Biogas Association

Canadian Biogas Study

Benefits to the Economy, Environment and Energy

Summary Document

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Anaergia etic EPS HARVEST Power of We hydro one Ontario

Authored by: Kelleher Environmental

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The Canadian Biogas Study and this Summary Document were authored by: Kelleher Environmental

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Introduction to Biogas

Biogas is a renewable source of methane, the main ingredient in natural gas. **It can be used for heating and cooling, or to generate electricity that can be used on-site or fed into the distribution grid**. It can be refined into **renewable natural gas that can be injected into gas pipelines**, **or compressed and used as a vehicle fuel**. The entire system, including the energy generating components, is typically referred to as a *biogas facility* or a *biogas plant.*

Biogas is produced when organic materials—anything from crop residues and animal manures to municipal organic wastes and food processing by-products—break down in an oxygen-free environment. The process is called *anaerobic digestion* (AD) and usually occurs in a specialized tank or vessel—the *anaerobic digester*. AD is also the process that generates biogas or landfill gas (LFG) within landfills.

Anaerobic digesters produce not only biogas, but *digestate*, a nutrient-rich slurry that can be applied directly on agricultural land, dried to make animal bedding or processed and marketed as a commercial fertilizer and soil amendment.

The capturing and utilization of biogas is a powerful tool for **reducing greenhouse gases** (GHGs) that are the principle cause of human-induced climate change. GHGs are reduced in two ways: first, the biogas produced is a source of renewable energy that can replace fossil fuels and, second, the capturing of biogas reduces methane, a very potent greenhouse gas that would otherwise be free to escape into the atmosphere.

There are other important environmental benefits. As materials such as animal manures or food wastes are processed in biogas systems, the pathogens are significantly reduced, and nutrients like nitrogen and phosphorous are made more available to plants. These biogas systems reduce and provide greater control of our air and water pollution sources.

All of these critical functions—**generating renewable energy, reducing solid wastes, managing nutrients, reducing greenhouse gases, and mitigating pollution risks**—can be realized from a biogas facility in an economically sound and sustainable manner. The technology is proven and reliable. The required components and services are available across Canada. Biogas production generates diverse revenue streams for farms, industries and municipalities. It creates new jobs in the green economy, and attractive investment opportunities that leverage multiple economic and environmental benefits.

Biogas production is a small but growing industry in Canada, with significant potential for expansion and development. In fact, biogas production is on the verge of a major expansion across North America.

This report reviews the diverse range of biogas production opportunities, and looks at the specific benefits available to farms, businesses and communities. It includes a summary of key data and recent research focused on establishing metrics and measuring the potential of biogas production for energy production, environmental improvement and economic development. This summary is derived from a comprehensive technical report, completed in 2013, and all references can be found in the *Canadian Biogas Study Technical Document*.

Biogas Energy Development Is:

- A solution for agriculture, providing economic, environmental, community benefits.
- A solution for sustainability, providing major GHG, air and water quality benefits.
- Waste management solution which captures energy from waste, diverts waste from landfill, reduces odour, and can fuel waste trucks.
- A renewable energy solution which can produce 3% of our natural gas demand, or 820 MW of reliable, clean, green electricity. This potential is calculated without considering the use of energy crops.

Biogas Potential in Canada

Biogas is a valuable renewable alternative to fossil fuels. It delivers a reliable, dispatchable flow of energy in all weather conditions. AD technologies are proven and the required components and services are available across Canada, so that projects can be developed in a timely and efficient manner. While biogas energy is in the relatively early stages of development in Canada, the opportunities for growth are significant, and would contribute to sustainability in communities across the country. Biogas production offers a wide range of benefits for energy utilization, environmental protection, and economic development.

Energy

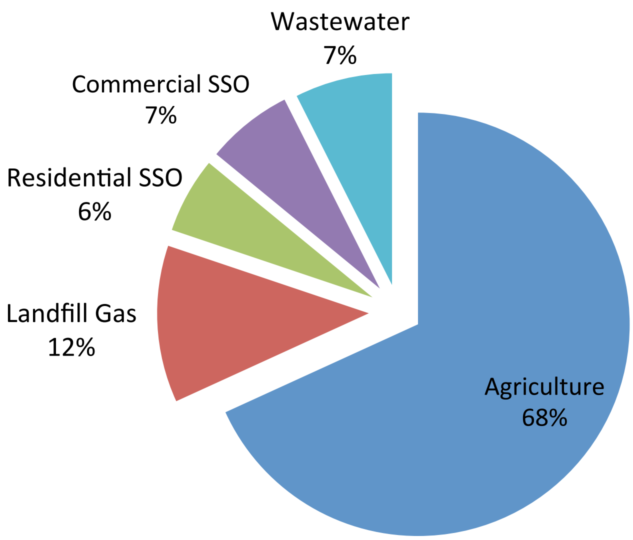
All biogas sources together, without the use of energy crops, have the potential to meet about 3% of Canada's natural gas demand (biogas contribution is 2,420 Mm^3/year of renewable natural gas, or RNG) or 1.3% of its electricity demand (biogas contribution is 810MW).

Table 1: Energy Potential From Biogas Sources in Canada

	Agriculture	Landfill Gas	SSO Residential	SSO Commercial	Wastewater	Total
Electricity Production (MW)	550	95	48	54	60	810
Renewable Natural Gas (RNG) Production (million m^3/year)	1,650	290	140	160	180	2,420
Contribution to Canada's Electricity Demand	0.9%	0.2%	0.1%	0.1%	0.1%	1.3%
Contribution to Canada's Natural Gas Demand	2.1%	0.4%	0.2%	0.2%	0.2%	3.0%

The relative contribution of biogas from the five major sources addressed in the study are presented in Figure 1.

Figure 1: Biogas Energy Production Potential By Source



Environment

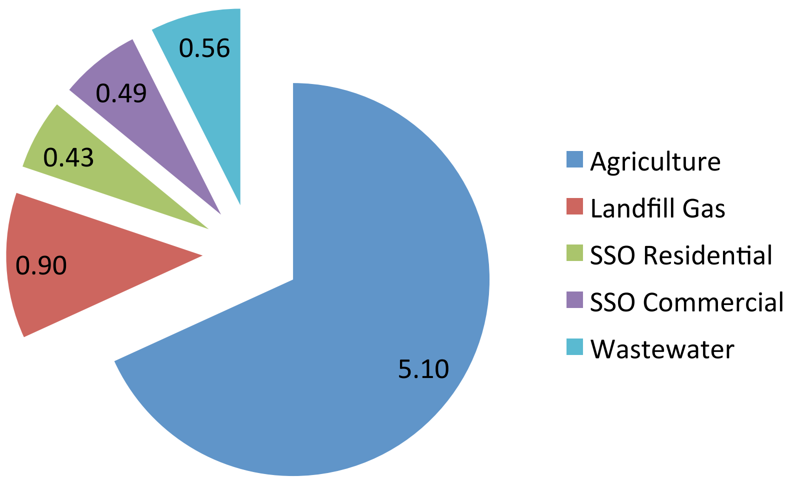
All biogas sources together have the potential to reduce Canada's GHG emissions by 37.5 million tonnes eCO2 per year, which is the equivalent of taking 7.5 million cars off the road. The potential contribution of each biogas source to GHG reduction shows that agricultural digesters have significant potential to reduce GHG (68% of the biogas opportunity), followed by LFG projects (12% of the biogas opportunity). Digesters for commercial and residential SSO and also for wastewater treatment residuals present opportunities of approximately equal size, at 6% to 7% each of the total opportunity.

