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**KY DEDI  
Bioenergy Day  
Murray State  
Anaerobic Digestion  
by  
Steve Killian**

**CATERPILLAR®**

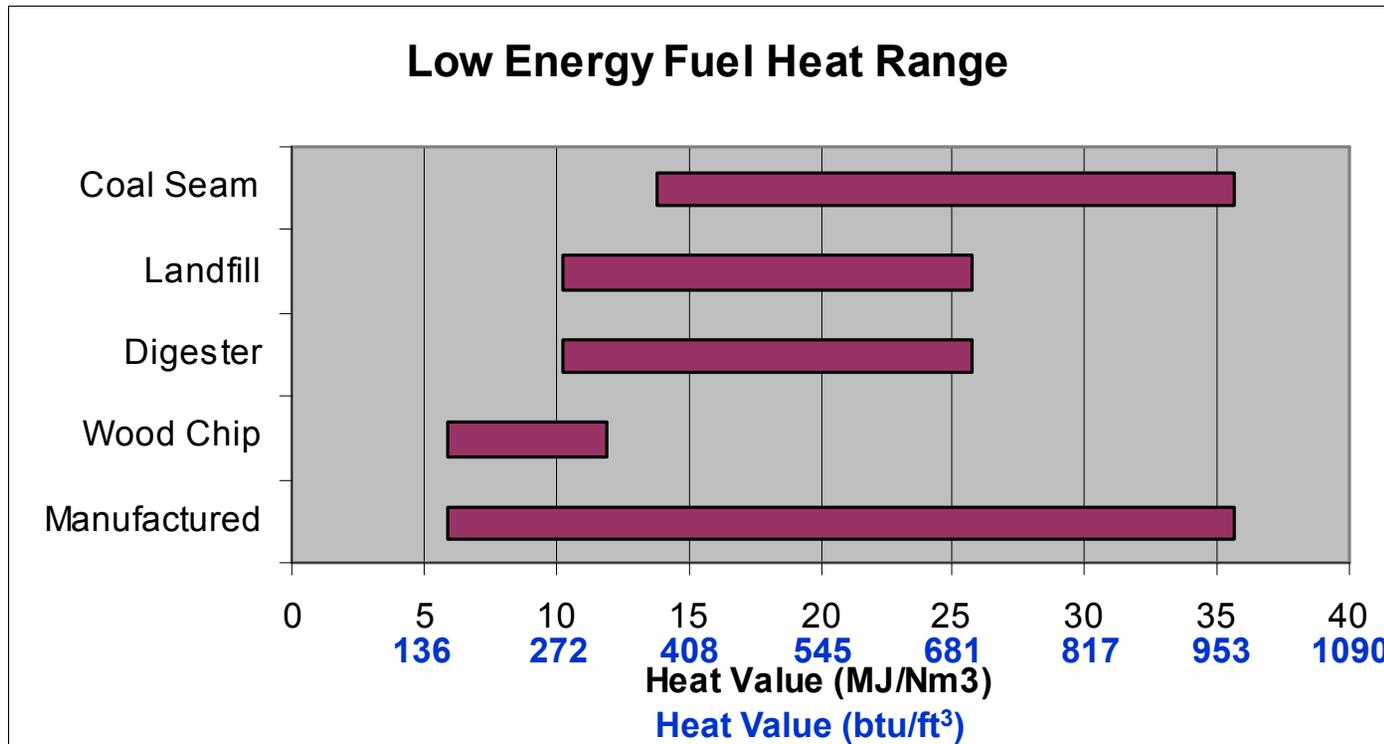
# What Is Anaerobic Digestion?

