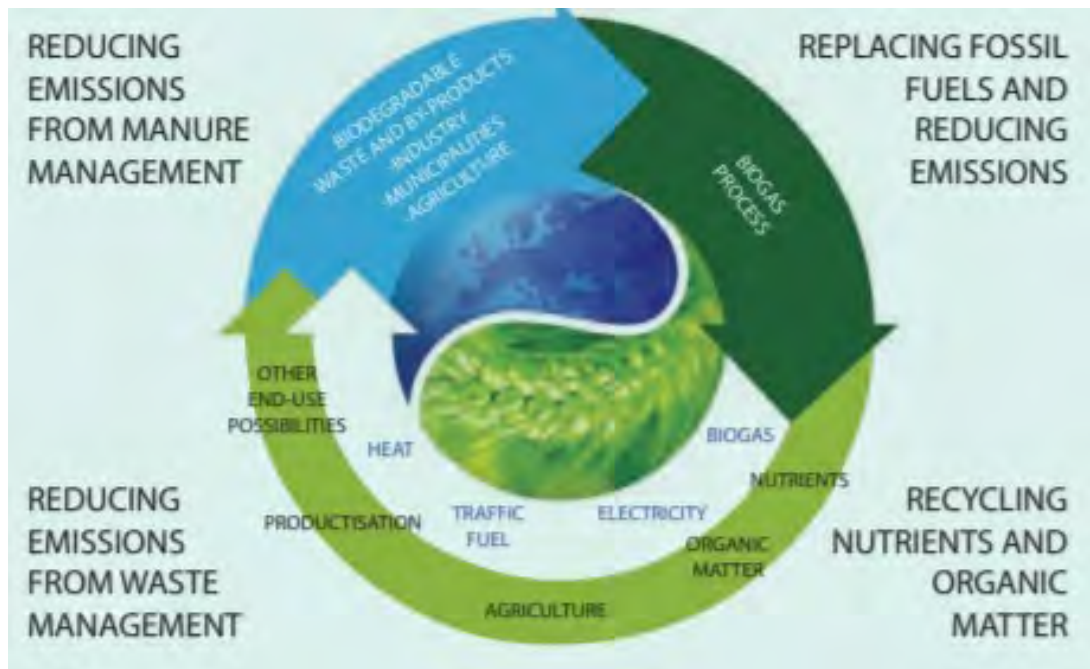


# Don't throw it away!

## Recovering Energy from Food Waste

Jan DeWaters<sup>1</sup>, Stefan Grimberg<sup>2</sup>



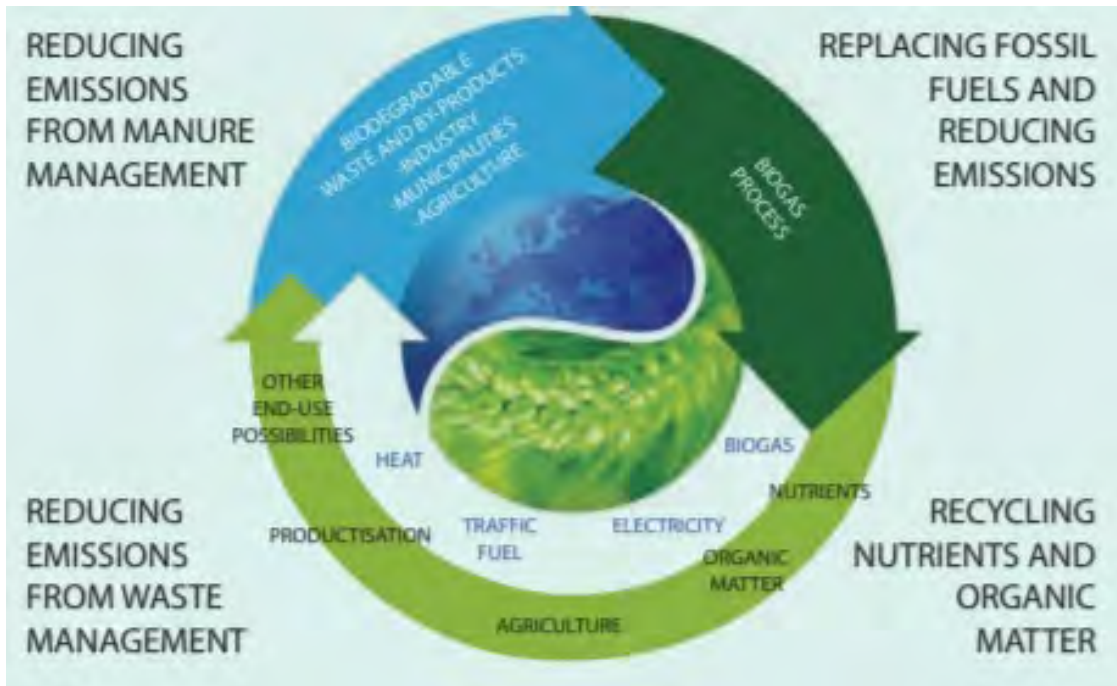
<sup>1</sup>School of Engineering and STEM Institute, Clarkson University

<sup>2</sup>Civil Environmental Engineering, Clarkson University



Clarkson™

# Food to Energy: Cross-fertilizing a K12/University Partnership to develop a Resource Recover Program



A funded partnership in our second year



# Part 1. Let's Talk Trash

Do you know how much the average American 'throws away' each day?

*According to the EPA, the average American person will produce about 5.91 pounds of trash, with about 1.51 pounds being recycled; **4.40 pounds is the rough average daily waste per person.** (epa.gov)*





## MSW Generation Rates 1960 to 2014

# Part 1. Let's Talk Trash

*According to the EPA, the average American person will produce about 5.91 pounds of trash, with about 1.51 pounds being recycled; **4.40 pounds is the rough average daily waste per person.** (epa.gov)*

Do you know what happens to the things that you 'throw away'? (WHERE is AWAY?)



