

# Anaerobic Biodigestion as a Renewable Energy

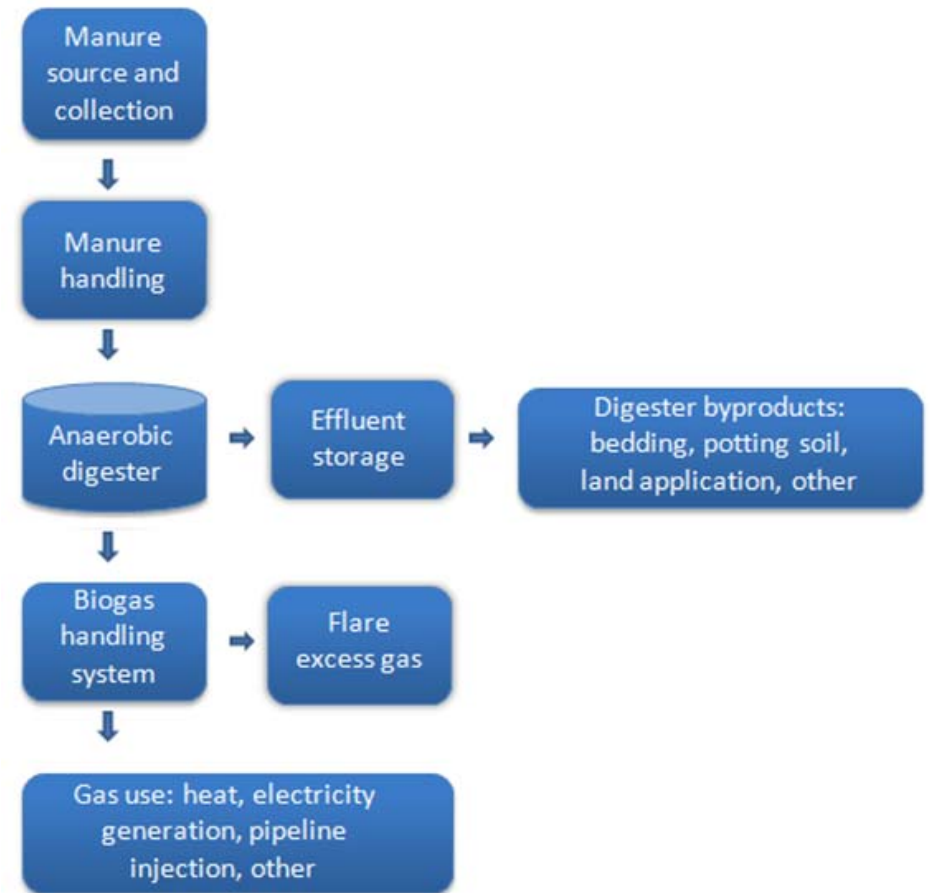
By Thomas King

# What does Anaerobic Biodigestion mean?

- Anaerobic – “without air”
- Digestion – “The process of decomposing organic matter through microbial activity”
- Anaerobic Biodigestion – slightly redundant – decomposing organic matter through microbial activity in the absence of oxygen
- Releases mostly methane, which can be used in place of traditional fossil fuels
- Often called “biogas recovery systems” – recover biogases that replace natural gases

# Process Overview

- Collection of food and sewage waste
- Filter and prepare for digestion
- Digestion of waste
- Biogas and effluent handling
- Power generation



