WISCONSIN WASTEWATER
OPERATORS' ASSOCIATION

52nd Annual Conference
October 2018

Energy Reduction and Biological Process Performance Improvements with Right-Sized Equipment and Next-Generation Process and Aeration Controls

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Operations

Engineering

Civil / Mechanical / I&C

Management

SCADA

Process / Aeration Control

Energy Reduction and Biological Process Performance Improvements

Aeration

Process Optimization

Reference Sites

Lebanon, PA 10MGD

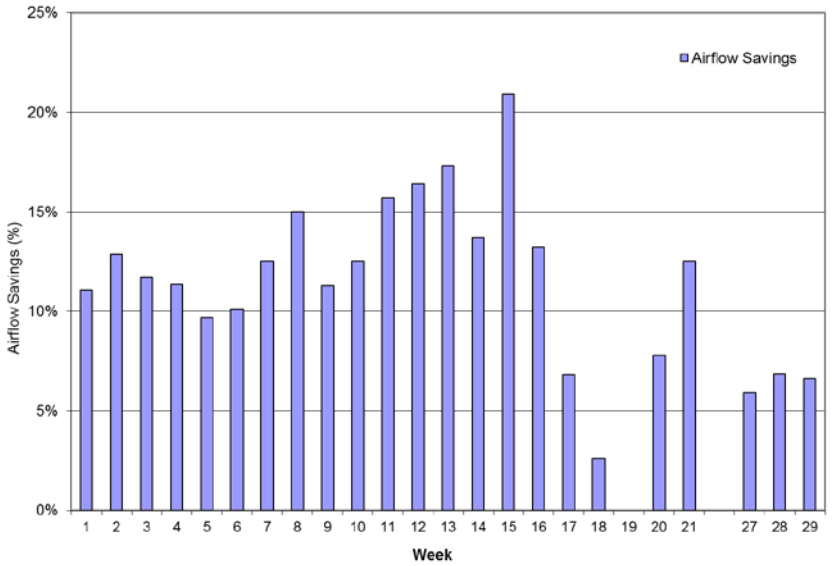
TF + MLE / IFAS

True hands free performance
"when in auto, we are exceeding our goals"

45% Reduction
in **Aeration Energy**

55% Less TN Discharge
Against permitted limit*

Denver Metro 140MGD



13.5% Reduction
in **Aeration Energy**

**PI aeration control; greater savings available with next-gen aeration control*

Bailonggang, China 1BGD

AnAxO

20% Reduction
in **Aeration Energy**

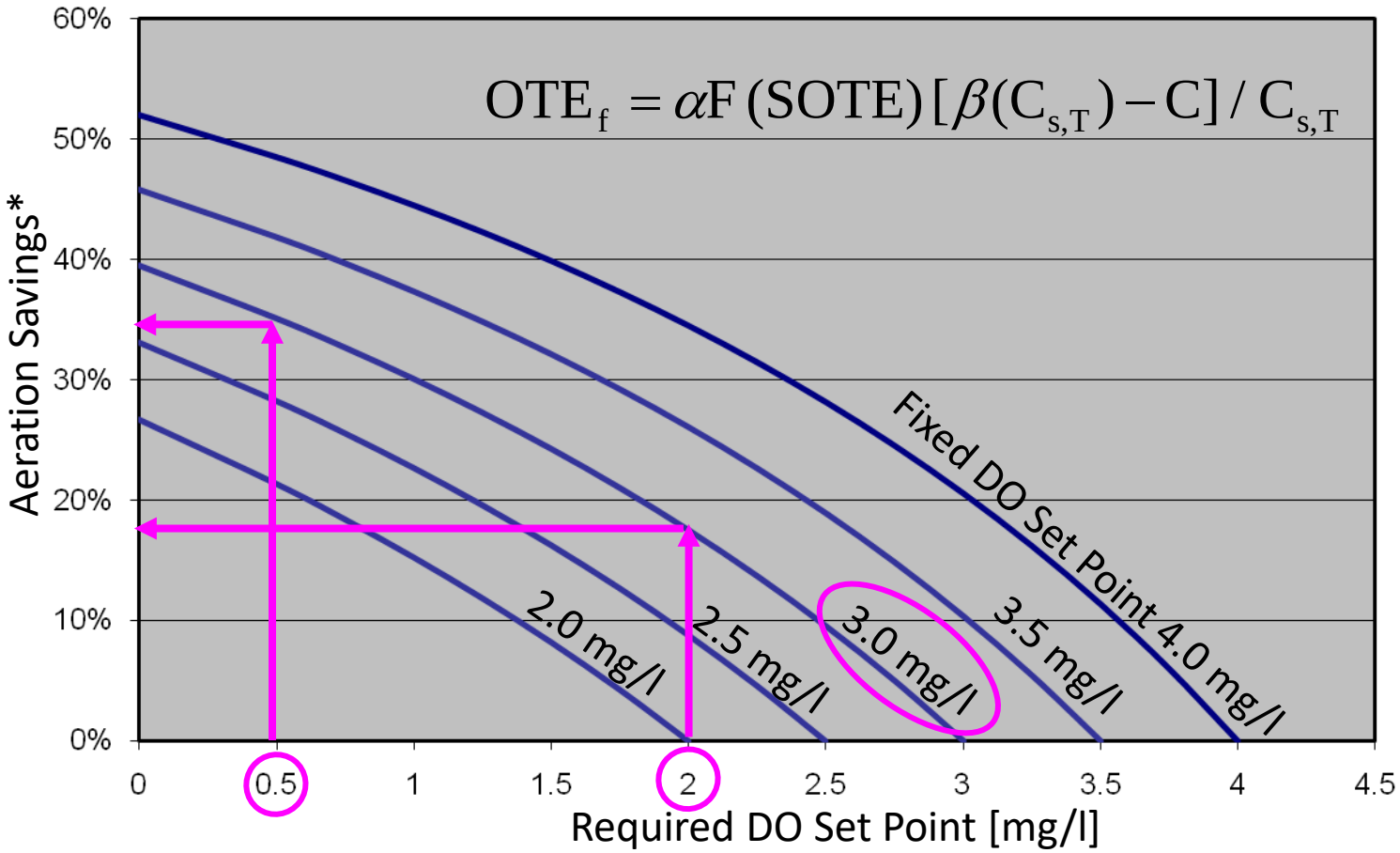
$500,000 savings per year
20 month payback

Operations

ENERGY USE

Airflow Reduction Potential

(Operating residual DO concentration)



* Assuming constant oxygen demand

Plant Performance
Getting the 'most' from the Plant
Capacity, Energy Efficiency & Process Performance

Right – Sized
Physical Assets

Asset
Management

Smart
Automation

Aeration: Focus on Energy

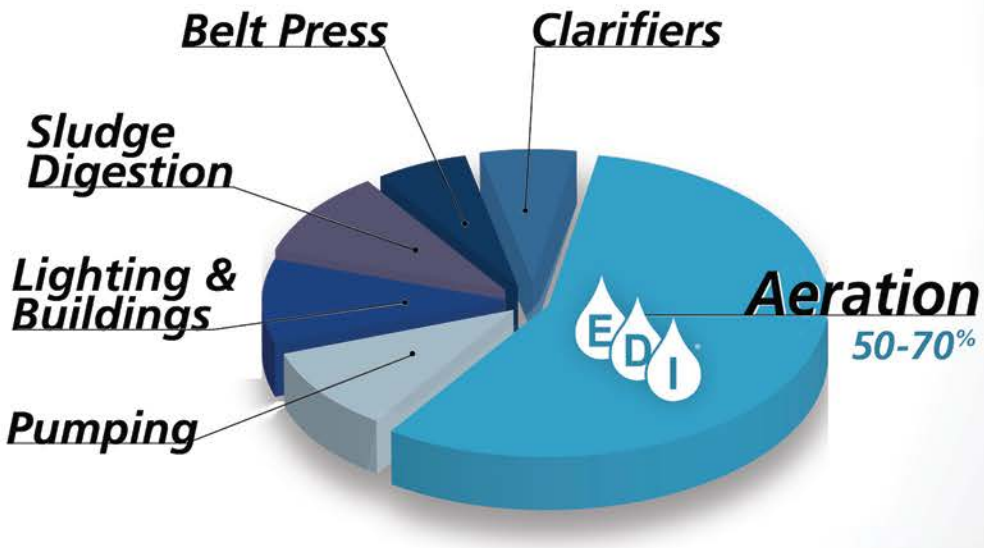
Water and Wastewater Infrastructure

- Nearly 4% of every kilowatt generated in the U.S. goes to the movement and treatment of water & wastewater

- In a typical mid-sized city, 30% - 40% of energy use results from water & wastewater treatment operations

Aeration

- 50% - 70% of energy use at wastewater treatment plants



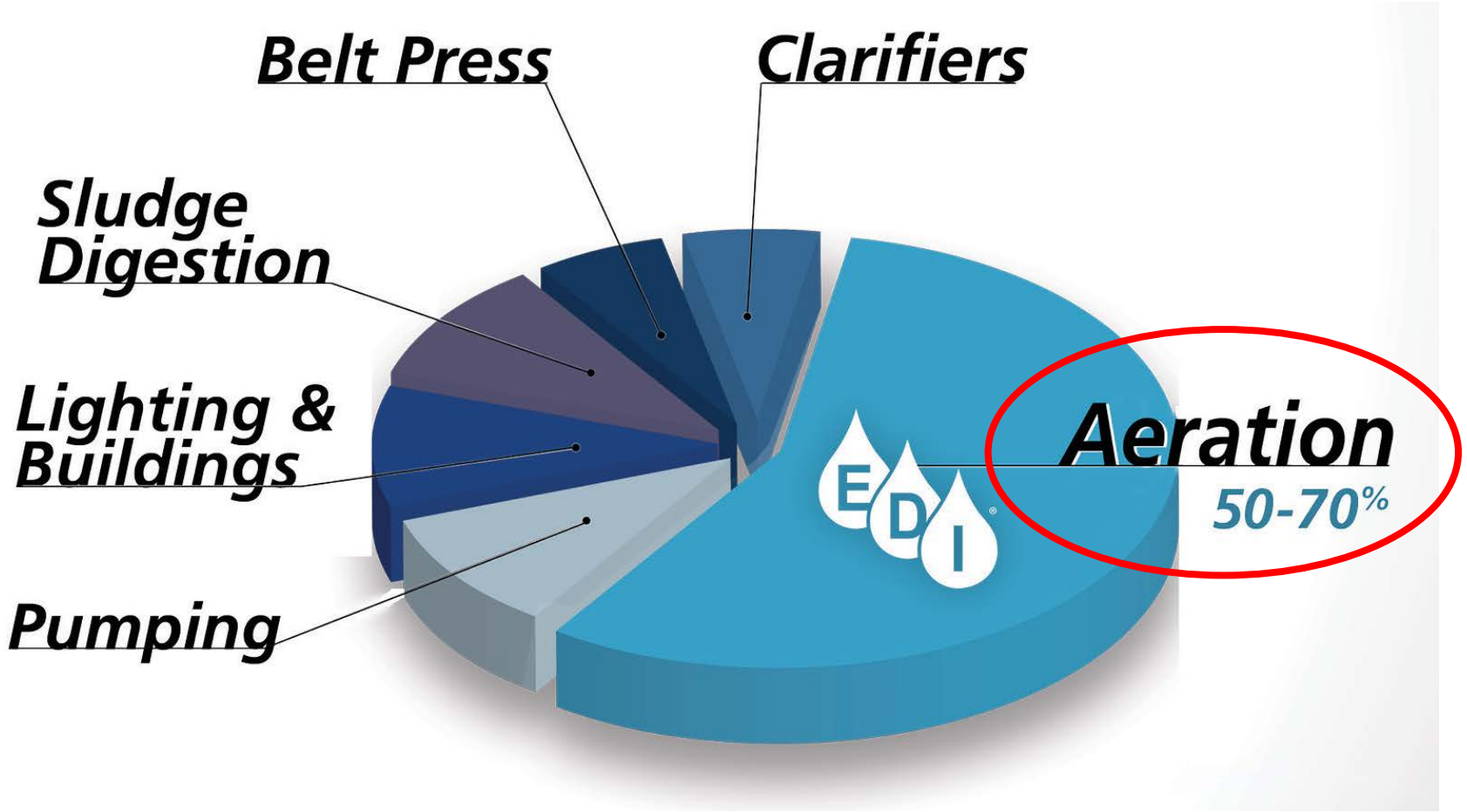
Aeration: Focus on Technology

Standard Efficiency

kg/kwh	lb/hp-h	
	13	
7	12	
	11	
6	10	Low Fluxrate / High Density Diffusers
	9	
5	8	
	7	
4	6	Typical Fine Bubble Diffuser System
	5	
3	4	
2	3	Jet Aerators Coarse Bubble Diffuser Systems
	2	Mechanical Floating Aerators
1	1	Aspirating Floating Aerators

Lessons Learned

- ✓Up to 50% reduction in aeration energy available from diffuser product selection



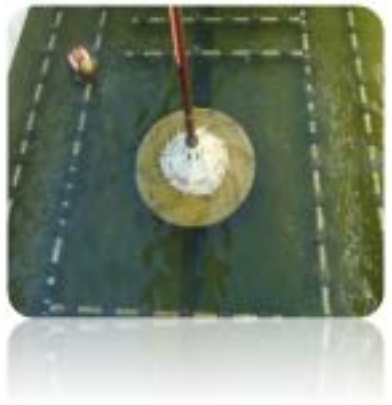
Lessons Learned

- ✓Up to 50% reduction in aeration energy available from diffuser product selection
- ✓Right-sized blower

Lessons Learned

- ✓Up to 50% reduction in aeration energy available from diffuser product selection
- ✓Right-sized blower
- ✓Right-sized mixing
  - ✓Mix with diffusers
  - ✓Independent mixing

