



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.

Anaerobic digestion and biogas

Producers and 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.

Biogas consists mainly of methane and carbon dioxide gases. Burning biogas can produce energy like natural gas; however, the energy produced using biogas is renewable, unlike natural gas. Nowadays, renewable energy sources are preferred over the natural fossil fuel energy sources, 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 the following topics:

- challenges using cattle feedlot manure
- co-digestion opportunities
 - challenges in adopting co-digestion techniques
 - land application
 - digestate disposal
 - social/economic effects

Energy produced using biogas is renewable, unlike natural gas.

Feedstock availability, biogas yield and energy potential

Agricultural and related operations in Alberta produce large amounts of biomass waste streams. A significant amount of this biomass can be made available for biogas energy production. Table 1 shows the inventory of available feedstock materials, biogas yields and energy potentials along with the compositions of total and volatile solids.

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	22,955,019	8.7 - 21.1	53
Hog manure: grower to finisher	9 - 11	80 - 85	28 - 46	1,848,415	1.0 - 1.7	58
Dairy manure	12	80 - 85	25 - 32	3,217,714	1.6 - 2.1	54
Poultry manure	25 - 27	70 - 80	69 - 96	284,342	0.4 - 0.5	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 - 2.2	N/A
Municipal wastewater sludge	30 - 20	90	17 - 140	539,835	0.2 - 1.5	65
Household waste	N/A	N/A	143 - 214	N/A	N/A	N/A
Total straw and other roughages	70	90	105 - 158	2,654,585	5.6 - 8.4	60 - 70
Thin stillage (ethanol by-product)	7	–	58	105,000	–	50 - 60
Total manure (including municipal sludge) and straw and other roughages	–	–	–	31,850,933	21 - 39	50 - 70

Reference sources given at the end of this document.

Notes:

- 1 m³ of biogas is equivalent to 20 MJ. When used as fuel for co-generator, 1 m³ 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).
- Percentage of recoverable manure is the percentage of number of animals that have either liquid or solid manure storages to total number of animals in the province – 46, 82, 91 and 100 per cent for beef cattle, dairy cattle, pigs and poultry, respectively).
- The requirement of straw for cattle feed and conditioning the soil was taken into consideration in estimating the availability of total straw and other roughages.

Table 1 above shows that the livestock industry in the province produces most of the available biomass in the form of manure. However, not all the manure produced by livestock facilities is available for biogas production since roughly 40 per cent of cattle facilities do not have manure storages, especially for cow-calf operations.

Most confined feeding operations produce recoverable manure as opposed to open range farming where manure is not recoverable. The estimated recoverable percentages of manure from the available statistical data for beef cattle, dairy cattle and swine are 46, 82 and 91 per cent, respectively. These factors were considered in estimating the biomass availability in Table 1.

The total and volatile solid contents of the livestock manure shown in Table 1 are based on an “as excreted basis.” The actual numbers for manure may differ from the numbers given in Table 1.

Most manure on the feedlot dries up and loses a considerable amount of its moisture before it is removed and stored. Such stored cattle manure can have total solid contents of 30 to 70 per cent.

According to the statistical data, 94 per cent of cattle facilities have solid manure storage facilities while 88 per cent of swine production facilities have liquid manure storages. The solid contents in swine manure may well be lower (1 to 9 per cent) than the values shown above in Table 1, mainly due to the varying quantities of water used to clean the barns.

Apart from livestock manure, a considerable amount of straw and other crop roughages, municipal sludge and food residues such as fat, oil and animal carcass/remains can also be made available for biogas production.

It is estimated from the above table that about 1 to 2 per cent of the total energy demand of Alberta could be derived from mainly agricultural and 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.

Challenges in using cattle feedlot manure

Compared to other biomasses, considerably large amounts of cattle manure are available for biogas production. However, using these large amounts of available manure has its share of challenges, especially with regard to diluting, pumping and mixing.

