

The Basics of Anaerobic Digestion

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Why Anaerobic Digestion?

- Stabilize sludge (DEC regulation)
- Reduce solids volume (~30%)
- Produce methane gas
- Can also generate tipping fees from AD
- Can provide safe sustainable disposal method for organic waste generators



Organic Decomposition

- Has occurred naturally for ~~thousands~~ ~~millions~~ billions of years
 - Organic material + bacteria = Simple compounds
 - Inorganic material will not break down
- Given time, organics will breakdown but AD equipment and operators help the process move faster
- Activated sludge process (with oxygen)
Anaerobic Digestion (without oxygen)

Where does Anaerobic Decomposition Occur?

- Landfill, (anaerobic, gas flare or electricity generation)
- Wastewater Anaerobic Digesters (Mesophilic 95 F most widespread)
- Septic Tank (no gas collection!)
- In all of the above, similar bacteria doing the decomposition

Anaerobic Digestion Everywhere...

1. Human Digestion 15 hours
 2. Anaerobic Digestion 15 days
 3. Landfill Digestion 15+ Years
- Unfortunately, energy recovery occurs only in both 2 & 3!



Why AD at WWTP?

- A 10 MGD activated sludge plant processes wastewater with a BOD concentration @ 228 mg/l . Facility treats **19,015** lbs. BOD/day.
- Dump three 8,000 gallon tankers of Mountain Dew into the headworks. BOD concentration 95,000 mg/l. Additional loading to facility **19,015** lbs. BOD/day
- Low strength waste: treat aerobically
- High strength waste: treat anaerobically, recover energy
- AD: great place to treat sludge, food waste, etc.

Simple Comparison of Processes

Landfill

- Solid chunks
 - Less surface area
- No mixing
- No temperature control
- Biogas capture not immediate
- Simple operation
- 15 years to do the job

Anaerobic Digester

- Slurry feed (3 – 10% TS)
 - More surface area
- Mixing
- 95 degrees F typical range
- Sealed system captures all biogas
- More complex
- **Done in 15 days**

Disadvantages of Anaerobic Digestion

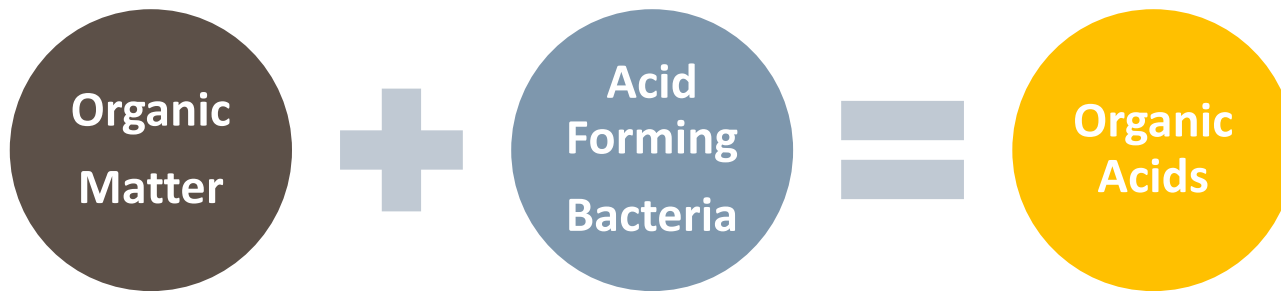
- High capital cost
- Produces a poor quality side-stream (digestate)
- Methane-forming bacteria grow slowly

