SURERUS MURPHY

A JOINT VENTURE COMPANY

Helping Canada meet its 2050 net-zero commitments

According to the Government of Canada, biofuels are forecasted to represent 12% of the total end use energy demand in Canada by 2050.

BIOENERGY

Bioenergy is one of many diverse resources available to help meet our demand for energy while pursuing a net-zero economy.

Bioenergy is a form of renewable energy that is derived from recently living organic materials known as biomass. Biomass is broken down to produce biofuels, such as ethanol and biodiesel, as well as other useful products. Bioenergy is going to play a large role in our net-zero economy. In fact, by 2050, the Government of Canada is forecasting biofuels will represent 12% of the total end use energy demand in Canada.

Sources of bioenergy include crop wastes, forest residues, urban wood waste, food waste, and municipal wastes including landfills or wastewater treatment facilities. To produce biofuel, the waste typically undergoes further processing such as fermentation to produce bioethanol, or anaerobic digestion to produce a biogas (as seen in the production of renewable natural gas).

In this brochure, we will dive deeper into the greenhouse gas emissions associated with bioenergy, as well as the two main bioenergy types: Biofuels and Biogases.

Our Services

Recognizing the ambitions for global decarbonization, we are capable of developing and constructing the infrastructure to support our clients needs in the low-carbon economy.

Already leaders in the industry, our teams in the UK have engineered and constructed numerous projects over the past decade including the Mutton Island Wastewater Treatment plant, Huddersfield Energy and Recycling Facility, and the Deephams Sewage Treatment Upgrade; all of which use biogas generated by the facility to power a combined heat and power plant.

Drawing from an extensive and worldwide resource pool of professional engineers, project managers, and construction experts, SMJV is well-positioned to support all aspects of the energy transition, including:

- Biogas and Wastewater Treatment Facilities
- Biofuel Production and Upgrading Facilities
- Front End Engineering and Design (FEED)
- Constructability/Buildability Studies

GHG Emissions and Net Zero

During their lifecycle, plants act as carbon sinks, absorbing large amounts of carbon dioxide from the atmosphere through a process known as photosynthesis. This allows plants to store energy from sunlight in the form of sugars and starches. Simply speaking, if we were to utilize a plant on the spot, as is for a fuel, the net emissions would be close to zero since over its short-term lifespan it would have removed carbon dioxide from the air, only to re-release it when utilized.

Now if this same plant were to be processed into a biodiesel, emissions created during the transporting and processing phases must be accounted for. The net amount of CO_2 emitted is dependent on variables such as production and upgrading methods, or the type of feedstock used.

It should be noted there is still some divide within the scientific community on whether wood-burning is truly net zero. However, in 2018, the Environmental Protection Agency (EPA) declared wood-burning as carbon neutral.

As you can see, all bioenergy uses are not necessarily net zero, but they result in significantly less emissions than the fossil fuel alternative.

