Next Generation Anaerobic Digestion

Dave Parry, PhD, PE, BCEE

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JACOBS®

Digesters are the Engine of Water Resource Recovery Facilities

Energy (Fuel, Heat, Power)

Organic Waste

Biosolids & Nutrients

Resource Supply

Reclaimed Water & HydroThermal

BNEW: Biosolids, Nutrients, Energy, and Water

Digester Optimization Components

1. Digestion process (mesophilic, thermophilic, pasteurization, hydrolysis)
2. Digester Structure and Shape (pancake, eggs, tall glass of OJ, waffles)
3. Sludge cleaning (grit removal, screenings)
4. Feeding (continuous, high solids thickening, codigestion feedstock)
5. Withdrawal (surface overflow, emergency overflow, bottom withdrawal)
6. Mixing (type, higher solids concentration, rapid volume expansion)
7. Digested sludge dewatering,
8. Sidestream treatment (ammonia, struvite, vivianite)
9. Digester gas (handling, treatment, use)
10. Temperature management (heating, cooling)

High Performance Anaerobic Digestion Limitations

- Maximum Organic Loading Rate
  - Thickened sludge solids concentration
  - Digestion process
- Digester Mixing Capability (solids concentration in digester)
- Ammonia Toxicity
  - Ammonia – N concentrations greater than 3,000 mg/L can be toxic

Features of Digestion Processes for Optimizing Capacity and Performance

Feature	Mesophilic	Mesophilic High Solids	Mesophilic Acid Hydrolysis	Thermophilic	Mesophilic Thermal Hydrolysis
Increase in Capacity	Add digesters	Small-Moderate	Add acid digesters	Moderate-High	High
VS Loading Rate	125-175	150-200	150-200	200-300	300-400
Increase in VS Reduction	Small	Small	Small	Moderate-High	High
Increase in Gas Production	0-5%	0-5%	0-5%	10-15%	15-20%
Decrease in Foam Potential	Small	Small	Moderate	Moderate	High
Class of Biosolids	Class B	Class B	Class B	Class A with Batch Tanks	Class A

Digester Mixing Considerations

- Consider site specific conditions, mixing characteristics, and operator preferences
- Be aware of digester mixing types and characteristics
- Be aware of mixing impact on gas entrainment (volume expansion)
- Recognize when ability to mix is the load limiting factor
- Examples of digester mixing installations

Objectives of Digester Mixing

- Biological exchange of food and waste
- Provide even temperature distribution
- Avoid bottom deposition
- Avoid surface accumulation
- Enable high performance anaerobic digestion

Comparison of Digester Mixing

	Pumps and Nozzles	Open Impellers	Draft Tubes Internal	Draft Tubes External	Gas Mixers	Linear Motion Mixers
Energy Demand	High	Low	Low	Low	Medium	Low
O&M	Pumps	Accessible	Roof access	Side access	Compressors	Developing
Location	Wall	Cover	Cover	Wall	Cover, Floor	Cover
Intensity	High	High	Low	Low	Low	Medium
Flow Rate	Low	High	High	High	Low	Oscillating
Feature	Bottom Scouring	High Solids	Single draft tube for silos	Multiple draft tubes	High solids Manage gas	New product

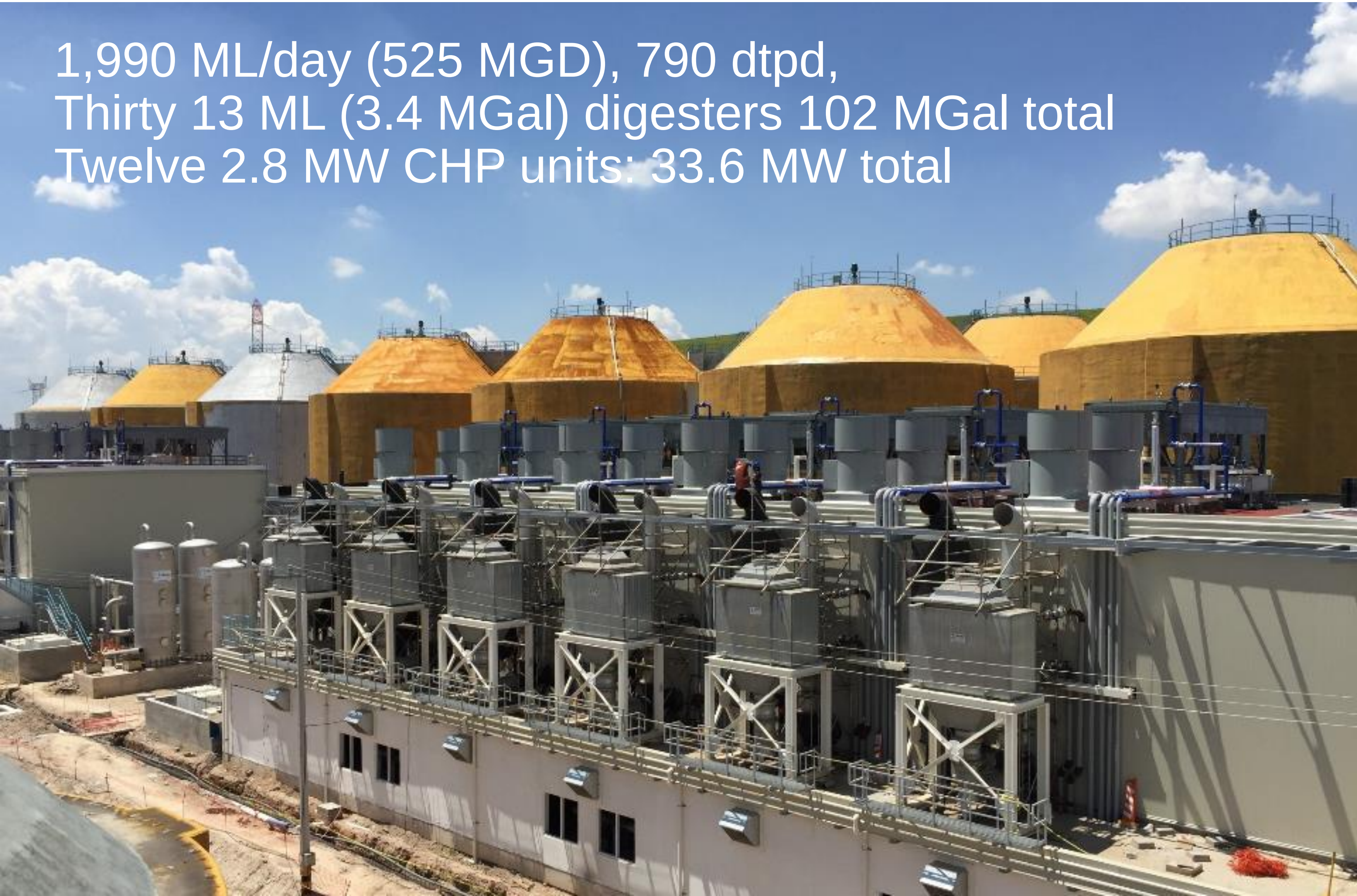
Examples of Anaerobic Digester Optimization