Range of Mixing Products



Mechanical Interaction

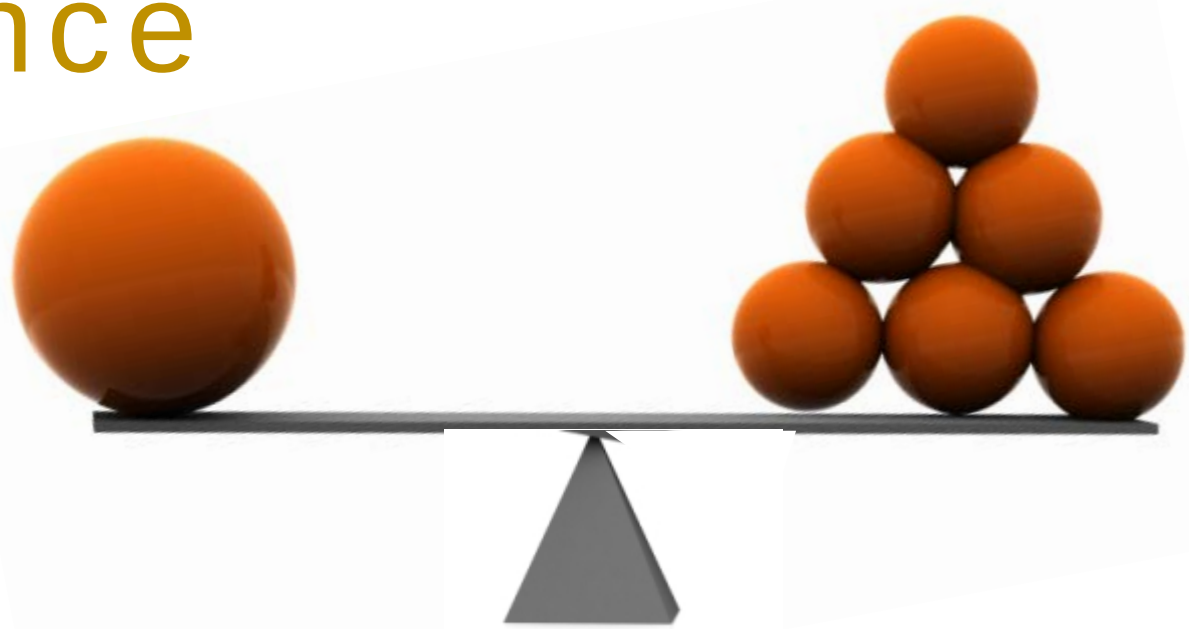
Intermittent Use

Efficiency

Effective Utility Management

Operational Excellence

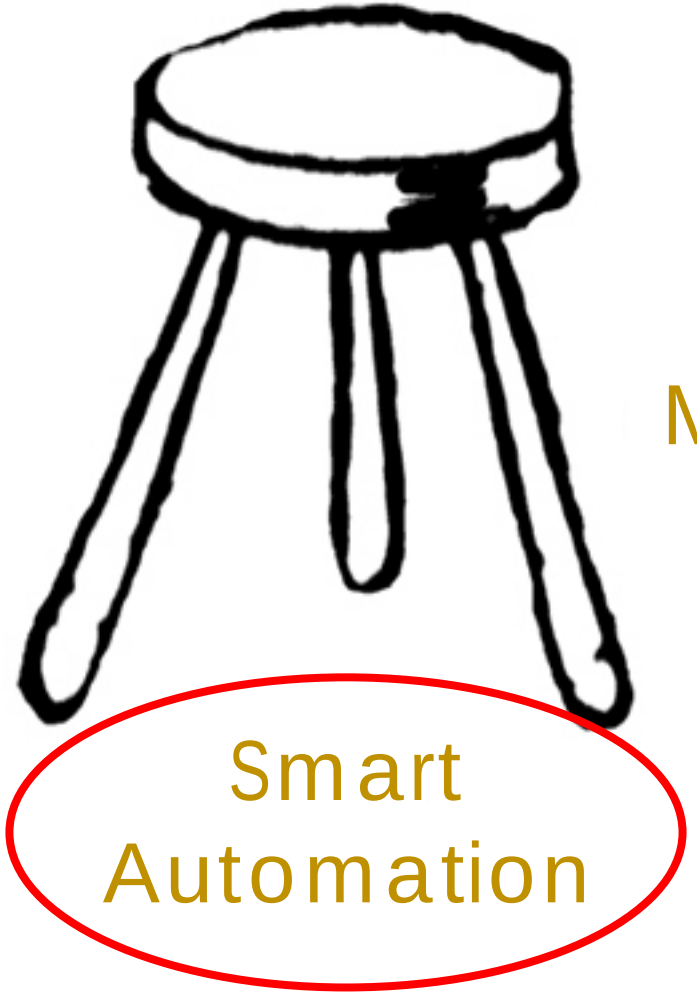
~~*More Tools*~~
Better Tools



Right – Sized Physical Assets

Plant Performance
Getting the 'most' from the Plant
Capacity, Energy Efficiency & Process Performance

Right – Sized
Physical Assets



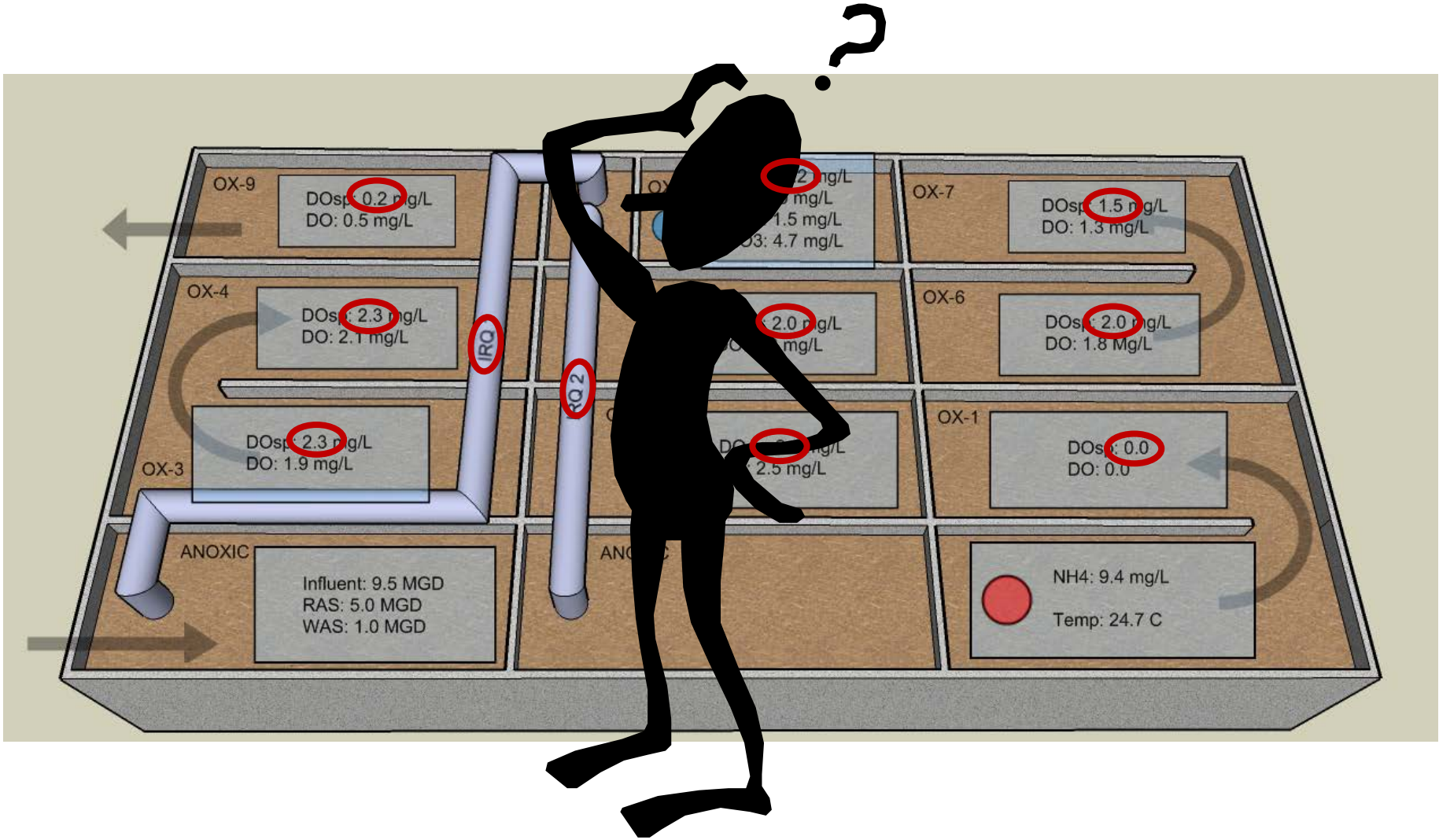
Asset
Management

Smart
Automation

The Modern Plant (biological treatment unit)

