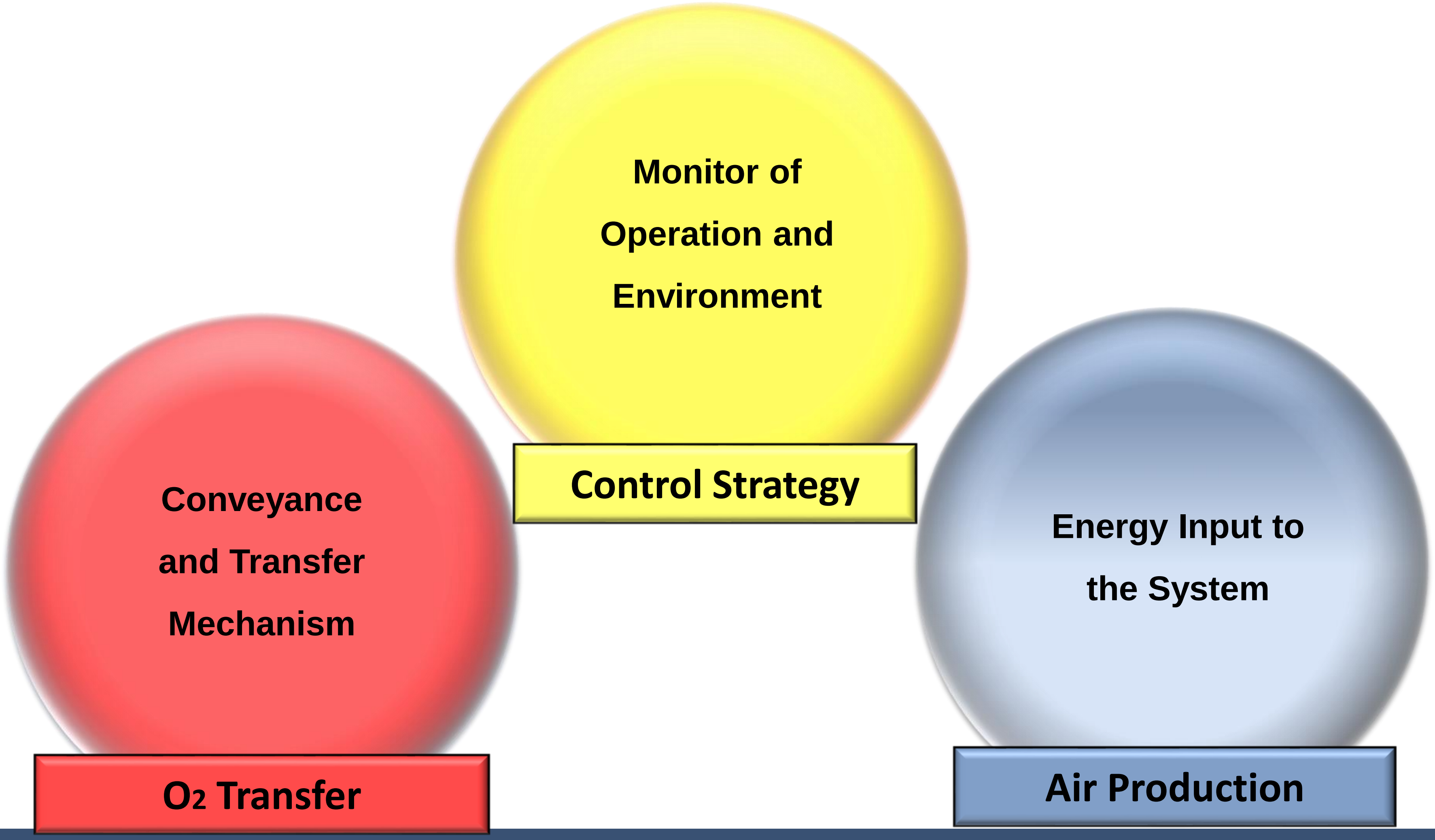
Aeration Systems
Wastewater Treatment Biggest Energy "Sink"

- Typically, 45 – 75% of total electrical costs
- Why necessary?
  - Conversion of particulate to soluble material
  - Oxidation of soluble organic material
  - Nitrification
- Aeration system components
  - Oxygen control strategy
  - Oxygen transfer system (i.e. diffusers)
  - Air production (i.e. blowers, aerators, etc.)

What is an Aeration System?



Aeration System Evaluations
Three Areas of Consideration



Aeration System Evolution

1970s	1980s	1990s	Present
Major infrastructure investments	Construction & operation of WWTP	Fine bubble diffusers widely adopted	Equipment reaching end of useful life
“Quick and Cheap” solutions	Medium/Fine bubble diffusers	Auto DO controls implemented	Big advancement in technologies
Technology was limited	Manual controls (some auto)	Blower equipment advancement	Suppliers are in “sell, sell, sell…”

Air Production Evolution

Multi-Stage Centrifugal
Positive Displacement

Oil Bearing Single-Stage Centrifugal

Air/Mag Bearing Single-Stage Centrifugal

7-10 mpg

16-18 mpg

20-25 mpg

>100 mpge

Oxygen Transfer Evolution

Coarse Bubble Diffusion

Medium Bubble Diffusers

Fine Bubble Diffusers

Ultra Fine Bubble Diffusers

Control Strategy Evolution

Complete Manual Operation

In-Field Monitoring Only

Single-Parameter Control

Multi-Parameter Control

Typical WWTP Aeration System Upgrades

Original Construction

1990s Upgrade

2000s Upgrade

So, what type of system do you have?

30-year old blowers with ultra-fine bubble diffusers with in-field monitoring only?

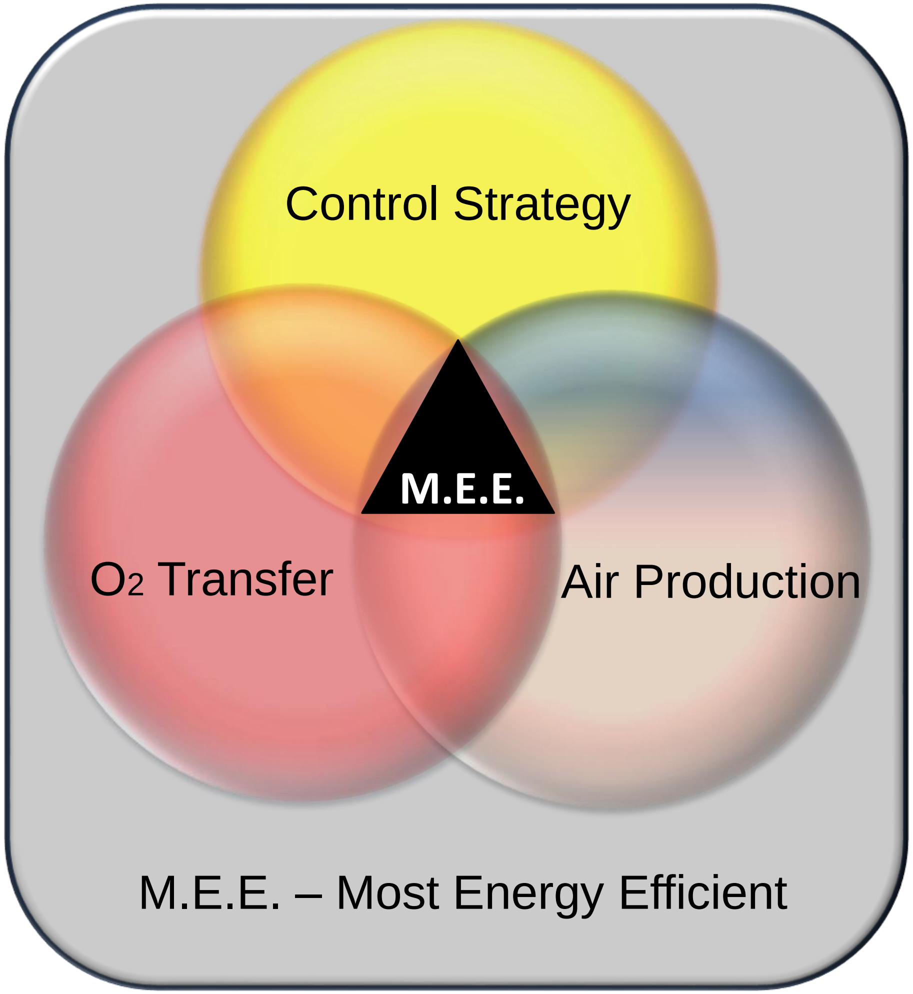
Are state of the art blowers with coarse bubble diffusers that is manually operated?