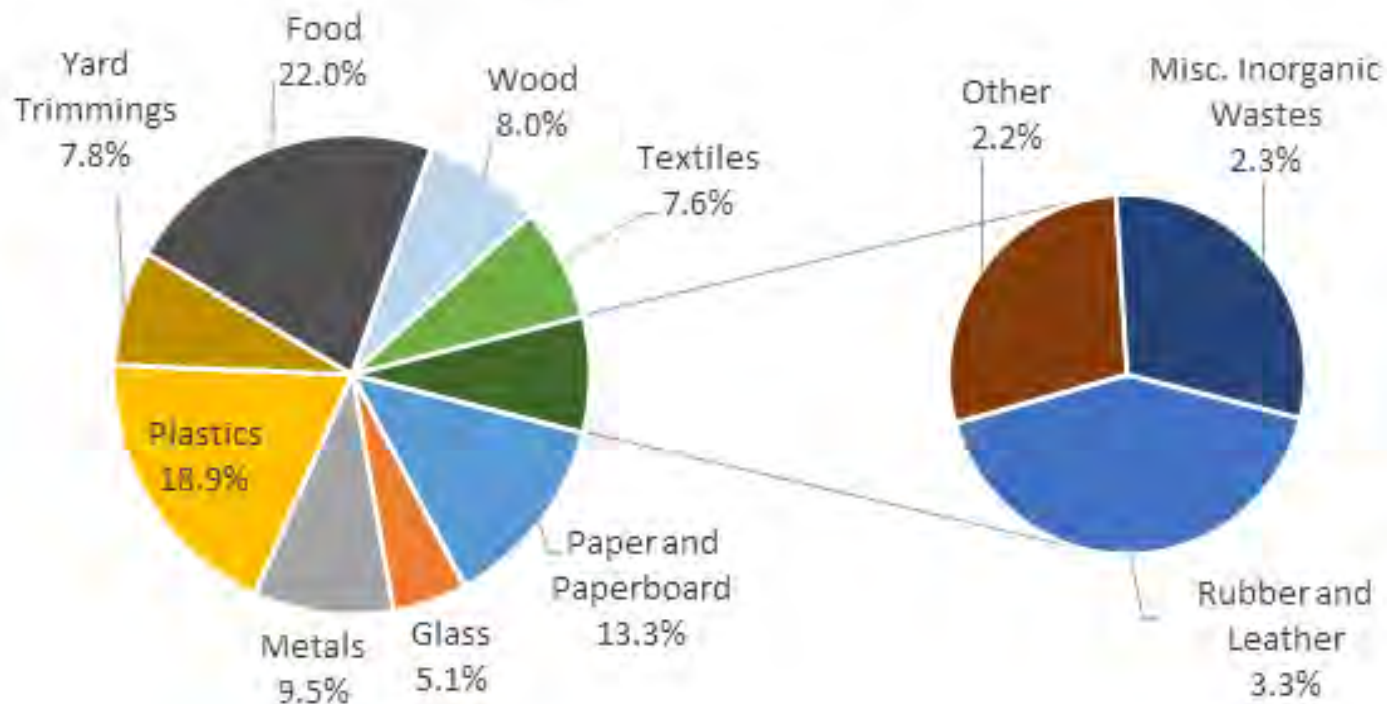
# Development Authority of the North Country (DANC) Solid Waste Management facility Rodman, NY



*The solid waste generated in St. Lawrence County is brought to the DANC Solid Waste Management Facility (Landfill) in Rodman, NY*

# What goes to the landfill

Total MSW Landfill by Material, 2015  
(137.7 million tons)



About 36.39 million tons on food waste is buried in U.S. landfill each year

- With limited oxygen, water, sunlight, and organisms food waste decomposes very slowly

# Trash vs. Recycling vs. ....? ....

Not all of our waste belongs in the landfill!

Let's look at some typical items and talk about where they should go when we are finished with them.



Trash vs. Recycling vs. ....? ....

# Where Does the Trash Go?

[Landfill and Garbage video](#) (~4 min)

[Large scale resource recovery operation video](#) (~5 min)



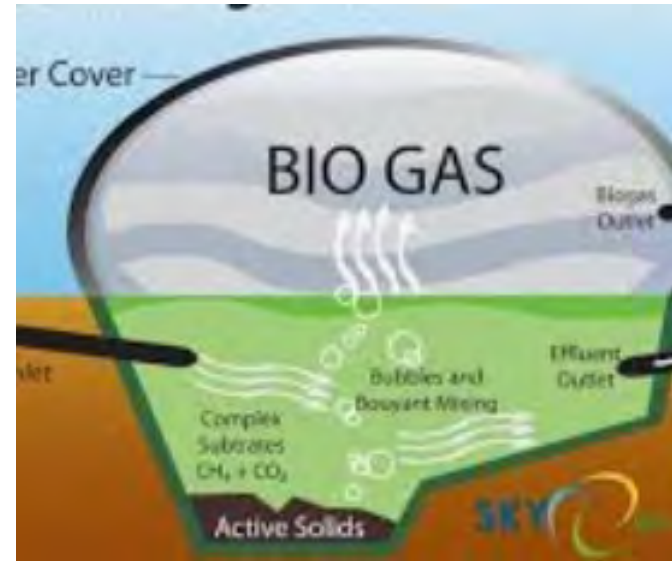
# What to do with Trash?

Options:

Composting



Anaerobic  
Digestion



Recycling



Incineration



Landfill



Or, special handling?



# North Country Recycles

DEVELOPMENT AUTHORITY OF THE NORTH COUNTRY

Jefferson County

Lewis County

St. Lawrence County

Education & Outreach



<https://www.northcountryrecycles.org/>

## Upcoming Household Hazardous Waste Collection

August 28, 2019

The Development Authority of the North Country, in cooperation with its regional county partners and the New York State Department of Environmental Conservation, will be sponsoring three free household hazardous waste collection days this fall to help residents in Jefferson, St. Lawrence and Lewis c...

[More Info](#)



News



Recycling Map



Materials Memos



Learn More



Calendar



Contact Us

## How Do I Dispose Of...?

Below is a list of materials and directions on how to dispose of them properly.

If there are any questions or materials that are not answered or listed below, please [contact us!](#)

**Aerosol Cans**

**Ammunition and Explosives**

**Antifreeze**

**Asbestos Products**

**Batteries**

**Bulky Rigid Plastics**

**Cardboard Products**

**Cleaning Products**

**Clothing Hangers**

**Construction and Demolition Debris**

**Dishware**

**Driveway Sealer**

**Egg Cartons**

# Focus on Food: Food Waste Trivia

Americans waste an unfathomable amount of food. In fact, according to [a \*Guardian\* report](#) , roughly 50 percent of all produce in the United States is thrown away—some 60 million tons (or \$160 billion) worth of produce annually, an amount constituting “one third of all foodstuffs.”



