Digesting POTW Residuals and Maximizing CHP Recovery

2010 IWEA Annual Conference
Indianapolis, IN

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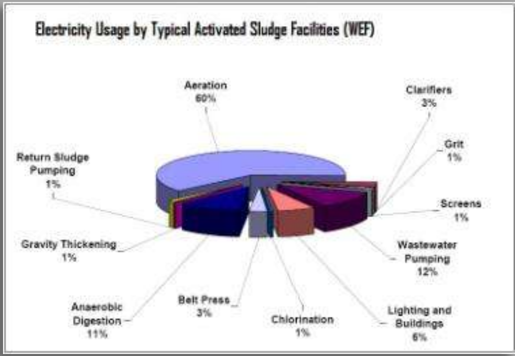

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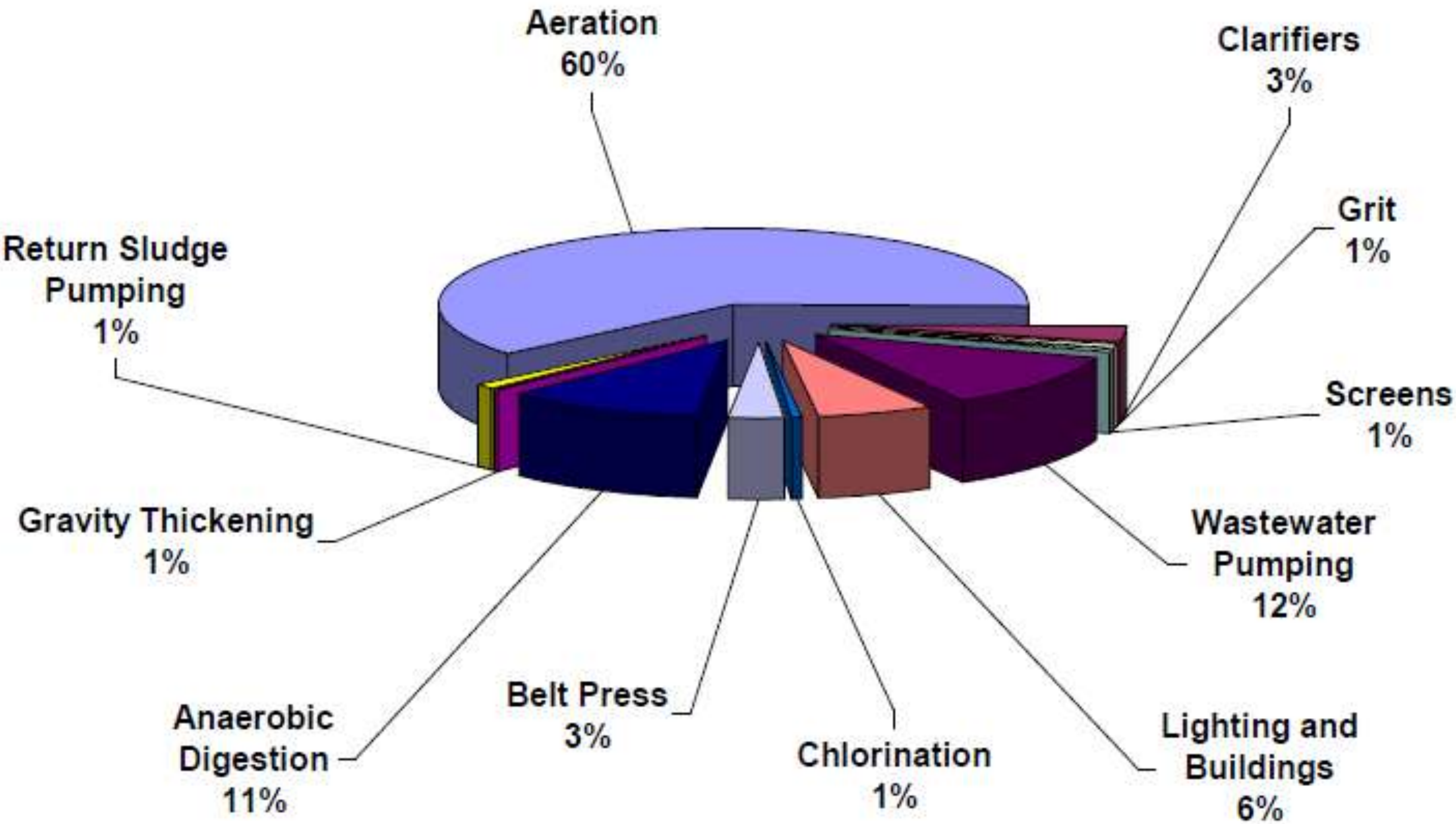
Presentation Overview

- Energy Used in Treating Wastewater
- Turning WW Organics into Energy and Other Products
- Production of Biogas
- Enhancing Gas Production
- Combined Heat and Power
  - ✓ Gas Cleanup
  - ✓ Power Production
  - ✓ Heat Recovery

Electricity Requirement for Typical Activated Sludge Facilities



Resource Centers Convert Wastes into Valuable Products

Wastewater

Water Reuse

Energy

Beneficial Use

- **Nutrients**
- **Water**
- **Organics to build soil**

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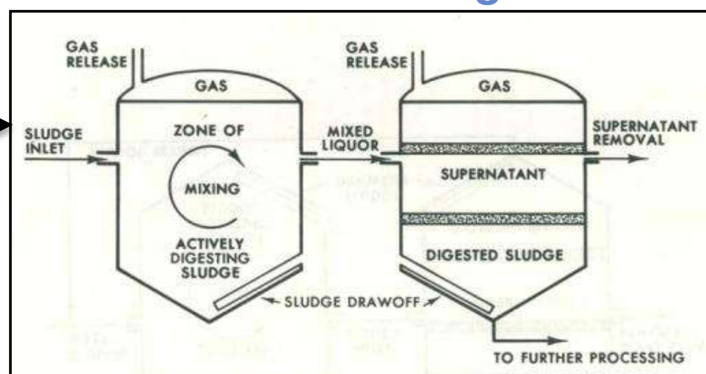
Utilize Materials in Wastewater to Create Valuable Products like Energy

