Chat question for the week

What is one of your favorite fall activities?

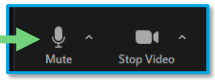
1

Using Zoom!

Mute yourself!

Have a question?
Use the chat feature.

Controls accessed at the bottom



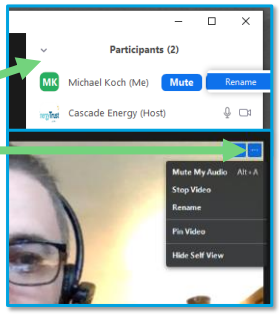
Rename yourself

"Name (Company)"

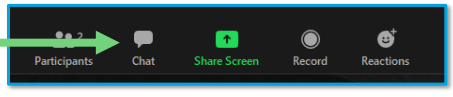
Right click on your picture or 3 dots

OR

Controls accessed at the right after clicking 'Participants' at bottom.



Access Chat at the bottom

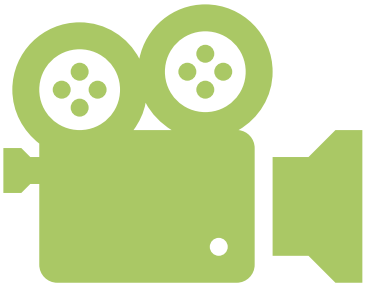


2

Recording

This meeting is being recorded (both audio and video)

If you do not consent to being recorded, please let the meeting moderator know ASAP and we will facilitate your participation in another way or adjust our procedure.



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WASTEWATER VINPLT
SESSION 7 - DEWATERING, DIGESTION, & DECARBONIZATION

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Thank You!

Sponsor

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Today's Agenda

Welcome and Homework Recap	Decarbonization
Opportunity Register Check-in	Dissolved Air Flotation
Utility of the Future	Kahoot
Dewatering	Q&A
Digestion	

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OPPORTUNITIES?

Opportunity Example

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For Our Last Session:

- Find 5 opportunities and fill out your Opportunity Register.
- Be prepared to report out on 1 or 2 of your opportunities.
- Use the template that is sent to you, to describe 1 of your opportunities.
- MAKE THIS SIMPLE. PROJECT DESCRIPTION & SAVINGS

HOMEWORK

SRT EXERCISE

$$Q_{WAS} = \left(\frac{V_a}{SRT_{target}} \times \frac{MLSS}{TSS_{WAS}}\right) - \left(Q \times \frac{TSS_{EFF}}{TSS_{WAS}}\right)$$

From experience the process control engineer knows that an SRT target (aerobic) of 7 days will meet the effluent NH3 requirements during the winter. However, because the supernatant in the modified settleometer test has been turbid, she wants to increase the SRT target to 7.5 days.

From the following recent data, calculate the new WAS flow rate (gal/hr):

Q = 2.6 Mgal/d

MLSS = 2,550 mg/L

Va = 0.65 Mgal (aerobic)

TSS_{EFF} = 16 mg/L

TSS_{WAS} = 7,700 mg/L

WAS = gal/hr

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HOMEWORK

OPTIMIZING RETURN RATE EXERCISE

This equation,

$$Q_{RASmin} = \frac{Q \times SSV_{30}}{1{,}000 - SSV_{30}}$$

Can be rearranged to:

$$\frac{Q_{RASmin}}{Q} = \frac{SSV_{30}}{1{,}000 - SSV_{30}}$$

The factor below and on the left hand side of the equals sign, as calculated (times 100 to get %) is the minimum RAS flow percentage:

$$\frac{Q_{RASmin}}{Q}$$

Calculate the minimum RAS flow percentage for SSV_{30}s of 125, 150, 175, 200, 250, 300, 400, 500, and 600 mL/L. Comment on the impact that sludge compaction has on the potential for lowering RAS pumping costs.

SSV30, mL/L	Q_{RASmin}/Q
125	14.3%
150	17.6%
175	21.2%
200	25.0%
250	33.3%
300	42.9%
400	66.7%
500	100.0%
600	150.0%

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We Operate Multi-Billion, Multi-Million Dollar Facilities With Someone Else's Money

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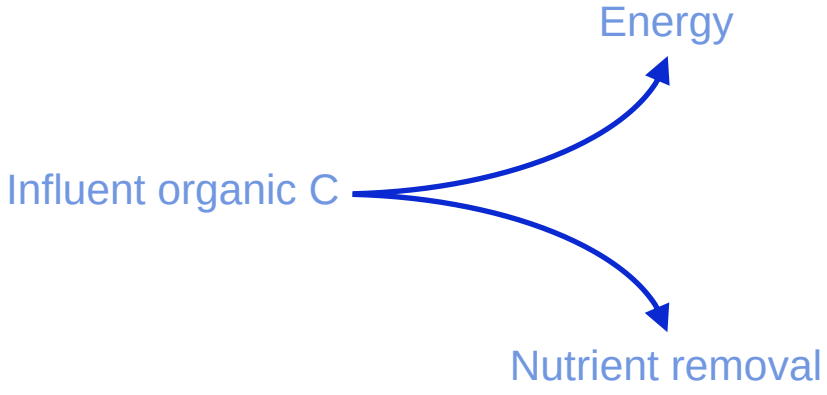
The Wastewater Treatment Industry is At a Crossroads



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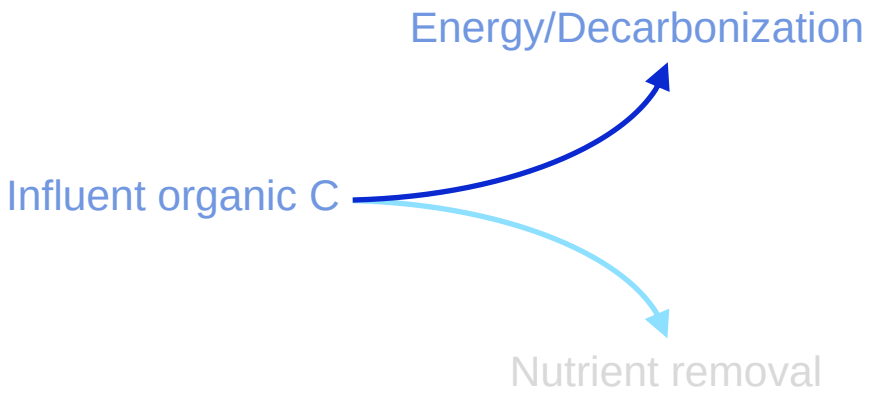
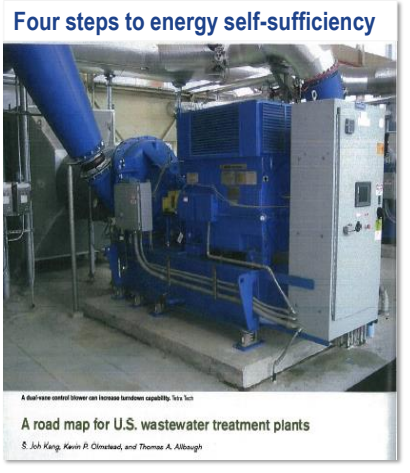
Today's Focus: Using Influent $C_{organic}$ for Energy Generation *via* Methane Production



Four Steps to Energy Self-sufficiency

1. Commitment to saving energy throughout organization
2. Energy generation
3. Process energy conservation
4. Assess and refine



Can't Generate Energy Without Using the Gas Produced by Anaerobic Digestion

1. Commitment to saving energy throughout organization
2. **Energy generation**
3. Process energy conservation
4. Assess and refine

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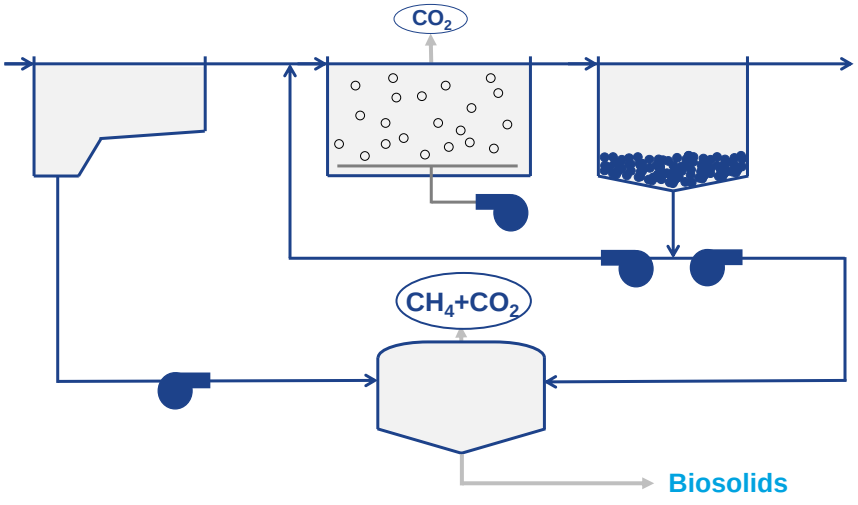
To Increase Gas Production, There are Essentially Three Options



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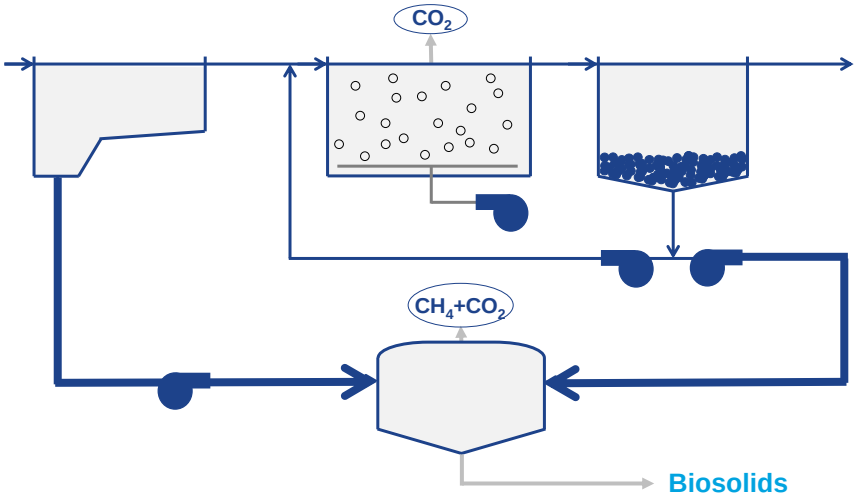
1. Increase VS Load From Within the Plant