# How long does paper take to degrade in landfills?

Paper takes typically 2 weeks or as much as 5 months to degrade in a landfill. This may true for most cases, but researchers have found:

- Newspapers dated back 40 years.
- 40 year old hot dogs
- 25 year old lettuce
- Guacamole from 1967!

William L. Rathje, professor of archeology at the University of Arizona studies garbage as insight into human behavior. The only way to know who a people are is by what they throw away he says.

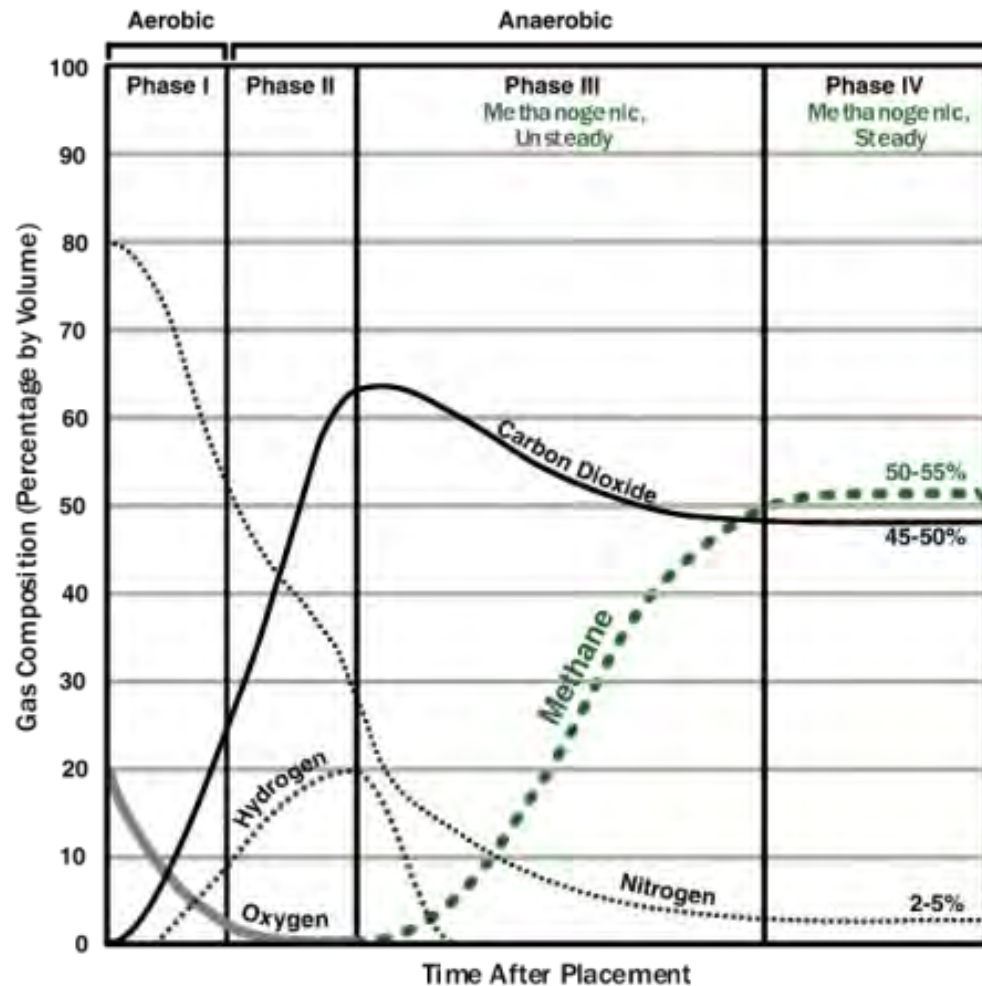


**The garbage dumped in landfills tends not to biodegrade. It becomes mummified.”**

# So what is the big deal with disposing organic waste in landfills?

## BUT WHEN IT DOES DEGRADE .....

- Methane gas is 23 times more powerful than carbon dioxide and it's one of the biggest contributing factors to global warming.



Most older landfills are not set up to recover methane

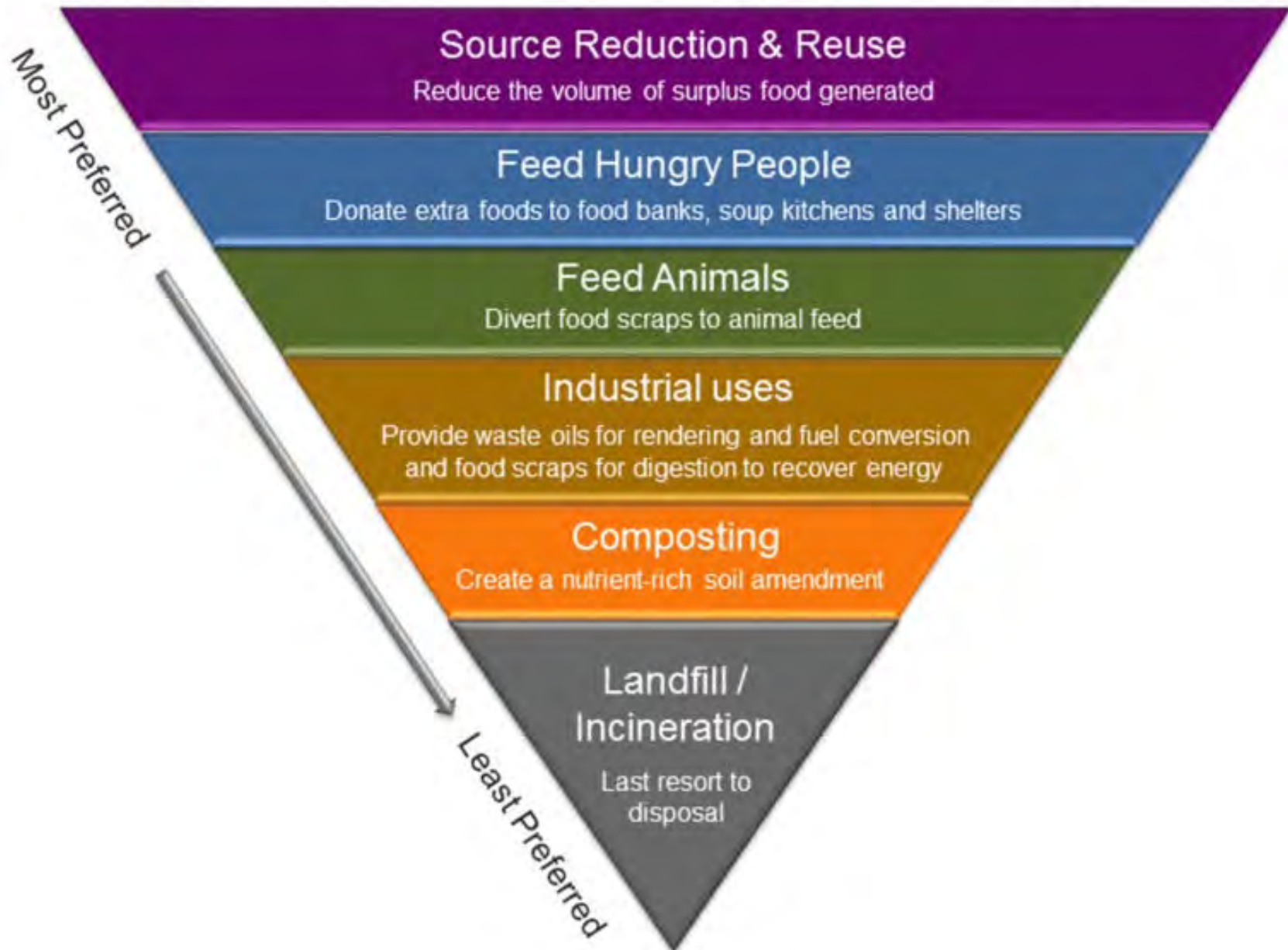
According to U.S. EPA  
Municipal solid waste  
(MSW) landfills are the  
**third-largest source of  
human-related methane**  
emissions in the United  
States, accounting for  
approximately 15.4  
percent of these  
emissions in 2015.







