Biogas Association

Farm to Fuel

Developers' Guide to Biomethane

AAC agricultural adaptation council

Agriculture and Agri-Food Canada / Agriculture et Agroalimentaire Canada

CGA Canadian Gas Association / Association Canadienne du Gaz

FortisBC

Biogas Greenlane A Flotech Group Company

PlanET Biogas Solutions design, construction & service

Tenergy

Authored by: Viking Strategies

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AAC agricultural adaptation council

Agriculture and Agri-Food Canada   Agriculture et Agroalimentaire Canada

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Authored by: Viking Strategies, with feedstock mapping and input by Regenerate Biogas, for the Biogas Association

Viking Strategies

ReGenerate Biogas

Disclaimer

Readers should note that the ability to generate biomethane through anaerobic digestion is site specific. Information presented here should be evaluated and interpreted by the reader for their own applications. Information is provided to the user at his or her own risk. The authors and sponsors of this Guide will not be liable for any claims, damages, or losses of any kind arising from the use of, or reliance upon, this information.

Contents

Introduction

This Developers' Guide to Biomethane was written to help farmers determine if biomethane production is a good fit for their farm and operations. For those farmers considering developing biogas systems, and upgrading the biogas to biomethane, the Guide walks them through the planning process, offering a check-list of questions to ask relevant technology and service providers. It also alerts farmers to important considerations, such as feedstock, financing, permits and safety.

Biomethane poses a new opportunity for farmers in Canada. There is significant potential for long-term financial gain where farmers can sell their biomethane to utilities or customers willing to pay a premium over conventional natural gas. Additional socio-economic and environmental advantages of biogas in general to farmers include:

- Improved water quality due to virtual elimination of pathogen load of manure subsequently reducing the risk of nitrogen and phosphorous leaching
- Reduced greenhouse gas emissions from livestock
- Enhanced fertilizer for crops by recovering nutrients in organic materials
- Reduced greenhouse gas emissions by replacing fossil fuel consumption with renewable energy consumption
- Greater on-farm innovation and job creation
- Reduced odour and pathogens

Biomethane projects require considerable research and planning and are tailored to large farm operations that have access to significant quantities of available feedstock (both on and off the farm) as well as the financial capability of entering a multi-million dollar investment.

This Guide is written in simple terms, avoiding overly technical terminology wherever possible and points you in the direction of further resources if you would like to investigate any elements in more detail.

What is Biomethane?

Biogas is created when organic material is broken down in an oxygen-free environment, called anaerobic digestion (AD). Biogas is a mixture of 55%-60% methane (CH_4), 40%-45% carbon dioxide (CO_2) and some small amounts of other gases, including hydrogen sulfide (H_2S) and ammonia (NH_3). Biogas, in its raw form, can be combusted. However it does not produce as much energy as natural gas found in existing pipelines in Canada which contains approximately 98% methane. Biogas generated from anaerobic digestion can be upgraded to pipeline-quality natural gas by removing all of the gases, particularly carbon dioxide, except methane. This purified or upgraded gas is called biomethane or renewable natural gas.

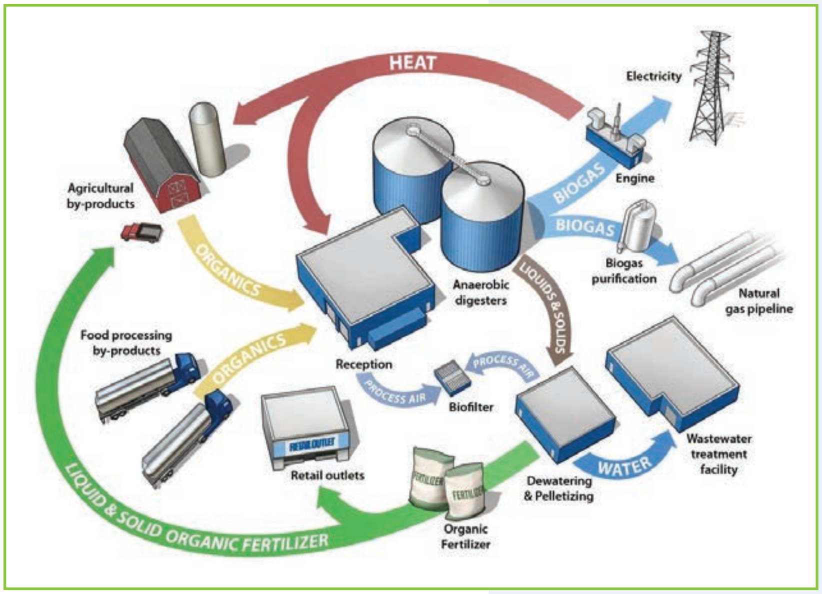


Image courtesy of Harvest Power

What this Guide Covers

This Guide is specifically written to aid in the development of projects which can produce biomethane for injection into the existing natural gas system. This guide does not discuss other options for utilizing digester-generated biogas produced on farms to:

- Generate electricity for sale to the electricity grid
- Consume the energy on-site to power operations, heat facilities or fuel farm vehicles

Outlining economic and non-economic farm scenarios is beyond the scope of this Guide. Technology suppliers and consultants can advise farmers on the economic viability of producing biogas or biomethane at their farm. In addition, some studies referenced in the "Additional Resources" section of this Guide outline some scenarios that may be useful.

Guide Development Methodology

The methodology used for preparing this Guide focused heavily on interviews with:

- Farmer developers who built biogas facilities to produce biomethane and electricity
- Technology and waste (feedstock) providers
- Governments and utilities
- Financial services providers

Internet research was also conducted to augment the interview information gathering.

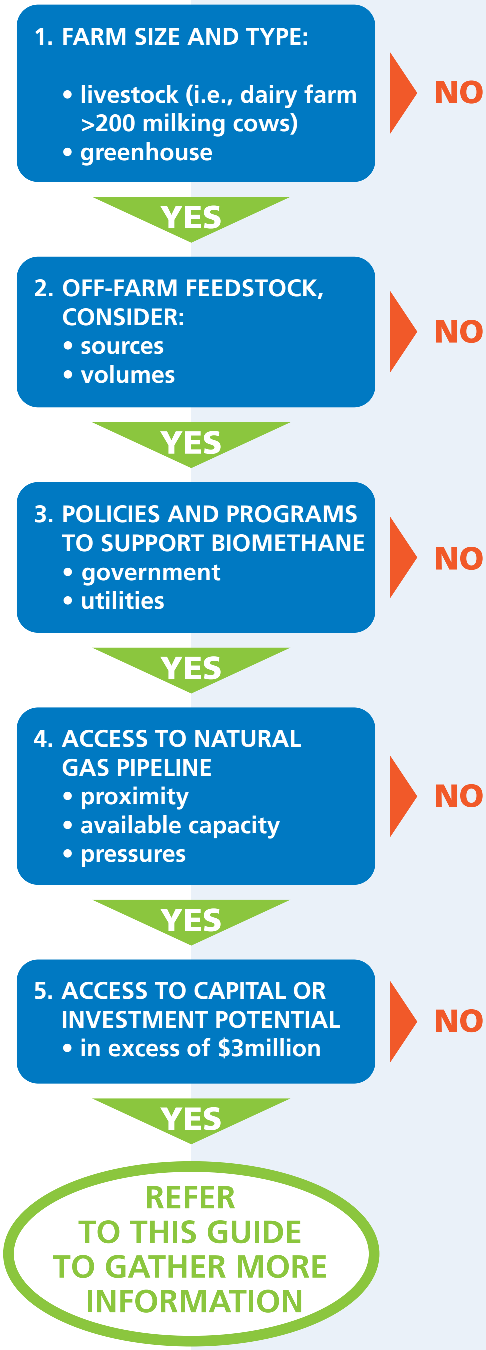
The Guide was then reviewed by a team of experts (listed in Acknowledgements) for accuracy and clarity.

Project Drivers

A farmer may have many reasons for considering a biomethane project which are unique to his or her own business. Potential drivers that may be applicable include:

- **Availability of on-farm materials.** This is a reflection of the size and type of existing agricultural operation and abundance of livestock manure or other on-farm materials. Large livestock or greenhouse operations are examples of farms that could make a biomethane project viable.
- **Ability to address manure management.** Anaerobic digestion provides improved manure management and pathogen reduction, in addition to reductions in weed seeds and odour.
- **Access to high energy feedstocks.** Locally available, high-energy off-farm materials are needed for biomethane production and can be a win-win partnership for the farm and local businesses
- **Biomethane policies or incentives.** Policies and incentives created to support biomethane development will vary by utility and province. Are there such opportunities available in your area to help support your project and do you have the willingness/ability to enter into regulatory processes and contractual negotiations?
- **Proximity and access to natural gas pipeline.** The closer you are to a natural gas pipeline the more economical it will be to connect your project. A natural gas pipeline that is in the range of 5 km to your project site, that has system capacity, ability to connect, and pressure to accept biomethane produced during periods of minimal gas demand are all necessary factors.
- **Access to capital.** Projects will require several million dollars of investment, and require an acceptance of longer term financial returns.