Digestion Optimization Examples

Project	Digestion Process, Biosolids, Energy
Atotonilco, Mexico City	• *Mesophilic Digesters, Class B Biosolids* • *Biogas fueled cogeneration*
Shafdan, Tel Aviv, Israel	• *Thermophilic Digesters, Class A Biosolids* • *Biogas fueled cogeneration*
Blue Plains, DC Water	• *Thermal Hydrolysis, Mesophilic, Class A Biosolids* • *Biogas fueled cogeneration*
Gold Bar, Edmonton	• *Conversion of fermenters to Acid Digesters, conversion of Mesophilic to Thermophilic digesters* • *Class B Biosolids, Composting*
MBC San Diego	• *High solids, Mesophilic, Class B Biosolids* • *Biogas fueled cogeneration*
Des Moines, Iowa Gresham, Oregon	• *Codigestion, Mesophilic, Class B Biosolids* • *Biogas fueled cogeneration and renewable nat. gas*

Atotonilco WWTP, Mexico City

1,990 ML/day (525 MGD), 790 dtpd,
Thirty 13 ML (3.4 MGal) digesters 102 MGal total
Twelve 2.8 MW CHP units: 33.6 MW total



Atotonilco Modified Eggs

Atotonilco Biogas Holding and Treatment

Seven Gas Holders

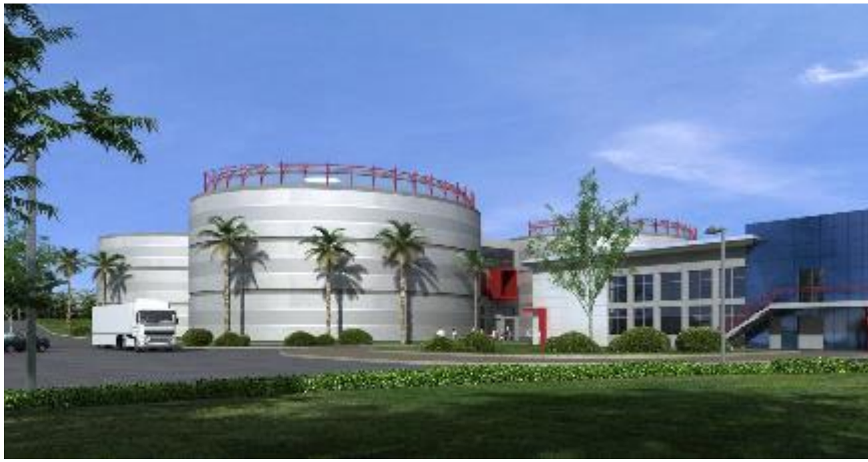
Atotonilco 33.6 MW Cogeneration System

Twelve 2.8 MW CHP units

Shafdan Wastewater Treatment Plant

Biosolids and Energy Resources Instead of Sludge in the Mediterranean Sea

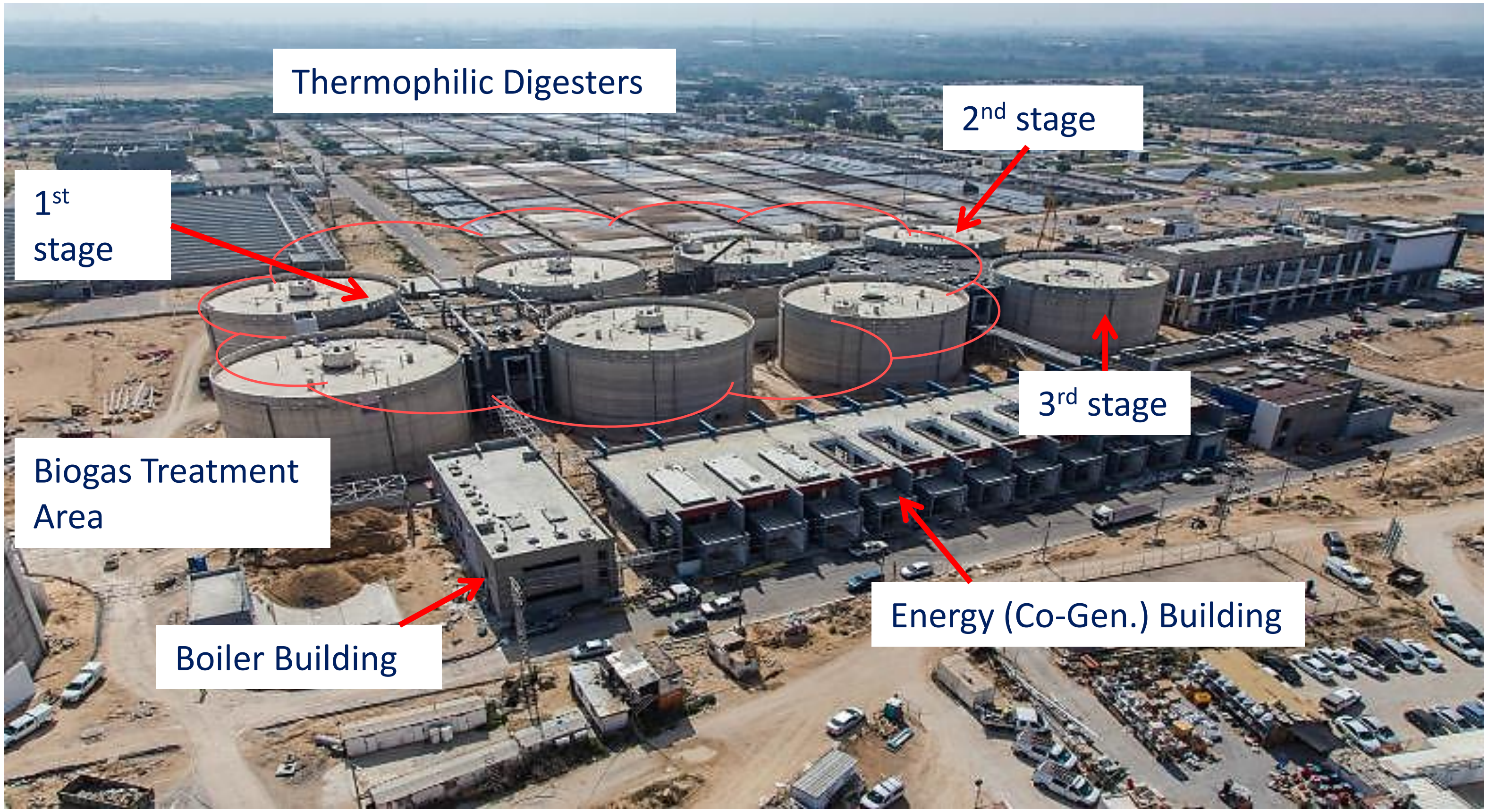
Class A Biosolids



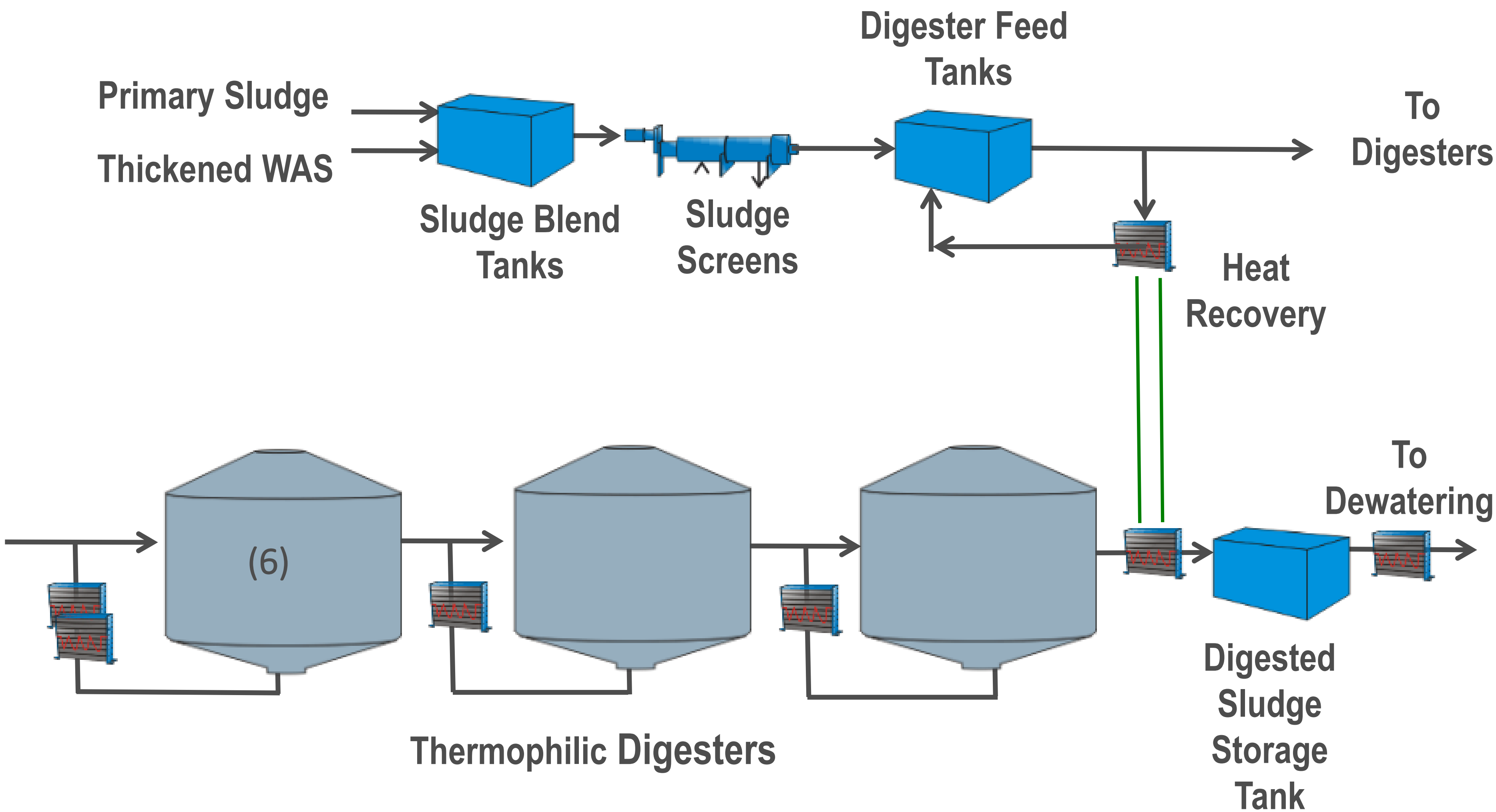
Renewable Energy

Reclaimed Water

Shafdan Wastewater Treatment Plant Digestion and Cogeneration Facility



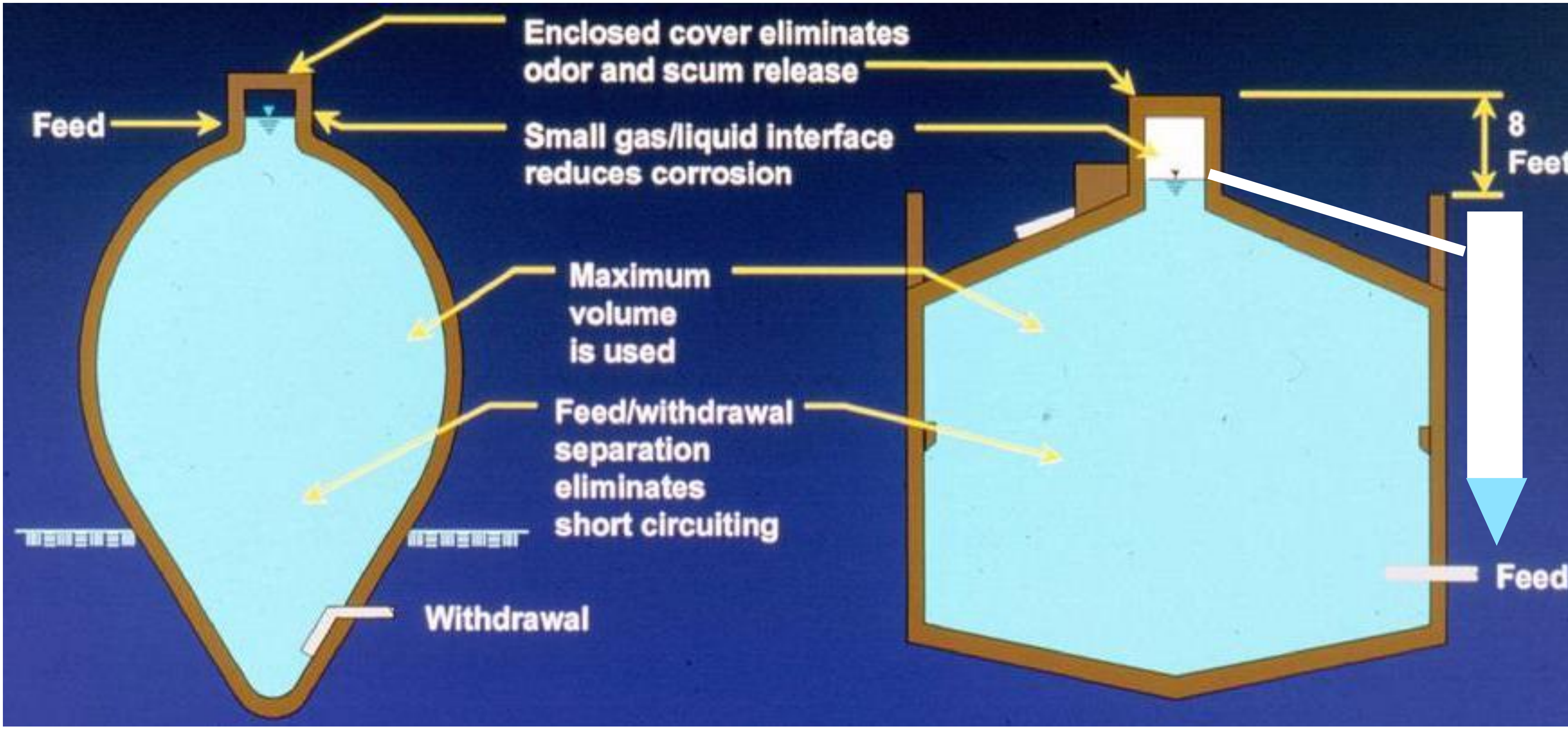
Multi-Staged Thermophilic Digestion (with storage before and after digesters)



Shafdan Sludge Screening Improve Biosolids Quality and Reduce Digester Cleaning

Similar screening installations at Alexandria and Blue Plains

Surface Withdrawal for Handling Foam and Volume Expansion



Egg-shaped

Modified Egg

Shafdan Submerged Fixed Cover Digesters with Surface Overflow Withdrawal to Standpipes