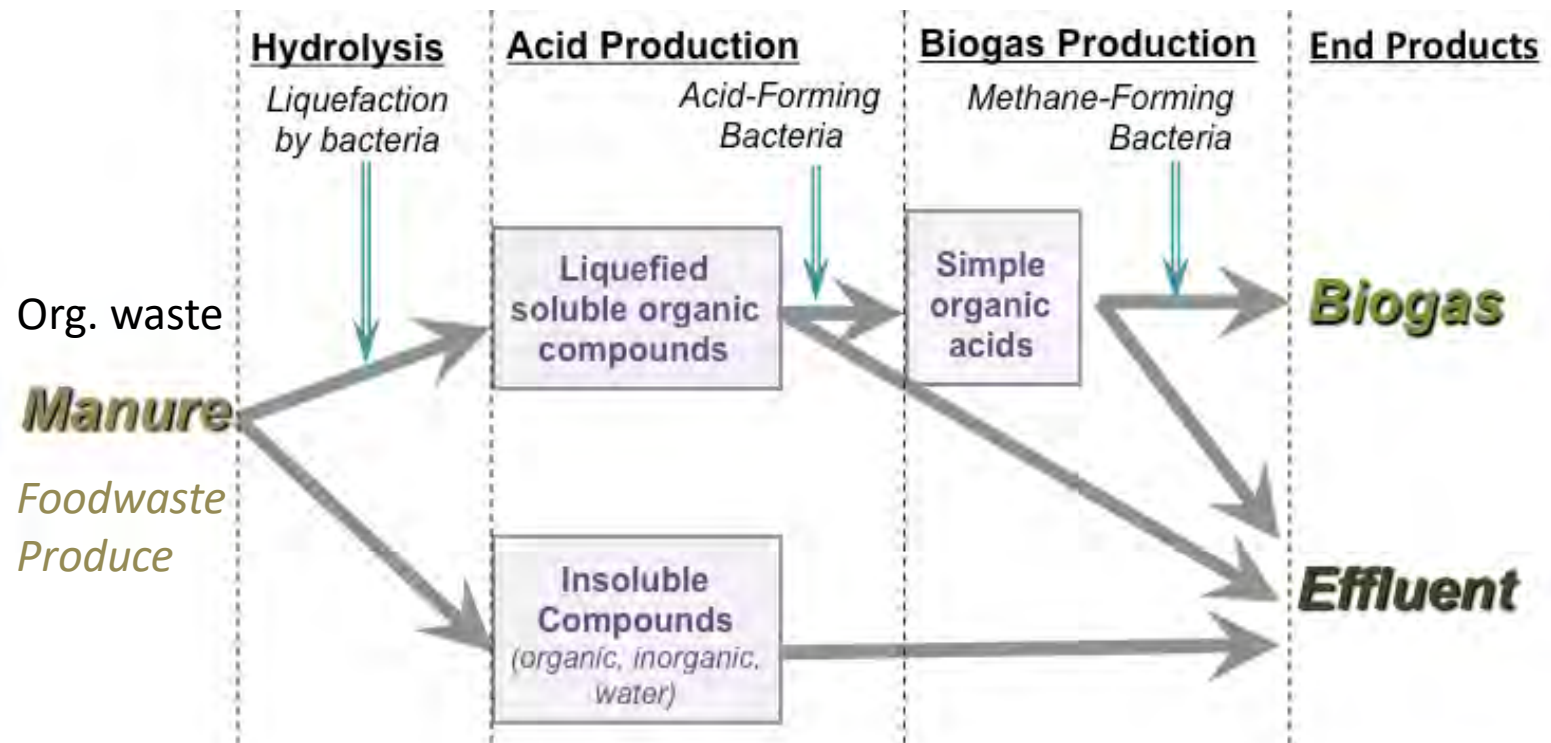
# Food Recovery Hierarchy



# Introduction to Anaerobic Digestion

## Process Description

- **Anaerobic digestion:** Degradation of organic matter by microbes without oxygen



# Process Description: Operation

## How much energy is in biogas?

- Average fuel value of methane = 1000 BTU/ft<sup>3</sup>
- Average fuel value of propane = 2500 BTU/ft<sup>3</sup>
  - Propane produces 2.5 times more energy per unit of volume

