Solid State Anaerobic Digester

Frequently Asked Questions

PAMI Applied Bioenergy Centre

Saskatchewan Ministry of Agriculture

Canada — Natural Resources Canada, Western Economic Diversification, Agriculture & Agri-Food Canada

Western Beef Development Centre, Division of PAMI

What is Anaerobic Digestion?

A biological process in which organic material is broken down by microorganisms resulting in the generation of biogas. The biogas can be used to generate heat, electricity, or as a natural gas substitute. The leftover substrate can be used as a fertilizer.

What kind of material can be digested?

Any organic material will produce biogas when anaerobically digested. For optimal gas production, the material should have a carbon to nitrogen ratio of ~30-40, a neutral pH, and a structure that will support liquid and gas movement within the substrate.

What temperature does the material have to "cook" at?

The microbes that produce methane (called methanogens) are most stable at mesophilic temperatures (35-50°C). After digestion, the digestate should be aerobically composted at thermophilic temperatures (>50°C) for 4-5 days to destroy pathogens and weed seeds.

How long does it take?

Retention times will vary based on substrate and use of innoculum (active microbial cultures). Without innoculum, biogas will begin to be generated within 15 days and will peak at 30 days and the material will be digested after 40-50 days. With innoculum, retention times can be cut in half.

What is the difference between wet and dry digestion?

Wet (or liquid) digestion requires the material to have a dry matter content less than 5%. This allows the material to be pumped, metered, mixed, and stirred mechanically.

Dry (or solid) digestion allows the material to be processed in it's (usually) natural state with a dry matter content anywhere from 15 to 50%. Mixing is usually achieved by recirculating the percolate (liquid leachate) through the solid mass. Because dry digestion requires minimal amounts of water, the units can be smaller and the process generates no wastewater. Due to the lack of moving parts, dry digestion systems typically require less maintenance and have lower energy requirements than wet digestion systems.

What is the fertilizer value of the digestate?

While some N is lost to NH_3 and N_2 during the digestion process, the total loss is LESS than the N that would be lost during traditional manure storage. Other macronutrient contents (P, K, S) are virtually unchanged during digestion. Digestion also converts nutrients into their plant available forms, making digestate a valuable fertilizer. Digestate is also more homogeneous, has less odour, and is easier to apply than raw material. Depending on the material some volume reduction may also be achieved, resulting in lower transportation costs to haul to the field.

Why hasn't this been done before?

Dry fermentation systems are successful in Europe and some parts of the U.S. However, the Canadian climate poses problems for the air-tight sealing mechanism used in these units. Research in Canada on anaerobic digestion will hopefully help to overcome these and other hurdles.

How does anaerobic digestion affect greenhouse gas emissions?

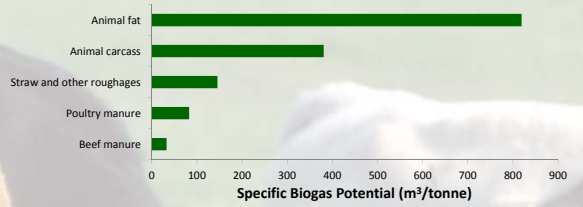
Methane is a potent greenhouse gas with a global warming potential of approximately 25 times that of carbon dioxide. During conventional manure storage, some methane is naturally produced, but it is lost to the atmosphere. During anaerobic digestion, methane production is enhanced, but it is captured and used for energy production. In addition, land application of digested material has been shown to have lower GHG emissions than spreading raw manure. Overall, anaerobic digestion can help to significantly reduce the carbon footprint of animal agriculture.

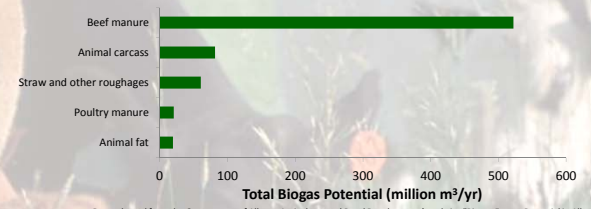
How much substrate is required to make it feasible to digest?

This will depend on the complexity of the digester, the biogas potential of the material, and the value of green energy incentives. This is the kind of question we hope to be able to answer based on the research being conducted with the pilot scale digester. PAMI's pilot digester can handle 10 to 15 tonnes of material per reactor per batch. This means approximately 200 to 300 tonnes can be digested per year at the facility.

How much biogas can be generated?