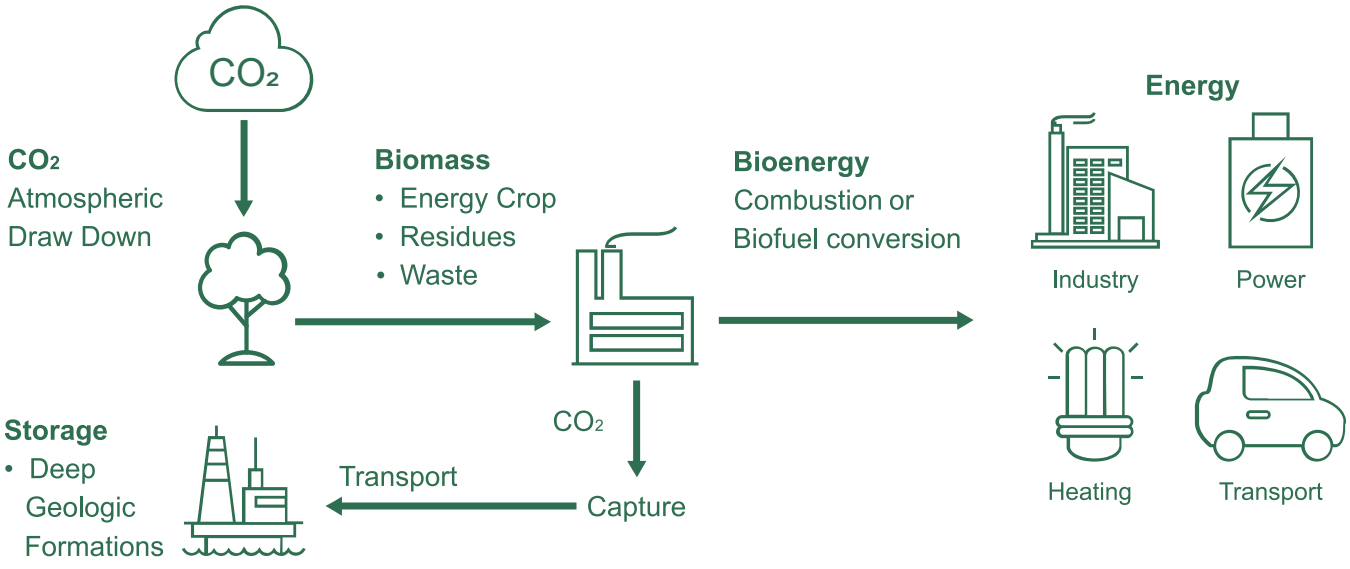
Bioenergy with Carbon Capture and Storage (BECCS)

Bioenergy with carbon capture and storage (BECCS) involves the same process of extracting energy from biomass and adds in carbon capture and storage during the combustion or biofuel conversion phase.

Carbon capture and storage (CCS) technology serves to intercept the release of CO_2 into the atmosphere and redirect it into geological storage locations for permanent sequestration.

The main appeal of BECCS is the potential for carbon negative energy production. Over time, industrial processes have released too much CO_2 to be absorbed by conventional carbon sinks, such as trees and soil, to reach low emission targets.

BECCS is a suggested technology to reverse the emission trend and create a global system of net negative emissions. This implies that emissions would not only be zero, but negative, so that emissions and the absolute amount of CO_2 in the atmosphere would be reduced.



