Biogas Association

Farm to Fuel

Developers' Guide to Biomethane as a Vehicle Fuel

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Viking Strategies thanks all those interviewed for this guide, listed in *Appendix D*.

Authored by:

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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

1.0 Introduction

Biogas production is an excellent opportunity for many farm operations. It provides a host of benefits, including:

- Renewable energy production for use on-site, or for sale
- Odour and nutrient management, reducing pathogens from manure and improving water quality
- Production of valuable bi-products such as high quality fertilizer, and animal bedding
- Job creation, and the opportunity to market the farm as innovative and environmentally progressive

As a fuel, biogas can be used in a variety of ways – for generating electricity, heat, and if biogas is converted to biomethane and used as a vehicle fuel, it has the added benefits of cleaner combustion when compared to gasoline and diesel fuels, reductions in air emissions that contribute to smog and climate change, and related respiratory health benefits.

Some farms have installed biogas systems primarily to reduce odour and as a nutrient management approach, with the energy production and associated revenue as added benefits. The bi-products provide additional value to farm operations and can augment revenue streams.

This *Developers' Guide to Biomethane as a Vehicle Fuel* was developed to help farmers determine if producing biogas to be used as a renewable vehicle fuel is a good fit for their farm operations. The Guide reviews technical and economic considerations, addresses trends and barriers, highlights case studies, and connects readers to resources such as the *Developers' Guide to Biomethane*.

1.1 What are Biogas and 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), 45%-40% carbon dioxide (CO_2) and smaller amounts of other gases, including hydrogen sulfide (H_2S) and ammonia (NH_3). Biogas, in its raw form, can be combusted in specially designed engines. However, it does not produce as much energy as natural gas delivered from 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 unwanted gases, particularly carbon dioxide, hydrogen sulphide and water. The purified or upgraded gas is called biomethane or renewable natural gas (RNG).

2.0 Who Can Use This Guide?

Biogas can be used as a furnace or boiler fuel in engines specifically designed to operate for this purpose. Few vehicles can accept biogas; however, there are increasingly more vehicles available that can operate on compressed natural gas (CNG) or compressed biomethane. The following sets out general options for consideration by farmers, based on their location relative to a natural gas pipeline, and size of their farming operation.

There are two scenarios that lend themselves to the production of biomethane by a single farm to be used as a vehicle fuel.

2.1 Larger Farms

The first is a large farm operation that can justify the cost of gas technology cleanup to produce biomethane. Biomethane is interchangeable with natural gas, and can be used to fuel vehicles either blended or at 100 percent.

For large farm operations that are on the natural gas pipeline, and are able to connect, using the pipeline to store the biomethane produced is an option.

For large farms that are not on the natural gas pipeline, biomethane production and on-site storage is possible. Similarly, biomethane can be transported to other customers through tube trailers.

Natural gas (or biomethane) is stored on the vehicle in one of two forms – compressed or liquefied. Compressed natural gas (CNG) is more common than liquefied natural gas (LNG). CNG is stored at high pressure in tanks. The amount of energy stored in compressed gas is less than the energy stored in liquid fuel for the same liquid volume, so the operating range is reduced. To address the range issue, some heavy duty vehicles use LNG.

