Energy Opportunities
Anaerobic Digestion: Manures

Livestock manure can be an alternative energy source for livestock farmers. An anaerobic digester will partially convert manure to energy in the form of biogas which contains methane (CH_4).

Multiple sources of manure were collected from Alberta and processed to determine their potential energy production. The average potential energy used (see referenced map) from all sources combined was 1537 MJ per tonne of raw manure. A description of each manure source is below as well as the methane yield and energy production specific to the source of manure, Table 1.

Table 1. Potential energy from livestock manure sources.

Source	Description	Total Solids (%)	Volatile Solids (%)	Accumulated CH_4 (NL/kg VS)	Energy ($MJ/T_{feedstock}$)
Feedlot		48	61	233	2187
Dairy	Free Stall	15	79	233	895
Dairy	Wash Water Included	7	78	231	413
Dairy	Young Stock Pens	13	75	188	594
Poultry	Layer	39	70	243	2149
Poultry	Broiler	62	86	253	4371
Hog	Farrowing to Weaning	2	81	271	156

Feedlot manure from a variety of operations was collected for analysis. Manure was collected from pens that had recently contained approximately 200 animals. Before the pens were cleaned samples were taken from multiple points. The average diet of animals was 60% barley silage, varying amounts of corn silage and other supplements.

Dairy manure was collected before the manure entered the storage facilities. The manure collected from barns with washwater and manure mixed were collected and analyzed separately from barns that only stored manure. The manure from young stock pens were collected and analyzed separately as well. All operations fed a variety of barley silage, hay silage, and dairy supplements.

Manure from both layer and broiler barns were collected and analyzed. The manure from the broiler barn was sampled the day after the birds were removed and manure was collected from the layer barn while birds were present. Fifteen to

Funded by
Alberta Innovates Bio Solutions
Alberta Government
Agriculture and Agri-Food Canada
Agriculture et Agroalimentaire Canada

twenty random samples were taken using a point sampling method.

Hog manure collected was from systems including farrowing to weaning operations. Each barn fed grain, including wheat, cornmeal, peas, and soy beans, as well as hog supplements. Samples were all collected where the manure and washwater entered the storage facilities.

Background for Methane Yields

Volatile Solids (VS) analysis determines the total amount of organic matter (OM) in a feedstock. It is a definitive measure of OM on a mass basis. Feedstocks containing more than 60 to 70% VS on a dry matter basis are good candidates for anaerobic digestion. The non-volatile solids, or ash content, of a feedstock takes up valuable digester volume and will not contribute to biogas production (Hamilton, 2012).

The methane yield is determined by taking a sample of feedstock, seeding it with anaerobic microorganisms, mixing with a nutrient medium, and incubating it. The volume of CH_4 produced during the incubation period is measured and interpreted as specific methane yield or the volume of CH_4 produced per mass of VS added (Hamilton, 2012). The methane yield is reported as normalized litres per kilogram VS added (NL/kg VS).

To convert from methane yield to Energy (Vik, 2003):

- Convert the VS (%TS) to kg of VS/T of feedstock
- Use VS (kg) to convert the methane yield from NL/kg VS to m^3/T of feedstock
- Apply a 90% efficiency rate to represent commercial operations
- Use the lower heating value for CH_4, 36 MJ/m^3, to determine MJ/T of feedstock
- To determine the potential MW the overall supply of the feedstock available must be determined. This is the power output from the feedstock that went into the digester.

NOTE: The energy potential displayed on the map is the pure energy calculated above. The CH_4 can be used by a combined heat and power (CHP) unit to transfer the pure energy into electrical output and heat. On average, units produce 40% electricity (Clarke Energy, 2013).

A CHP unit is typically a reciprocating gas engine that uses the gas, CH_4, to drive a crank shaft. The crank shaft turns an alternator to produce electricity. Heat is released during the gas combustion process (Clarke Energy, 2013). This heat can be recovered during cogeneration in order to maximize the heating value of the system.

References

Clarke Energy. 2013. CHP efficiency for biogas. www.clarke-energy.com/2013/chp-cogen-efficiency-biogas/

Hamilton, D.W. 2012. Anaerobic digestion of animal manures: methane production potential of waste materials. BAE-1762. Oklahoma: Oklahoma Cooperative Extension Service.

Vik, T.E. 2003. Anaerobic digester methane to energy a statewide assessment. MCM. No. W0937-920459. Neenah, Wisconsin: McMahon Associates, Inc.