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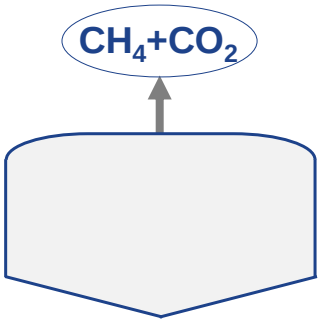
2. Optimize Digester Performance



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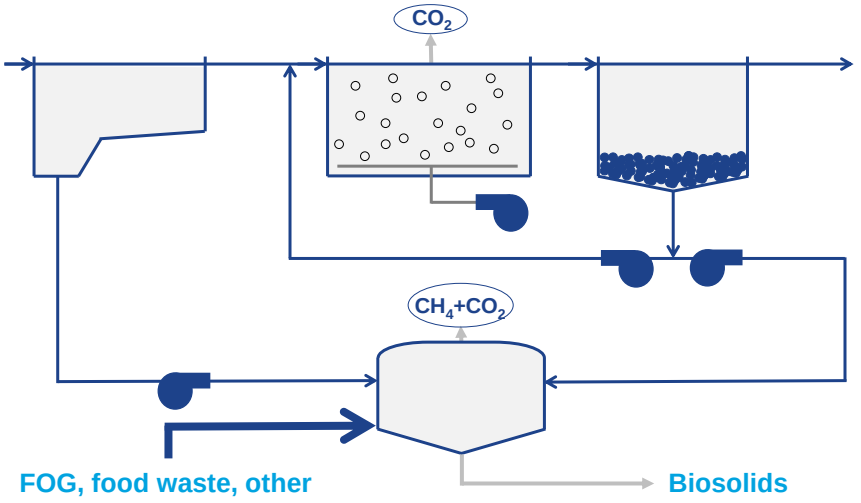
3. Add External Carbon Source



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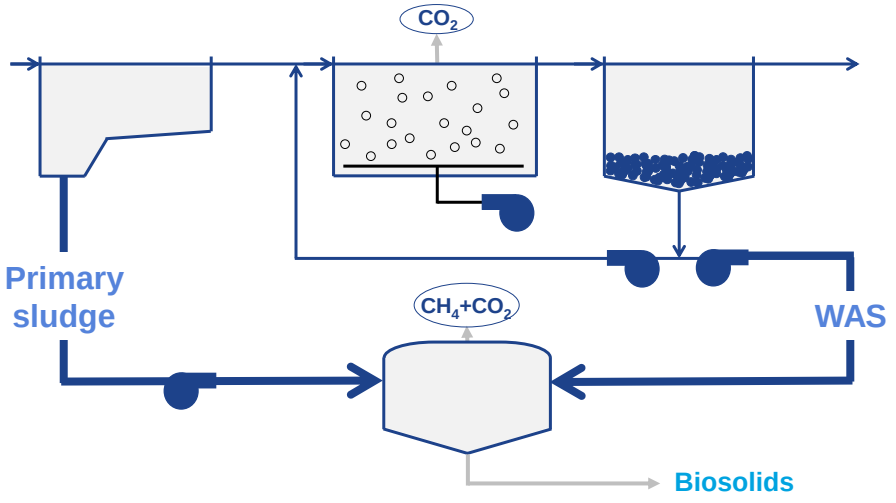
Two VS Inputs to Anaerobic Digester



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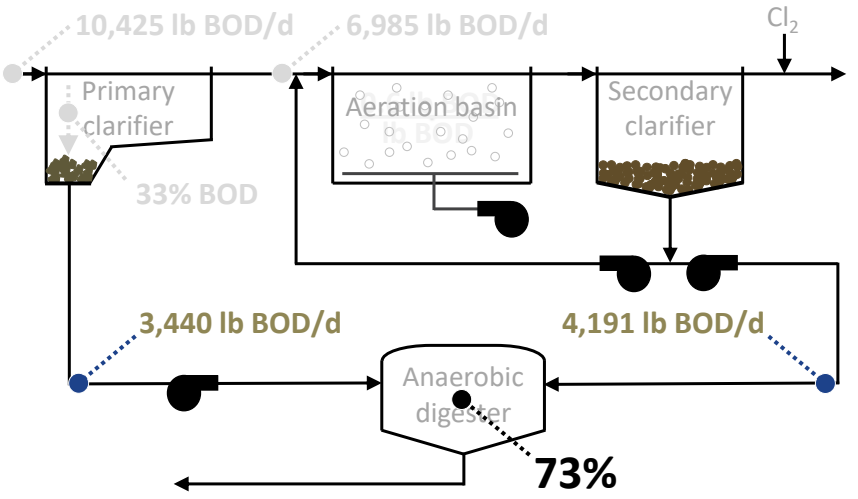
But Not All BOD (VS) is Created Equal



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Two Guiding Principles When Maximizing VS Load to Digesters from Internal Sources

1. VS in primary sludge are **significantly easier** to digest than VS in WAS
2. VS in WAS become **more difficult to digest** and **there's less of them** with increasing SRT

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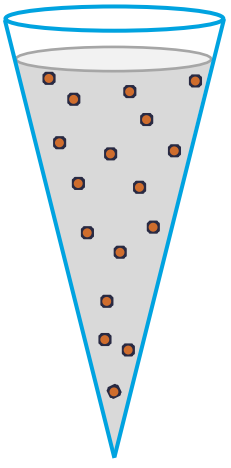
TRANSLATION

1. Capture as much as possible in primary clarifiers
2. Operate activated sludge systems at lowest SRT possible

A Very Simple KPI—Capture as Much as Possible in Primary Clarifiers (CEPT?)

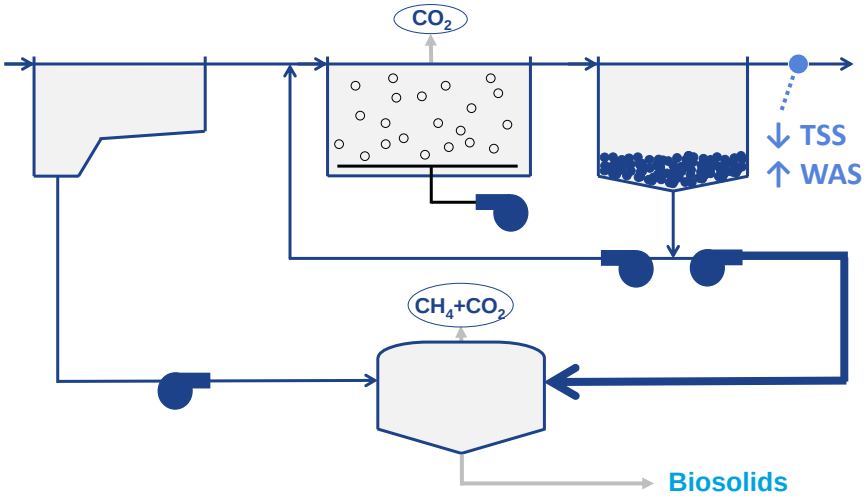


NO *TSS_{set} in primary clarifier effluents*

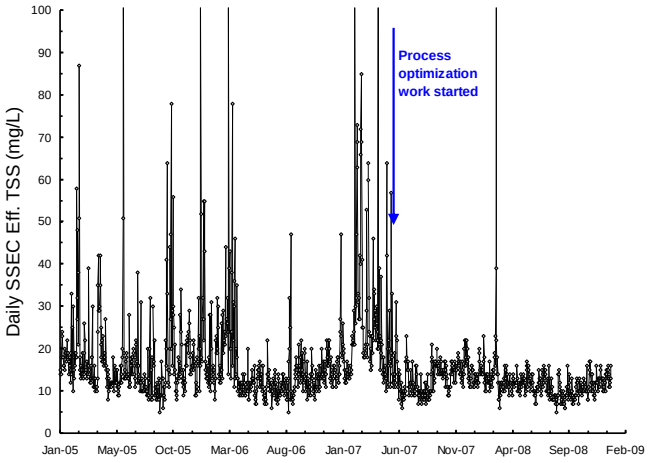
Setting SRT_{TARGET}

1. **Effluent ammonia requirement**
2. **Best sludge quality**
3. **Minimum SRT_{TARGET} that will satisfy 1 and 2**

Minimize TSS (and VSS) Loss to Effluent With Best Sludge Quality



Optimized Activated Sludge Process: SRT control, Minimum SRT_{TARGET}, Q_{RAS} Control



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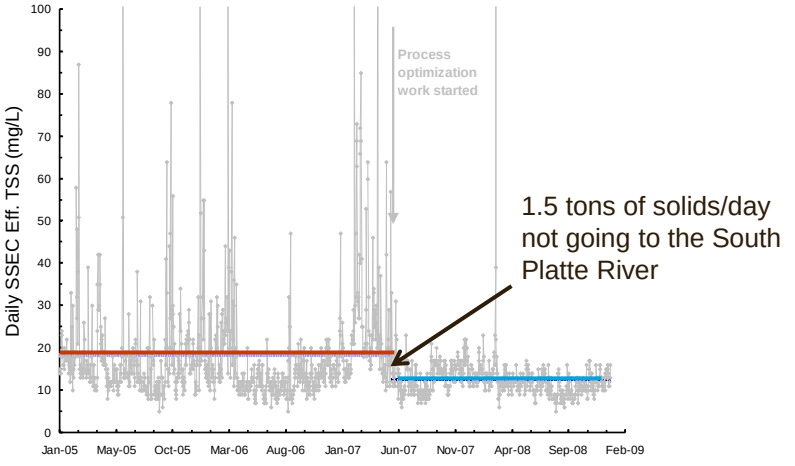
If Not to the River, Where Are These Solids Going?