# Wastewater collection

Sewage collected from sewer and screened for foreign objects



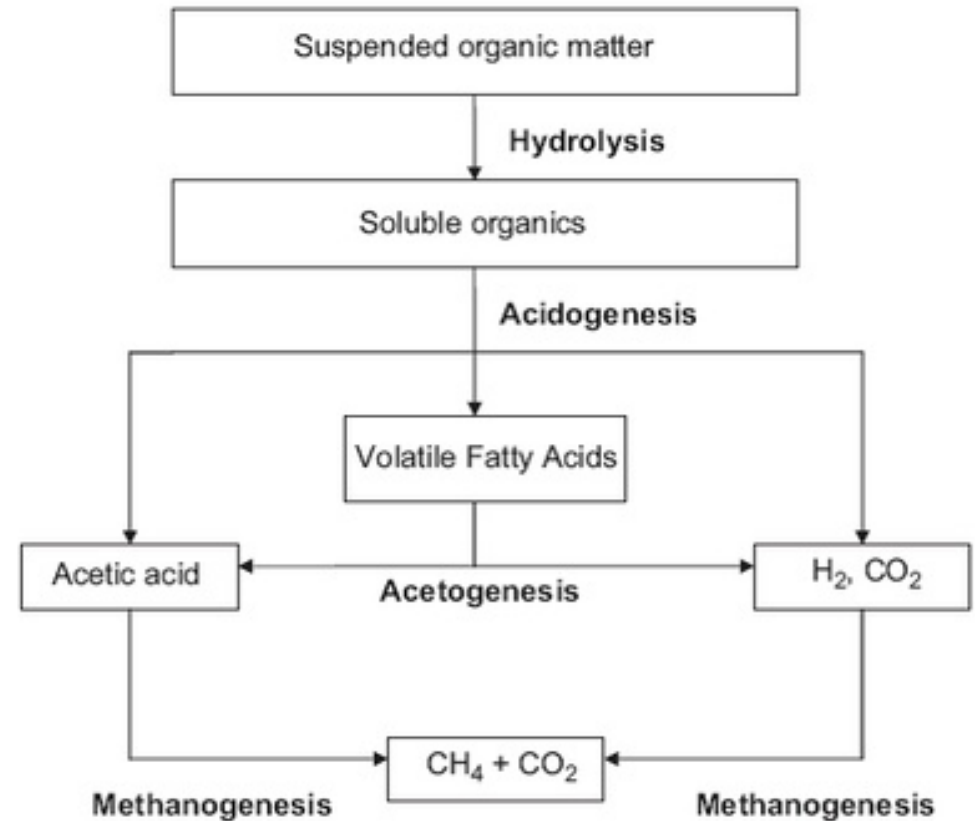
Wastewater is handled by water treatment plant



Clean water is recycled and leftover sludge is sent off for digestion.

# Digestion Process

- 4 Stages:
  1. Thermal Hydrolysis
  2. Acidogenesis
  3. Acid Fermentation
  4. Methanogenesis
- Sequential in nature, but all happening simultaneously inside digester.



# Digestion Process

- 4 Stages:

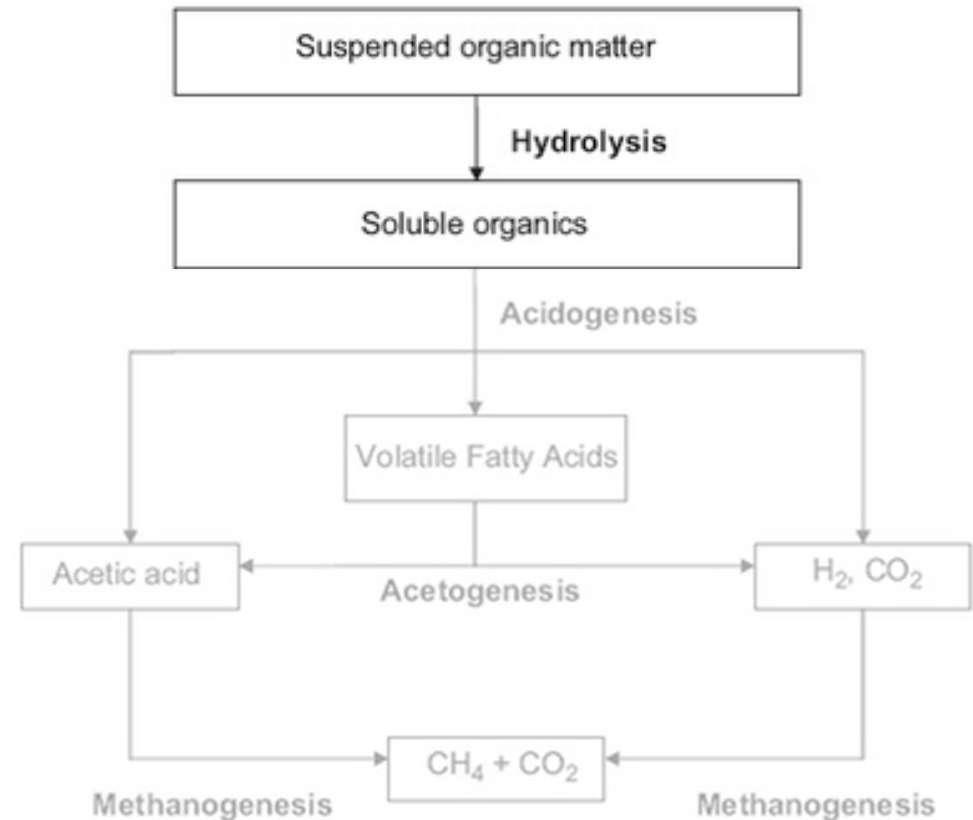
1. Thermal Hydrolysis

- Pre-treatment for digestion, makes waste more biodegradable
- High-pressure boiling of waste, followed by rapid decompression
- Disintegrates cell structure/organic materials
- Bacteria ferment products of hydrolysis and dissolve cell polymers into more fluid-like sludge that is easy to digest

2. Acidogenesis

3. Acid Fermentation

4. Methanogenesis



# Digestion Process

- 4 Stages:

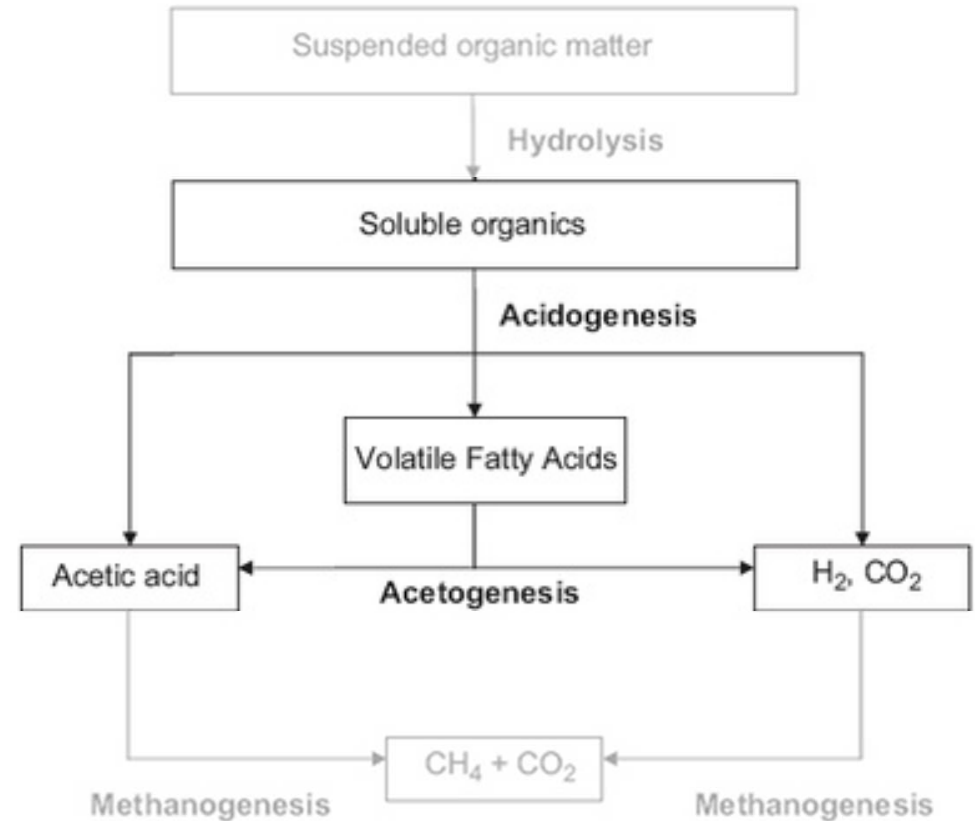
1. Thermal Hydrolysis

2. Acidogenesis

- Natural Hydrolysis
- Anaerobic bacteria break down remaining fats, proteins, and polysaccharides.
- They then ferment these products, creating simple organic compounds and hydrogen