Conducting this initial scan will help to understand what is important in your project and help to guide various decision making steps along the way. The following flowchart has been provided to help determine whether your project is a good candidate for biomethane and gives consideration to some fundamental elements required to support such a project.



Your Research Approach

This Developers' Guide to Biomethane proposes an approach that is informative and mindful of the pertinent steps to take and questions to answer. As every project is site specific, the approach is not exhaustive to all circumstances and many steps are likely contemplated in parallel.

Though the list of questions and considerations below is valuable, you should plan to visit at least one farm-based biogas system to start the learning process for your own project. Seeing biogas systems in operation first-hand and speaking with the operators provides valuable insight and experience. Biogas systems can be toured throughout Canada, the US and Europe. Multiple visits to operational facilities are encouraged to understand the depth and detail of the process. Come prepared with a list of questions asking what the farmer would do differently on their own farms, what they would repeat, and essential things they have learned from their project.

As a farmer developer, you are well advised to ask a series of questions as you set out to determine if biomethane production is a good fit for your farm. These questions represent a high level assessment for your specific project. The list is summarized below with additional detail provided in the following sections.

1. Who will purchase the biomethane I produce?
2. What is the potential scale of my project?
3. Can I connect to the natural gas grid?
4. What are the financing and tax implications?
5. What return on investment (ROI) can I expect?
6. What inputs do I need?
7. What technology is required?
8. How do I choose a supplier?
9. Can I expect costs and revenue to change over time?
10. How long does construction take?
11. How many working hours per day/week are required on an ongoing basis?
12. What permits and approvals do I need?
13. What should I know about safety?
14. Should I consider a co-operative approach?

1. Who will purchase the biomethane I produce?

In Canada, the development of the biomethane opportunity has been led by natural gas utilities, not government policy. Biomethane development supports some provincial policies, such as British Columbia's *Clean Energy Act* (2007), which calls for a reduction in greenhouse gas emissions, and the *Natural Gas Strategy* (2012).

FortisBC saw a need to respond to consumer demand for fuel with a lower carbon footprint. FortisBC also wanted to comply with provincial legislation, and were encouraging the development of biomethane as it fit with its corporate direction and fosters innovation. In BC, the regulatory agency approved an opt-in program whereby customers pay a premium to have 10% of their natural gas come from renewable sources as biomethane (see: www.fortisbc.com). FortisBC was able to work with the provincial government to get the *Carbon Tax Credit* applied to biomethane. In effect, this reduces taxes paid on biomethane.

FortisBC markets its program to its customers, and has been able to match supply with demand, as of mid-2012. It purchases biomethane from a farm in Fraser Valley and it will be adding gas from a landfill in Salmon Arm before the end of 2012. Contracts are negotiated on a case-by-case base, with a maximum price set by the regulator.

In Ontario, the energy regulator reviewed a 2011 application from the natural gas utilities, Enbridge Gas Distribution and Union Gas, to provide their customers with up to 2% biomethane in their natural gas supply. Consideration of this application is on-going. Ontario's *Green Energy and Economy Act* (2009) encourages renewable energy sources, but is focused on the electricity sector.

In other provinces, biomethane producers would need to rely on the voluntary market to sell their biomethane. Since no premium price would be paid to producers, natural gas utilities would pay the same price to biomethane producers as producers of natural gas. To recoup their costs, biomethane producers may be able to sign long term agreements with customers that are interested in purchasing the "environmental attributes" of biomethane, notably the greenhouse gas reductions associated with its production. Producers would connect to the natural gas pipeline and purchasers would use the natural gas system as they currently do, but since they were responsible for having biomethane injected into the system, they are able to claim the attributes associated with the fuel.

Bullfrog Power is a provider of 100% renewable electricity and natural gas. Its customers voluntarily pay a premium for these fuels, and it is possible to sell your biomethane to Bullfrog Power. However, the company is only able to pay producers what the market can bear. As of mid-2012, this was approximately $8/GJ.

In Alberta, the province provides no incentive for biomethane. Alberta Innovates is able to conduct methane potential analysis and other tests for potential developers.

The Government of Saskatchewan website says it is well suited to biogas production, but has no policies to support this yet.

The New Brunswick Climate Action Fund supported a farm-based biogas facility in 2010, but the province does not have incentives to support biogas or biomethane development.

Biomethane activity in Quebec is growing, with a municipal landfill near Montreal connected to the natural gas grid, and other municipal projects in development. However, incentives are for municipalities, not farms at this time.

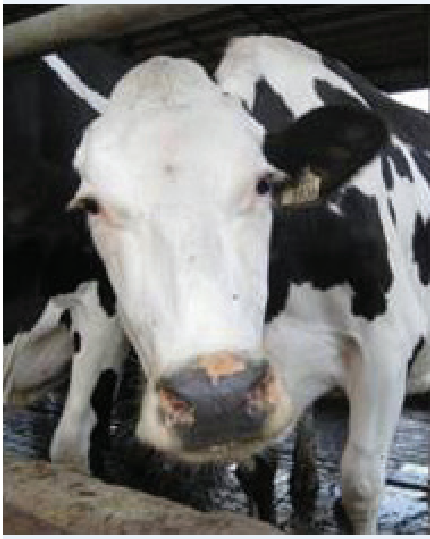
While Nova Scotia and Prince Edward Island have biogas plants, they are not farm-based, and are not supported by government incentives or policies.

2. What is the potential scale of my project?

For your project, the main factors that influence how big a project you can build are feedstock availability and the size of the investment into the project.

The production of biogas, and in turn biomethane revenue, is determined by the contents fed to the digester, their quality, and the efficiency by which these are converted into energy. The digester plant, including any substrate pre-treatment technologies, must be designed around the availability and quality of the feedstock(s) which can deliver the desired production goal.

Determining an exact return on investment ("ROI") for a biomethane project can be difficult initially until the amount of biogas that can be generated is determined. Digester system performance often depends more on the system's biological environment than its mechanical system. Energy production depends upon the balance of consistent feedstock tailored for a specific equipment design, or conversely, a tailored technical design to match the specific feedstock available. Some considerations are below.



- How much volume and quality of feedstock can the farm sources provide, and what additional feedstocks can be brought to the farm? The farm's production of agricultural byproducts (primarily manure) plus other agricultural byproducts are the starting points to determine the biogas system size. Most biogas systems will also rely on off-farm materials to boost biogas production. These off-farm materials will often have significantly more biogas potential than the farm-based materials. Local regulations will limit how much and what types of high strength off-farm materials can be mixed with farm materials. In all of these cases, the economic balance of system cost, feedstock cost or revenue, and energy sales will have to be determined. See the biogas calculator tools in the Resources section.
- What will a specific digestion technology cost, scaled to process a specific volume and quality of feedstock? Visit examples of various digesters scaled to process similar feedstock volumes. In most cases, a digester design size requires a minimum amount of daily feedstock to achieve biological stability and generate biogas in adequate and stable quantities. The biogas vendor you work with will be able to help finalize the system size and configuration based on feedstocks available and other technical constraints.
- What consistent revenue stream will the biomethane produce and over what time period? Does that revenue stream satisfy the individual ROI test (see page 9) for the capital investment?
- What volume of other feedstock (such as from neighboring farms), or what specific off-farm feedstock may be available, and what energy generation will those new volumes yield? See the Feedstock section in the appendix for assistance answering these questions.

3. Can I connect to the natural gas grid?

There are considerations a producer needs to take into account when contemplating connecting a biomethane project to the natural gas pipeline.

Location and local conditions

In certain rural areas, there may not be gas service or there may be insufficient service to support biomethane developments. The natural gas utility will need to evaluate the nearest connection opportunities available to accept biomethane injections. Each of these evaluations will be site specific; results will be dictated by the producer's proximity to the natural gas utility's system and the local customer demand for natural gas in that particular area.

Natural gas travels through the transmission and distribution network by means of a pressure gradient, moving from areas of high to low pressure. Transmission pipelines operate at higher pressures and typically feed multiple distribution systems. A distribution system operates at a lower pressure and is isolated from the transmission system feeding it, providing service to a limited number of customers.

The demand for natural gas in any one distribution system is dependent on the number and type of customers, and is weather sensitive (the highest demand occurring during cold winter weather and the lowest demand occurring during warm summer weather). Small distribution systems with few customers may experience very limited demand for natural gas during summer months, which can preclude the injection of biomethane into that system. This can be determined by contacting your local natural gas utility.

Image courtesy of Flotech/Greenlane

Contractual requirements

The natural gas utility will also be able to provide its expectations with respect to gas quality requirements for the biomethane to be injected into its system. As a reference, the Canadian Gas Association has published a Biomethane Guideline highlighting a general consensus of gas quality expectations for RNG by the utilities across Canada.

In addition, the utility will also be able to define the physical connection requirements necessary to inject biomethane into its system. Typically, the utility will require the installation of a producer station which includes components for billing measurement, pressure regulation, odourization, and gas quality monitoring, as well as a length of interconnecting pipe necessary to tie into the nearby distribution system. The treatment of costs for the interconnection will vary by utility, ranging from the entire cost of the connection being borne by the producer, to a share of costs or entire costs being borne by the utility. There may also be operating costs for the utility's management of the interconnecting facilities.