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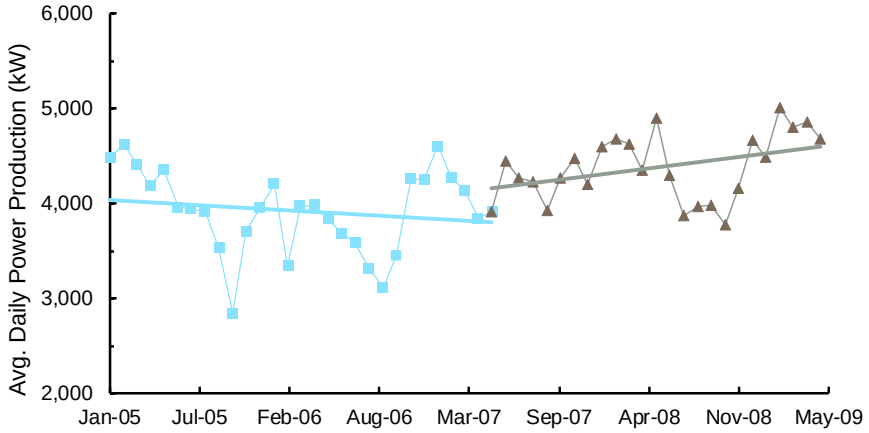
More VSS to Digesters, More Gas, More Heat and Power



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Factors Affecting Anaerobic Digestion Process Performance

Misconceptions and Realities of Anaerobic Sludge Digestion Process Performance

Richard M. Jones* and Peter L. Dold

EnviroSim Associates Ltd.
*E-mail: jones@envirosim.com

ABSTRACT

This paper considers the analysis of anaerobic digester performance, including volatile solids destruction and the potential for biogas production. The paper demonstrates that the potential digester VS destruction and biogas production are strongly influenced by (a) the raw influent unbiodegradable particulate COD fraction (Fup), and (b) PST removal efficiency. For a given PST performance, activated sludge operating SRT has a relatively minor impact on digester performance per unit load to the digester. However, operating at a very short SRT results in a higher load to the digester, with increased gas production. The analysis in the paper is based on COD as the underlying variable because this allows the different components making up the volatile solids to be tracked separately. An important factor is that the COD approach facilitates tracking the unbiodegradable particulate components; these essentially set the performance limits.

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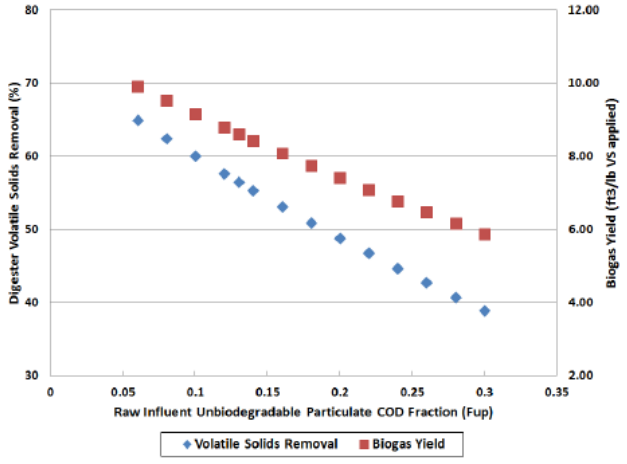
"Performance Strongly Influenced By:" ISS_{INF}



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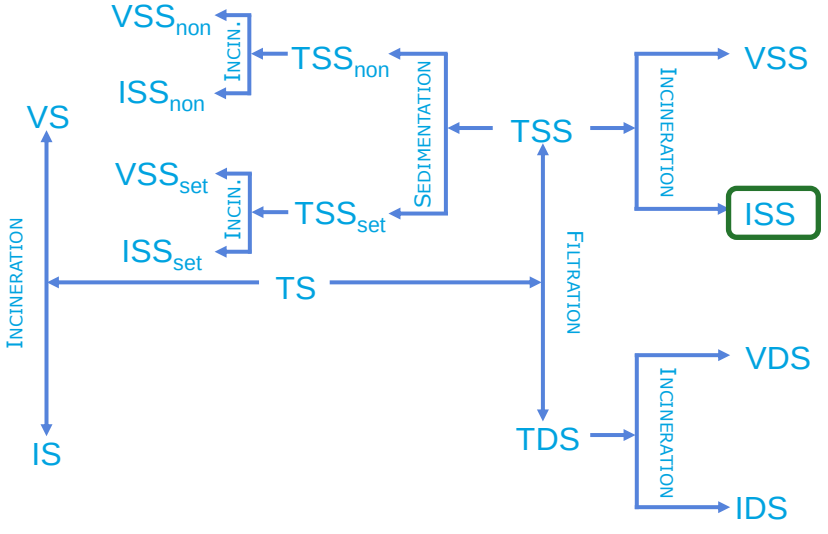
ISS Coming Down the Pipe at Us



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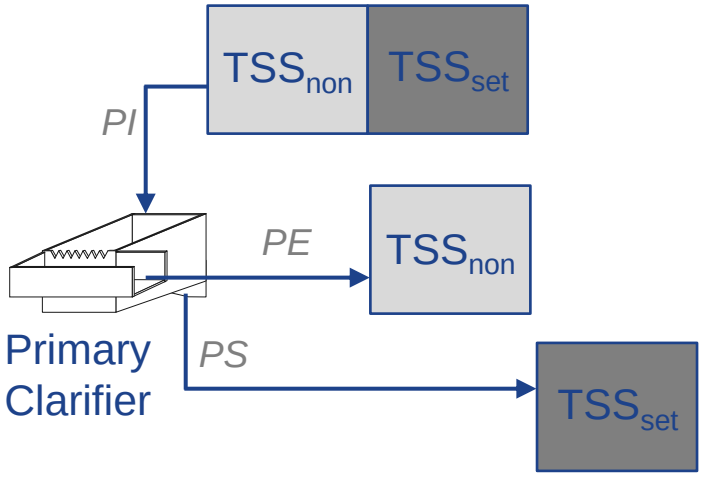
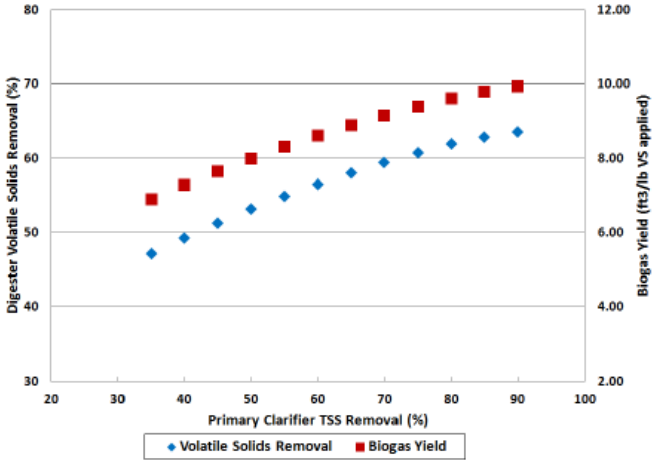
Remember the Influent Characteristics that Define Primary Clarifier Performance?



38

"Performance Strongly Influenced By:" Primary Clarifier TSS Removal Percent



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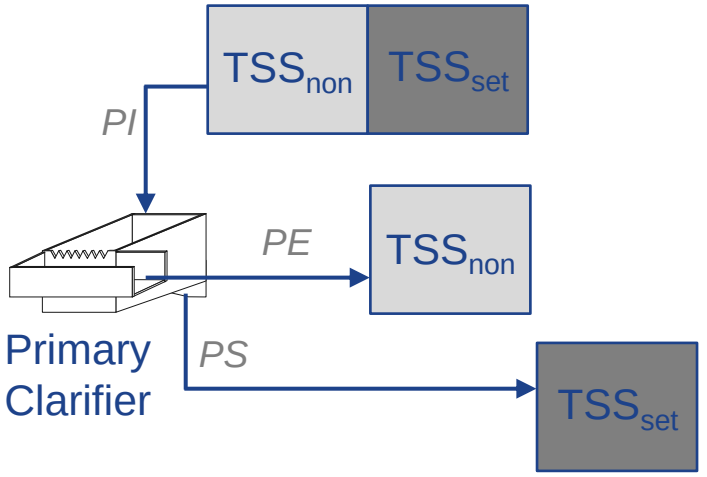
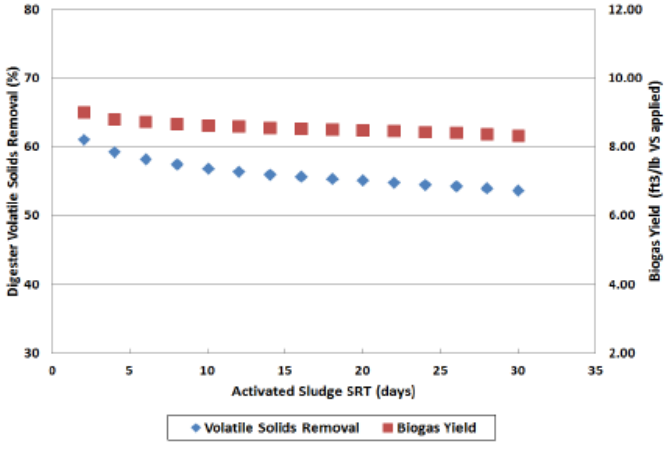
TSS Removal Fixed by TSS_{non} and TSS_{set} (Not Really in Our Control)



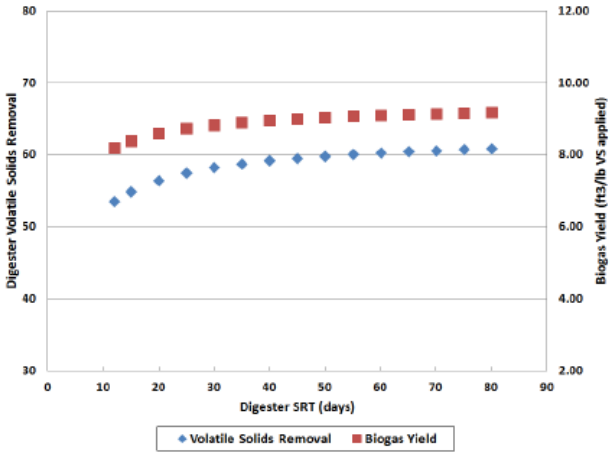
"Relatively Minor Impact:" Activated Sludge SRT