Transformation Like Anaerobic Digestion

Organics in Wastewater

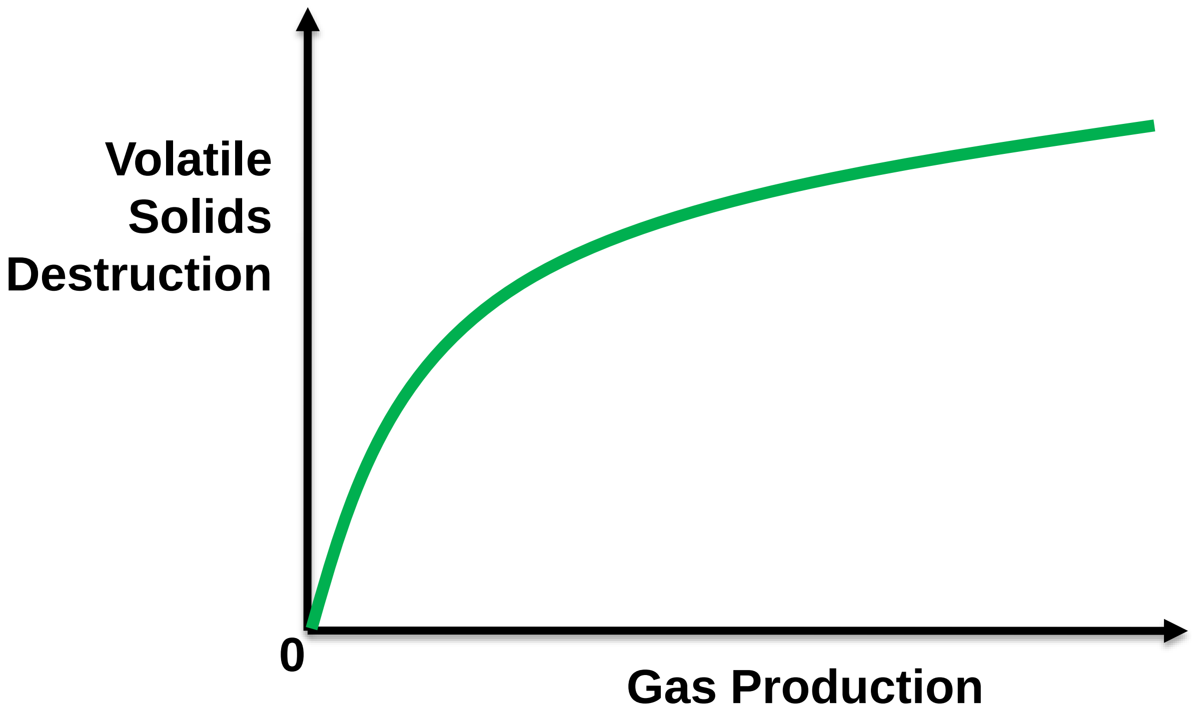


Energy

- Biogas
- Other Product

Biosolids for Beneficial Use

Relationship Between the Organics in Wastewater / Residuals and Biogas



12 cf gas/lb VS consumed

600 BTUs/cf gas

Requirements for Anaerobic Digestion

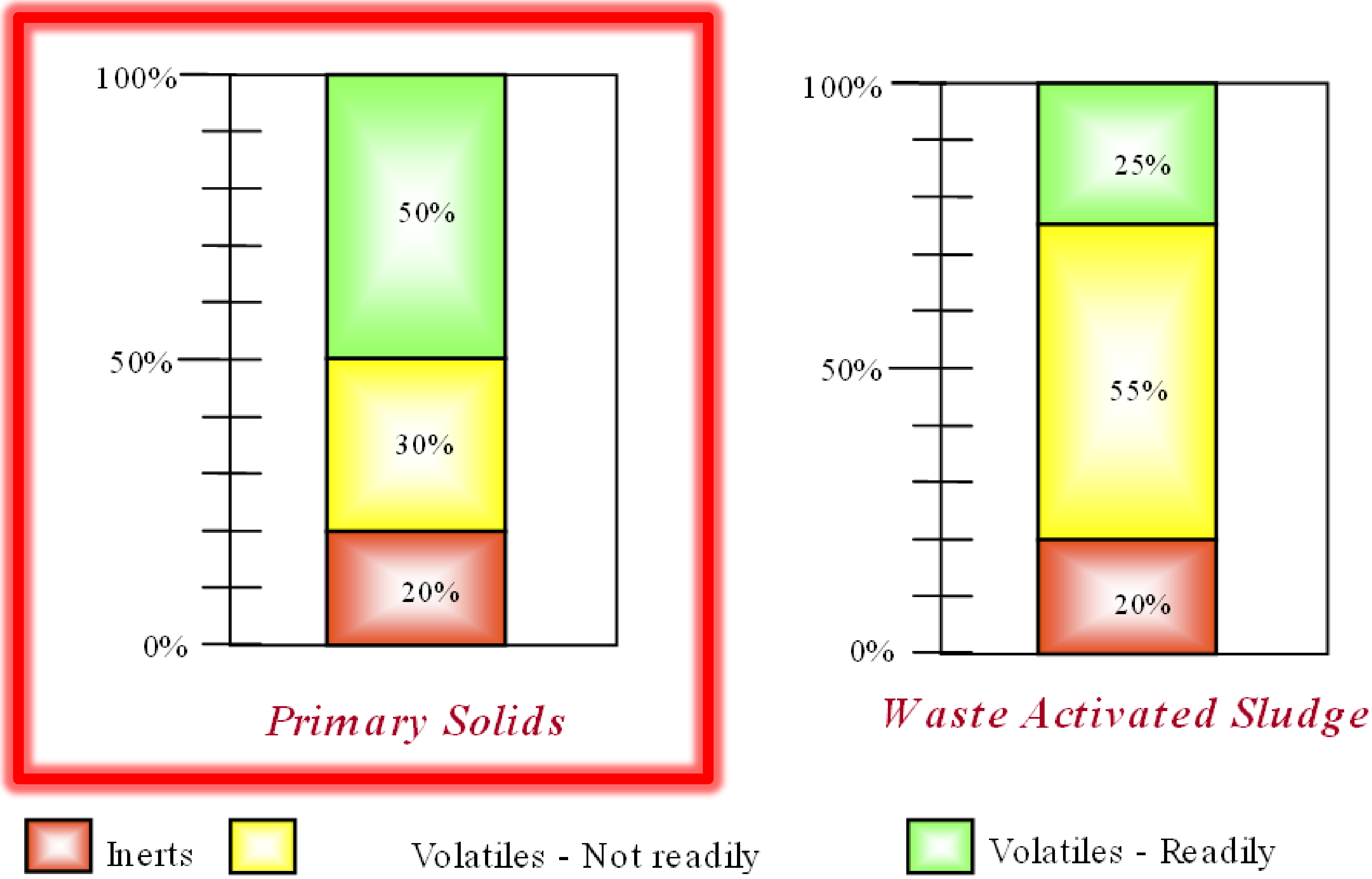
Process Conditions

- temperature
- retention time
- organic loading rates
- chemical environment (pH, volatile fatty acids, ammonia, etc.)