Operator's Challenge

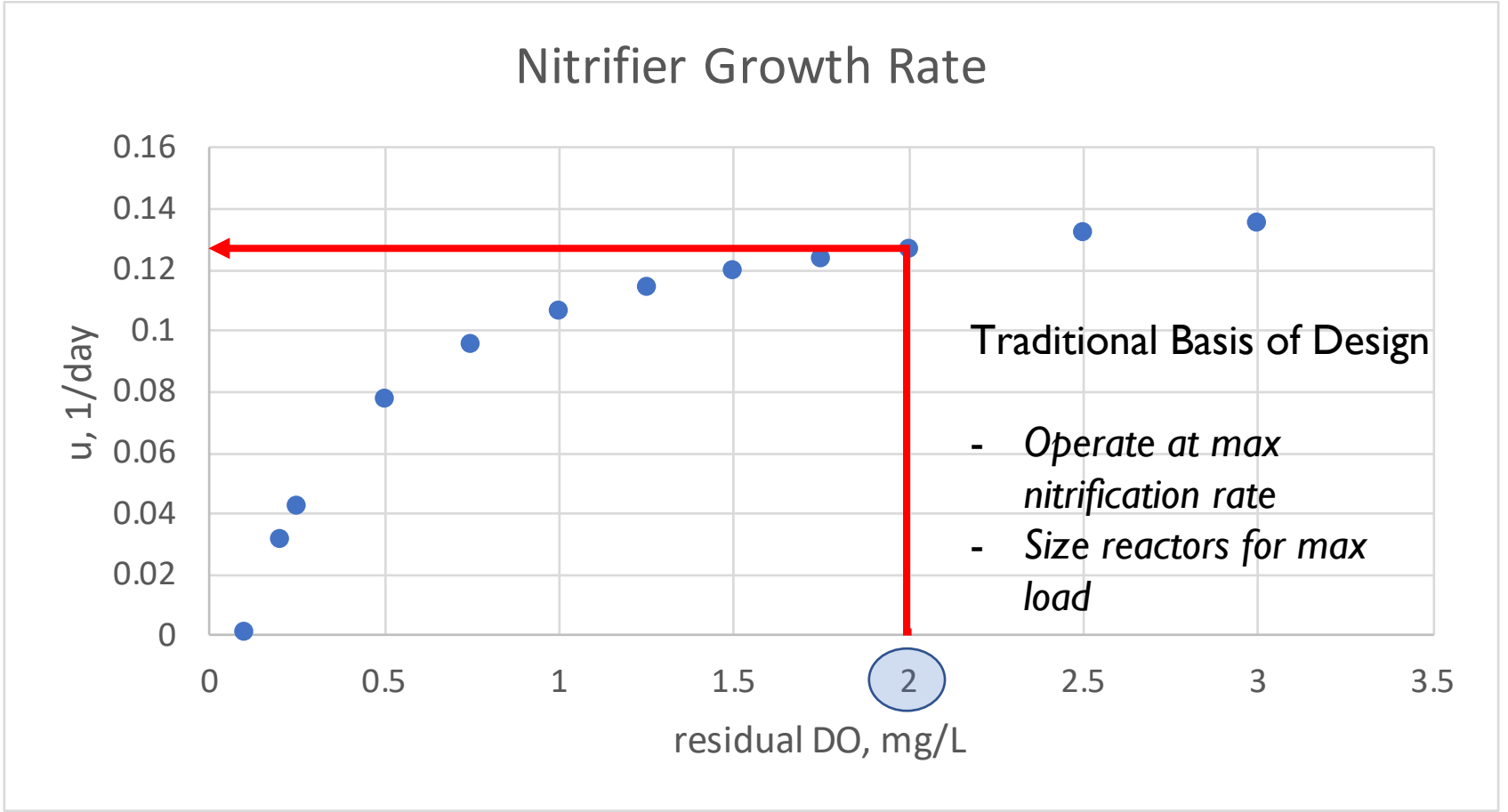
- ***What DO, Where, Why, and How?***



Operations

PROCESS OPTIMIZATION

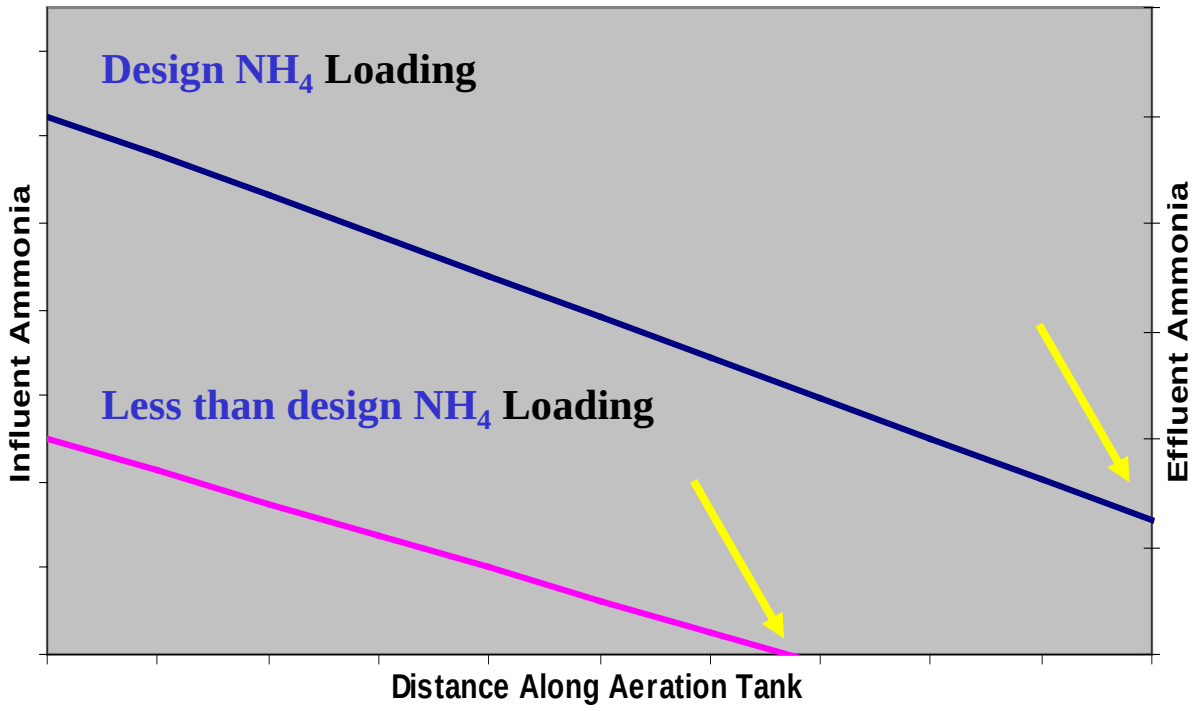
Nitrification



Operations

PROCESS OPTIMIZATION

Ammonia Profile – Fixed DO Setpoint

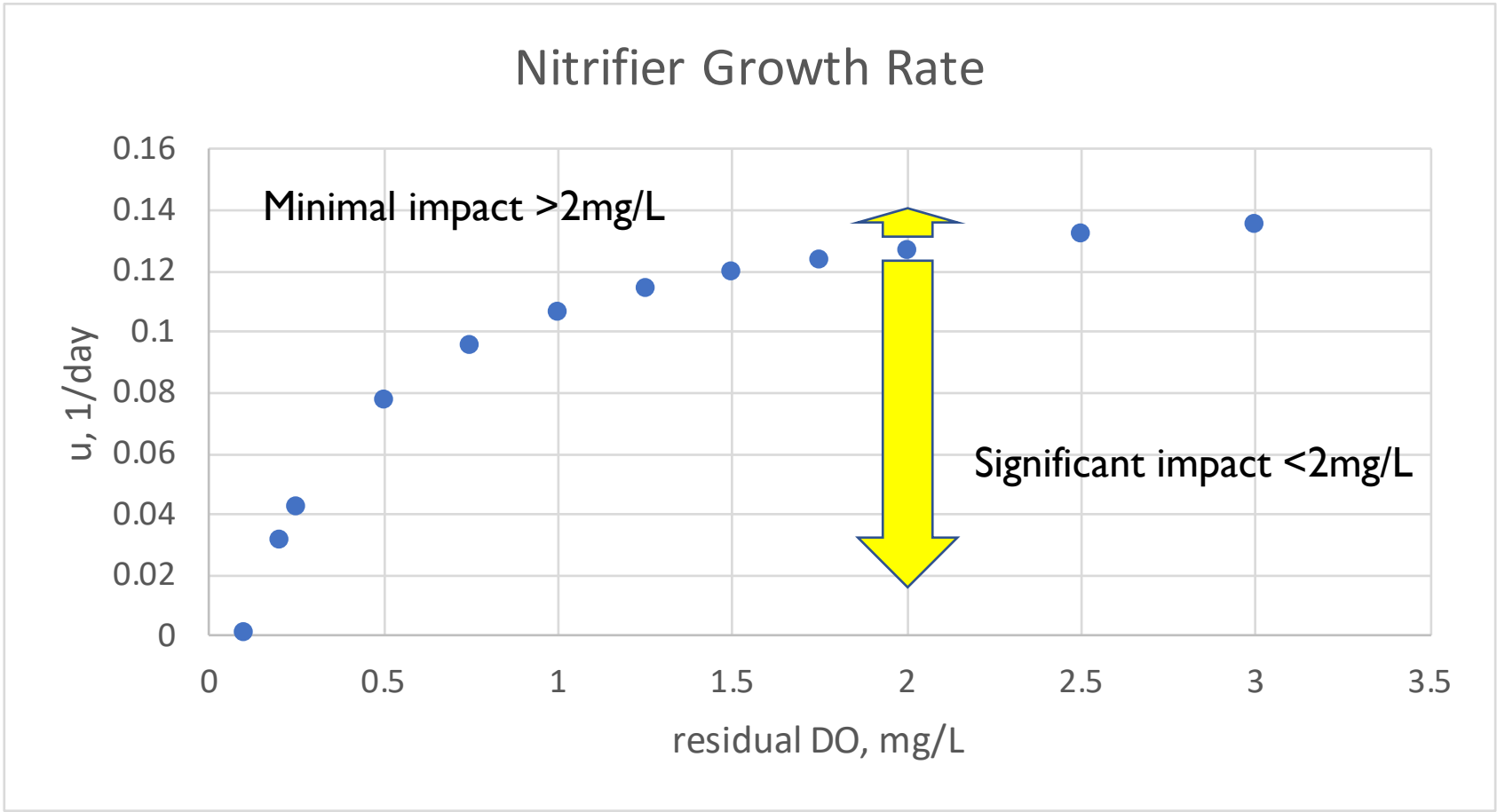


- Near complete ammonia conversion at max load
- Full nitrification well within the tank at reduced loads
- Endogenous decay at reduced loads
- Proportional reduction in aeration during low loads

Operations

PROCESS OPTIMIZATION

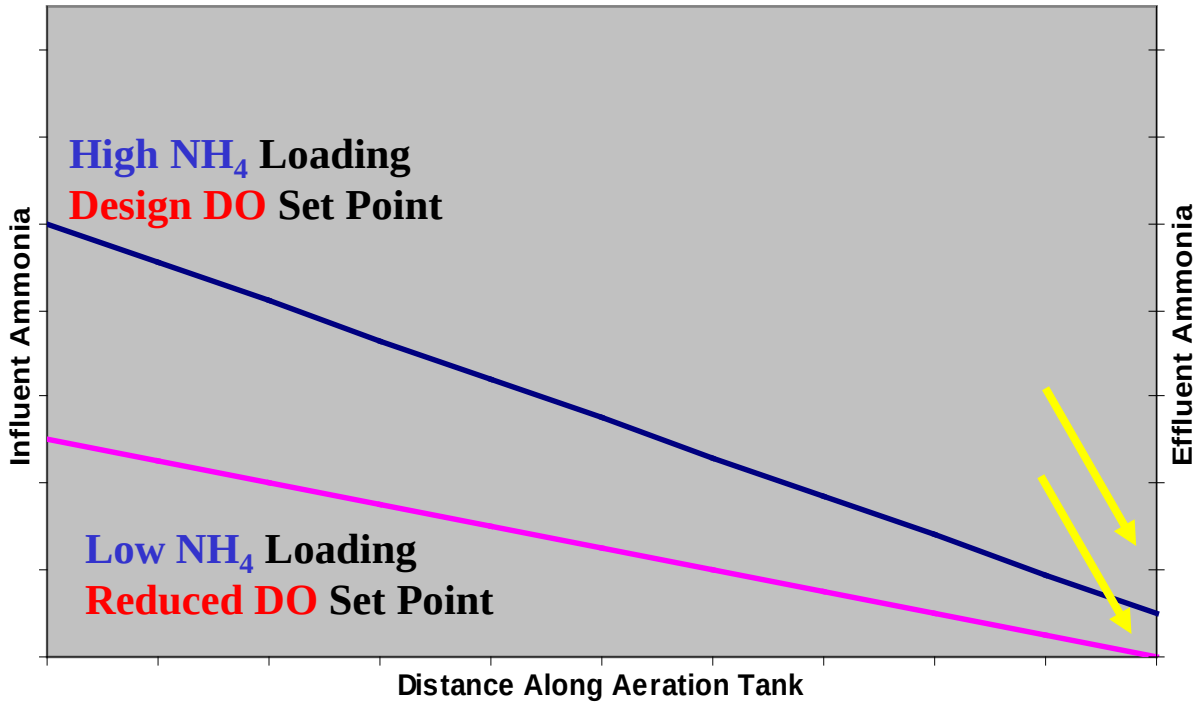
Nitrification



Operations

PROCESS OPTIMIZATION

Ammonia Profile – Dynamic DO Setpoint(s)



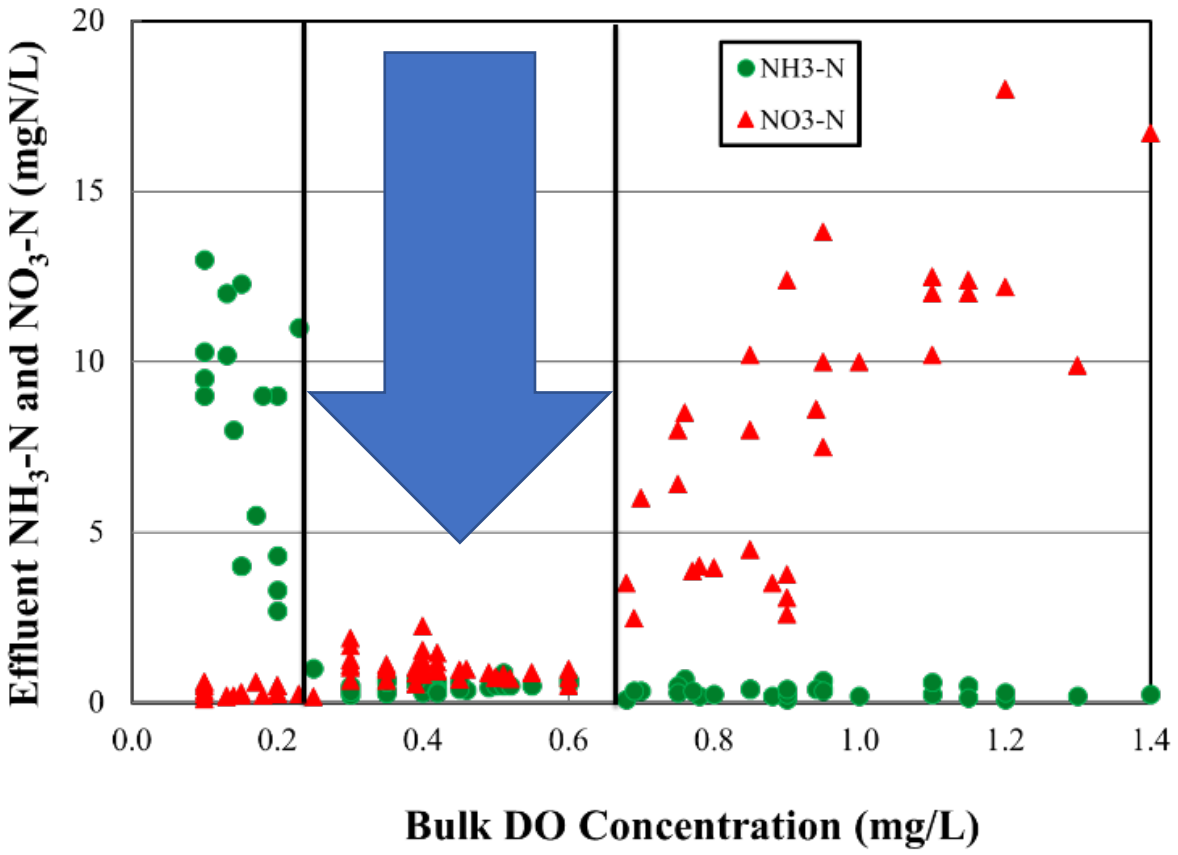
- Near complete ammonia conversion at max load
- DO adjusted to yield desired nitrification rate based on load
- Healthier bugs; improved SVI & *kinetics*
- Additional reduction in aeration during low loads

Operations

PROCESS OPTIMIZATION

What DO, where and why?

Simultaneous Nitrification and Denitrification



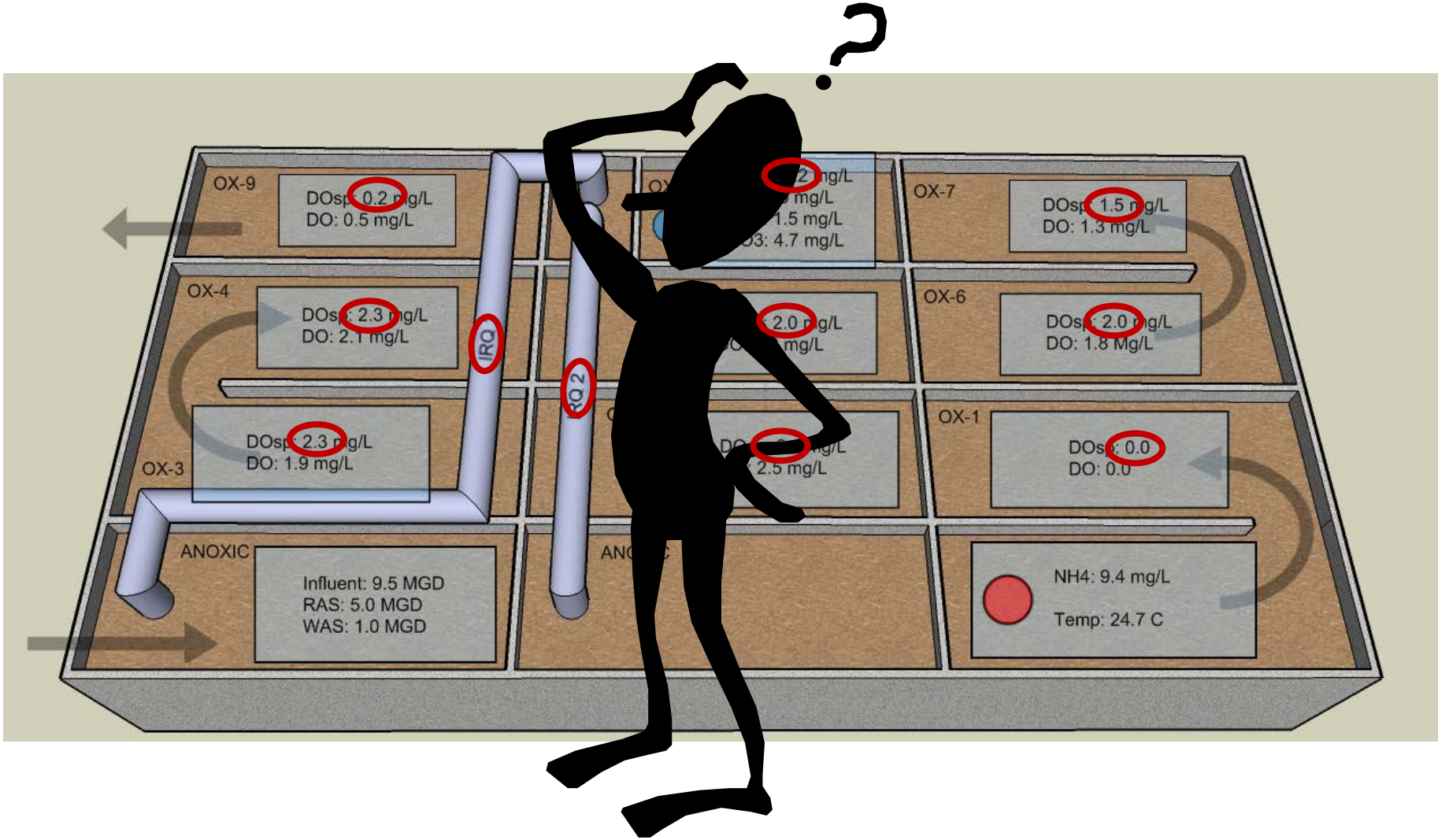
Courtesy of Jimenez, J, Brown and Caldwell

The Modern Plant (biological treatment unit)