Photo: Fiba Canning

2.2 Smaller Farms

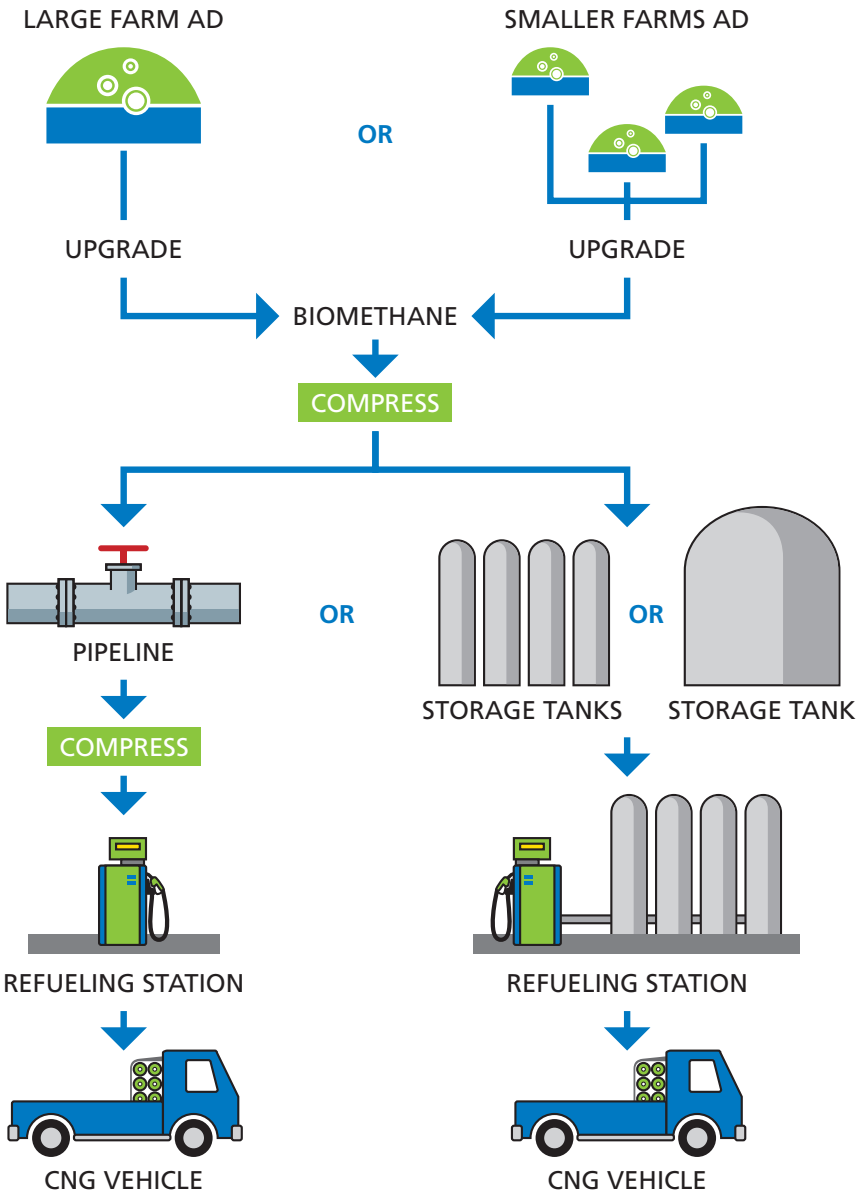
The second option is for smaller farms that choose anaerobic digestion as a means to treat organic material and generate energy for their own farm use or for sale to other users. It is a consideration for producers who: cannot connect and sell to their provincial electricity grid; are in areas where grid connection is not economically justifiable; or, where not all energy produced can be used on-farm for heating barns, greenhouses, or generating electricity. Biogas that is not upgraded to biomethane and compressed does not lend itself to affordable and/or practical transportation fuel. The lower energy content and large volume storage requirements are limiting factors to biogas fuel utilization.

In these situations, a small number of nearby farms could consider pooling their biogas using low pressure underground interconnection lines. This would permit the establishment of a shared-cost gas cleanup technology and the joint marketing of biomethane via pipeline injection or truck transport to a user site. These farms can take back their effluent for field application and not lose their on-farm nutrients.

2.3 Joint Projects

Ideally, some business interests may choose to come together in a joint venture to develop biogas as a vehicle fuel. Rather than projects resting solely on farmers to develop, the associated agricultural and food processing industries, and waste transportation sectors could develop a joint venture to reduce greenhouse gas emissions and save money on fuel. While this has not yet occurred, some industry experts expect it will in future. (Voell, May 2013). 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. For information on co-ops, consult the first guide in this series: the Developers' Guide to Biomethane.

The diagram below provides an overview of the process for developing biomethane as a vehicle fuel.



3.0 Biomethane as a Vehicle Fuel

Biomethane as a vehicle fuel is not new, and is being driven in other parts of the world by a range of environmental and economic factors. To help develop the adoption of the fuel, Europe has completed tests, and some countries have adopted targets and built infrastructure to support this fuel type.

3.1 Drivers

In Europe, biomethane is increasingly being used as a transportation fuel. The drivers for this are regulation and taxes on waste disposal, increasing need for renewable fuel sources, the European Commission's Biofuels Directive, measures to improve local air quality, and the need for clean transportation fuels in urban areas.[1] Given the development curve for biomethane as a vehicle fuel in Europe, Canada can become a significant producer in the medium term.

The environmental benefits of displacing diesel or gasoline with biomethane are significant. While combustion of biomethane produces carbon dioxide (CO_2), a greenhouse gas, the carbon comes from plant matter that fixed this carbon from atmospheric carbon dioxide. It has the added benefit of converting decaying matter that would normally release methane, a potent greenhouse gas, into usable energy, Therefore, biomethane production and consumption is near carbon-neutral.

Switching from diesel or gasoline to natural gas or biomethane also brings air quality improvements. Water quality improvements are also significant from anaerobic digestion (AD) of farm outputs such as manure. Water quality and odour improvements can be the primary drivers for some farmers to choose AD, with energy production and the associated revenue providing a secondary benefit.

In Canada, the economics of using biomethane as a vehicle fuel are challenged because the environmental benefits are not recognized through carbon pricing, except in BC. In addition, there is no renewable fuel requirement for natural gas in the same way that ethanol is required in gasoline and biodiesel has been mandated in diesel in some jurisdictions. The US has a Renewable Fuel Standard that is spurring some biomethane development. In Canada, customers that purchase biomethane as a vehicle fuel do so voluntarily.

In 2013, the prices of traditional vehicle fuels – gasoline and diesel – are at historic highs and the price of natural gas is at a historic low. As a result, fleet managers are increasingly exploring the option to switch to natural gas as a vehicle fuel. While financial and infrastructure barriers persist, the landscape is changing for natural gas fueled vehicles, which can also be powered in part or entirely by biomethane.