Advantages of Anaerobic Digestion or Co-Digestion

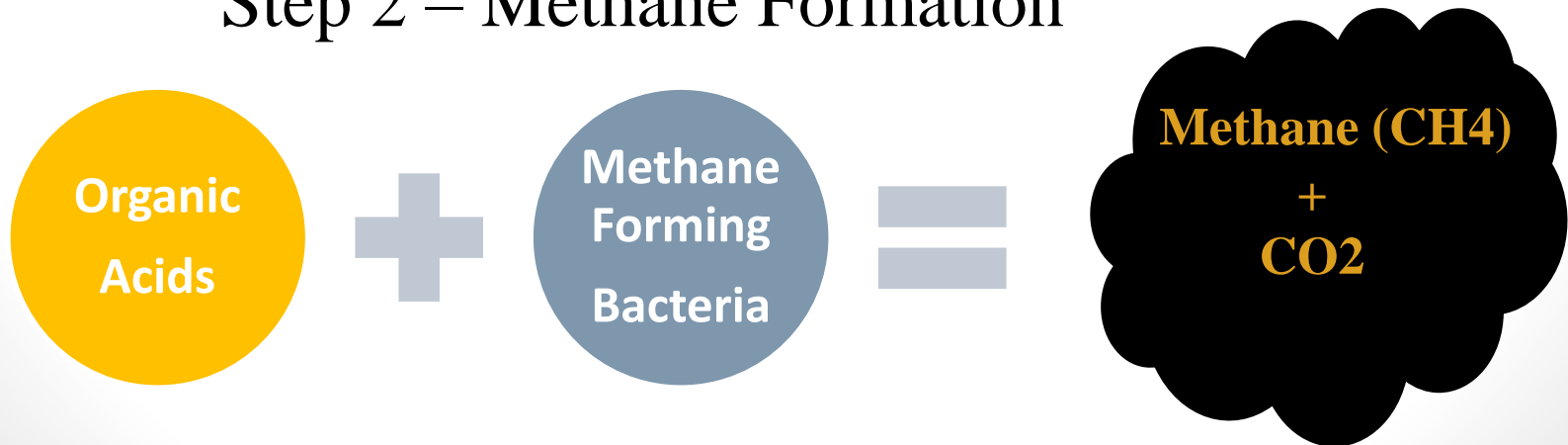
- Significantly reduces amount of end product
- Can process liquid and/or sludge waste
- Stabilizes end product
 - Reduced odors and vector attraction
 - Soil conditioner
- Produces methane (energy efficient)
- Inactivates many pathogens

What Happens inside AD Tank?