Operator's Challenge

- *What DO, Where, Why, and How?*

- *Aeration Controls*
- *Process Controls*



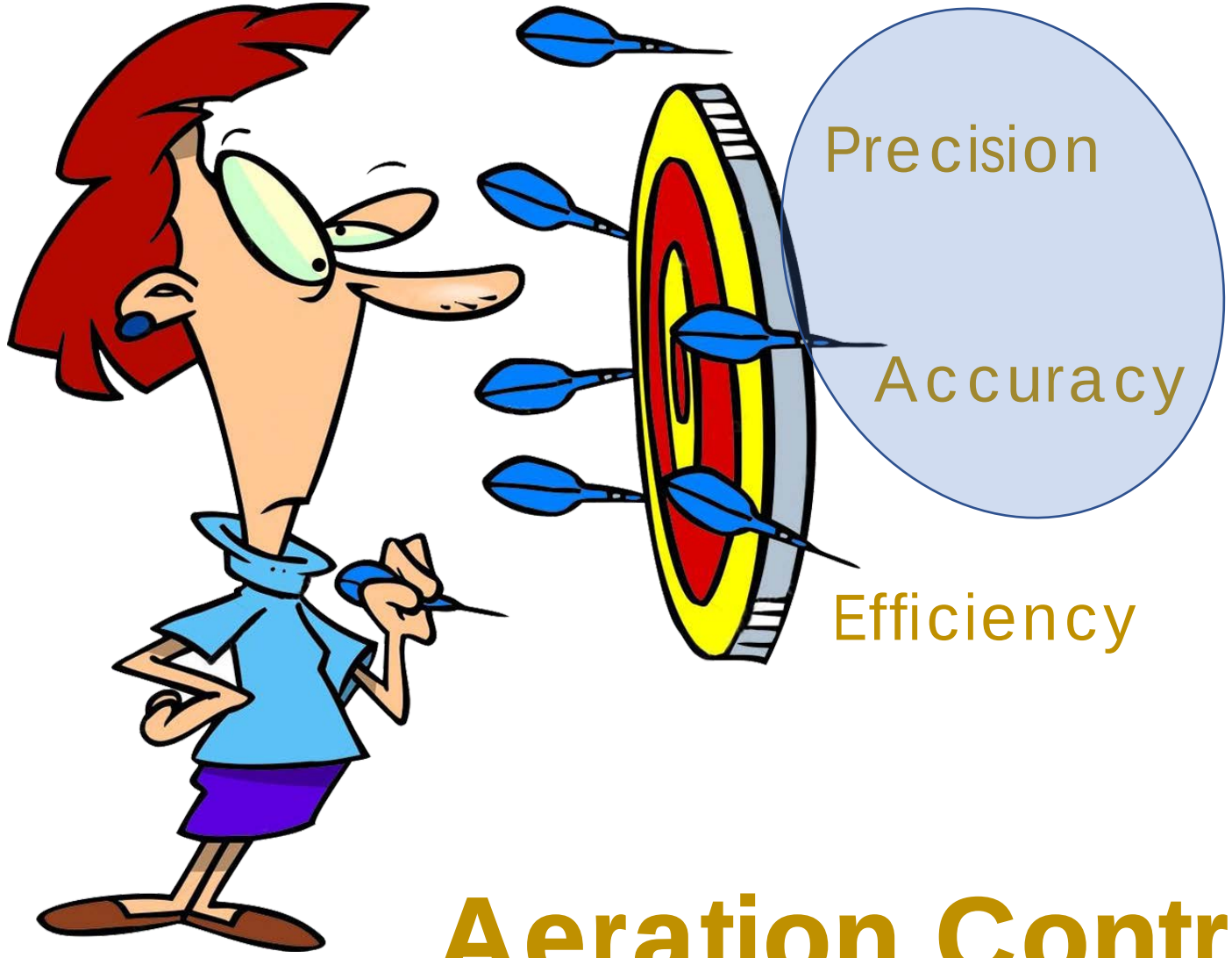
Precision

Accuracy

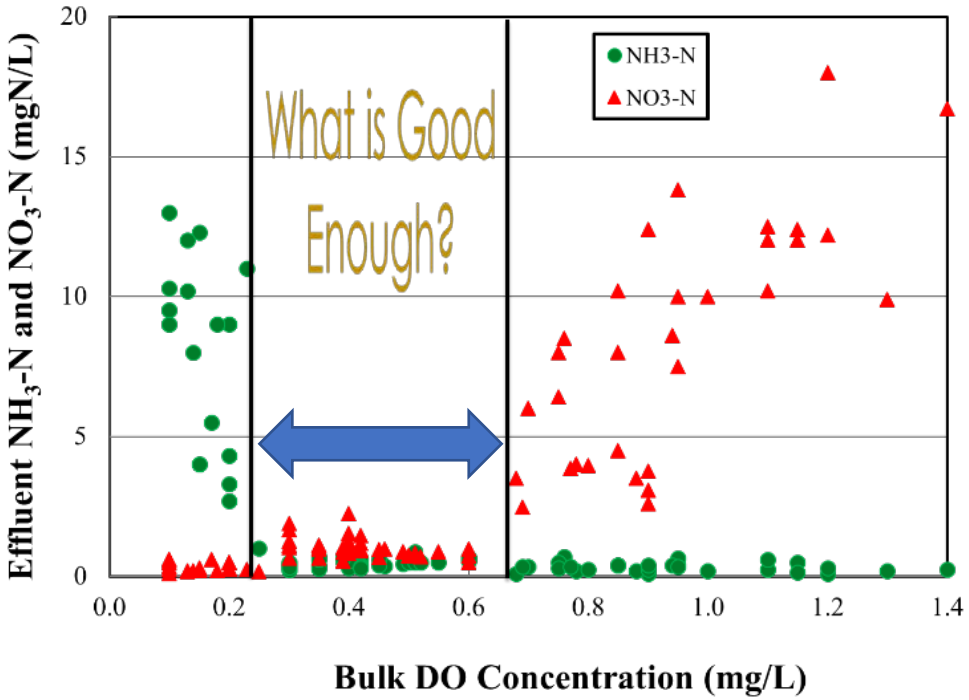
Efficiency

What is Good Enough?

Aeration Control



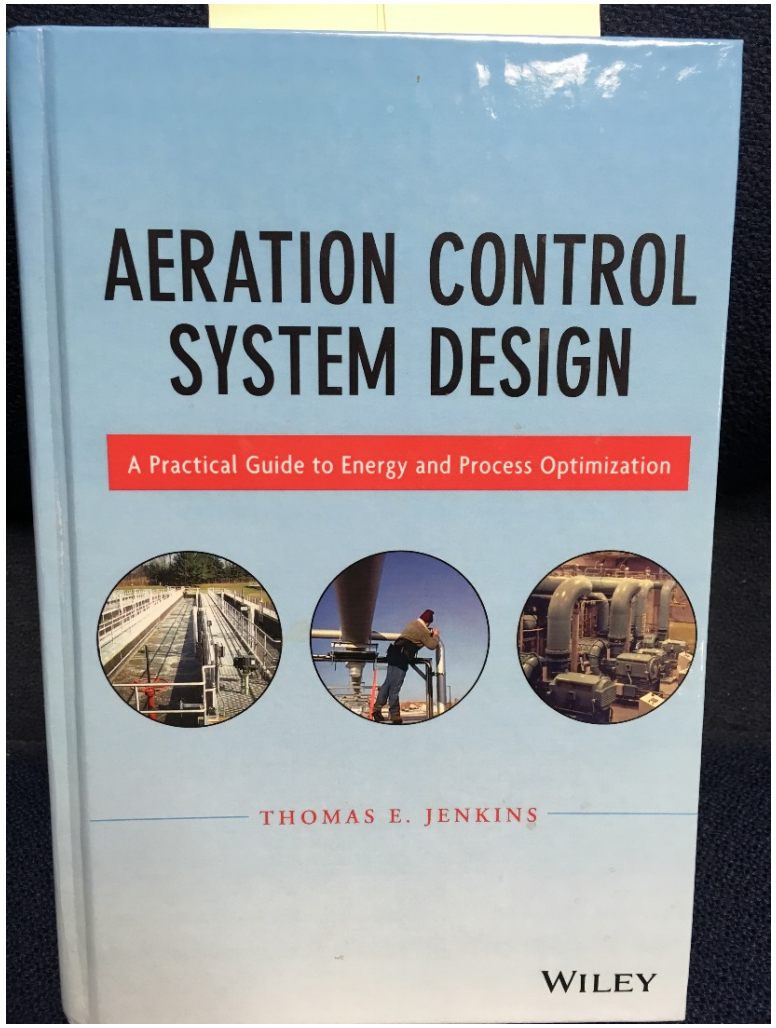
Simultaneous Nitrification and Denitrification



Courtesy of Jimenez, J, Brown and Caldwell

Aeration Control

Technical Reference



2014

Current Generation Industrial (PID) Controls

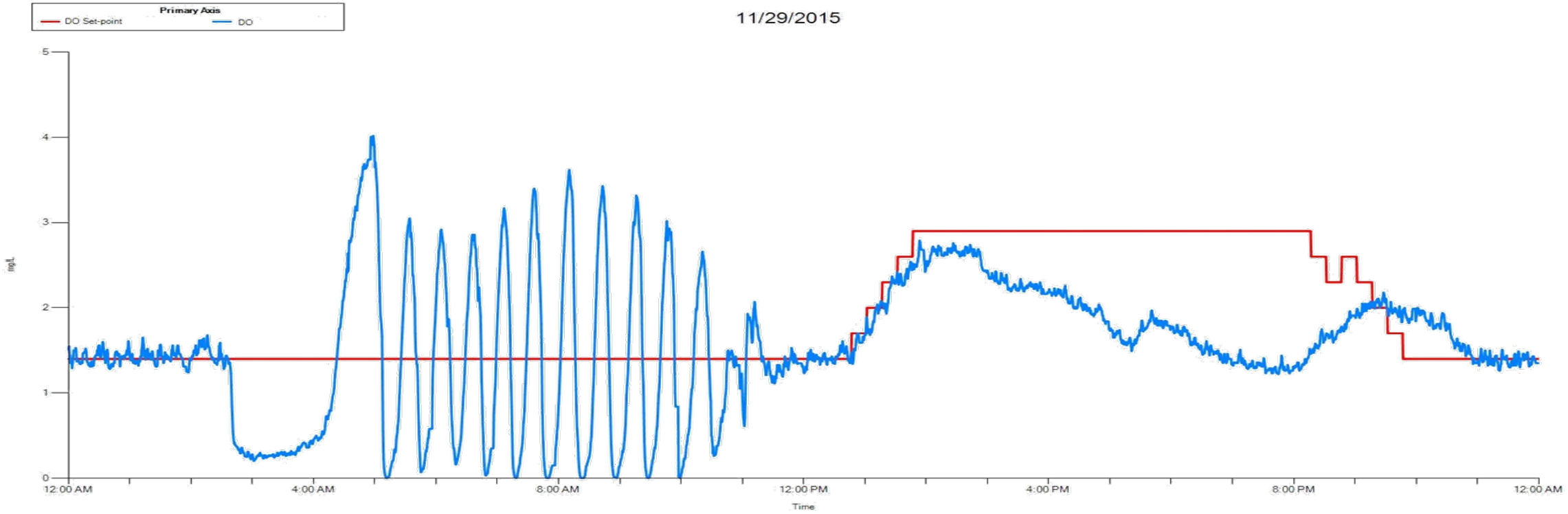
page 274 *- "DO control is one of the most difficult control loops to implement since DO control is nonlinear, has significant process time lags, is a multivariable process, and has extreme variations in loading."*

"These factors make the PID algorithm poorly suited for DO control."

State of the Market - Reference Site(s)

DO oscillates between values as low as 1.9 mg/L and as high as 5 mg/L

State of the Market - Reference Site(s)

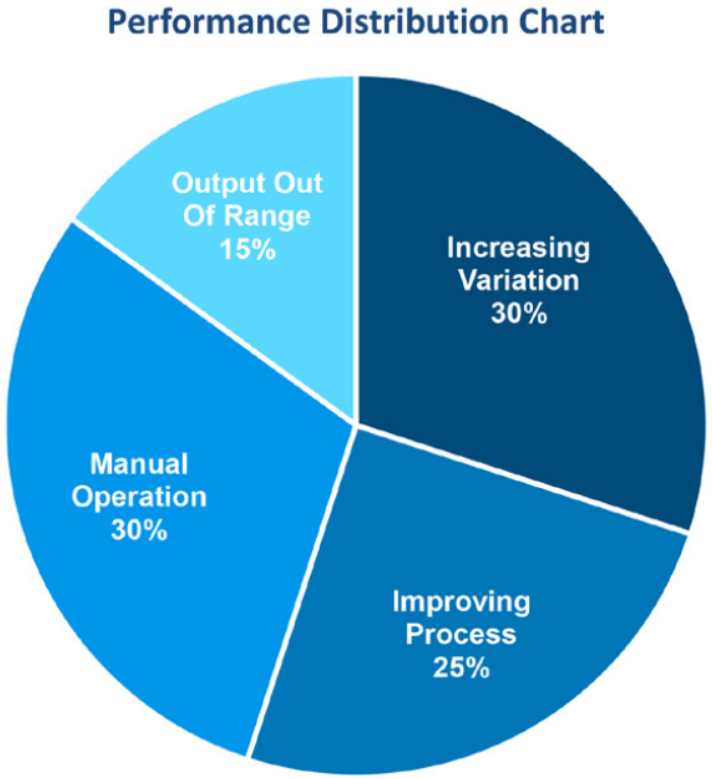


----------24-hr time period----------

DO oscillates between values as low as **0** mg/L and as high as **4** mg/L

Technical Reference

Current Generation Industrial (PID) Controls

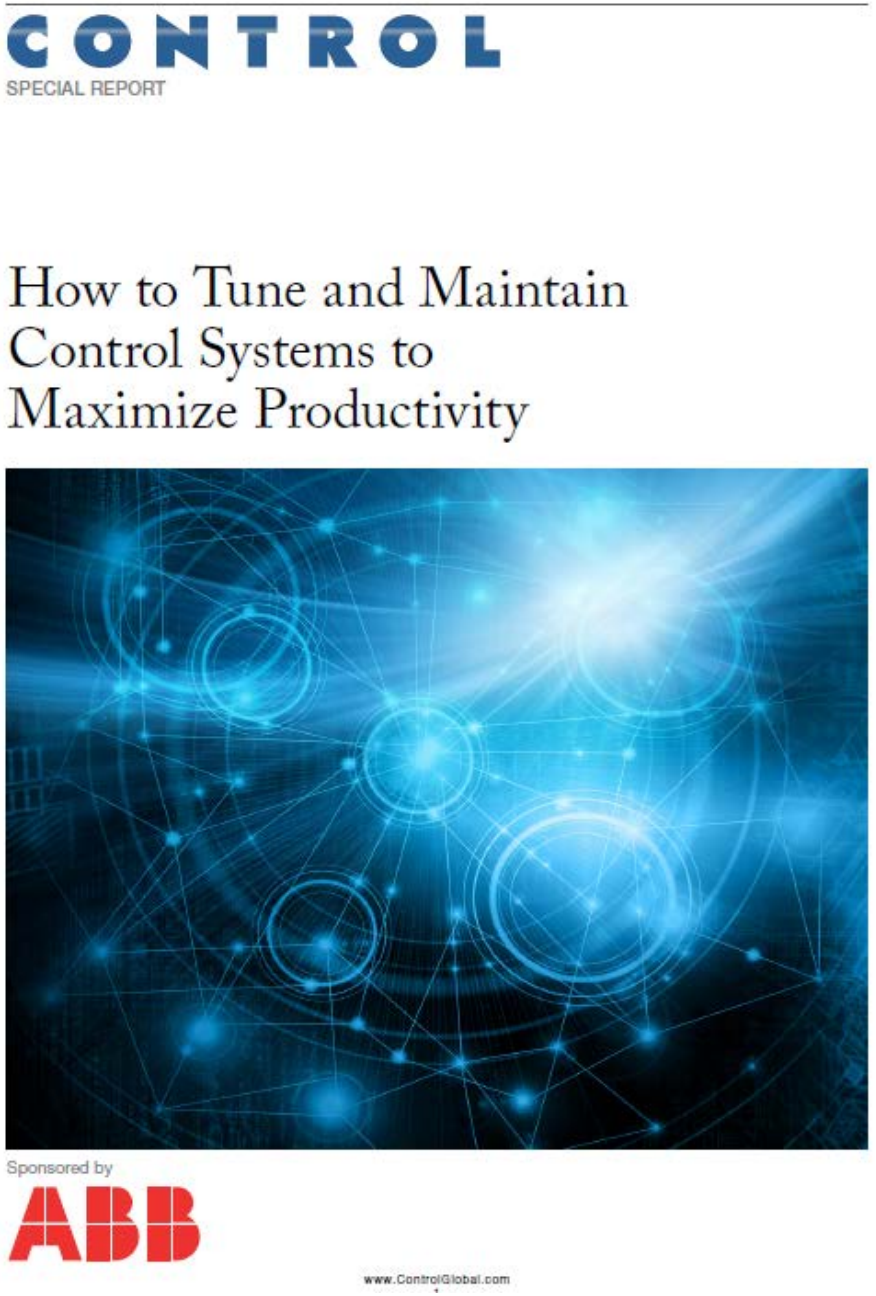


Recent ABB analysis has found that in many industrial production sites, control performance distribution is 30% manual operation, 30% increasing variation, 25% improving process and 15% output out of actuation range. This indicates that many control system owners are under-utilizing their automation investments.