Aeration System
Most Energy Efficient Operation

Three systems must work together

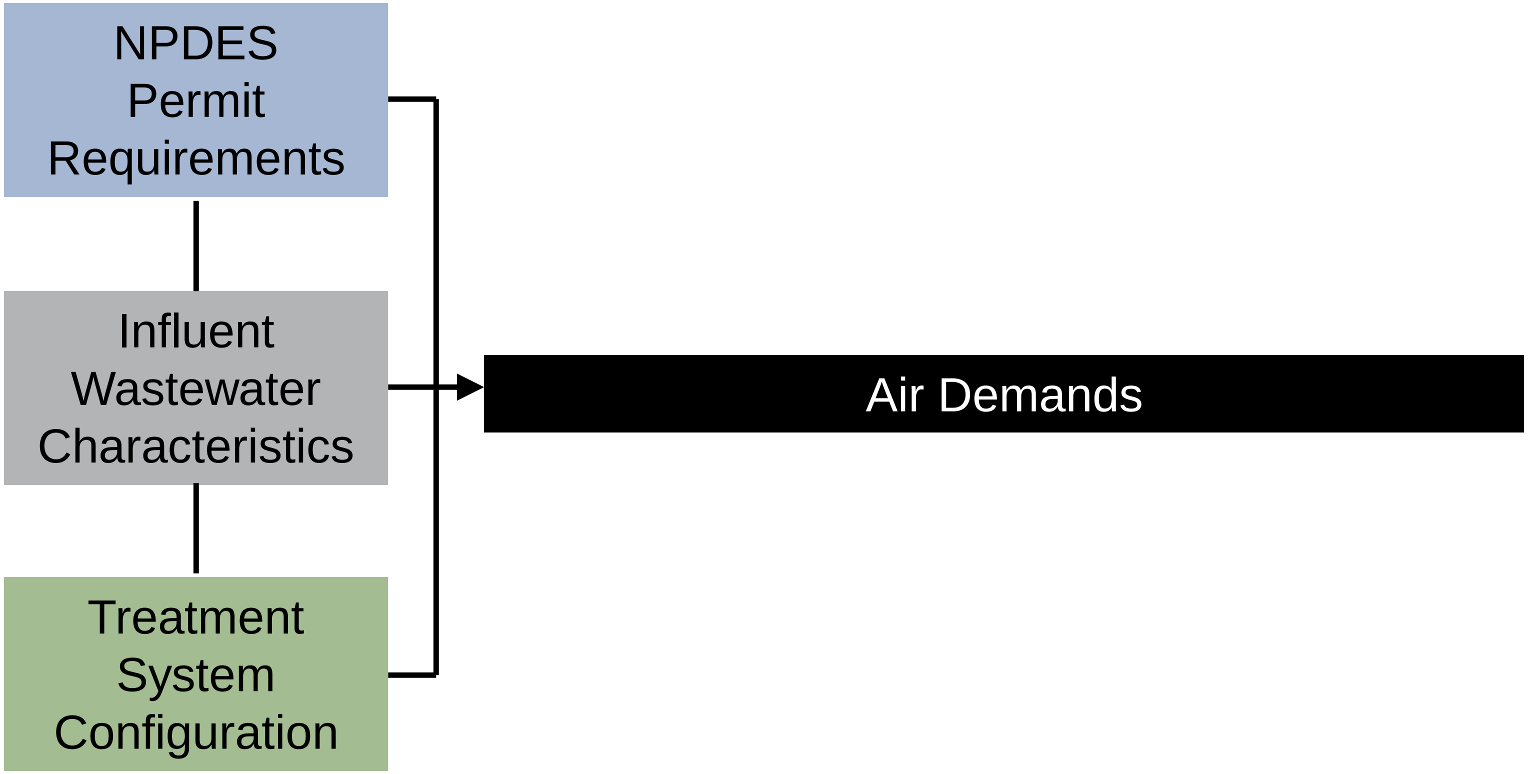
Improvements to one +/- impacts other two “circles”

Environmental & operational conditions control frequency in M.E.E triangle



Aeration System Performance

Baseline Operational Efficiency Criteria

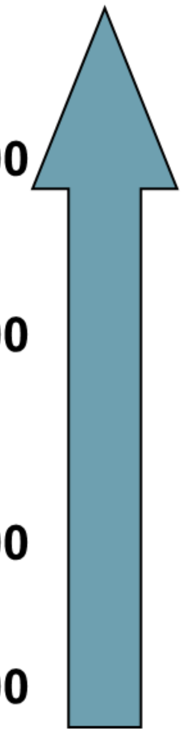


NPDES Permit Requirements

Electrical "Sink" Requirements

<u>Secondary Treatment</u>

- Activated Sludge with advanced treatment and nitrification — **1,900**
- Activated Sludge with advanced treatment, no nitrification — **1,600**
- Activated Sludge with no advanced treatment or nitrification — **1,400**
- No Activated Sludge — **1,000**
  - Trickling Filter



kWh/MG

Average is

1,800 kWh/MG

Influent Characteristics

Stable:

Low variability throughout the day, month, and year

Diurnal:

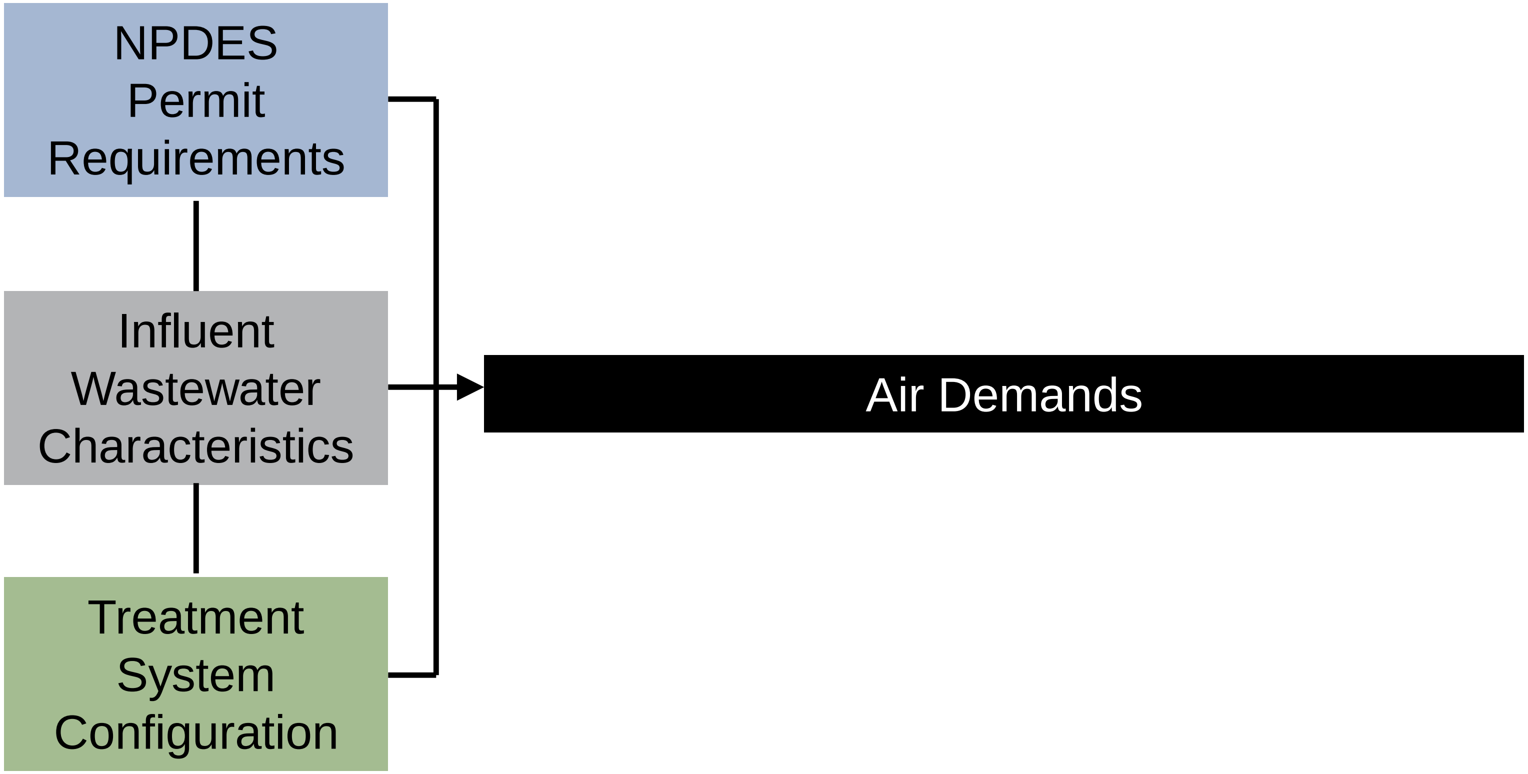
Daily variability with additional seasonal variability

Dynamic:

Dramatic changes hour to hour, and throughout the year

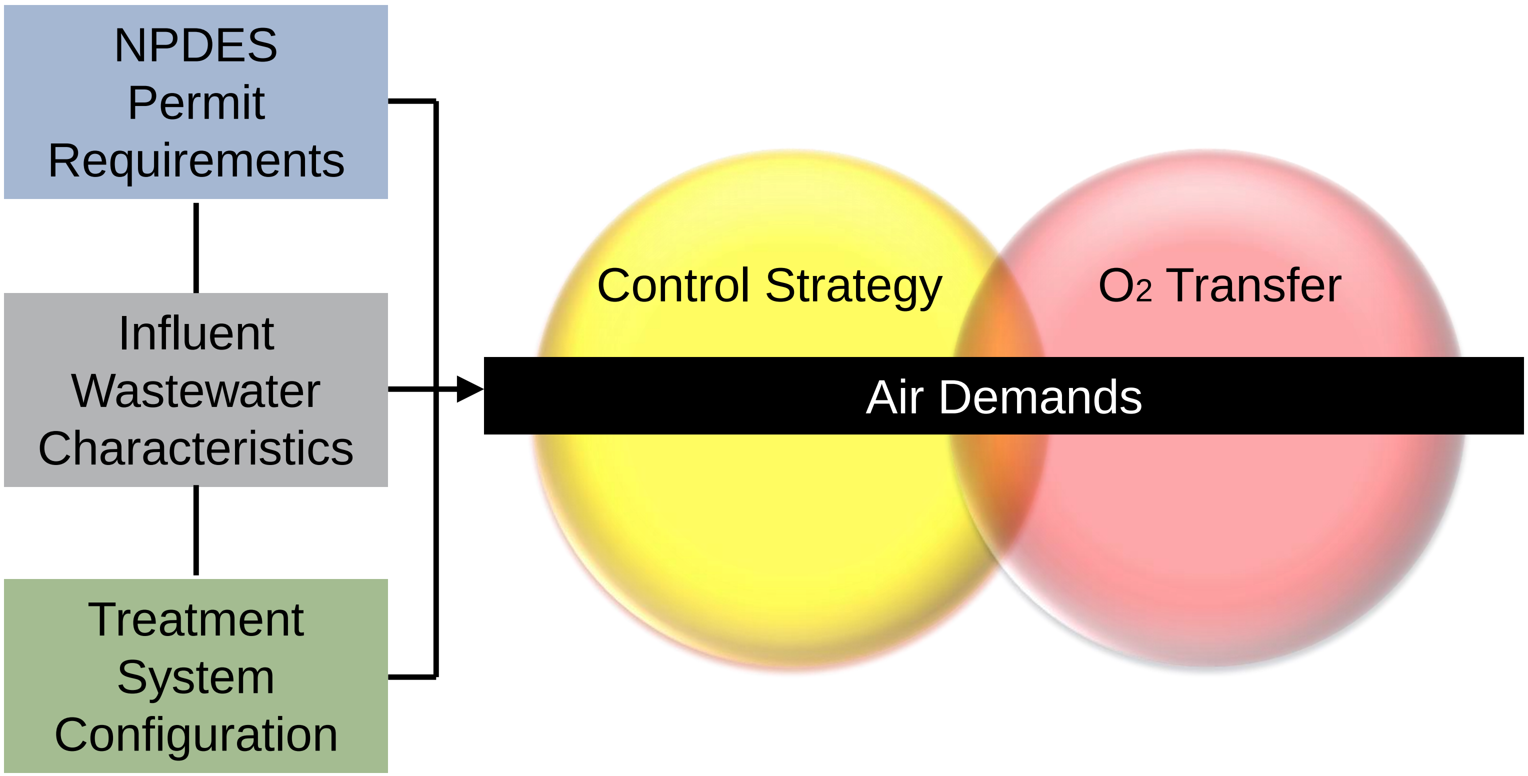
Aeration System Performance

Baseline Operational Efficiency Criteria



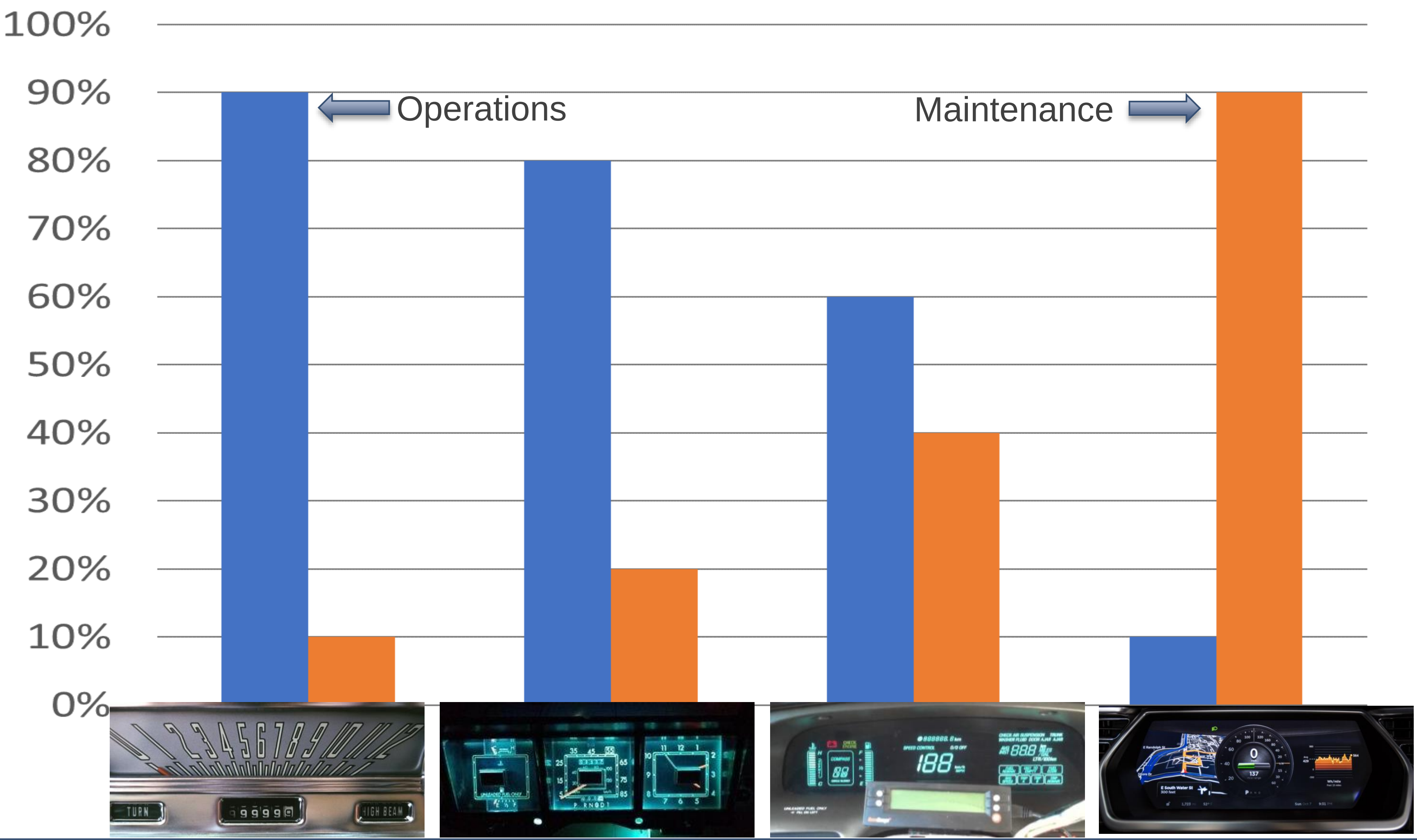
Aeration System Performance

“Mostly Defined” Efficiency



Control Strategy Characteristics

Where your $$$$ are spent for energy efficiency



Oxygen Transfer Characteristics

Improves Electrical Efficiency	Decreases Electrical Efficiency
Clean Water	Wastewater
New Membranes	Older Membranes
Deeper Submergence	Shallower Submergence
Lower Air Flows	Higher Air Flows



Diffuser Performance over Time

Represented by alpha-fouling factor (αF)

Diffuser Flux

More is better…for transfer efficiency

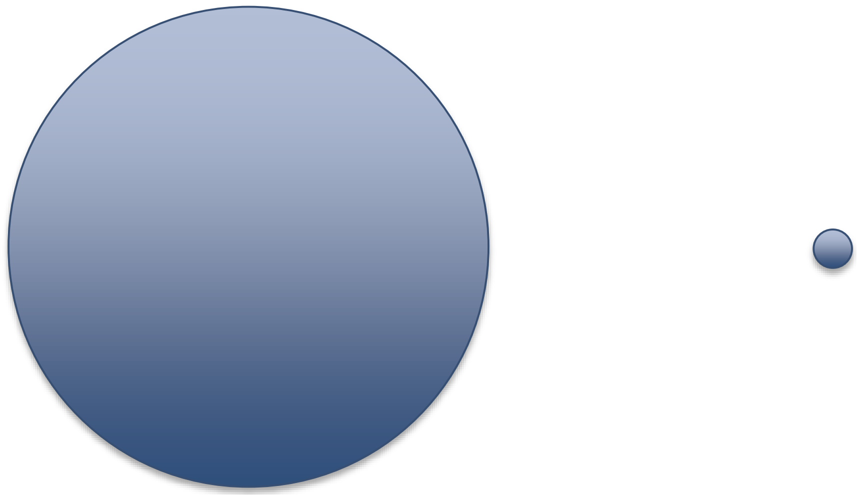
More Diffusers	Less Diffusers
Less air flow per diffuser	More air flow per diffuser
Smaller bubbles	Larger bubbles
Higher transfer efficiency	Lower transfer efficiency

Bubble Size

Small….but mighty efficient!!!!!