Further detail on environmental impacts can be found in the *Canadian Biogas Study Technical Document*. Specifically, water quality benefits are in section 3.4.2, nutrient management and soil benefits are in section 3.4.4, and odour impacts are in sections 3.4.3, 4.2.2, 5.2.2, 6.4. All environmental impacts are summarized in Section 10 of the *Technical Document.*

Table 2: GHG Reduction Benefits of Biogas Energy

	Agriculture	Landfill Gas	SSO Residential	SSO Commercial	Wastewater	Total
GHG Reduction (million tonnes eCO2/year)	25.5	4.5	2.2	2.5	2.8	37.5
Cars Off the Road	5,100,000	900,000	430,000	490,000	560,000	7,500,000

Figure 2: GHG Reduction Benefits of Developing Biogas - Equivalent to Cars Off the Road (Millions)



Economy

Realizing the full potential of biogas development would lead to up to 1,800 separate construction projects with a capital investment of $7 billion and economic spin-off of $21 billion to the Canadian economy. These construction projects would create 16,700 construction jobs for a period of one year and 2,650 on-going long term operational jobs. In addition, over 100 new and expanded companies, including biogas system designers and developers, equipment suppliers, laboratories, etc can be supported through this expanded sector. This figure does not include the many construction companies, building supply companies, mechanical and electrical contractors and suppliers who would benefit from biogas development across Canada.

Further detail on economic impacts can be found in the *Canadian Biogas Study Technical Document*. Specifically, economic impacts to farmers are in section 3.5, economic impacts to municipalities are in section 5.3, and all economic impacts are summarized in section 10.

Table 3: Economic Benefits of Developing Biogas Energy

	Agriculture	Landfill Gas	SSO Residential	SSO Commercial	Wastewater	Total
Construction jobs (for one year)	10,200	2,000	1,800	1,700	1,000	16,700
On-going operating jobs	1,320	120	500	460	250	2,650
Direct capital investment ($Billion)	$3	$0.3	$1.7	$1.3	$0.6	$7.0
Indirect economic spinoff ($Billion)	$9.3	$1.0	$5.1	$4.0	$1.7	$21.0

Figure 3: Direct Capital Investment For Biogas Projects ($Billion Can)

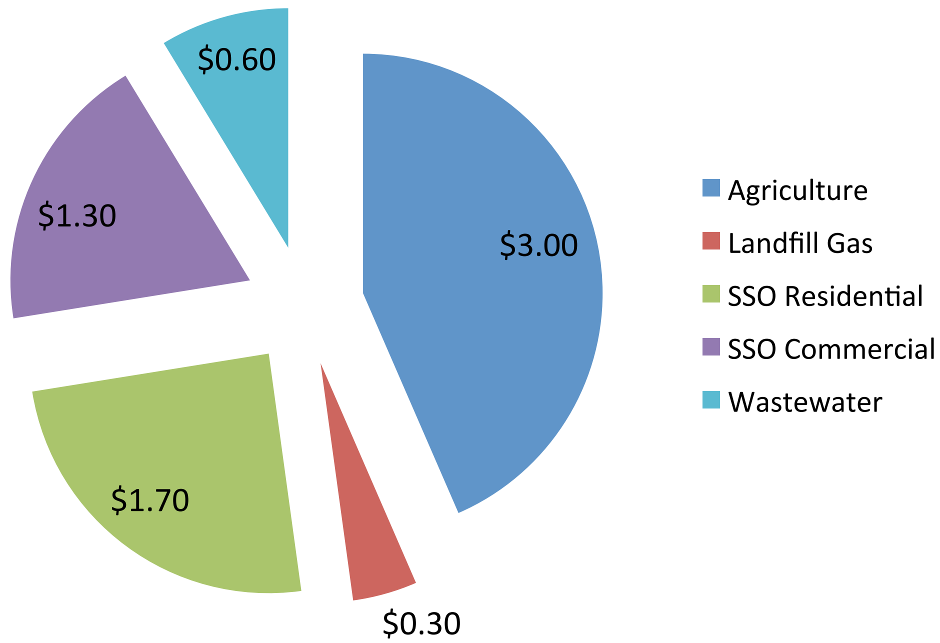
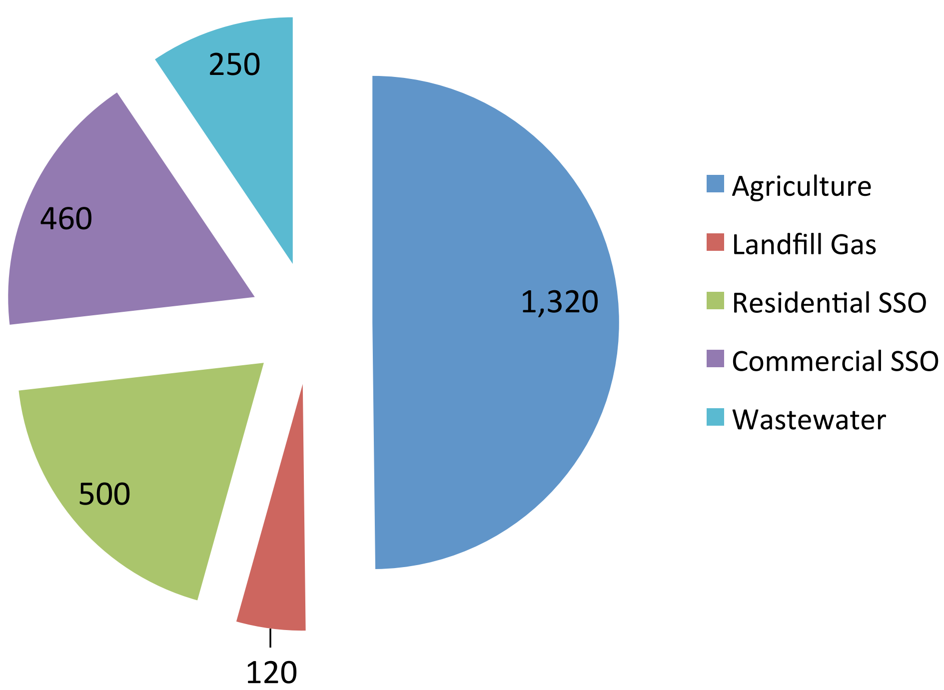


Figure 4: Long-Term Operating Jobs From Biogas Project Development



Biogas production plays many important roles in local economies and energy systems:

- Renewable energy generation
- Waste reduction
- Nutrient management
- Greenhouse gas reduction
- Environmental protection
- Green job creation
- Green investment opportunities

Biogas: Flexible, Adaptable and Renewable

A critical feature that distinguishes biogas from other renewable energy technologies is a high degree of flexibility and adaptability.

Biogas systems may obtain organic matter from a variety of sources and at various quantities. The generation of biogas through the process of AD may be accomplished by two general methods. AD may occur within an anaerobic digester, where the biogas is generated and contained, or AD may occur within buried landfill wastes, where biogas is known as landfill gas (LFG), and collected by a series of wells and pipes. Once biogas is captured, it may be used to power multiple types of energy systems.

The biodegradable materials that can be used as inputs include: crop residues, animal manures and energy crops produced on farms; commercial food wastes produced by businesses and institutions; and, organic wastes collected by municipalities, including materials from the growing number of *Green Bin* programs.

Biogas is a flexible energy source with multiple applications depending on energy requirements and market opportunities. It can be burned as a fuel for heating or cooling, or used to run a co-generation unit to produce both heat and electricity. The electricity from biogas can be fed into the electricity distribution grid, taking advantage of feed-in tariff (FIT) rates where available. It can be cleaned and refined into *renewable natural gas* (RNG), and injected into natural gas distribution pipelines or compressed and used as a vehicle fuel.

This flexibility means that biogas systems can be carefully designed to suit the specific requirements of diverse industries, farms and municipalities across Canada. The range of possible biogas projects—in terms of scale, capacity, complexity and design—is virtually endless.

The feedstocks for biogas systems can be grouped into five broad categories, based on the primary source of the organic material:

- Agricultural organics
- Residential source separated organics (SSOs)
- Commercial SSOs
- Landfill gas (LFG)
- Wastewater treatment residuals

Biogas systems are an economically viable and highly reliable process to manage a wide range of organic residues and make farms, businesses and waste management systems more sustainable.

A biogas project can be highly specialized, utilizing any one of these feedstocks, or designed as an integrated, multi-purpose system accepting and processing multiple materials for a range of energy applications.