- Organic matter fed into large, sealed airless container
- Anaerobic means “in the absence of oxygen”
- In this oxygen free environment, bacteria produce biogas
- Biogas is about 65% methane and 35% CO<sub>2</sub>
- Contents are heated to accelerate the process (38°C or 56°C)
- Biogas can be used to generate heat or electricity or both
- Essential nutrients for soil (N, P, K) are preserved
- Therefore, use of fossil fuel based fertilizers reduced

# Potential Gas Production

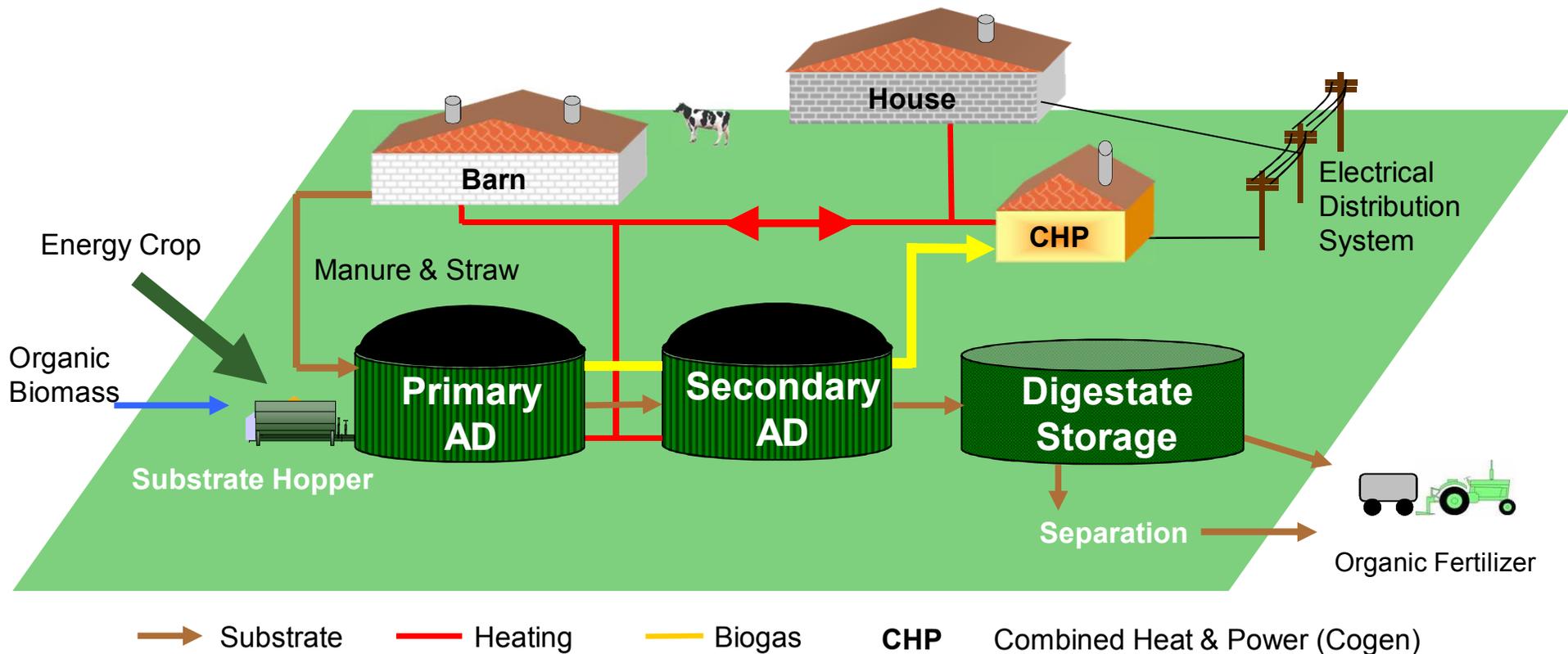
	Swine (150 pounds)	Dairy (1,200 pounds)	Poultry (4 pound bird)	Beef (1,000 pounds)
Gas yield, cubic feet per pound volatile solids destroyed	12	7.7	8.6	15
Volatile solids voided, pounds per day	0.7	9.5	0.044	5
Percent reduction of volatile solids	49	31	56	41
Potential gas production cubic feet per animal unit per day	4.1	22.7	0.21	31
Energy production rate, Btu per hour per animal	103	568	5.25	775
Available energy Btu per hour (after heating digester)	70	380	3.5	520