Control Loop Half-Life

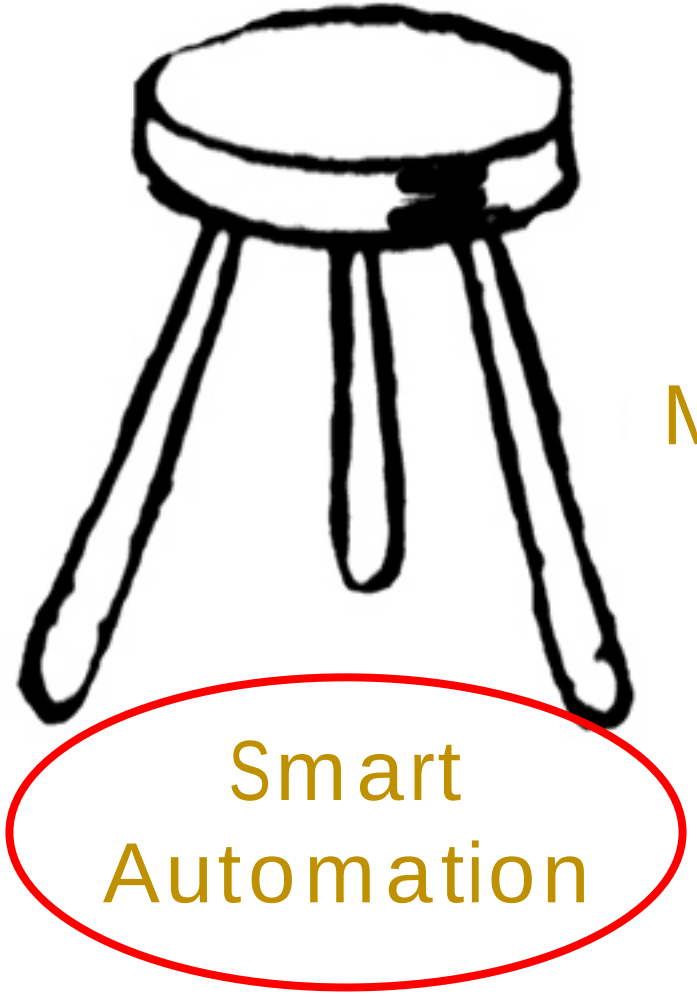
6

Months



Plant Performance
Getting the 'most' from the Plant
Capacity, Energy Efficiency & Process Performance

Right – Sized
Physical Assets



Asset
Management

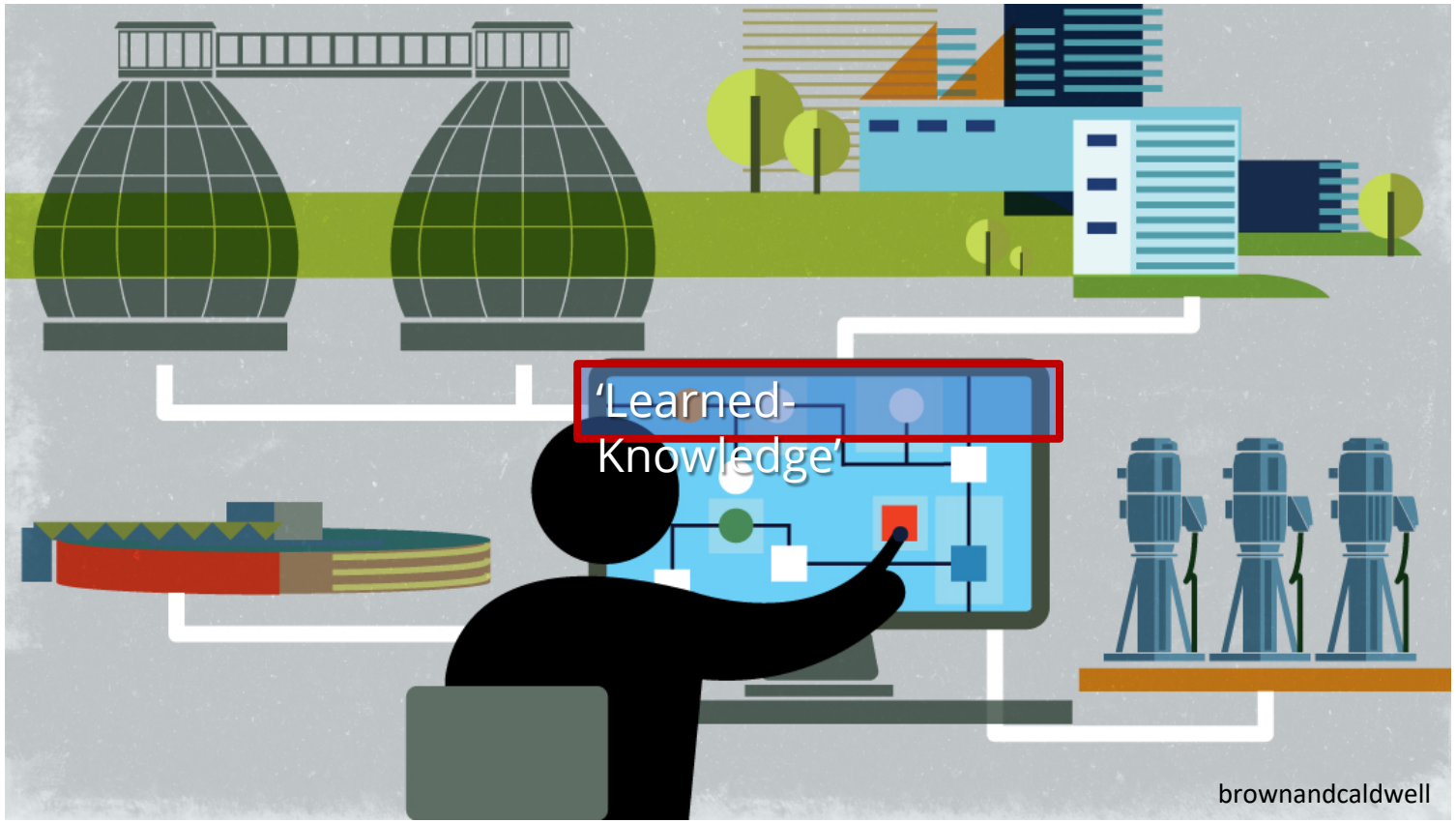
Smart
Automation

Modern WWTP (BNR)

Next-Generation Controls

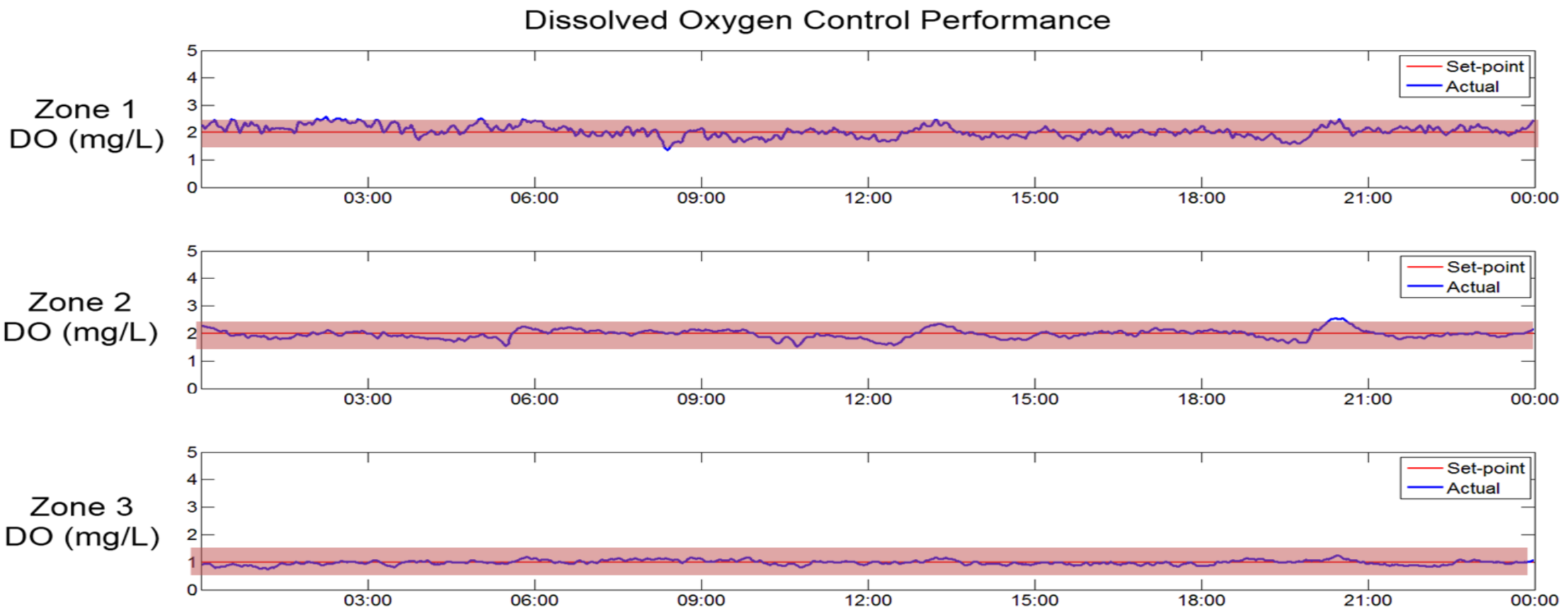
How are they different?

4th Industrial Revolution



- Convert data into action (model - based algorithms)
  - IBM - Watson
  - Google - Know what your data knows
  - EDI - 'Learned – Knowledge'

Next - Generation Controls - Cyprus / Camelot



----------24-day time period----------

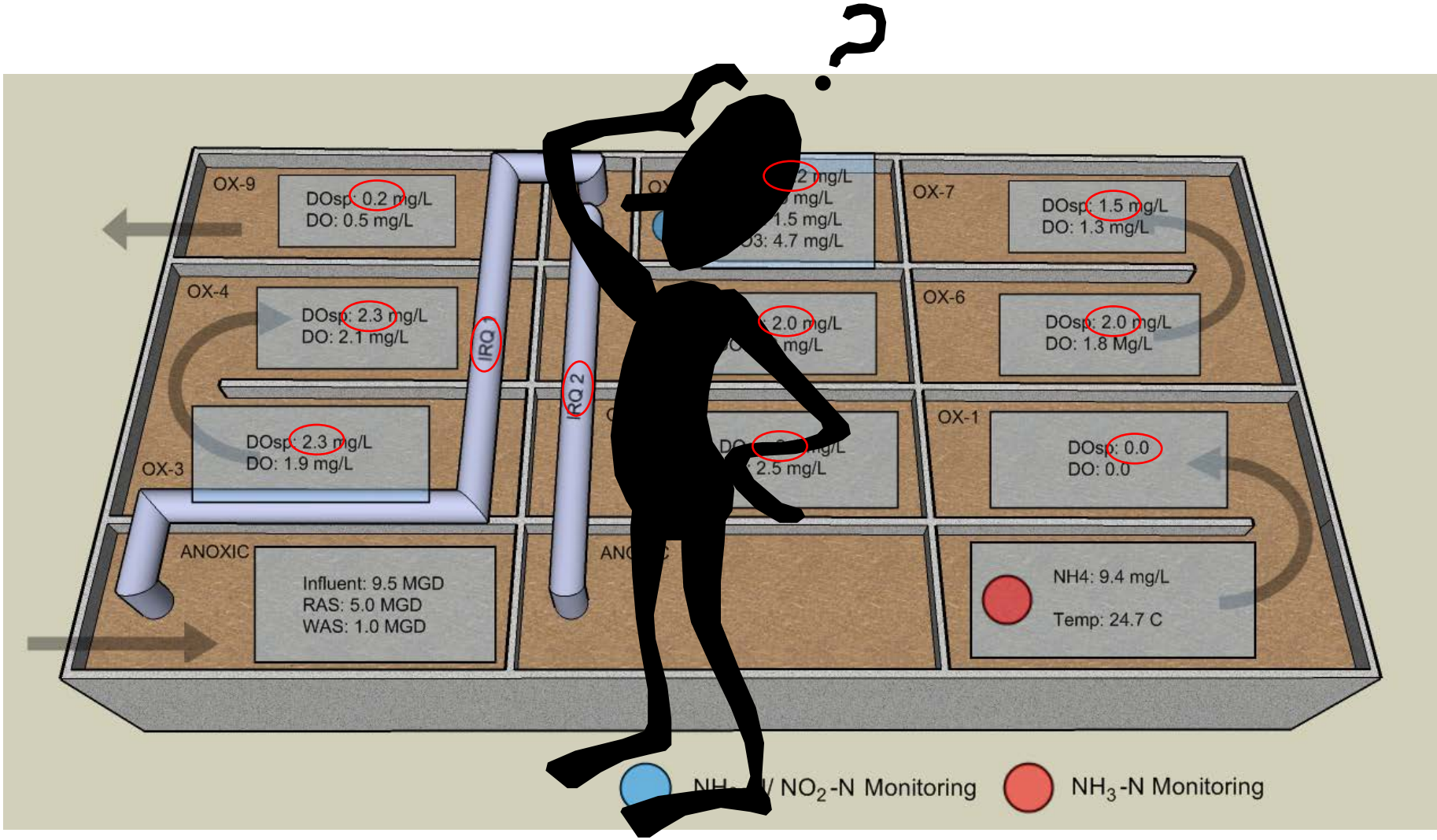
DO oscillates by no more than **0.5** mg/L from zone setpoint, 95% of the time

guaranteed automation tolerance

The Modern Plant (biological treatment unit)

