September 2013

Energy Opportunities Anaerobic Digestion: Straw, Silage, Waxed Cardboard

Agricultural straw and silage from farms can be an energy source. Waxed cardboard from supermarket produce and pet food packaging can also be an energy source. An anaerobic digester will partially convert the products into energy in the form of biogas which contains methane (CH_4).

Straw samples collected for this study were from farms in Southern Alberta with two to five year old wheat and barley straw. The samples were collected from large square bales, large round bales, and small square bales and blended together to make one homogenized sample. From each bale random samples were collected from the exposed section of the bales and from weather protected areas. Silage samples were collected from pits containing barley, alfalfa, and corn. Random samples were collected from the open side of the pit after the exposed material was removed. Waxed cardboard was collected from a variety of sources. The range of characteristics, potential CH_4 and energy production is shown in Table 1.

The potential pure energy (MW) was not determined for these feedstocks because the overall supply of the feedstock available must be determined. This is difficult to estimate accurately because:

- The amount of straw and silage available is dependent on the growing seasons and
- Waxed cardboard is used in the food packaging industry which fluctuates partially due to new items and new packaging options.

Table 1. Potential energy from straw, silage and waxed cardboard

Source	Description	Total Solids (%)	Volatile Solids (%)	Accumulated CH_4 (NL/kg VS)	Energy ($MJ/T_{feedstock}$)
2 Year Straw	Wheat & Barley	82	91	214	5174
New Straw [d]	Wheat	95	93	304	8766
Straw [b]	Wheat	94	92	96	2675
Silage	Barley	31	82	312	2570
Silage [c]	Timothy &	26	97	300	2434
Cardboard	Waxed	93	97	189	5524
Straw [a]	Rye		855 (kg)	360 (m3/kgVS)	9973
Straw [a]	Barley		846 (kg)	200 (m3/kgVS)	5482
Straw [a]	Wheat		873 (kg)	150 (m3/kgVS)	4243

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

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 or 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 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

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