Furthermore, for every one cent per litre increase in fuel prices, Canadian farmers' annual machinery fuel bill is up by about $27 million (Statistics Canada, Agriculture and Agri-Food Canada).

Photo: Quasar Energy Group

[1] *National Society for Clean Air and Environmental Protection, Biogas as a Transport Fuel, June 2006*
http://www.cleanvehicle.eu/fileadmin/downloads/UK/nsca_biogas_as_a_road_transport__084926300_1011_24042007.pdf

3.2 Current Market

As the Natural Resources Canada Natural Gas Vehicle Deployment Roadmap indicates, the most suitable current applications for natural gas in vehicles, given engine technology, fueling infrastructure, and vehicle availability, is the heavy duty tractor trailer and return to base fleets.[2] The dairy industry is exploring how to close the loop and use one of their industry outputs (manure, converted to biomethane) as a vehicle fuel for their milk trucks. In Europe, a three year study published in 2010 found the following[3]:

- Biomethane works to augment natural gas and provide renewable fuel content (0-100% mix)
- Vehicle operation is not affected negatively by switching to biomethane, based on monitoring of 4.5 million km
- Positive attitudes toward biomethane by drivers
- Increased sales of vehicles in Italy, Sweden and Switzerland due to government incentives
- Driving forces for further expansion include environmental awareness, economic incentives, green marketing advantage
- Limiting factors for further growth include higher purchase cost and limited supply of natural gas vehicles, lack of economic advantage of biomethane over natural gas, and lack of refueling stations

Sweden currently has 20 biomethane plants and runs 2,300 vehicles on biomethane, mostly buses. Biomethane accounts for 55% of methane used in transportation.[4] It also has a series of dedicated filling stations.

The Canadian Natural Gas Vehicle Alliance notes that factory-built natural gas vehicles offer advantages related to warranty, parts and maintenance support. (Milner, Nov. 2011) Existing vehicles can also be converted on an after market basis. Check to ensure conversion kits are emissions-certified.

[2] *Natural Gas Use in Transportation Roundtable, 2010, http://oee.nrcan.gc.ca/sites/oee.nrcan.gc.ca/files/pdf/transportation/alternative-fuels/resources/pdf/roadmap.pdf*
[3] *Biogasmax, Biomethane Vehicle in Five European Cities, February 2010*
[4] *Peter Boisen, NGVA Europe, Biomethane potential as a vehicle fuel*

4.0 Considerations

The following section outlines some of the key considerations farmers should understand before they decide to proceed with using biomethane as a vehicle fuel. These include economic, technical, environmental, and safety considerations, and are divided into the following sections below:

- Economic:
  - Fuel prices
  - Biomethane production
  - Fueling equipment
  - Vehicle conversion
- Technical:
  - Vehicle conversion
  - Compression and storage
  - Refueling
- Energy Value of Fuels
- Safety

In terms of a development timeline, including planning, permits, construction and commissioning, expect an on-farm AD plant with gas clean up technology in place to take about three years.

4.1 Economic

There are several things to consider when evaluating the economics of using biomethane as a vehicle fuel. These include: the prices of various vehicle fuels; the cost to generate biomethane; the equipment costs needed to utilize biomethane as a vehicle fuel; and, vehicle conversion or new vehicle purchase costs.

When calculating if this is a good fit for your farm operations, also consider the cost of labour to build and operate the biomethane system and related infrastructure. Some of the factors to consider when assessing the economic viability of a project include:

	Expenditure	Gas Produced	Price/ Litre	Revenue	Profit
Gas production	▬				
Vehicle conversion or purchase	▬				
Refueling station:	▬				
• Compression	▬				
• Storage	▬				
• Safety	▬				
Labour	▬				
TOTAL EXPENDITURE	▬				
Volume of gas produced		▬			
PRICE PER LITRE (EXPENDITURE ÷ VOLUME)			▬		
Fuel savings from not purchasing conventional fuel				▬	
Fuel sales to external customers				▬	
TOTAL REVENUE				▬	
PROFIT (REVENUE - EXPENDITURE)					▬

If you are planning to sell your biomethane, you need to have a license from the Technical Standards and Safety Act (TSSA). Refer to the Facility Licensing webpage for details.

4.1.1 Fuel Prices

First, a farmer needs to consider their current annual fuel costs for farm vehicles and other potential local users of the renewable fuel in order to determine the business case for producing biomethane as a vehicle fuel. A review of annual fuel bills would provide the most accurate costs; however, this could be calculated by way of an estimated volume multiplied by the current fuel prices. As an example, in 2013 the prices of various vehicles fuels are approximately as follows:

Fuel	Price
Compressed natural gas	$0.60/litre
Gasoline and diesel	$1.20/litre
Compressed biomethane	>$1.00/litre[5]

For five-year fuel price trends, see *Appendix A*.