# Low Energy Fuels

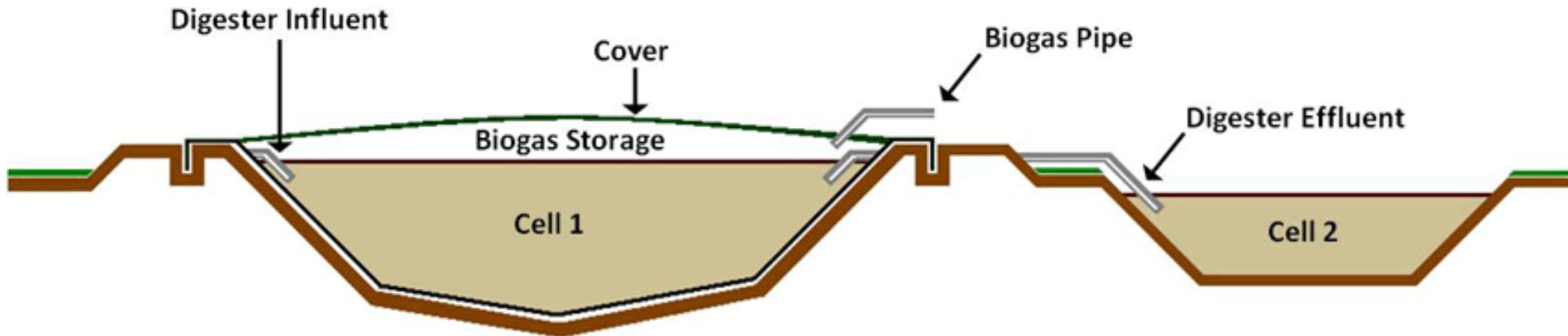


- Low Energy Fuel Heat Range
  - Coal Seam Gas 13.8-35.6 MJ/Nm<sup>3</sup> (370-955 btu/ft<sup>3</sup>)
  - Landfill Gas 10.2-25.7 MJ/Nm<sup>3</sup> (275-700 btu/ft<sup>3</sup>)
  - Digester and Biogas 10.2-25.7 MJ/Nm<sup>3</sup> (275-700 btu/ft<sup>3</sup>)
  - Wood Chip Gas 5.9-11.9 MJ/Nm<sup>3</sup> (160-320 btu/ft<sup>3</sup>)
  - Manufactured Gas 5.9-35.6 MJ/Nm<sup>3</sup> (160-955 btu/ft<sup>3</sup>)
    - Other emerging technologies

# Functional Schematic On Farm Biogas System



# Covered Anaerobic Lagoon



An anaerobic lagoon is sealed with a flexible cover, and the methane is recovered and piped to the combustion device. Some systems use a single cell for combined digestion and storage.

