

B.C. On-Farm Biogas Benchmark Study (Version 2)



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Acknowledgments

The B.C. On-Farm Biogas Benchmark Study, Version 2, was funded through the Canadian Agricultural Partnership, a five-year, \$3 billion investment by federal-provincial and territorial governments, which will strengthen the agriculture, agri-food and agri-based products sector, ensuring continued innovation, growth and prosperity.

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The objective of the B.C. On-Farm Biogas Benchmark Study, Version 2, is to provide an informational benchmark from which B.C.'s agriculture sector can make informed decisions pertaining to on-farm biogas plants. Readers should be aware that on-farm biogas plants are highly site-specific. Individual technology suppliers may be different to the cost, specification, design and parameters identified in this study.

Prior to building an on-farm biogas plant, B.C. farmers should engage an experienced biogas consultant/company to ensure soundness of all assumptions and confirm biogas plant parameters. Information in this study is provided to the user at their own risk. Hallbar Consulting Inc. and the Research Institute of Sweden will not be liable for any claims, damages or losses of any kind arising out of the use of, or reliance upon, the B.C. On-Farm Biogas Benchmark Study, Version 2

Date & Version

Version 2 of the B.C. On-Farm Biogas Benchmark Study was published in 2020. Updated versions of this Study will be published as new information pertaining to on-farm biogas plants in B.C. becomes available. If using this Study please be sure you have the most recent, updated version.

Author

The B.C. On-Farm Biogas Benchmark Study was written by Hallbar Consulting Inc. (www.HallbarConsulting.com), with support from the Research Institutes of Sweden (www.Ri.Se/en) and in collaboration with the B.C. Ministry of Agriculture.



Glossary of Terms

- Agricultural Feedstock: feedstock for a biogas plant produced on-farm (e.g., manure or crop residues).
- Biogas: renewable methane-rich gas produced by biogas plants.
- Biogas Plant: built to produce biogas from feedstocks.
- Biogas Upgrading: removal of carbon dioxide and other contaminants from biogas to produce renewable natural gas.
- Biogas Yield: amount of biogas produced per unit of feedstock.
- CAPEX: Capital expenditures required to build an on-farm biogas plant.
- Co-digestion: mixing of different feedstock inside a digester tank.
- Digestate: material removed from a biogas plant once most useable dry matter has been converted to biogas.
- Digestate Management: increasing concentration of digestate nutrients to enable cheaper transportation.
- Digester Tank: vessel where feedstock is converted to biogas by microorganisms.
- Dry Matter: percentage of feedstock left after all moisture has been removed.
- Economic Feasibility: analysis of a project's costs and revenues to determine whether or not it is financially logical to complete.
- Feasibility Assessment: study that assesses the suitability of a biogas plant for your farm.
- Feedstock: organic material, such as manure and food waste, used in a biogas plant.
- Gigajoule (GJ): measurement of energy approximately equivalent to 277 kilowatt hours of electricity.
- Greenhouse Gas: a gas that contributes to the greenhouse effect by absorbing infrared radiation (e.g., carbon dioxide).
- Internal Rate of Return: measure of an investment's rate of return.
- Mixed Food Waste: non-agricultural feedstock.
- Non-Agricultural Feedstock: feedstock for a biogas plant produced off-farm (e.g., food processing and residential waste).
- Nutrient Recovery: extraction of nutrients from digestate into a more concentrated form.
- OPEX: Operating expenditures required to run an on-farm biogas plant.
- Pasteurization: heating of feedstock to kill bacteria.
- Renewable Natural Gas (RNG): renewable replacement for natural gas made from biogas.
- Sensitivity Analysis: assessment of how changes to costs and/or revenues impact economic feasibility.
- Tip Fee: price you are paid to accept, or have to pay to acquire, feedstock.
- Unlevered Internal Rate of Return: money the farm has before paying its financial obligations.