1 cubic foot of air…

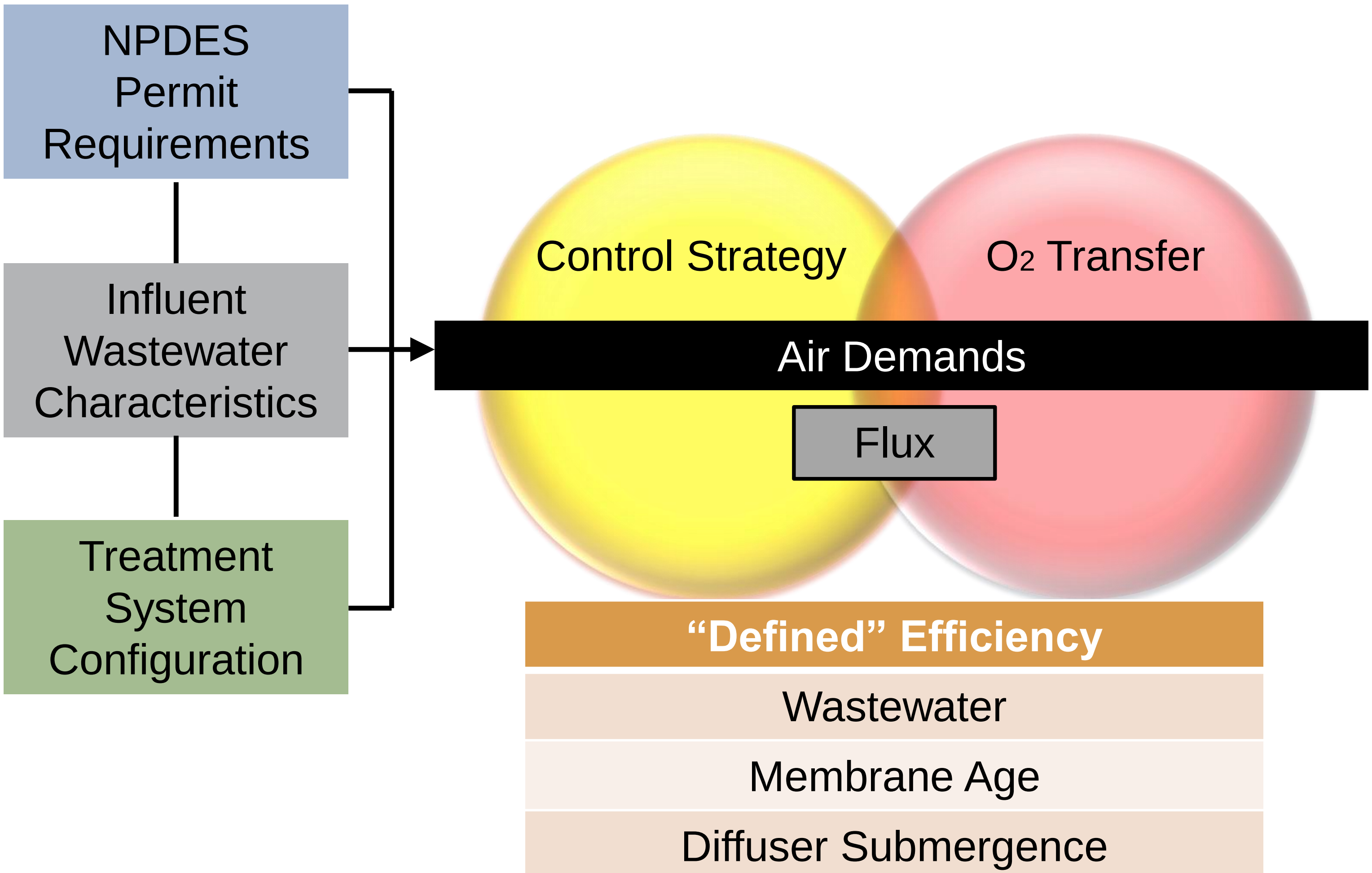
~60 times more area



Criteria	Large Bubble	Fine Bubble
Diameter of Bubble	14.9-inches	0.25-inches
Surface Area per Bubble	4.9 sq ft	0.0014 sq ft
Number of Bubbles	1	212,200
Total Surface Area	4.9 sq ft	288 sq ft

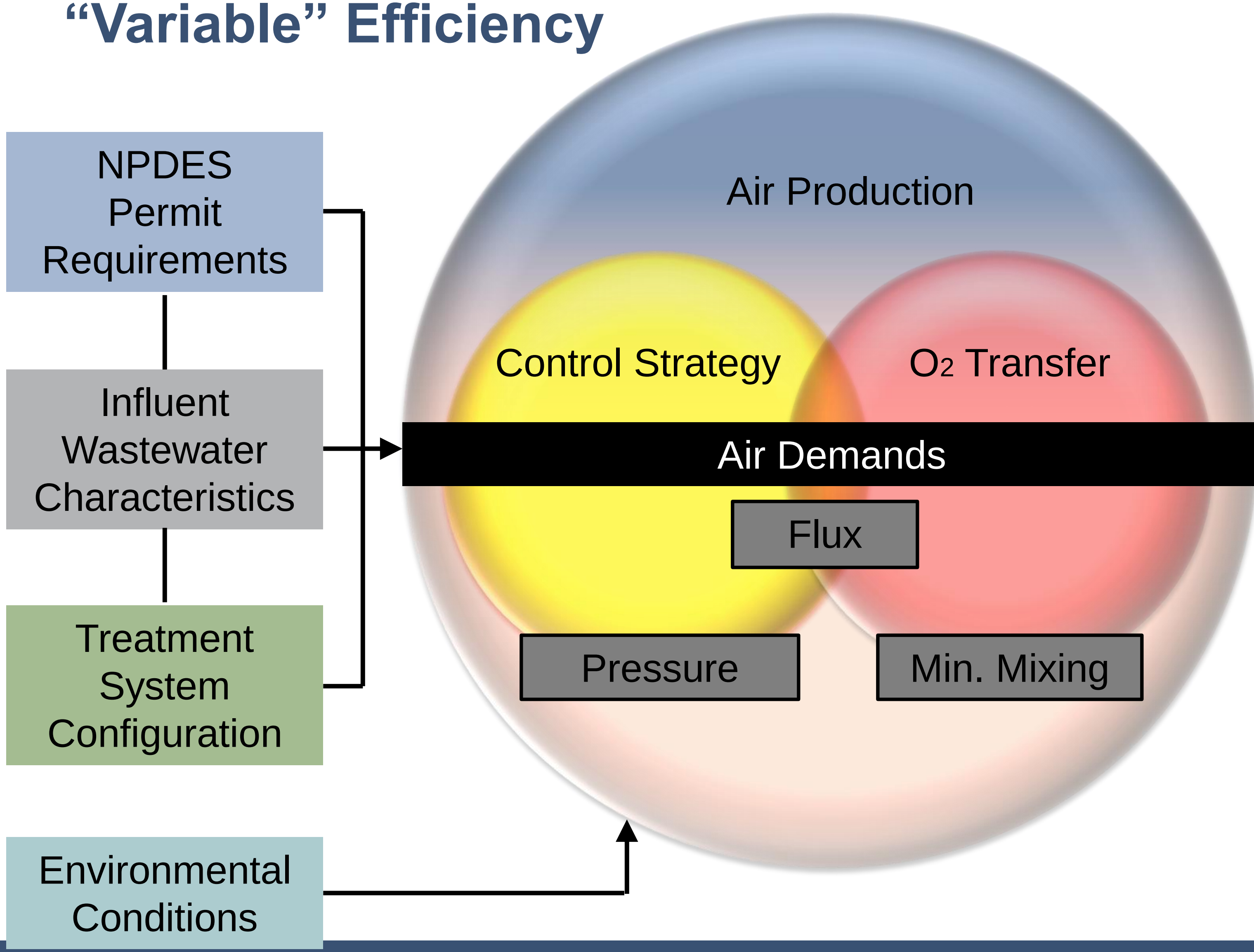
Aeration System Performance

“Mostly Defined” Efficiency



Aeration System Performance

“Variable” Efficiency

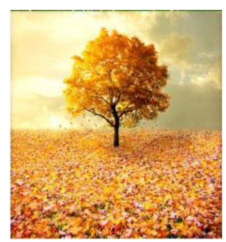
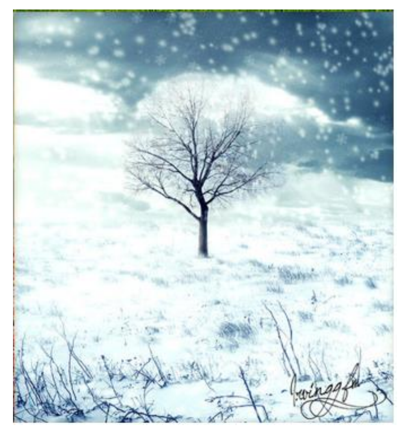


Environmental Characteristics

Decreases Electrical Efficiency
Higher Elevation
Higher Ambient Temperatures
Higher Relative Humidity
Higher Wastewater Temperature

Improves Electrical Efficiency
Lower Elevation
Lower Ambient Temperatures
Lower Relative Humidity
Lower Wastewater Temperature




Variability of Efficiency




Have you heard this before?

If you implement _________, our product will save you (enter a number)% on your electrical consumption.

Don’t look at the capital cost…it will be a 2 year payback.

Seems like a really good deal…

What they don't tell you is what was evaluated?

New Diffuser
Stable Loadings

Blower Sized for
Highest Efficiency Point

Perfect Weather Conditions
68°F and 36% Relative Humidity

Control System has
100% Accurate and Repeatable

So, what does a thorough evaluation look like?