**Example:** We want 40 lbs of propane-equivalent

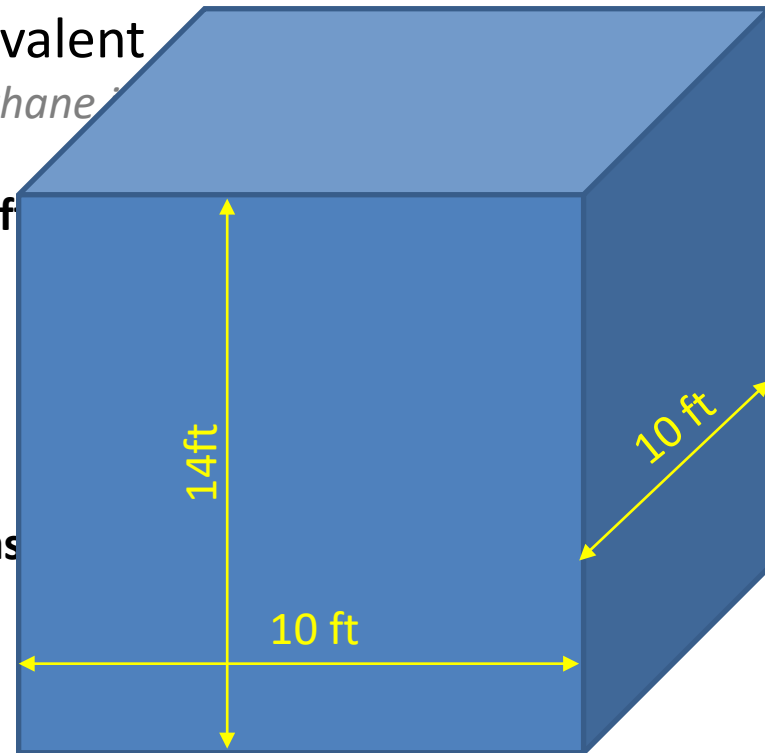
----- assume 60% methane

$$40 \text{ lbs. propane} \times \frac{1 \text{ gallon}}{4.2 \text{ lbs.}} \times \frac{35.97 \text{ ft}^3}{\text{gallon}} = 342.57 \text{ ft}^3$$

$$856,430 \text{ BTU} \times \frac{1 \text{ ft}^3 \text{ methane}}{1,000 \text{ BTU}} = 856 \text{ ft}^3 \text{ methane}$$



$$856 \text{ propane} \times \frac{1 \text{ ft}^3 \text{ biogas}}{0.6 \text{ ft}^3 \text{ methane}} = 1427 \text{ ft}^3 \text{ biogas}$$



# Small Digesters



Capacity: 6 liters (1.5 gal)/day of food waste or 20 liters (5 gal)/day of animal manure.

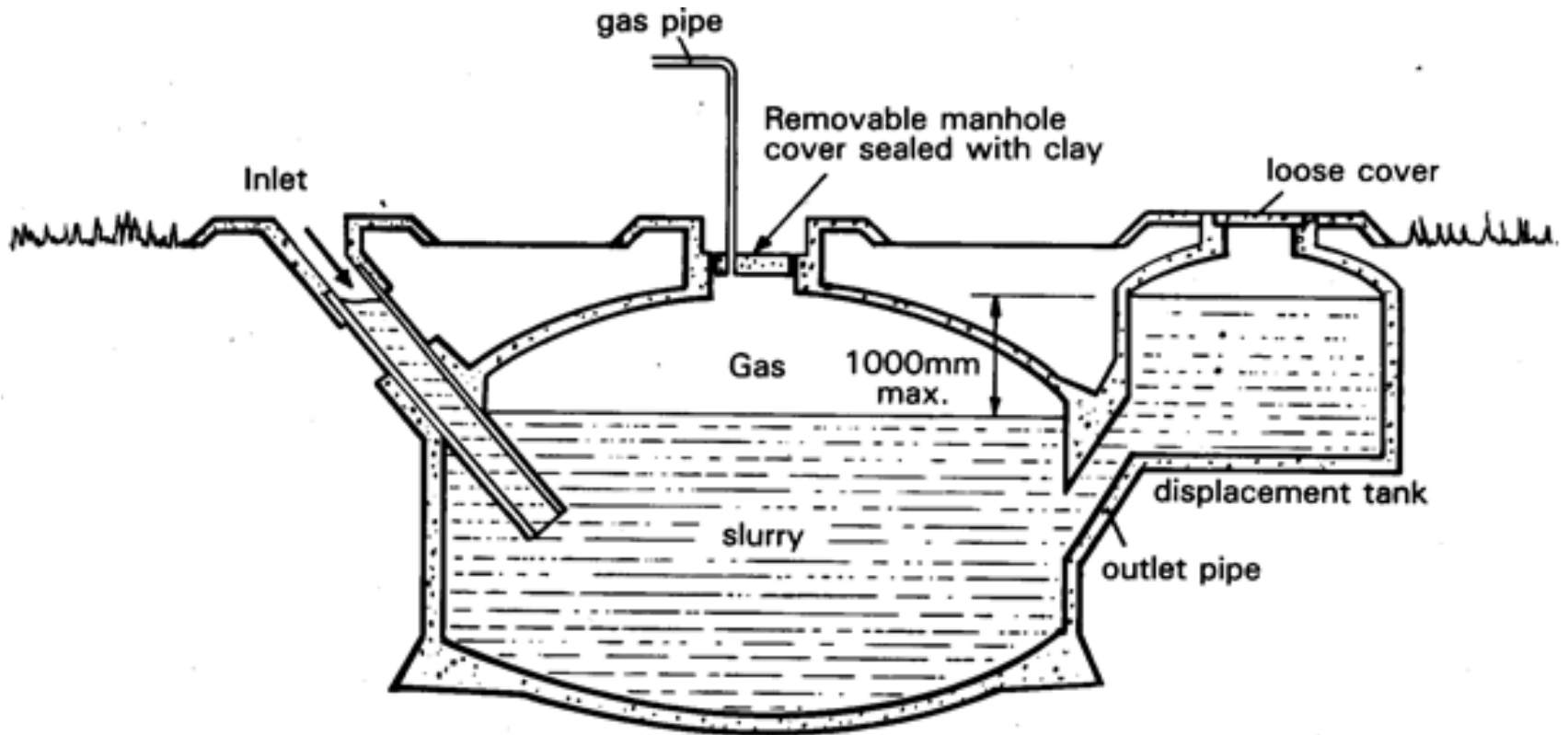
No heating (optimum at 20°C),  
no mixing



Every kilo of food waste recycled with HomeBiogas 2.0 produces about 200 liters of biogas, the amount needed for approximately one hour of cooking.