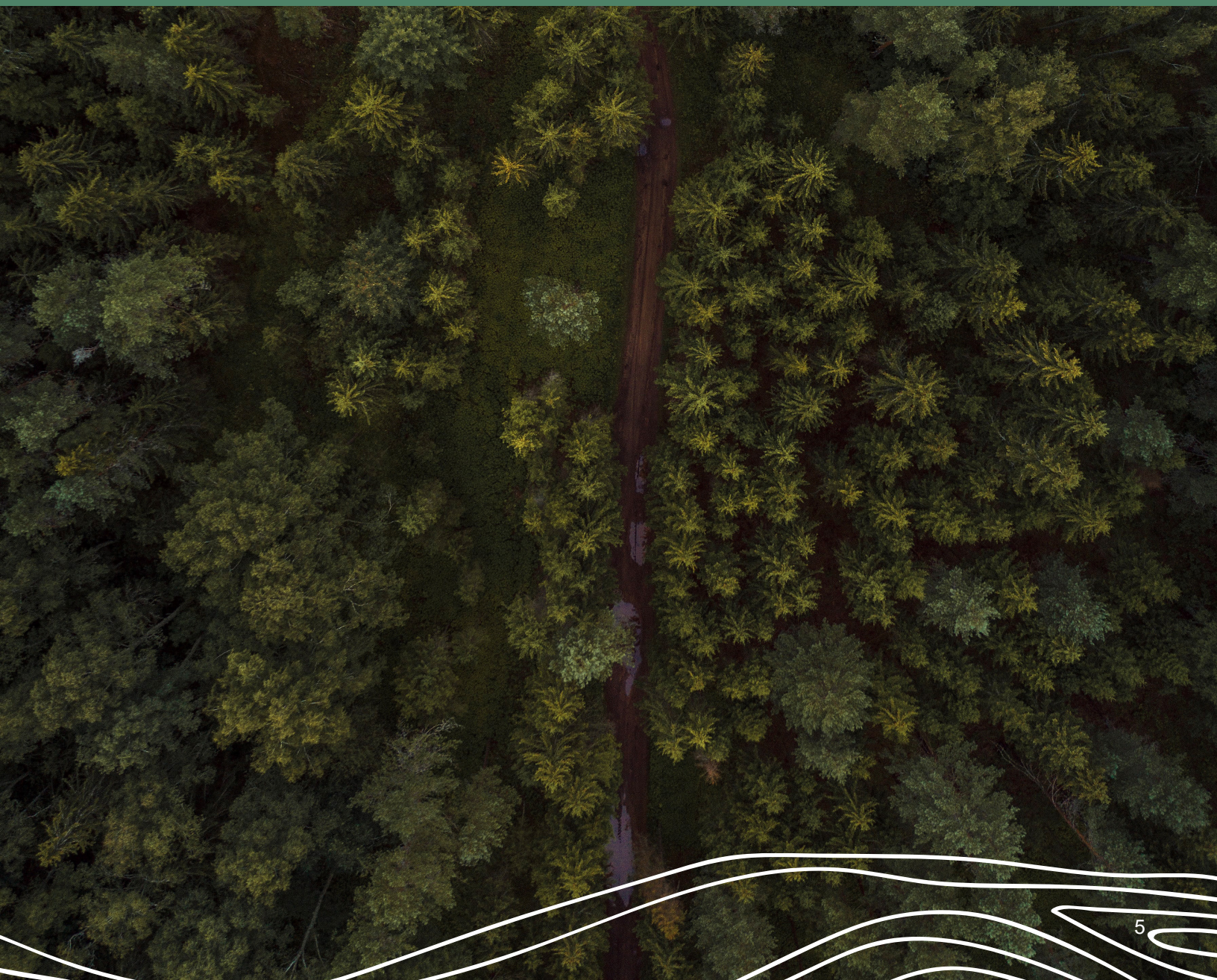
Biofuels

Unlike other renewable energy sources, biomass can be converted directly into liquid fuels, called biofuels, to help meet transportation fuel needs. The two most common types of biofuels in use today are ethanol and biodiesel, both of which represent the first generation of biofuel technology. Biofuels will play an important role in decreasing the carbon intensity of transportation fuels and are an integral part in both federal and provincial fuel standards.

The Clean Fuel Standard recently proposed by the federal government of Canada requires fuel suppliers to reduce the carbon intensity of their liquid fuels progressively each year towards 2030 and notes the integration of biofuels blended with petroleum fuels as a pathway to meeting this requirement.

In Alberta, the Renewable Fuels Standard requires a minimum annual average of 5% ethanol in gasoline and 2% biodiesel in diesel fuel sold in Alberta. These numbers vary from province to province with Ontario recently mandating a 15% ethanol blend in their gasoline by 2030.

Biofuels will play an important role in our net-zero economy. However, there are constraints on expanding the supply, and possible trade-offs with sustainable development goals. These include avoiding conflicts at local level with other uses of land, notably for food production and biodiversity protection.



Ethanol

Ethanol is a renewable fuel made from various plant materials such as hemp, sugarcane, potato, cassava, or corn. When used as a blending agent in gasoline, ethanol increases octane content and reduces carbon monoxide and other smog causing emissions resulting from combustion. In Canada, ethanol is primarily made from corn and wheat.

The most common blend of ethanol is E10, which consists of 10% ethanol and 90% gasoline. Some vehicles, called flex-fuel vehicles, are designed to run on E85—a gasoline-ethanol blend containing up to 85% ethanol. The 15% gasoline is required to assist cold starting the engine (due to pure ethanol being more difficult to ignite in cold weather).