1. Agricultural Organics

Anaerobic digester based biogas systems in the agricultural sector are designed to handle the manure from one farm and perhaps neighbouring farms, along with crop residues and energy crops. An advantage of on-farm systems is that the digestate can be spread directly on nearby fields to recycle nutrients and reduce the need for commercial fertilizers.

Agricultural biogas systems are a natural fit on farms as manure is produced continuously from livestock. Manure is rich with methane-producing bacteria and produces significant quantities of biogas when mixed with off-farm organics, integrating the biogas system with existing farm operations. Farm biogas systems are scaled to process the manure and other agricultural biomass and produce distributed electricity generation for a viable economic return on investment. Farms can use heat generated from the biogas system for barns, crop drying, or greenhouses. In some cases, a fraction of the electricity produced is used to power the farm. Capturing the energy from manure, crop residues, and food wastes is smart and economical. For larger farm and food processing operations, generating RNG as a vehicle fuel, or for injection into the natural gas system, may be an option.

Farm-based systems may accept off-farm materials such as commercial food processing by-products. This has several benefits: the digester can achieve better economies of scale, thereby reducing the unit cost of digesting manures and crop residues; the farmer can receive tipping fees; and the digester will generate more biogas. Several provincial governments have recognized these benefits and permit regulated off-farm material processing.

2. Landfill Gas (LFG) Systems

Biogas or LFG is a by-product of the decomposition of organic waste buried in landfills. The operation of a landfill normally requires the installation of a LFG collection system. Currently, there is no requirement to utilize LFG for energy production, and most of the collected LFG is typically flared to the atmosphere. A preferred option is to use the captured biogas as an energy source to create heat, electricity or vehicle fuel. LFG is already produced at landfills, and the infrastructure is in place at many landfill sites to support the services needed for LFG capture, processing and utilization.

Landfills represent relatively large producers of biogas concentrated at a relatively small number of sites across Canada. Many of these sites offer sufficient economies of scale to develop the systems needed for co-generation, production of RNG for injection into natural gas pipelines and/or conversion to fuel for vehicles. Landfills are typically owned by municipalities or waste management companies, so opportunities exist to integrate LFG processing with the anaerobic digestion of other municipal organic wastes. Opportunities also exist to use RNG to power the fleet vehicles used for waste management and other services, creating local closed-loop energy systems.

3. Residential Source Separated Organics

Many municipalities across Canada have implemented *Green Bin* programs to collect household organic wastes, including food wastes. These source separated organics (SSOs) are available as a separate stream of materials for processing, in addition to traditional residential organics such as leaf and yard wastes.

The separation of food waste from other waste has environmental benefits, since organic materials break down in landfills, producing acidic leachate that precipitates metals and creates a potential source of ground and surface water contamination. In addition, the methane produced as these materials degrade naturally is a powerful greenhouse gas unless captured. Longer term, these programs will result in a decrease in landfill gas production as the amount of organics going to landfill decreases, but this benefit is many years into the future.

Residential SSOs represent a substantial and relatively undeveloped new source of material for renewable energy production.

4. Commercial Source Separated Organics

Industrial, commercial and institutional (IC&I) facilities, such as restaurants, hotels, hospitals and food processing plants, generate considerable volumes of organic wastes and by-products. Most of these facilities manage such materials through waste management hauling companies, some of which offer separate collection for source separated food wastes. More often, however, food waste is disposed of in landfills, representing a major lost resource that could be used in biogas production.

Biogas systems can be designed and built by waste generators or waste management companies specifically to process commercial SSOs. They may be scaled to meet the heating requirements of a particular facility, or to manage the by-products on-site from several food processing facilities. Industries with high-strength liquid wastes such as breweries or dairy processing plants may construct AD facilities on-site to manage materials prior to discharge into local sewers or disposal off site.

Commercial SSOs can also serve as feedstock for agricultural biogas systems or municipal systems designed for residential SSOs. Some IC&I generators produce materials such as fats, oils and greases (known in the industry as FOG) which are an asset to the biogas process because they produce high amounts of biogas.

5. Wastewater Treatment Residuals

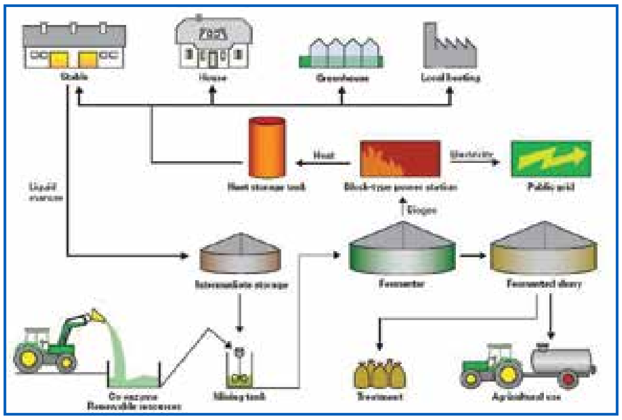
More than 80% of households in Canada live in dwellings connected to municipal sewer systems. All of these systems are connected to wastewater treatment plants. Wastewater is treated in primary or secondary wastewater treatment facilities or water pollution control plants, and each of these treatment options produces wastewater residuals (also referred to as bio-solids or sludge), ideal materials for biogas production.

At some wastewater treatment plants in Canada the biosolids are already processed through anaerobic digestion. The biogas is used for internal plant heating requirements, and the excess biogas is flared. In some cases, biogas is used to produce power for distribution into the electrical grid. In addition, biogas is upgraded to RNG and is injected into the natural gas grid. There are a number of co-generation facilities in place in wastewater treatment facilities across Canada, but a large amount of biogas is flared with no energy recovery. This large source of biogas presents a significant opportunity to increase the production of green energy from biogas which is already being produced.

Biogas Systems Can Integrate Many Sources and Uses

As anaerobic digestion technologies develop and expand across Canada, there will be opportunities to develop highly integrated biogas production strategies, with multi-purpose AD facilities functioning as intermediaries that convert organic materials from multiple sources into a range of different energy outputs adapted to suit local needs and market opportunities. For example:

- Materials from several farms and food processing plants could be transferred to a centralized biogas facility serving a rural or semi-urban area. The biogas produced could be used to heat commercial facilities, fuel a co-generation plant, or supply a district heating system, while also delivering surplus electricity into the local distribution grid. Digestate could be distributed on nearby farmland or processed on-site to create animal bedding or a marketable soil amendment including fertilizers.



- Biogas from a large municipal facility located at a landfill site to process LFG could be expanded to accommodate biogas systems for residential and commercial SSOs. The biogas could be used to power a co-generation system that provides heat for on-site facilities or nearby customers as well as electricity that can be fed into the local distribution grid. Economies of scale could be sufficient to justify refinement of biogas into RNG for injection into natural gas pipelines or to power municipal fleet vehicles. The capacity to produce both electricity and RNG, for municipal uses as well as off-site distribution, would provide significant flexibility to adapt to changing needs and market conditions.

The case study that follows illustrates how a biogas system can integrate many sources for multiple uses.

Case Study:
Closing the Loop: From Organic Wastes to RNG-Powered Waste Management Vehicles
Surrey, BC

Overview

In October, 2012, the City of Surrey, BC, launched a bold new waste management plan consisting of three components:

- Mandatory source separation of organic wastes by residences and businesses;
- Exclusive use of natural gas-powered vehicles for waste collection and recycling services;
- Construction of a new waste-to-biofuels production facility where organic wastes will be processed into a renewable natural gas (RNG) for the waste collection and recycling vehicles.

This plan will create a closed loop system that converts a significant portion of the City's solid waste stream into a clean, renewable vehicle fuel for waste management services. The plan will cut operating costs, reduce air pollution and greenhouse gas (GHG) emissions, and serve as a closely watched model for communities across North America.