Shafdan Pumped Mixing

Biological Hydrogen Sulfide Removal System

Shafdan 11.2 MW Cogeneration System

Eight 1.4 MW Packaged Cogeneration Units

Sludge Heat Exchangers for Thermophilic Digester Heating and Heat Recovery

DC Water, Blue Plains WWTP
Thermal Hydrolysis Process and Anaerobic Digestion

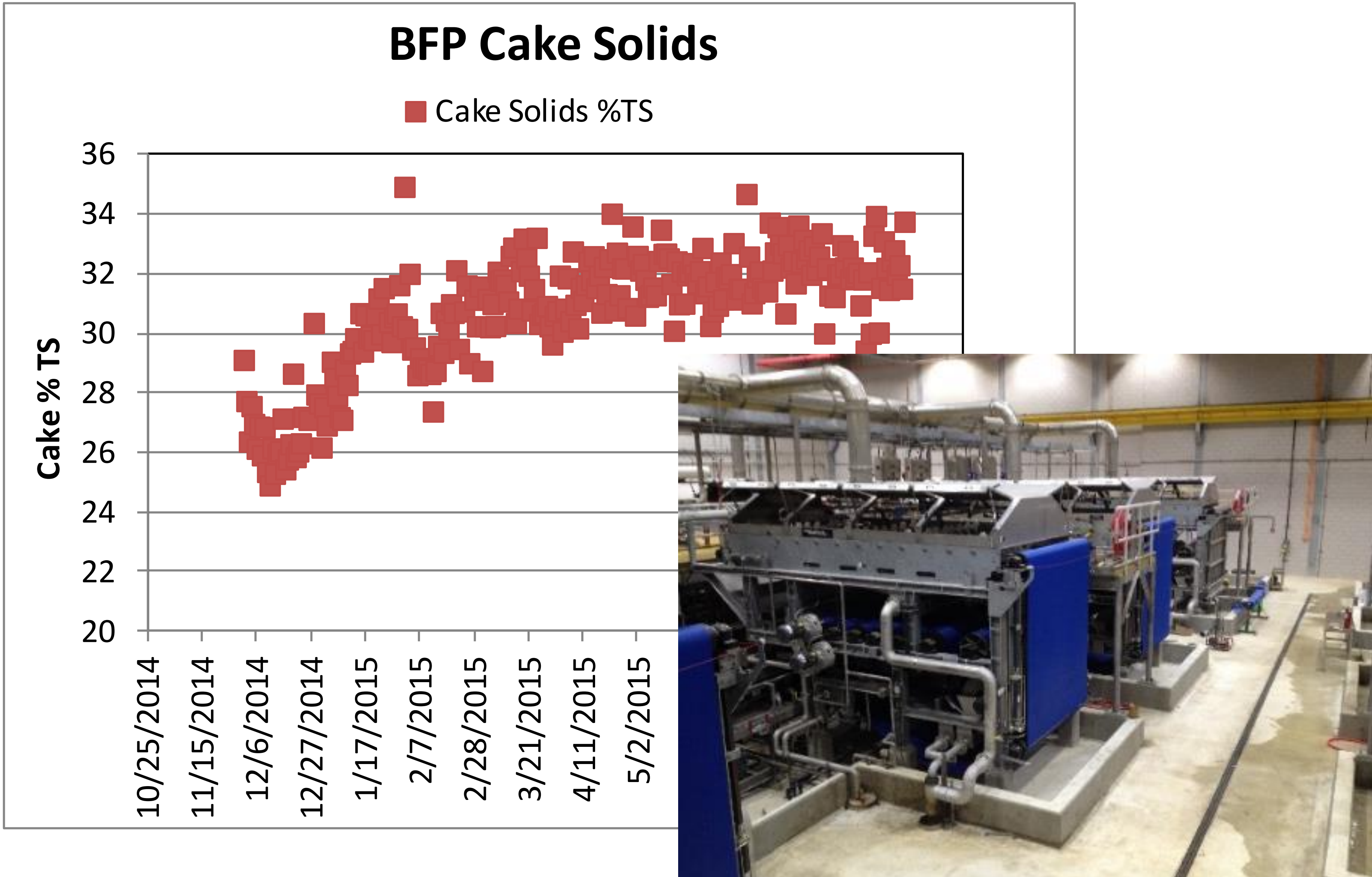
Producing Class A Biosolids for Resource Recovery was the main goal!

Sludge Withdrawal and Provisions for Volume Expansion

- Volume reserved for expansion
- Three overflows: normal, backup, and emergency

DC Water Draft Tube Mixing

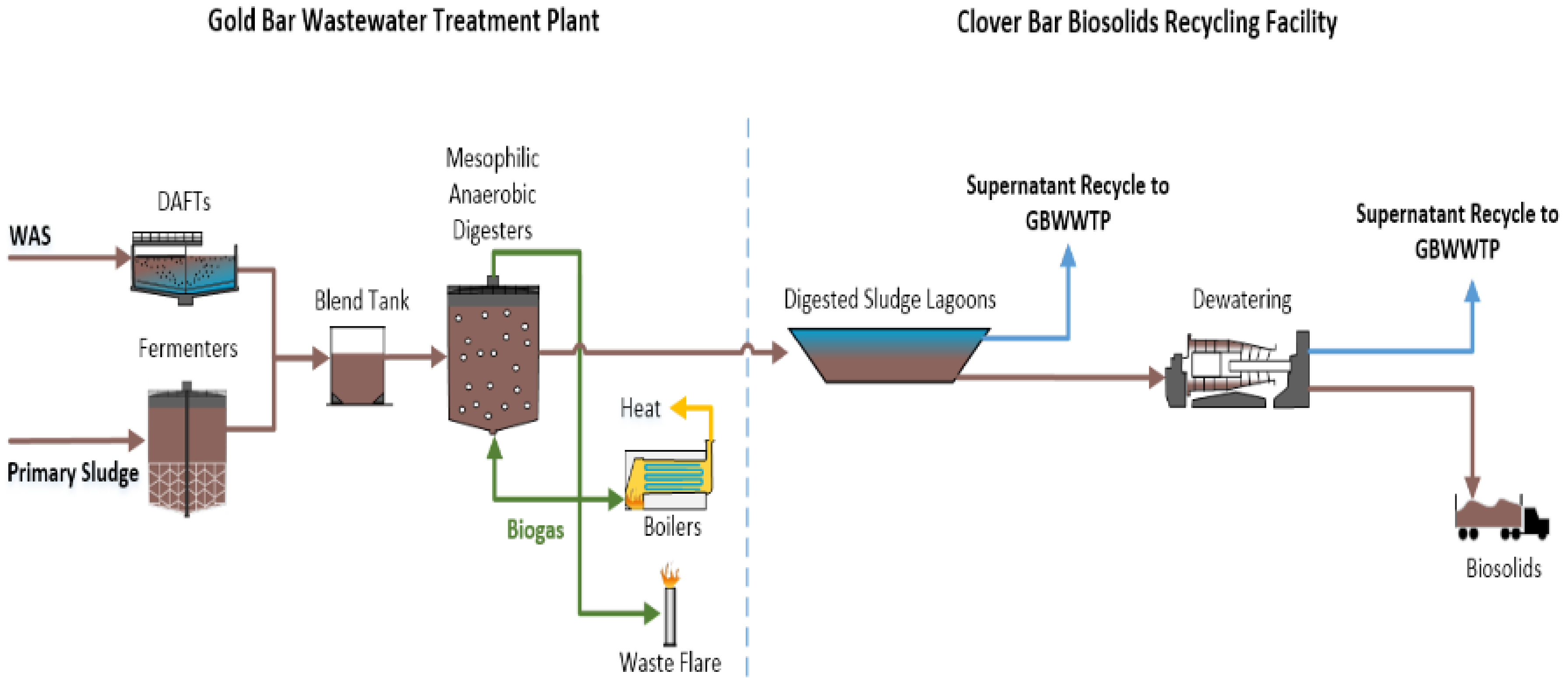
The belt filter presses are producing an excellent cake because of thermal hydrolysis