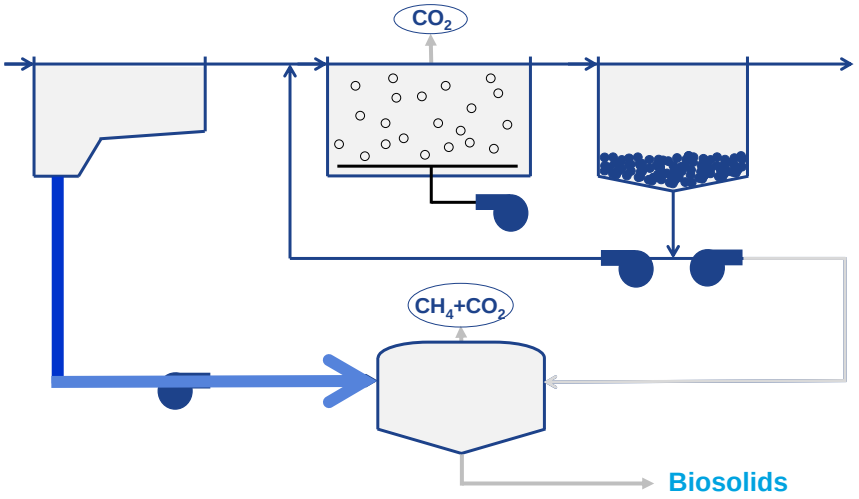
"However, Short SRT Results in Increased Gas Production"

1. **Effluent ammonia requirement**
2. **Best sludge quality**
3. **Minimum SRT_{TARGET} that will satisfy 1 and 2**

"Relatively Minor Impact:" Digester HRT (especially more than 25 days)

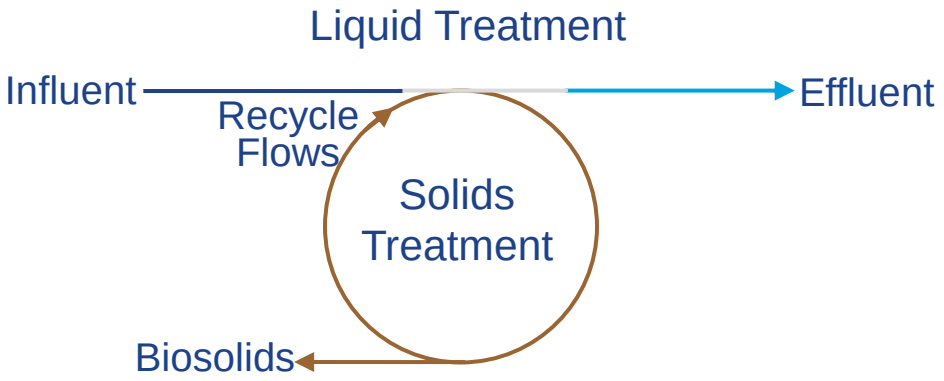


Least Cost Operation: Maximize VS_{PS}, Minimize VS_{WAS}



Look Inside and Outside (Upstream) to Optimize Digester Performance

A WWTP is Like a Manufacturing Plant



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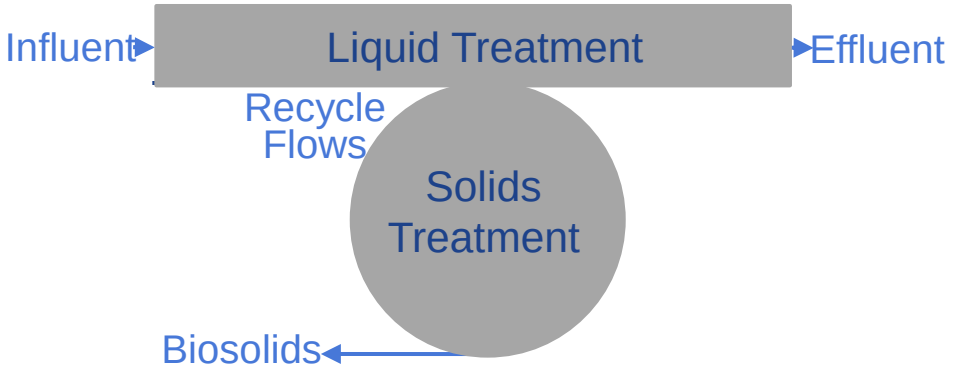
Treatment in Process Steps Each Dependent on Performance of Upstream Steps



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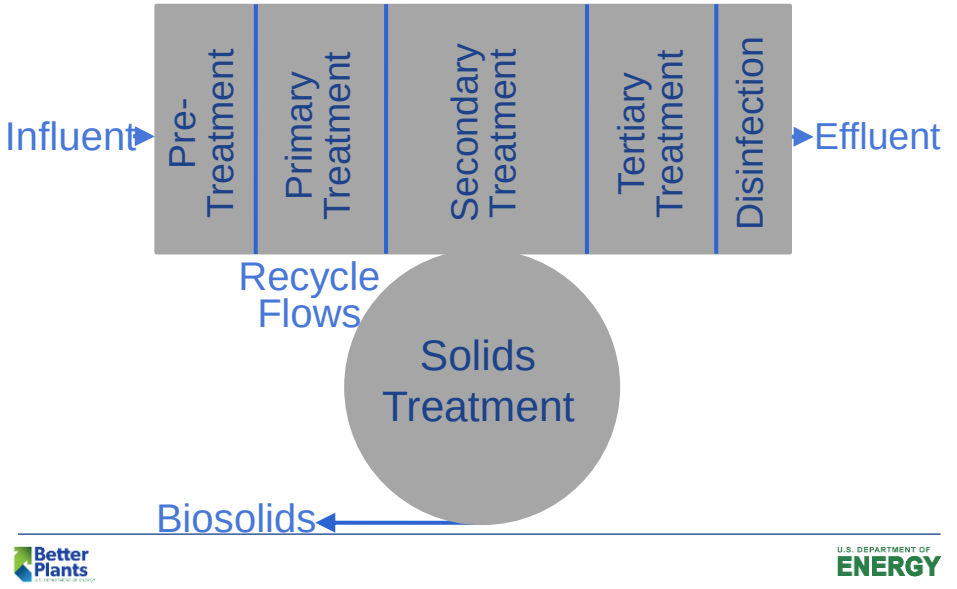
Liquid Treatment Train Broken Down Into Steps



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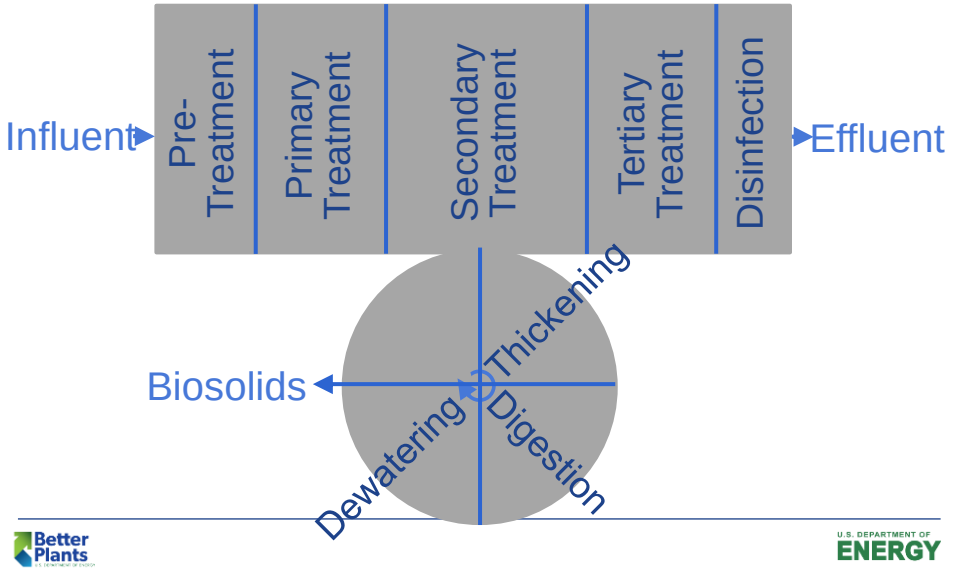
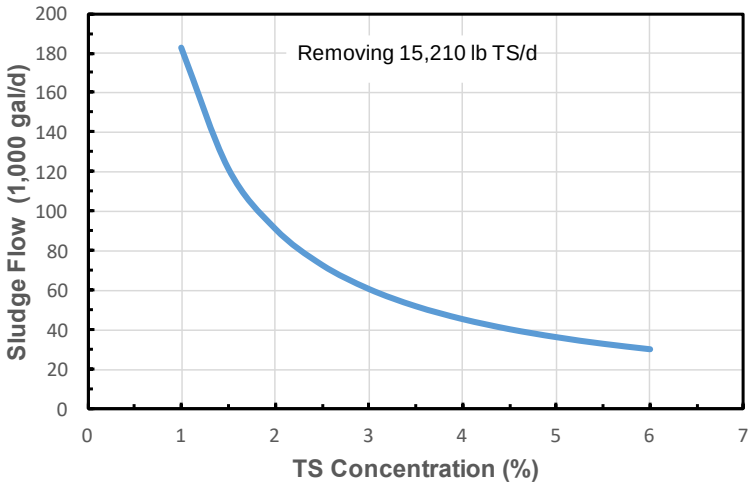
Solids Treatment Train as Well



49

Pumping:
Thickening is ABSOLUTELY Critical



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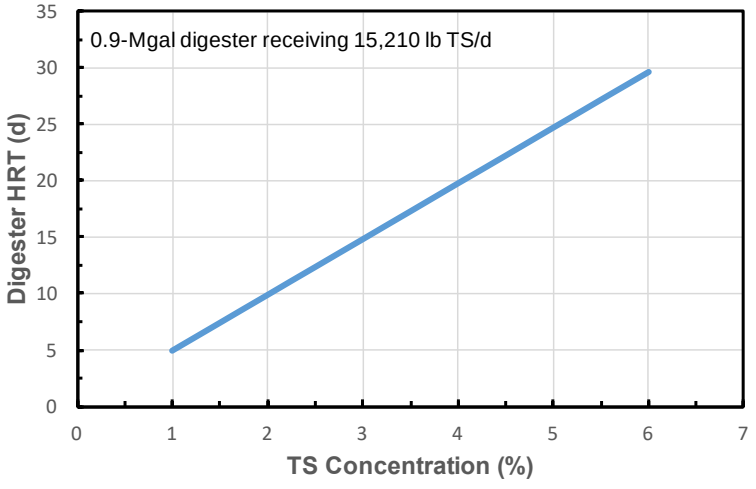
Detention Time:
Thickening is ABSOLUTELY Critical