Features

- Surrey has entered into a seven-year waste-disposal contract with BFI Canada that requires the exclusive use of natural gas-powered vehicles. This is a first for municipalities in Canada and also for BFI, a major waste management company.
- The trucks incorporate latest gas-powered engine technology and operate on compressed natural gas (CNG). Gas-powered trucks in general emit 23% fewer carbon emissions and 90% fewer air particulates compared to diesel-powered trucks, while enabling the City to reduce dependence on diesel fuel, which has been expensive and subject to volatile price swings.
- Replacing each diesel truck with a natural gas truck is the equivalent of taking 475 cars off the road from a GHG perspective.
- Construction of an Organic Waste Bio-fuel Processing Facility, on City-owned property adjacent to the Surrey Transfer Station, is expected to start in 2014. It will produce RNG for vehicles and possibly for injection into the region's natural gas pipeline network, as well as digestate to be processed into fertilizer and soil amendment for distribution through local retailers.
- The facility will be developed as a Public Private Partnership. The Government of Canada, through the PPP Canada Fund, will contribute up to 25% of the capital costs.
- Local governments in BC are subject to a carbon tax of $30 per tonne. The City of Surrey, by signing the BC Climate Action Charter and committing to becoming carbon neutral, is eligible for the Climate Action Rebate Incentive Program and will receive carbon credits for the innovative bio-fuel program.

Future Plans

Surrey's new Organic Waste Bio-fuel Processing Facility, when completed, will enable full implementation of the City's Waste Management Plan, which in turn will help the City achieve the Metro Vancouver regional goal of diverting 70% of all wastes from landfills by 2015. A regional ban of all organics from landfill disposal has been proposed.

The Benefits of Biogas Production

Energy

- Fuel for boilers, furnaces and chillers
- Co-generation of combined heat and power (CHP)
- Grid-tied power for distribution to local utilities
- Support for distribution grid resilience and efficiency
- Renewable natural gas (RNG) for vehicle fuel
- RNG for injection into natural gas pipelines

Environment

- Reduction of greenhouse gases (GHGs)—carbon dioxide and methane
- Stabilization of nutrients for reduced water contamination risks
- Substantial reduction of pathogens in manures and food wastes
- Reduced emissions of volatile organic compounds (VOCs)
- Reduction of odours

Economy

- Diversification of farm revenues
- Production of marketable fertilizers and soil amendments
- High-quality digestate for improved land management
- Municipal waste management efficiencies
- Revenues from sale of grid-tied electricity—eligibility for feed-in tariff (FIT) subsidies
- Potential carbon emission credits
- Cost savings and/or revenues from RNG

Biogas Benefits: Energy, Environment and the Economy

Biogas production through anaerobic digestion is a multi-purpose process providing an array of benefits for farms, businesses and communities. The benefits can be grouped into three broad areas:

- Energy
- Environment
- Economy

Biogas projects can be designed to optimize benefits in each category, responding to local needs and opportunities.

Energy

Biogas-powered generators can be used to supply electricity to the grid. This solution is most common for farms where a single biogas system can power ten or more other farms. The biogas system can supply emergency back-up power, and create an independent power source for residences, barns and other facilities.

Biogas producers located on rural distribution systems utilizing synchronous generators have demonstrated positive impacts on distribution system operations by providing voltage support and improving power quality.

Unlike other renewable energy alternatives such as wind and solar power, biogas delivers a reliable flow of energy regardless of weather conditions and has a very high capacity factor. The flexibility and reliability of biogas systems are important assets. They can produce power during periods of peak system demand, be dispatched down, and configured to store fuel during periods of excess power or surplus base load.

Biogas, as a source of methane, is a valuable renewable alternative to fossil fuels. It can be used directly to fuel on-site boilers, furnaces or chillers for larger applications such as crop drying, barns, greenhouses, swimming pools, commercial facilities and industrial processes.

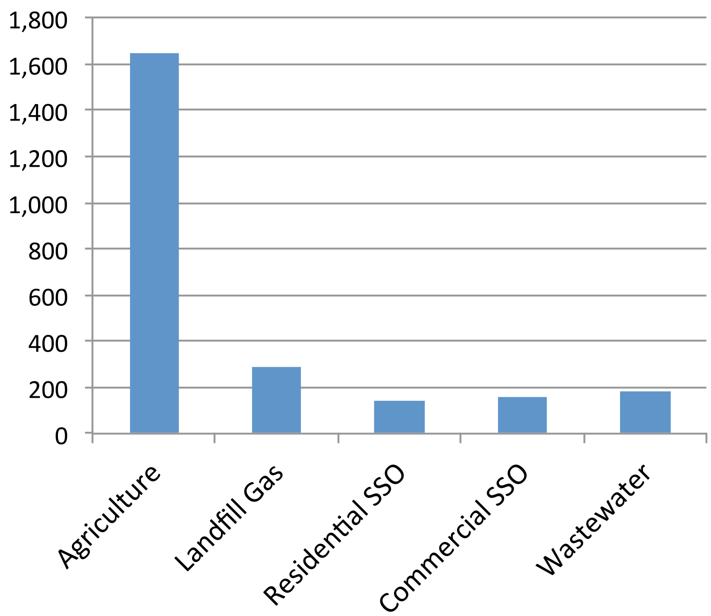
Biogas can be used to fuel co-generation systems in combined heat and power (CHP) configurations.

Finally, the ability to clean and refine biogas into renewable natural gas (RNG) is a vitally important addition to the portfolio of energy options available to biogas producers. RNG can be produced to meet all of the technical standards and requirements of conventional natural gas, and therefore offers the same degree of versatility. Already, some European countries are fueling their cars, buses, and trucks with RNG. Several companies in the

USA are using RNG for milk hauling and municipal truck fleets, and one large Canadian municipality (Surrey, BC) will fuel its garbage collection fleet with RNG produced from a biogas facility processing *Green Bin* materials starting in 2015.

In BC, residents can pay about $5 more per month for an average home, and designate 10 per cent of the natural gas they use as renewable natural gas. FortisBC then injects the equivalent amount of renewable natural gas into their distribution system. The program is sold to residents on the basis that it helps reduce their carbon footprint and supports sustainable energy produced in BC. RNG is also offered to BC businesses. Projects supplying the RNG are featured on the FortisBC website.

Figure 5: RNG Production Potential (Mm³/year)



Environment

Biogas projects reduce two critically important greenhouse gases—carbon dioxide (CO_2) and methane (CH_4). Carbon dioxide emissions are reduced whenever biogas is used as a substitute for fossil fuels such as diesel or natural gas. Methane, which is 21 times more potent than CO_2 as a greenhouse gas, is captured within an anaerobic digester or from a LFG collection system and converted to energy.

This dual GHG-reduction impact makes biogas projects a very effective strategy for helping communities meet GHG-reduction targets. Some biogas projects may become a significant source of carbon emission reduction credits as carbon credit markets increase in value.

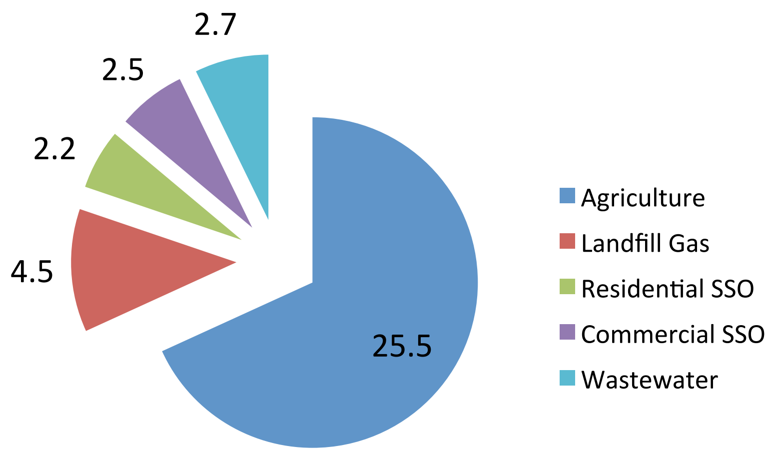
The use of an anaerobic digester to process organic wastes helps to protect water quality. Pathogens are reduced up to 99% when compared with undigested manure and the nutrients in the digestate are more available to crops. Energy can be recovered through the digester and the liquid digestate from the process is fully contained and managed. Proper management and use of liquid digestate can significantly reduce the risks of pathogens and pollution risks in soils, groundwater, and surface water.