Depending on the type of contractual arrangement available through your local natural gas utility, there may be opportunity to sell biomethane in a number of ways, including:

- To the utility at fluctuating commodity rates for natural gas
- To the utility at a specified premium price (above fluctuating commodity rates), if such a price is approved by the provincial regulator
- To notionally transport the biomethane through the utility's system and market the product to other customers at a negotiated price

The terms of each purchase or transportation agreement will vary by utility.

Typical expectations

The process to receive a gas purchase contract from a utility will require several steps. You should be talking to the utility early in your development planning. At a minimum, you will need to have a firm understanding of your expected energy production and proposed location of your project to start the process.

The process covers the following basic steps, and the timing to move through each step may vary between jurisdictions.

1. Initial contact
2. Preliminary analysis (evaluation of energy/location)
3. Go/No-Go decision
4. Detailed evaluation
5. Contract
6. Regulatory review
7. Interconnection engineering
8. Installation
9. Final acceptance testing

Start-up testing may be conducted over a month period, and verification testing may accompany the first few months of testing.[1]

4. What are the financing and tax implications?

Biogas is new to most Canadian financial institutions, and they are not always familiar with biomethane facilities. Renewable energy opportunities are not new, however, and financial institutions generally want to support their farm customers in their renewable energy investments. They stress that the underlying economics of the farm are what determines their willingness to support investments of the scale of biogas operations. Banks indicate they look for existing debt servicing capacity to support the cash drain of the biogas facility during its development and commissioning, so that if there are issues with the plant coming on line, the business itself does not experience financial difficulty.

If a farm has a strong financial position, and presents the business case and long-term revenue stream for the biomethane system, obtaining financing should not be a hurdle. Financial institutions warn that if a farm plans to use the biomethane system as part of the foundation for the economic viability of the farm, this will be considered problematic.

It is important to involve your lender early in the process as you consider a biomethane system. Farm Credit Canada (FCC) was cited by developers as good to work with. Farmers reported that FCC understood the technology and its benefits. FCC also positions itself as supportive of biogas, and encourages farmers to investigate this opportunity, providing some guidance to them as well. Enter "biogas" in the search function on www.fcc-fac.ca for more information.

If your project experiences delays, or requires unforeseen access to capital, your financial institution needs to be your partner in the project.

Depending on the type of farm operation, the tax treatment of a biomethane system may be similar to the farm operations. You should consult with a tax specialist to ensure your biomethane project is structured appropriately for your business needs.

[1] *Saber, Diane, "How to Speak Natural Gas" Biocycle Magazine, May 2012, Vol 53, No 5, p.41*

5. What return on investment (ROI) can I expect?

Calculating ROI is an important step and is as accurate as the information that you factor in for your specific project. ROI is a means of assessing the financial stability of a project and whether it can generate sufficient reward in return for the invested capital, labour and management demands.

Biomethane injection into a natural gas pipeline will have a premium price, either set by a regulator or a utility in order to make projects economical, or by biomethane gas brokers who source biomethane and sell equivalent amounts of gas to customers requiring renewable energy. Your jurisdiction's prices and circumstances will define the project's economic return.

In a similar way to most construction projects, several factors that will influence a project's actual return include:

- Cost control during design, construction, and operation
- Ability to achieve and maintain the predicted operation level
- Availability of other revenue streams (tipping fees for off-farm materials can contribute significant operational revenue, while others might actually pay to receive high-quality inputs).

Each project will be different and subject to many variables which in turn will result in a very individualized ROI calculation for your project. The ROI that you target must balance acceptance of technology and market risks against the investment. Considerations of these risks and other important variables include:

- **Capital Investment** – the estimated costs of all equipment and ancillary components, soft costs (consulting, design, approvals), and infrastructure costs such as excavation and laneways, and a contingency of 8-20%
- **Technology** – is the technology selected proven at many other sites or is it novel? What are the component efficiencies and availability?
- **Feedstock** – do you have ability to source energy-producing feedstock from on and off the farm and ensure these are available for an extended period?
- **Construction** – develop a reasonable expectation for construction duration, season, and potential for delays (2-5 years based on current experience); consider construction insurance, or hiring bondable contractors
- **Labour**– can additional revenue from development and sale of biomethane be generated using existing labour and skill sets, or will additional staff need to be hired?
- **Revenue Diversification** – digester systems generating biomethane can be a natural extension of the farm operation and can offer diversified revenues from other existing revenue sources (e.g., milk quota)

In simple terms, ROI is represented by the quantity of all revenue dollars generated by the project over a defined period of time minus all dollars spent for all costs for the project for the same period of time. That residual number of dollars divided by the total investment is the ROI over that defined period of time. Commonly the total ROI is a projection calculated over the useful life of the investment. See *Appendix B* for additional information on calculating ROI.

6. What inputs do I need?

To produce biomethane economically for injection into the natural gas pipeline, your farm will need to have sufficient sources of feedstock to be viable. As with any biogas system, the energy production is dependent on the energy content of the inputs. The feedstock section below includes the following, to assist you in understanding what your feedstock can deliver:

1. Biogas yield by feedstock volume: a comparison of the energy content of different feedstock sources
2. Feedstock considerations
3. High level feedstock mapping, including industrial and commercial density mapping, and including which municipalities collect residential organic material.

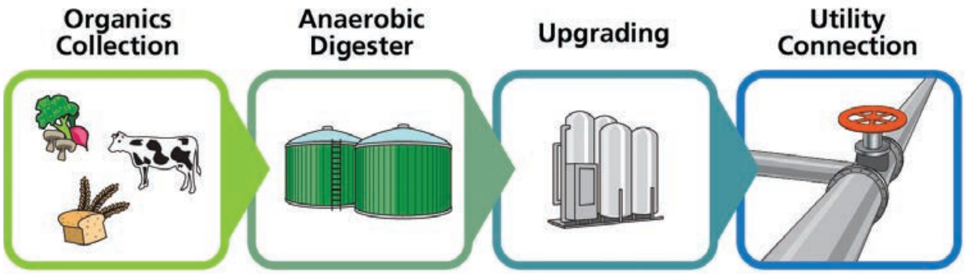
A technology supplier can advise you on what feedstocks are required to achieve a specific volume of gas production. This should be further substantiated by scientific measurement and analysis where possible. There are several approaches to determine the actual gas production of materials, including simple biochemical methane production tests. If your farm volumes are insufficient, you may be able to work with neighbouring farms and use a common upgrading facility. See the *Co-op Considerations* section below.

You can also get feedstock advice from anaerobic digestion system providers, or from independent consultants. As more systems are operational in Canada, these professionals are increasing their experience with feedstock "recipes" and increasing successful results with their customers in different locations.

7. What technology is required?

To generate biomethane, you will need an anaerobic digestion system, and an upgrading system. An overview of suppliers is listed below. Take time to understand the integration of the different parts of the system. This understanding will be derived from the suppliers, and their answers will help you determine which supplier(s) to choose. You may choose to engage a consultant with expertise in the area of biogas projects to help with the selection of equipment. The basic components of any biomethane project are the anaerobic digester, the upgrade plant and the utility connection (figure below). This section describes the anaerobic digester and the upgrade plant.

Biomethane producers should note that there is usually no by-product of waste heat, which there is with other applications of biogas. Biomethane production needs a net input of heat. Installing a small combined heat and power (CHP) unit as part of the operation is one option.

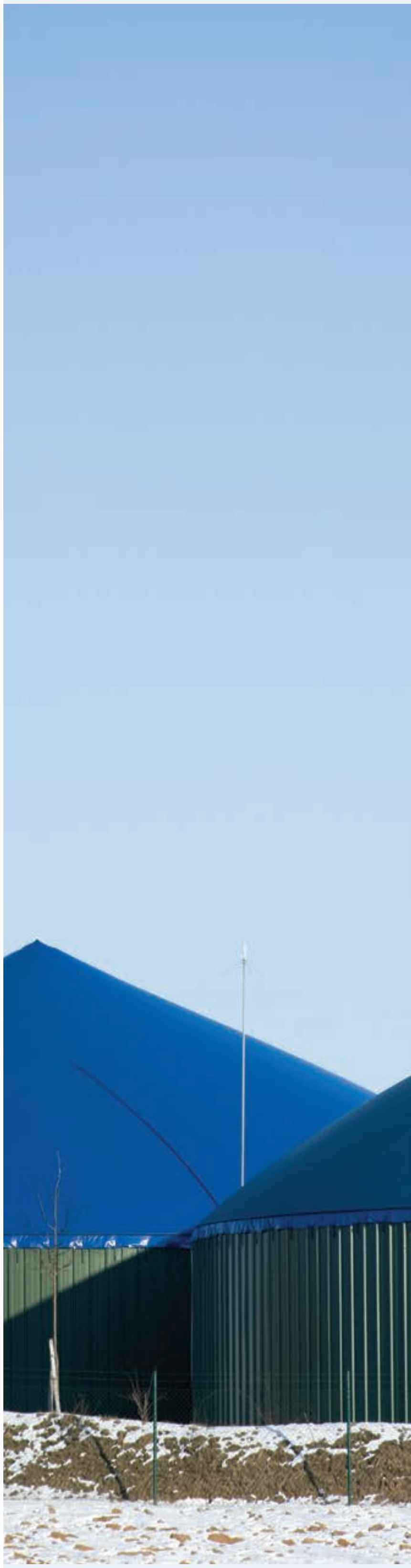


Upgrading Technology

The biogas will include substances which will need to be removed in order to inject it into the pipeline, including carbon dioxide, water, hydrogen sulfide, oxygen, nitrogen, ammonia, siloxanes, and particles. Concentrations depend on the compositions of the substrates used to create the biogas. To prevent corrosion and mechanical wear of the equipment, it can be advantageous to clean the gas before upgrading.