3. Acid Fermentation

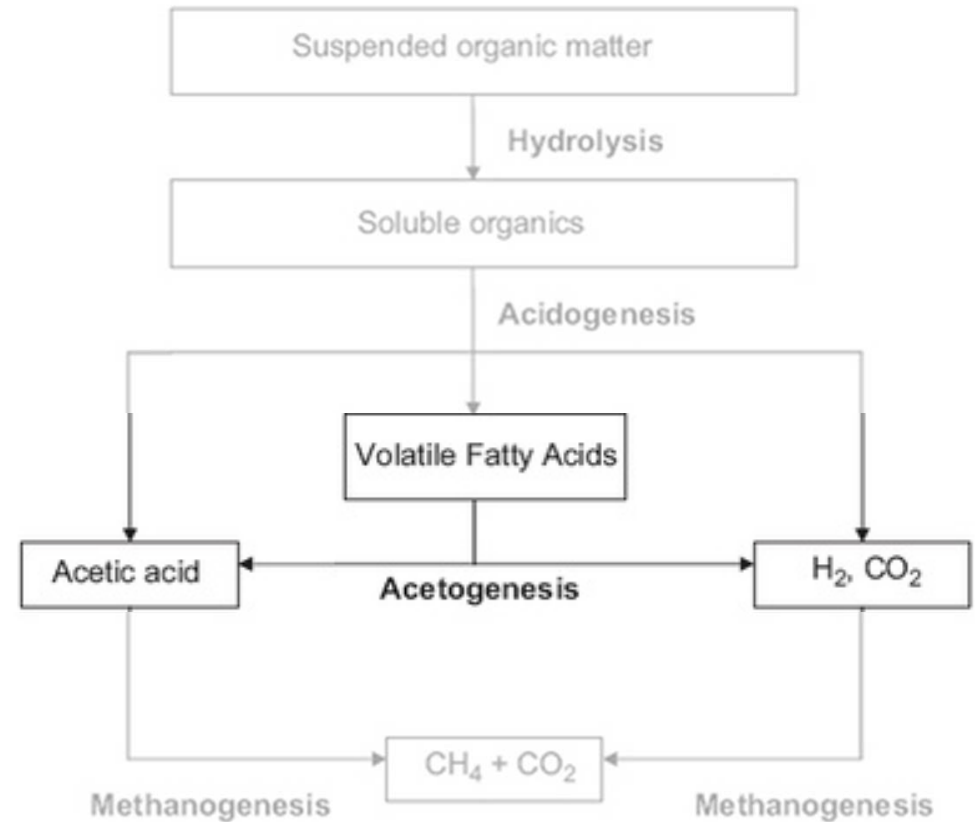
4. Methanogenesis



# Digestion Process

- 4 Stages:

1. Thermal Hydrolysis
2. Acidogenesis
3. Acid Fermentation
  - Organic material converted to organic acids, alcohols, and new bacterial cells.
4. Methanogenesis