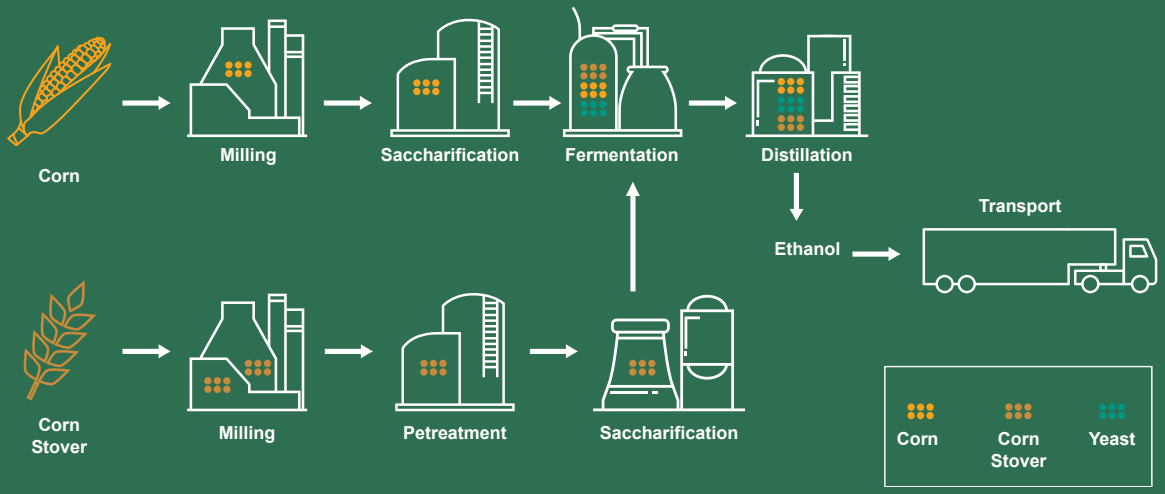
Most ethanol is made from plant starches and sugars. Scientists are continuing to develop technologies that allow for the use of cellulose and hemicellulose, the non-edible fibrous material that constitutes the bulk of plant matter.

The common method for converting biomass into ethanol is through a process called fermentation. During fermentation, microorganisms, such as bacteria and yeast, metabolize plant sugars into ethanol and CO_2. Ethanol is separated and purified by a combination of adsorption and distillation, removing the yeast solids and water. From there, ethanol can be blended with gasoline and sent to retail gas stations for purchase by consumers.

Consumption of ethanol in Canada has increased steadily every year, from 1.7 billion litres in 2010, to 3.1 billion litres in 2018. In Alberta, gasoline is blended with 5-10% ethanol depending on the supplier. This means, if you were to fill up with 100L of gasoline, 5-10L of the total volume would be from a bio-sourced ethanol.

As the transportation sector continues to evolve with an increasing demand for both electric and hydrogen fuel cell vehicles, biofuels will continue to play a role in fueling the older, existing fleet of internal combustion engine vehicles. This is until they are eventually retired permanently from the road.

Example of Ethanol Production:



Biodiesel

Biodiesel is a liquid fuel produced from renewable sources, such as vegetable oils or animal fats, and is a cleaner burning replacement for petroleum-based diesel fuel.

Biodiesel is nontoxic, biodegradable, and is typically made by chemically reacting lipids such as animal fat, soybean oil, or vegetable oil with an alcohol. This creates the biodiesel through the process of transesterification.

Transesterification converts fats and oils into biodiesel and glycerin—a useful coproduct of the reaction. If 100 pounds of oil or fat are reacted with 10 pounds of methanol (in the presence of a catalyst such as sodium hydroxide [NaOH] or potassium hydroxide [KOH]), it will form 100 pounds of biodiesel and 10 pounds of glycerin.

Like petroleum-derived diesel, biodiesel is used to fuel compression-ignition diesel engines. Biodiesel can be blended with petroleum diesel in any percentage, including B100 (pure biodiesel) and, the most common blend, B_20 which contains 20% biodiesel and 80% petroleum diesel.