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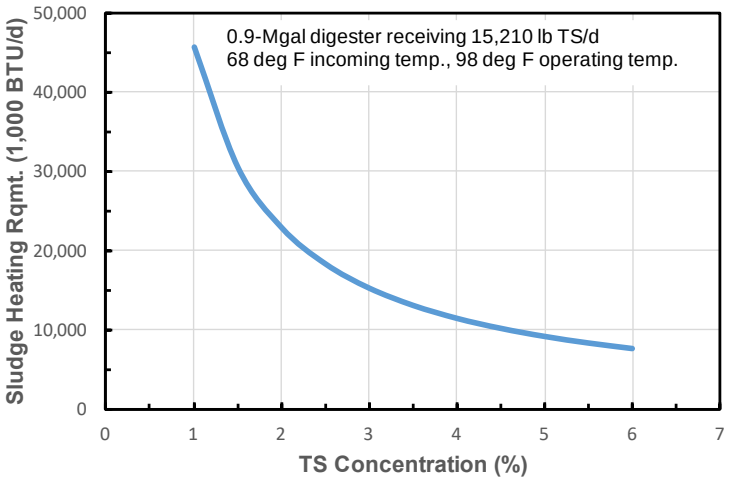
Heating Requirements: Thickening is ABSOLUTELY Critical



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Gravity Thickener

53

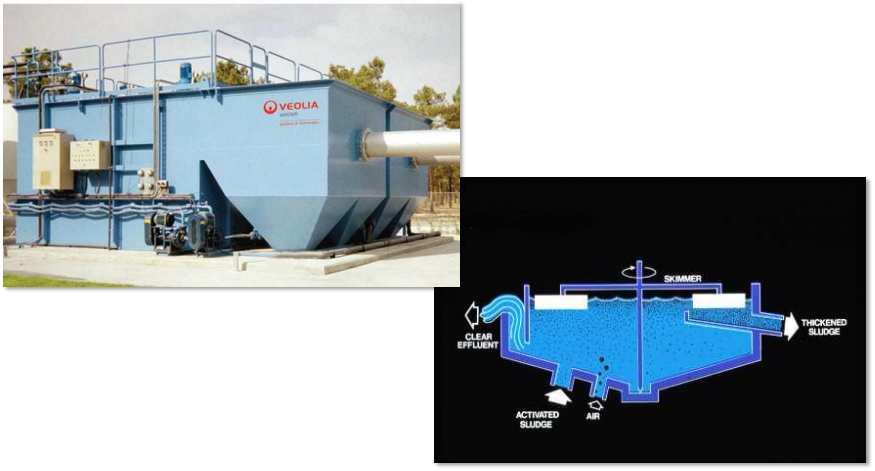
Gravity Belt Thickeners

54

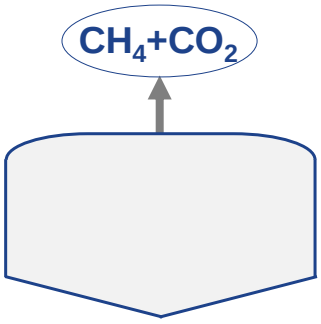
Rotating Drum Thickener

55

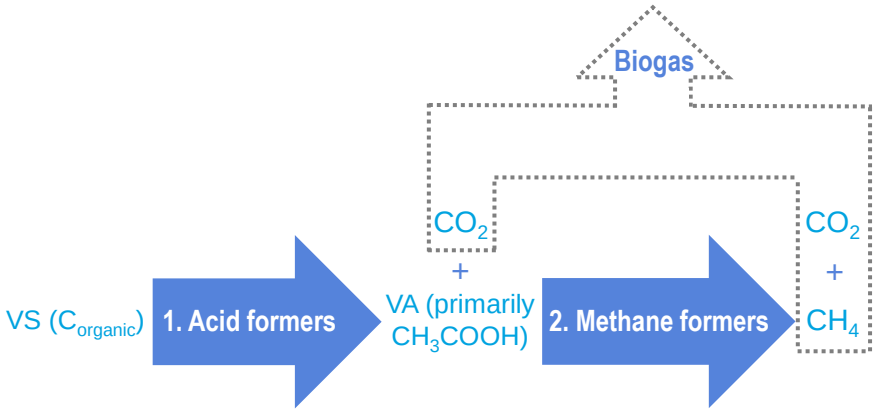
Dissolved Air Flotation Thickener



Past Performance is Not Indicative of Future Results



Microbiological Simplification Explains A Lot



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Three Words Capture Essence of Process Control Approach

1. **Stable**
2. **Consistent**
3. **Uniform**

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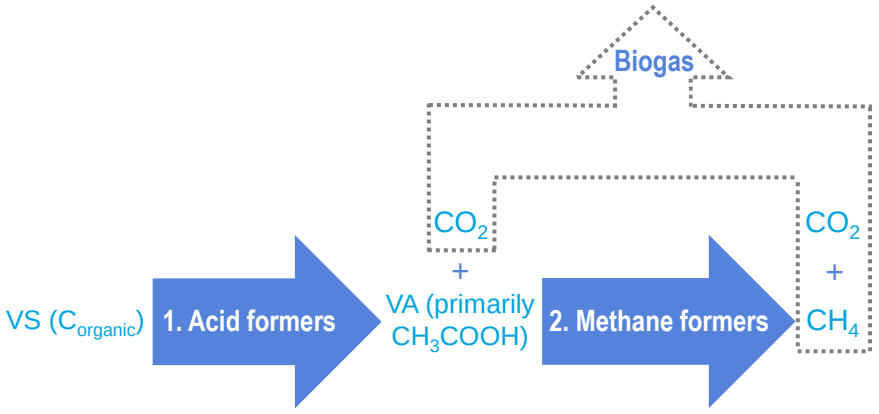
Objective of Process Control: Maintain Balance



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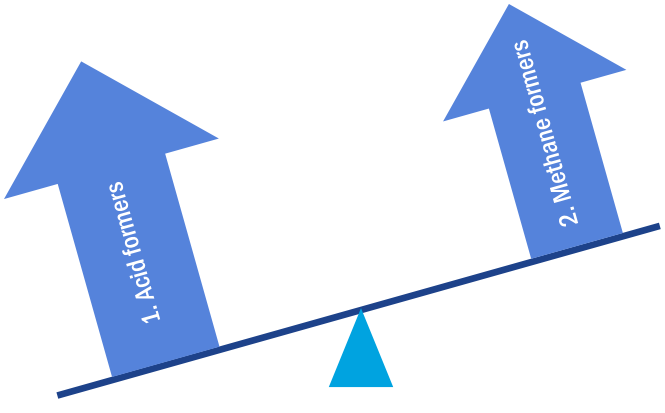
Objective of Process Control: Maintain Balance



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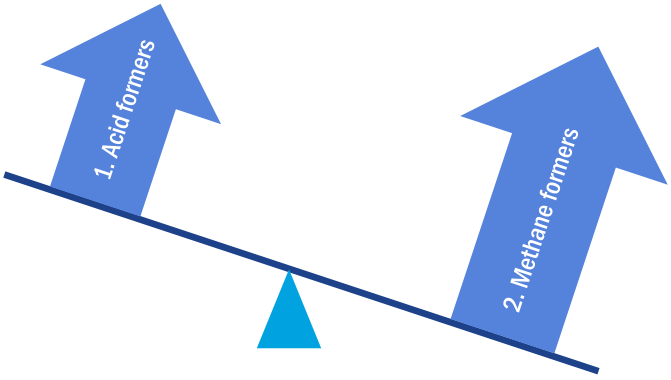
Objective of Process Control: Maintain Balance



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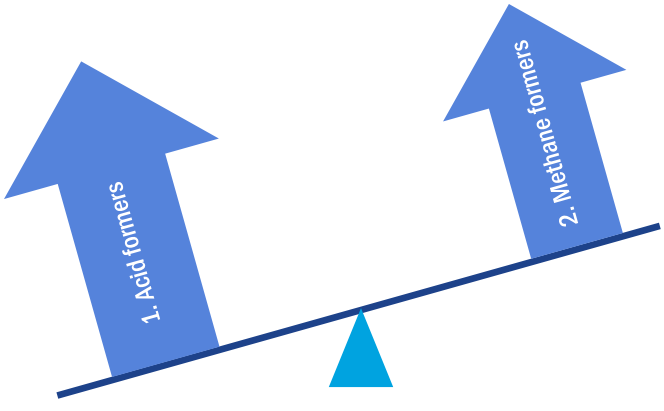
Objective of Process Control: Maintain Balance



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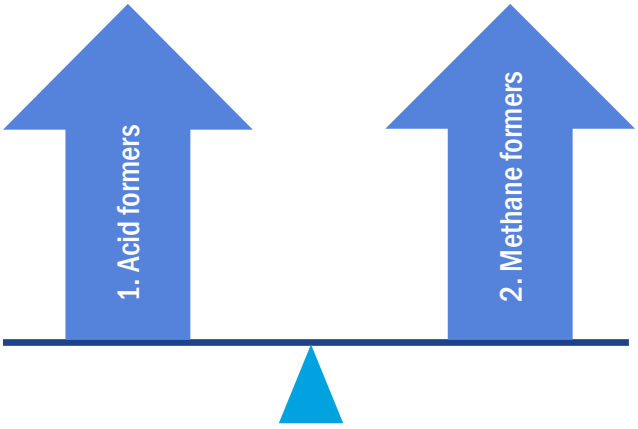
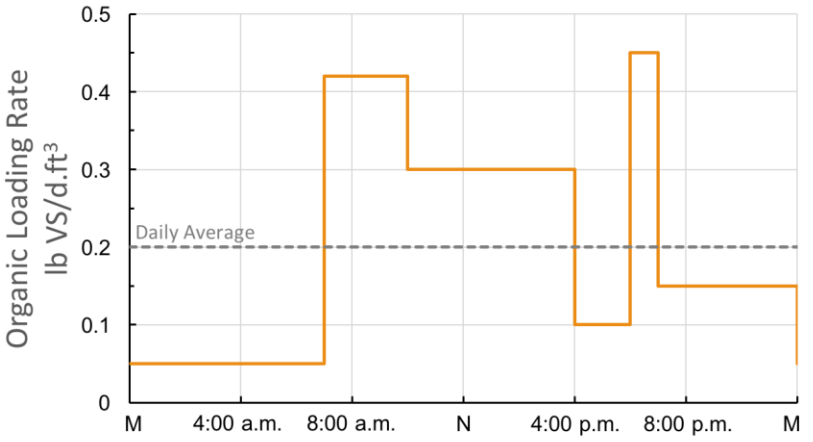
Objective of Process Control: Maintain Balance