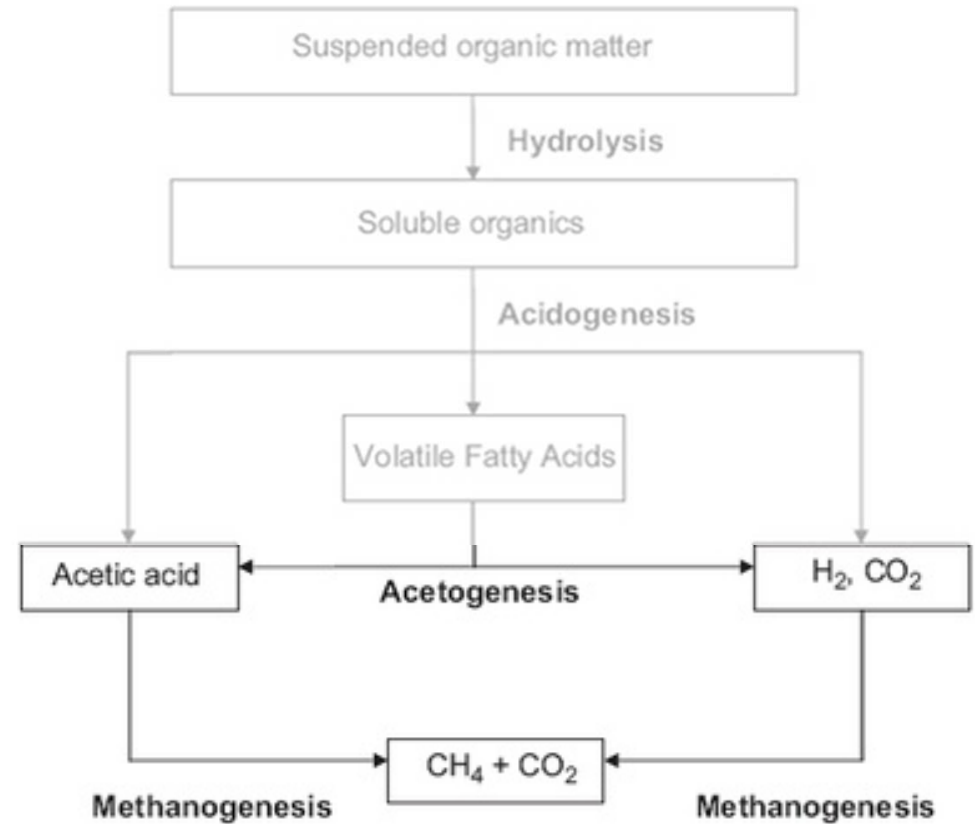


# Digestion Process

- 4 Stages:

1. Thermal Hydrolysis
2. Acidogenesis
3. Acid Fermentation
4. Methanogenesis

- Anaerobic bacteria convert these new products into gases (mainly CH<sub>4</sub>, and CO<sub>2</sub>)



# Types of Anaerobic digesters

- Complete Mix Digester
- Covered Anaerobic Lagoon
- Plug Flow Digester



<http://www.epa.gov/agstar/anaerobic/ad101/anaerobic-digesters.html>  
[http://commons.wikimedia.org/wiki/File:Klaerwerk\\_Emschermuendung.jpg](http://commons.wikimedia.org/wiki/File:Klaerwerk_Emschermuendung.jpg)