Step 1 – Acid Formation



Step 2 – Methane Formation

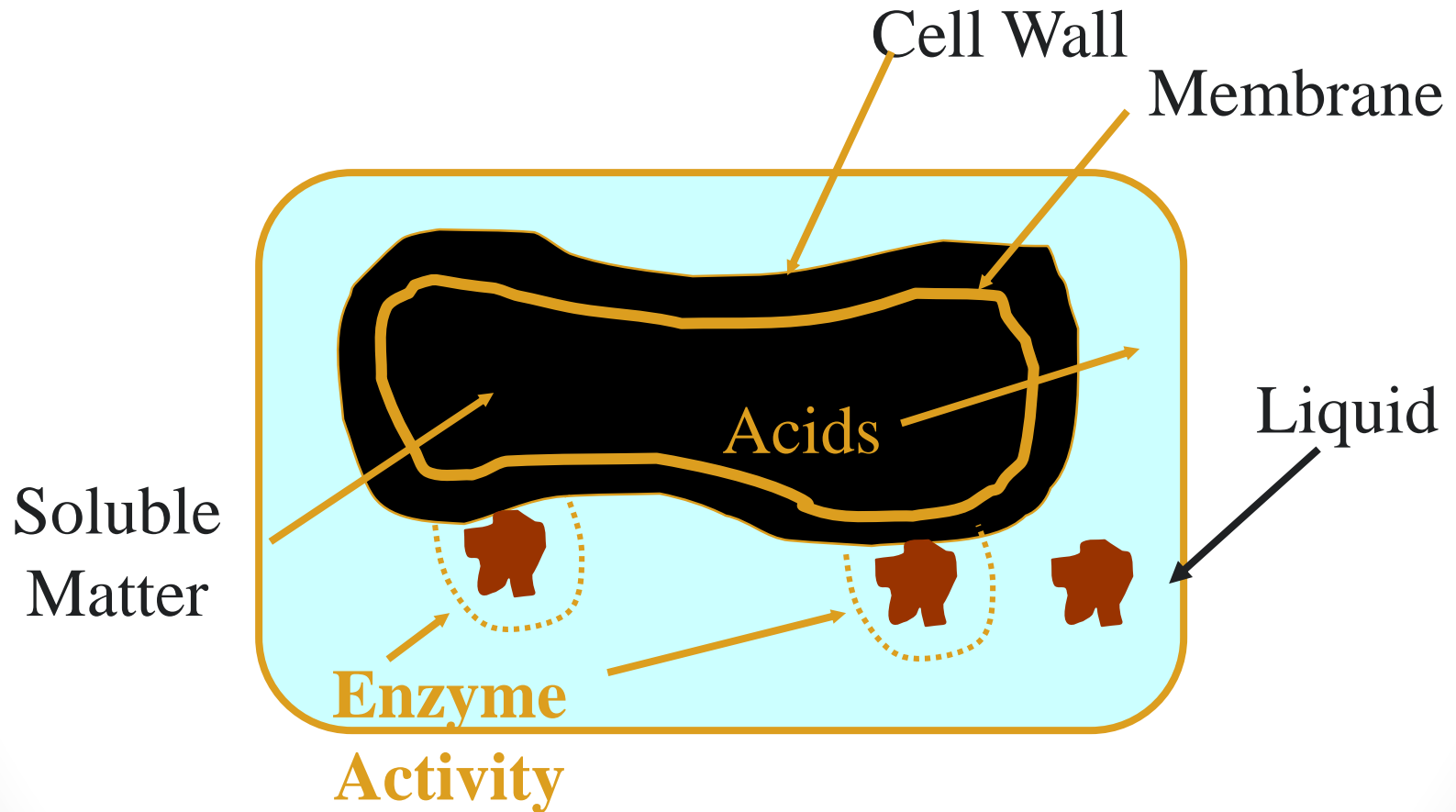


Anaerobic Decomposition

Step 1

- Breakdown of complex organics
- Conversion of organic material in sludge to “Intermediate Degradation Products:” H_2O , CO_2 , and organic acids by ‘acid formers’

Typical Acid Forming Bacteria



Grow **FAST** and do well in a variety of environments!

Anaerobic Decomposition – Step 2

The Real Work!!!

- Breakdown of organic acids formed in step one
- Organic acids converted to CO_2 and CH_4
- Stabilization accomplished, original intent of AD

What About the Methane Formers?

- Many different methane bacteria
 - Grow much more slowly
 - Sensitive to environment & environmental changes
- WWTP Operators: keep these microbes happy...
 - Anaerobic digester system tailored to meet the needs of methane formers

Controlling the Anaerobic Digester Process

- Keep the slow growing methane formers happy
 - Anaerobic conditions – No oxygen
 - Even feed rate: do not wash out
 - Constant, proper temperature range
 - Good mixing
 - Neutral pH
 - No toxics

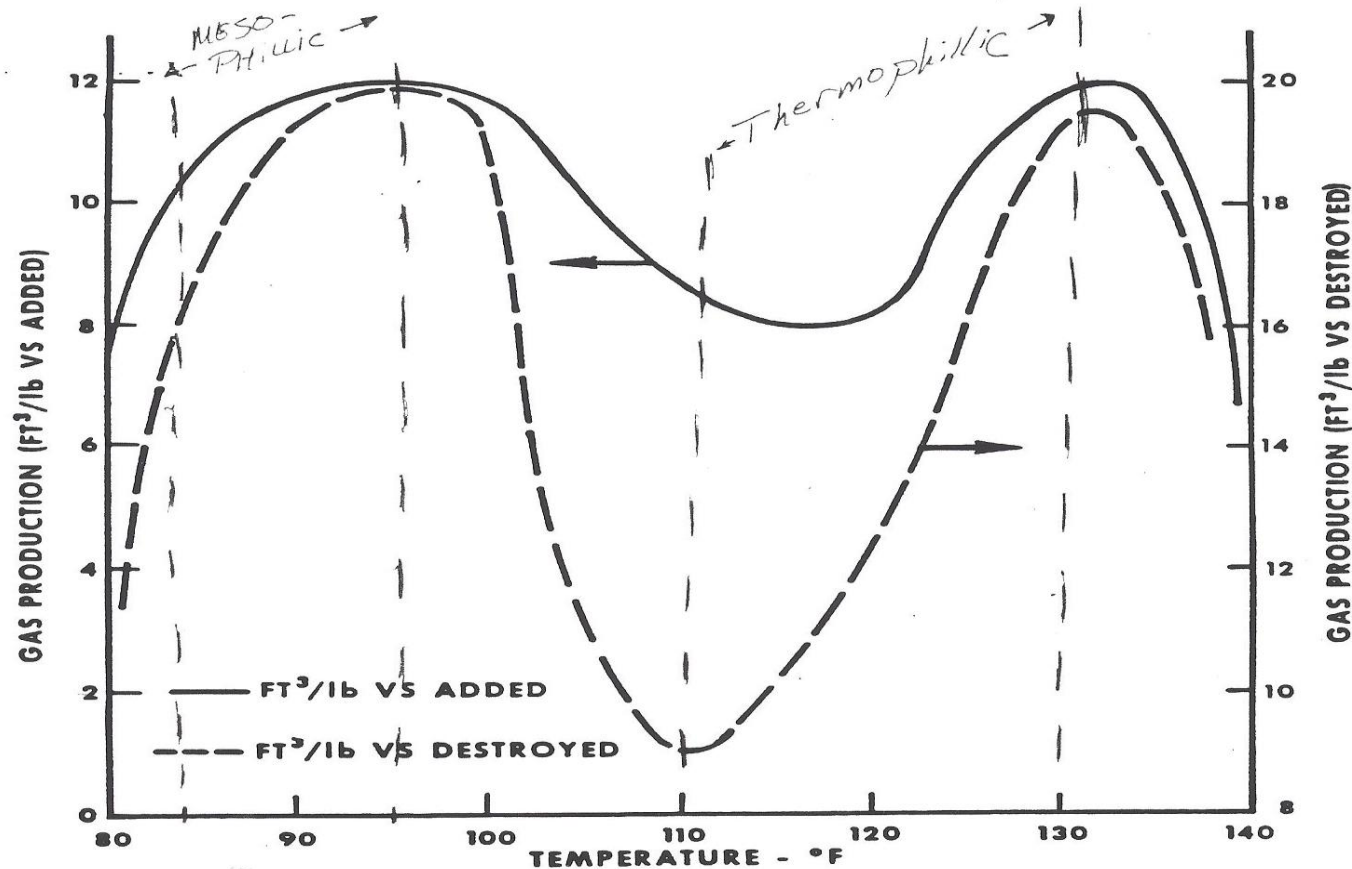
Temperature is Important!