Gold Bar Wastewater Treatment Plant Edmonton, Alberta, Canada

- Integration plan for biosolids, nutrients, energy, water, and solid waste
- Drivers: Increased digester capacity, class A biosolids, energy neutral
- Strong desire to avoid building additional digesters
- Near term consistent with long term plan

Existing Mesophilic Anaerobic Digestion Solids Processing System



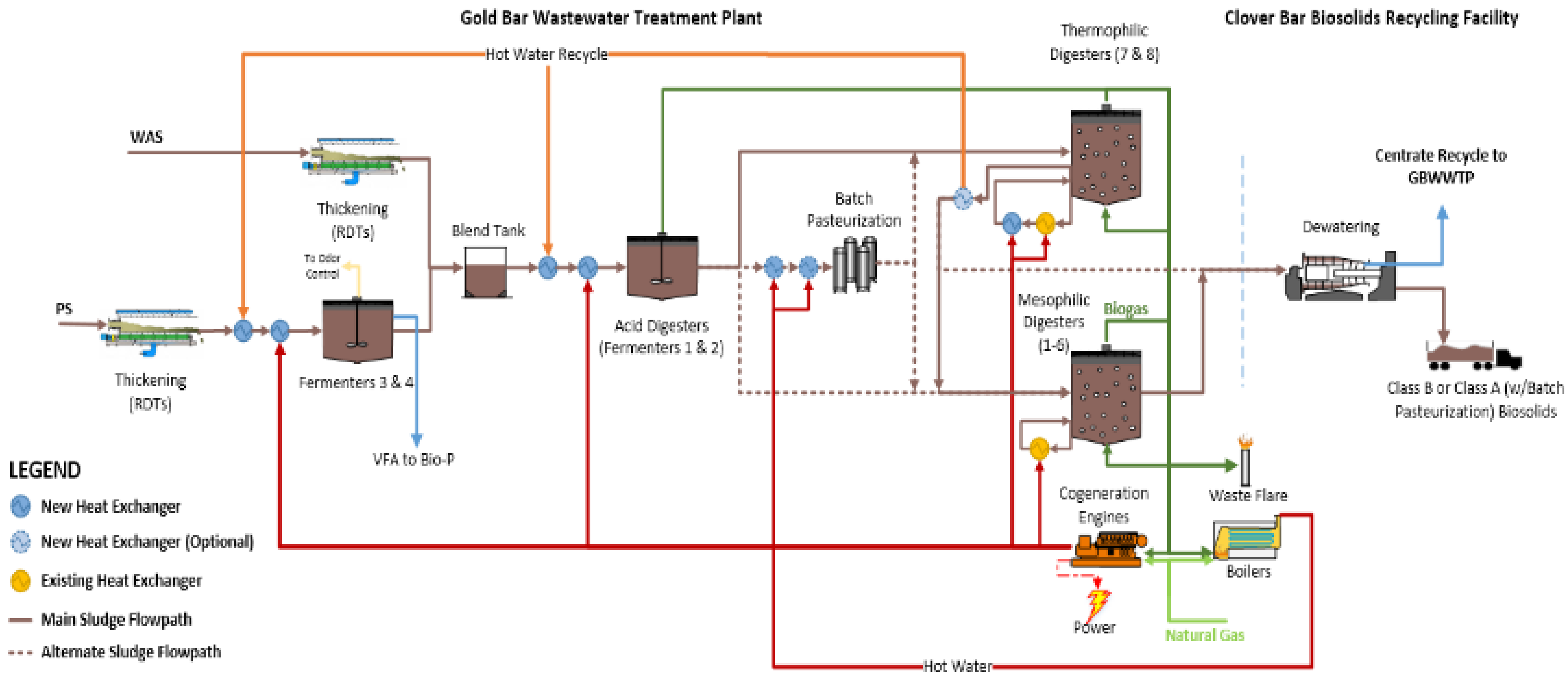
Gold Bar Submerged Fixed Cover Digesters 7&8 Designed for Thermophilic Digestion Operation

Surface Withdrawal to a Standpipe Handles Foam
Digesters 1-6 are being Converted to Surface Withdrawal

Foam Management at Gold Bar

- Prevent foam
  - Controlling foam in secondary treatment
  - Don’t overload digesters
  - Don’t abruptly change digester feed characteristics
- Detect foam
  - Measure surface and liquid level
- Control foam
  - Provide surface withdrawal in digester
  - Entrain foam at surface
  - Provide separation from foam and biogas connection
  - Provide process water spray at surface
  - Add anti-foam suppressant
  - Handle foam in gas line with proper condensate tank connection

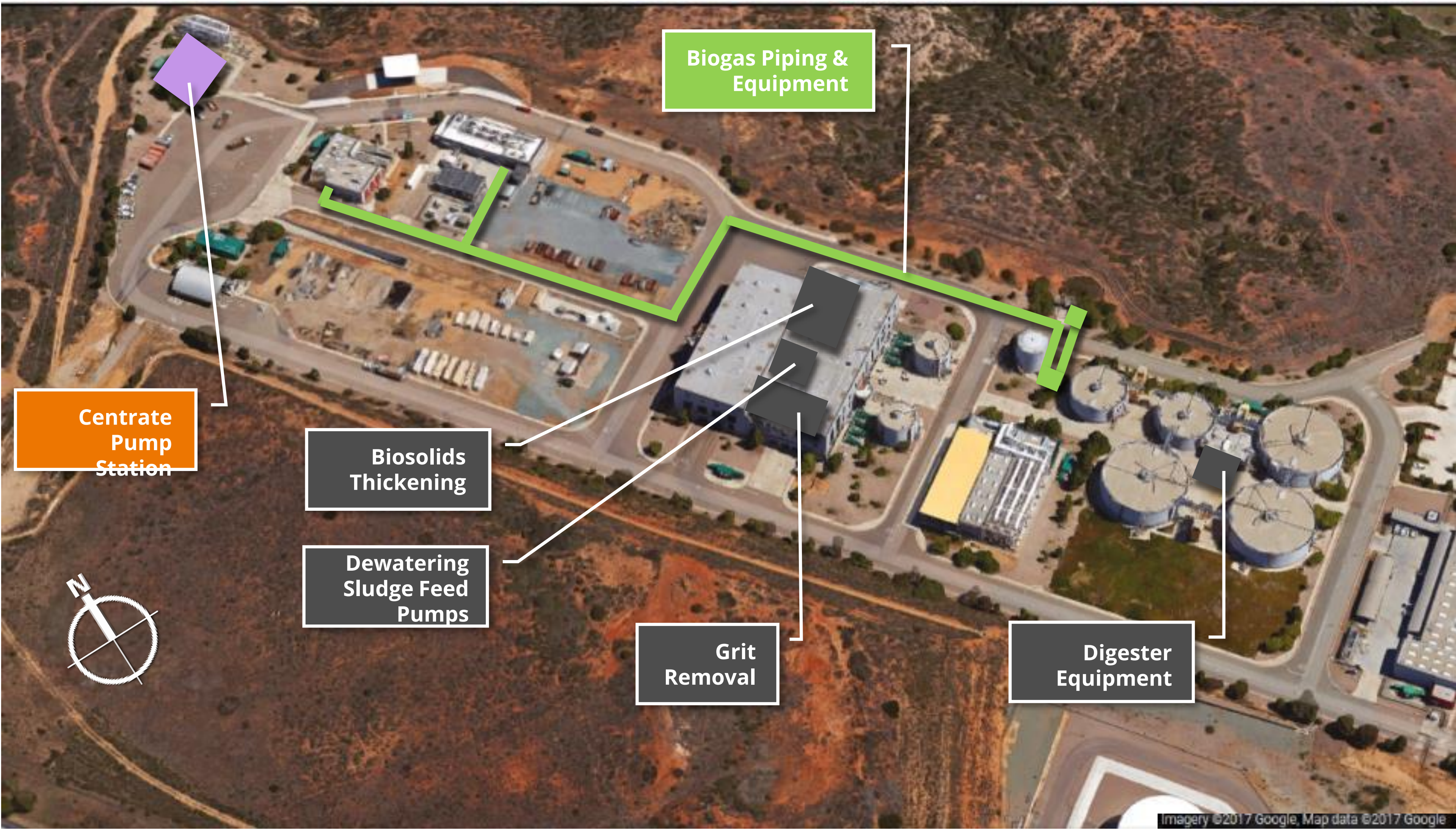
Customized Biological Hydrolysis/Thermophilic Anaerobic Digestion System