Operator's Challenge

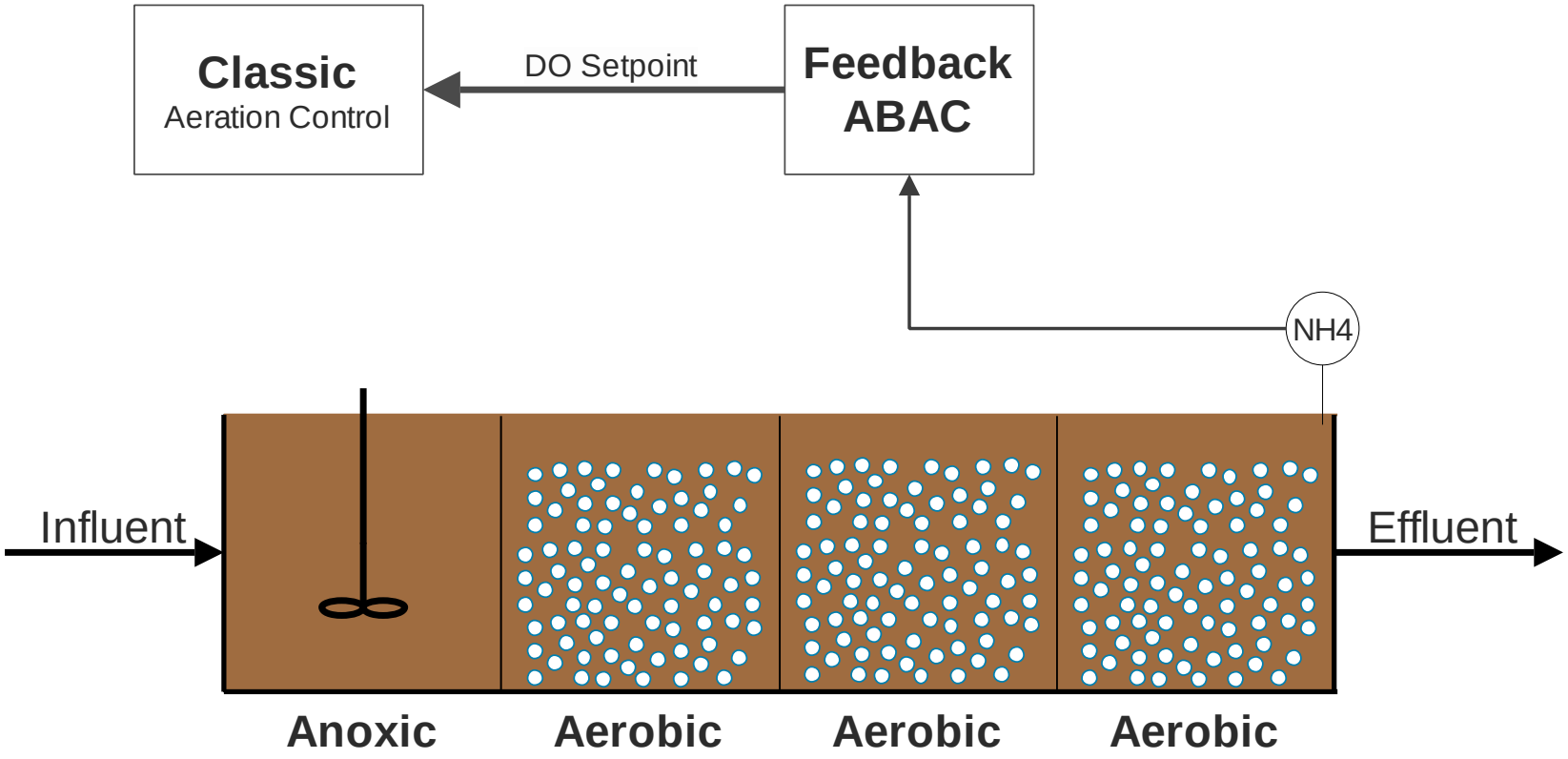
- ***What DO, Where, Why, and How?*** ✓



Process Optimization Control

Conventional Ammonia-based Aeration Control (ABAC)

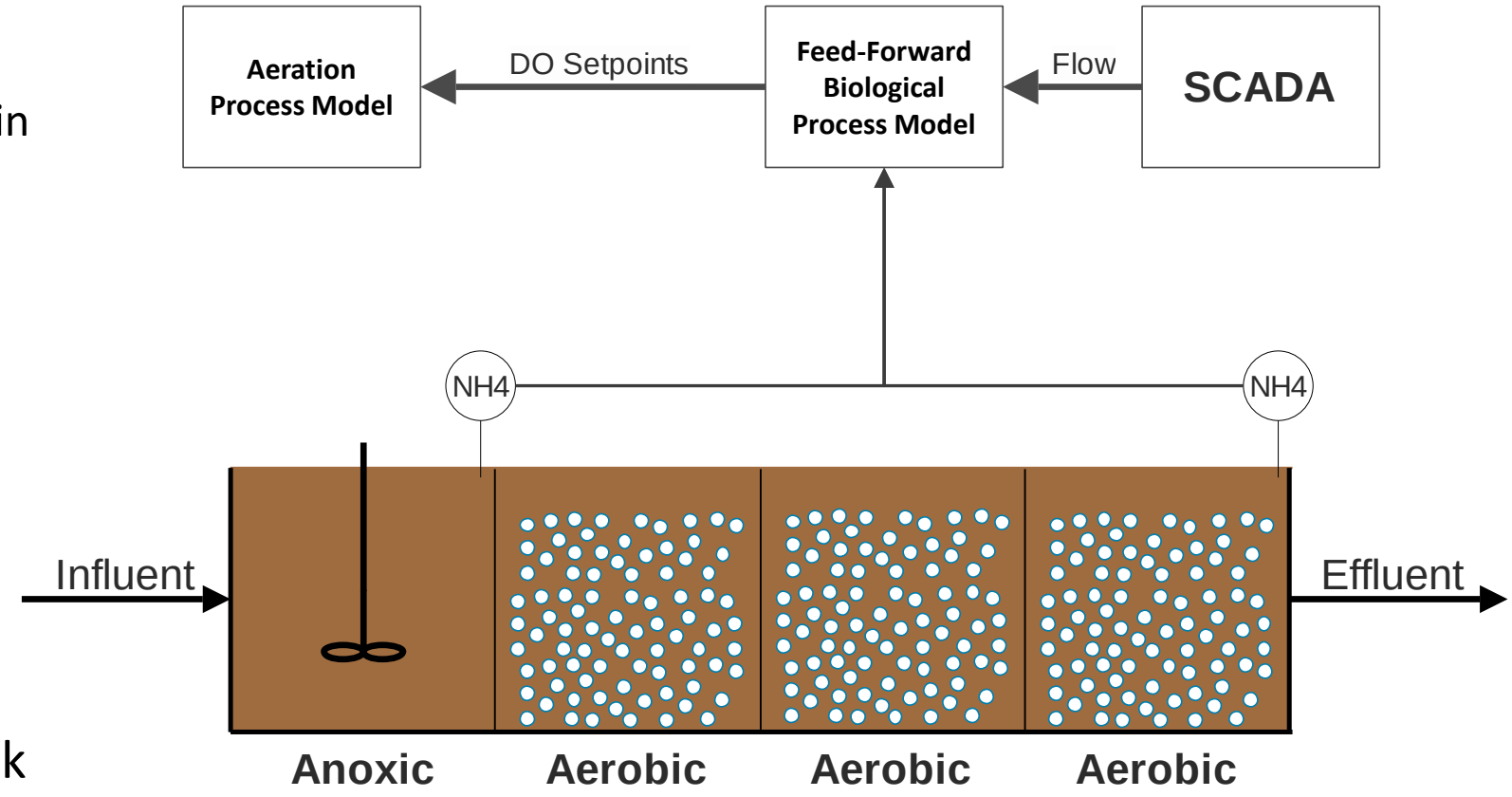
- Feedback control
- Adjust residual DO setpoint based on effluent ammonia concentration
- Proportional or Step Function Algorithm



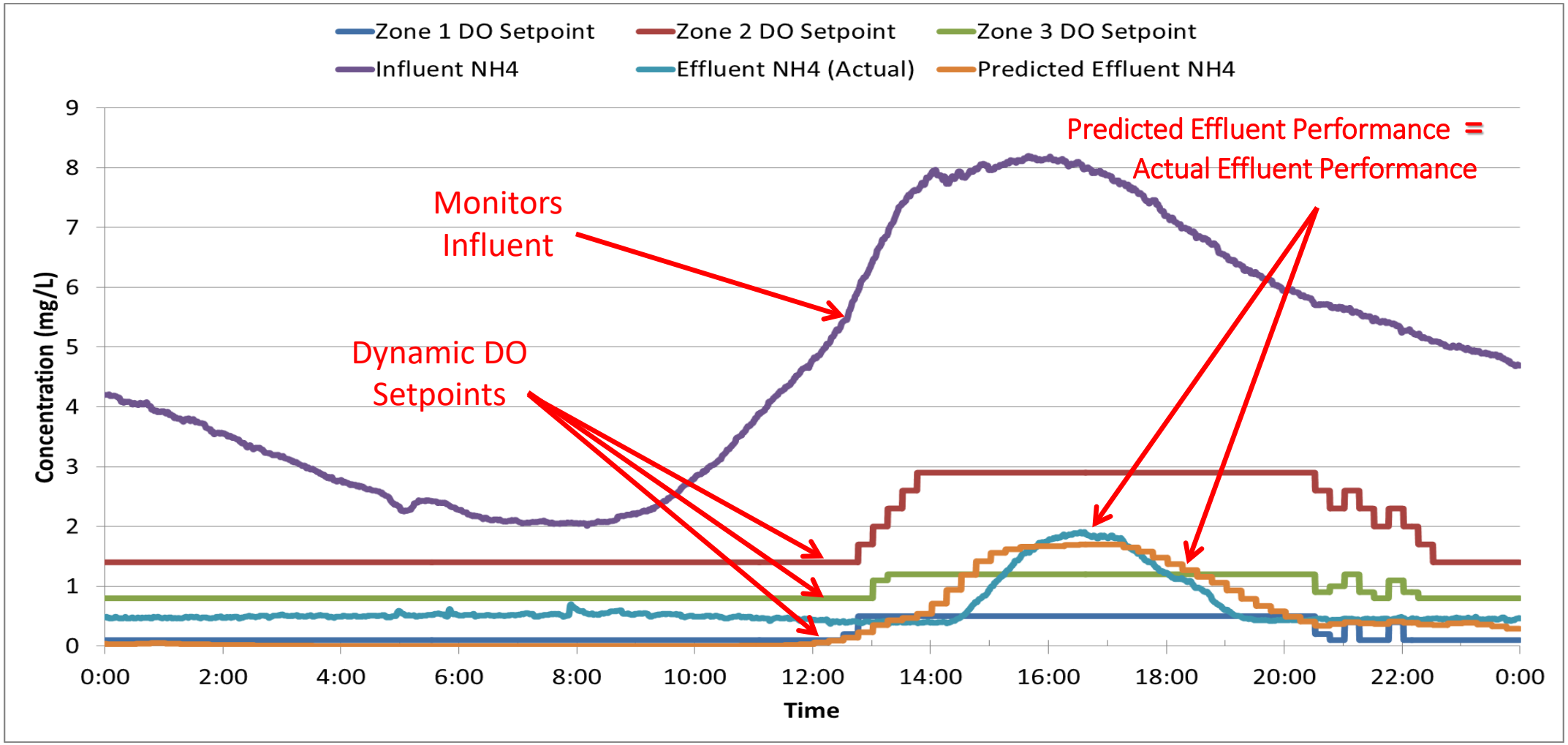
Process Optimization Control

Next-Generation Process Optimization Control (ABAC)

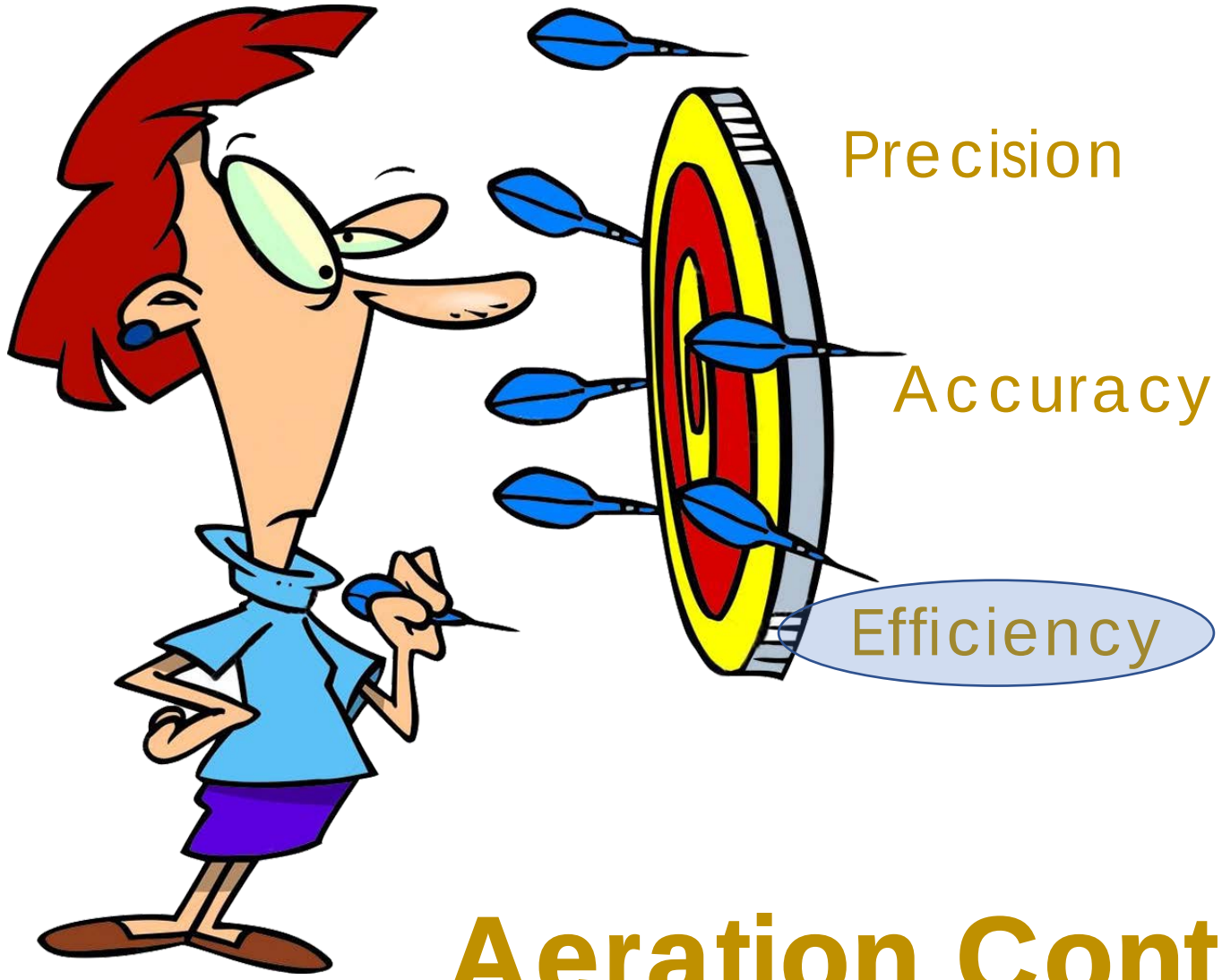
- Feed-forward process algorithm
  - 1st full-scale installation in 2004
- Evaluates process responses to influent conditions
- Calculates best setpoints for desired treatment
- Evaluates setpoints for lowest power use
- Auto-corrects for temperature
- Self-tunes using feed-back loop