- Constant temperature is best
 - Limit daily temperature change to 1° F
- Most digesters run in the mesophilic temperature range
 - 93° F to 100° F textbook range
 - 95° F to 98° F seems like best target
 - **Stay in recommended temperature range!**

Mesophilic vs. Thermophilic

FIGURE 6

EFFECT OF DIGESTION TEMPERATURE ON GAS PRODUCTION
BASED ON DATA FROM 23 STUDIES (6)



pH Control

- Acid forming bacteria work fine down to pH of 5 (or even 3 or 4!)
- Methane formers must have neutral pH
 - 6.8 – 7.2
 - Can go higher, don't go lower
 - If low pH, methane formation rate **dramatically** reduced

Anaerobic Digester Mixing

- Provide regular mixing
- Need to bring food into contact with bacteria
- Good mixing, along with heating, will help to assure a good digestion rate
- Mixing critical to good operation

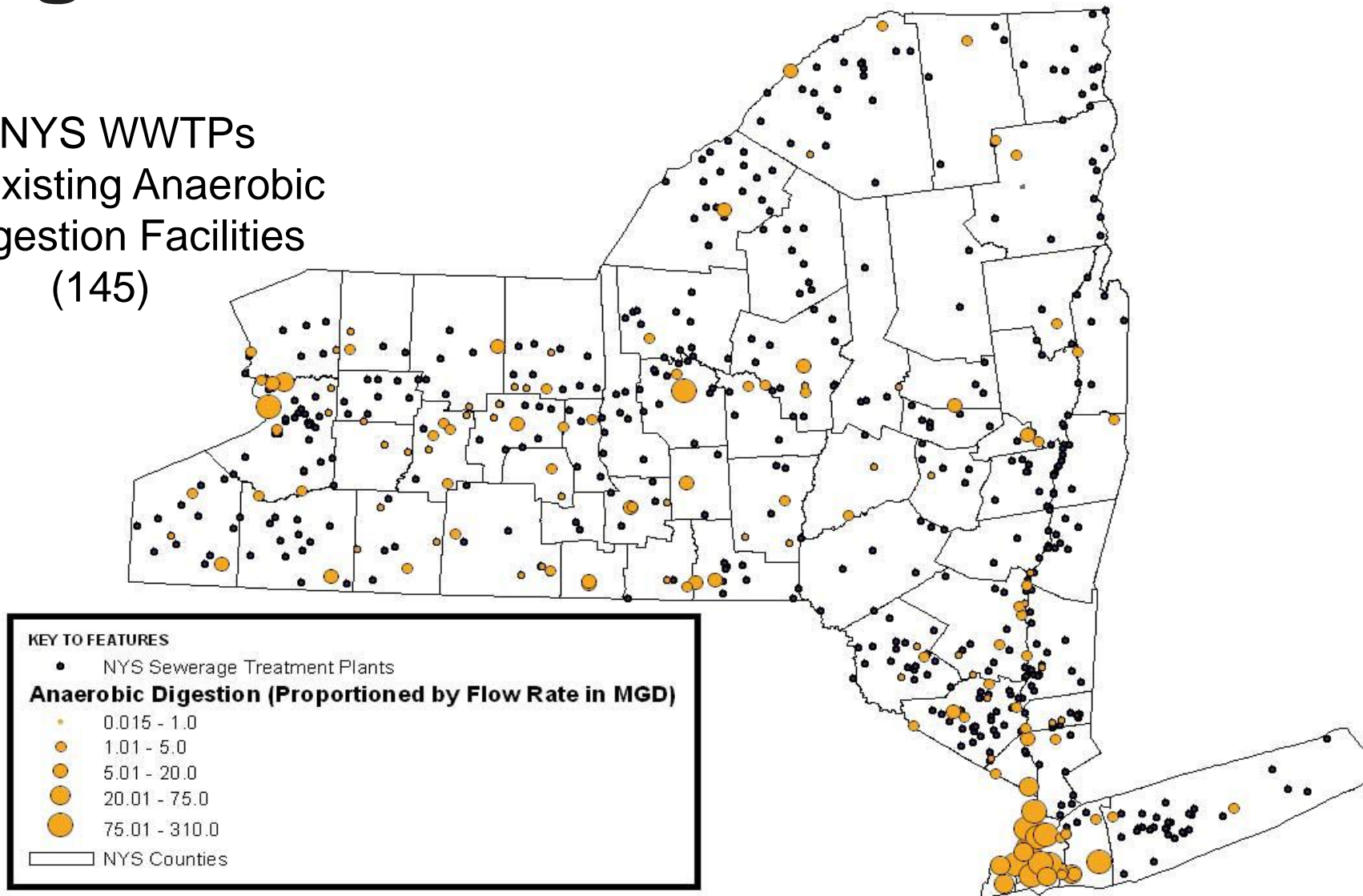
Mixing Systems

- Propellers
- Gas mixing
- Pumped recirculation system
- Linear Motion: low HP disk



Network of Wastewater Digester Locations (NYSERDA)

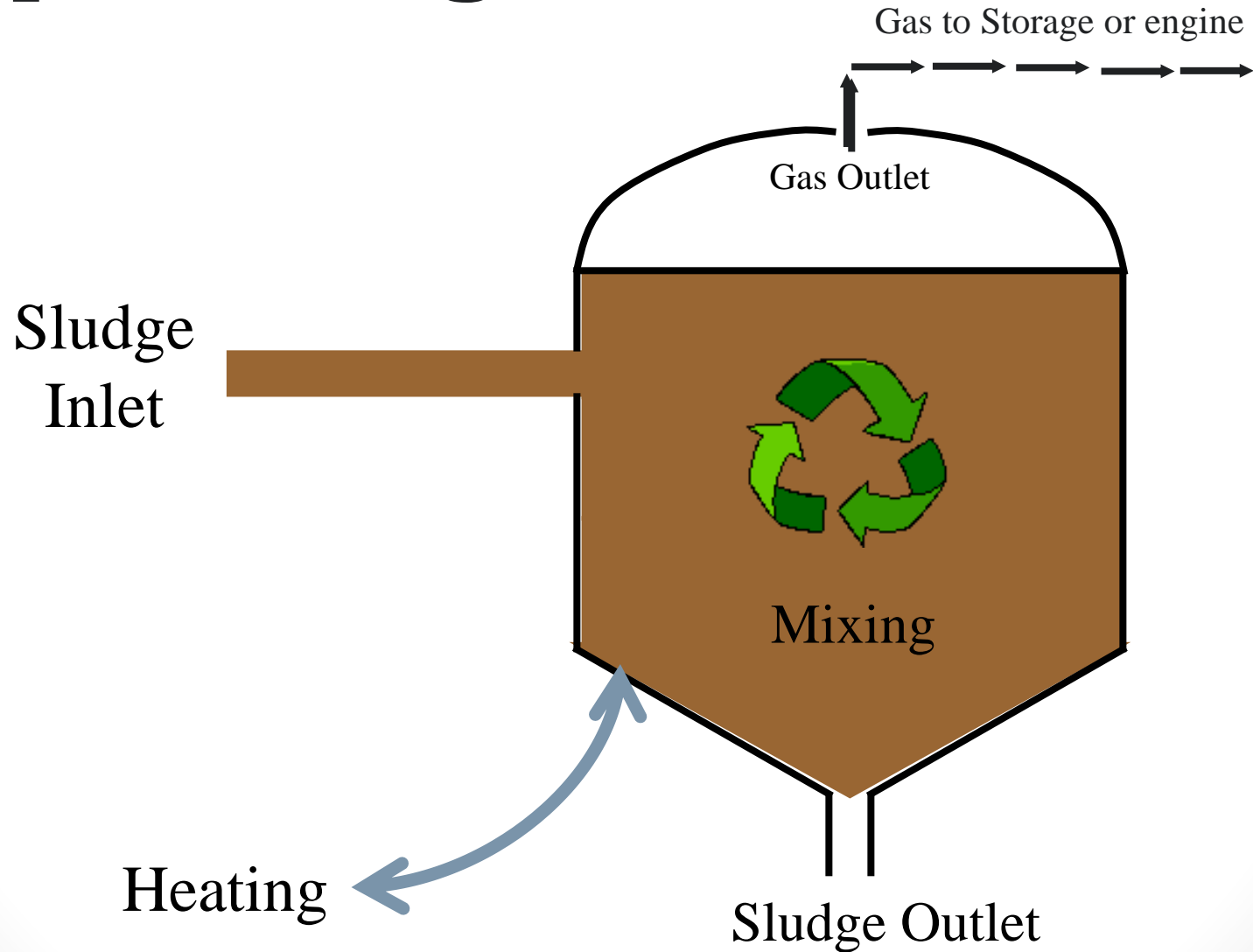
NYS WWTPs
w/Existing Anaerobic
Digestion Facilities
(145)