Biogas systems protects water resources in another way—biogas requires minimal amounts of water for energy production in comparison with other biofuels.

Biogas projects also help to protect air quality. The destruction of VOCs and other smog pre-cursors through the capture of decomposing organic material helps to improve air quality by reducing the potential for smog and the associated respiratory health and safety concerns.

Anaerobic digesters can reduce or eliminate odours from farms, landfills and waste processing facilities. AD occurs in a tightly controlled environment where exhaust air is cleaned in a biofilter. Digesters tend to have much tighter and more effective odour control mechanisms than other processing operations. Odours are also reduced whenever decomposing organic material, which contains trace amounts of sulphur, is captured.

Figure 6: GHG Reduction From Biogas Projects (million tonnes eCO2/year)



Economy

Biogas production offers a range of interrelated economic benefits. There are opportunities to diversify farms, business and community revenues beyond conventional sources. The largest revenue stream often comes from the sale of renewable energy into the power grid. This is a primary driver for biogas project investments, particularly in jurisdictions such as Ontario with feed-in tariff rates for renewable power. Even when biogas electricity is used on-site prior to exporting the excess electricity, savings from reduced conventional energy use can be realized.

Other potential revenue streams include nutrient recovery and management, tipping fees, thermal usage, bedding savings for farms, and carbon offsets, where available.

Additional economic benefits are also realized from digestate. The digestate has good soil enhancement qualities and can be applied to growing crops without damage making it a marketable and valuable soil amendment. The digestate delivers nutrients in a form that is more consistent, more readily absorbed and more concentrated, reducing the need for and cost of synthetic fertilizers. Handling digestate vis-a-vis storage, mixing, pumping and spreading is easier and requires less energy resulting in reduced costs.

Biogas production facilities that are designed to process landfill gas or SSOs create economic benefits that are typically realized by the municipalities or waste management companies that own these facilities, as well as the broader community. Direct revenue sources include commercial tipping fees for SSOs and renewable energy revenues.

Anaerobic digestion of SSOs helps to preserve landfill capacity, a valuable and limited resource in many communities. The footprint of anaerobic digestion systems is much smaller than composting facilities of similar capacity, which supports the efficient use of land and increases the feasibility of locating facilities in or near urban areas.

The economic benefits of biogas production at wastewater treatment facilities include energy savings, and the potential for renewable energy revenues, typically accruing to the municipalities that own most of these facilities across Canada. Many wastewater treatment facilities in Canada are large, and the possibility of integration with other community biogas sources such as LFG and SSOs creates the potential for improved economies of scale. This, in turn, creates further opportunities for developing diverse energy revenue streams through both electricity and RNG production.

Over 100 new and expanded companies are operating across Canada as a result of the recent interest in biogas projects. These companies include biogas system designers and developers, equipment suppliers, laboratories, etc. This number does not include all the construction companies and other related industries which benefit from development of the biogas sector.

Construction of over 1,260 biogas facilities across Canada would result in capital investment of $7 billion, with an economic spinoff of $21 billion. Construction projects would create about 16,700 FTE jobs for one year, and about 2,650 long term operational jobs.

Figure 7: Indirect Economic Spinoff from Biogas Project Development in Canada ($Billion Can)

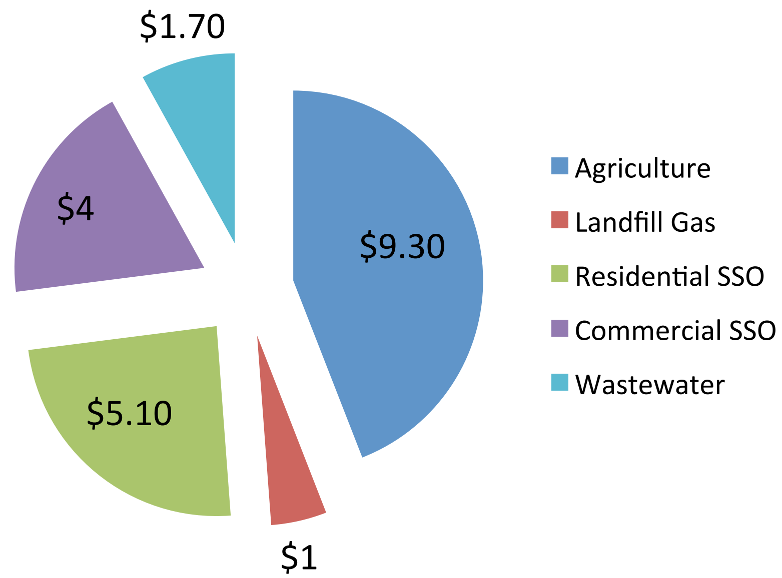
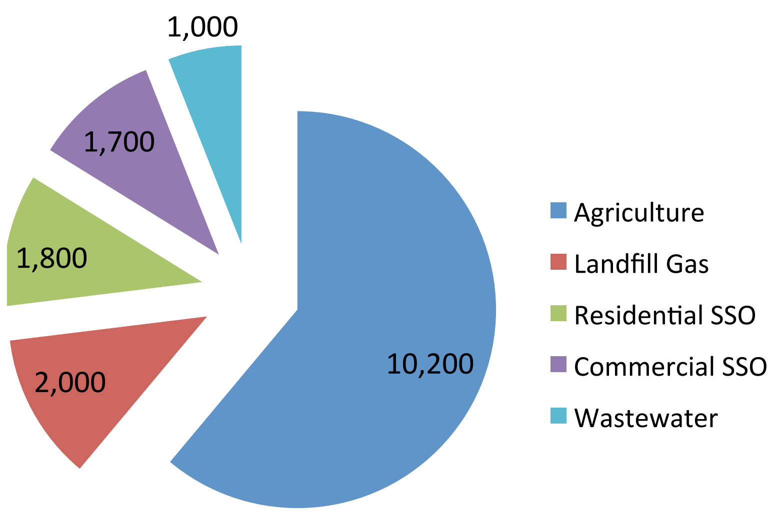


Figure 8: Construction Jobs From Biogas Project Development in Canada (For One Year)



The Biogas Vision: A New Renewable Energy Network

The production of biogas is now underway from all major sources—agricultural organics, landfill gas, residential and commercial SSOs, and at wastewater treatment facilities. In general across Canada, however, biogas production is still in the early stages of development and the potential for growth and expansion is significant. It is estimated that the total production of biogas from all sources combined, without the use of energy crops, could be equivalent to 2,420 Mm^3 per year of RNG (representing 3% of Canada's natural gas demand) or up to 810 MW of electricity from renewable sources (representing 1.3% of Canada's annual electricity demand). Biogas could therefore contribute up to 3% of Canada's energy needs through a reliable, renewable source.

The full realization of biogas potential in Canada presents many challenges. In practice, any renewable energy alternative must service multiple energy needs and markets, integrate well into existing energy distribution systems and networks, and offer a range of practical and sustainable economic opportunities.

In this respect the inherent flexibility, adaptability and reliability of biogas production offers critically important advantages.

The long-term vision for biogas development includes an extensive and diverse portfolio of biogas projects on farms, commercial sites, landfills and wastewater treatment facilities across Canada. Facilities will range from the small and simple, to the large and complex.

Some systems will be the backbone of a micro-grid, supplying site-specific energy needs and contributing to local strategies for energy independence, self-reliance and energy cost reduction. Most will be connected to existing energy distribution systems. In the case of electricity, grid-tied biogas-powered generators will serve as multiple point sources of distributed energy generation peak power, reducing line losses and increasing service stability and power quality. The capacity to store fuel during periods of surplus power will be valuable assets, contributing to distribution system reliability and efficiency.

