Biomethane Greenhouse Gas Emissions Review

FortisBC

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OFFSETTERS

Executive Summary

Based on a review of BC Government Policy and the expected lifecycle emissions for biomethane produced from landfill gas and anaerobic digesters, Offsetters considers FortisBC's renewable natural gas to be a carbon neutral fuel. As such, participants that sign up for renewable natural gas will see a reduction in their carbon footprint by 5.03 $kgCO_2e$ per gigajoule, based a fuel mix of 10% biomethane. One gigajoule of 100% biomethane will provide a savings of 50.3 $kgCO_2e$ when replacing conventional natural gas in BC.

Existing policy related to biomethane shows that the Government of British Columbia considers biomethane from organic waste (including agriculture, landfill or wastewater sources) to be a carbon neutral fuel source. The following are organizations and documents that refer to the carbon neutrality of biomethane:

i. Provincial Government of British Columbia in the "Budget and Fiscal Plan 2011/12- 2013/14" (February 15th, 2011)
ii. Provincial Government of British Columbia, Ministry of Energy, Mines and Petroleum Resources in the BC Bioenergy Strategy
iii. Report by Biocap for the BC Ministry of Energy, Mines and Petroleum Resources and the BC Ministry of Forests and Range. Document titled, "An Information Guide on Pursuing Biomass Opportunities and Technologies in British Columbia"

In the case of renewable natural gas, Carbon Neutral status means that both combustion and lifecycle emissions do not contribute any net greenhouse gases into the atmosphere. The combustion of biomethane releases biogenic carbon dioxide, which is not additional to the natural carbon cycle. From a lifecycle perspective, the emissions savings from displacing conventional natural gas production far outweigh biomethane's production emissions.

Throughout the life cycle of biomethane, expected sources of greenhouse gas (GHG) emissions include:

a. Energy required for processing biomethane including the electricity and fuel consumed by facilities, equipment and support vehicles;

b. Methane slip that may occur during processing, transport and distribution;

c. Energy required for transport and distribution, such as the electricity consumed in distribution facilities and pipeline operations;

d. Methane and nitrous oxide emissions resulting from biomethane combustion at the point of consumer use; and,

e. By- product waste created throughout all life cycle stages such as wastewater and solid deposits.

Expected GHG sinks in the biomethane life cycle that reduce greenhouse gas emissions include:

a. Methane capture and destruction from landfill gas, manure management and wastewater treatment. Under baseline conditions, organic material would typically decompose and release methane directly into the atmosphere;

b. Avoided emissions from the combustion of natural gas, a fossil fuel that emits 50.3014 $kgCO_2e/GJ$ in BC. Biomethane emits only 0.3034 $kgCO_2e/GJ$;

c. Avoided life cycle emissions from extracting and processing natural gas; and,

d. Avoided emissions from nitrous oxide released from untreated biomass.

It is important to consider renewable natural gas' additional benefit of converting naturally occurring biomethane into carbon dioxide as mentioned above. The process of biomethane "capture and destruction" reduces global warming impacts considerably. Methane has a global warming potential (GWP) of 21 while carbon dioxide's GWP is 1, which means that each molecule of methane has 21 times the impact on climate change as one molecule of carbon dioxide. Utilizing biomethane for heating and other purposes creates carbon dioxide and prevents biomethane from directly entering the atmosphere, which reduces overall greenhouse gas emissions.

Contents

Figures

Tables

1 Introduction

1.1 Purpose

This report has been conducted by Offsetters on behalf of FortisBC. The purpose of this report is to:

1. Summarize existing policies in British Columbia that define biomethane as a 'carbon neutral' fuel source.

2. Identify emissions sources and overall net emissions associated with the life cycle of biomethane produced from landfills and anaerobic digesters.

1.2 Disclaimer

All greenhouse gas emissions quantified in this report are estimations based on existing data from previous studies conducted and therefore Offsetters is not responsible for inaccuracies of 3rd party information.

1.3 Life cycle Assessment (LCA) Background

Drawing from the World Resources Institute's Life Cycle Standard, there are two LCA boundaries that we recognize in the preparation of this study:

1) Cradle-to-Grave:

A cradle-to-grave life cycle assessment includes all GHG emissions in the complete life cycle of a product from the beginning of acquiring raw materials through final disposal or post-consumer end-of-life.