# Covered Anaerobic Lagoon



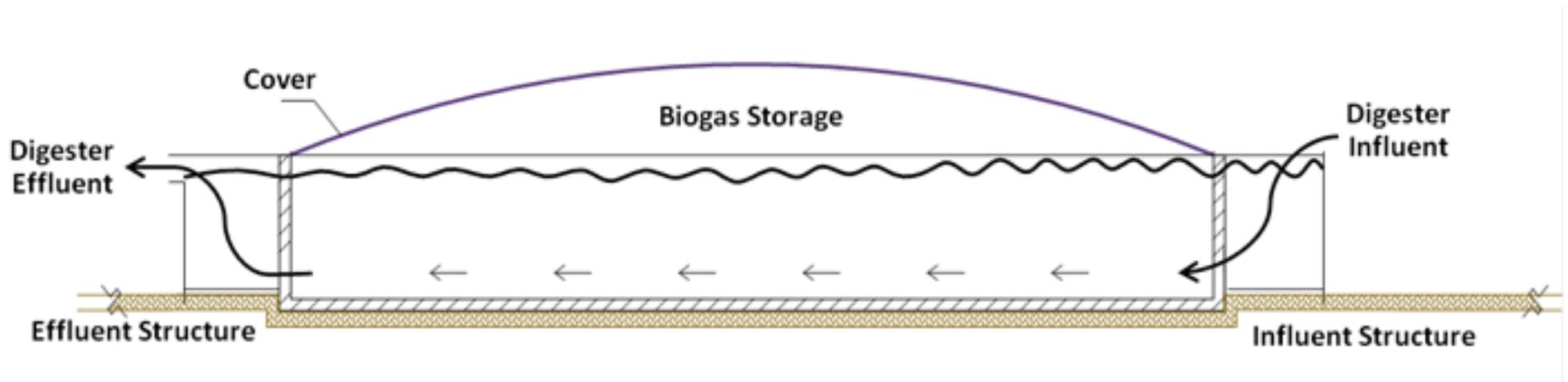
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# Plug Flow Digester



A plug flow digester has a long, narrow concrete tank with a rigid or flexible cover. The tank is built partially or fully below grade to limit the demand for supplemental heat. Plug flow digesters are used only at dairy operations that collect manure by scraping.

# Plug Flow Digester



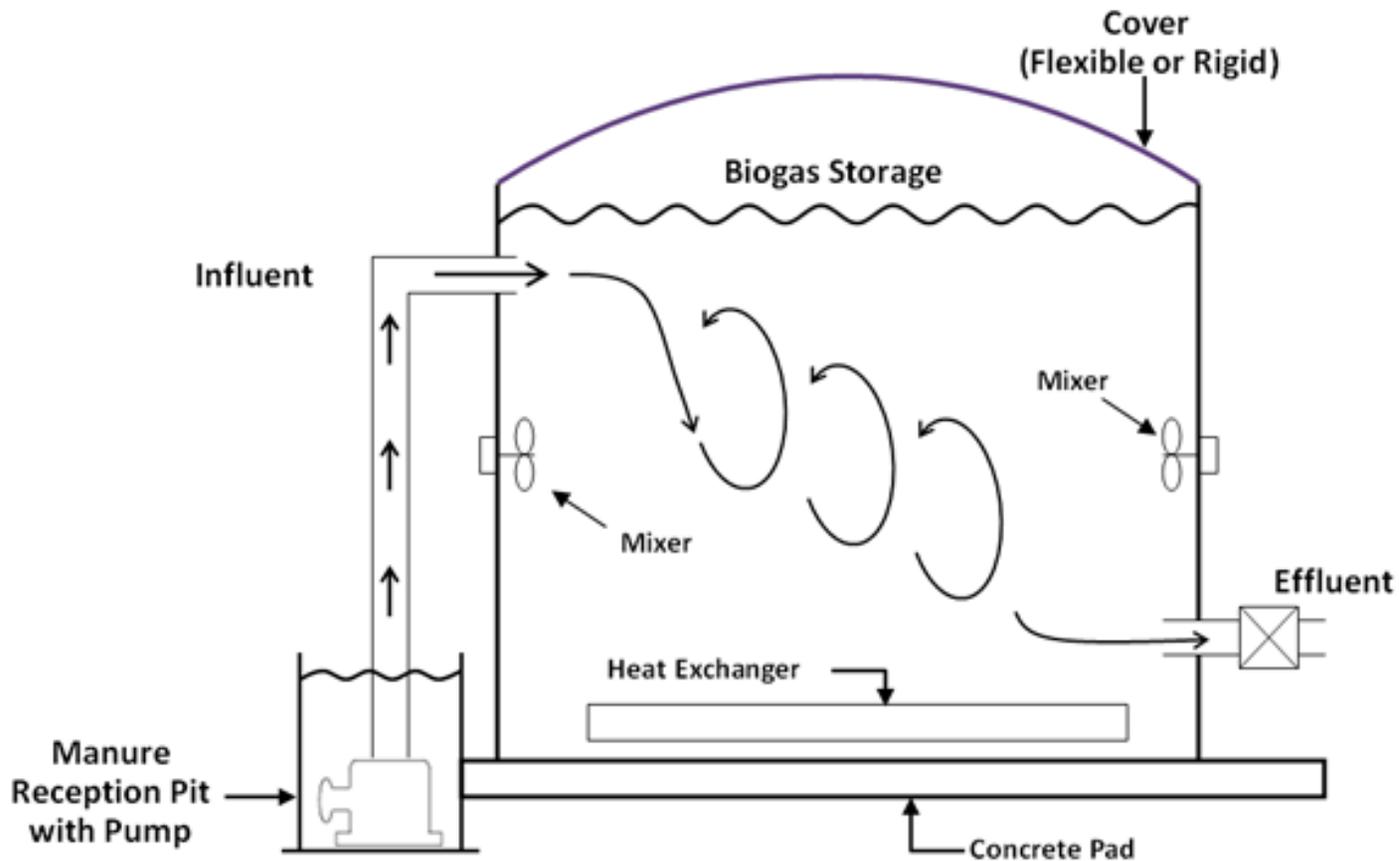
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# Complete Mix Digester