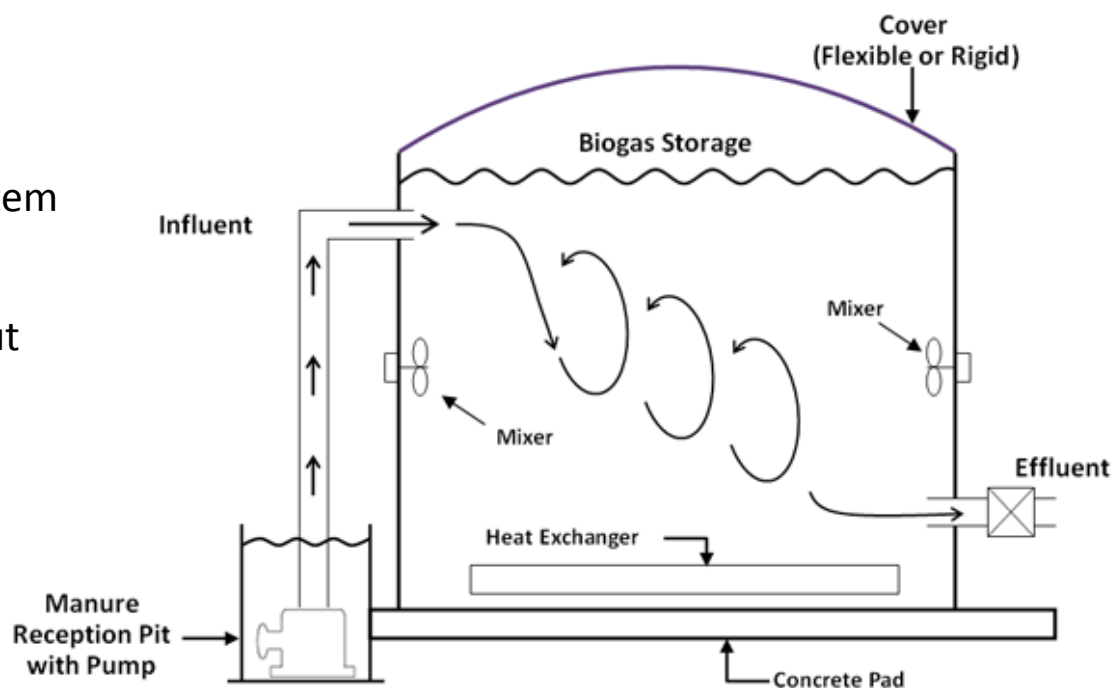
# Types of Anaerobic digesters

- **Complete Mix Digester**

- Most common
- Closed, heated tank with gas mixing system
- Rigid or flexible cover
- Influent pumped in, effluent pumped out
- Enormous

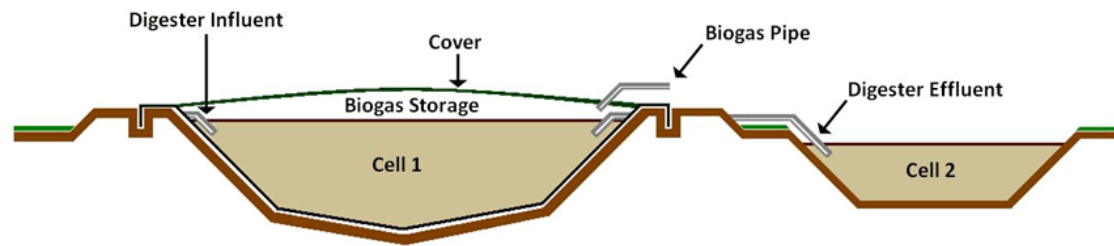
- Covered Anaerobic Lagoon

- Plug Flow Digester



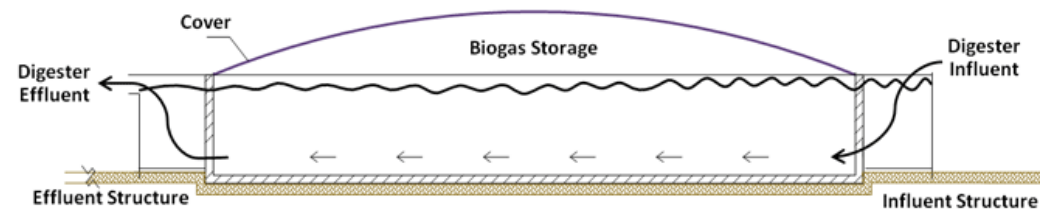
# Types of Anaerobic digesters

- Complete Mix Digester
- Covered Lagoon
  - Sealed with flexible cover
  - Methane gas recovered and piped out from the top.
  - Effluent can be piped to separate cell
  - Can use single cell for both digestion and storage
- Plug Flow Digester



# Types of Anaerobic digesters

- Complete Mix Digester
- Covered Anaerobic Lagoon
- Plug Flow Digester
  - Long concrete tank with either rigid or flexible cover.
  - Built below ground level to limit need for extra heat
  - Optimized to perform in any climate
  - Typically used at Dairy farms where manure is scraped into system



# Biogas Handling and Processing

Digester Produces raw biogas



If humid, remove moisture to get dry gas



Remove any impurities (sulfide, siloxane)