In the case of a fuel cycle, the cradle-to-grave emissions are also referred to as well-to-wheels (WTW). The WTW life cycle includes resource extraction, feedstock production, fuel production, refining, blending, transportation and distribution, consumption and evaporation.

Figure 1 below illustrates the five life cycle stages of a product.

Figure 1: Cradle-to-Grave Emission Stages

2) Cradle to Gate:

A cradle to gate inventory does not include the use or end-of-life stages. For fuel, the cradle to gate emissions are also referred to as well- to- tank (WTT). The WTT life cycle therefore includes resource extraction, feedstock production, fuel production, refining, blending, transportation and distribution.

Figure 2: Cradle- to- Gate Inventory

This report examines emissions information up to the biomethane producer's gate, where the biomethane is transferred into FortisBC's pipeline distribution network.

2 Review of BC's Biomethane Policies

Offsetters has conducted a review of existing government policy related to biomethane and carbon neutrality in British Columbia on behalf of FortisBC. Tables 1-3 below provide excerpts from these documents. They are either Provincial Government documents or are written by third parties on behalf of the Government.

The consensus from these documents is that the Government of British Columbia considers biomethane sourced from organic waste (including agricultural, landfill or wastewater sources) to be a carbon neutral fuel source. The Government's position states biomethane releases no more carbon into the atmosphere than it absorbs in its lifetime.

2.1 British Columbia Budget

In BC's latest Budget and Fiscal Plan, published on February 15th, 2011, biomethane produced from agricultural and other organic waste is referenced as a carbon neutral renewable fuel. According to the Carbon Tax Act, the biomethane portion of a fuel blend is to be exempt from the carbon tax as a result of its carbon neutrality. Table 1 below provides a summary of this section of the Budget and Fiscal Plan, with a quote directly from page 42 of the document.

Table 1: Provincial Government: Budget and Fiscal Plan 2011/2012 (Excerpt)

Organization
Provincial Government of British Columbia
Document
Budget and Fiscal Plan 2011/12- 2013/14 (February 15th, 2011)
Quote Page 42:
"Biomethane is a carbon neutral fuel produced from biomass (eg. Agricultural and other organic wastes). Purchases of 100% biomethane are exempt from carbon tax. The biomethane portion of a blend is exempt from the carbon tax where the actual amount of biomethane in the blend is known. Effective February 16, 2011, a credit is provided for blends of biomethane and natural gas sold under qualifying contracts by registered retail dealers of natural gas who inject biomethane into the system. Qualifying contracts must clearly stipulate the amount that purchasers are paying for a specified volume or percentage of biomethane. The credit is equal to the carbon tax payable on the specified volume or percentage of biomethane. Similar to the Residential Energy Credit, eligible purchasers will receive the biomethane credit on their natural gas bills."

2.2 BC Ministry of Energy, Mines and Petroleum Resources

The BC Provincial Ministry of Energy, Mines and Petroleum Resources published a report titled, *BC Bioenergy Strategy: Growing Our Natural Energy Advantage*. In this report, biomass refers to organic sources including agricultural waste and manure. The report also states that when used for energy, biomass including organic waste is carbon neutral. Table 2 below provides a direct quote from page 4 of this report, which relates to biomass and carbon neutrality.

Table 2: BC Bioenergy Strategy

Organization
Provincial Government of British Columbia, Ministry of Energy, Mines and Petroleum Resources
Document
BC Bioenergy Strategy
Quote Page 4:
"Bioenergy is energy derived from organic biomass sources – such as trees, agricultural crops, food processing and agricultural wastes and manure. Biomass can be generated from logging, agriculture and aquaculture, vegetation clearing and forest fire hazard areas. When used for energy, biomass such as organic waste, wood residues and agricultural fibre is considered clean or carbon neutral because it releases no more carbon into the atmosphere than it absorbed during its lifetime. When used to replace non-renewable sources of energy, bioenergy reduces the amount of greenhouse gases released into the atmosphere."