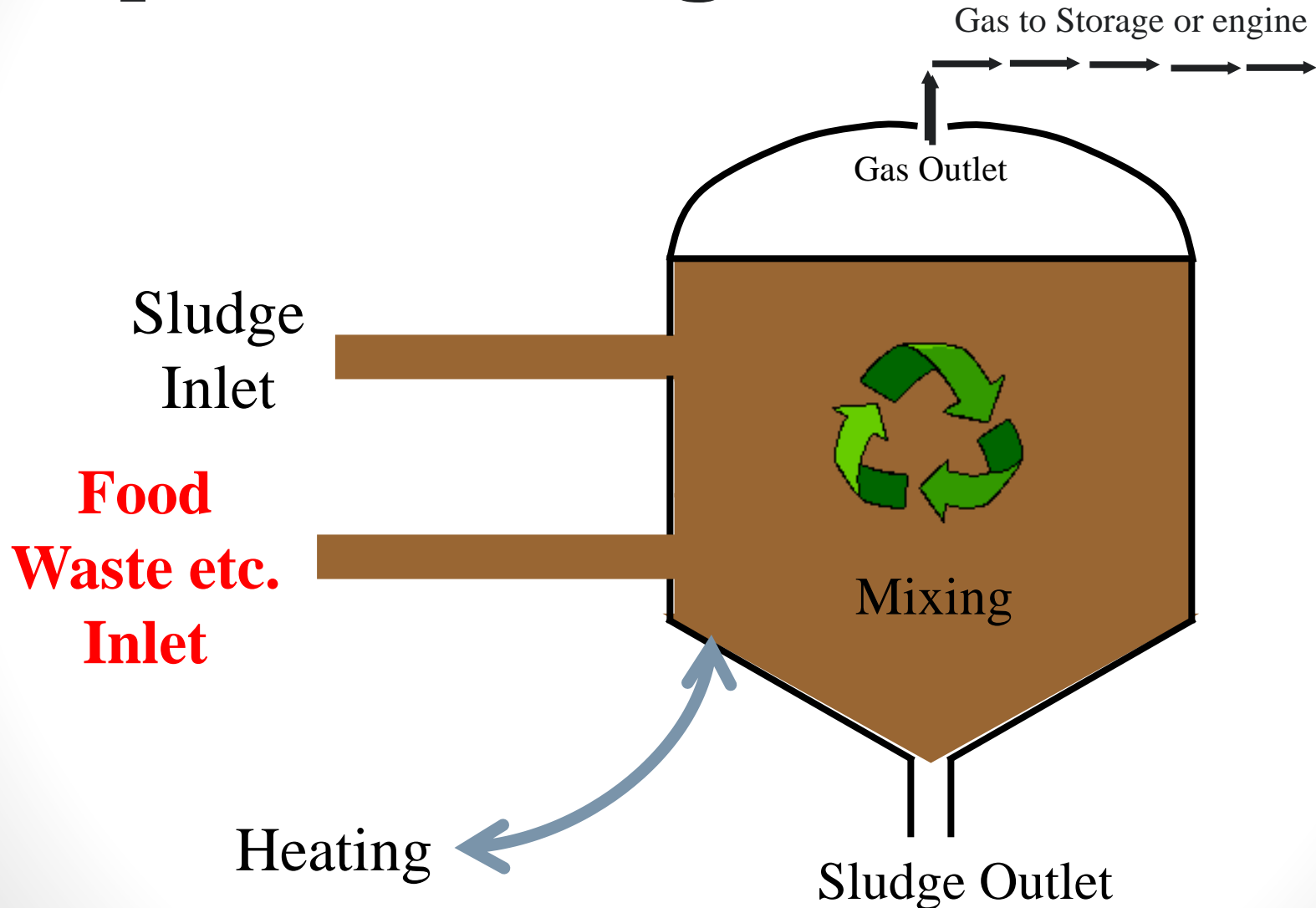
Enclosed Tanks for AD @ WWTP



Simplified Digester



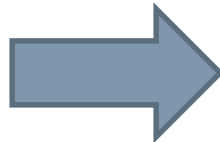
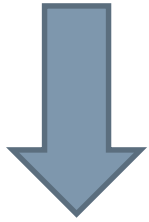
Simplified **Co**-Digester