The most widely used technologies for biogas upgrading are the following, as described by the International Gas Union (see reference under *Resources*):

1. **Pressure swing adsorption.** This technology purifies the gas by way of adsorption of impurities on active coal or zeolites.
2. **Physical absorption.** Water or another liquid such as alcohol can be used to bind carbon dioxide. This is called water scrubbing or pressurized water wash.
3. **Chemical absorption.** Chemical absorption is comparable to water absorption. A liquid such as amine is chemically bonded to the carbon dioxide. In order to recycle the solution, a heat treatment is applied.
4. **Membrane separation.** Methane can be separated from carbon dioxide using semi-permeable membranes. The force can be a pressure difference, a concentration gradient, or an electrical potential difference.
5. **Cryogenic separation.** Trace gases and carbon dioxide are removed by cooling down the gas in various temperature steps.



The International Energy Agency's Biogas upgrading technologies – developments and innovations document is also a useful resource. Because of the high cost of upgrading, it is important to choose a system that has low energy consumption and high efficiency, giving high methane content in the upgraded gas. The document also notes that the best technology choice is based on the parameters of your plant, such as the prices of electricity and heat. It is possible to lower the methane loss, but at the expense of higher energy consumption.[2]

An important criterion during upgrading is loss of methane, or "methane slippage". Methane is a potent greenhouse gas – at least 21 times the global warming potential of carbon dioxide – so the consequences of methane leaks or losses are significant. The methane content in the reject gas, in the water from the water scrubber, or in any other stream leaving the upgrading plant, should be kept to a minimum.

Carbon dioxide, hydrogen sulfide and other waste gases are vented from upgrading equipment. These gases can be both an environmental and a human health risk. Greenhouses are able to use the excess carbon dioxide in their operations.

Anaerobic Digestion Systems and Additional Services

The following is a listing of anaerobic digestion system suppliers in alphabetical order, and a summary of what they provide.

Bio-En Power: provides turn-key design, planning, commissioning from green field to completion of the biomethane production system. They also offer feedstock advice. Bio-En uses hybrid methophilic and thermophilic anaerobic digestion systems, depending on the inputs. www.bio-en.ca

CHFour Biogas Inc.: provides feasibility studies, business plans, permits, plant design, implementation, commissioning, start up, and ongoing support for biogas production. CHFour assists with feedstock contracts as well. CHFour uses mesophilic anaerobic digestion of material in its process. The company would sub-contract the upgrading system work. www.chfour.ca

Dairy Lane Systems Ltd.: provides affordable turnkey digesters to customers throughout Ontario. Dairy Lane Systems Ltd. has partnered with several European bioGas engineers and equipment manufacturers to provide Ontario's dairy producers with practical and efficient biogas solutions. www.dairylane.ca

MT-Energie: offers turn-key technology for the production of raw biogas, systems for upgrading biogas to natural gas quality and installations for connection to the gas grid. The company uses a patented amine-scrubbing system to remove the CO_2 from the raw biogas. It also offers complete injection facilities including increasing pressure, odourization, and all necessary measuring equipment. www.mt-energie.com/ca.html

PlanET Biogas Solutions: prefers to be the complete design-build contractor for each biogas project in which it is involved, and also conducts the feasibility study for each project (as required). Through their experience in British Columbia, the company learned that having the process under one roof is beneficial to the farmer, and transfers risk from the farmer to the technology provider. PlanET partners with Greenlane or other firms to supply the equipment to upgrade the fuel from biogas to biomethane. This includes a wash water system, and monitoring. PlanET controls the process, design and gas pressure. PlanET has a microbiologist on staff, who tests feedstock in partnership with a lab. The company also has a maintenance and best practice consultant. www.planet-biogas.ca

[2]*International Energy Agency (IEA) Bioenergy, Anneli Peterson and Arthur Wellinger, Biogas upgrading technologies – developments and innovations, October 2009, p.12*

Upgrading Systems and Other Services

The following is a summary of technology suppliers, in alphabetical order, that provide products or services related to upgrading biogas to biomethane.

Flotech/Greenlane: provides complete biogas upgrading systems using water scrubbing. Greenlane has the only Canadian on-farm biogas to biomethane installation in Canada, located in Abbotsford BC. Greenlane provides upgrading equipment including gas measurement and effluent treatment, along with installation and commissioning support, remote monitoring and maintenance. www.flotech.com

Tenergy Services North America Ltd./European Power Systems Ltd.: is dedicated to the automated dispatching of cogeneration systems and real-time monitoring or biomethane quality, composition, heating value and volume. www.tenergyservices.com

Xebec: provides upgrading and compression, construction, monitoring and maintenance, interconnection between the digester system and the natural gas pipeline. Xebec can also own and/or operate the system as well. Their system uses pressure swing absorption. They have commercialized an innovation overseas that will enable higher volume processing. www.xebecinc.com

8. How do I choose a supplier?

There are several steps that you can take that will help you choose the best technology supplier for your farm operation.

a. **Appoint a project manager.** The farm needs a biomethane project manager to devote a significant amount of time over several years. They can defer to this Guide as a checklist for ensuring they understand how to proceed.

One important consideration in appointing a project manager is the amount of time dedicated to the task and whether the supplier or farmer can adequately manage this role or whether an outside project manager is required. The project manager would work closely with the various team members - farmer, supplier, consultants, etc. The project manager will also need to be aware of all the workplace, health and safety, and regulatory requirements.

Sometimes a farmer chooses to general manage the project themselves. This ensures the farmer gets what they want, and can be one way to manage costs. This approach may extend timelines, and expose the farmer to some increased risk if they are not aware of all workplace, health and safety, and regulatory requirements for a project of this scale.

Consider sending your specifications to several suppliers and asking for proposals. These suppliers could be consultants, general contractors, or suppliers that design and build. Choose some criteria to evaluate the bids, such as price, experience, design and the total costs listed below. Suggest that the supplier break out the quote into component parts so you understand how much each element costs. However, some suppliers provide turn-key services and do not break out their quotes; in these cases, be sure to understand what the quote includes and excludes.

b. **Understand total cost.** Upfront cost is only one consideration. The total cost and associated revenue depends on the system installed. Ask the supplier the following questions:

- How efficient is your system?
- What is the repair process?
- How much down-time should I expect? Outline the maintenance regime.
- What is the life expectancy of the equipment?
- What is the availability of equipment and parts? (Are they available locally or sourced from abroad?)
- What are the operating and maintenance costs for each part of the system? Given my location, how much compression will be needed?
- Are there chemical usage and any handling/disposal costs?

c. **Consider the track record.** Ask about the suppliers' other installations, and check their references. Considerations for the consultant and/or supplier include experience in design, operations and construction, performance record (including ability to stay on time and on budget), and expertise. Make sure to decide what role you want to play: will you be the general contractor, or just an advisor?

You may want to conduct a feasibility study completed by a professional independent from the supplier/builder for objective analysis.

9. Can I expect costs and revenue to change over time?

First adopters of biomethane systems in a region may pay more for systems since all parties involved take extra time to learn about local requirements, set-up and other factors. Over time, some costs are expected to decrease as experience and economies of scale translate into time and resources saved. For example, upfront engineering costs will likely decrease as more plants come online.

Feedstock prices are also likely to fluctuate over time pending supply and demand. It is recommended that long term contracts be reached with feedstock stock suppliers wherever possible.

Image courtesy of Seacliff Energy

10. How long does construction take?

Construction itself should take roughly one year. However, research, planning, signing contracts with suppliers and energy purchasers can take years. Previous developers report that this process took 2-5 years. This length of time should shorten as government regulators, utilities, and local support services become more familiar with the technologies.

11. How many working hours per day/week is required on an ongoing basis?

This is a key question to answer. While feeding a digester is similar to feeding an animal, gauging the health and performance of a digester is done differently. Visit existing digester operations and ask the operators and owners about level of work required for their systems.

For biomethane projects, the size, level of automation and the complexity of the system determines the amount of hours per week required to operate the system. This can range from one part time operator for several hours each day to full time operators. Talk to your supplier as well for a more accurate assessment for your system.

12. What permits and approvals do I need?

Government permits and approvals required for biogas systems vary from province to province.