2.3 BC Ministry of Energy, Mines and Petroleum Resources and the BC Ministry of Forests and Range

In 2008 the BC Ministry of Energy, Mines and Petroleum Resources and the BC Ministry of Forests and Range published an information guide on biomass energy opportunities in British Columbia. This report was prepared by Biocap Canada on behalf of the two Ministries. In this report, biomass refers to municipal solid waste, agricultural waste including livestock manure and forestry waste. This report states that biomass as a carbon neutral energy source can play an important role in helping BC achieve its GHG targets. Table 3 below provides a summary of the explanations provided in this report related to biomass and carbon neutrality. Of note, page 20 of this report recognizes the potential of methane emissions from biomass contributing to GHGs and how this should be avoided through a biofilter.

Table 3: Information Guide to Biomass in BC

Organization
Report by Biocap for BC Ministry of Energy, Mines and Petroleum Resources and the BC Ministry of Forests and Range
Document
An Information Guide on Pursuing Biomass Energy Opportunities and Technologies in British Columbia (February 7th, 2008)
Quote Page 4:
"The Province of British Columbia has committed itself to maintain a share of at least 90% of its electricity generation from clean and renewable energy sources, and to mandate that all new facilities will have net zero greenhouse gas emissions. Biomass, as a "carbon neutral" renewable resource, can make a major contribution towards this goal. In addition, biomass can also support energy and greenhouse gas emission reduction goals in the fields of heat and transportation fuels. One tonne of dry biomass (bdt) can displace between 1.5 and 3 barrels of oil, depending on the application, technology and process efficiency applied."
Quote from Page 20:
"Note that carbon contained in biomass is usually considered part of a regeneration cycle and processes using biomass can therefore be considered carbon neutral. However, any methane emissions should be avoided as they would otherwise constitute GHG emissions. Methane emissions can occur during curing of the material, but can be partly eliminated by the biofilter. The anaerobic digestion process will generate GHG credits through avoided emissions in the field or from open lagoons, as well the from the electricity or natural gas displaced when using the digester gas for energy purposes."

2.4 Considerations

1. Non-Biogenic Emissions

Notwithstanding the BC Government's position on biomethane, it should be noted that biogenic emissions from biomethane combustion refer to carbon dioxide (CO_2) emissions only. The use of biomethane also results in greenhouse gas emissions of uncombusted methane (CH_4) and nitrous oxide (N_2O), which total 0.3034 kgCO_2e/GJ. However, the BC Government considers these non-biogenic emissions to be immaterial and negligible as they represent only 0.6% of the total emissions from conventional natural gas that has an emissions factor of 50.3 kgCO_2e/GJ in BC as reported by Environment Canada[1] and the BC Ministry of Environment[2].

2. Biomass vs. Woody Biomass

The use of the term "biomass" can sometimes refer to all types of biomass (including biomethane) or it can refer to the subset of woody biomass only. This distinction is important because the BC Reporting Regulation for the Greenhouse Gas Reductions (Cap and Trade) Act[3], exempts woody biomass from a reporting facility's emissions total. However, facilities are required to report emissions from biomass sources other than those listed in Schedule C, including biomethane emissions. It is unclear why biomethane emissions are not exempt.

"Biomass" is defined as:

> "(a) non-fossilized plants or parts of plants, animal waste or any product made of either of these and includes, without limitation, biomass derived fuels, wood and wood products, agricultural residues and wastes, biologically derived organic matter found in municipal and industrial wastes, landfill gas, black liquor, kraft pulp fibres and sludge gas, and
> (b) any fuels in respect of which the entire heat generation capacity is derived entirely from biomass described in paragraph (a);"

"Woody Biomass" is defined as "Type 1 biomass" in Schedule C as follows:

> Wood biomass, or the wood biomass component of mixed fuels, including
> (a) wood residue within the meaning of the Forest Act,
> (b) wood-derived fuel, red liquor and black liquor from pulp and paper production processes, and
> (c) woody matter from agricultural trimmings, tree thinning and orchard removals,
> but not including wood biomass that fails to meet the criteria for carbon neutrality established by the jurisdiction in which it was produced, if any.