Feedstock

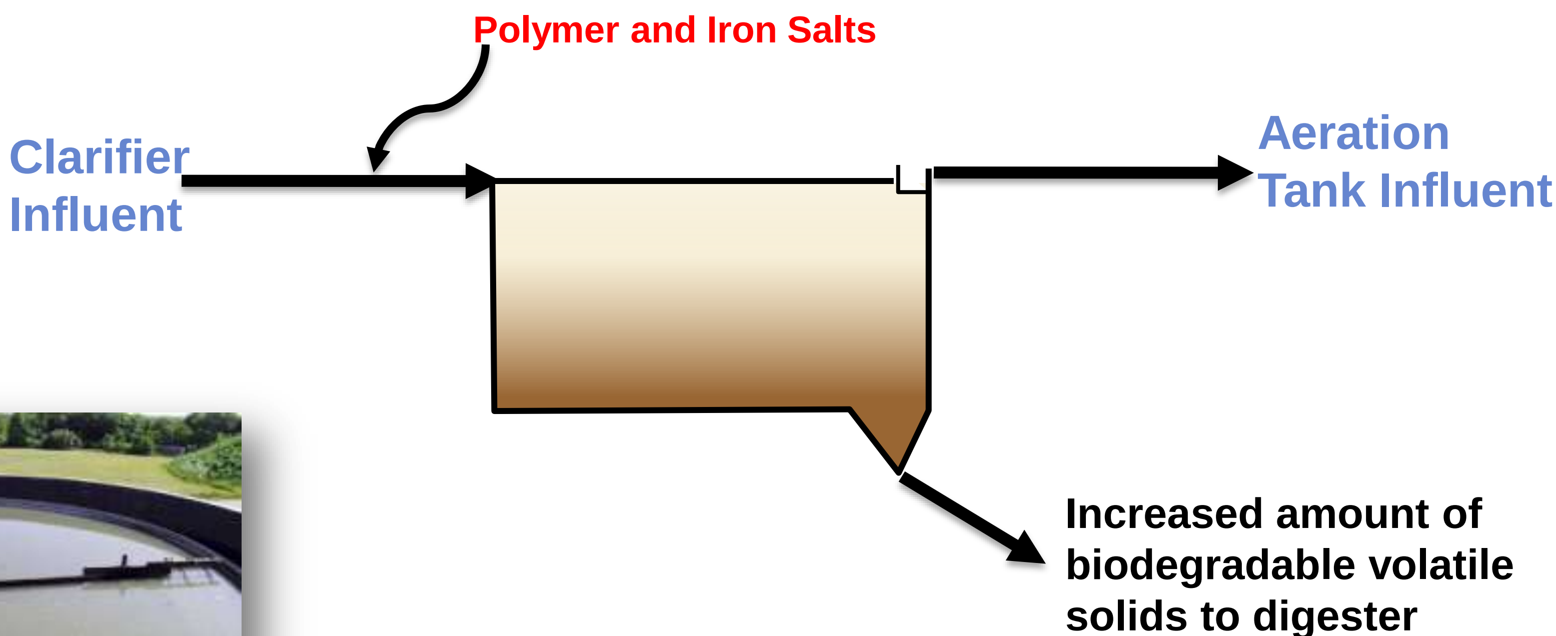
- biodegradability
- moisture content and particle size
- C/N ratio
- presence of inhibitory or toxic compounds

Composition of Raw Primary and Waste Activated Sludge Solids



Enhance Primary Clarification

- Polymer addition
- Get other benefits (p-removal)