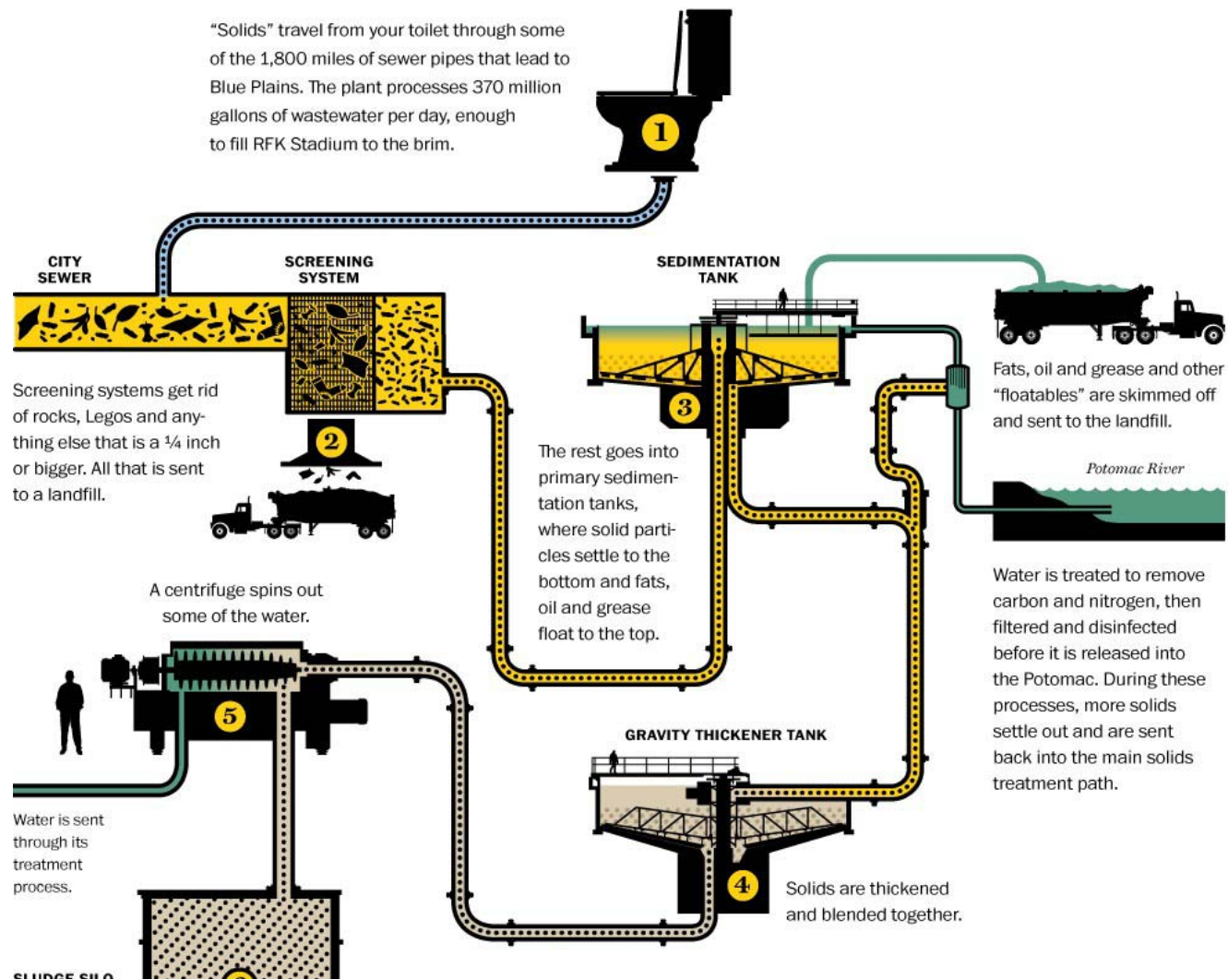
Ready for pumping to generator to make electricity. Or, remove CO<sub>2</sub> and compress gas for automotive use and other gas powered utilities.