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[1] 1990-2008 National Inventory Report (April 2009), Greenhouse Gases and Sinks in Canada http://www.ec.gc.ca/Publications/default.asp?lang=En&xml=492D914C-2EAB-47AB-A045-C62B2CDACC29

[2] BC Methodology Manual, Reporting Regulations for Greenhouse Gas Reduction Act, Dec 2009, http://www.env.gov.bc.ca/cas/mitigation/ggrcta/reporting-regulation/pdf/methodology-manual.pdf

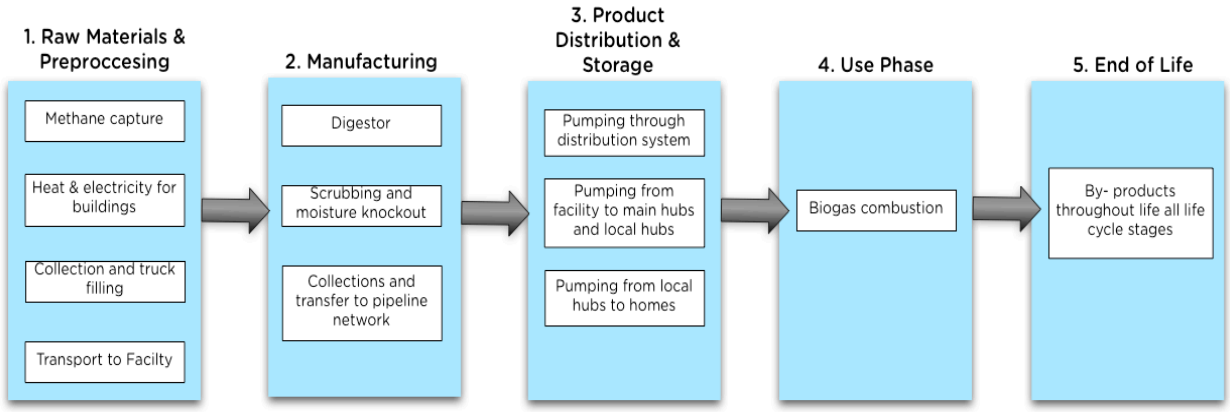
[3] http://www.bclaws.ca/EPLibraries/bclaws_new/document/ID/freeside/10_272_2009

3 Life Cycle Emissions from Biomethane

This section of the report examines the life cycle emissions of biomethane and provides insight into the impacts each life cycle stage will have on the overall GHG inventory. Section 3.1 provides a description of expected GHG emissions sources and sinks while Section 3.2 is a summary of findings from existing life cycle studies conducted on biomethane.

Figure 3 below illustrates the general life cycle stages associated with biomethane. Each of the five life cycle stages are labelled above the corresponding box.

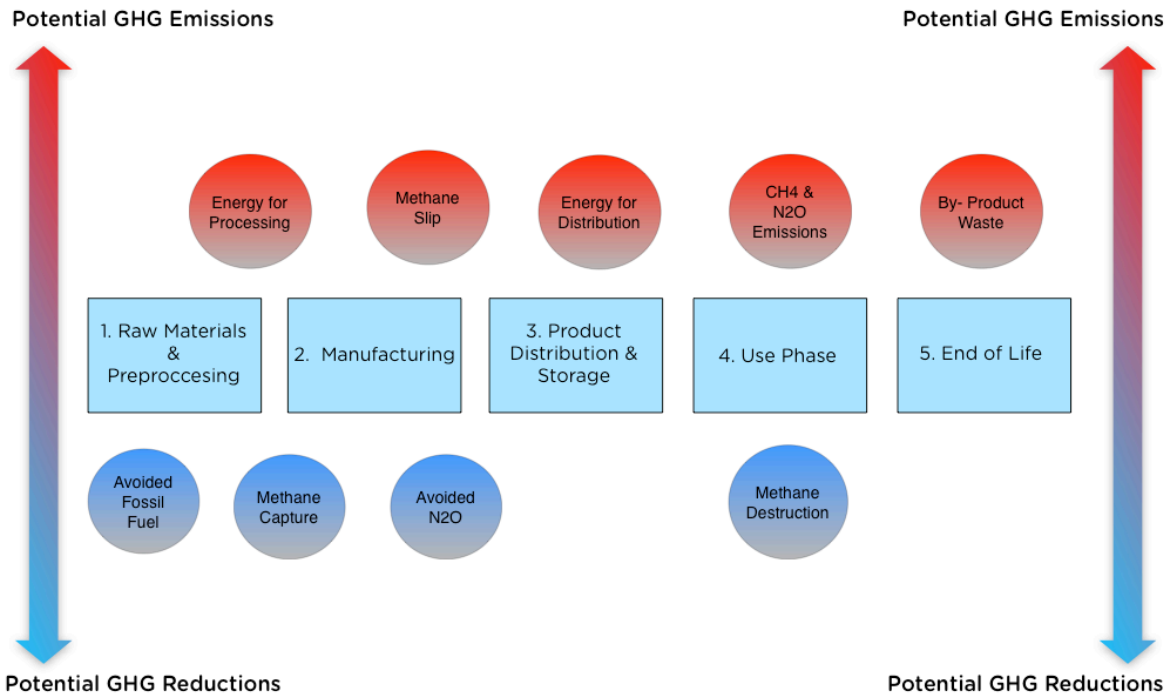
Figure 3: Process Map of Biomethane Life Cycle