In the case of renewable natural gas (RNG), some biogas systems will inject RNG into natural gas pipeline networks, representing unique new sources of feedstock that require no drilling or fracking, yet match the quality and end-market versatility of conventional natural gas. RNG in compressed form will provide an increasingly important renewable vehicle fuel. Most importantly, RNG provides consumers with a renewable energy option.

Biogas, in short, can make major contributions to the efficiency, cost-effectiveness and resilience of energy systems at the local, regional and national level, while at the same time playing a key role in environmental protection and greenhouse gas reduction.

To accomplish all of this, biogas production draws from the many common organic materials cited above—agricultural manures, crop residues and energy crops, landfill gas, residential and commercial SSOs, and from wastewater treatment facilities. Most of these have traditionally been viewed as wastes, and in many cases simply allowed to degrade where they add to the burden of greenhouse gases, or have been flared-off with no energy recovery. Biogas production instead captures these materials and converts them into a practical form of renewable energy, while simultaneously producing high-grade fertilizer for agricultural crops and soil restoration.

It is an effective *closed-loop* solution to a wide range of conservation and resource management challenges as Canadians move toward a more sustainable economy.

Figure 9: Biogas Vision for Canada—Integrated Renewable Energy Network

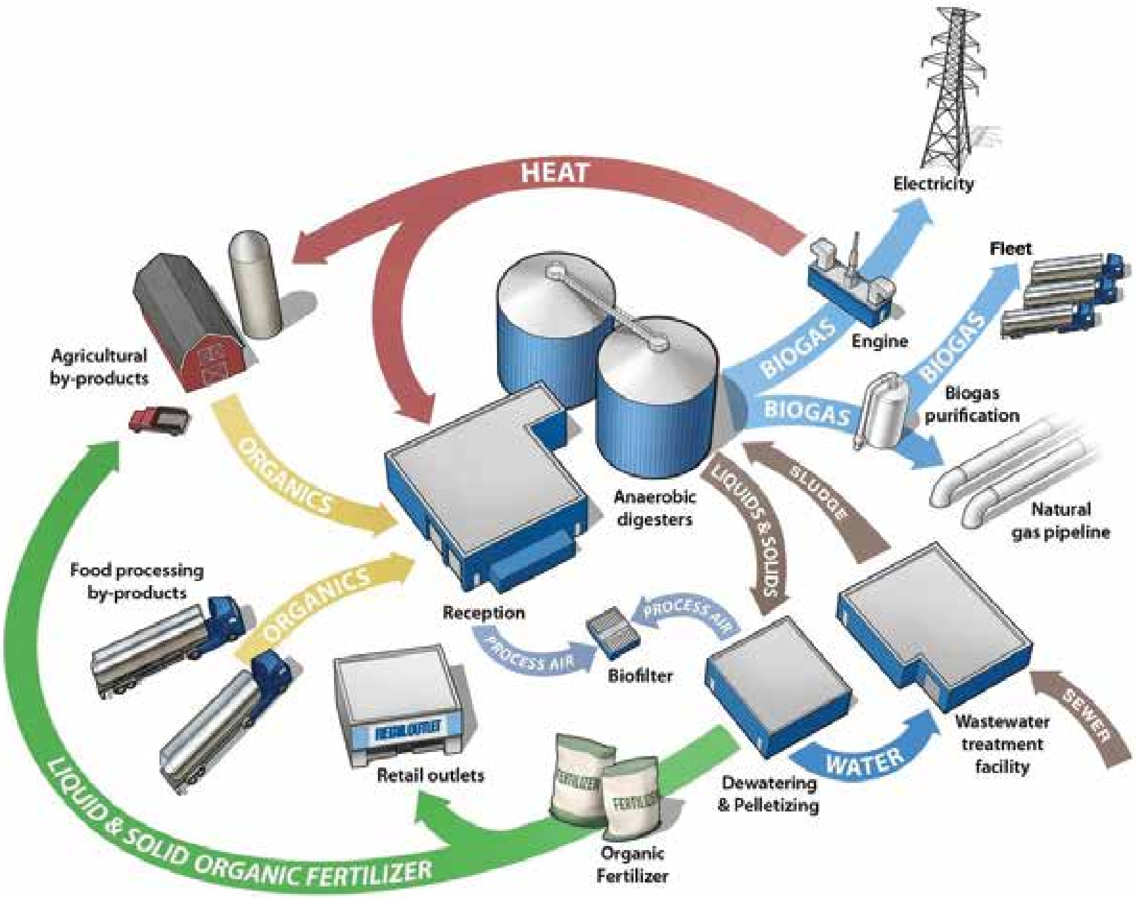


illustration by Stormfisher

Biogas Metrics: Measuring the Potential of Biogas Production

A growing body of data is available to support the evaluation of biogas production opportunities by farms, businesses, communities and governments at all levels. These data provide metrics and performance indicators in key areas: renewable energy production, environmental improvement and economic development.

Agricultural Organics

Table 4: Energy, Environmental and Economic Benefits of Agricultural Biogas Projects in Canada

Energy	• Agricultural digesters in Canada using 50% of available manure and crop residues have the potential to produce 1,650 Mm^3/year of methane, which can be converted to 550 MW of renewable electricity. • Together, agricultural digesters could supply 2.1% of Canada's natural gas demand. • If energy crops were added, agricultural digesters could produce an additional 800MW of electricity, contributing up to 2% of Canada's electricity demand. • Biogas systems provide unique benefits to the electricity system as they are distributed throughout the grid and can provide electricity supply, reliably, regardless of the weather, 24/7. • Biogas can be stored when the electricity is not required, a significant benefit in some systems. • Electricity generated by biogas systems is synchronous and can provide voltage and power quality support to local, rural feeders which may be challenged by poor power quality.
Environment	• Anaerobic digestion of animal manures reduces pathogenic bacteria by up to 99%. • The addition of a biogas system at a dairy farm can reduce methane emissions by 75%. • 6.4 Mt eCO2 equivalent were emitted from manure management in 2011. • Digesting half of animal manures and crop residues across Canada would reduce GHG emissions by an estimated 25.5 million tonnes of eCO_2 per year. This is the equivalent of taking 5,100,000 cars off the road. • Biogas systems typically achieve odour reduction in the order of 80%. • 90% of the phosphorus and 43% of the total nitrogen can be concentrated in the waste solids, enabling better control and efficiency in nutrient management. • Digestion reduces weed seeds by up to 99%. This can reduce farm costs for herbicides while reducing the requirement for the broad-spectrum application of synthetic pesticides.
Economy	• On-farm biogas systems create a number of revenue streams that support income diversification and long-term sustainability for farm families. They provide an opportunity, and sufficient income, for an additional full-time job. • Renewable energy is the primary income source for biogas systems; other potential revenue streams include tipping fees (from off-farm materials), sale of thermal energy, bedding savings, nutrient recovery and carbon offsets where available. • Agricultural digesters provide local employment, consisting of 1.2 FTE at the digester and additional haulage jobs if off-farm waste is accepted. • Avoided cost of fertilizer is estimated to equal $15 per animal unit per year. • Solid fiber in digestate may be extracted using a liquid/solid separator to make bedding for use on the farm. This can save as much as $84 per cow per year. • Surplus digested manure solids bedding can be sold as a soil additive for up to $20 per tonne. • It is estimated that the construction of more than 1,100 digesters to process 50% of available manures and crop residues would create 28,900 construction-related jobs for one year. • Establishing 1,100 farm digesters across Canada will create about 1,320 permanent operational jobs across Canada. • Construction of 1,100 farm digesters would require a total investment of $3.5 billion with an economic spin-off of $10.5 billion for a total economic impact of $14 billion across Canada.

Case Study:
Farm-Based Biogas Production with a Feed-in Tariff (FIT) Contract for Renewable Energy Generation
Cobden, Ontario

Overview

Fepro Farms is a dairy farm with 300 head of cattle, including 142 milking cows, as well as 350 acres of corn, 70 acres of small grain and 210 acres of alfalfa. It is owned and operated by brothers Paul and Fritz Klaesi and located in Cobden, Ontario, near Ottawa.