Biodiesel can be used with precaution, in diesel engines in many sectors including on-road vehicles, off-road mobile equipment and vehicles, and stationary equipment such as generators or heaters.

On average, consumption of biodiesel in Canada has increased yearly and constituted 711 million litres of the diesel pool in 2018. In Alberta, petroleum diesel is blended with a minimum of 2% biodiesel. This means if you were to fill up with 100L of diesel at a refueling station, roughly 2L of the total volume would be from a bio-sourced diesel.

As the transportation sector continues to evolve and place emphasis on hydrogen fuel cell applications for heavy haul transport applications, biodiesel will continue to play a role as a transition energy source. This will be done by fueling the older, existing fleet of internal combustion engine vehicles until they are eventually retired permanently from the road. Biodiesel also plays an important role in lowering emissions in the hard to electrify sectors, including the aviation and construction industries fueling heavy equipment (such as excavators, dozers, and side booms) where technology has yet to advance another feasible power source.

Ethanol and Biodiesel can be used in many applications.

Stationary:

- Electricity generators (gensets)
- Furnaces

On-road:

- Fleet vehicles
- Heavy-duty trucks
- School buses
- Urban transit buses

Off-road:

- Agricultural equipment
- Construction equipment
- Forestry equipment
- Locomotives (trains)
- Marine vessels
- Mining equipment

Renewable Natural Gas

Renewable natural gas (RNG) is a pipeline-quality gas that is fully interchangeable with conventional natural gas and can also be used as a fuel in natural gas vehicles. RNG is a biogas (the gaseous product of the decomposition of organic matter) that has been processed to purity standards. Like conventional natural gas, RNG can be used as a transportation fuel in the form of compressed natural gas (CNG) or liquefied natural gas (LNG).

There are over 250 biogas projects spread throughout Canada, however recent studies indicate the vast majority of Canada's biogas potential remains untapped. RNG is produced from various biomass sources through biochemical processes, such as anaerobic digestion. This process produces a biogas consisting of methane, CO_2 and other trace gases. With minor processing, this biogas can be used to generate electricity and heat.

Biogas and RNG Energy Capacity

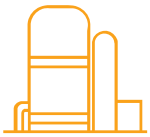
Operational and initiated projects generate:

6PJ of RNG	196MW of clean electricity	260Mm^3 of biogas for direct use

In 2017, Canada produced approximately six Petajoules of RNG—enough to heat over 74,800 homes for a year. Research indicates Canada has the potential of producing 1,300 Petajoules/year, filling 36% of current pipelines and heat nearly 14 million homes. RNG is a great source of carbon-neutral fuel, except its main limitation is the volume that would be required to replace our current consumption of natural gas, which simply isn't available. RNG has the potential to serve as a supplement blended into the existing natural gas network to reduce the carbon intensity of the fuel and can be considered complimentary to hydrogen sourced heating.

To fuel vehicles, this biogas must be processed to a higher purity standard through a process called conditioning or upgrading, involving the removal of water, carbon dioxide, hydrogen sulfide, and other trace elements. The resulting RNG, or biomethane, has a higher content of methane than raw biogas, making it comparable to conventional natural gas.