Feeding

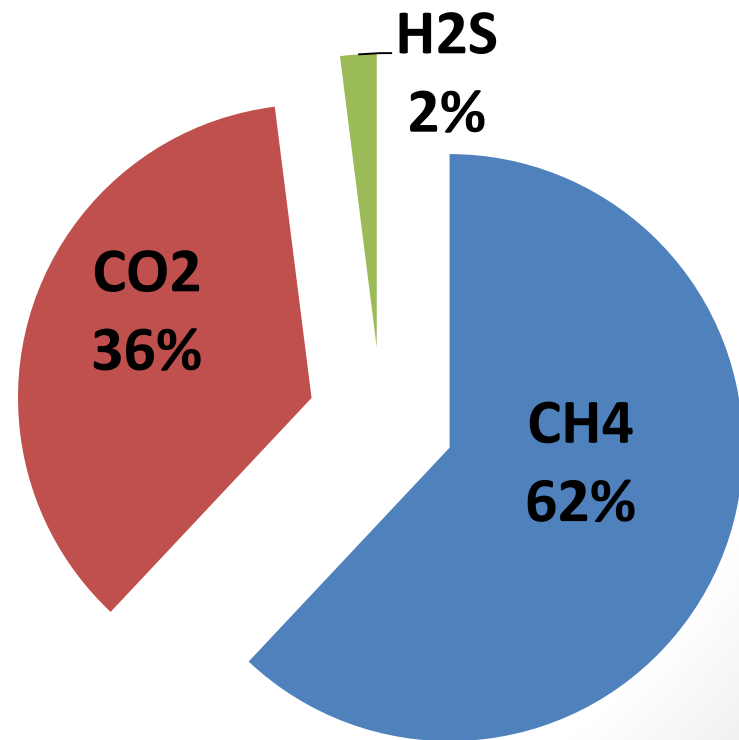
- Like us, methane formers prefer several small meals:
 - Best – continuous feed at low rate
 - Okay - Small meals, many times a day
 - Bad - One feeding a day no good
 - Too much food = too much acid
 - Think Thanksgiving dinner

Sludge, Liquid Waste, Food Waste all great AD Feedstock



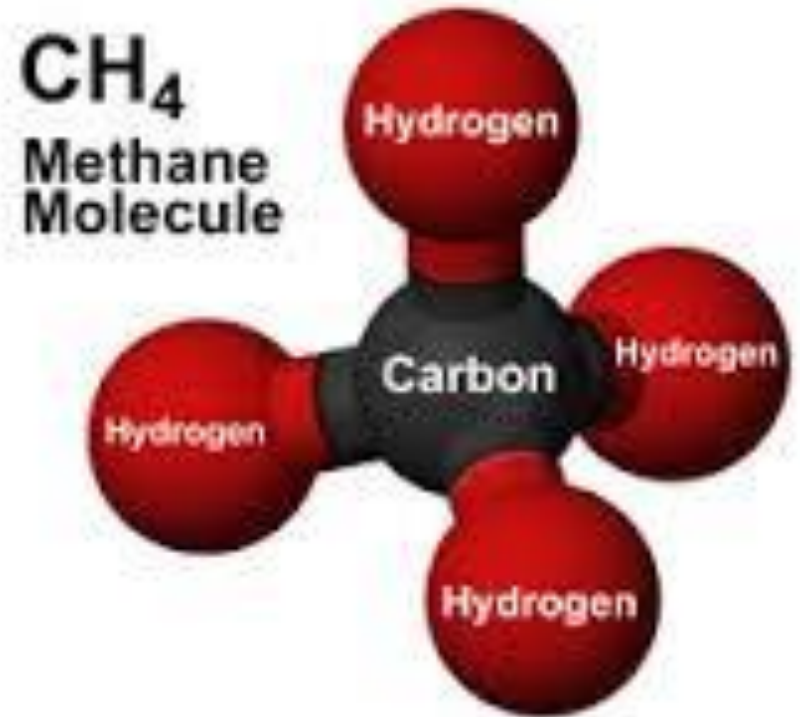
Biogas Generation

- Biogas mostly methane and CO₂
- Biogas plus oxygen and spark = flame or combustion
- Successful AD = maximum methane generation and beneficial use