[5] *Biogas Association submission to Ontario Energy Board Proceeding, May 2012. Price will vary according to the volume of material being processed, and the size and price of the technology installed.*

4.1.2 Biomethane Production

Next is it important to determine the gas production potential and cost to generate biomethane. In order to do so, consult the *Developers' Guide to Biomethane*. Note there are separate costs for AD equipment, biomethane upgrading equipment, and compression and injection equipment. Costs are site-specific, and suppliers and their contact information are listed in the Biomethane Guide. Biogas system technology suppliers can assist in providing you with a quote. Based on experience in Ontario, typical farm biogas systems cost approximately $2-3 million, including the co-generation equipment and grid connection costs. Upgrading technology providers can provide separate quotes for their equipment.

Some experts in Canada and the US suggest it is economically feasible for a farm to install an anaerobic digestion system and upgrade to biomethane provided they produce enough to feed the equivalent of a 500 kW generator, or 3,000 diesel litre equivalents per day. This expenditure results in fuel cost that is lower in cost than diesel or gasoline, factoring in a 10-year return on investment, excluding the cost of vehicle conversion.

For farms that are considering a joint biomethane project, costs will be site specific. Technology providers can provide quotes for equipment, piping, construction, and related costs. A listing is provided in the Biomethane Guide or on the Biogas Association website.

4.1.3 Fueling Equipment

Third, a farmer needs to investigate the cost of equipment needed to utilize biomethane as a vehicle fuel, including:

- Small-scale refueling with a Vehicle Refueling Appliance (VRA). The VRA compresses the gas and pumps it into the vehicle fuel tank. A VRA costs about $7,500[6]
- Compression equipment to take biogas or biomethane from a digester or from the pipeline to be used by the vehicle at 3,000 pounds per square inch (psi). A system that fuels at 5 cubic metres (m3)/hour costs about $12,000. A larger capacity compressor, which fuels at 100 m3/hour costs about $100,000. (Vodden, April 2013)
- A compressor is used in combination with gas storage. Storage tanks start at $16,000 (Wilkinson, May 2013)
- For a six-vehicle fueling station, fueling the equipment consists of low-pressure piping, compressor, high-pressure tubing to storage tanks, and fill hose assembly from storage to the vehicle's storage tanks. This costs a total of about $45,000, including $24,000 for the compressor, $16,000 for storage, and $5,000 for the temperature and pressure compensation system, fill hose assembly, piping and valves, and automatic blow-down expansion capability. The exact price depends on location and system choices. (Wilkinson, June 2013). Refer to CSA code B108.
- TSSA infrastructure requirements include a concrete slab, signage, electrical supply to compressor, and six-foot high fence to protect the area. This costs $5,000 - $10,000.
- TSSA application, inspection and license fees total about $1,500
- A dispenser, which costs $35,000, may be added to track usage for vehicles in fleets, or to charge external customers. It is not needed for private dispensing.

Photo: CNG Energy Group

The TSSA website includes a section on Fuels for Transportation that is a useful resource and provides details on its requirements.

[6] *S Clarke and J DeBruyn, Vehicle Conversion to Natural Gas or Biogas, Ontario Ministry of Agriculture, Food and Rural Affairs, August, 2012*

4.1.4 Vehicle Conversion

A fourth economic consideration is the cost to purchase or convert vehicles that use biomethane as fuel. To convert a SUV or pickup truck that uses gasoline to bi-fuel costs between $6,000-12,000[7], depending on the vehicle make and model. The differential to purchase a CNG tractor trailer versus one that uses diesel is $50,000-60,000. (Hitchon, Feb. 2013)

Industry experts recommend a fleet of six or more vehicles to make the economics work, in terms of purchasing or converting to CNG or bi-fuel trucks, and installing a CNG fueling station.

4.2 Technical

Key technical considerations for farmers relate to converting vehicles, compressing and storing biomethane, and refueling.

4.2.1 Vehicle Conversion

First, it is possible to convert gasoline vehicles to bi-fuel (gasoline and CNG) through conversion kits. Conversion kits consist of fuel storage cylinders and brackets, fuel lines, a regulator, and a fuel-air mixer. Licensed natural gas conversion companies provide the equipment and installation service. A switch is installed on the dashboard to allow the driver to easily switch between gasoline and natural gas or biomethane. In general, hybrid fuel vehicles automatically switch to the reserve tank of conventional gas/diesel fuel when the natural gas tank is empty.[8]

Increasingly, manufacturers are coming out with factory-built dedicated CNG vehicles, with over 50 options available for medium and heavy duty trucks. Custom conversions/installations are also possible. Westport, an engine supplier, reports that the company converted a diesel industrial forklift to natural gas, noting that the diesel parts were removed. (Chisholm, Nov. 2012)
For a listing of the light duty conversion equipment and services suppliers, visit the Canadian Natural Gas Vehicle Alliance website.