Operating Biogas and RNG Projects in Canada



45 Agriculture Digesters

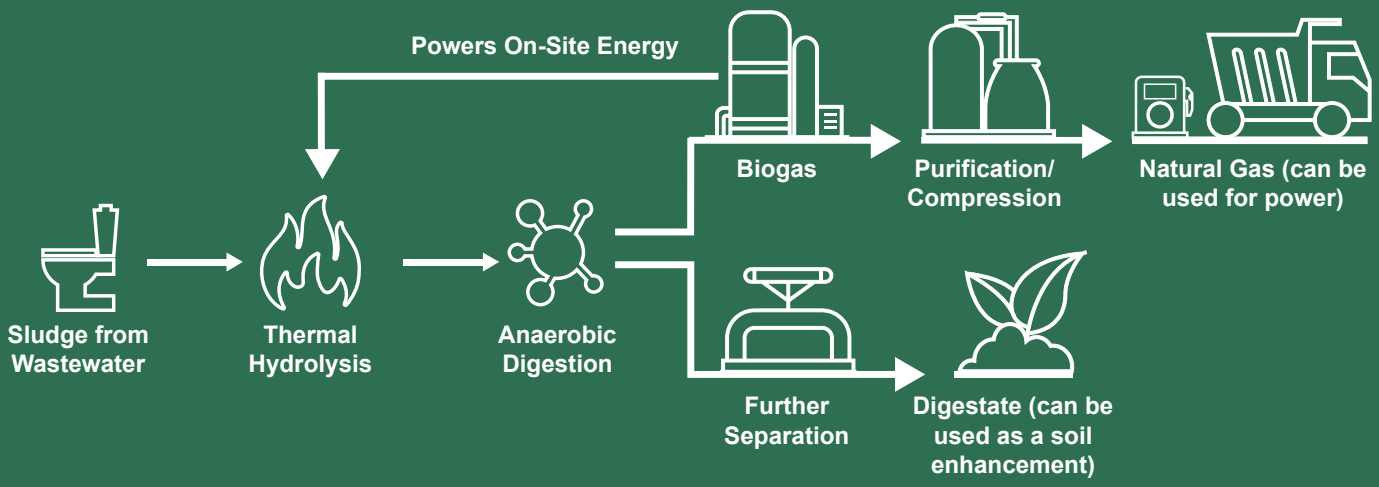
9 Industrial Digesters

126 Wastewater Treatment Facilities

99 Landfill Gas Capture Systems

Biogas from Wastewater Treatment Plants

The biogas component of a wastewater treatment plant starts with pre-treating the sewage sludge to ensure it consists of the optimal solids content with the aim of improving the gas yield. The sludge is pumped into the anaerobic, Continuously Stirred, Tank Reactor (CSTR) where digestion takes place. During a retention time of around 20 days, microorganisms break down part of the organic matter that is contained in the sludge and produce biogas, composed of methane, CO_2 and other trace gases. The gas is then collected, treated, and purified into RNG. In Canada, there are over 120 wastewater treatment facilities producing either raw biogas or RNG.



Other Sources of Biogas

Other sources of biogas include organic waste from industrial, institutional, and commercial entities. Examples include, food manufacturing and wholesalers, supermarkets, restaurants, hospitals, and educational facilities.

Biogas is produced from lignocellulosic material such as crop residues, woody biomass, and dedicated energy crops via thermochemical conversions, co-digestion, and dry fermentation.

To produce biogas from municipal organics a process which mirrors the wastewater biogas generation is used (including anaerobic digestion and purification) to produce a clean renewable natural gas. There are currently nine industrial digesters producing raw biogas or RNG in Canada.

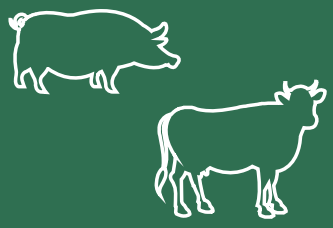
Biogas from Livestock Operations

Biogas recovery systems at livestock operations can also be used to produce renewable natural gas.