Sidestream: Struvite Harvesting

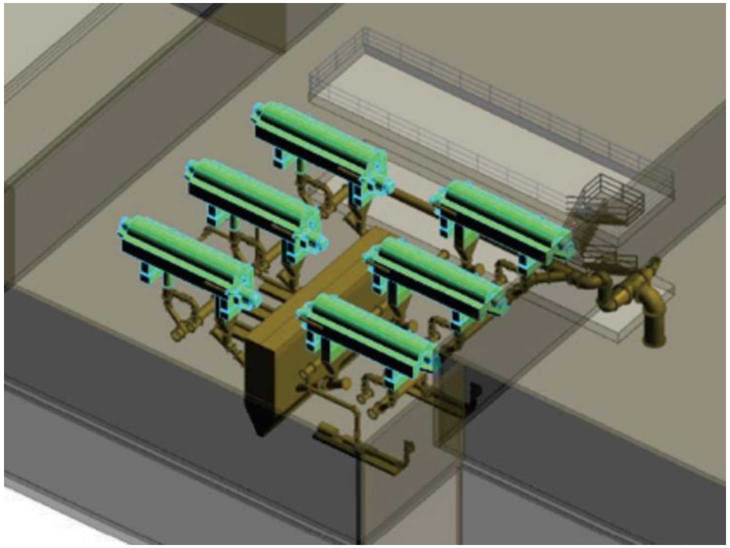
First Pilot Tested at Gold Bar

San Diego Metropolitan Biosolids Center (MBC)

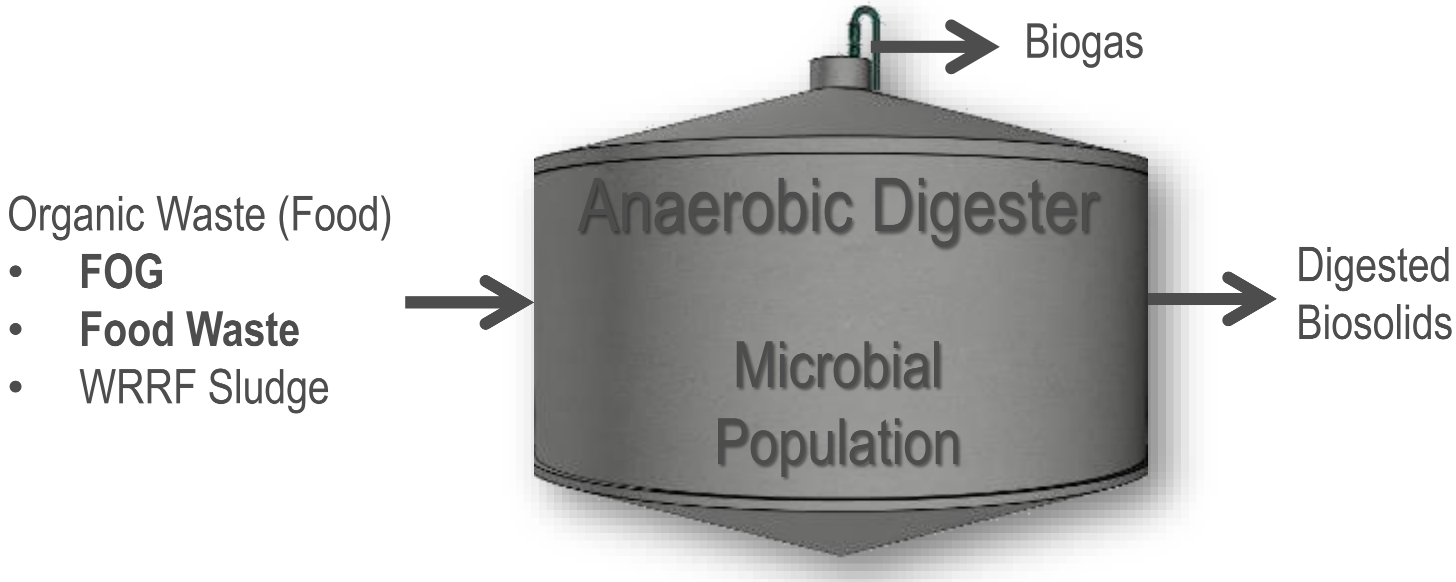


Sludge Thickening, Pumping, and Digester Mixing designed as an integrated system.

- Remove five old thickening centrifuges
- Replace with six new centrifuges
- Replace thickened sludge pumps and enlarge thickened sludge piping
- Equipment sizing and hydraulic design based on 6.5% solids feed to digester
- Digester mixing designed for up to 4.0% solids in digester