Cattle manure usually contains sand and feed spills such as straw and hay, which can cause operational problems. In addition, solid cattle feedlot manure requires diluting before processing in an anaerobic digester. Despite these challenges, at least one anaerobic digester plant that uses cattle feedlot manure is operational in Alberta.

Co-digestion opportunities

The term co-digestion means processing different streams of agricultural wastes in an anaerobic digestion facility. European countries have a number of co-digestion facilities, most of which were designed to produce biogas in the range of 40 to 150 m³/ton of materials fed.

Adopting co-digestion techniques to produce biogas may also provide flexibility for farmers to rotate crops appropriately and grow energy crops to make additional revenue.

Table 1 above lists the feedstocks that are available in significant quantities in Alberta along with their characteristics and respective bio-energy potential. As noted from this table, the total and volatile solids of the available biomass vary. Similarly, the chemical compositions will also vary and so will the conversion rate of volatile solids into biogas during anaerobic digestion. Therefore, developing successful co-digestion techniques to convert various biomasses into biogas simultaneously and steadily under anaerobic conditions will be useful.

Liquid manure is easier to handle in biogas processing facilities when compared to solid manure. Solid manure requires diluting before processing. Most of the dairy and swine facilities in the province have liquid manure storages. In addition, thin stillage, which has solid contents of up to 7 per cent, is a by-product from ethanol facilities and is available to produce biogas.

The availability of large quantities of livestock solid manure as well as liquid manure along with thin stillage provides a wonderful opportunity for the developing biogas industry in Alberta. In addition, the availability of plant materials such as crop residues, straw and roughages along with animal fat and animal remains with higher

biogas yields (m³/tonne) compared to livestock manure certainly increases the bio-energy potential in the province.

Challenges in adopting co-digestion techniques

Adding different streams of organic wastes can increase the biogas production capabilities of that facility. However, this approach requires careful handling of the process to avoid production failures. The co-digestion process often requires more treatment steps, which may mean higher capital investment, compared to processing a single organic waste stream.

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.

Anaerobic co-digestion is a controlled process that requires careful monitoring and regulating to maximize biogas production. In addition, process inhibitors such as fatty acids, H₂S (hydrogen sulphide), ammonia and pH should be monitored and controlled. Some other inhibitors such as pesticides, antibiotics and heavy metals may also pose problems.

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 effects

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 groundwater contamination originating from intensive livestock operations. Adopting this technology may also increase employment opportunities in rural populations as it requires trained operators.

Utilizing the maximum amount of agricultural biomass to produce biogas may offer farmers an additional revenue stream while successfully managing/mitigating manure-related environmental issues. Despite these advantages, this technology remains expensive and unproven in terms of substantial economic benefits.

Summary

Large amounts of agricultural biomass can be made available for renewable energy production. 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 the energy potential have been tabulated in Table 1. The cattle industry in Alberta produces most of the available biomass in the form of manure. In addition to this manure, a considerable amount of straw and other crop roughages are also available. However, utilizing all the available biomass has its share of challenges.

The availability of various biomasses highlights the need for the development and adoption of successful co-digestion techniques. The co-digestion process provides the opportunity to process more than one agricultural organic waste stream to increase biogas production. However, this process may require additional treatment steps, which means higher capital investment. In addition, the co-digestion process is complex and requires careful monitoring and controlling.

Biogas renewable energy will be useful in reducing global warming effects while paving the way for better manure management and odour control. The digestate from anaerobic digesters has almost the same nutrient value as the feedstock materials and can be safely land-applied as per the appropriate regulations. 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 resources, check the following:

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

Anaerobic Digesters: Frequently Asked Questions, Agdex 768-2, [http://www1.agric.gov.ab.ca/\\$department/deptdocs.nsf/all/agdex11290](http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex11290)

Integrating Biogas, Confined Feedlot Operations and Ethanol Production, Agdex 768-4, [http://www1.agric.gov.ab.ca/\\$department/deptdocs.nsf/all/agdex11839](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](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](http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex12280)

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

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

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For more information

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