A complete mix digester is an enclosed, heated tank with a mechanical, hydraulic, or gas mixing system. Complete mix digesters work best when there is some dilution of the excreted manure with water (e.g., milking center wastewater).

## Complete Mix Digester



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# Biogas Handling Systems

Captured biogas is transported via pipe from the digester, either directly to a gas use device or to a gas treatment system (e.g. for moisture or hydrogen sulfide removal). If the manure contains high concentrations of sulfur, then hydrogen sulfide is removed from the gas to prevent corrosion of the combustion device. In most cases, however, the only treatment needed is to remove excess moisture prior to combustion.



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# Gas Use Devices

While a variety of gas use options are available, the collected biogas is most often used to generate electricity for on-farm use or sale to the local electric utility. Thermal energy in the form of waste heat, produced during electricity generation, can be recovered to heat digesters or adjacent buildings. Other uses include:

- Heat generation by burning biogas in boilers
- Upgrading biogas to pipeline quality
- Converting biogas to compressed natural gas (CNG) for a variety of fuel applications



A 120 kW engine generator set combusts recovered biogas, generating electricity for on-farm use.



Biogas can be fired directly in boilers or heaters as a replacement for propane.

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Flares are used to combust excess biogas or to combust biogas during periods when the primary gas use device is undergoing maintenance or repair. In cases where the primary purpose of the digester is odor control or the generation of carbon credits, all of the biogas may be flared.

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Biogas can be cleaned to pipeline quality and sold to the local gas utility.

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Biogas can be converted to compressed natural gas (CNG) which can be used in applications such as vehicle fuel.

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# Digester Byproducts

- The liquid effluent from a digester can be used as a fertilizer, reducing the purchase of commercial fertilizers.
- Digested solids can be removed from the digester effluent by means of a solids separator. The separated solids are commonly used as livestock bedding. It can also be sold for use in landscape products, such as soil amendments or biodegradable planting pots.
- Emerging applications for effluent solids include their use in structural building materials, such as deck boards and particle board



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# Historical Low Energy Use By kW Size

- Each model has historically found a niche\*  
Size of gen set typically determined by the amount of fuel available
  - G3300 (85-125 kW)
    - Digester, ag biogas, coal seam gas
  - G3400 (125-360 kW)
    - Ag Biogas , digester, landfill, coal seam gas
  - G3500 (480-1165 kW)
    - Landfill gas, coal seam gas, digester, ag biogas
  - G3600 (1145-3860 kW)
    - Coal seam gas, landfill gas, digester gas



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