4.2.2 Compression and Storage

Second, compression is required to convert biomethane into a usable vehicle fuel. Biogas comes out of a digester at 5-10 psi, but needs to be scrubbed to minimum 98% pure methane and compressed to at least 60 psi to be injected into a natural gas pipeline. For vehicles, the compression needs to be at least 3,000 psi.

If storing the gas prior to fueling vehicles, gas can be stored in tanks at higher pressure than the vehicle needs to enable effective fuel flow. If storing the gas using the natural gas pipeline, refer to the *Farm to Fuel: Developers' Guide to Biomethane* regarding connection considerations.

Industry experts are monitoring developments in the liquefied natural gas (LNG) market, watching leaders such as Prometheus Energy in the US. LNG vehicles are more expensive than CNG vehicles due to the more expensive double-walled fuel storage tanks. However, if the economics of LNG improve, it will gain wider spread adoption. However, it should be noted that LNG will be produced at a limited number of sites quite removed from points of vehicle fueling so there is still an associated transportation cost.

Photo: CNG Times

[7] *Enbridge Gas Distribution, quoted in Vehicle Conversion to Natural Gas or Biogas, Ontario Ministry of Agriculture, Food and Rural Affairs, August, 2012*
[8] *S Clarke and J DeBruyn, Vehicle Conversion to Natural Gas or Biogas, Ontario Ministry of Agriculture, Food and Rural Affairs, August, 2012*

4.2.3 Refueling

As mentioned above, depending on the scale of the project, there are a few different refueling options.

For refueling one or two light duty vehicles, a farm can opt to purchase a Vehicle Refueling Appliance (VRA), which pressurizes gas to 3000 psi and feeds it directly into storage tanks on the truck. A VRA is an easy to use, affordable, on site system which takes regular low pressure natural gas from an existing utility gas line at any business or home and compresses it for use in a natural gas fueled vehicle. "Time-fill refueling" takes place overnight or while the vehicle is not in use, completely unattended. When refueling is complete, the VRA shuts off automatically.[9] The time required for refueling limits this system's appeal. However, suppliers indicate some advantages of this system include:

- On site convenience saves time and money because drivers no longer have to go out of their way during the work day to refuel.
- Installation is simple and inexpensive.
- The VRA's reliability record is strong.

For larger operations that require fast or repeated filling on shorter fueling intervals, on-site storage or pipeline connection is required. A comprehensive fueling station with several component parts and accessories that meet safety standards requirements could include the following:

- Dispensing system to measure flow while refueling
- "In-line breakaway" option to prevent vehicles that are refueling from accidentally driving away after refueling while still connected to the refueling apparatus
- Larger storage capability
- More elaborate filtration and fill hose assemblies

A key consideration for CNG vehicles is the current lack of re-fueling infrastructure on public roads. At this time, they are best suited to vehicles that return to a base, such as a farm, for refueling. The bi-fuel models make re-fueling options less of an issue. For a listing of natural gas refueling stations across Canada, go to the Canadian Natural Gas Vehicle Alliance website.

[9] *http://www.atwautomotive.com/vra.html*

4.3 Energy Value of Fuels

As a vehicle fuel, it is shown that biomethane generates the greatest amount of vehicle fuel energy for a given amount of feedstock,[10] making it environmentally preferable to biodiesel or ethanol.

Biomethane has the same energy content as conventional natural gas, since both energy sources are comprised of methane.

Energy Yield from Different Biofuel Crops[11]

Fuel	Yield (L/ha/yr)	Fuel Equivalent (L/ha/yr)	Energy Yield GJ (ha x yr)	Driving Performance (km/ha)
Biodiesel from canola	1,550	1,410	51	23,300
Corn ethanol	2,560	1,660	54	24,400
Biogas from corn silage	3,560	4,980 (kg/ha)	178	67,600

4.4 Safety

The Technical Standards and Safety Act (TSSA)(2000) outlines the requirements and regulations for operations that provide refueling using compressed gas. Operators need to consult the Ontario Regulation on Compressed Gas (O. Reg. 214/01) and understand the certification and operational requirements, registration processes and other pertinent safety information.

The TSSA published a corresponding Code Adoption Document in 2009, which updates the standards and requirements.

According to the TSSA, since the VRA is considered an "appliance" just like a gas stove, anybody can use it without pre-approval requirements.[12]

[10] *NGVA Europe Fact Sheet: Biomethane production potential in the EU-27+EFTA countries compared with other biofuels, http://www.ngvaeurope.eu/downloads/fact-sheets/2020-biomethane-production-potential.pdf*
[11] *Data from Biomotion Biofuels, as quoted in Vehicle Conversion to Natural Gas or Biogas, Ontario Ministry of Agriculture, Food and Rural Affairs, August, 2012*
[12] *Bill Barr, City of Guelph, Biogas Pick-up Quick Facts*