Really Only Two Things in Operators' Control

1. **Organic loading**
2. **Temperature**

Loading Pattern Hits Target for Daily Average, But Not Consistent, Not Stable



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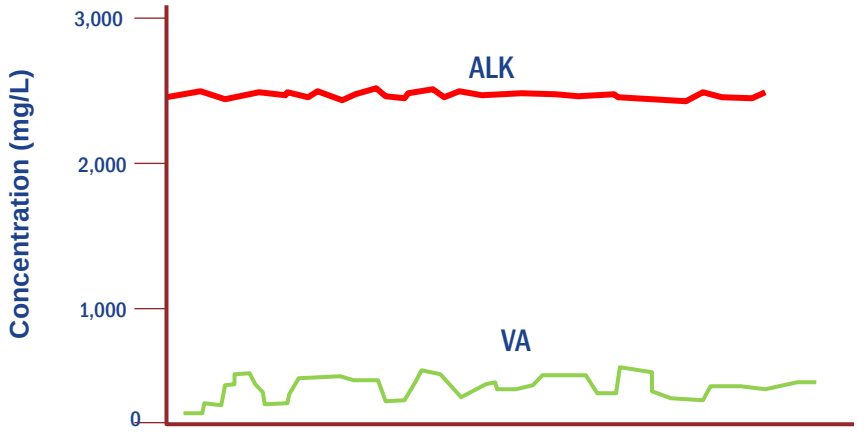
Forget About VA/ALK Ratio, Individual Trending Provides More Insight



Source: Schafer *et al.*, WEFTEC 2014

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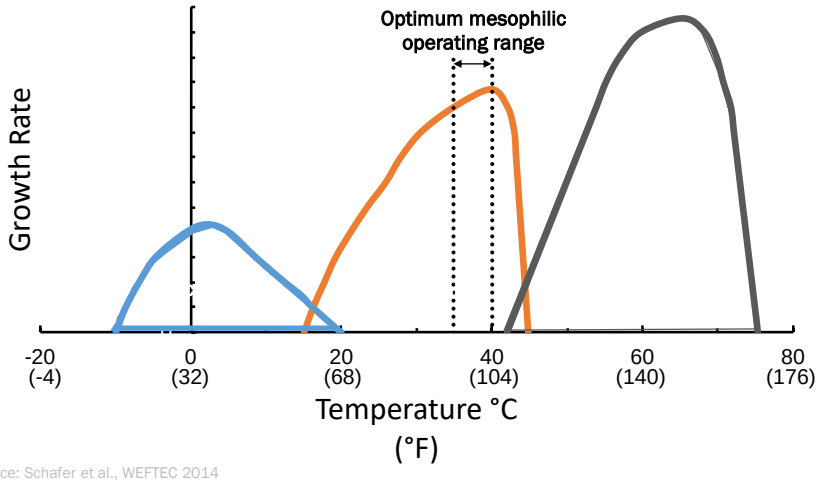
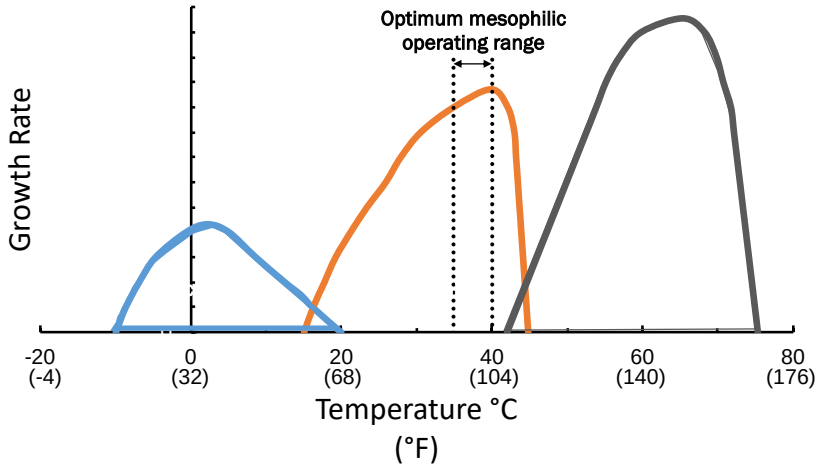
Stable, Consistent, and Uniform Temperature ABSOLUTELY Essential



Source: Schafer et al., WEFTEC 2014

Break until 8 after the hour

Stable, Consistent, Uniform Temperature Not Possible Without Good Mixing



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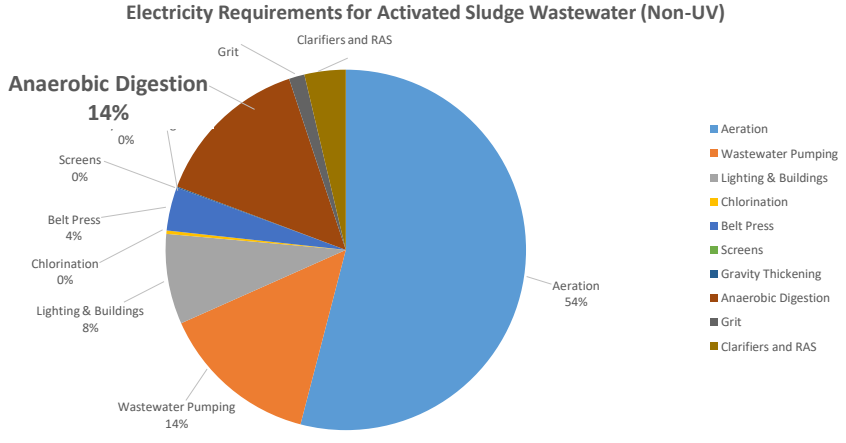
Anaerobic Digestion Electricity Use: Pumps and Lots of Head Loss



Derived from data from Focus On Energy WWOA 49th Annual Conference, October 7, 2015 presentation by Joseph Cantwell, PE

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Heat Exchangers, Heat Loops, Pump Mixing, and Spaghetti Bowls

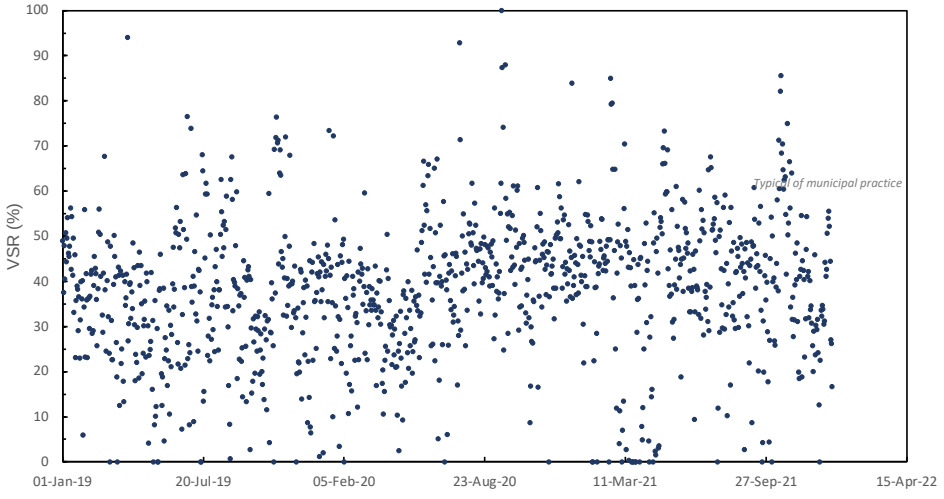
72

Anaerobic Digestion is Sooooo Important Performance Monitoring is Paramount

1. **VA concentration**
2. **Volatile solids reduction**
3. **Gas production per VS destroyed**
4. **Gas composition**

73

Such Poor Performance is Unbecoming an Operations Professional



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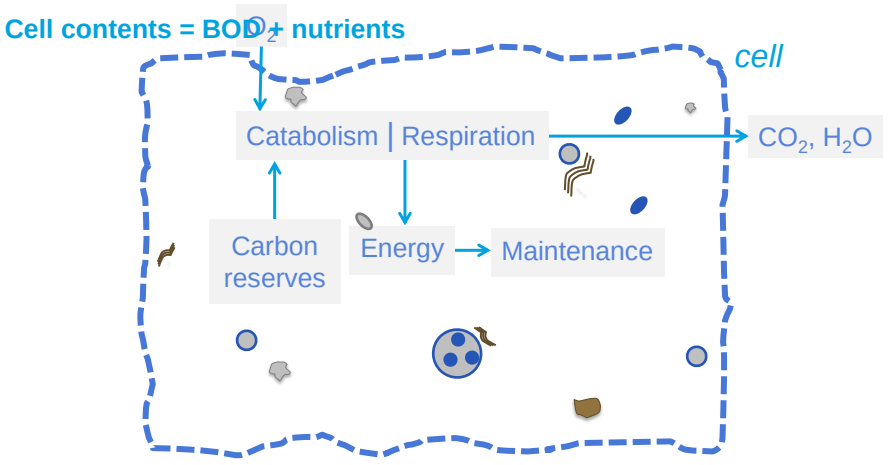
Aerobic Digestion

75

Depleted Carbon Reserves Leads to Cell Death, Cell Contents Substrate to Survivors



Aerobic Digestion

Basically an aeration tank with a LONG retention time.

Aerobic digestion is often only "slightly" aerobic – blowers are run by "nose" at small facilities.

Very coarse bubble diffusers are used – like ¼" holes drilled along the bottom of the air pipe.

Can be a good place to retrofit blowers.