Biogas-powered generators on the farm supply electricity for all farm operations and residential uses. Heat captured from the generators is used to supply hot water and the heating requirements of the biogas system. Surplus electricity is fed into the electricity distribution grid and sold under a Feed-In Tariff (FIT) contract. The FIT Program was developed by the Ontario Power Authority (OPA) to encourage the development of renewable energy generation projects. Qualified renewable energy producers have an opportunity to enter into a 20-year contract with the Province of Ontario, through which the Province agrees to purchase all electricity that is delivered into the distribution grid, at a price sufficient to cover the costs of the project with a reasonable return on investment.

Fepro Farms uses biogas production to meet on-farm energy needs and create a substantial new revenue source. The system also provides an efficient and environmentally sound method for converting animal manure into a high-quality, nutrient-rich digestate for land application.

Features

- A 500 cubic metre (m^3) anaerobic digester generating 50kW of electricity was installed at Fepro Farms in 2003. This system was expanded to its current capacity of 2,500 m^3 and a 500 kW in 2007.
- The primary feedstock for anaerobic digestion is manure from the farm. In addition, off-farm organic residuals collected from restaurants, grocery stores and commercial SSO, are heat treated prior to digestion and used to increase biogas production.
- Heat is used seasonally for grain drying and heating of buildings on site.
- The digestate, a nutrient enriched soil amendment, is land applied to enhance crop production.
- Since signing the FIT contract, Fepro Farms has been able to eliminate electricity costs that were over $30,000 per month, while generating an additional revenue source.
- The biogas system also has a number of environmental benefits: the capture of methane from manure helps to reduce greenhouse gas emissions. Pathogens are reduced in the high-temperature anaerobic digestion process, thereby reducing the risk of ground or surface water pollution. The odours associated with conventional manure spreading are removed. The off-farm materials used in the process are diverted from local landfills.

Creating Opportunities

The biogas project at Fepro Farms represents an innovative form of local economic development. The project has supported renewable technology providers who are developing expertise and capacity in an emerging market. It has created opportunities for on-farm revenue diversification and employment for family members, at a time of limited growth in the dairy industry. By delivering reliable, dispatchable electricity into the distribution grid, the project is also helping Ontario move toward a cleaner, more sustainable energy system.

Landfill Gas

Table 5: Energy, Environmental and Economic Benefits of Landfill Gas Projects in Canada

Energy	• An estimated 68MW of electricity and large amounts of heat are produced through existing LFG projects across Canada. • The opportunity exists to almost double existing energy capture at landfills across Canada economically, resulting in significant GHG reductions. • About half of the methane captured at landfills across Canada is used for energy production while the other half is currently flared with no energy recovery. • There is significant potential to utilize LFG at existing sites to produce 95 MW of electricity economically. Alternatively, the recovered LFG could be upgraded to RNG and injected into the natural gas grid, or be used to fuel trucks and replace diesel which is a higher GHG emitting fuel.
Environment	• There are more than 10,000 landfills of which 800 are active landfills in Canada. • LFG is the third largest source of anthropogenic methane emissions in Canada. • LFG represents 3% of Canada's national GHG emissions. • LFG is generally the largest source of GHG over which a local community has direct control. • Approximately 27 megatonnes (Mt) of eCO_2 are generated annually from Canadian landfills, of which 20 Mt eCO_2 are being emitted annually. Approximately 7 Mt eCO_2 are captured and combusted at Canadian landfills today, representing the equivalent of removing about 1.5 million cars from the road. • LFG biogas projects significantly reduce community GHG emissions and help communities to meet GHG reduction targets. For example, the LFG project in Salmon Arm BC reduces eCO_2 emissions by 1,250 tonnes, the equivalent of taking 250 cars off the road, while supplying heating energy for 300 homes. • Each diesel truck replaced with a gas fueled truck is equivalent to taking 475 cars off the road from a GHG perspective.
Economy	• There are at least 41 economically viable LFG projects which are currently undeveloped across Canada • The estimated capital cost of these 41 projects is $322 million with net annual revenues of $57 million. • Each new LFG project creates 2-3 full time local operating jobs long term and creates $3 in economic output for each $1 spent on construction. • The 41 LFG projects would create about 80-120 long-term operational jobs. • A typical 3 MW LFG electricity project adds more than $1.5 million in new project expenditures for the purchase of equipment during the construction year • A typical 3MW LFG project increases economic output by $4.3 million and employment by 20-26 people during the construction year. • LFG projects will be a significant source of carbon emission reduction credits as the carbon credit market increases in value. • GHG credits of 3.7 million tonnes CO_2 per year can be created by landfills across Canada at a very attractive rate of under $4/tonne. This provides significant opportunities for landfills to capture and reduce GHGs and sell credits at a profit. • Where LFG is used to fuel truck fleets, CNG-powered trucks are significantly cheaper to operate than conventional diesel-powered alternatives. Large LFG projects provide the opportunity to produce RNG for truck fleets.

Case Study:
Converting Landfill Waste into Green Energy - Progessive Waste Solutions (BFI Canada) Launches Largest Transformation Project of Biogas Into RNG in Quebec

About one third of the waste from Greater Montreal is landfilled at the Lachenaie landfill in Terrebonne, Quebec. In September, 2013, Progressive Waste Solutions (BFI Canada), a subsidiary of the Canadian company Progressive Waste Solutions, announced that it is investing $40 million to convert the biogas produced by the waste from Greater Montreal into RNG.

Approximately 17,000 m^3/hour will be used to power the equivalent of 1,500 heavy trucks for a period of twenty years, avoiding the consumption of 350,000 barrels of fuel oil per year.

The new plant is expected to reduce GHG emissions by about 1.2 million tonnes of carbon dioxide (CO_2) over a period of ten years.

The new biogas processing facility should be in operation by mid-year 2014. The RNG produced will be injected into the TransQuébec & Maritimes Pipeline adjacent to the landfill in Terrebonne.

Progressive Waste Solutions (BFI Canada) opened the first power plant fueled by biogas in Quebec in 1996, which generates electricity for the equivalent of 2,500 homes each year.

Progressive Waste Solutions (BFI Canada) operates the largest fleet of trucks running on compressed natural gas (CNG) in the waste collection and recyclable materials industry. By the end of 2013, the company plans to have about 150 trucks powered by CNG in Canada. In 2014, it is expected that 50 to 55% of the total number of new trucks, acquired through the normal fleet replacement, will run on CNG.

Residential Source Separated Organics

Table 6: Energy, Environmental and Economic Benefits of Residential SSO Biogas Projects in Canada

Energy	• About 40% of the residential waste discarded in Canada each year consists of biodegradable material (food, etc.) that could be used to generate green energy. • The Green Bin waste from 300,000 households is sufficient to produce 1.4MW of electricity, which is sufficient to meet the electricity needs of 800 homes. • Capturing half of the discarded organics in Canada could produce 48MW of power, or 140Mm^3/year of RNG. • Municipalities involved in SSO digestion can integrate SSO biogas utilization with other potential biogas sources such as wastewater treatment plants and LFG facilities.
Environment	• Anaerobic digesters have a very small footprint compared to other organics processing technologies, and can therefore be located at existing waste management sites or in urban areas. • Capturing half of the discarded residential organics in Canada would result in reduction of 2.2 million tonnes eCO2/year, the equivalent of taking 430,000 cars off the road. • Anaerobic digestion, over the life of a project, has a positive net energy balance, while other technologies consume net energy. • AD of SSO facilitates the conversion of municipal fleets from diesel to RNG which can be produced by the digester in a closed loop system. Replacing a diesel truck with a CNG truck is equivalent to taking 474 cars off the road from a GHG point of view.
Economy	• The capital investment required for digesters across Canada is about $1.7 billion, with an economic spin-off of an additional $5 billion. • The Dufferin Digester in Toronto (which is the only municipal AD facility currently operating in Canada handling a mixture of residential and commercial SSO) processes 25,000 to 40,000 tonnes/year with a staff of 13 running three shifts per day. • Up to 494 long term operations jobs could be created across Canada should the biogas potential of residential SSO be developed. • Green Bin programs can divert 200kg/household/year from disposal and into productive uses. A city of 300,000 households could divert 60,000 tonnes/year of Green Bin material, saving 60,000 m^3 of landfill capacity annually, thereby delaying the need to establish a new landfill facility, which is becoming increasingly challenging across Canada.