3.1 GHG Sources and Reductions throughout Life Cycle

Throughout the life cycle of biomethane, there are both emissions sources and sinks that balance to create a net reduction in greenhouse gases when compared to natural gas as a fossil fuel. Figure 4 below illustrates these expected emissions and reductions in the life cycle of biomethane production. The circles in red above the life cycle stages illustrate GHG emission sources, while the blue circles underneath represent GHG sinks. Further explanation of GHG sources and sinks can be found in sections 3.1.1 and 3.1.2 respectively.

Figure 4: GHG Sources and Reductions from Biomethane Life Cycle



3.1.1 Life Cycle GHG Emission Sources from Biomethane

1. Energy Required for Processing

- Electricity, natural gas, diesel fuel or propane can be used in buildings and other facilities used to process and manufacture biomethane.
- Emissions associated with support equipment and vehicles used to move materials such as manure or landfill waste within a facility. Support equipment can also include wastewater pumps in the case of a wastewater treatment facility.

2. Methane Slip

- A small percentage of methane is lost in processing, transport and distribution, which can be referred to as fugitive emissions.
- For example, there may be inefficiencies and venting events that occur that result in leaked emissions from an anaerobic digester, or there may be fugitive emissions from a gas pipeline network.

3. Energy Required for Biomethane Transport distribution

- Fuel consumed for transportation can include fuel used in natural gas tanker trucks.
- Electricity usage consumed for distribution facilities and gas pipeline network pumps.

4. Methane and Nitrous Oxide Emissions from Combustion

- According to greenhouse gas accounting protocols, such as the WRI GHG Protocol, methane (CH_4) and nitrous oxide (N_2O) emissions are to be accounted for when combusting biomass.
- CH_4 and N_2O are not considered to be biogenic like CO_2. In other words, non-biogenic greenhouse gas emissions are not part of the natural carbon cycle.

5. By-Product Waste

- Waste created throughout the life cycle stages, such as wastewater, solid deposits and other organic material will result in methane emissions during decomposition that may not be completely captured by the biomethane facility.

3.1.2 Life Cycle GHG Sinks from Biomethane

1. Avoided Fossil Fuel

- Emissions from the combustion of natural gas are avoided when biomethane is used as a alternative fuel source. Because biomethane captures emissions from decomposing organic materials, the CO_2 emitted is considered to be part of the natural carbon cycle and no net increase in greenhouse gas emissions occur.
- In addition to replacing natural gas combustion emissions which occurs in the use phase, biomethane's cradle-to-gate life cycle also results in far fewer emissions than the life cycle of natural gas. Fossil fuel production includes extraction and processing of natural gas, which is avoided in the use of biomethane.

2. Methane Capture and Destruction

- While avoided fossil fuel emissions result from biomethane displacing natural gas, there are also emissions reductions simply from transforming methane into carbon dioxide. Methane capture and destruction takes advantage of the global warming potential (GWP) difference between the two gases. For example, destroying one tonne of methane is the equivalent of destroying 21 tonnes of carbon dioxide because methane has a greater effect on climate change than carbon dioxide does.
- Under baseline conditions, methane from organic waste would typically decompose anaerobically and release methane into the atmosphere in the natural world. Capturing this methane prevents it from contributing to climate change.

3. Nitrous Oxide Reduction

- Avoided nitrous oxide (N_2O) emissions from processing of biogas

3.2 Literature Review of Biomethane Life Cycle Assessment

Offsetters has conducted a literature review of existing research conducted on the greenhouse gas emissions associated with biomethane from landfill gas, wastewater treatment and anaerobic digester facilities. The following sections 3.2.1 to 3.2.3 detail the research findings for each biomethane type.