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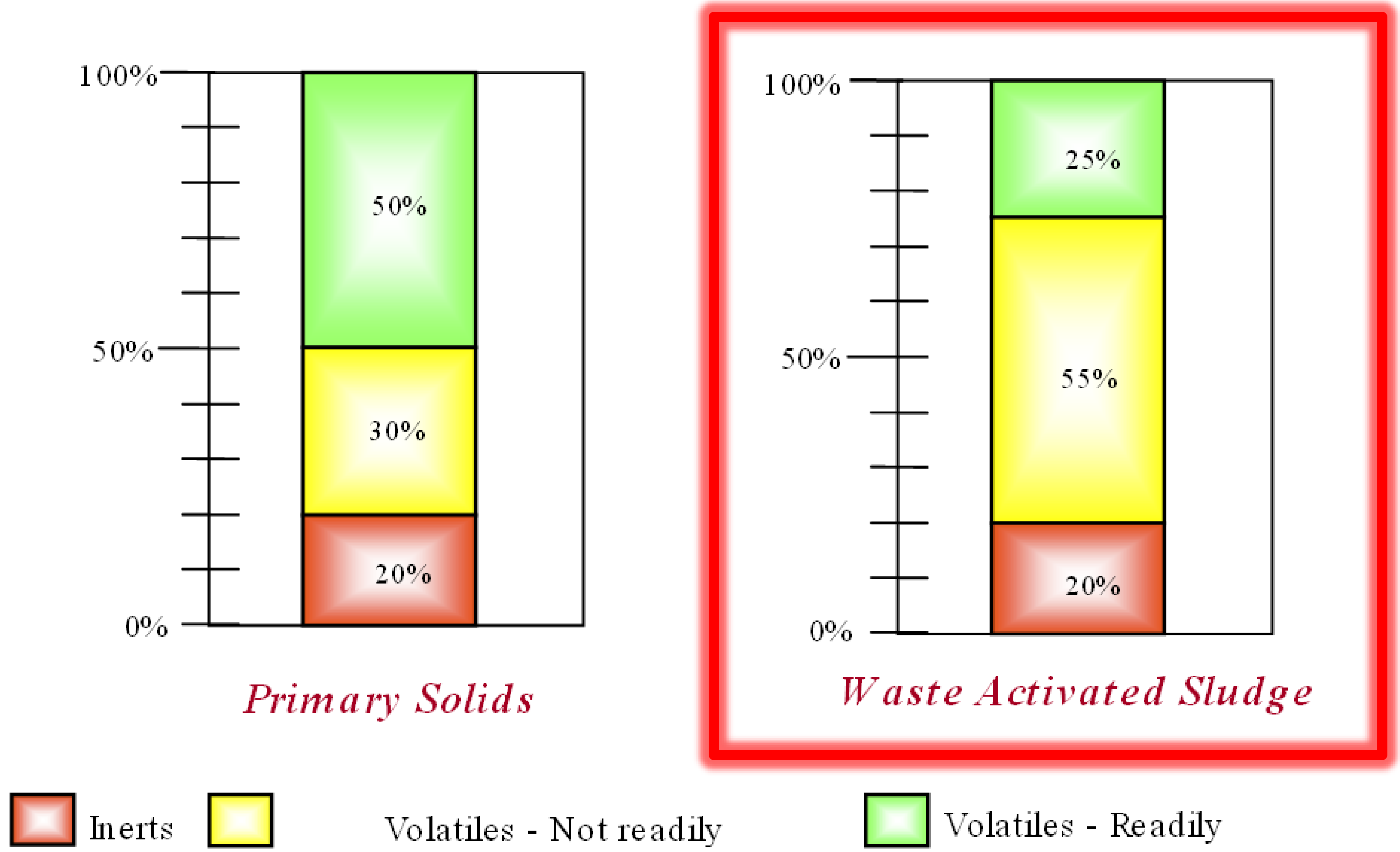
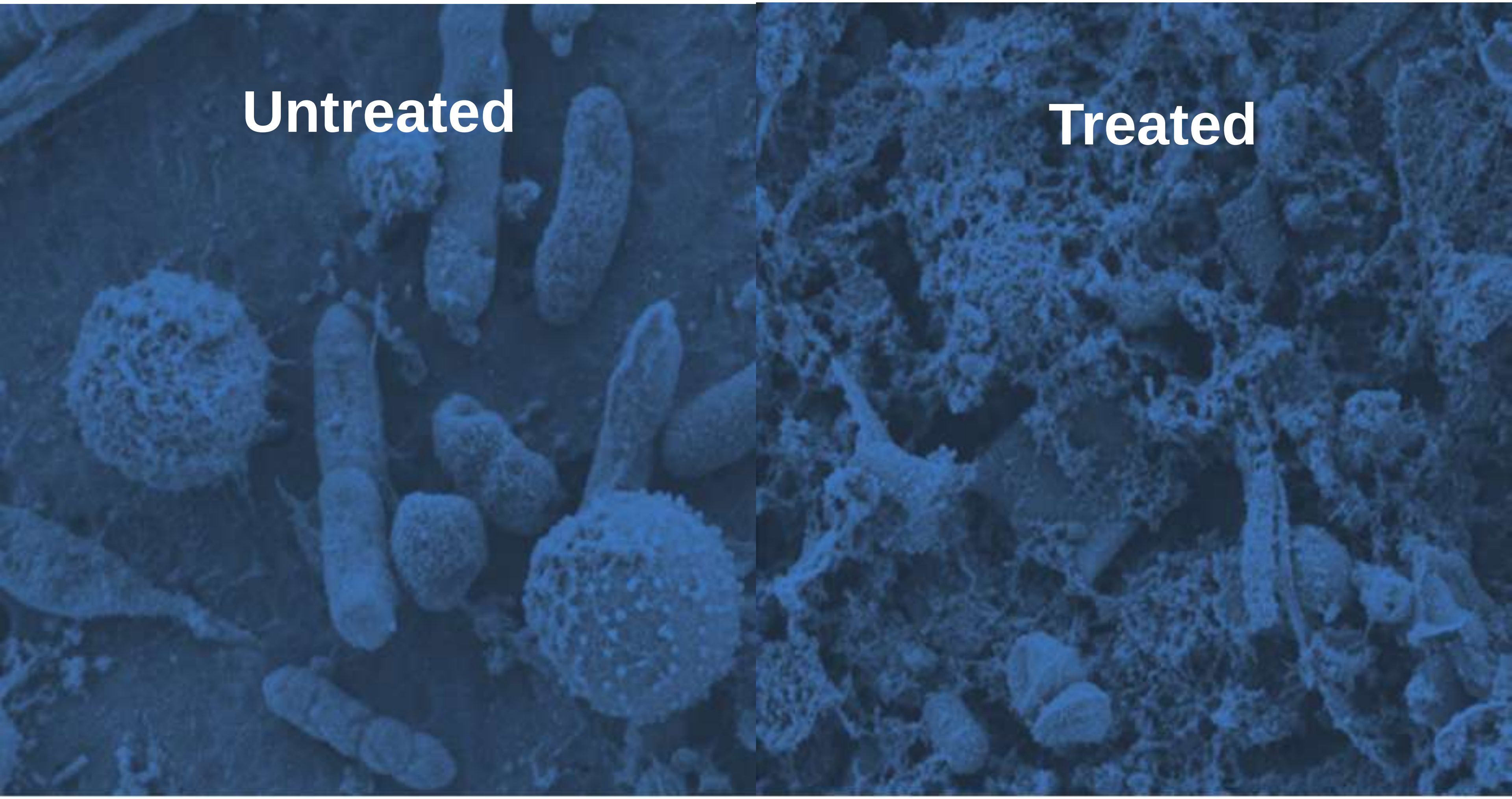
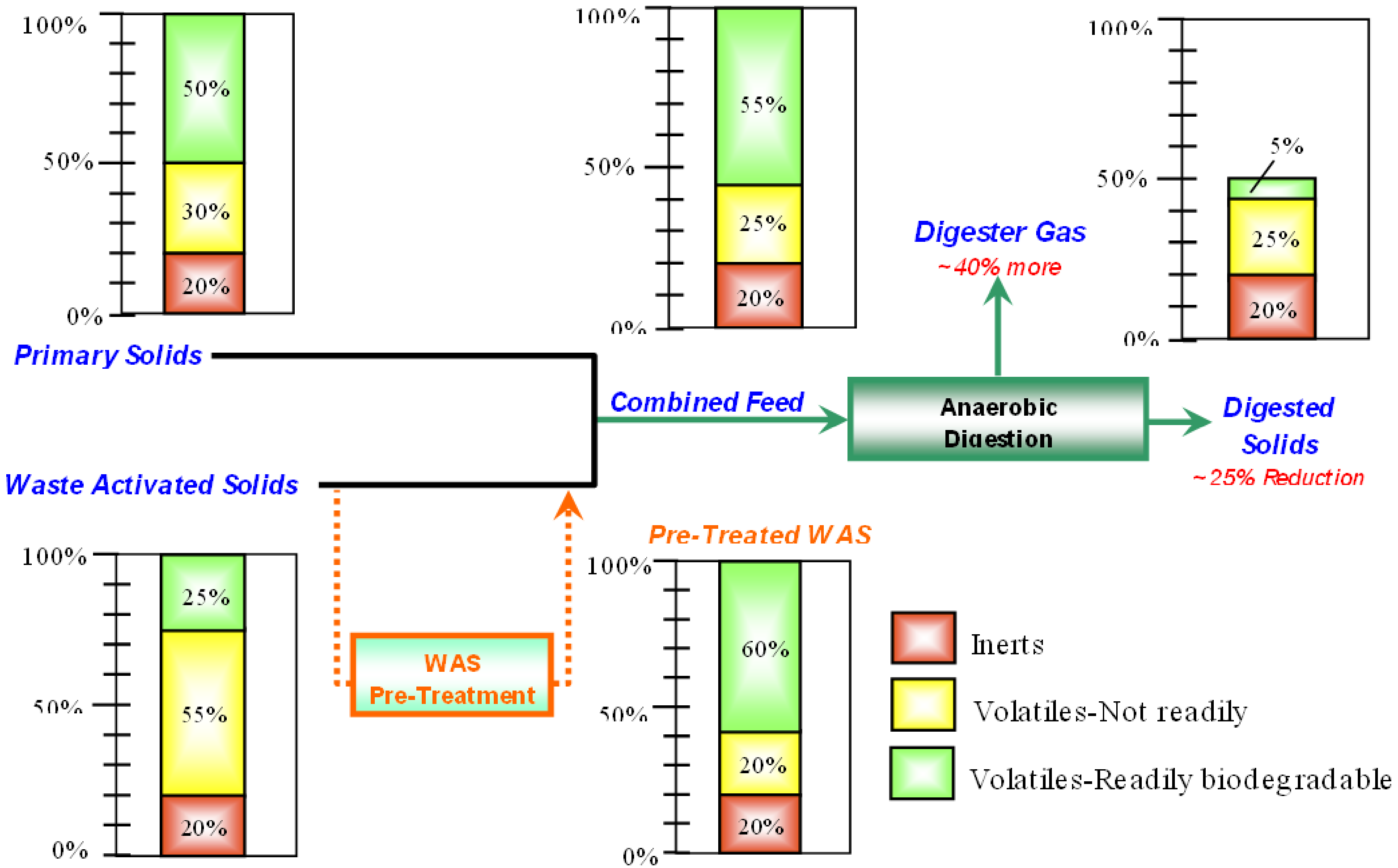