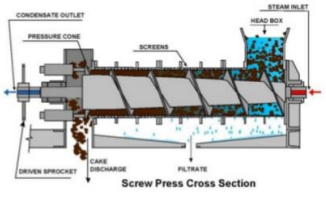
If your permit requires 38% reduction, is there a benefit to getting 45% or 50% reduction? What is the energy cost of that benefit? Other costs?

Nitrification unavoidable so denitrify (*mixed not aerated*) to lower aeration requirement and recover alkalinity

Dewatering Equipment Considerations

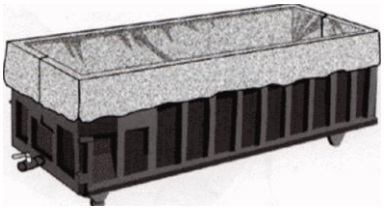
78

Lots of Ways to Skin This Cat



Screw Press Cross Section

Courtesy: FKC



Degremont Heliantis solar drier

Sludge Disposal is Third or Fourth Greatest Expense for Many Plants

Power Costs – dewatering, pumping, washing, odor control

Recycle Costs – return streams

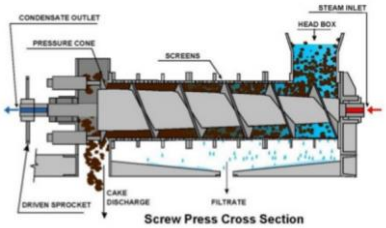
Disposal Costs – hauling and ultimate disposal

Polymer & Other Chemical Costs

Labor Costs

Maintenance Costs

Beware the Use of W3 Water in Thickening and Dewatering (it's not free)



Screw Press Cross Section

Courtesy: FKC

At Most Plants, Dewatering is a Batch Process

Opportunities to save when batch dewatering:

Does odor control run continuous?

Is building heating/cooling set to different temp at night than in day?

Can W3 water pressure be reduced because demand is reduced?

Would moving to longer run times eliminate a batch (and associated start-up/shut-down energy)?

Would shifting batch operation time of day reduce total plant electrical demand? Improve plant performance?

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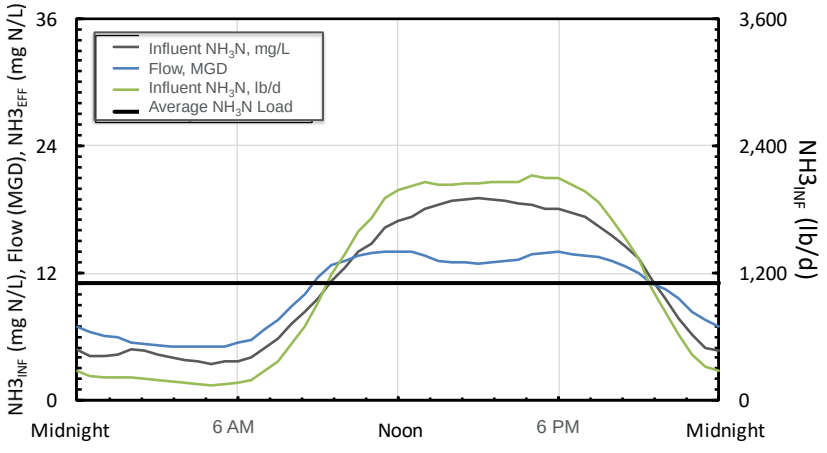
Diurnal Variation in Flow, NH_3-N Concentration, and NH_3-N Load



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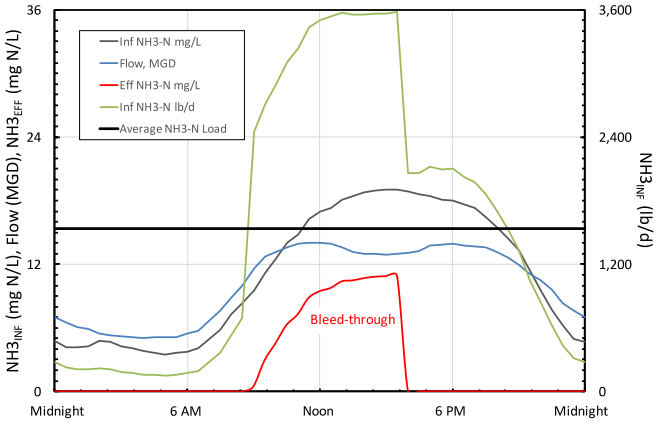
First-shift Dewatering Operation With No Return Equalization



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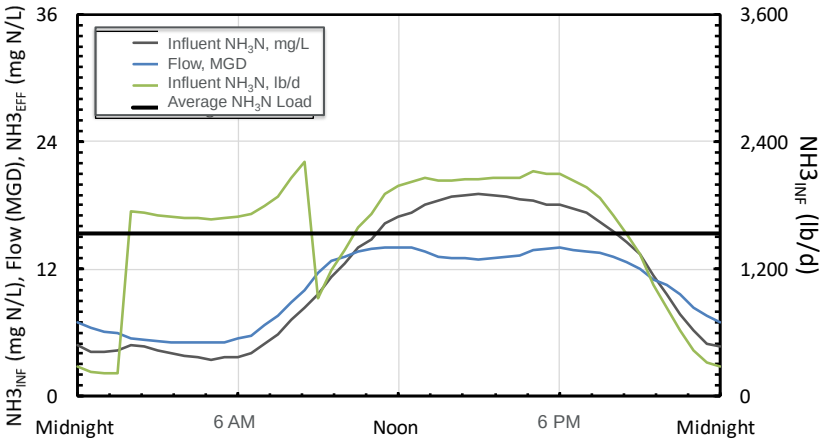
Dewatering in Early Morning Eliminates Bleed-Through



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Other Cost-saving Considerations

If you have a choice, what is the most efficient unit in the line-up?

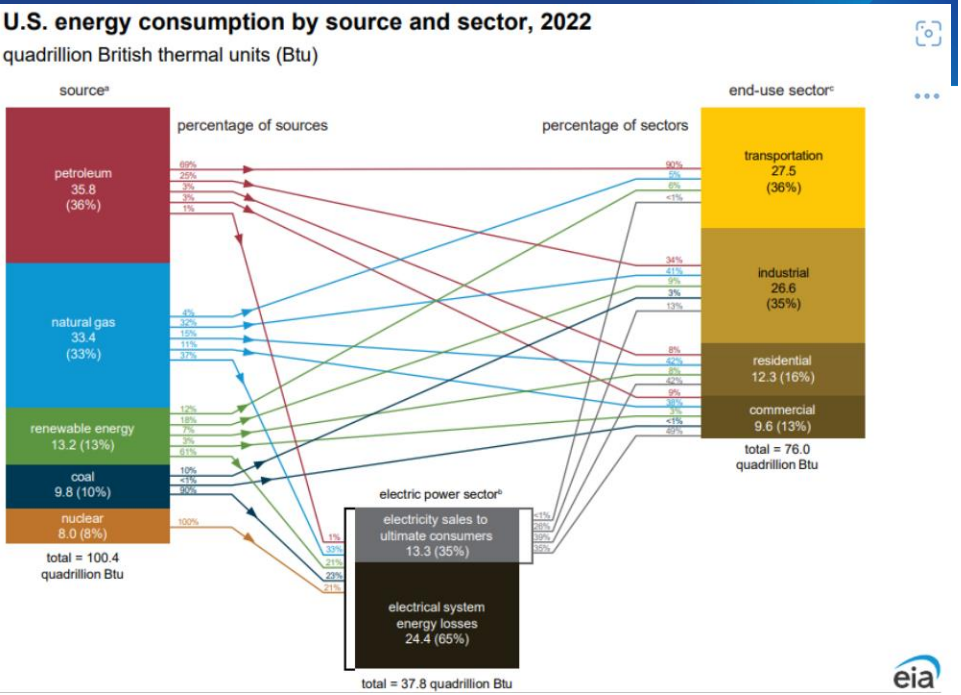
Are you only scrubbing "odorous air" or are you scrubbing entire building volume?

Does cake handling equipment run continuously or only as needed?

Energy, Carbon, and GHG Considerations

- Historical transition from “sewage plant” to “wastewater treatment plant” to “water resource recovery facility”
- WRRFs can and have become major players in the “New Energy Economy”
- New Energy Economy???

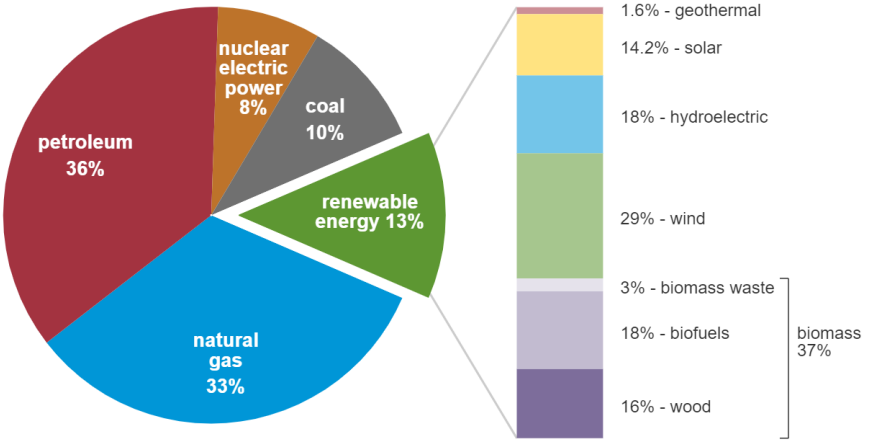
https://www.eia.gov/energyexplained/us-energy-facts/images/consumption-by-source-and-sector.pdf



https://www.eia.gov/energyexplained/us-energy-facts/

U.S. primary energy consumption by energy source, 2022

total = 100.41 quadrillion British thermal units (Btu)



Data source: U.S. Energy Information Administration, *Monthly Energy Review*, Table 1.3 and 10.1, April 2023, preliminary data
Note: Sum of components may not equal 100% because of independent rounding.

90

Energy, Carbon, and GHG Considerations

- Historical transition from “sewage plant” to “wastewater treatment plant” to “water resource recovery facility”
- WRRFs can and will become major players in the New Energy Economy
- WRRF as Community Energy Plant?