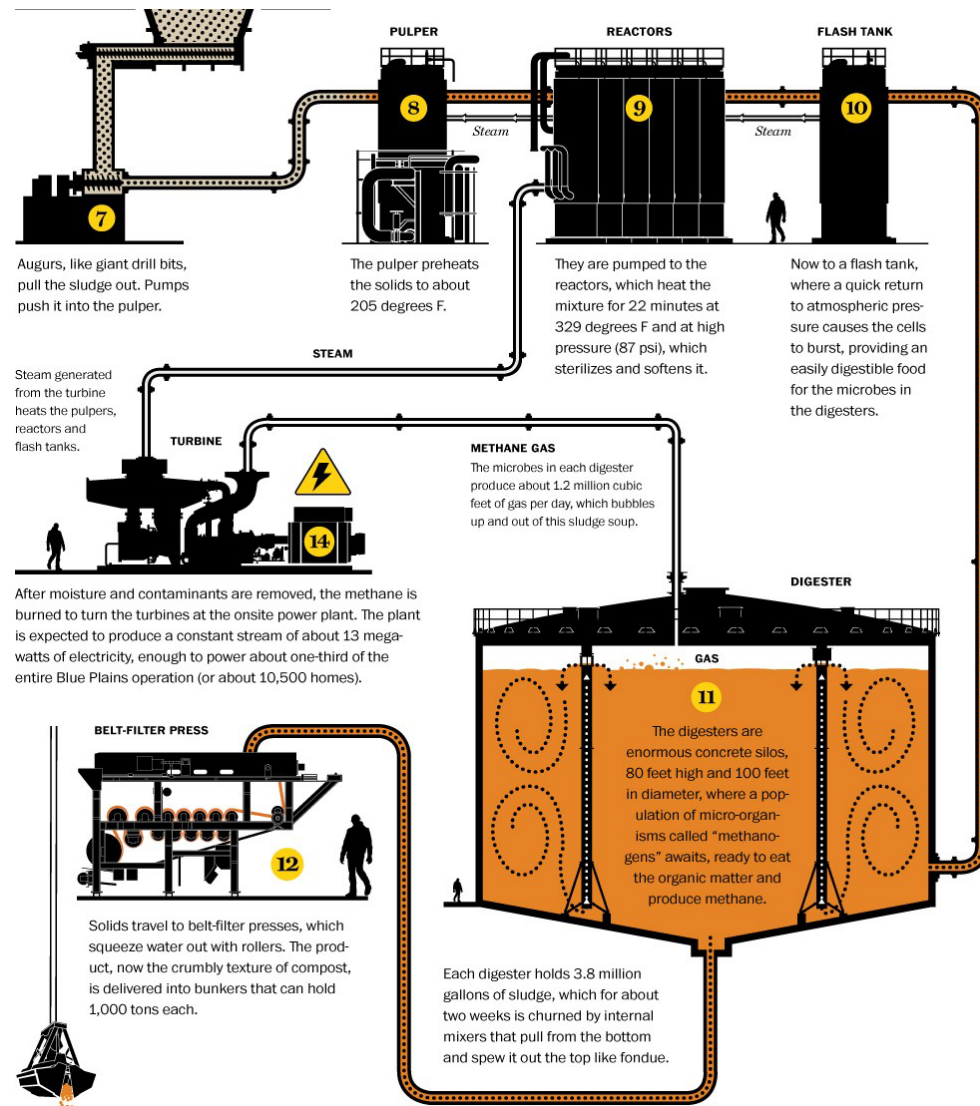
# Biogas Uses

- Biogas most often used to generate electricity for on-site use or for sale
- Waste heat from electrical generators can be recycled to heat digesters or buildings
- Gas can also be pumped into gas grid or used to power automobiles
- Effluent from digestion processed is compressed and sold or used as fertilizer

# Putting It All Together







# Current Use



- Oslo, Norway – biogas plant processes 50,000 pounds of food waste annually
  - Converted to biogas to power 135 city busses
  - Provide natural fertilizer for 100 small farms
- Washington DC – first in North America
  - Built by same Norwegian company
  - \$470 million system
  - Less than a year old

<http://ens-newswire.com/2012/03/23/food-waste-to-fuel-oslos-city-buses/>  
<http://www.cambi.no/wip4/detail.epl?cat=10643&id=1006317>

# Overview / Future

- Most efficient way of dealing with waste (human and food)
- Renewable resource
- Used mostly by municipal waste plants where wastewater treatment is already in place
- Relatively new technology, slow acceptance