<https://homebiogas.com/>

# Digesters in Developing Countries



No heating, no mixing

# Digester in Cuba for Hog Manure Treatment



Manure of 4-6 pigs provides enough gas for cooking

Cardenas, Cuba



# Multifamily Digester

Cardenas, Cuba



Manure of 20+ pigs provides cooking gas for several households

## *Introduction to Anaerobic Digestion*

# Process Description: Compatible Wastes

- ***Wastes that yield biogas***

- Manure
- Waste grass, corn and silage
- Slaughterhouse waste
- Fats, oils and grease from restaurants
- Organic household waste such as food



Add this waste to digesters

- ***Wastes that do not***

- Fiber rich waste such as wood, leaves, etc.
- Plastics or other refractory organics
- Inorganic materials (salts, metals, sand, etc.)



Good for compost but not for anaerobic digester

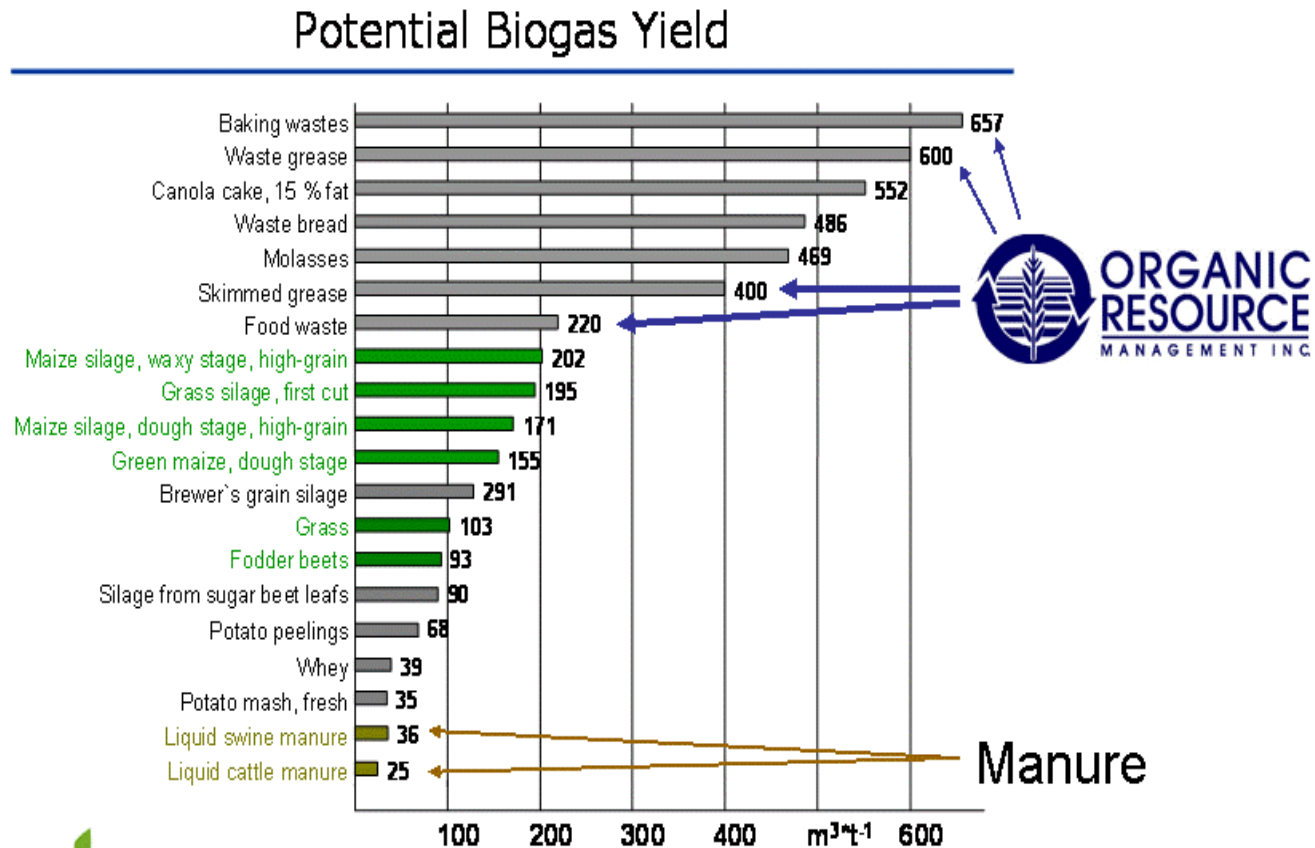


Don't add this waste to digesters



# Food Waste Potential

- Food waste has higher biogas potential than other sources like agriculture and wastewater sludge.



# What's going on at Canton Central School?

A Partnership between:  
Canton public schools -

Financial support provided by



Megan Smith, Tom van de Water, Jim Burdick, Kristen Ames  
Cornell Cooperative Extension - Nick Hamilton-Honey  
Clarkson University - Jan DeWaters, Stefan Grimberg

It's more than just  
teaching students  
about how to  
minimize their waste!



# Food-to-Energy: Cross-Fertilizing a K12/University Partnership to develop a Resource Recovery Program



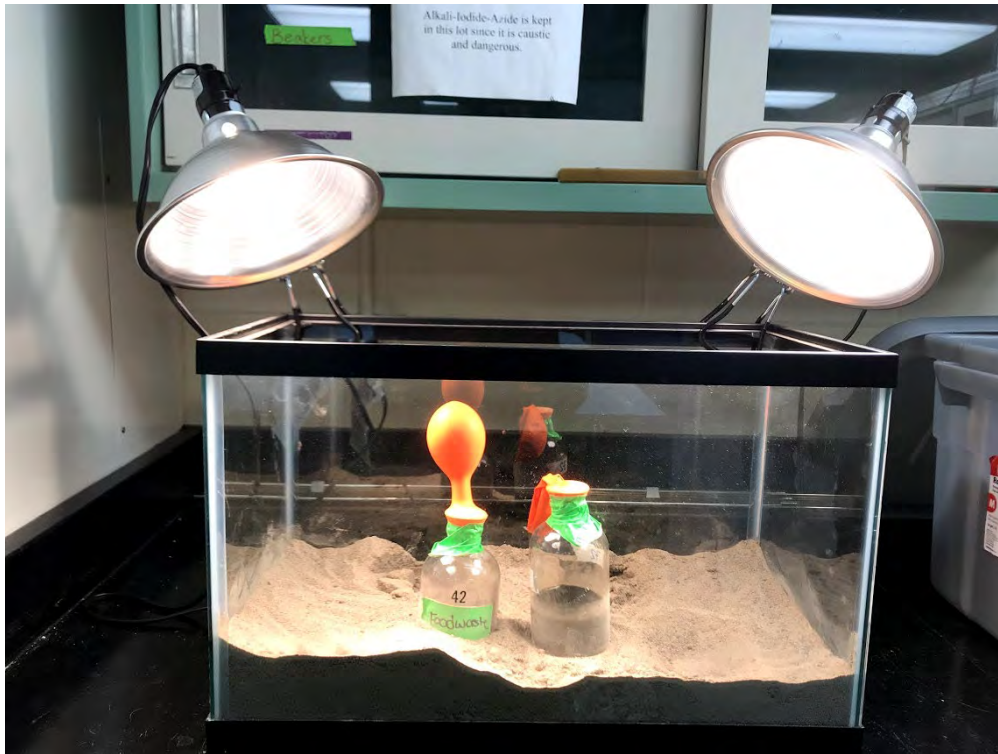
- (1) educates students about anaerobic digestion (AD) of organic solid waste
- (2) increases source separation behavior at Canton Central School District
- (3) can be replicated at other regional schools