3.2.1 Landfill Gas to Liquefied Natural Gas Life Cycle Assessment

A study conducted by the California Air and Resources Board (CARB) examined the GHGs associated with the life cycle of landfill gas when converted into compressed natural gas (CNG). The CNG is used as an alternative to natural gas for vehicle fuel. Figure 5 below illustrates the pathway of CNG from landfill gas collection to fuel combustion, also referred to as 'well- to-wheel'. Table 4 provides a summary of the study and life cycle emissions.

Figure 5: Process Map of Landfill Gas to CNG

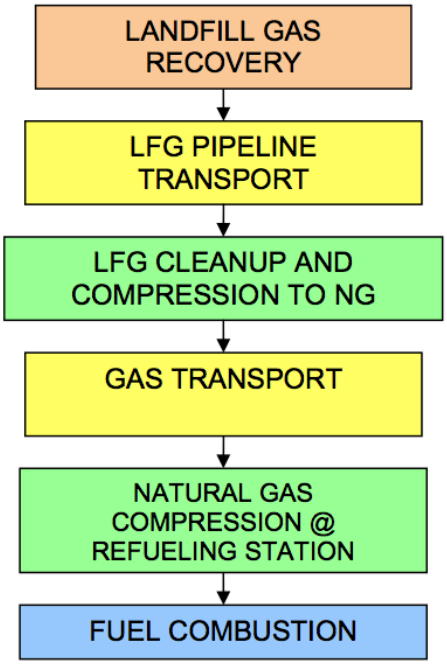


Table 4: Summary of CARB Landfill Gas Study

Study
California Environmental Protection Agency: Air Resources Board (CARB). Detailed California- modified GREET pathway for compressed natural gas (CNG) from landfill gas. Version 2.1. February 28, 2009.
Source
http://www.arb.ca.gov/fuels/lcfs/lcfs.htm#lca
Summary Points:

• 11.26 grams CO_2e of GHG emissions are generated for every MJ during the production and use of CNG in a passenger vehicle
• Emission sources in this study include:
  ○ Electricity consumption for landfill gas recovery, transport and compression and distribution
  ○ Tailpipe carbon dioxide, methane and nitrous oxide emissions
• Emission credits in this study include
  ○ A flare GHG credit of -64.65 gCO_2e per MJ has been included

3.2.2 Dairy Digester to Compressed Natural Gas Life Cycle Assessment

The California Air and Resources Board (CARB) also conducted a similar study on the life cycle of biogas converted from a dairy digester into compressed natural gas (CNG). The CNG is used as an alternative to natural gas for a vehicle. Figure 6 below illustrates the pathway of CNG from a dairy digester to fuel combustion, also referred to as 'well- to- wheel', provides a summary of the study and life cycle emissions.

Figure 6: Process Map of Dairy Digester to CNG

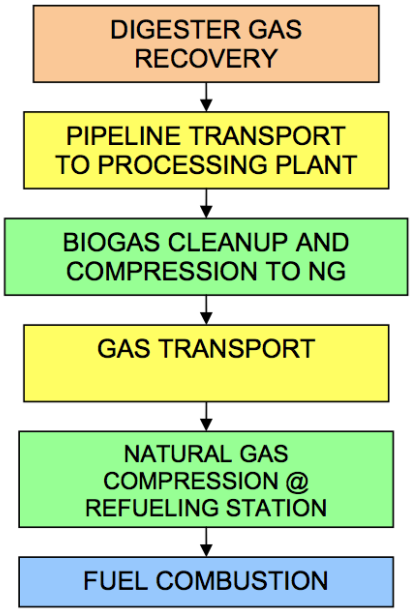


Table 5: Summary of CARB Dairy Digester Study

Study
California Environmental Protection Agency: Air Resources Board (CARB). Detailed California- modified GREET pathway for compressed natural gas (CNG) from dairy digester biogas. Version 1.0. July 20, 2009.
Source
http://www.arb.ca.gov/fuels/lcfs/lcfs.htm#lca
Summary Points:

• 13.45 grams CO_2e of GHG emissions are generated for every MJ produced and combusted in a passenger vehicle
• Emission sources in this study include:
  ○ Electricity consumption for digester biogas gas recovery, transport and compression and distribution
  ○ Tailpipe carbon, methane and nitrous oxide emissions
• Emission credits in this study include
  ○ A biogas GHG credit of -63.05 gCO_2e per MJ has been included based on the carbon content of the emitted biogas

3.2.3 Methane and Nitrous Oxide Emissions from Dairy Cattle Slurry

In this study published in the journal, *Agriculture, Ecosystems and Environment*, methane, nitrous oxide and ammonia emissions were measured during the storage and application of dairy cattle slurry. The study examined the impact of these emissions based on various treatment methods. In Table 6 below provides a summary of this article and the emission reductions associated with treating dairy cattle slurry through an anaerobic digester.