Can Waste Activated Sludge Be Made More Biodegradable?



Effect of Waste Activated Sludge Pretreatment on Biodegradation



Processes for Pre-Treating WAS

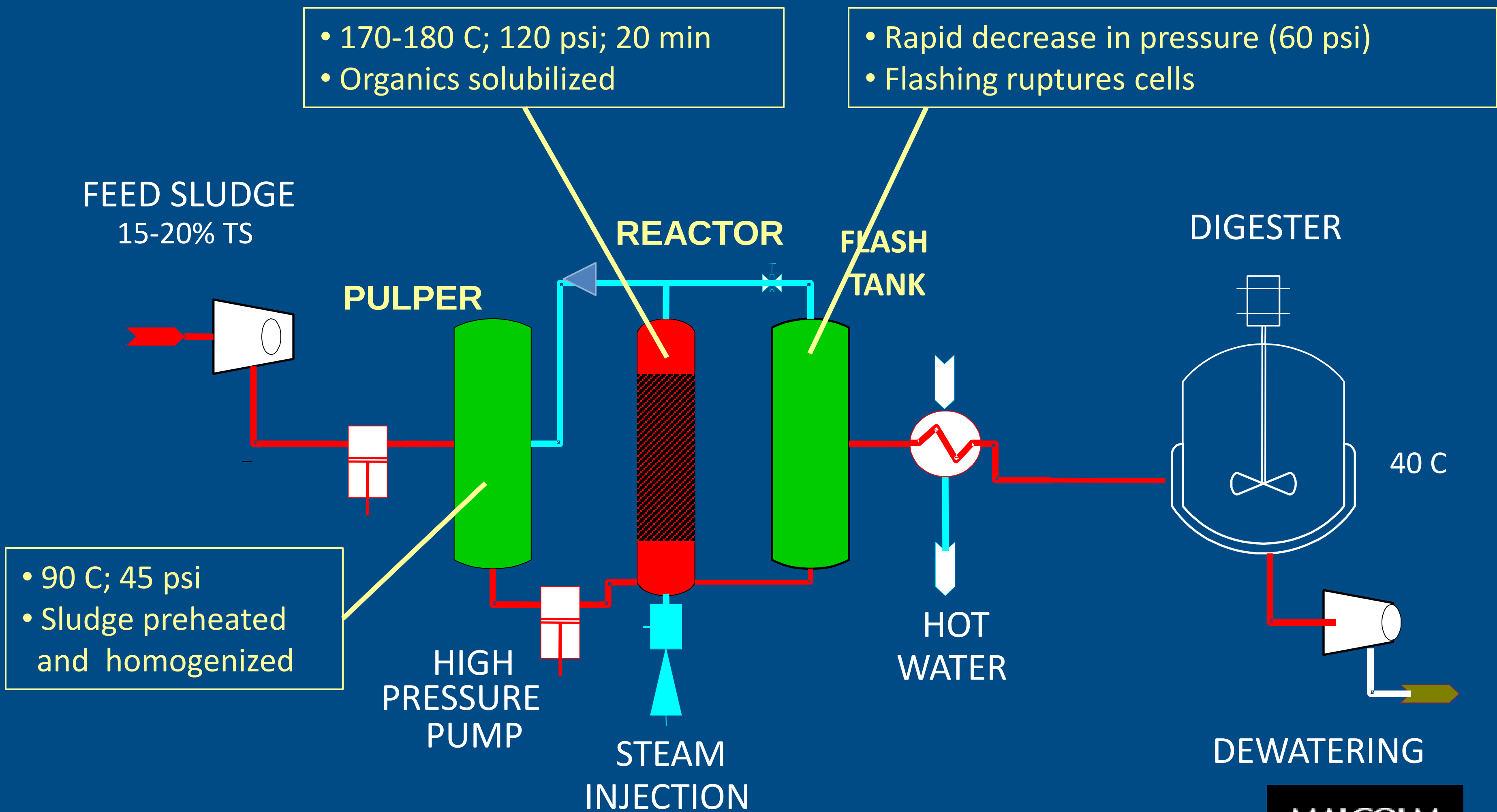
- Thermal hydrolysis
  - ✓ Cambi (13 installations)
  - ✓ Veolia (3 installations)
- Pressure release
  - ✓ Crown Biogest (17 installations)
- Electrical
  - ✓ OpenCEL (1 installation)

Cambi

Crown

OpenCEL

Thermal Hydrolysis (Cambi)



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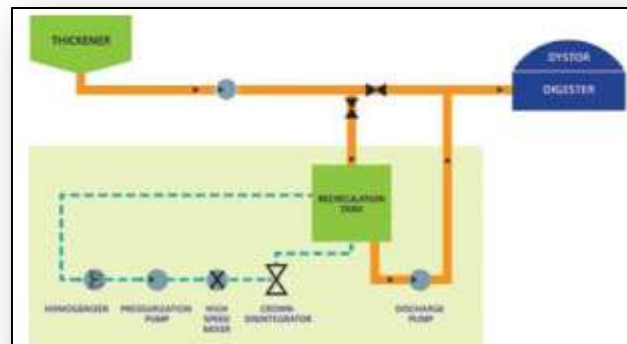
CAMBI's Performance Claims