Next – Generation Process Optimization and Aeration Control



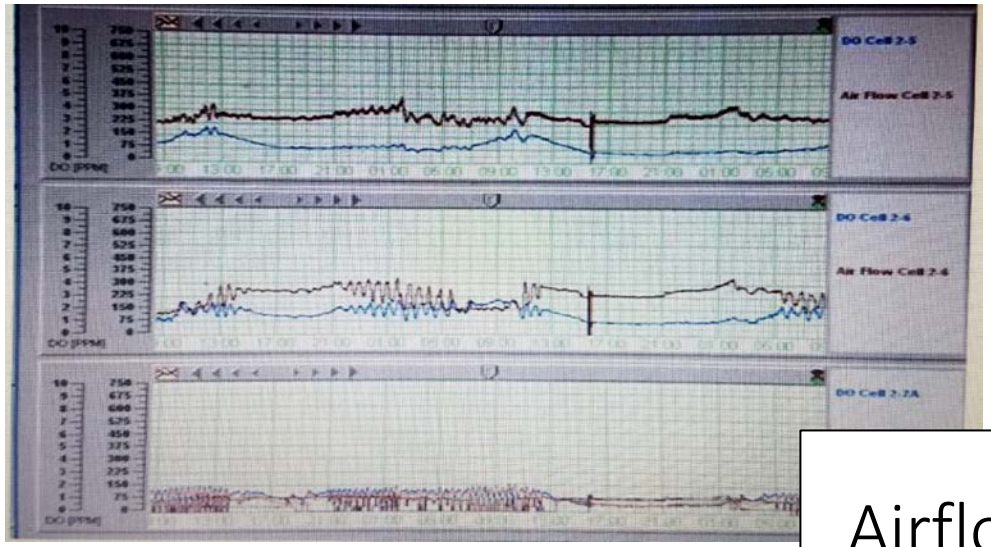
guaranteed optimized process setpoints



What is Good Enough?

Aeration Control

Current Generation Aeration Control System

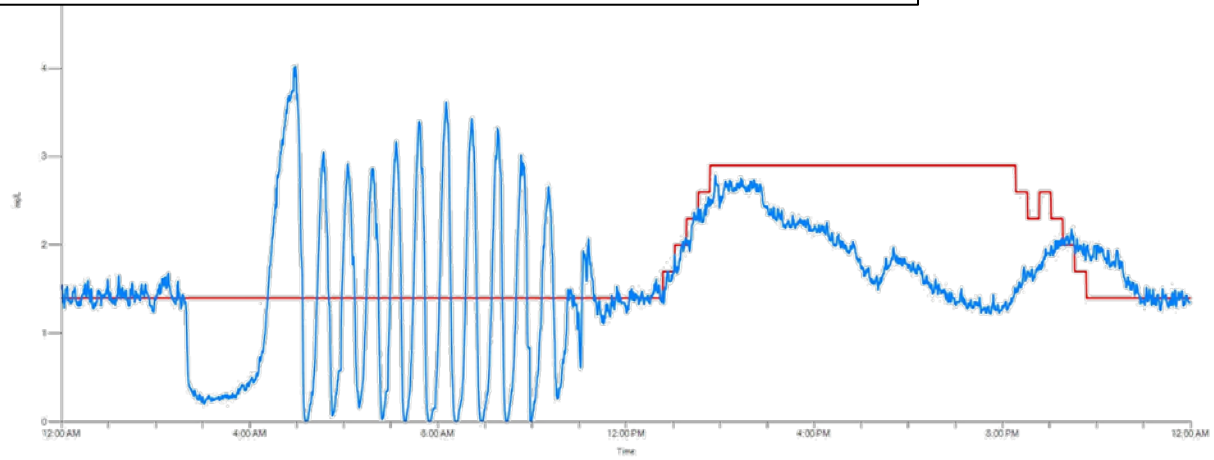


Airflow (valve & blower) Modulation

Equipment Life

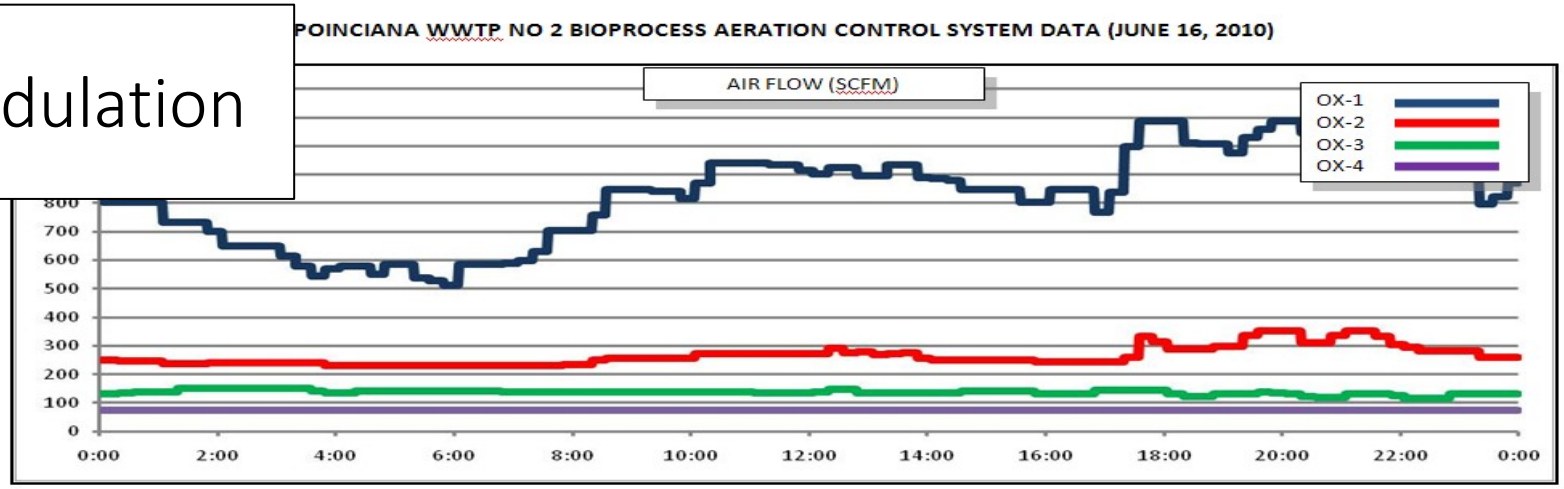
High Service Duty Application

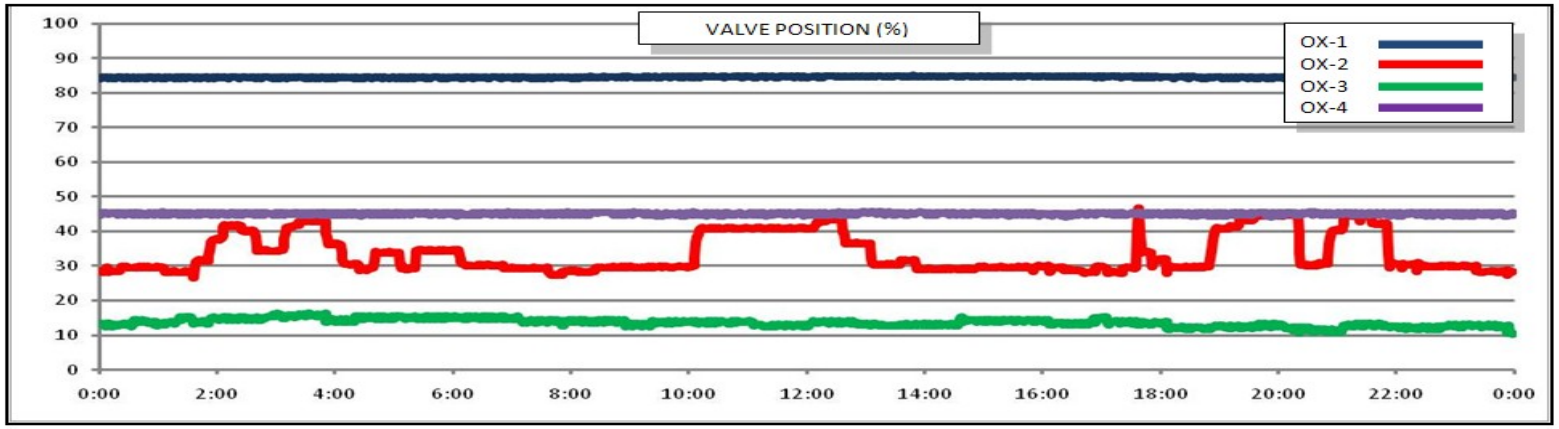
- Short Equipment Service Life (valves, actuators, & potentially blowers)



Next – Generation Aeration Control System

Airflow (valve & blower) Modulation





Equipment Life

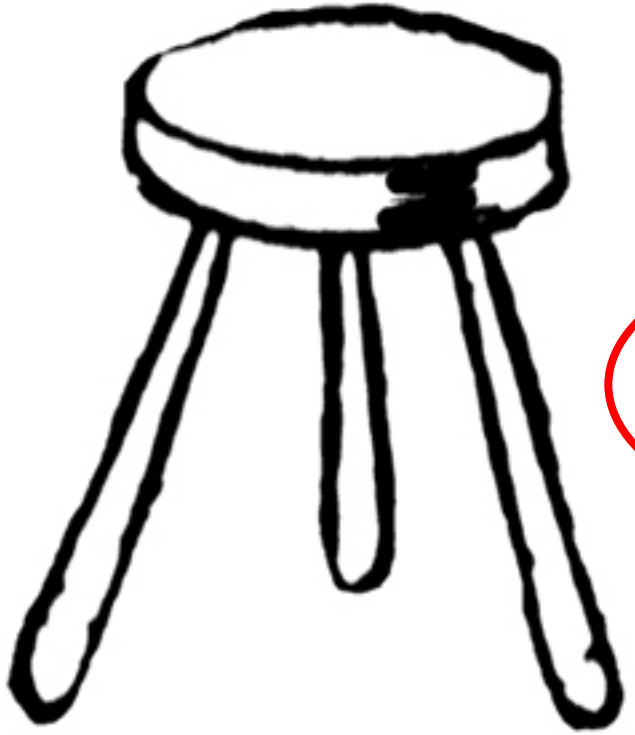
Normal Service Duty

- Eliminates Premature Equipment Failure

(as few as 1/10th number of starts)

Plant Performance
Getting the 'most' from the Plant
Capacity, Energy Efficiency & Process Performance