Table 6: Summary of Study on Dairy Cattle Slurry

Study
Methane, nitrous oxide and ammonia emissions during storage and after application of dairy cattle slurry and influence of slurry treatment. From *Agriculture, Ecosystems and Environment* 2006. Volume 112 (153-162).
Author
Amon, B., et al.
Summary Points:
• Untreated slurry emitted 92.4 kgCO_2e for every cubic metre from storage and field application. For slurry treated through anaero$_b$ic digestion, emissions were reduced to 37.9 kgCO_2e for every cubic metre.

3.2.4 Bioenergy vs. Fossil Fuel Emissions

In this study, the life cycle analysis of biomass and fossil fuel energy systems is conducted in order to compare overall greenhouse gas emissions. Emissions throughout the biomass and fossil fuel life cycle are taken into account. Table 7 below provides a summary of this article including the GHG reductions from using biogas from manure as an alternative to natural gas.

Table 7: Summary of Study Comparing Fossil Fuel to Bioenergy

Study
Greenhouse gas emissions of bioenergy from agriculture compared to fossil energy for heat and electricity supply. From Nutrient Cycling in Agroecosystems 2001. Volume 60 (267-273).
Author
G. Jungmeier & J. Spitzer
Summary Points:
• The life cycle emissions of biogas from cow, pig manure and co- digestion for combined heat and power plants (CHP) are negative   ○ The GHG benefits from the use of by- products and from the avoidance of methane from manure storage are incorporated into the measurements • According to this study, using biogas from manure and co- digestion for CHP rather than natural gas, will reduce GHGs by between 129% and 286%.

4 GHG Benefits and Conclusion

During the life cycle of biomethane, opportunities for emission reductions include the following:

- Methane capture
- Methane destruction
- Avoided emissions from fossil fuel extraction and processing
- Avoided nitrous oxide emissions

Of these emission reductions, the most relevant savings come from methane capture and destruction. Additionally, as in the case of FortisBC's biomethane offering, there are emission reductions associated with the displacement or avoidance of fossil fuels. The reduction of nitrous oxide (N_2O) emissions is the most unknown and least likely to be quantified at this time.

4.1 Methane Capture and Destruction

Methane capture and destruction is the most common opportunity for realizing GHG emissions savings in biomethane production. These savings are generated by first installing a biogas control system which captures the methane emitting from organic waste. Then the methane is destroyed through combustion either by flaring or during it's end use application, either on-site or off-site.

The GHG reductions result from avoiding methane emissions associated with the organic material's baseline condition. Without the efforts of biomethane project, biomass is stored under anaerobic conditions and decomposes to release methane into the atmosphere. By capturing this biogas and combusting it to create carbon dioxide, the methane is transformed into a much less impactful greenhouse gas. Specifically, the global warming potential (GWP) of carbon dioxide is 1, while the GWP of Methane is 21.

4.2 Avoided Fossil Fuel Life Cycle Emissions

Biomethane is a clean alternative to non- renewable fossil fuels such as natural gas. In the natural gas pipeline network, each cubic meter of biomethane effectively prevents life cycle GHG emissions from being produced for the equivalent amount of natural gas. These life cycle emissions result from the extraction and processing of fossil fuel natural gas, including the production, refinement and storage of fossil fuels.

4.3 Conclusion

The benefits of using biomethane as a fuel source include:

- Prevention of naturally occurring methane from directly entering the atmosphere
- Lifecycle GHG emissions savings from the displacement of conventional natural gas
- No net increase in greenhouse gas emissions from combustion because biomethane is a carbon neutral energy source in BC

The FortisBC renewable natural gas program allows customers to achieve significant greenhouse gas savings and reduce their own carbon footprint.

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