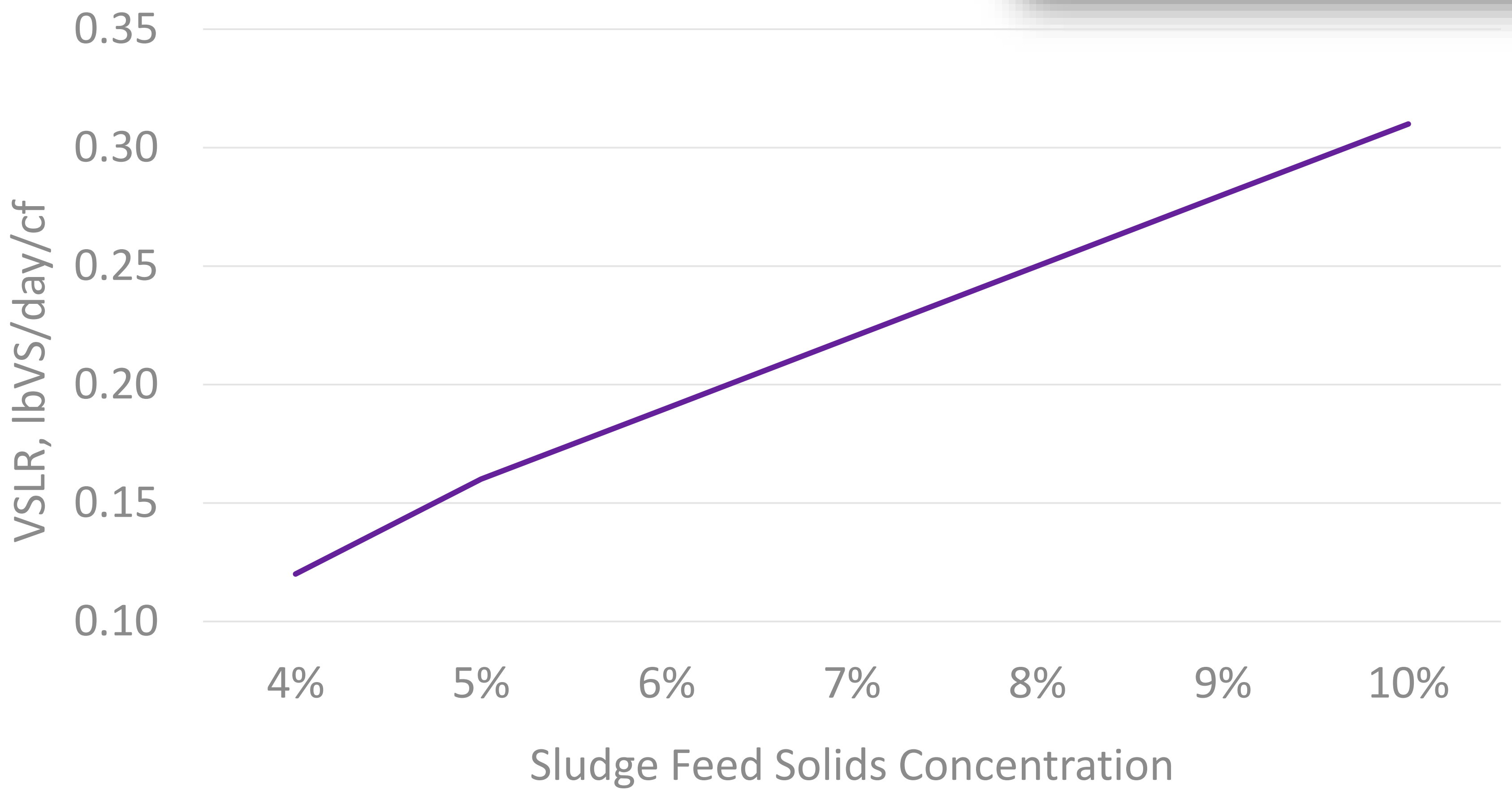


F:M Organic Loading Rate for Anaerobic Digesters

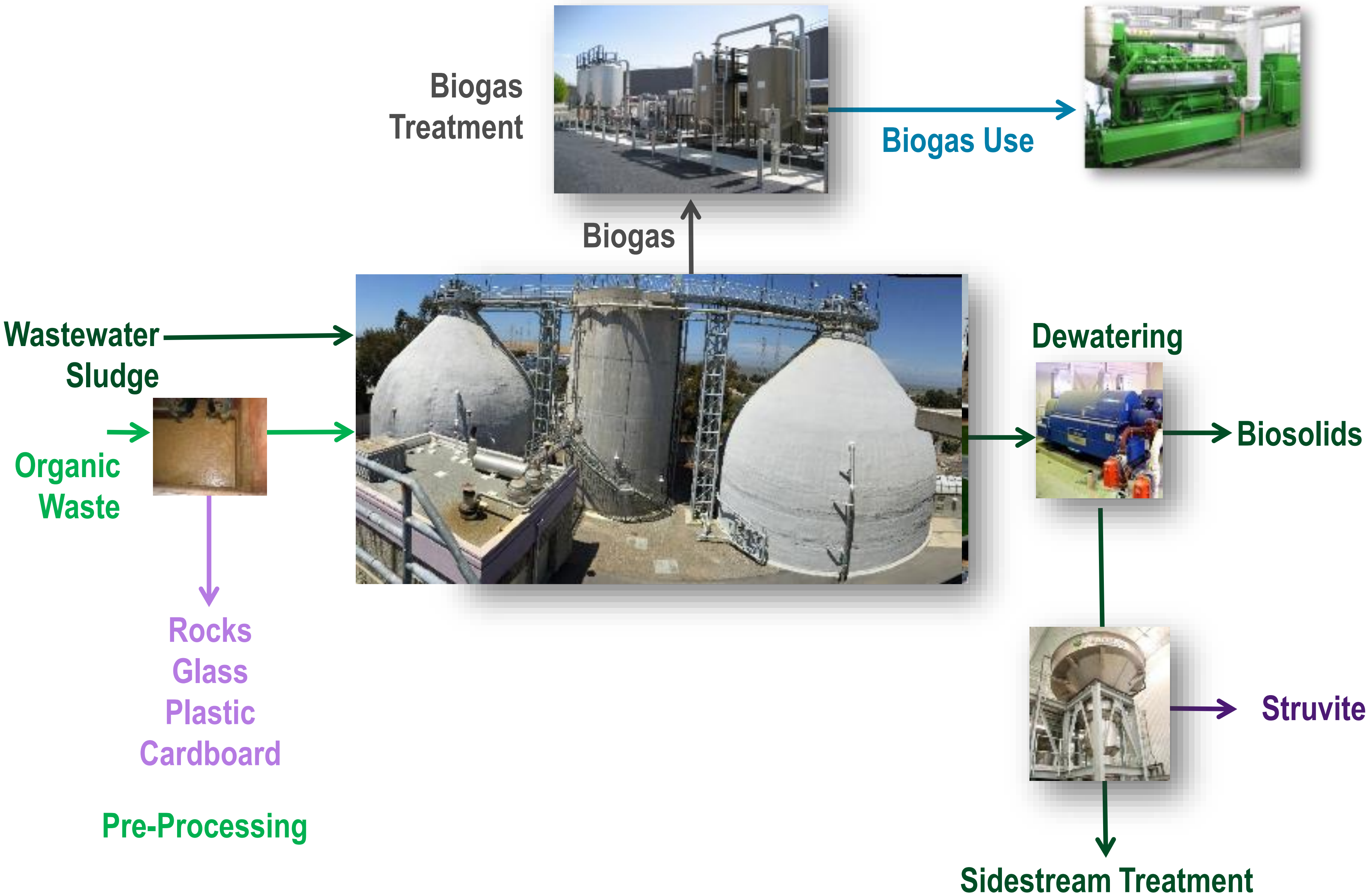


- Specific Energy Loading Rate (SELR) accounts for both feed and digester characteristics
- The strength of the feed is measured by COD and the microbial population by VSS in the digester: SELR: 0.24 kgCOD/day/kgVSS
- SELR is a food to microorganism (F:M) ratio for digesters
- Digesters with greater microbial populations (measured as VSS) can be fed more food (measured as COD)
- For WRRF sludge only, the Specific Volatile Solids Loading Rate (SVSLR) can be used: SVSLR: 0.16 kgVS/day/kgVSS