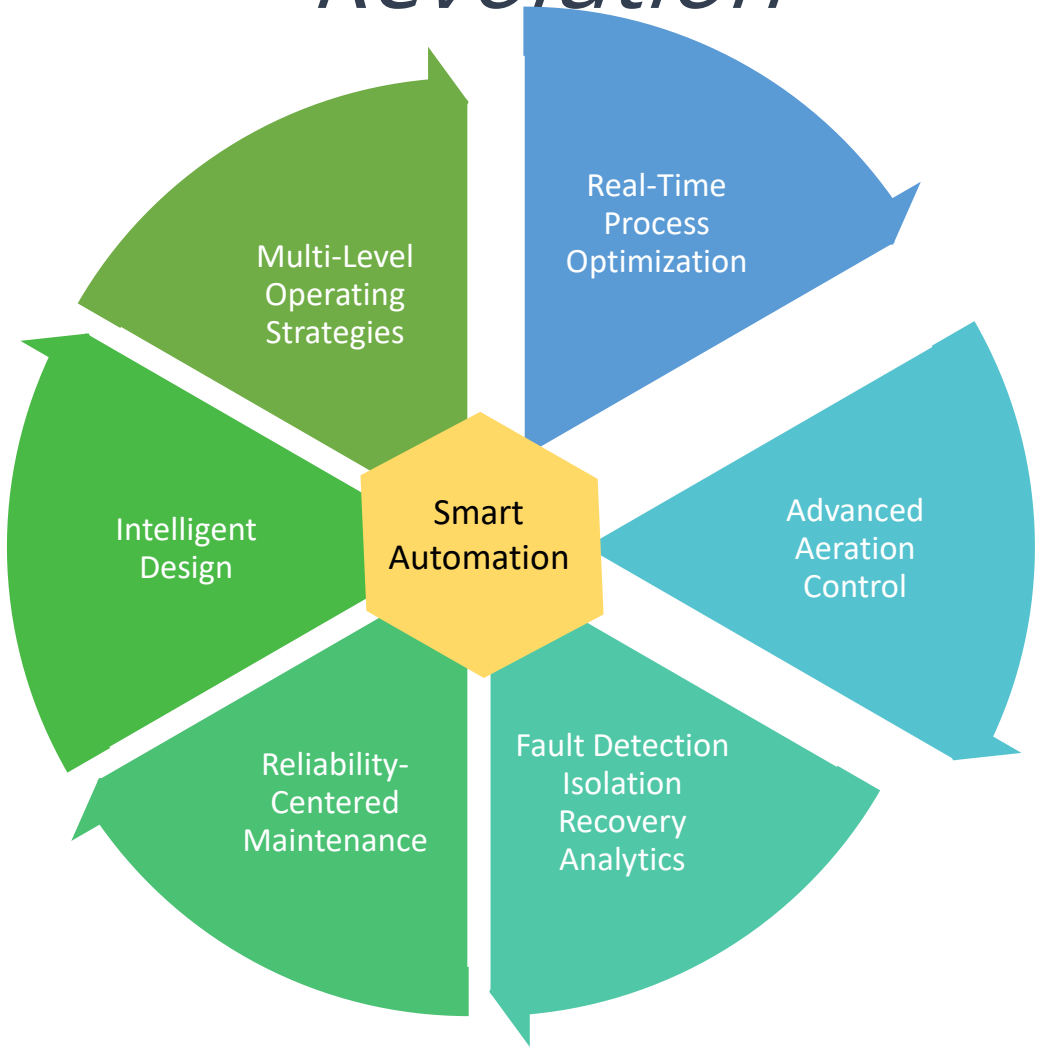
Right – Sized
Physical Assets



Asset
Management

Smart
Automation

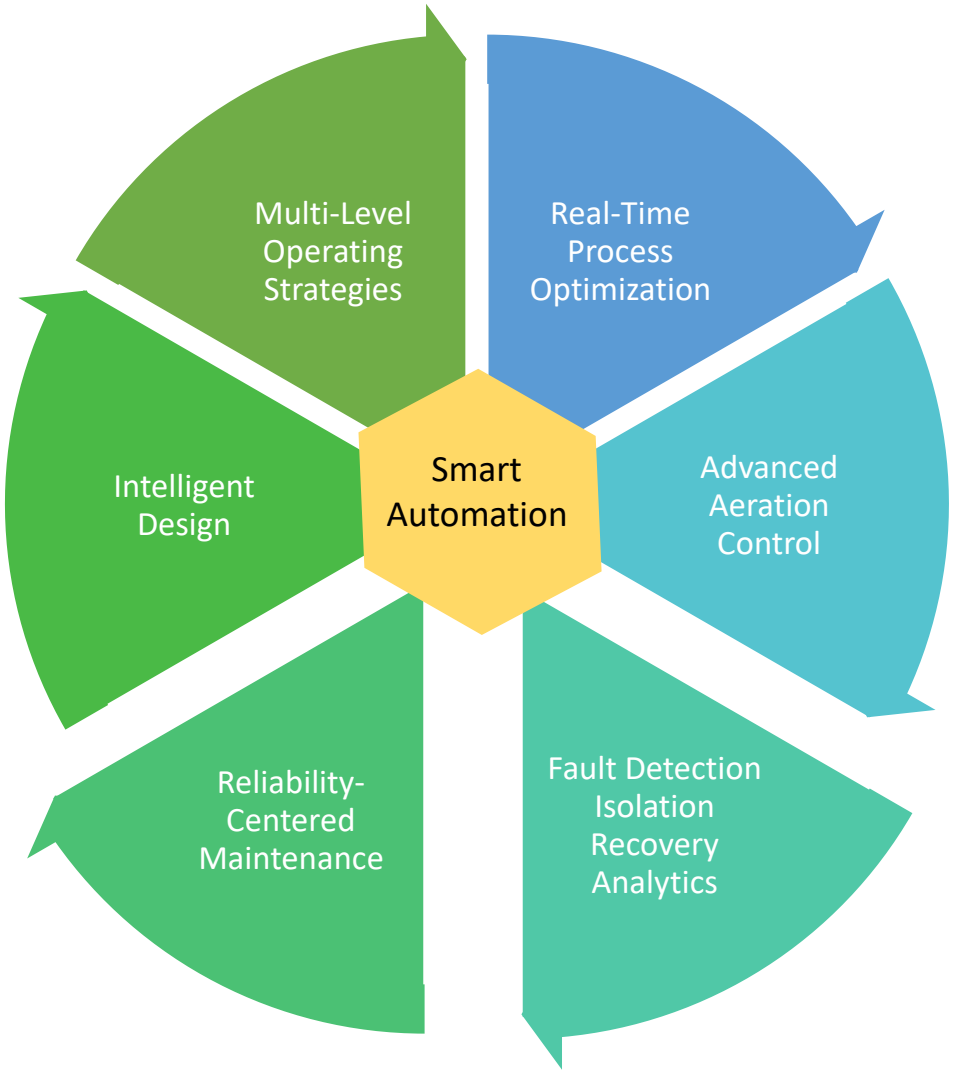
The Future & The 4th Industrial Revolution



'Learned – Knowledge'

- Optimized Setpoints
- Precise, Accurate & Efficient Aeration Control
- All with No Retuning

The Future & the 4th Industrial Revolution



'Learned – Knowledge'

Quantifies Efficiency Losses (fouling)

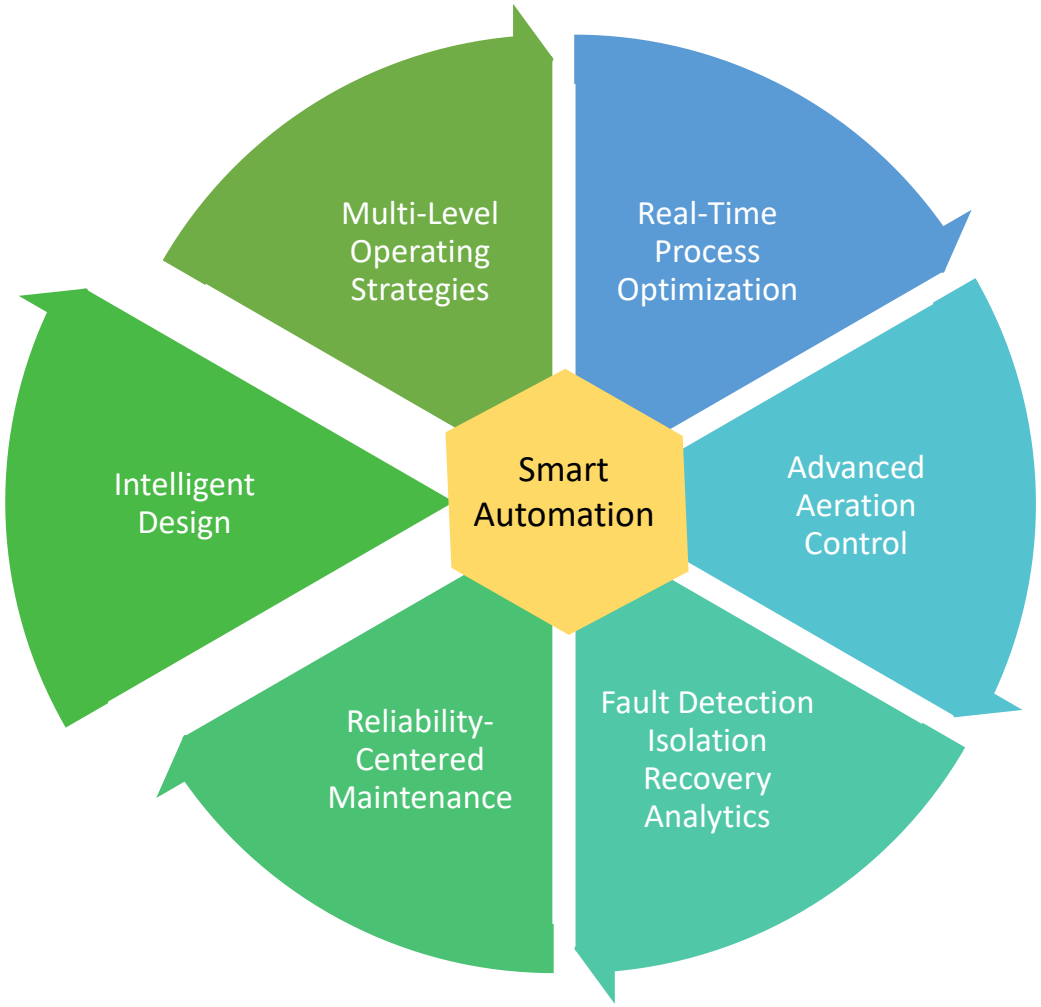
'Learned – Knowledge'

Knows when a Fault Condition exists

The Future & the 4th Industrial Revolution

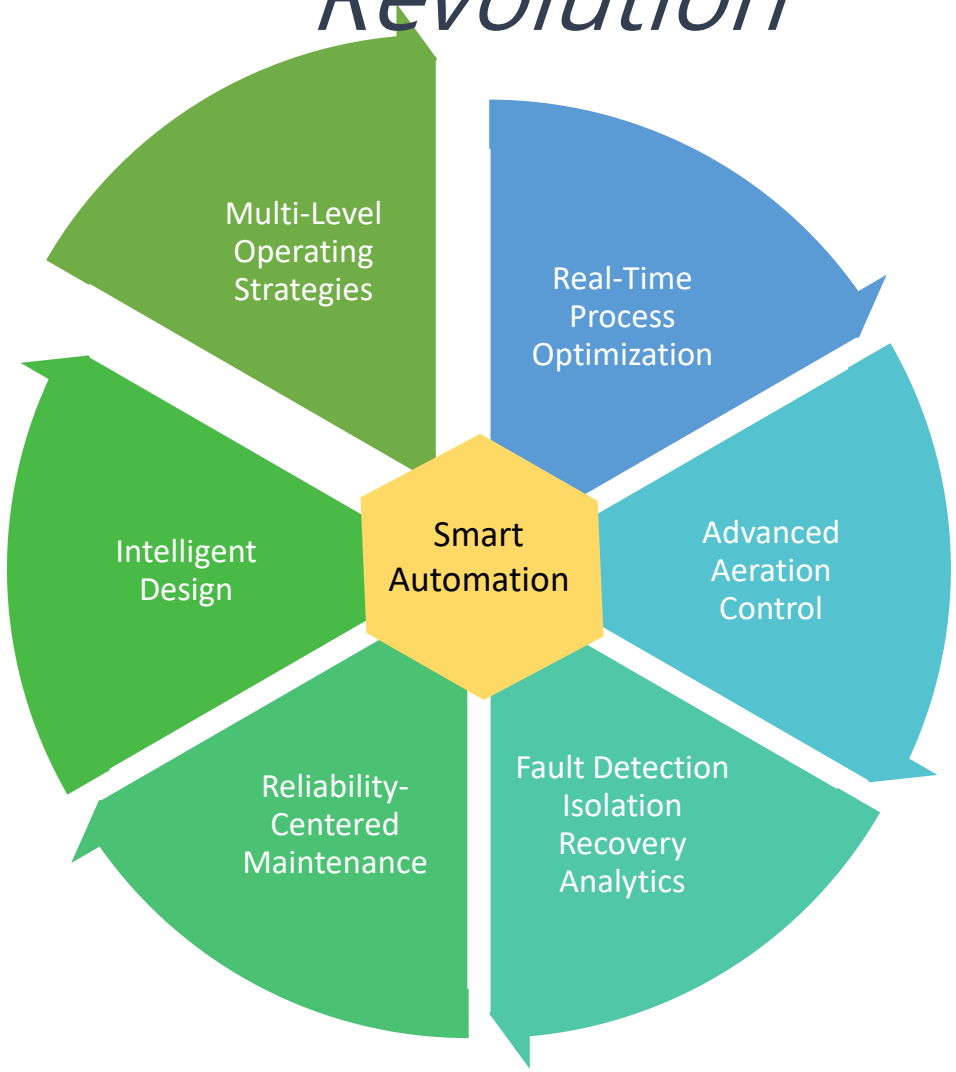
'Learned – Knowledge'

Knows the Operating Potential and Key Design Factors for Equipment



The Future & the 4th Industrial Revolution

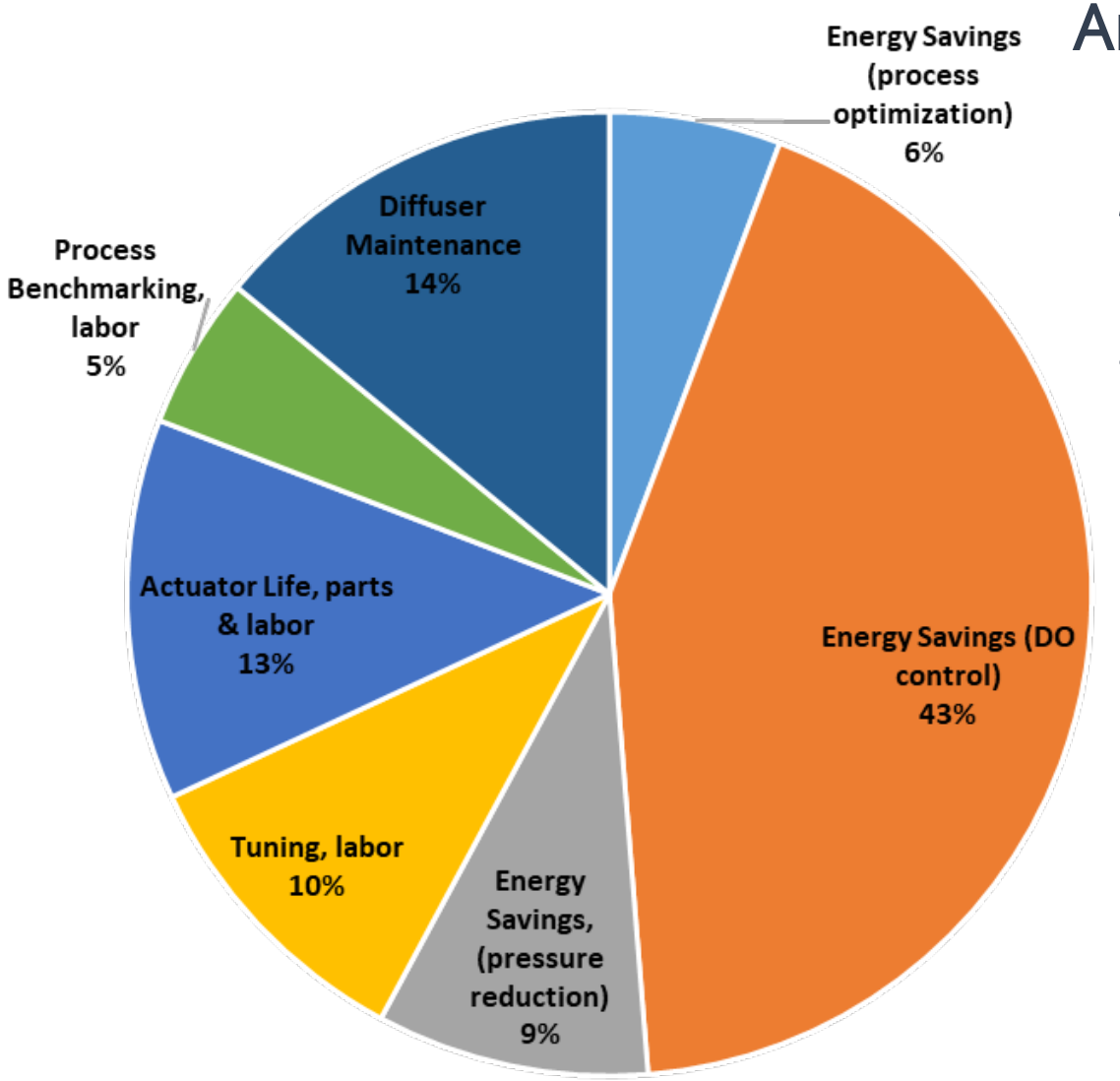
'Learned – Knowledge'
Provides Direct Operational Control and Supports Precise Operational Strategies



Lessons Learned

- ✓Aeration to excess is old school
- ✓Significant savings (electricity) and process gains are available
- ✓Tools are available to help you get the ‘most’ from your plant
- ✓Right-sized equipment (aeration, blowers, and mixers), both capacity and turndown, is critical
- ✓All plants benefits; software upgrade for existing aeration control systems
- ✓Next-generation digital solutions is the pivotal technology advancement that closes many gaps
- ✓Lets give operations the tools they need to get the ‘most’ from the plant

Opportunity Potential[1]



Annual Savings, $50,000

Next – Gen Process Controls

Savings

- ✓ Electricity
- ✓ High process optimization
- ✓ No tuning labor
- ✓ Extended actuator life
- ✓ High operational confidence, FDIR
- ✓ Targeted equipment maintenance, RCM

[1] Assumes 1MGD, 4mg/L DO condition, $0.11/kWh, aeration hp = 75hp/MG @ 2mg/L DO, approx. $125k annual power cost

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