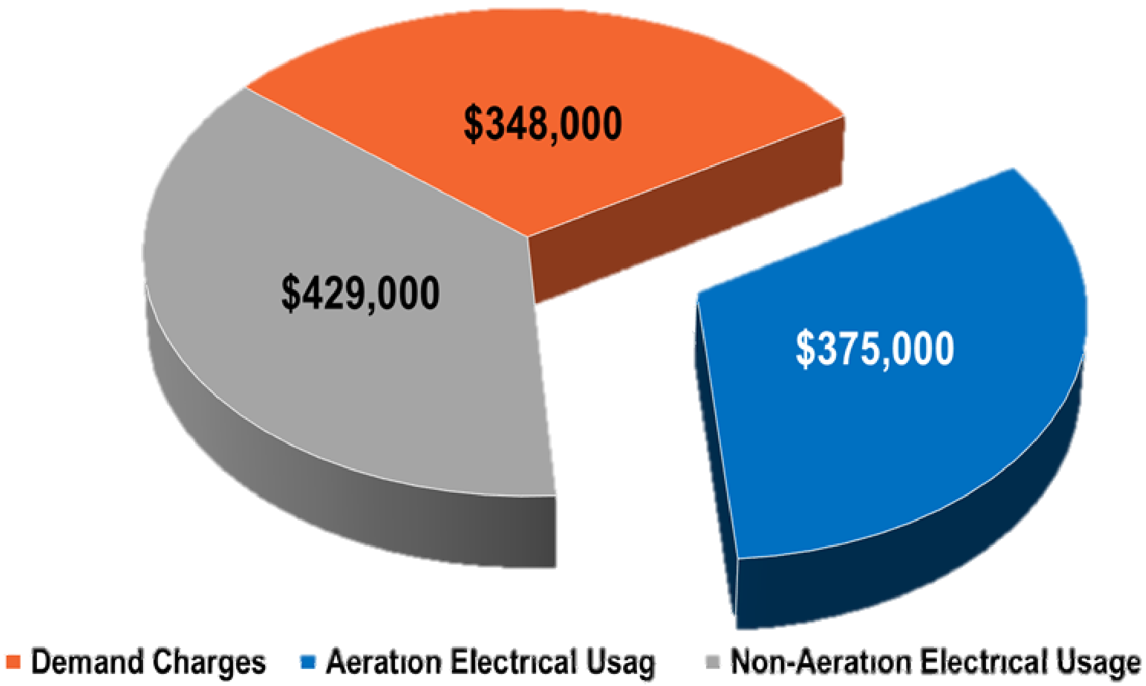
Case Study from Down South

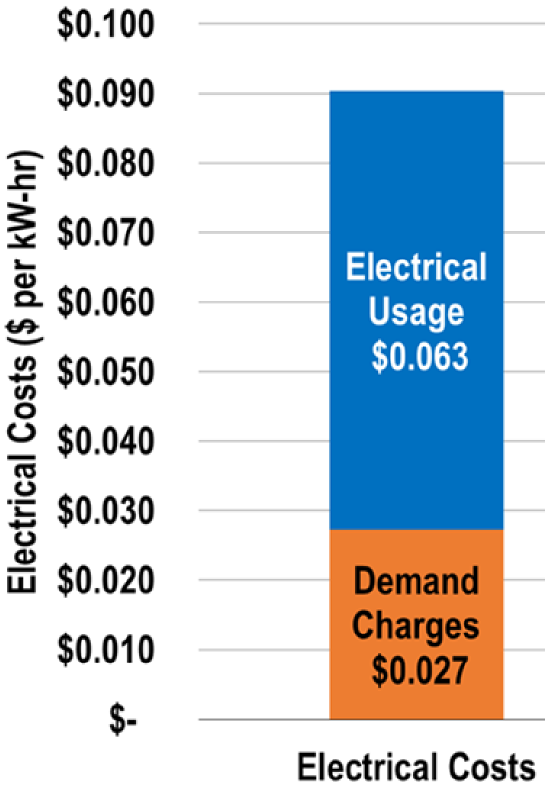
Existing System
1,500 hp oil bearing single-stage blowers
Coarse bubble diffusers
Manual controls

