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Biogas Energy Potential in Alberta

Alberta has a significant number of large agricultural operations. These agricultural operations produce a considerable amount of organic waste in the form of manure, crops, crop residues and animal remains. Handling such large amounts of organic waste, especially manure, in an environmentally friendly manner is a challenge.

Producers, scientists and other stakeholders are exploring various options to tackle this issue, and using anaerobic digesters is a promising one among them. Anaerobic digesters are specially designed tanks used to facilitate the anaerobic digestion process under a controlled atmosphere.

Anaerobic digestion is a natural process that occurs in the absence of air. During this process, micro-organisms stabilize the waste organic matter and release biogas as a by-product.

Energy produced using biogas is renewable, unlike natural gas

Biogas consists mainly of methane and carbon dioxide gases. Burning biogas can produce energy like natural gas. The energy produced using biogas is renewable, unlike natural gas.

Some scientists and academics anticipate that renewable energy sources will be preferred over the natural fossil fuel energy sources in the near future to slow the global warming effect.

Stabilized organic wastes from a digester, known as digestate, contain less odour than the unstable waste or no odour at all, yet retain almost all the nutrients from the feed material. Applying the digestate to cropland may replace commercial fertilizers, so anaerobic digesters can bring several benefits.

The primary objective of this factsheet is to illustrate the following:

- feedstock availability
- biogas yield
- biogas renewable energy potential in Alberta

This factsheet also provides concise information related to substantial biogas production:

- co-digestion
- essentials for successful operation
- land application
- digestate disposal
- social/economic effect

Feedstock availability, biogas yield and energy potential

Livestock operations in Alberta produce large amounts of organic waste streams. However, not all agricultural organic waste streams are available for further processing as significant amounts of them, especially straw, are used as cattle feed and soil conditioners to minimize wind erosion.

Table 1 and Table 2 show the inventory of available feedstock materials, biogas yields and energy potentials along with the compositions of total and volatile solids. Table 1 mainly shows the availability of feedstock materials from livestock and related industries, while Table 2 shows the availability of feedstock materials from the major agricultural crops.

Apart from agricultural and food wastes, some industrial and municipal organic waste streams, such as thin stillage from distilleries and sludge from municipal wastewater treatment plants, can also be potential feed material, as shown in Table 1 and Table 2.

It is estimated from these tables that about 2 to 4 per cent of the total energy demand of Alberta can be derived from agricultural organic waste materials. Even though this percentage is small, initial efforts to utilize the available waste organic materials to produce renewable energy may be an important step in reducing fossil fuel usage to slow global warming effects.

Table 1. Inventory of livestock and municipal feedstock materials and biogas energy potential in Alberta						
Feed material	**Total solids %**	**Volatile solids % of total solids**	**Biogas yield m^3/tonne**	**Annual biomass production in tonnes***	**Annual energy potential in PJ**	**Methane content %**
Beef cattle manure	8 - 12	80 - 85	19 - 46	51,890,736	20.0 - 48.0	53
Hog manure-grower to finisher	9 - 11	80 - 85	28 - 46	2,452,800	1.4 - 2.3	58
Dairy manure	12	80 - 85	25 - 32	3,994,195	2.0 - 2.6	54
Poultry manure	25 - 27	70 - 80	69 - 96	1,728,987	2.4 - 3.3	60
Animal fat	89 - 90	90 - 93	801 - 837	87,000	1.4 - 1.5	N/A
Animal carcass (homogenized-bovine)	34 - 39	90 - 93	348 - 413	264,023	1.8 - 1.2	N/A
Municipal wastewater sludge	3 - 20	90	17 - 140	539,835	0.2 - 1.5	65
House-hold waste	N/A	N/A	143 - 214	N/A	N/A	N/A
Total manure (including municipal sludge)	–	–	–	60,606,553	25.7 - 57.4	50 - 70

* Reference sources given at the end of this factsheet.

Note:

- 1 m^3 of biogas is equivalent to 20 MJ. When used as fuel for co-generator, 1 m^3 of biogas can produce 1.7 kWh of electricity and 7.7 MJ of heat. 1 PJ is 1,000,000 GJ.
- Total manure production is estimated by multiplying the total number of animals in the province by the manure production coefficients (as excreted basis).

Table 2. Inventory of agricultural crops and biogas energy potential in Alberta						
Feed material	**Total solids %**	**Volatile solids % of total solids**	**Biogas yield m^3/tonne**	**Annual biomass production in dry tonnes***	**Annual energy potential in PJ**	**Methane content %**
Barley	36 - 86	90 - 95	169 - 291	1,404,671	4.75 - 8.18	60 - 70
Wheat	32 - 97	N/A	48 - 146	1,390,222	1.33 - 4.106	N/A
Oats	64	68	147 - 187	172,085	0.51 - 0.64	49 - 57
Rye	25 - 61	91 - 95	112 - 457	4,423	0.00 - 0.04	N/A
Triticale	27 - 66	93 - 97	150 - 554	9,526	0.03 - 0.11	60 - 70
Sugar beet leaves	N/A	N/A	40 - 50	197,887	0.16 - 0.20	49 - 57
Fodder corn	25 - 37	95	182 - 436	89,674	0.33 - 0.78	
Tame hay	N/A	N/A	80	699,344	1.1	
Leaves	80	90	72 - 216	N/A	N/A	N/A
Whey	1 - 5	80 - 95	6 - 45	N/A	N/A	
Grass silage	20 - 25	90	75 - 126	N/A	N/A	N/A
Distiller grain wastewater	N/A	N/A	58	N/A	N/A	57 - 60
Total straw and other Roughages	70	90	105 - 158	3,901,007	8.19 - 12.33	60 - 70

* In this estimation, the requirement of cattle straw and soil conditioning was taken into consideration.