British Columbia Ministry of Environment requires three permits for biogas systems: effluent; air; and solids. Permits are issued by the regional offices, and are site-specific. Currently, a maximum of 25% off-farm materials is allowed as feedstock into the anaerobic digestion systems. This percentage may increase in future, but the timeline is unknown. The Ministry of Environment has a guidebook in development that will assist developers in understanding the requirements. View the draft guidebook, which is open for comment.

Currently, inquiries are directed to the BC Agricultural Research and Development Corporation (www.ardcorp.ca).

In Ontario, a maximum 25% off farm materials is currently the limit, but this is under review as of mid-2012. While electricity-generating projects have their own environmental approval path, biomethane projects would require an Environmental Compliance Approval. Approvals are required for air/noise, sewage works, and waste. These may be combined into one approval, depending on the project. An additional permit may also be required if the project takes water. An environmental assessment is needed if the project is processing off-farm waste at volumes exceeding 1,000 tonnes/day on average in a year. The ministry requests that project developers contact them directly. View the guide.

View a summary of Ontario incentives and requirements. Note that a portion of the information applies only to electricity-generating systems.

In other provinces, consult with your Ministry of Environment regarding permits and approvals required.

You will need a building permit from your municipality. Developers report these are not difficult to obtain.

See the *Safety* section below for additional requirements.

13. What should I know about safety?

Handling natural gas requires training and it needs to be handled responsibly. Although this section does not cover all aspects of safety, it provides a starting point for developers to explore. Every project should develop a safety plan with the help of industry experts.

For example, farm staff working on digesters will likely need specific training related to hydrogen sulfide, which is a poisonous gas often contained in digesters. Safety procedures in this case may require that staff with potential exposure to hydrogen sulfide carry personal (hand-held) gas detectors to identify leaks.

In addition, farmers should be aware that typical Canadian oil and gas pipeline standards require that an odourant be added to domestic natural gas for quick and easy detection of gas leakage during distribution. This procedure is applicable for biomethane distribution as well, and is typically done by the natural gas utility and not the producer.

Courses are provided by the private sector (which can be searched online), and in Ontario by University of Guelph (Ridgetown, Ontario) and by OMAFRA. An *eLearning* module is available. It consists of three modules and a final test:

- Module 1: Flammable and Hazardous Gases
- Module 2: Emergency Management
- Module 3: Daily Onsite Activities

In Ontario, the Technical Standards and Safety Authority (TSSA) provides oversight for gaseous fuel safety. Contact them at www.tssa.org

BC producers should consult with the BC Safety Authority about biogas flare requirements, inspections and approvals. The Safety Authority regulates biomethane under the *Safety Standards Act* and *Gas Safety Regulation*. Their primary focus is related to the design and installation of the facility, and adherence to the *CAN/CGA-B105-M93 Code for Digester Gas and Landfill Gas Installations*, and applicable regulations. A provincially licensed gas contractor needs to obtain an installation permit from the Safety Authority. Contact them at www.safetyauthority.ca

Plan for *Confined Space Rescue Training* costs in addition to safety equipment and training. Several private companies offer this training.

14. Should I consider a co-operative approach?

In order to produce sufficient biogas to upgrade to biomethane and connect to the natural gas grid, you may consider creating a co-operative (co-op) with neighbouring farms that are also interested in the biomethane opportunity.

Renewable energy co-ops are not new, and are in fact an excellent way to increase the number of renewable energy projects, and the financial, environmental and social benefits associated with them. They are more common with wind and solar projects, however, since the ongoing inputs and maintenance requirements are much lower than biogas systems.

Farms may opt to co-operatively share input materials, such as manure, crops and silage, or have anaerobic digesters on each participating farm, and pipe the biogas to a common facility which would upgrade the biogas to biomethane and inject it into the natural gas pipeline. Again, location is a critical factor; farms would need to be within approximately 5 km of the upgrading facility.

In Ontario, two community biogas co-ops are in development, and both are aiming to generate electricity. One is at the Toronto Zoo, called *Zooshare*, and the other is in development is farm-based and in the Waterloo area, led by *Local Initiative for Future Energy Co-operative* (LIFE Co-op).

There are legal issues to be considered, such as shares to be issued (common shares, membership shares, preference shares), and whether the co-op is for-profit, not-for-profit, or a corporation. In the case of biogas co-ops, one major hurdle to overcome is that of feedstock contracts. In raising the capital to finance a biogas co-op, a financial institution will want to know if the feedstock is secure for the long-term. Farms in the co-op may produce most of the feedstock themselves, in which case security of supply will not be a concern; however, farmers in the co-op would be well advised to clearly spell out feedstock agreements over the long-term in the co-operative agreement. Associations of cooperatives will assist in working through these details.

For information on co-op types, rules, benefits, and other information, contact *Community Energy Partnership Program* at www.communityenergyprogram.ca

Additional Resources

- LinkedIn has a "Biomethane and Biogas Upgrading" discussion group
- Gas Technology Institute, ***Pipeline Quality Biomethane: North American Guidance Document for Interchangeability of Dairy Waste Derived Biomethane***, 2009. Concluded that dairy operations are good sources of biomethane and can be easily upgraded to pipeline quality biomethane.
- International Energy Agency International Energy Agency (IEA) Bioenergy, ***Biogas upgrading technologies – developments and innovations***, October 2009
- International Gas Union, ***Renewable gas: the sustainable energy solution***, June, 2012
- CHFour Biogas Inc., ***British Columbia Anaerobic Digestion Benchmark Study***, (no date). The study evaluated the feasibility of developing anaerobic digestion systems at 12 agricultural sites in BC.
- Electrigaz Technologies Inc., ***Feasibility Study – Biogas upgrading and grid injection in the Fraser Valley, British Columbia***, BC Innovation Council, 2007.
- Economics for Ontario farmers
- Agstar, Market opportunities and calculations
- Feedstock databases:
  CROPGEN on the NNFCC (UK) site or
  at Basisdaten Biogas Deutchland
- Saber, Diane, "How to Speak Natural Gas" Biocycle Magazine, May 2012, Vol 53, No 5, p.41
- Vehicle fuels and stationary heat: Biogas Association, ***Innovation Forum: New Markets for Biogas***, May 2012.
- Alberta on-line fact sheet
- Alberta biogas potential page
- Manitoba Hydro biogas information
- Ontario Ministry of Agriculture, Food and Rural Affairs biogas page, with fact sheets

Appendix A: Feedstock

Projected Biogas Yields

In projecting the biogas yield from a particular feedstock, the components of interest are:

- Organic content – fat and protein constituents, and carbohydrates assessed by measurement of volatile solid content and carbon-to-nitrogen (C:N) ratio
- Inorganic content - also known as minerals or ash, which includes metals, and
- Water

To determine volatile solid (VS), total solid (TS) and water content, a sample of feedstock is first weighed before and after drying. Only biologically degradable organics can be converted into biogas, so volatile solid (VS) content is a key measure of the maximum biogas-generation potential of a substrate.

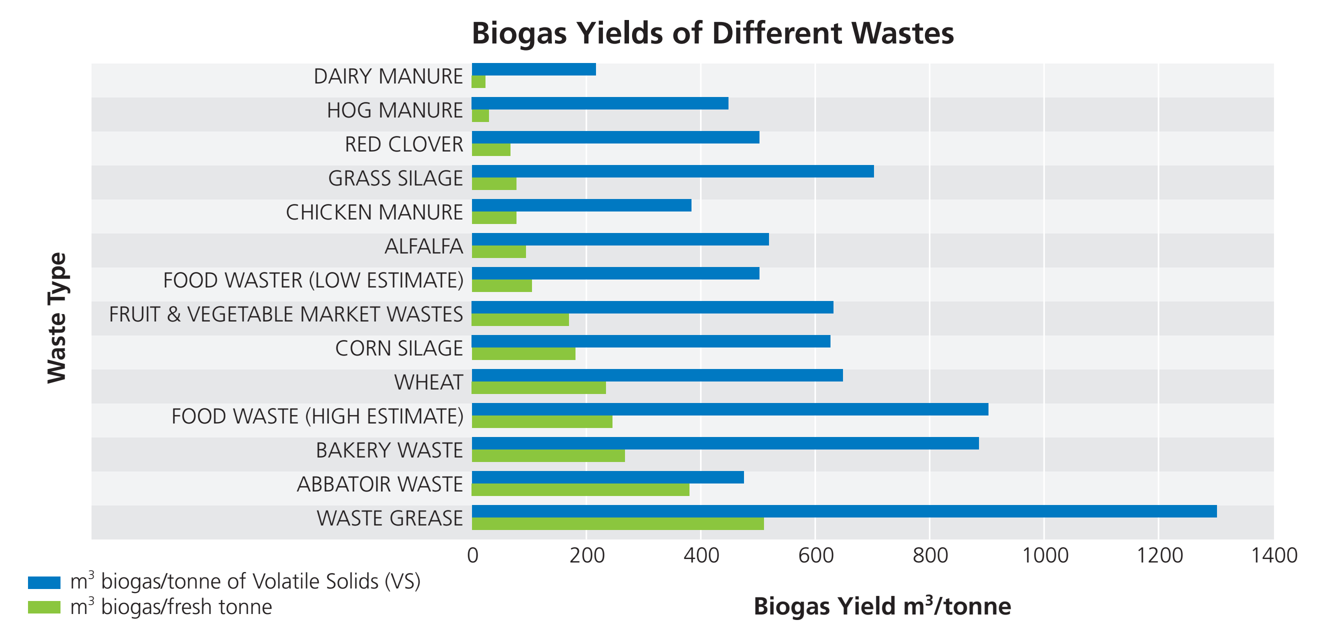


Table 1.Source: Regenerate Biogas, 2012 [3]

The wide range in potential yields of organic material can be largely explained by the relative amounts of fat, protein and carbohydrate. The biogas yield of a mixture of substrates can be estimated by a sum of the proportional contributions of each component of the mixture. For example, a 2:1 blend of dairy manure at 25 m^3/wet tonne and grease trap fats, oils and grease (FOG) at 250 m^3/wet tonne can be expected to generate an average of 100 m^3 of biogas per tonne of feedstock mix.