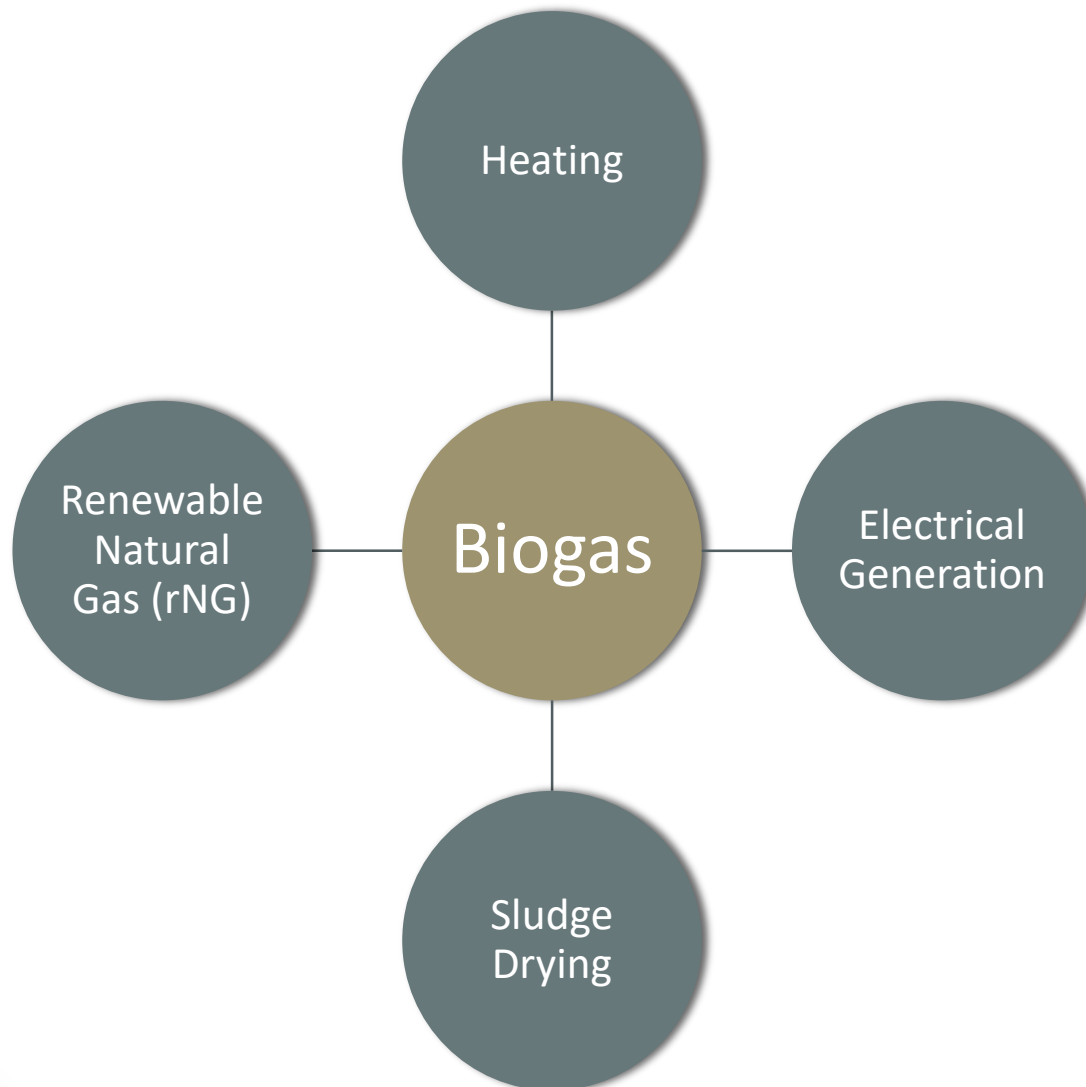


What does AD have to do with Climate?

- Methane makes up 55 – 75% of Digester Gas
- Methane to atmosphere: not a good thing
- Digesters harvest carbon: create methane molecule
- We can use biogas for beneficial use



Beneficial Uses of Biogas



Official Score 6,000 to 200:

AD in NYS

- 145 AD at wastewater
- 23 AD at farms
- ?? Industrial AD
- Total: ~200+

AD in Germany

- ~6,000 digesters constructed and operational



Questions?