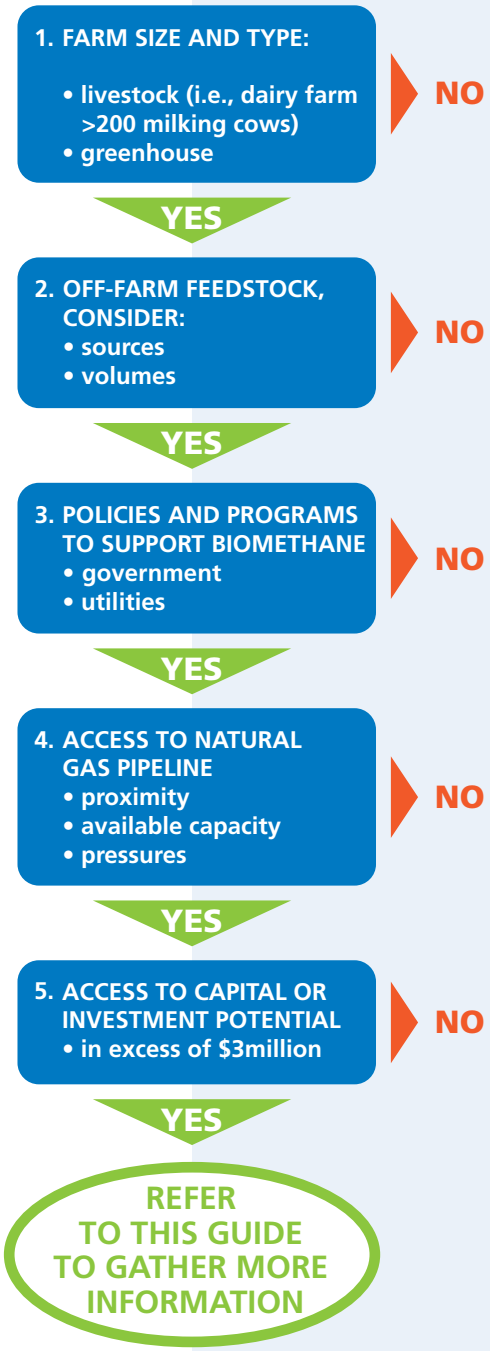
5.0 Biomethane Basics

Resources currently exist for those looking to develop biomethane projects. In 2012, the Biogas Association published *Farm to Fuel: Developers' Guide to Biomethane*. The *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.

The Guide points out that 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, and the Guide provides additional detail on each question, and how you can approach your research.

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

There is also a significant section on feedstock, outlining projected biogas yields, farm and off-farm substrates, sourcing feedstocks, realizing maximum yields, and national feedstock mapping.



5.1 Connection Charges

If you are planning to use the natural gas pipeline to store or transport your biomethane, you will need to enter into an agreement with the local distribution utility. For a listing of gas utilities across the country, visit the Canadian Gas Association website. You will be expected to pay all of the costs of connecting your facilities to the natural gas distribution system. These customer facilities include the necessary piping and measurement to allow the producer's supply to flow (and be controlled and metered) into the system. The charge is dependent on the site-specific facilities requirements and can vary based on the length of piping required to connect to the system, outlet delivery pressure and flow rate from the supplier into the system. The requirement to pay the facilities cost to connect is the same for all gas suppliers.

Typically, the utility will 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.

5.2 Gas Quality Expectations

The natural gas utility also regulates gas quality of all gas entering its distribution system. Producers need to follow guidelines laid out by the industry. The Canadian Gas Association has published a *Biomethane Guideline* highlighting a general consensus of gas quality expectations for RNG by the utilities across Canada.

6.0 Case studies

Three case studies, one each in the US, Europe and Canada, help illustrate the application of biomethane as a vehicle fuel.

6.1 Fair Oaks Dairy, Indiana

Fair Oaks Farms, based in northwestern Indiana, includes twelve dairies with over 35,000 dairy cattle for the production of milk, cheese, ice cream and butter.

In March, 2013 Anaergia officially launched the operation of the facility that converts biogas from cow manure into the equivalent of nearly 38,000 litres (10,000 gallons) per day of diesel fuel.[13]

Manure collected from 11,000 dairy cows is anaerobically digested to produce biogas composed of roughly 60% methane. Anaergia cleans, compresses and upgrades the biogas using technology from Greenlane Biogas to over 98% methane under a 15 year operations contract. The biomethane is odourized to form renewable natural gas (RNG) and then further compressed up to 4,000 psi into compressed natural gas (CNG) for vehicle fueling.

A fueling station supplies the renewable natural gas to fuel a fleet of 42 milk trucks operated by Fair Oaks Farms and AMP Americas. The renewable fuel avoids the consumption of diesel fuel for their daily milk deliveries that run in excess of 32,000 km (20,000 miles) per day across the Midwest United States. Excess renewable natural gas generated at Fair Oaks Farms that is not used for onsite fleet fueling is injected into the natural gas grid to offset fossil fuel based consumption by other CNG fueling stations. The project is saving $10,000/day in fuel costs, and is expected to reduce greenhouse gas emissions of the fleet by roughly 36,000 tonnes per year or the equivalent of over 7,000 passenger cars.