Due to the high variability of VS, TS and water in organic materials, it is highly recommended that developers obtain and test, over a period of time, several different samples of all locally available substrates being considered for the digester. Plans should allow for maximum flexibility in the feedstock mix, taking into account seasonal availability and any other considerations which may impact VS content and biogas potential.

[3]Data from CROPGEN , MacViro study Appendix A, 'Generating Biogas from SSOWaste for Energy Production' 2002, and Z. Wang, C.J. Banks / Process Biochemistry 38 (2003) 1267 /1273

Farm and Off-farm Substrates

Potential biogas feedstock sources can include almost any organic waste stream, but lack of availability or a low energy yield relative to the cost of digestion eliminates many from serious consideration. Cost of digestion is calculated as the total cumulative impact of capital and operating costs for a period divided by the units biogas produced by the feedstock processed during that period. For example, although livestock manure is readily available for farm-based digesters, its energy value is very low relative to other organic wastes.

In spite of its low energy value, dairy manure has a key advantage relative to other manures: coming from a ruminant animal, the manure is of the correct pH, alkalinity and carbon-to-nitrogen ratio to nurture its inherent anaerobic microbe population. If fresh manure is added to the digester without significant exposure to air, it can serve as a continuing source of inoculant, maintaining diversity and stability of the digester culture. This makes dairy manure – uncontaminated by bedding – a good base for co-digestion with higher energy substrates.

Other farm-based substrates such as crop silage or purpose-grown crops require careful consideration of the economic benefits of anaerobic digestion in comparison with the alternative uses of the land (such as cash crops) or the feedstock material's cash market value. Net revenues from purpose-grown crops are generally higher if the energy-dense seed or kernel is processed into food or liquid biofuels rather than biogas. For crop residues such as stalks or husks, chopping and ensiling or hydrolyzing will be necessary to improve anaerobic digestibility and maximize biogas yields. These technologies require additional mechanical equipment and operating expense, increasing the feedstock's cost impacting returns on the overall plant investment.

For on-farm biogas projects, it may be possible to comply with provincial nutrient management regulations while also accepting a certain percentage of off-farm waste sources. At present, off-farm feedstocks, particularly those comprising significant amounts of energy-rich fat, oil or grease (FOG) are the most feasible option for making a business case for digesters without simultaneously creating a digestate disposal problem. Farm based digesters are not readily adapted for processing residentially generated organic waste because of the contamination from plastic and other non-organic material, and secondly because of the required permits. See the *Permits and Approvals* section for more details.

Sourcing Feedstocks

There are several ways to procure off-farm materials. One is to work with a company in the waste industry that will contract with you to deliver specific consistent feedstock supplies. Another method is to contract directly with neighbouring farms, or with food processors in your area.

Other considerations with regard to off-farm material include:

- Bio-hazardous or pathogen-containing material is not suited for on-farm digesters
- Highly odorous substrates, such as slaughterhouse waste, are likely to cause complaints without intensive odour controls during reception, storage and processing
- Composition and volume of organic wastes is highly variable, changing by season and by source
- Collection, handling and delivery of organic waste from a large number of point sources is generally prohibitively expensive
- As the digester industry develops, tip fees will be commensurate with the value of the feedstock, with the highest fee revenue obtained for the least-desirable feedstock in terms of its biogas potential.

Successful digester projects are those which have ongoing access to abundant, local, clean ('trash'-free), energy-dense feedstock sources, and can acquire and process feedstock at a total cost less than the revenue generated by biogas production. A thorough understanding of the biogas-production value of available feedstocks and the technology cost to obtain this yield is therefore essential to make an informed go/no-go decision on a potential digester project.

Realizing Maximum Biogas Yields

Whether the maximum potential biogas yield is achievable in a given anaerobic digester system is largely determined by the biodigestibility of the feedstock mix and the biogas conversion efficiency of the digester technologies employed. The most important factors are:

- Presence of indigestible or less-digestible carbohydrate polymers such as lignin and cellulose, the structural components of woody and non-woody plants, respectively. Higher 'fibre' containing materials are much less digestible, and may require pre-treatment to break the polymers down to digestible carbohydrate monomers.
- Optimal environment in the digester to promote and maintain a healthy microbe population – constant (warm) temperature, neutral pH, and a continuous supply of nutrients.
- A high surface area (i.e. small pieces), appropriate mixing in the digester, and a long residence or retention time, to obtain optimal contact between the microbe population and the substrates.
- A suitable C:N ratio (e.g. in the range of 25 to 30:1), which effectively ensures that sufficient protein is supplied to maintain the microbe population. An oversupply of protein results in too high nitrogen and sulfur levels, causing toxicity in the digester, post-engine emission problems and potential odour concerns with digestate.
- Absence or minimal amount of toxic substances which can poison the microbe population or reduce contact between the microbes and methane-producing substrates. Interactions of the microbe population within a digester system are very complex; substances which are necessary or beneficial at low concentrations or within particular mixtures may be toxic at other concentrations or within other mixtures.

The inorganic or ash component of feedstock, while not directly contributing to biogas generation, is nonetheless needed to provide micronutrients and alkalinity, which helps to maintain and balance pH, supporting an optimal environment for the microbe population. The useful inorganics are generally a small fraction of the total; the majority of minerals either pass through the system in the digestate, or collect in the base of the digester, necessitating occasional cleanout of the bottom of the digester. The solid content of dairy manure, for example, is typically 80-85% volatile and 15-20% inorganic; the inorganic content results in a gradual accumulation of sand in the digester.

The water content of the feedstock is another important consideration, particularly as it relates to the loading rate and mixing of the digester contents. Obtaining the maximum possible biogas yield requires optimal viscosity and nutrient density of the digester contents—essentially, maintaining "thickness" and flow conditions such that nutrients arrive at the microbes and products are removed at the fastest rate that the microbe population can handle without being choked or blocked. Mixing and flow are improved with higher water content, but too much water is to be avoided since it doesn't produce biogas and is expensive to heat and stir for the extended period it is retained in the digester. Thicker, more viscous substrates such as crop residues or mixed food waste require additional water or a longer retention time. A longer retention time or lower feed rate results in less efficient mixing and allows time for "thinning" that occurs as more complex (polymeric) organic solids are hydrolyzed into smaller, more soluble substances.

High energy feedstocks can be trucked further than low-energy feedstocks and still be cost effective. Grease separation is required by regulation in each province. Fats, oils and grease (FOG) is highly sought-after as an input because of its high energy content. Similarly, dissolved air floatation – known as DAF – is used by food processing plants to skim grease off their products, and this is also used as a feedstock. Prices can fluctuate based on supply and demand.

To summarize, potential biogas yield and production revenues are directly related to the organic or volatile solids content of the feedstock mix. Yet to realize the maximum yield for a particular feed mix requires careful optimization of equipment and operating technologies for that feedstock mix. To some extent, the microbe population within a digester will adapt to a shift in substrates, but extreme changes should be made as slowly as possible. Feedstock is the most important part of a biogas project, as the systems must be designed around the available feedstock, not the other way around. As much as possible, continuity and consistency of supply should be assured through long-term contracts with a few trusted suppliers.

Questions to ask your potential feedstock supplier include:

1. What is the primary source and content of this feedstock?
2. Is it available all year round or only seasonally?
3. What is the revenue or cost?
4. Are there plastics and other inorganic materials in the waste stream? What percentage of the total do these materials make up, if any?
5. Will there be any processing before the waste is brought here?
6. Has the feedstock been tested in a lab to determine total volatile solids, chemical composition, and potential biogas yield? If yes, what do you estimate the biogas yield per tonne of raw material to be?
7. Are you willing to sign a long term supply contract (5 years+)?

Please see *Appendix A* for a series of feedstocks maps that will assist you in understanding feedstock volumes and types in your area.

There are advantages and disadvantages to different types of feedstock. These are summarized in Table 2.