Parameter	Mesophilic AD	CAMBI + Meso AD
Digester Feed (%TS)	4 – 6	12 – 15
VSLR (kg VS/m^3/d)	1.5	3.5
VS Destruction (%)	40 – 55	55 – 65
Pathogen Content	Class B	Class A
Dewatered Cake TS (%)	20 – 25	30 - 35

Sludge Disintegration Processes

- Macerate sludge to homogenize
- Increase pressure (12 Bar) with PC pump
- High pressure mixer, flow into disintegration nozzle
- As the flow exits the nozzle, cavitation occurs rupturing cell structure
- Sludge can be passed through system three times before discharge to the digesters

Crown Disintegrator
Wiesbaden WWTP - 60m3/hr



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Pressure Release

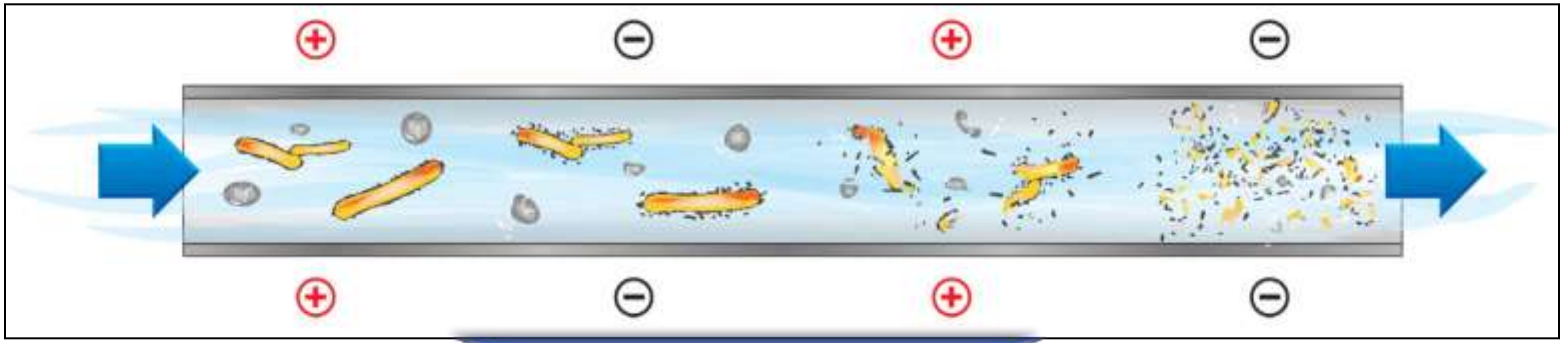
Vendor Claims:

- Minimum 20% increase in biogas production
- Minimum 15% reduction in dehydrated sludge volume
- Carbon augmentation for BNR

Performance Data by Crown

Site Name	VSr %			Biogas production cf/lb VS des		
	Before	After	% inc	Before	After	% inc
Wiesbaden Biebrich	32%	38%	20.0%	25.1	24.7	-1.7%
Taunusstein	32%	44%	38.9%	22.6	20.8	-7.8%
Ingelheim	36%	49%	34.1%	17.0	17.7	4.4%
Ginsheim	45%	54%	19.9%	14.7	14.3	-3.1%
Münchwilen	32%	43%	32.0%	20.2	19.1	-5.3%
Rosedale WWTP	51%	62%	21.6%	18.2	17.9	-1.8%
Average	**38.1%**	**48.3%**	**27.7%**	**19.6**	**19.1**	**-2.6%**

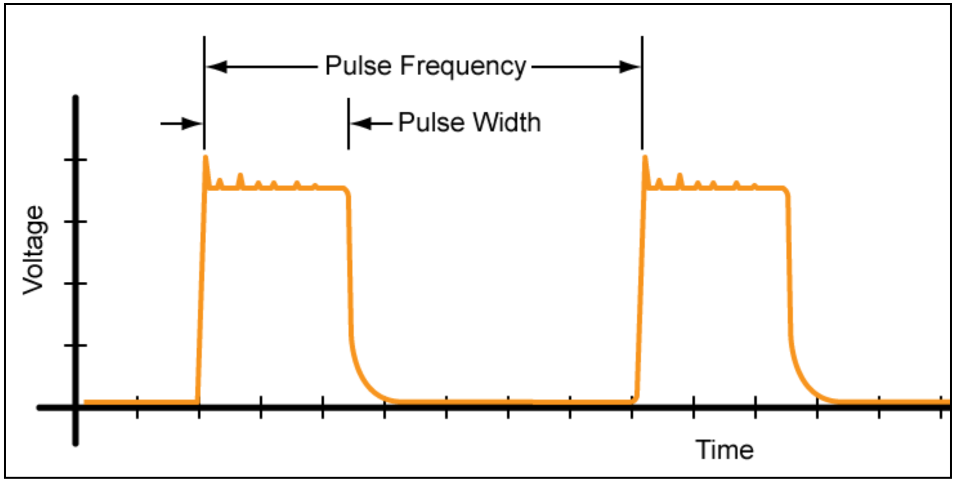
Pulsed Electric Field
How it Works



Key operating parameters

Field Strength	Pulse Duration	Pulse Interval
15 to 100 kV/cm	2 to 15 μs	2 to 10 kHz

Mono or bipolar pulse



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Full-Scale Installation in Mesa, AZ