The project received government grants to convert trucks to natural gas, which made the economics viable. Grants and loan guarantees came from the US Department of Energy, US Rural Development, and Clean Cities Coalition of Greater Indiana. (Bernie Sheff, March, 2013)

As well, Kroger's supplied the project with financial support in exchange for the ability to acknowledge the green move on their milk cartons. The green label enables them to charge more for the milk.

Photo: Biomass Magazine

6.2 Sweden

Sweden is a leading jurisdiction in biomethane production, whereby vehicle fuel is the primary use. The firm Valtra and the Swedish Ministry for Rural Affairs have launched a joint research project to develop the use of biogas in tractors and other implements. The research data will also be used as a basis for developing legislation for biomethane use in road traffic. The Swedish government's objective is for all vehicles in Sweden to run on renewable energy by 2030.[14]

In Vasteras, biomethane production is part of a large project of waste treatment, ley crop farming and production of organic fertilizers. It is a cooperative project between the regional solid waste company, the local energy company, the national federation of farmers, and 17 farmers in the town. Together they created a company, Svensk Vaxtdraft AB, which operates the biogas plant, upgrading plant, and two filling stations. One filling station provides biomethane to buses and waste trucks; the other is open to the public.

[13] *Anaergia Inc, http://anaergia.com/news/03-05-2013-2*
[14] *Valta news release, March 13, 2013*

The gas supply is backed up by storage tanks located at the bus depot. Of the total vehicles, 40 buses and 12 waste trucks are fueled by biomethane. Filling time is no more than five minutes for cars, and 15 minutes for buses. Two dispensers with two hoses each make it possible to fill four vehicles at once. The public filling station has about 50 customers a day.

Source: Carl-Magnus Pettersson, 2008, Svensk Vaxtdraft AB, in Biomethane fillings stations: five Swedish cases, by Biogas Ost (East).

6.3 Southwest Ontario

In South-west Ontario, multiple vehicle fuel opportunities are being considered. The Dairy Farmers of Ontario (DFO) is exploring the possibility of fueling milk trucks with biomethane from dairy operations, thereby reducing their carbon footprint, building a market for one of the industry's outputs, and providing a marketing advantage to the industry. DFO staff have looked into the cost of converting milk trucks to natural gas, as a first step, prior to fueling with biomethane. Given the travel of 100,000-150,000 km/year, the investment would pay back in about three years, using conventional natural gas and assuming the existing tax exemptions remain in place. (Hitchon, Feb. 2013) Of the 46 trucks on the road, DFO would like to phase in conversions and is working with their transport companies to develop a plan, which will include integrating biomethane into the fuel mix. Their research shows NGV trucks cost $50,000-$60,000 more than comparable diesel trucks.

CNG Canada has developed a strategic relationship with Faromor Energy Solutions and Stonecrest Engineering to promote biomethane as a vehicle fuel. Faromor and Stonecrest Engineering are sister companies that provide third party compression station design services, system installations, and customer support, with primary focus on the agricultural sector. CNG Canada has partnered with Hi-Tech Fuels to supply natural gas fueling station components. Collectively, these companies have been educating farmers on the opportunity to generate biomethane with a view to fueling vehicles.

For farms that could generate the equivalent of 500 kW of electricity from biogas, these companies have calculated that farms could make the economics work to generate biogas and upgrade it to biomethane for vehicles, instead of investing in electricity production and grid connection.

There has been some success in switching farms to CNG vehicles. For example, Four Corners Poultry in Staffa, Ontario installed a NGV fueling station from Hi-Tech Fuel Systems, and converted four vehicles to bi-fuel (NGV/gasoline). (Wilkinson, March 2013).

Faromor Energy Solutions also provides compression equipment for vehicles, and designs, engineers and installs compression fill stations for vehicle fleets. Faromor has installed a NGV fueling station for its own vehicles in Shakespeare, Ontario, and calculates that with current tax incentives, fleets with six or more vehicles would benefit from converting their vehicles to natural gas. (Hendry, April 2013)

Photo: CNG Energy Group

Appendix A:
Fuel Price Comparisons

Average Retail Prices for Regular Gasoline in Canada – 5 Year Trend

Average Retail Prices for Diesel in Canada – 5 Year Trend

Source: http://www2.nrcan.gc.ca/eneene/sources/pripri/prices_bycity_e.cfm

Appendix B: Resources and Developments

Published articles below may refer to biogas as a fuel source, but the vehicles use biomethane.

American Society of Agricultural and Biological Engineers, Using Biogas as a Fuel for Trucks and Tractors, Presentation 17-20 June 2007. Document contains performance and emissions data for different fuel types.

The Canadian Natural Gas Vehicle Alliance is an NGV industry alliance comprised of natural gas utilities, parts manufacturers and suppliers, consultants and researchers committed to the advancement of the NGV industry in Canada.

S Clarke and J DeBruyn, Ontario Ministry of Agriculture, Food and Rural Affairs, Vehicle Conversion to Natural Gas or Biogas, July 2012

Energy Vision, has published a report, Renewable Natural Gas (RNG): The Solution to a Major Transportation Problem, detailing the many benefits of converting US organic wastes into clean vehicle fuel, Dec 4, 2012, New York.