Evaluate the Entire System

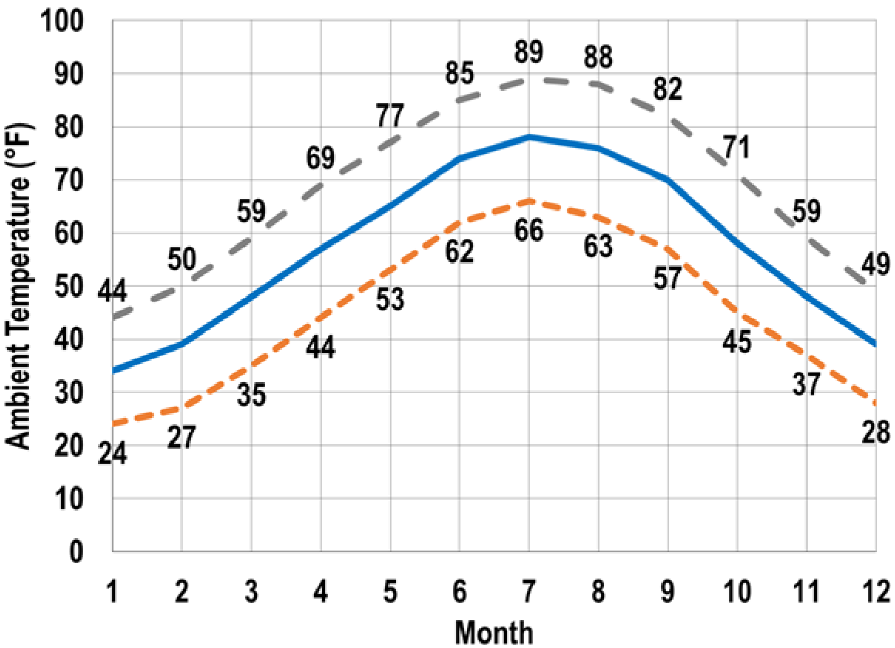
Project Background

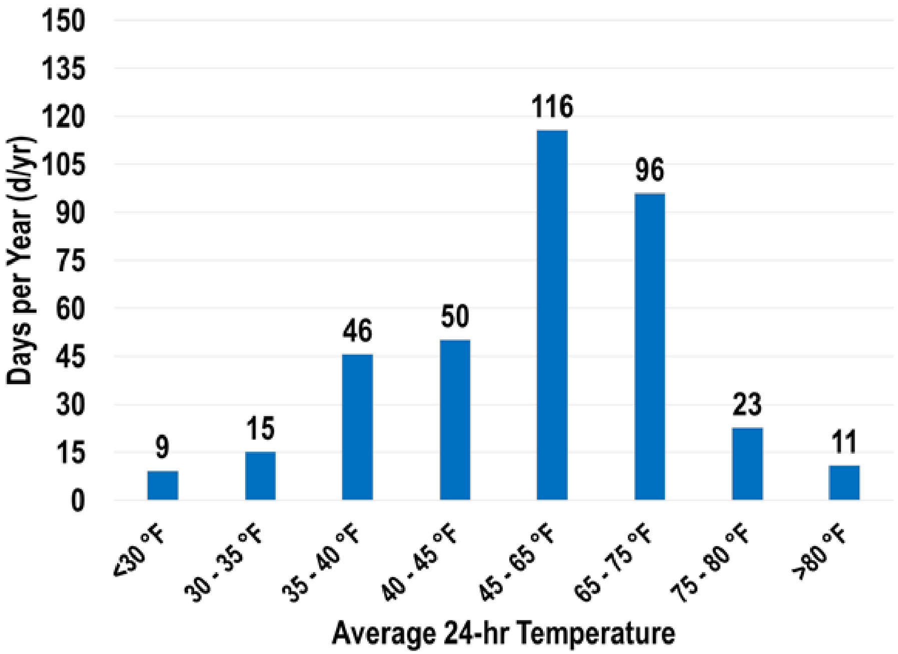
Historical Electrical Costs



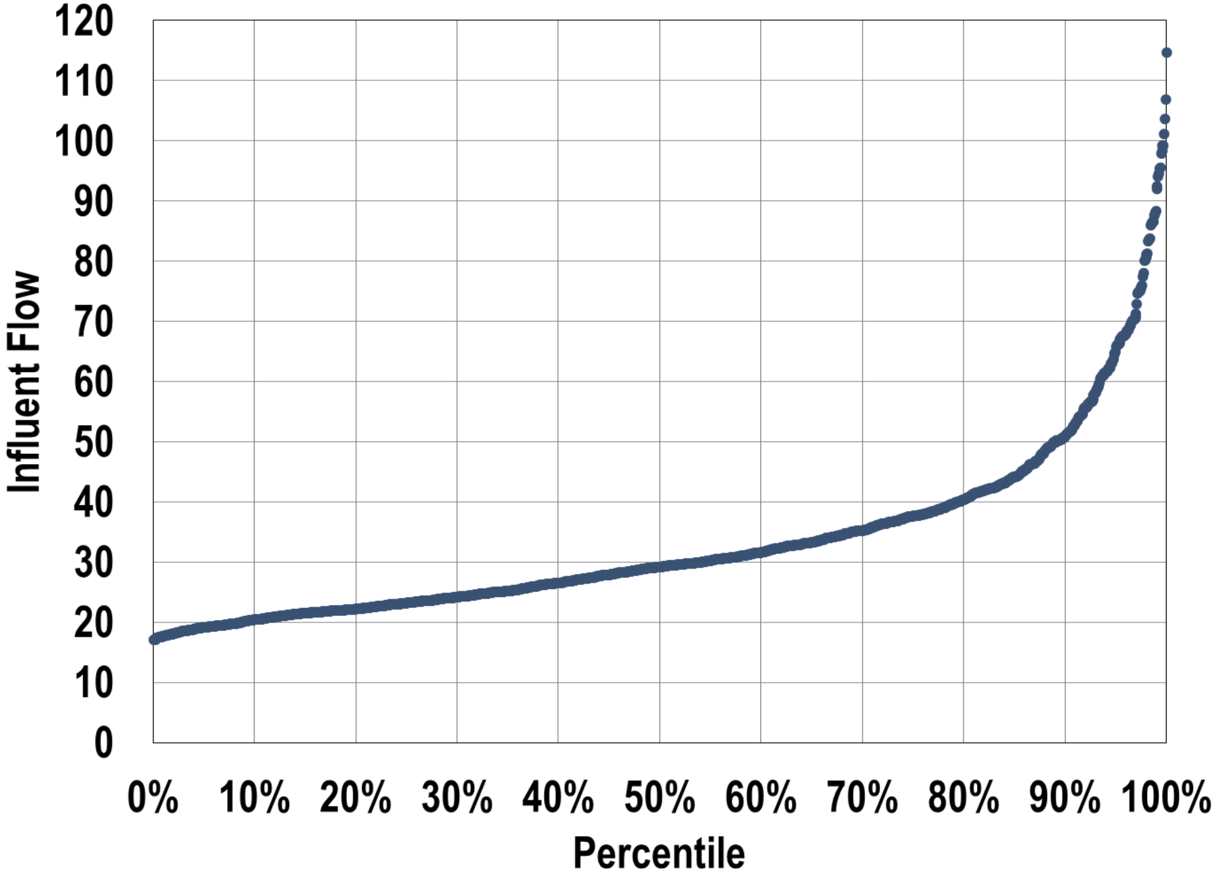


Environmental Conditions



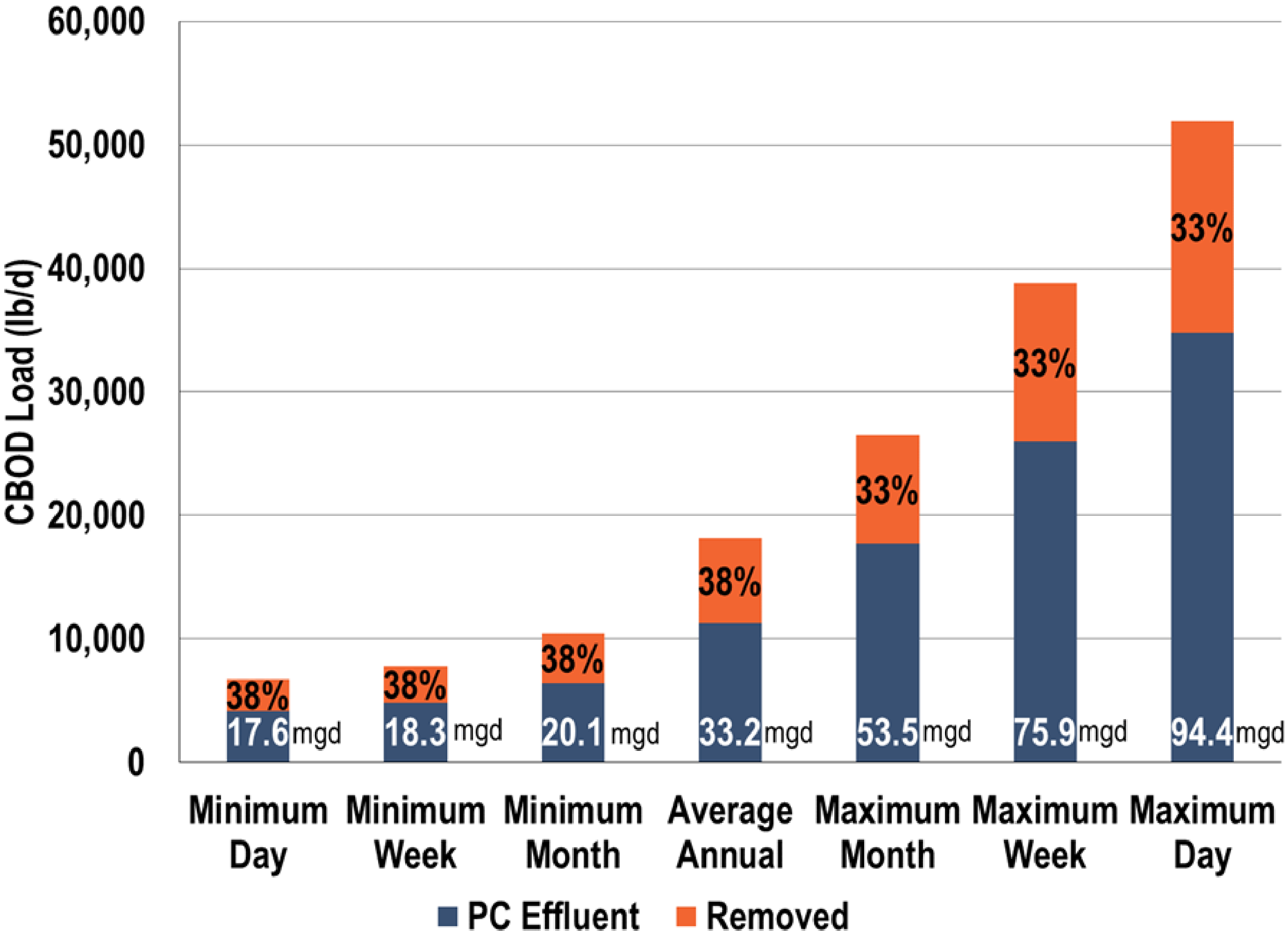


Historic Flow Analysis



Flow (mgd)	% Time
> 100	<0.3%
90 – 100	0.7%
80 – 90	1.2%
70 – 80	1.2%
60 – 70	3.1%
50 – 60	4.3%
< 50	>89%

Design Flow and Loading Criteria



Dry Weather

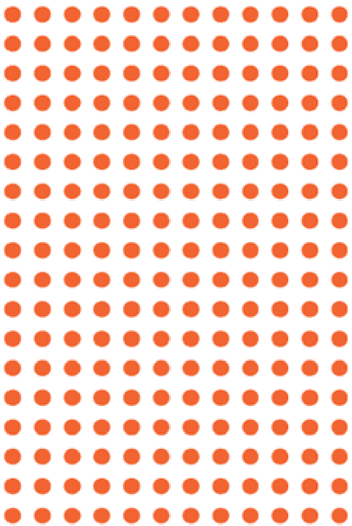
Wet Weather

First Screenings of Alternatives

- 72 combinations of “components”

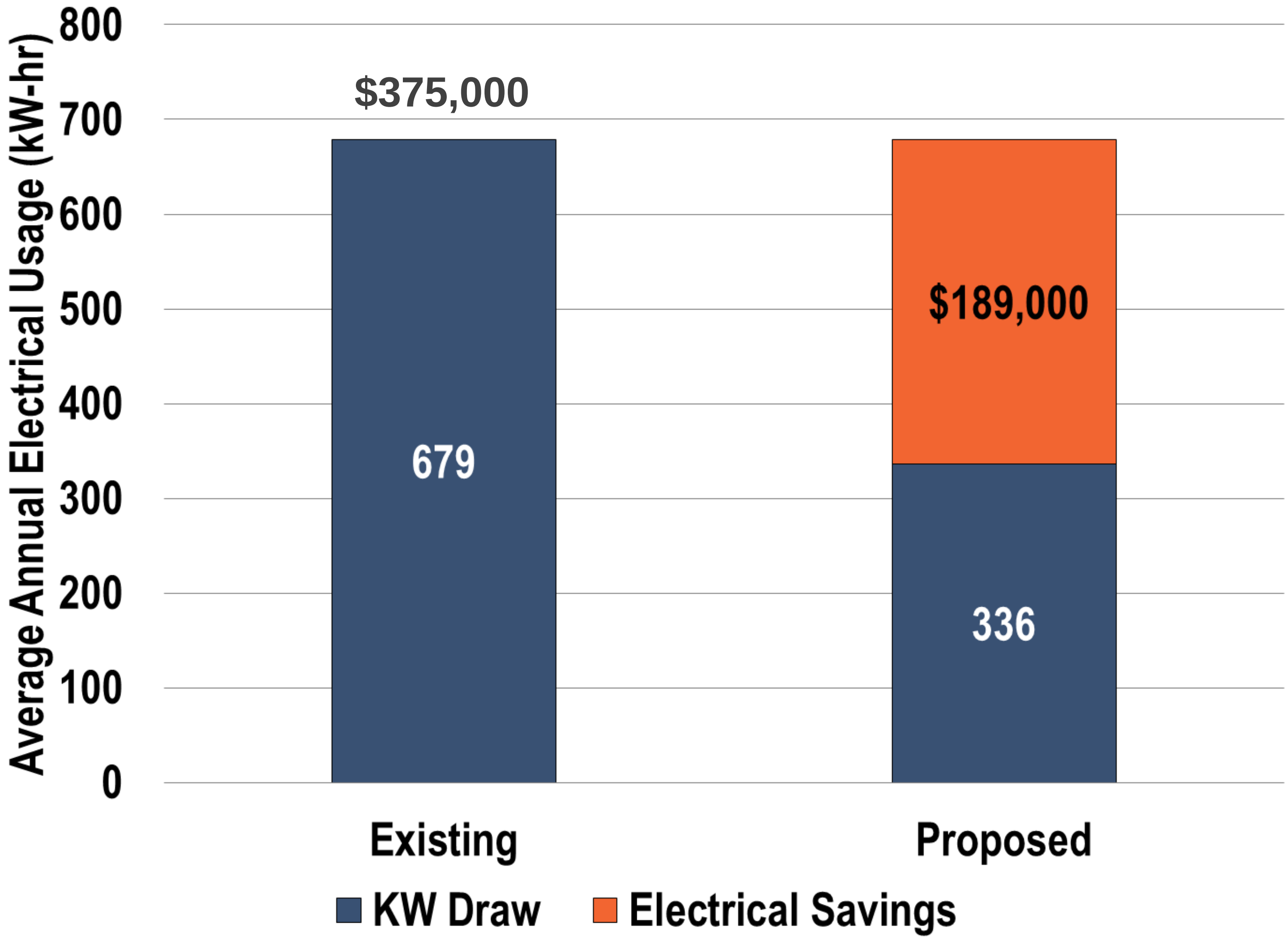
- Aeration evaluations
  - 216 configurations
  - 7 flow/loading conditions
  - 3 seasonal (environmental) conditions
  - 2 vs. 4-pass operation
  - ***>9,000 electrical demands generated***