# Food-to-Energy: Cross-Fertilizing a K12/University Partnership to develop a Resource Recovery Program



Task 1:  
Cafeteria food waste  
separation program

# Food-to-Energy: Cross-Fertilizing a K12/University Partnership to develop a Resource Recovery Program



Task 2:

Classroom Education  
(w/ curriculum development  
and teacher PD)

# Food-to-Energy: Cross-Fertilizing a K12/University Partnership to develop a Resource Recovery Program



## Task 3: Field Trips



# Digester Field Trips

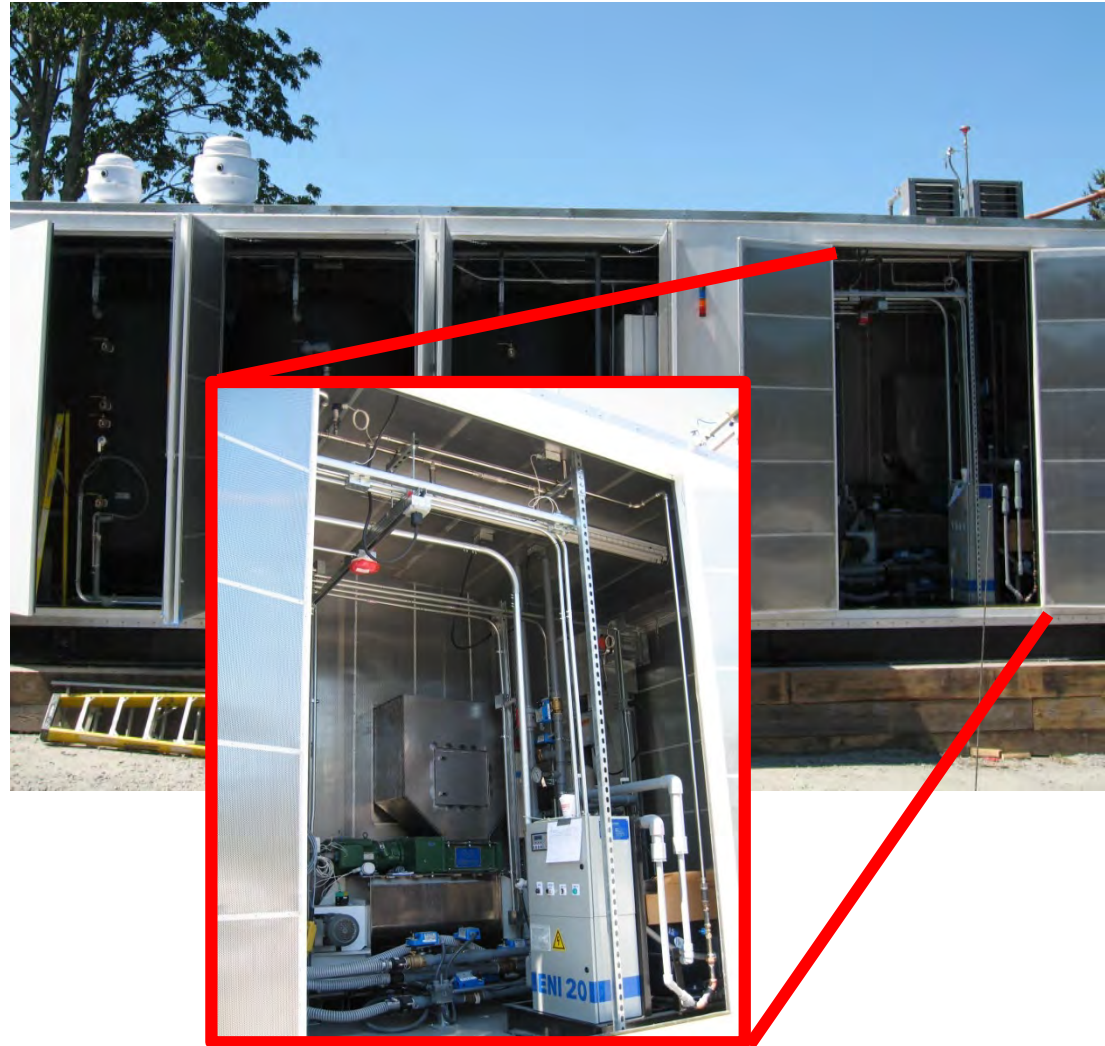
Clarkson Food Digester

Lisbon, Manure Digester

Cornell Cooperative Extension Digester

# Clarkson's Anaerobic Digester

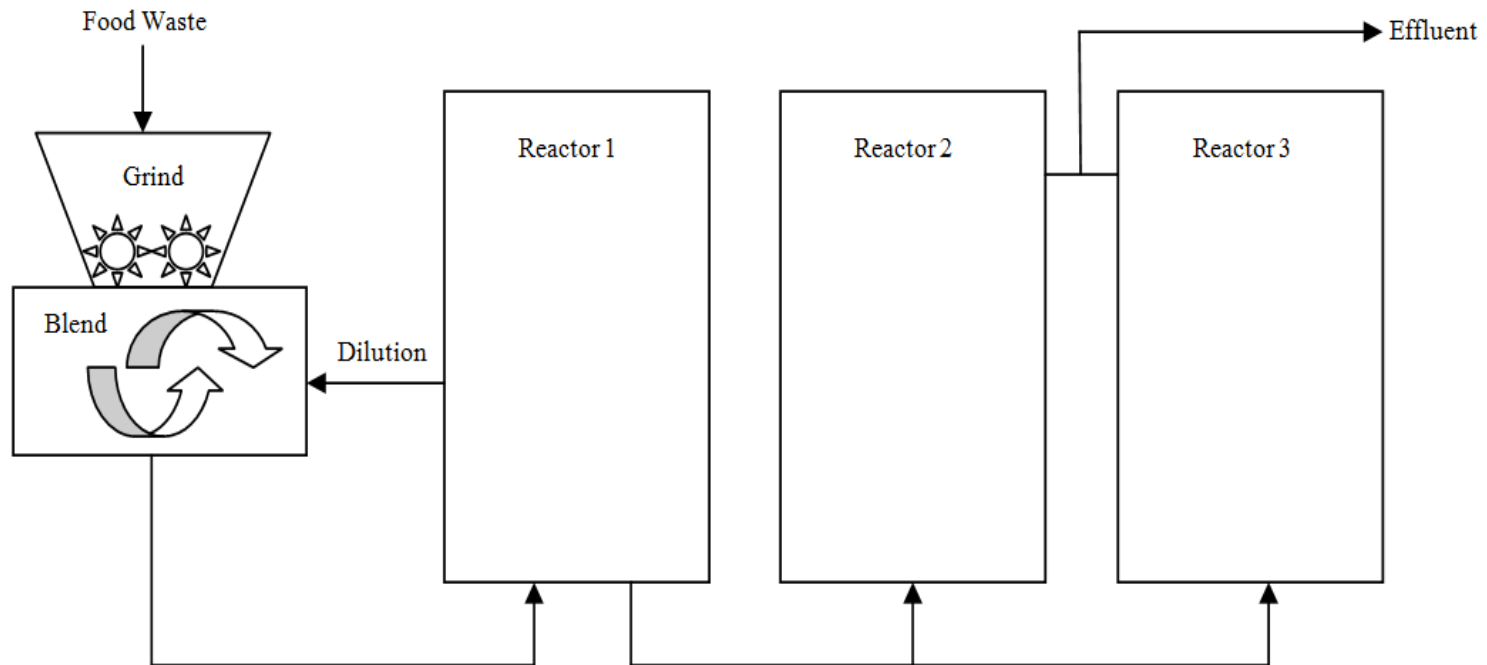
- Material grinding and feeding system
- Three 1,400 gallon reactors operated as two-stage digester
- Biogas generated in the anaerobic environment
- ENI 20kW co-generation combustion engine → CHP
- Instrumentation for independent operation and remote control





# Clarkson's Digester Operation

- Separate mixing cycles for each stage.





Anaerobic digester  
Up to 300 kg food waste/day  
Transformed into biogas  
Savings: \$250/ton food waste  
diverted from landfill



# Methane Content



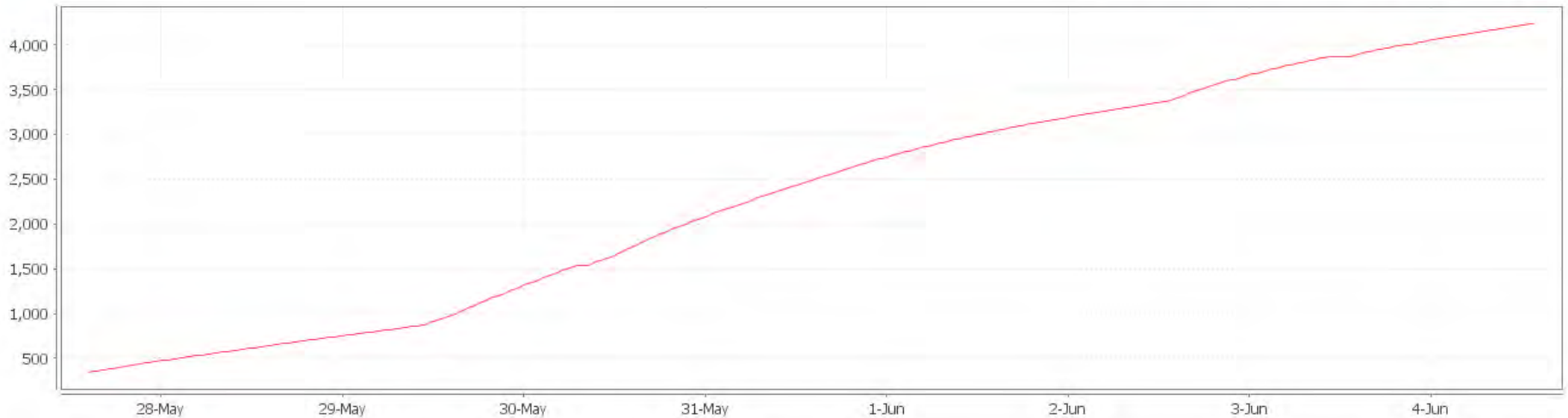