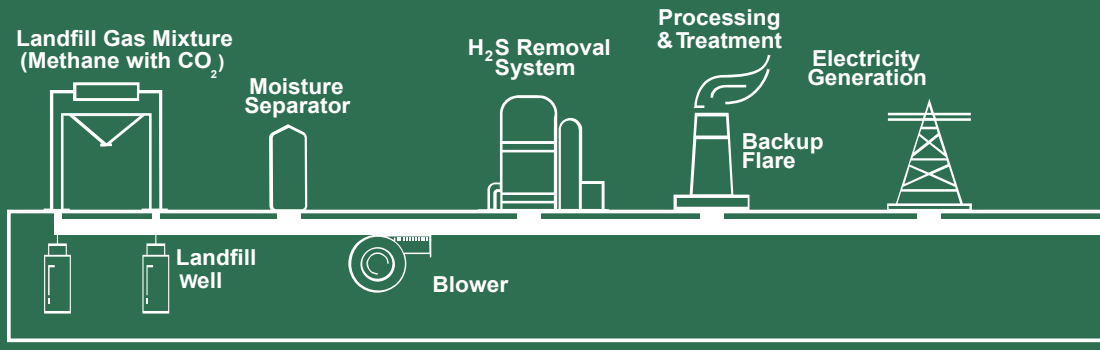
In this process, animal manure is collected and delivered to an anaerobic digester where it is allowed to stabilize for optimal methane production. The bacteria and other microorganisms then start decomposing the organic materials, releasing both methane and CO_2 gas.

This resulting biogas can be processed into RNG and is fully interchangeable to replace conventional natural gas. Any leftover effluent is a fantastic source of liquid fertilizer, while the solid sludge that collects at the bottom of the digester can be utilized for bedding or mulch. There are currently 45 operating agricultural biogas projects in Canada.