216
Configurations

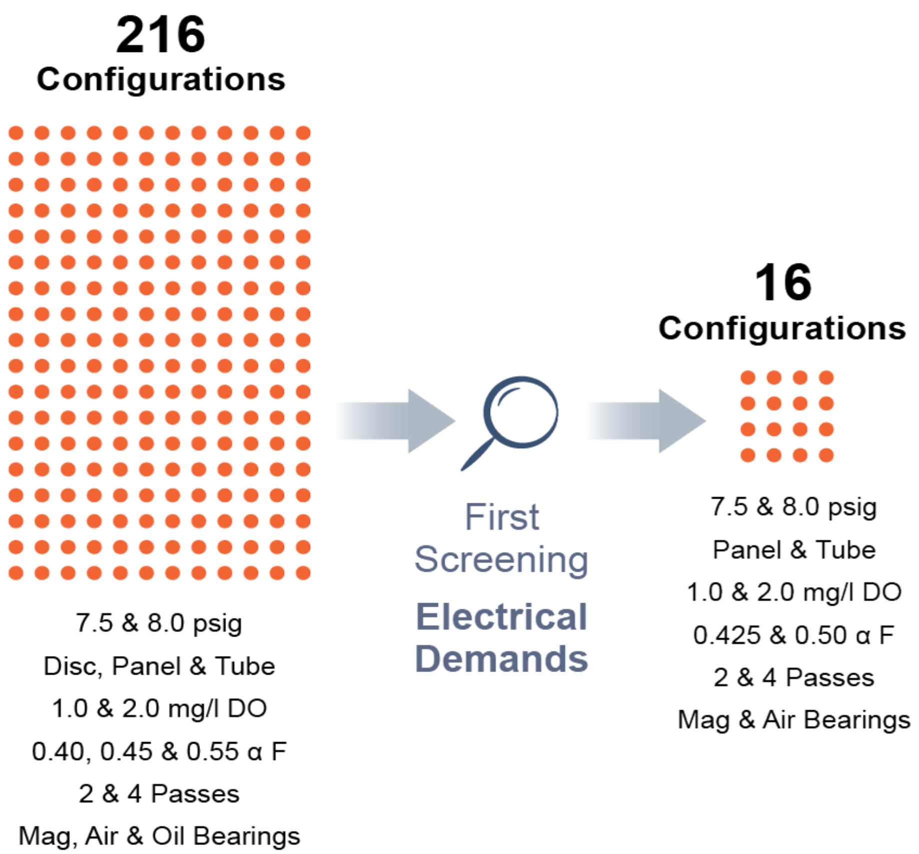


7.5 & 8.0 psig
Disc, Panel & Tube
1.0 & 2.0 mg/l DO
0.40, 0.45 & 0.55 α F
2 & 4 Passes
Mag, Air & Oil Bearings

Projected Average Electrical Demands

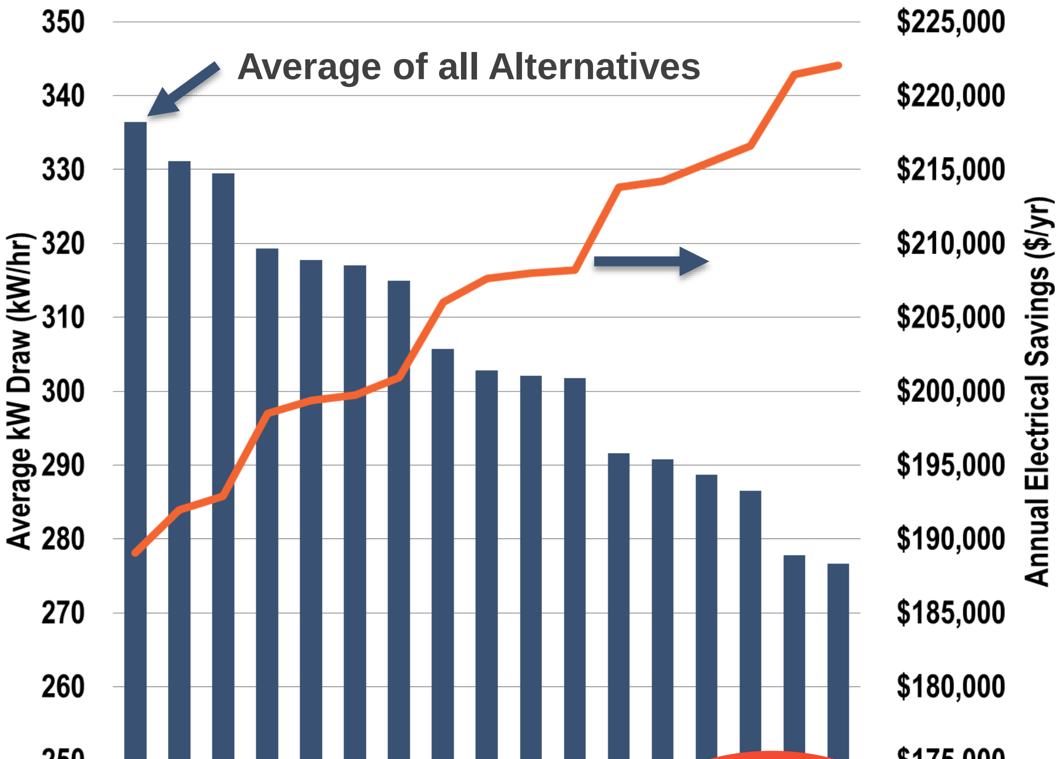


Alternative First Screening Results



- Eliminated
  - Full aerobic operation
  - “Normal” 4-Pass operation
  - Disc diffusers
  - Oil bearing blowers

Short-List Alternatives Electrical Consumption



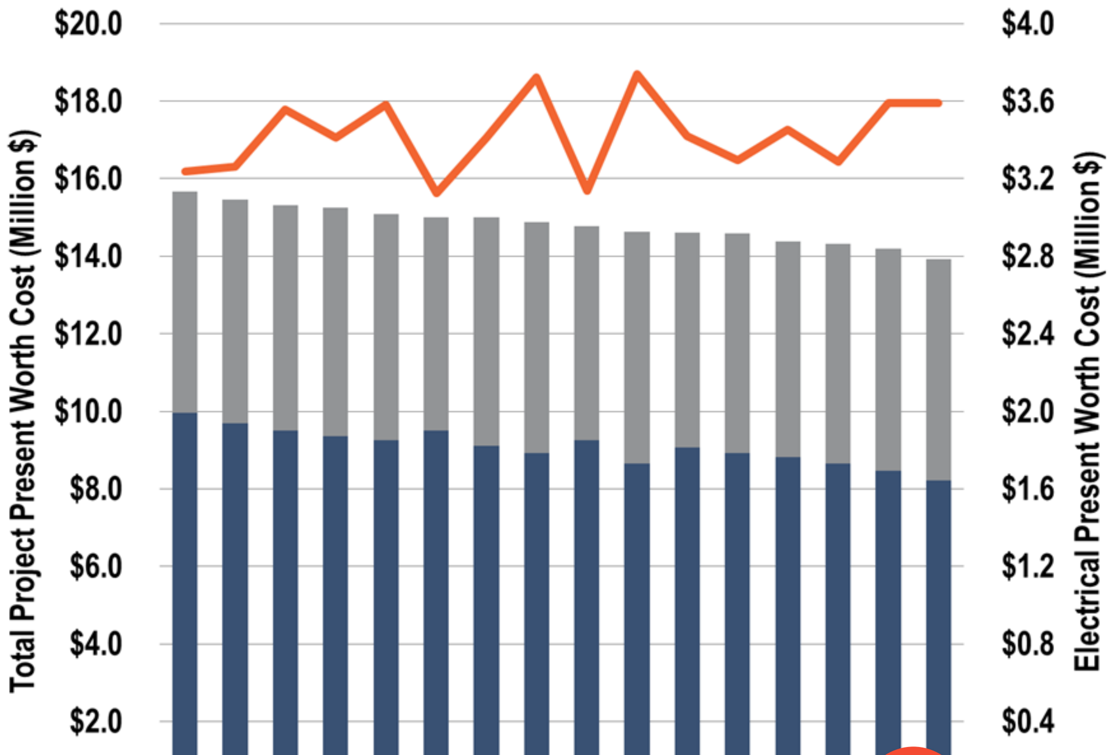
Blower	A	M	A	M	A	M	A	M	A	M	M	A	A	M	A	M
Diffuser	P	P	T	T	P	P	T	T	P	P	T	T	P	P	T	T
Pressure	8.0	8.0	8.0	8.0	7.5	7.5	7.5	7.5	8.0	8.0	8.0	8.0	7.5	7.5	7.5	7.5
DO	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