Commercial Source Separated Organics

Table 7: Energy, Environmental and Economic Benefits of Commercial SSO Projects in Canada

Energy	• 54MW or more and at least 160 Mm^3/year of RNG could be produced from commercial SSO across Canada which is currently disposed.
Environment	• About 23% of the solid waste generated in the industrial, commercial and institutional (IC&I) sector is food waste from businesses and institutions. • About 6 million tonnes of food waste is discarded in Canada each year. This food is a significant resource for digestion and renewable energy production. • Digesting half of the commercial organics currently disposed would save 2.2 million tonnes/year of eCO_2. This is equivalent to taking 490,000 cars off the road.
Economy	• Construction of 38 digesters in Canada to digest available commercial SSO could generate $1.5 billion in capital expenditures with a spin-off of $4.5 billion across Canada. • The construction of up to 40 digesters would result in 1,800 direct and 5,400 indirect jobs. • Operation of up to 40 digesters would produce 460 long term operating jobs across Canada.

Case Study:
Harvest Power Fraser Richmond BC Site

On 11th September, 2013, Harvest Power, along with its partners, officially launched its Energy Garden in British Columbia, the largest commercial-scale high solids anaerobic digester in North America. The Energy Garden is located at Harvest's site in Richmond, B.C. and has the capacity to convert up to 40,000 tonnes of food and yard waste per year from area homes, businesses, restaurants and supermarkets into clean energy and compost.

"This facility represents the innovation, passion and commitment required to usher in the future of organics management," said Paul Sellew, Harvest Power founder and CEO. "We are excited to continue our partnership with the Metro Vancouver and the City of Richmond community to cost-effectively convert organic materials once destined for the landfill into clean energy and compost products."

Harvest's Energy Garden, which uses GICON's batch two-stage anaerobic digestion technology, is the largest of its kind in North America. The facility produces enough energy to power approximately 900 homes per year, and provides hundreds of thousands of cubic yards of top quality soil products to local farms, gardens and landscapes.

"Our Government is supporting innovative projects across the country and positioning Canada at the forefront of clean energy technology to help protect our environment and create high-quality jobs," said the Honourable Kerry-Lynne Findlay, Canada's Minister of National Revenue. "Projects like this not only support our local economy but also demonstrate how we can use clean technology to reduce greenhouse gas emissions."

"The City of Richmond is pleased to work with Harvest Power to manage and beneficially reuse our organic waste," said Malcolm Brodie, Richmond Mayor and Chair of the Zero Waste Committee for Metro Vancouver. "Together we are creating opportunities to reach our recycling targets while improving the soil for future generations and developing the increased use of renewable energy sources."

Harvest's services and products help reduce landfill-bound waste and greenhouse gas emissions associated with transportation while providing clean, local renewable energy and top quality soil products.

"We see an organic cycle of energy and nutrients: a pizza crust from last night's dinner gets turned into power today, and soil that grows tomatoes in tomorrow's garden," continued Sellew.

Financing for the Energy Garden was supported by a $4 million contribution from Natural Resources Canada and a $1.5 million contribution from BC Bioenergy Network. Proud supporters of this effort include BC Hydro, Metro Vancouver and member municipalities, Port Metro Vancouver, haulers, landscapers and local residents. The energy is sold back onto the grid under a power purchase agreement with BC Hydro.

Wastewater Treatment Residuals

Table 8: Energy, Environmental and Economic Benefits of Wastewater Treatment Biogas Projects in Canada

Energy	• Biogas utilization at wastewater treatment plants across Canada has the potential to capture up to 180 Mm^3/year or more of RNG. • This could produce 60MW of green electricity. • About 55% of the biosolids from the largest treatment facilities in Canada are processed in biogas systems. There is significant potential to recover more biogas at wastewater treatment plants across Canada.
Environment	• Capturing additional biogas in wastewater treatment plants across Canada could reduce GHG emissions by 2.8 million tonnes eCO^2/year or more. • This is equivalent to taking 560,000 cars off the road.
Economy	• Construction projects at wastewater treatment plants across Canada to increase energy production from biogas would generate $600 million in capital expenditures with a spin-off of $1.8 billion. • Digester construction projects would result in 1,000 direct and 3,000 indirect jobs • Digester construction projects create up to 30 construction jobs for 52 weeks per project. • Digesters create about 4 operations jobs and 1–2 maintenance jobs; development of additional digesters at wastewater treatment facilities in Canada would create 250 on-going operations jobs.

Case Study:
RNG Production at a Wastewater Treatment Plant
Hamilton, Ontario

Overview

The City of Hamilton, Ontario, (population 520,000) has been using anaerobic digesters to process sludge from its Woodward Avenue Wastewater Treatment Plant for a half-century. In 2006, it stopped flaring off most of the biogas and began using it to fuel a combined heat and power (CHP) plant that generates electricity, provides space heating and warms the digesters. More recently, it began purifying the biogas into 98 percent methane—a product known as biomethane or renewable natural gas (RNG), and identical in performance to the conventional fossil fuel—that is injected into the local pipeline system operated by Union Gas Limited.

While commonplace for decades in parts of Europe, where it is supported by subsidies in Germany, France and Sweden, biomethane production is just beginning to grow in the United States, and lags even further behind in Canada. The country's first bio-methane facility is at an agricultural digester in Abbotsford, BC. Hamilton's $4 million project is, so far, the only one in Canada based on digested solids from a municipal wastewater treatment plant.

The City was able to leverage several initiatives, including innovative planning and design as well as a shared municipal, provincial and federal government infrastructure funding to achieve environmental benefits, create revenue, validate new technology, and provide a full-scale demonstration facility for an emerging renewable biogas market in North America.

Features

- The CHP facility and the RNG purification plant are owned by the City and operated and maintained by a civic corporation known as Hamilton Renewable Power Inc.
- The City has a "wheeling" agreement with Union Gas. In this arrangement Union Gas does not pay for the biomethane; it charges the city a small fee to transport the gas on its behalf. The City then buys the remainder of its required supply by conventional means, less the amount of biomethane it has injected into the pipeline. The City also paid for the purification and injection facility, built to Union Gas' gas quality specifications, and covers its annual operating and maintenance cost.
- The CHP facility usually operates at maximum capacity, consuming 15,300 cubic meters (m3)/day of biogas and accounting for most of the current daily biogas production of 17,150 m^3.
- As biogas production rises, more will flow to the Greenlane "Rimu" purification facility. The facility, with daily capacity of 10,000 m^3 of biomethane, was sized to handle the forecasted biogas supply until 2020, but the modular design enables expansion.
- The comparative economic benefits of CHP and RNG rise and fall with the market price of electricity and natural gas, and the availability of subsidies. The two uses are complementary, since outputs can be adjusted depending upon which offered the better return.

Future Plans and Opportunities

Hamilton is growing, and a formal master planning process identified the need to increase the treatment plant's daily capacity from 108 million to 132 million gallons/day. The expansion will generate additional sludge, so more digesters and dewatering centrifuges are also planned. These changes are expected to raise biogas production by 215 percent, to a daily average of about 37,000 m^3, within 20 years.

Biogas, CHP and RNG production are all part of the City's ambitious plan to make the Woodward Avenue Wastewater Treatment plant a zero-net-energy user'. Additional plans are in place to investigate co-digestion of fats, oils and greases from the restaurant industry as a supplemental fuel source for digesters.

Biogas Association

biogasassociation.ca