It depends on the biogas potential of the feedstock and how much feedstock is available:





Data adapted from the Government of Alberta Agriculture and Rural Development's website "Biogas Energy Potential in Alberta". Total biogas potential of beef manure based on manure production in SK (9,000,000 tonnes)

How much energy is in biogas?

Biogas is typically 60% methane and the energy value of methane is 35.7 MJ/m³. Therefore, 1 m³ of biogas contains roughly 20 MJ (20,000 BTU) of energy. When used as a fuel for co-generation, 1 m³ of biogas can produce 6 MJ (1.7 kW-hr) of electricity and 7.7 MJ of heat.

One tonne of manure and straw will generate approximately 70 m³ of biogas. Therefore, one tonne of manure contains 1.4 GJ (1.4 million BTU) of potential energy.

So what are you doing with the biogas?

Currently, the biogas is flared to convert the methane to carbon dioxide and water vapour. In the future, we plan to demonstrate the conversion of biogas to energy via combined heat and power units or by upgrading the biogas to natural gas.

How much energy is needed to run a digester?

For liquid systems (high energy demand) ~35% of the heat and electricity generated from the biogas is required to maintain digester operations. For solid systems ~25% is required.

The manure from all 1.3 million beef cows in SK would generate enough heat and electricity to operate the digester(s) and generate an additional 5.4 million GJ of heat energy (enough for 50,000 SK homes) and 4.2 million GJ (1.2 billion kW-hr) of electrical energy (enough for 140,000 SK homes).

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Schematic Diagram and Photo Description

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Process Control

Process Containers and Flare

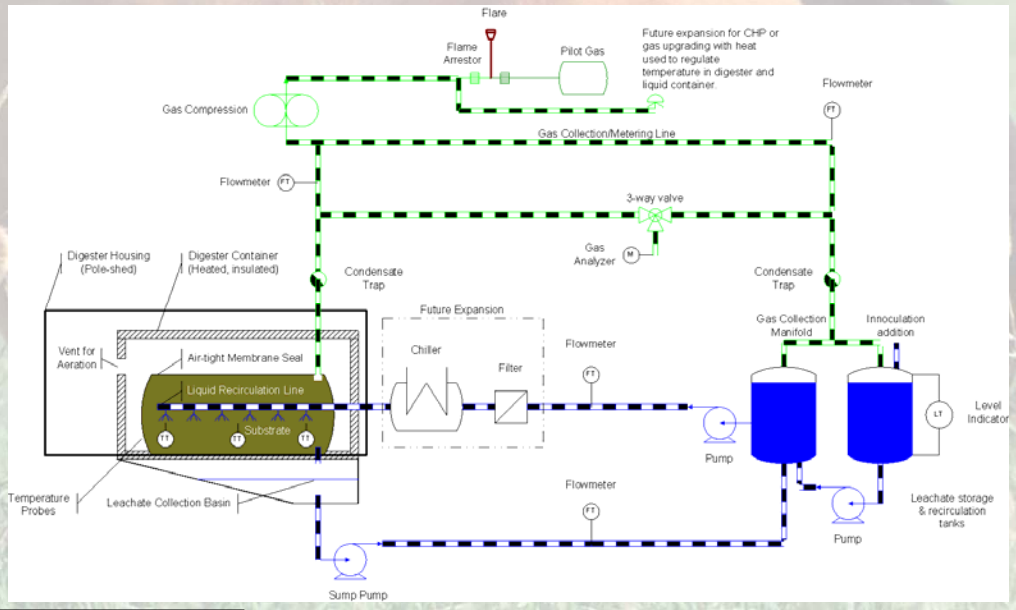
The ISO containers contain the control, gas, and liquid systems. The shed houses the reactors.

Reactors

The reactor (with removable lid) is loaded into the shipping container for added protection and secondary heating.

Gas Collection, Metering and Analysis

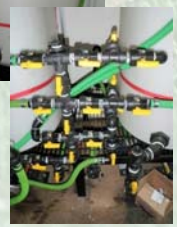
Three gas streams (one from each reactor, one from the liquid tanks) are fed into the gas container. The gas pressure, flowrate and composition are continually monitored.



Reactor Heating

Heated glycol is pumped through a series of pipes to help maintain mesophilic temperatures in the reactor. The shipping containers also have forced air heating.

Liquid Recirculation System



The leachate is pumped from the sump pit to the tanks in the liquid storage container. The leachate can then be stored or redistributed to the reactors.

Under the lid of the reactor, perforated pipes re-distribute the leachate inside the reactor. Drains in the reactor lead to the sump pit for collection.

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