<http://greenhouse.wlan.clarkson.edu:8080/mango/login.htm>

# Biogas Production

Chart

(as of 2014/06/04 14:27:47)

From 2014 May 27 14 : 27 : 00  Inception  
To 2014 Jun 04 14 : 27 : 00  Latest



Approximately 500 ft<sup>3</sup>/d feeding an average of 113 lbs/d at 12±8 % VS  
Approximately 1,362±544 L CH<sub>4</sub>/kg VS added  
Or 272 m<sup>3</sup> biogas per ton of foodwaste



### **Current Digester Food:**

- Campus kitchens (pre-consumer) ~100-300 lb/d
- On-going – new food provider is required to separate pre-consumer FW and deliver it to the digester, which should result in increased biogas production
- The effluent of the digester is used as fertilizer for athletic fields on campus

# Lisbon Manure Digester



# Woodcrest Dairy



1.2 Mgal Digester, feed by 2,500 cows  
400 kW Power generation +  
Bedding recovery  
Low odor effluent spread on fields





And on the smaller scale

Canton Public School food waste is delivered to the digester at the Cornell Cooperative Extension Farm in Canton





# Questions/Comments?

Contact us:

Stefan Grimberg, [grimberg@clarkson.edu](mailto:grimberg@clarkson.edu), 315-268-6490

Jan DeWaters, [dewaters@clarkson.edu](mailto:dewaters@clarkson.edu), 315-268-6577