Feedstock	Advantages	Disadvantages
Dairy Manure	• Balanced carbon/nitrogen ratio • Liquid slurry manure collection process simplifies AD adaptation	• Low energy value per tonne of raw material • May contain antibiotics/disinfectants • Low energy content may increase the need for larger digestion tanks
Beef Manure	• Balanced carbon/nitrogen ratio • Potentially large volumes of manure available at individual locations (at feedlots)	• Likely to contain more sand, silt, and mud, creating a need for separation technology or periodic shutdowns to clean out tanks. • Animals are commonly out to pasture, only possible at feedlots
Chicken Manure	• High energy value per tonne relative to other manure sources • Relatively simple manure collection process	• High levels of ammonia can have inhibitory effect on digestion; may require composting first • May contain antibiotics/disinfectants • May contain sand and grit
Hog Manure	• Typical flush manure collection process less suited to AD adaptation • Higher energy content than dairy manure	• High levels of nitrogen relative to cow manure • May contain antibiotics/disinfectants
Food waste (industrial, commercial, institu-tional)	• Higher energy value than manure • May have fewer contaminants than residential organic waste	• Biogas output varies greatly from one source to another • May require sorting and additional capital costs • Requires pasteurization before digestion • Potentially high acid or protein concentrations, which may require additional pre-treatment
Fats, Oils & Greases (FOG)	• Very high energy value if concentrated; • Relatively easy to manage, if pre-filtered to remove trash, as it comes in liquid form and does not require sorting	• May require pasteurization before digestion • Long term supply constraints are likely an issue • High levels of volatile fatty acids (VFA) can inhibit digestion • Variability in quality can impact digestion
Bakery waste	• High energy value per tonne	• Limited availability
Abattoir/slaughter-house waste	• High energy value	• May contain pathogens, requiring pasteurization before digestion • High levels of volatile fatty acids can inhibit digestion • High protein levels may cause foaming and inhibit digestion • Offensive odour may require special management of raw and digested material

Table 2. Source: Regenerate Biogas, 2012 [4]

Note that these are general guidelines only and it is strongly recommended that developers test several different samples of locally available substrates being considered for the anaerobic digester plant. Tests should include TS, VS and total nitrogen if high levels of ammonia or protein are expected. Feedstocks for which VS is less than 80% of the TS or C:N is < 15 will likely need pretreatment to be acceptable as a substantial component of the overall feed mix.

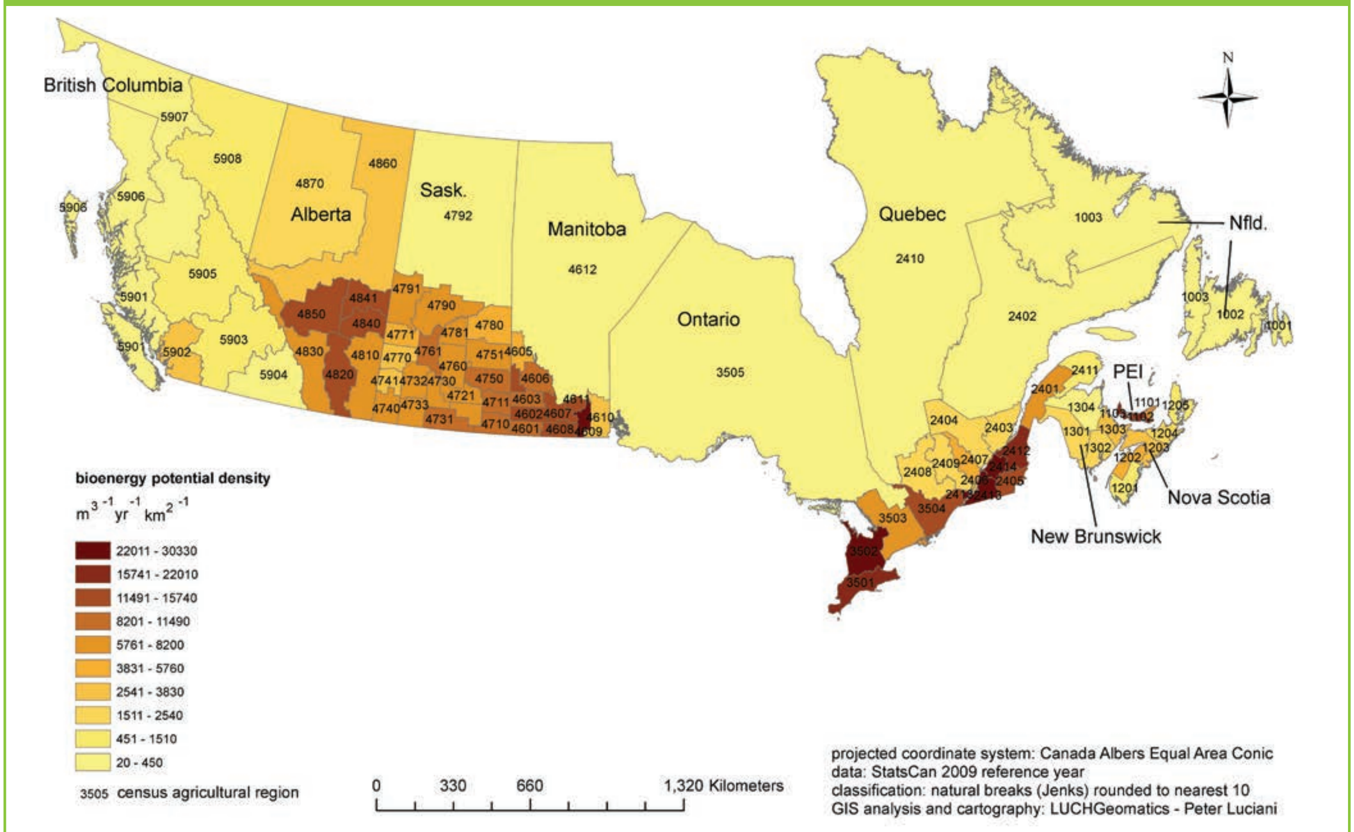
[4]*Data from CROPGEN , MacViro study Appendix A, 'Generating Biogas from SSOWaste for Energy Production' 2002, and Z. Wang, C.J. Banks / Process Biochemistry 38 (2003) 1267 /1273*

Feedstock Mapping

Maps descriptions/explanations

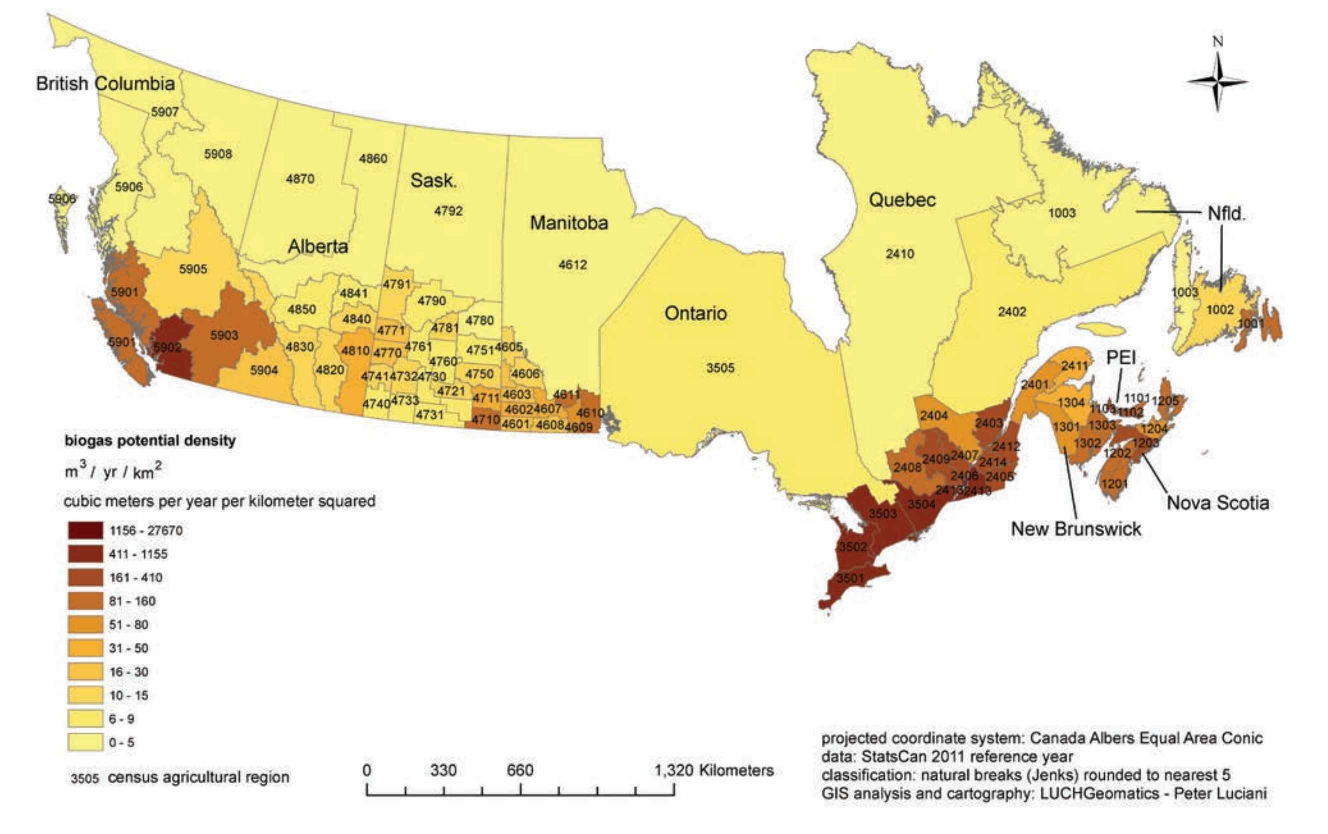
Agricultural – The map shows the total biogas potential per square kilometer, sorted by Census Agricultural Region (CAR) based on the total number of dairy cows, pigs, poultry and horses, and the current acreage of crops suitable for anaerobic digestion (corn silage, alfalfa and other fodder crops) from the 2006 Census of Agriculture. We assumed that only corn silage, alfalfa and other fodder cropland would be used for biogas, that every tonne of manure and silage produced would be used and that only manure from animals typically kept in barns would be suitable. Agricultural biogas potential (ABP) was calculated by multiplying average manure production per animal (M) or typical crop yield per acre (CY) by the expected biogas yield (BY) and dividing by the total area of each CAR (Area).