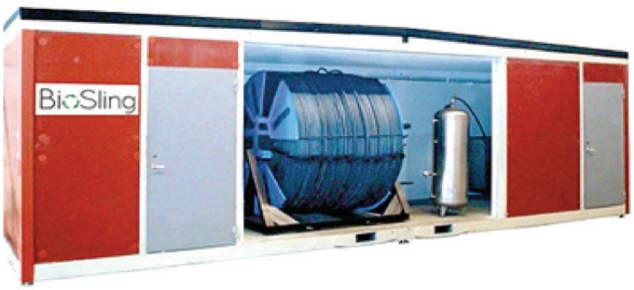
Western United Dairymen, Biomethane from Dairy Waste: A Sourcebook for the Production and Use of Renewable Natural Gas in California, July 2005

European Clean Fleets Project 2012-2015

NGV Global, January 17, 2013 – Starting August 1, 2012, the European Commission Intelligent Energy Initiative (IEE) started a three-year Clean Fleets project, providing forms of assistance to vehicle procurers in Europe to meet obligations under EC Clean Vehicles Directive (CVD), which has now been integrated into national law in all EU Member States. The directive — 2009/33/EC – presently supports three main alternative types of fuels and propulsion technologies which are being developed within the time horizon of 2020. Natural gas and biomethane fuels are included.

Energy-saving biogas cleaning with AC drives

Sweden, February 3, 2011 - A new technology for energy-saving biogas cleaning has been awarded the Skapa 2010 innovation prize. Farmers can now save money and the environment by producing their own vehicle gas on their farms using farm waste.



Bio-Sling: Photo by Arctic Nova

Valtra Plans Biomethane Bi-Fuel Tractor Production in 2013

Finland, September 15, 2012 - Valtra Inc., a manufacturer of agricultural equipment, has taken the decision to begin limited serial production of bi-fuel biomethane tractors during the course of 2013. The company says it is the first tractor manufacturer in the world to begin serial production of biogas tractors.

Biogas Waste Truck

Scania-manufactured biogas-fueled waste truck in Sweden goes about 350 kilometres on a full tank. The equivalent diesel vehicle does about 1,200 kilometres on a full tank. "You have to refuel more often than usual, but for us, the environmental aspect is still the most important," says Sven-Erik Bergendahl.

Appendix C:
CNG Farm Equipment Suppliers

The following companies supply farm equipment that runs on biogas, biomethane or CNG:

- Steyr supplies a natural gas tractor[15]
- Valta tractor: The T133 Dual Fuel runs on both biogas and diesel. In biogas mode, approximately 83 percent of power is produced by biogas and 17 percent by diesel or biodiesel. A small amount of diesel is required to ignite the biogas in the cylinders.
- In addition to compressed natural gas fueling, Safe serves the oil and gas sector with compressors and auxiliary systems for natural gas processing "from extraction to distribution," Landi Renzo says, and can outfit biomethane, hydrogen and liquefied natural gas plants.[16]
- Clean Air Power, a UK company, carries a patented Dual-Fuel™ system, which enables heavy duty diesel engines to operate primarily on natural gas, with diesel fuel acting as a "liquid spark plug". The diesel engine remains unchanged and retains its high performance and high efficiency 4-stroke diesel cycle. The technology works by efficiently burning up to 90% natural gas. Customers benefit from lower fuel costs and a lower carbon footprint. Dual-Fuel™ can operate normally on biomethane and biodiesel, giving it the potential to be carbon-neutral. Finally, if the natural gas supply runs out, the Dual-Fuel™ system changes seamlessly to operate on 100% diesel, giving complete diesel operational backup.[17]

Steyr Profi 4135 operates on CNG or biomethane

[15] *http://www.ngvglobal.com/steyr-presents-dedicated-natural-gas-tractor-1130*
[16] *Fleets & Fuels, Landi Renzo branches into CNG fueling, June 4, 2012*
[17] *http://www.cleanairpower.com/duel-technology.php*

Appendix D: Sources

Interviews and information for this Guide were provided by:

- Oscar Alonso, Technical Standards and Safety Association
- Dan Banks, City of Guelph
- Martin Blanchet, Gaz Metro
- Wayne Blenkhorn and Nick Hendry, Stonecrest Engineering/Faromor
- Brian Chisholm, Cummins Westport
- Steve Clarke, Ontario Ministry of Agriculture and Food
- Patrice Gouin, Xebec
- Bryan Goulden, Union Gas
- Dave Hitchon, formerly Dairy Farmers of Ontario
- Sean Mezei and Ricardo Hamdan, Greenlane Biogas
- Alicia Milner, Canadian Natural Gas Vehicle Association
- Bernie Sheff, Anaergia
- Brad Vodden, Hi-Tech Fuels
- Chris Voell, BioCNG
- John Wilkinson, CNG Canada

www.biogasassociation.ca