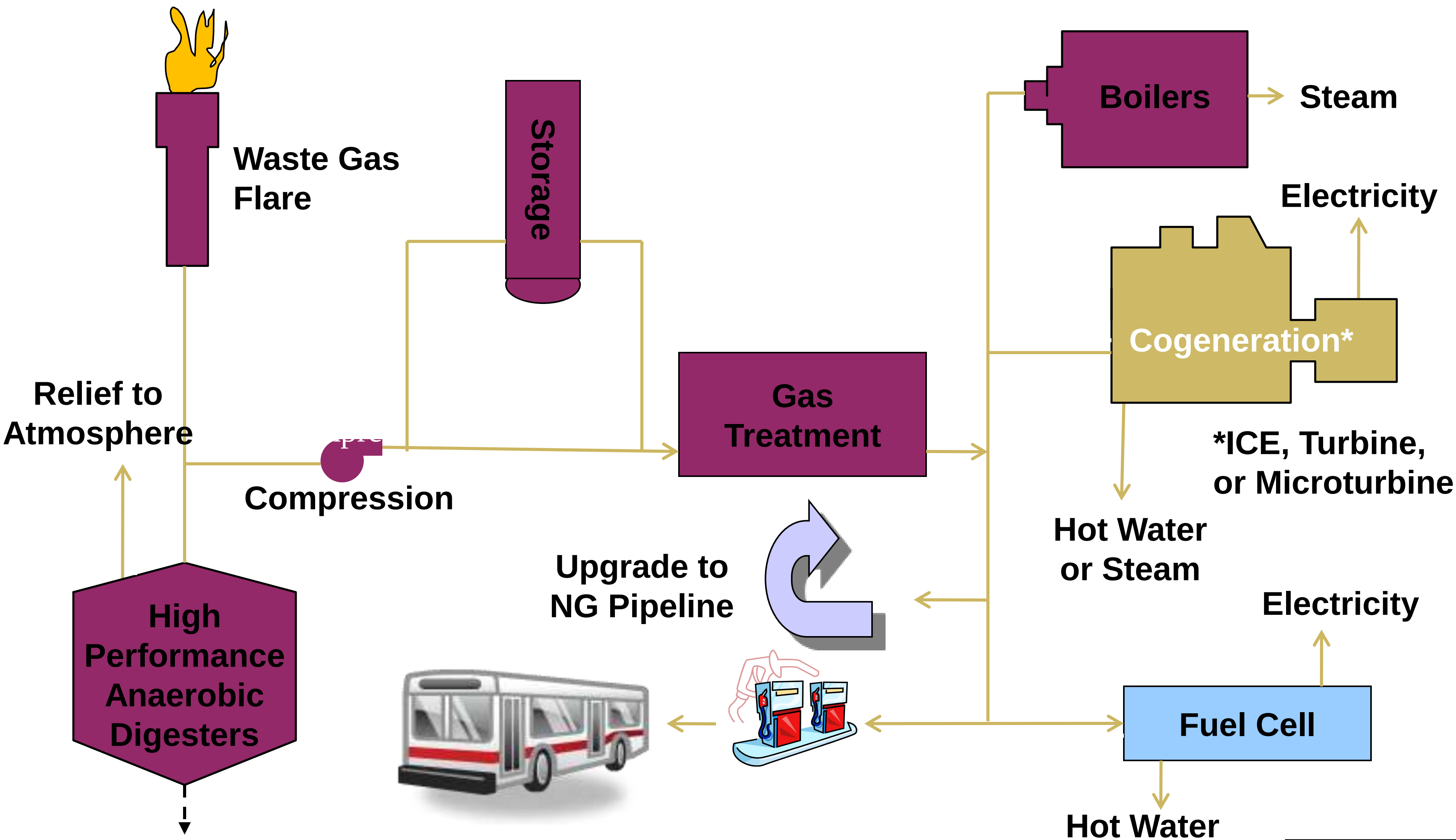
Performance Data:

- Greater than 10% increase in VSr
- Increase in methane by 55-60%
- Sludge treated with pulsed electric field is a potential carbon source for denitrification

Operating Data:

- Plant flow: 10-12 MGD
- Thickened PS/WAs mixture 50,000 - 60,000 gpd
- Solids content: 4 - 6%
- In operation since September 2007

Biogas Utilization Alternatives



Courtesy of Tim Shea of CH2M Hill

Problems from Contaminants

- Moisture
  - ✓ causes corrosion, together with acid gases
- H_2S
  - ✓ causes corrosion in mechanical moving parts of prime movers
  - ✓ causes breakdown of lubricants, leading to bearing, piston ring and seal failures
- Siloxanes
  - ✓ causes scaling leading to failure of mechanical components
  - ✓ causes breakdown of lubricants, leading to bearing, piston ring and seal failures

Comparison of Treatments for Biogas Contaminant Removal

Treatment	Technologies & Sample Vendors	Typical Removal Rates	Estimated Installed Equipment cost for 100 scfm of Biogas flow[1,2]
Drying	Desiccant : Van-Air Refrigerated Dryer : Van-Air Cyclic Refrigeration/Deep Dryer: Pioneer	Desiccant: 10-20 °F below ambient dewpoint (pressurized). Refrig. Dryer: down to 35-50 °F final pressurized dewpoint Deep Dryer: -20 °F final dewpoint	Desiccant: $3,500 – 5,500 Refrig. Dryer: $30,000 – 40,000 Deep Dryer: [3] $85,000 – 100,000
H2S Removal	Iron Sponge: Various Sulfa Treat: Sulfa Treat Activated Carbon: Various Liquid Catalyst: Apollo Biological: NIRAS	Iron Sponge, Sulfa Treat: 99% Alkaline sorbent: down to 50 – 100 ppm Biological – 90-99%	Iron sponge: $25,000-35,000 Sulfa Treat: $30,000-50,000 Act. Carbon: [4] $60,000-75,000
Siloxane Removal	Regenerable Activated Carbon: Applied Filter Technology Regeneratable Resins: various Cyclic Refrigeration/Deep Dryer: Pioneer Liquid Absorption: Dow Chemical, Selexol	Activated Carbon: down to ppbv levels	Act. Carbon (for siloxane only): $6,000 – 12,000 Deep Dryer: [3] $85,000 – 100,000