Feeding a Higher Solids Percent Results in Greater Digestion Capacity



Codigestion Components for Resource Recovery

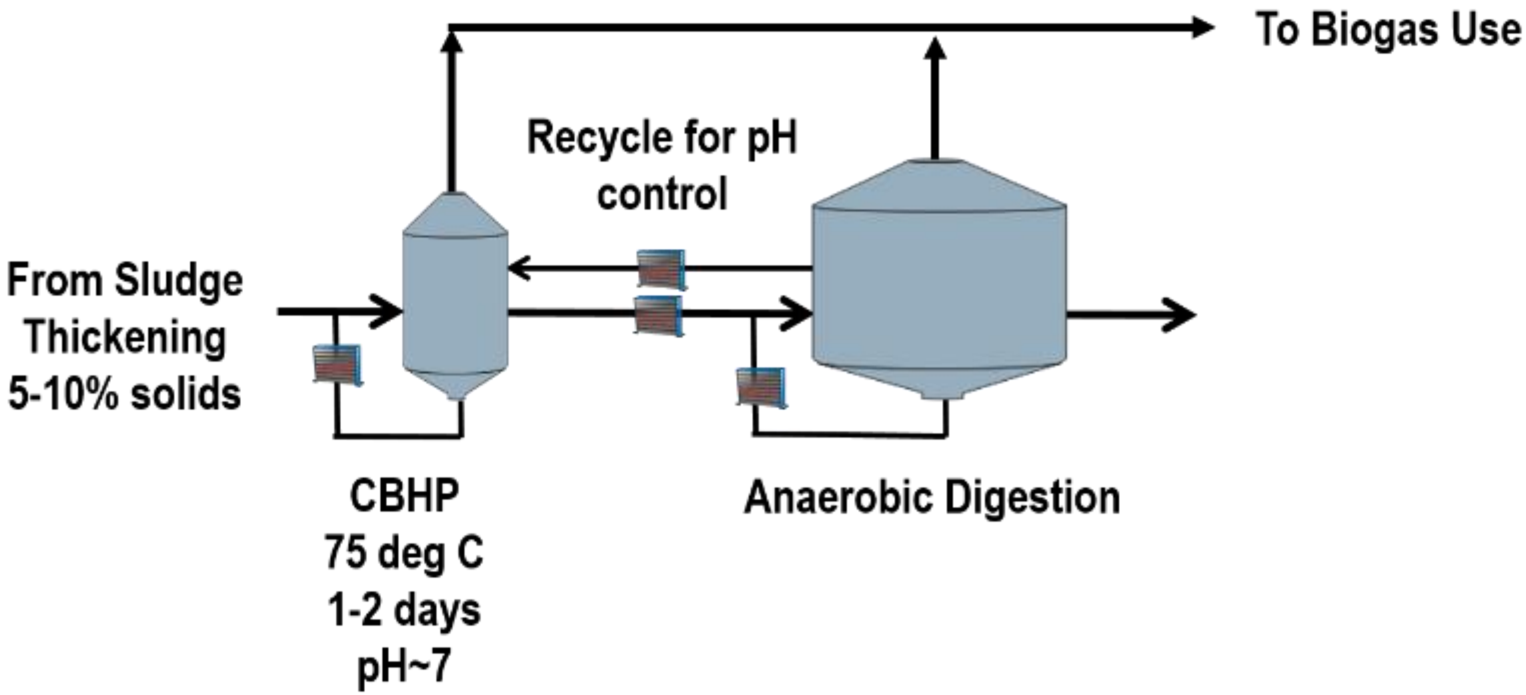


Digesters at the Des Moines Water Reclamation Facility

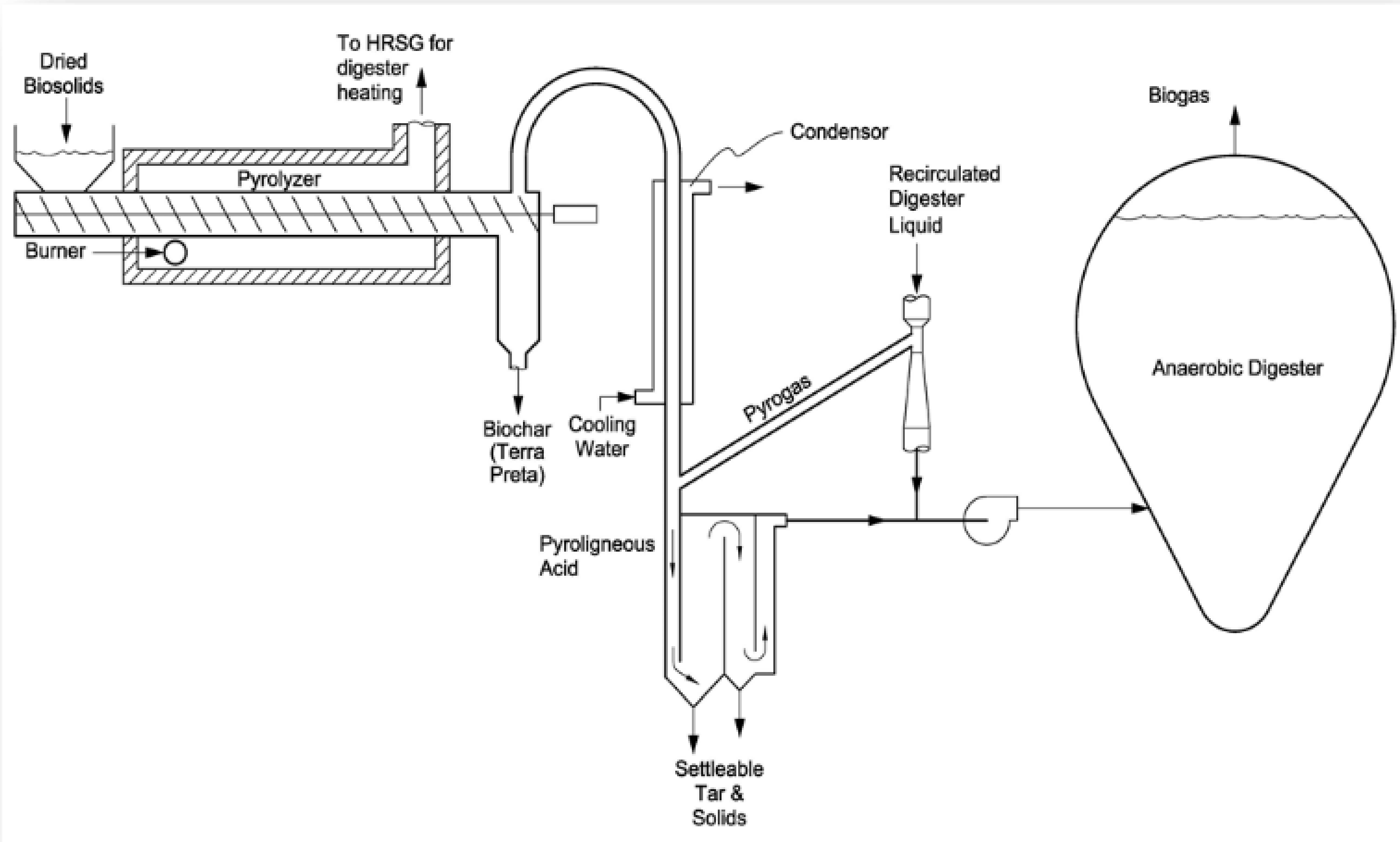
Truck Loading Facility for Receiving Organic Waste

Gresham Wastewater Treatment Plant
Gresham, Oregon

Process Diagram of C. Bescii Hydrolysis Process



Process Diagram of Pyrolysis of Dried Biosolids and Condensate Digestion



State of the Art Practice for Anaerobic Digestion Components

Component	State-of-the-Art Practice
Anaerobic Digestion Process	Site specific: pre-treatment (hydrolysis), mesophilic digestion, thermophilic digestion
Digester Tank and Cover	Modified egg-shape, tall silo configuration
Debris Removal	Sludge grit removal and sludge screening prior to digestion
Sludge Thickening	Thicken sludge for high solids concentration feed to digesters
Sludge Temperature Control	Reliable heat recovery and supply with compatible temperatures
Digester Mixing	Dependent on owner’s objectives
Sludge feeding and withdrawal	Storage, continuous feeding, surface and bottom withdrawal, emergency overflow provisions for volume expansion
Digested sludge dewatering and side-stream management	High solids dewatering and nutrient removal from sidestream treatment
Biogas handling, treatment, and use	Condensate removal, comprehensive biogas treatment including hydrogen sulfide, moisture, and siloxane removal; biogas fueled combined heat and power system; carbon dioxide removal and renewable natural gas to pipeline or vehicles

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Dave Parry, PhD, PE, BCEE

Dave.Parry@Jacobs.com

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