Anaerobic Digesters

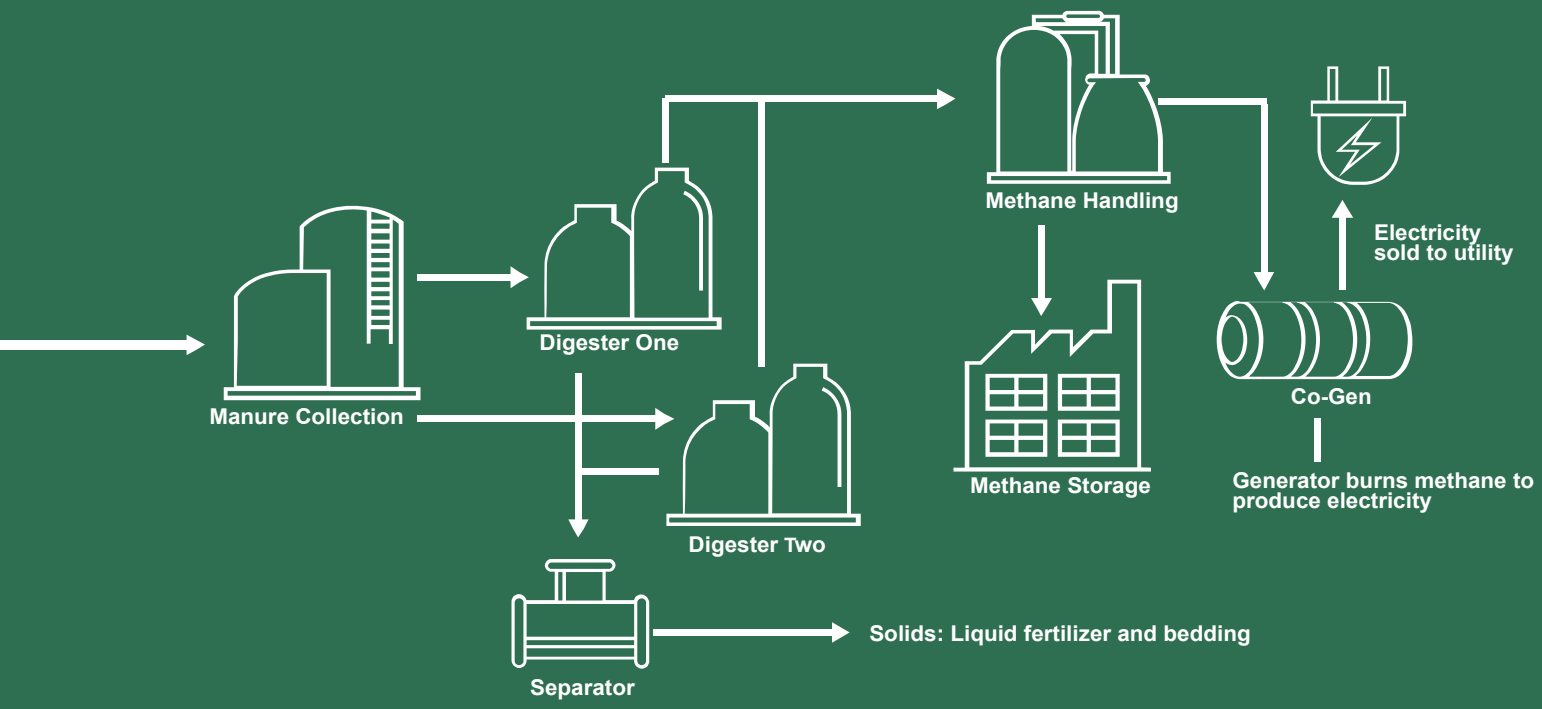


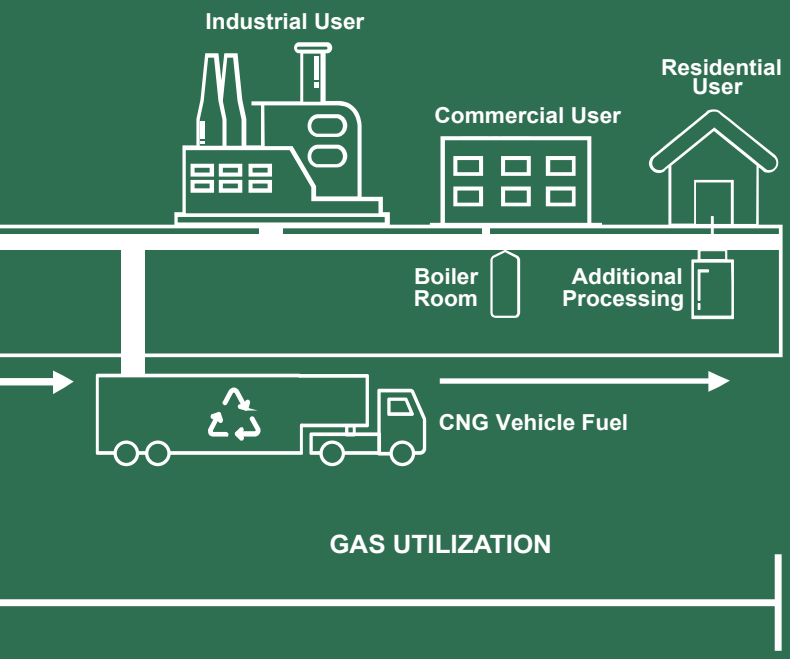
Landfill Gas System



GAS COLLECTION

GAS CONTROL AND PROCESSING





Biogas from Landfills

Landfill gas (LFG) is generated through the degradation of municipal solid waste and other biodegradable waste, by bacteria and other microorganisms.

In anaerobic conditions (meaning the absence of oxygen), which is typical of landfills, methane and CO_2 are produced at a ratio of approximatly 60:40, with the amount of methane produced depending on the composition of the waste. In a typical LFG sytem, the gas is collected by a number of wells, installed both horizontally and vertically, through the waste mass and piped to a main collection header. Gas undergoes treatment and compression to remove any impurities, condensates, moisture, and particulates before it is utilized. Landfill gas can be upgraded to pipeline quality gas and be used to heat homes, or fuel a compressed natural gas (CNG) vehicle. There are currently 99 landfill gas capture systems operational in Canada.

FURTHER READINGS

CANADA'S NET ZERO FUTURE

climatechoices.ca/wp-content/uploads/2021/02/Canadas-Net-Zero-Future_FINAL-2.pdf

NET ZERO EMISSIONS BY 2050

www.canada.ca/en/services/environment/weather/climatechange/climate-plan/net-zero-emissions-2050.html

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