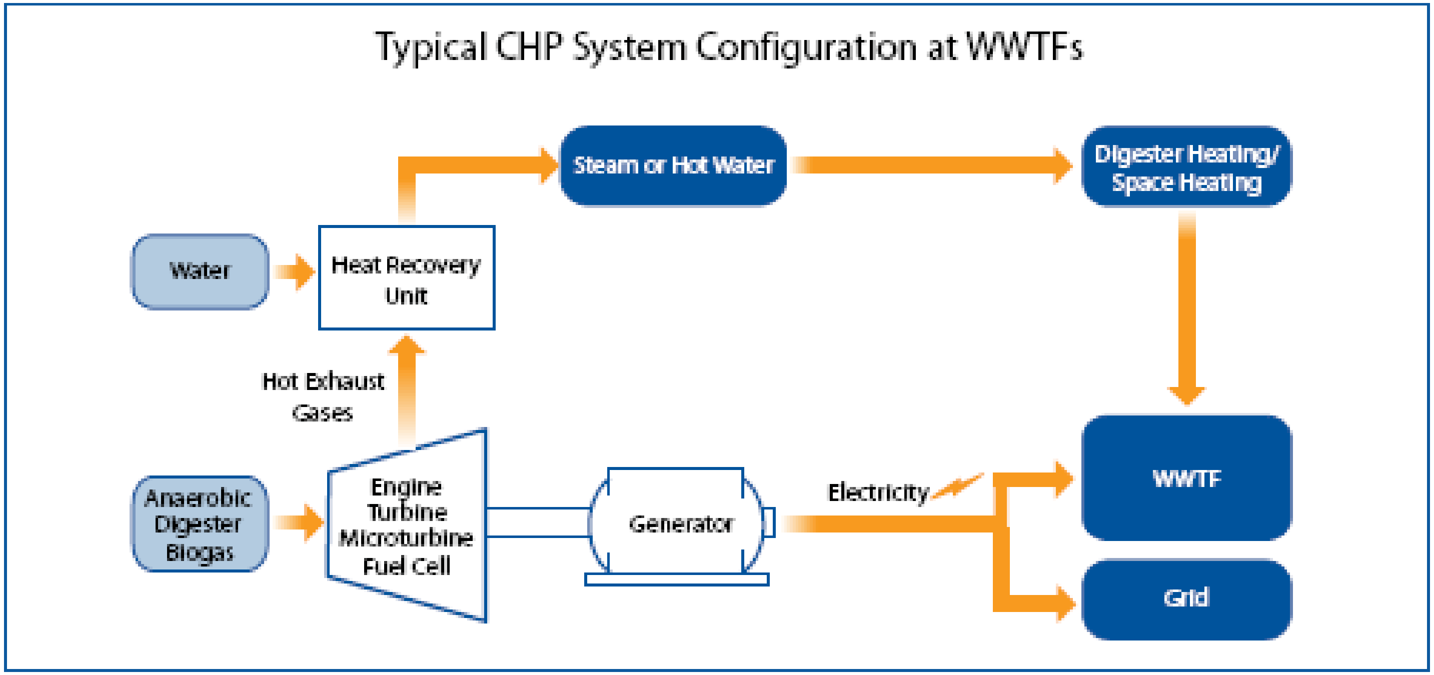
Problems with Siloxane

The sand-like material is SiO_2 produced through oxidation (burning) of the volatized siloxanes contained in the digester gas.

Figure shows siloxane deposition on boiler tubes

Combined Heat and Power

Definition: Utilizing equipment to simultaneously generate electricity and heat using anaerobic digester biogas



Cogeneration Alternatives

	Engine Generator	Turbine Generator	Micro Turbine	Fuel Cell
Unit Size, kW	150 to 1500	Over 1000	30	200
Appropriate Plant Size	Small to medium-size	Large	Small	Small
Efficiency, %	30	24 to 30	27	37
Thermal Efficiency, %	50	50	50	50
Overall Efficiency, %	80	74 to 80	77	87
Typical Costs				
Maintenance, $/kWh	0.01 to 0.015	0.005 to 0.008	0.005 to 0.008	0.005 to 0.015
Installed, $/kWh	1200 to 1500	1500 to 2000	1000 to 1500	4000 to 5000

Source: Digester Gas Utilization: Is the Time Right for On-Site Power Generation? Pittman, et. al., 16th Annual Residuals & Biosolids Management Conference

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Power Generation Cost Summary Comparison for Different Approaches

	Installed Cost ($/kW)	Operating Cost ($/kWh)	Power Production Cost* ($/kWh)
Gas Turbines	$2,000	$0.010	$0.04
IC Engines	$1,700	$0.015	$0.04
Microturbines	$3,000	$0.016	$0.06
Fuel Cell	$8,500	$0.035	$0.16

*10 year write down @5%

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Questions

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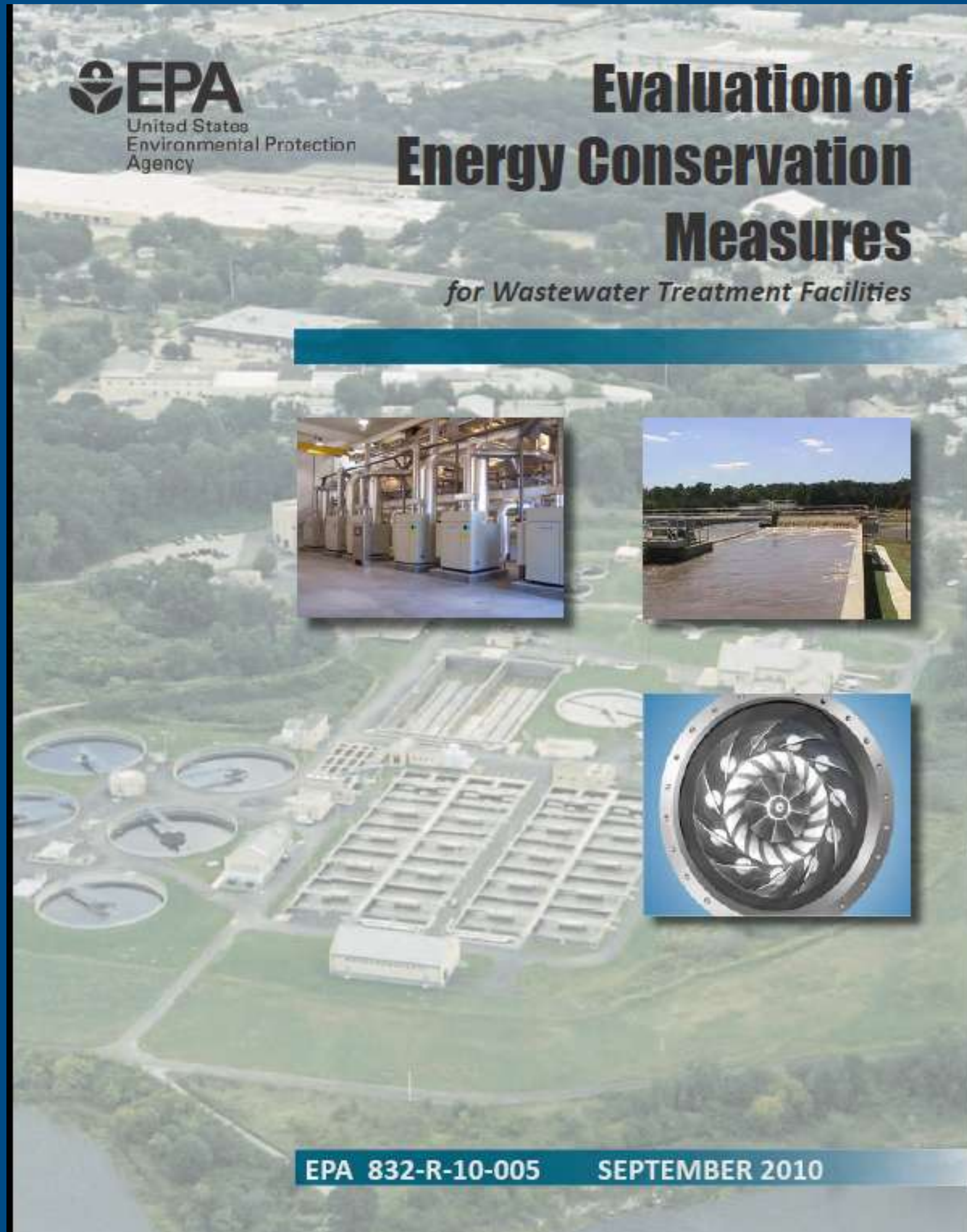

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Opportunities for and Benefits of Combined Heat and Power at Wastewater Treatment Facilities

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Prepared for:

U.S. Environmental Protection Agency

Combined Heat and Power Partnership

www.epa.gov/chp

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