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91

Scrubbed Biogas to Electricity

https://www.tpomag.com/editorial/2016/08/california_plant_boots_biogas_and_heads_twoard_net_zero_energy

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92

Scrubbed Biogas to Pipeline

https://webcms.pima.gov/cms/One.aspx?pageId=806426

County, Southwest Gas project converts wastewater gas into clean-burning methane

Oct 22, 2021 | Read More News

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Pima County Regional Wastewater Reclamation Department, in partnership with Southwest Gas, will start delivering clean-burning renewable natural gas made from biogas, a byproduct of wastewater treatment, to homes and businesses throughout the community.

County officials and Southwest Gas held a dedication ceremony Oct. 21 to mark the opening of the Tres Ríos Renewable Gas Center biogas cleaning facility. This site will produce 552,000 cubic feet of 99-percent pure renewable natural gas each day and patch it directly into the Southwest Gas conveyance system bringing major benefits to our environment and taxpayers.

"By finding a way to utilize a waste product and further the County's sustainability goals, this innovative project exemplifies the commitment and forward-thinking of our Pima County departments," Pima County Board of Supervisors Chair Sharon Bronson said.

than processes that produce diesel and gasoline.

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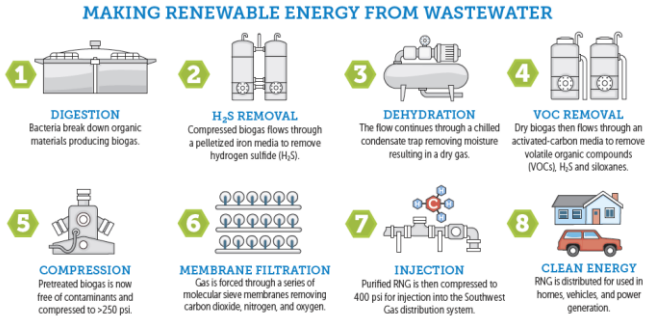
93

Scrubbed Biogas to Pipeline

https://webcms.pima.gov/cms/One.aspx?pageId=806426



- The daily production of RNG at Tres Rios is the equivalent of: 4,358 gallons of diesel and gasoline each day or 1.59 million gallons per year.
- As a clean-burning, renewable fuel source RNG:
  Emits 30 percent less carbon dioxide than diesel or gasoline
  Emits 50 percent less carbon dioxide than coal when burned for power generation.
  RNG produced at wastewater treatment facilities emits 95 percent less carbon emissions than processes that produce diesel and gasoline.

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94

Transportation Energy

Scrubbed, compressed biogas for fleet fueling operations.

https://www.longmontcolorado.gov/departments/departments-n-z/water/wastewater-treatment/biogas-renewable-natural-gas

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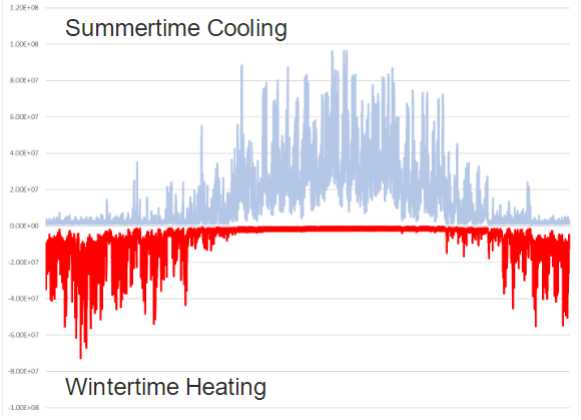
95

Thermal Energy

- Wastewater as heat source / heat sink:



From Jim McQuarrie, PE

One Water Innovation Lead at Tetra Tech

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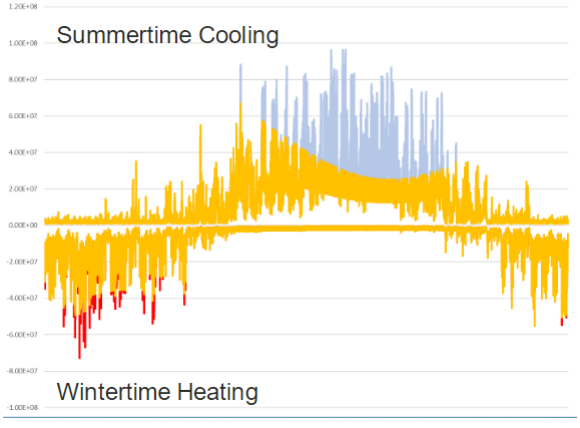
96

Thermal Energy

- Wastewater as heat source / heat sink:



Meets 70% of the cooling load

94% of the heating load

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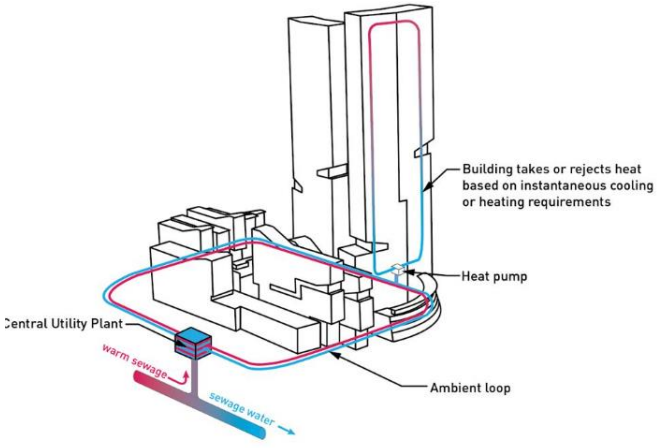
97

Thermal Energy

- District Energy System:



Building heat pumps used for heating and cooling

The interceptor provides the thermal source

Host Site (or Organization) for Solar

Municipal Authority of Westmoreland County, PA
3 MW (grid scale)

Sprague, CT
137 kW
(plant scale)

Floating Solar

https://www.northbaybusinessjournal.com/article/news/healdsburg-debuts-biggest-floating-solar-farm-in-nation

Healdsburg, CA 4.8 MW (grid scale)

On-site Wind

Credit: Mary Murphy, The Providence Journal

Narragansett Bay Commission, Fields Point WWTP

Providence, RI

Equalization for Load Shift / Load Shed

https://en.wikipedia.org/wiki/File:Wastewater_equalization_tank,_West_Park,_Nashville,Tennessee.jpg

102

Energy, Carbon, and GHG Considerations

Does this change our emphasis on Energy Efficient operations?

NO!

Power plants focus on reducing the "house load" – this is the energy consumed by the power plant itself that can't be sold to others.

Might it change the way we design and operate plants?

Likely yes!

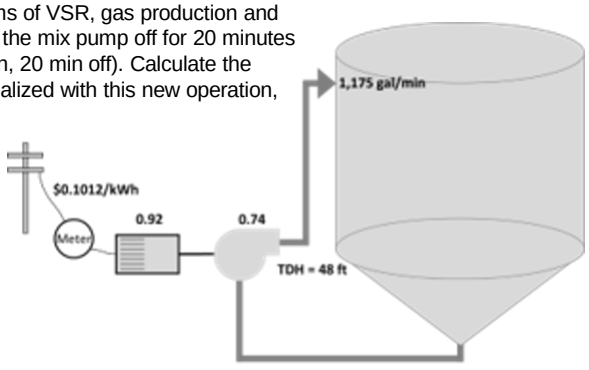
If a plant is now part of the supply chain or grid, operations & management will have to reflect that.

103

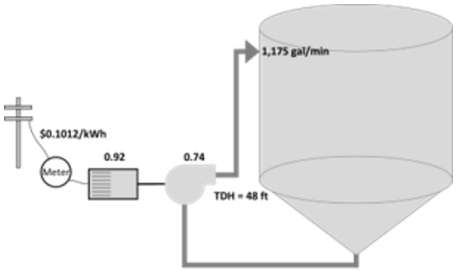
A Sample Opportunity……..

The anaerobic digester mix pump continuously pumps 1,175 gal/min against a total dynamic head of 48 ft. From the manufacturer's literature, the pump is 74% efficient and the motor is 92% efficient. The average cost of electricity is $0.1012/kWh. The CPO conducted a study that found no deterioration in performance—measured in terms of VSR, gas production and gas composition—when turning the mix pump off for 20 minutes every 30 minutes (i.e., 10 min on, 20 min off). Calculate the annual electrical cost savings realized with this new operation, ignoring demand charges.

Given:
Pumping rate, Q = 1,175 gal/min
TDH = 48 ft
Motor efficiency = 92% = 0.92
Pump efficiency = 74% = 0.74
Old operation = 24 h/d
New operation = 10 min/30 min
Cost of electricity = $0.1012/kWh



Answer:



Given:
Pumping rate, Q = 1,175 gal/min
TDH = 48 ft
Motor efficiency = 92% = 0.92
Pump efficiency = 74% = 0.74
Old operation = 24 h/d
New operation = 10 min/30 min
Cost of electricity = $0.1012/kWh

1. **Estimate kW:**
   kW = BHP * 0.746
   BHP = (Q * TDH)/(3960 * Eff_{Pump})

   BHP = (1,175 *48)/(3960*0.74)
   = 19.25 HP

   kW = (BHP * 0.746)/Eff_{motor}
   kW = (19.25*0.746)/.92 = **15.6 kW**

2. **Estimate Hours of operation**
   Old = **8760 hours/year**
   New =10min/30min = 1/3 of the time
   = 8760/3 = **2,920 hours/year**

3. **Estimate Savings:**
   kWh/year = kW * hours/year
   Savings = kWh_{old} – kWh_{new}
   kWh_{old} = 8760 * 15.6 = 136,737 kWh/year
   kWh_{new}= 2920 * 15.6 = 45,552 kWh/year

   kWh Savings = 136,737 – 45,552 = 91,185 kWh/year
   $$ Savings = 91,185 kWh/year * $0.1012/kWh
   = $9,227.92

For Our Last Session:

- Find 5 opportunities and fill out your Opportunity Register.
- Be prepared to report out on 1 or 2 of your opportunities.
- Use the PP template that is sent to you, to describe 1 of your opportunities.
- MAKE THIS SIMPLE. PROJECT DESCRIPTION & SAVINGS

Closing

See You Next Week