Agricultural Biogas Potential Density within Cencus Agricultural Regions of Canada



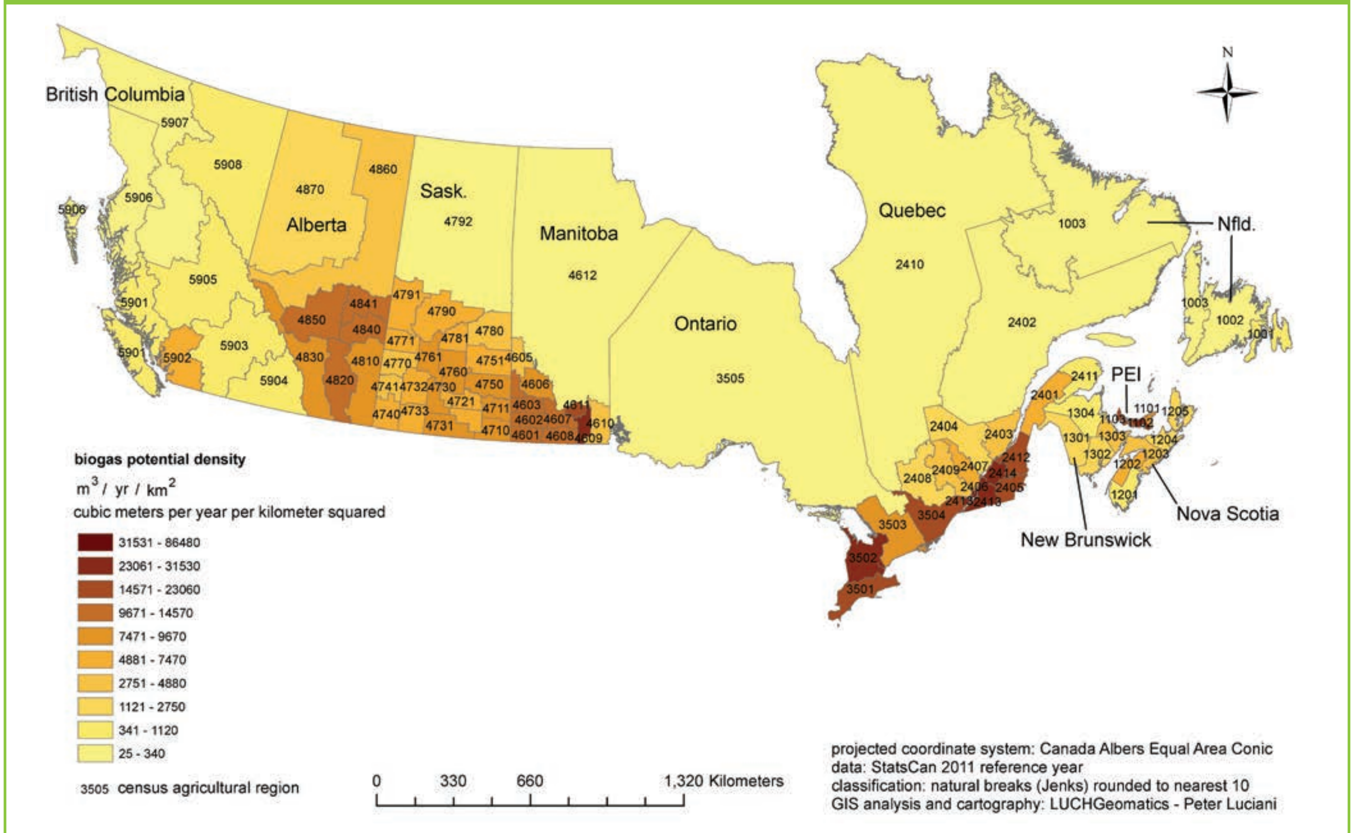
Industrial and Commercial – The map shows the total biogas potential from solid organic waste produced by select North American Industry Classification (NAICs) codes by Census Agricultural Region (CAR), based on average waste production per employee per year. Industries covered include commercial bakeries, pet food manufacturers, breweries, wineries, slaughterhouses, dairy product manufacturers, sugar and confectionary products manufacturers, fruit and vegetable canners and processors, and full service restaurants. Due to a lack of available empirical data across Canada across all covered industries, missing data for select NAICs was derived by multiplying total employees by NAICs code by province by the ratio of individual populations to the provincial total. We assumed that each industry existed in every CD, which may not always be true, and that the waste produced by the above industries was available for biogas production and not meant for another industry using the by-products. Industrial and Commercial biogas potential (ICBP) was calculated by multiplying average waste production per employee (WPE) by the number of employees (E) by the expected biogas yield for each respective industry (BY) and dividing by the total area of each CAR (Area).

Industrial and Commercial Potential Density within Cencus Agricultural Regions of Canada



Total – The map integrates data from the Agricultural, Industrial and Commercial sectors, and adds residential waste, organized by Census Agricultural Region. Total biogas potential (TBP) was calculated by summing up Agricultural, Residential, and Industrial/ Commercial biogas potential and dividing by the total area of each CAR (area).

Overall Biogas Potential Density within Cencus Agricultural Regions of Canada



Appendix B: Calculating Return on Investment

The ROI for a biomethane project is dependent upon the following three bookkeeping steps and two financial calculations:

- What is the total capital to be invested = ($X)
  - This includes every dollar spent directly for the investment; and, you should consider inclusion of any indirect investments (such as labour and management time)
- What is the total revenue stream generated by the biomethane and other products = ($Y) for a given period
  - This is third party outside revenue. If the project is also intended to replace current bedding costs with a lower cost alternative, then only include the net savings as a contribution to ($Y)
- What is the total spent for all operating and ownership costs = ($Z) for the given period
  - Every third party expense for all consumables, all repairs and maintenance, all labour (at market rates), the interest on any debt (but not principal payments), etc.
- Then ($Y) minus ($Z) = Net Free Cash Flow ($NFC)
- ($NFC) divided by ($X) = ROI% on the investment for the given period

The resulting percentage is the projected return on the funds, equity and labour risked on the investment over the projected period of time.

Your ROI depends upon your ability to select and operate a technology to successfully process energy-producing (on or off-farm) feedstock volume within your technology application choice (investment) and recover enough revenue to fund all operating and ownership costs. The final result is a residual 'net free cash flow' that, when divided by the investment, yields your ROI.

Appendix C: Interviews

The following individuals and organizations were consulted in the development of this Guide between October 2011 and April 2012.

Developers

- Chris Bush, Catalyst Power/Fraser Valley Farms
- Jim Callahan, Maryland Farms
- Doug Cleary, Clearydale Farms
- Leonard De Bruin, De Bruin Farms
- Dennis Dick, Seacliff Energy
- Jennifer Green, Ledgecroft Farms
- Dan Jones, Clovermead Farms
- Paul Klaesi, Fepro Farms
- Kim Marchand, University of Guelph Centre for Agricultural Renewable Energy and Sustainability
- Nick Terpstra, Birchlawn Farms

Technology and Waste Suppliers

- Bio-En Power
- CHFour
- European Power Systems and Tenergy
- Fiba Canning
- Flotech/Greenlane
- M-T Energie
- Organic Resource Management Inc.
- PlanET Biogas Solutions
- Xebec

Other suppliers that were contacted but declined to provide information include Air Liquide, ATCO Midstream, and Atlantic Hydrogen

Utilities

- Bullfrog Power
- FortisBC
- Union Gas
- Enbridge Gas Distribution

Government and Agency Representatives

- Alberta Innovates
- British Columbia Ministry of Environment
- British Columbia Ministry of Agriculture
- British Columbia Safety Authority
- Ontario Ministry of Energy
- Ontario Ministry of Environment
- Ontario Ministry of Agriculture, Food and Rural Affairs

Associations and Academics

- American Biogas Council
- Canadian Gas Association
- Dairy Farmers of Ontario
- European Biogas Association
- Ontario Federation of Agriculture
- University of Manitoba

Financial Institutions and Financiers

- CIBC
- Farm Credit Canada

Biogas Association

www.biogasassociation.ca