Reference sources given at the end of this factsheet.

Please visit the following website for information on the relative amount of manure production Alberta. http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex10335

Co-digestion

The term co-digestion means processing different streams of agricultural wastes in an anaerobic digestion facility. Most of the anaerobic digesters in the agriculture industry handle a single stream of organic waste, for example, manure and feed spills from a confined cattle feedlot operation.

Adding different streams of organic wastes can increase biogas production. However, this approach requires careful handling of the process to avoid production failures. European countries have some co-digestion facilities, which were designed to produce biogas in the range of 40 to150 m^3/ton of materials fed.

The co-digestion process often requires more treatment steps, which means higher capital investment, compared to processing a single organic waste stream. Beef cattle manure and some other industrial waste may require the removal of sand, glass and heavy metals.

Agricultural feedstock materials such as energy crops, crop residues and animal remains as well as domestic waste such as garden wastes and leaves require extended pre-treatment such as chopping, sieving, removal of metals and homogeneous mixing including thermal hydrolysis (the Canadian Food Inspection Agency has approved the use of the thermal hydrolysis process for the disposal of animal remains that may contain specified risk materials). Some other organic matter such as manure, municipal sludge, whey, oils and fats do not need extended pre-treatment; however, the optional use of sieve mesh is recommended.

Large quantities of manure produced in confined feeding operations are a concern to the public and a barrier to the expansion of existing operations. Thus, manure requires appropriate handling. The anaerobic digestion process is certainly a promising option to process and manage manure.

Even though plant materials such as crop residues, straw and roughages do not cause concern like manure, most plant materials have a higher biogas yield and slower release than manure. This difference provides the opportunity for the co-digestion process to maximize biogas production and reap economic benefits. The co-digestion opportunity also provides flexibility for farmers to rotate crops appropriately and grow energy crops to make additional revenue.

Essentials for successful operation

Anaerobic co-digestion is a controlled, natural process that requires careful monitoring and regulating to maximize biogas production. Following a recipe is ideal for a successful operation.

Some literature suggests that the feedstock materials be mixed as per the C:N:P (carbon:nitrogen:phosphate) ratio of (100 - 500):5:1. In addition to this method, process inhibitors such as fatty acids, H_2S (hydrogen sulphide), ammonia and PH should be monitored and controlled. Some other inhibitors such as pesticides, antibiotics and heavy metals may pose problems; however, their presence is rarely reported for agricultural wastes. Further process and technology improvements are necessary if a substantial amount of biogas were to be produced from most of the available feedstocks.

Digestate disposal

Processing a large quantity of various agricultural organic waste streams in anaerobic digesters will produce a large quantity of digestate. As digestate has almost the same nutrient value as in the feed materials, disposing of or land-applying these materials on croplands should meet the regulatory requirements or guidelines.

The land application of digestate should meet the allowable nutrient loading permitted by the *Agricultural Operation Practices Act* (AOPA) when manure and agricultural residues are processed on the same farm. Otherwise, producers may consult Alberta Environment and the Natural Resources Conservation Board (NRCB) for permission and guidance on disposal.

Social and economic effect

The main advantage of anaerobic digester technology is that it produces renewable energy while stabilizing waste organic matter. This renewable energy can be a part of solving some issues such as climate change and high energy costs. This system reduces odour and the risk of ground water contamination originating from intensive livestock operations. Adopting this technology may also increase employment opportunities in rural populations, as it requires trained operators.

Despite these advantages, this technology remains expensive and unproven in terms of substantial economic benefits.

Summary

Anaerobic digester technology can stabilize most agricultural, domestic and industrial organic waste and produce renewable energy by burning the biogas produced during this process. The availability of feedstock materials and their biogas yield along with energy potential have been tabulated in Tables 1 and 2.

The co-digestion process provides the opportunity to process more than one agricultural organic waste stream to increase biogas production. This approach may also provide the opportunity for farmers to rotate their crops appropriately and grow energy crops. However, the co-digestion process is complex and requires careful monitoring and controlling. Further process improvements are still necessary.

Biogas renewable energy will be useful in reducing the global warming effect while paving the way for better manure management and odour control. Even though capital investment is high, biogas energy production can result in an additional revenue stream for producers while increasing rural employment opportunities.

More information

For additional information, check the following web pages:

Anaerobic Digesters, Agdex 768-1, http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex10945

Anerobic Digesters: Frequently Asked Questions, Agdex 768-2, http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex11290

Integrating Biogas, Confined Feedlot Operations and Ethanol Production, Agdex768-4, http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex11839

Biogas: Cleaning and Uses, Agdex 768-5, http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex12276

Economic Feasibility of Anaerobic Digesters, Agdex 768-6, http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex12280

Biogas Distribution, Rural Utilities Division of Alberta Agriculture and Food, http://www1.agric.gov.ab.ca/general/progserv.nsf/all/pgmsrv13?opendocument

Incentives for biogas production, Alberta Bioenergy Producer Credit Program, http://www.energy.gov.ab.ca/BioEnergy/bioenergy.asp

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