Legend
A = Air Bearing
M = Mag Bearing
P = Panel Diffusers
T = Tube Diffusers

Conclusion:

7.5 psig & 1.0 mg/l DO most energy efficient

Short-Listed Alternatives Life-Cycle Cost Evaluation



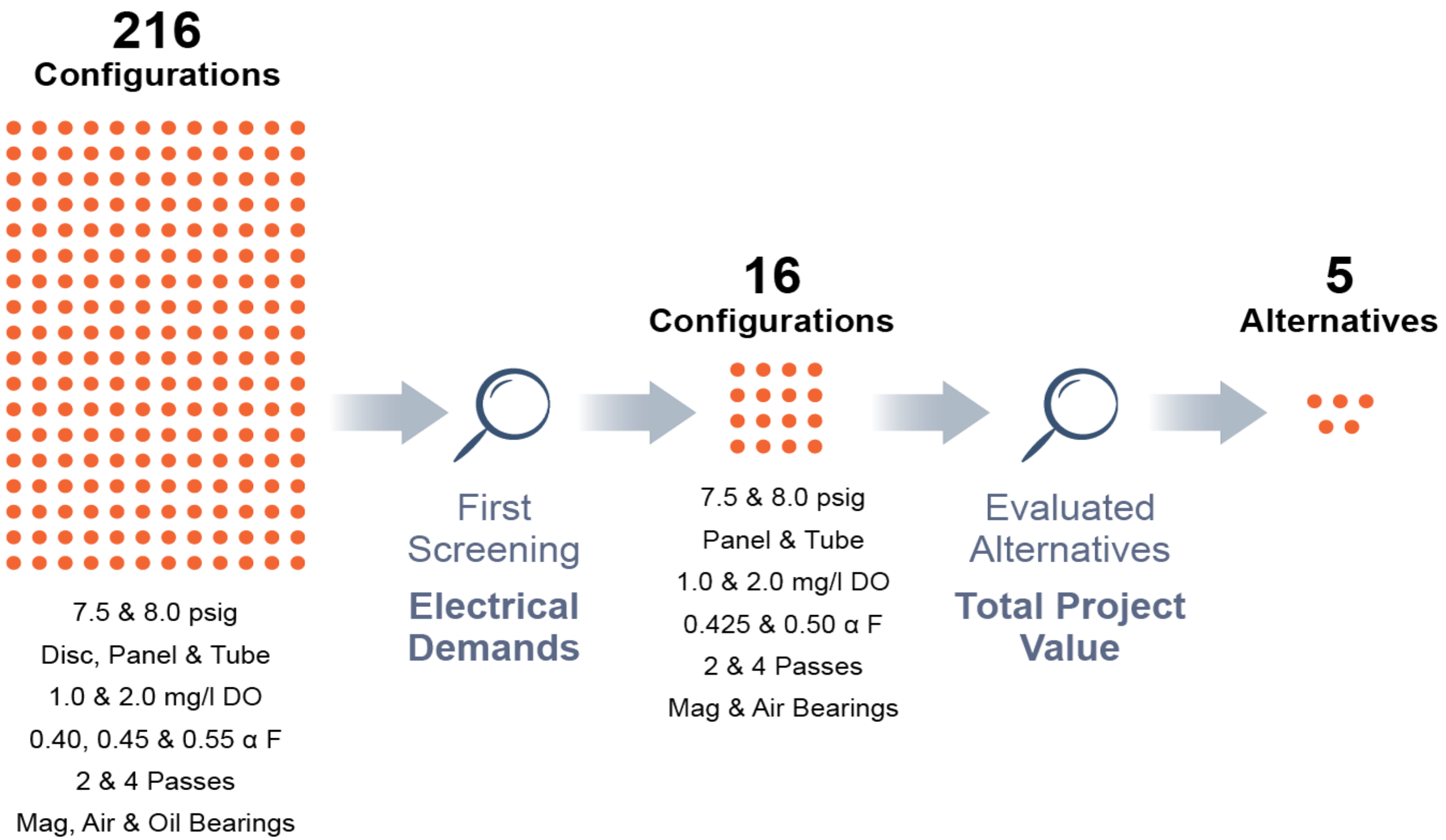
Blower	M	A	M	M	A	M	A	M	A	A	M	M	A	A	M	A
Diffuser	P	P	P	P	P	T	P	P	T	P	T	T	T	T	T	T
Pressure	7.5	7.5	7.5	8.0	7.5	7.5	8.0	8.0	7.5	8.0	7.5	8.0	7.5	8.0	8.0	8.0
DO	1.0	1.0	2.0	1.0	2.0	1.0	1.0	2.0	1.0	2.0	2.0	1.0	2.0	1.0	2.0	2.0

Legend
A = Air Bearing
M = Mag Bearing
P = Panel Diffusers
T = Tube Diffusers

Conclusion:

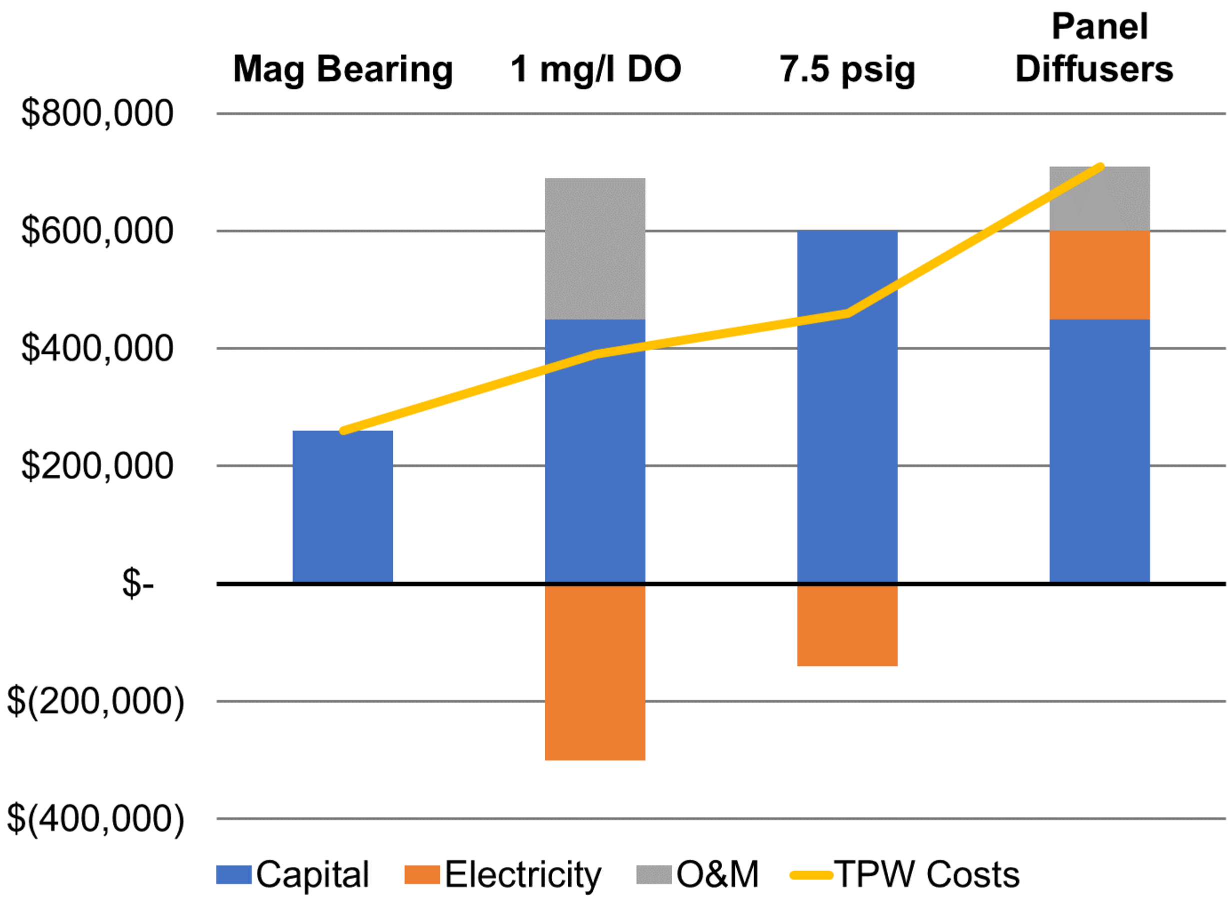
8.0 psig &
2.0 mg/l DO
lowest Life-Cycle Cost

Final Screening of Alternatives



Lowest Total Project Worth Cost Alternatives

Criteria	Value
Blower	***Air***
Diffuser	***Tube***
Pressure	***8.0 psig***
DO	***2.0 mg/l***
Capital $	$8.21 M
Electrical $	$3.59 M
O&M $	$2.13 M
TPV Cost	**$13.93 M**



Conclusion

Evaluate the System

Most energy efficient is not always the most cost effective!