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Executive Summary

The basic concept of an on-farm biogas plant is simple; place organic material into a warmed, airtight tank and let naturally occurring microorganisms convert this material into biogas and digestate. Biogas can be upgraded to renewable natural gas and sold to a local gas utility. Digestate, which contains all of the nitrogen, phosphorus and potassium of the input organic material, can be land applied as fertilizer.

On-farm biogas plants come in a variety of shapes and sizes, from small and technologically simple, to large and technologically complex. Variability is because the availability of organic material and the type of biogas plant equipment required can vary greatly between farms. The B.C. On-Farm Biogas Benchmark Study (Version 2) was created to provide B.C. farmers and government with economic feasibility estimations for building on-farm biogas plants across as wide a range of B.C. farms as possible.

In total, fourteen farms are assessed in the B.C. On-Farm Biogas Benchmark Study (Version 2). These farms range from small to large dairy (100 – 2,500 cows), cattle (1,000 – 2,500 cattle) and poultry (2.5 – 5 million chickens) farms. Each of these farm are assessed assuming different amounts/type of available organic material (i.e., manure and mixed food waste), and with and without three key pieces of equipment; mixed food waste cleaning, renewable natural gas compression, and nutrient recovery equipment.

Farm Scenario #1 – 6 assess the required renewable natural gas sale price for different sized dairy farms co-digesting 51% dairy manure and 49% mixed food waste. Results for Farm Scenario #1 – 6 show that farms with ≥ 150 dairy cows can be economically feasible in B.C. if they build a biogas plant without mixed food waste cleaning, renewable natural gas compression or nutrient recovery equipment.

If mixed food waste cleaning equipment is required, farms need ≥ 200 dairy cows to be economically feasible in B.C. If renewable natural gas compression or nutrient recovery equipment is required, or if mixed food waste + renewable natural gas compression, or mixed food waste cleaning + nutrient recovery equipment are required, farms need ≥ 300 dairy cows to be economically feasible in B.C. If renewable natural gas compression + nutrient recovery, or mixed food waste, renewable natural gas compression + nutrient recovery equipment are required, farms need ≥ 400 dairy cows to be economically feasible in B.C.

Farm Scenario #7 and 8 assess the required renewable natural gas sale price for different sized cattle feedlots co-digesting 51% cattle manure and 49% mixed food waste. Results for Farm Scenario #7 and 8 show that farms with $\geq 1,000$ cattle can be economically feasible in B.C. if they build a biogas plant without food waste cleaning, renewable natural gas compression or nutrient recovery equipment. If mixed food waste cleaning, renewable natural gas compression or nutrient recovery equipment are required, farms need $\geq 2,500$ cattle to be economically feasible in B.C.

Farm Scenario #9 – 13 assess the required renewable natural gas sale price for different sized dairy farms co-digesting 80% dairy manure and 20% poultry manure, or digesting 100% dairy manure. Results for Farm Scenario #9 – 13 show that farms with $\geq 2,000$ dairy cows co-digesting dairy and

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poultry manure, or farms with $\geq 2,500$ dairy cows digesting dairy manure can be economically feasible in B.C. if they build a biogas plant without mixed food waste cleaning, renewable natural gas compression or nutrient recovery equipment.

If renewable natural gas compression equipment is required, farms co-digesting dairy and poultry manure need $\geq 2,000$ dairy cows to be economically feasible in B.C. (farms with $\leq 2,500$ dairy cows digesting dairy manure cannot be economically feasible). If nutrient recovery equipment, or renewable natural gas compression + nutrient recovery equipment are required, farms with $\leq 2,000$ dairy cows co-digesting dairy and poultry manure or farms with $\leq 2,500$ dairy cows digesting dairy manure cannot be economically feasible in B.C.

Farm Scenario #14 – 18 assess the required renewable natural gas sale price for different sized dairy farms co-digesting 80% dairy manure and 20% poultry manure using modular, low-cost biogas plant technology. Results for Farm Scenario #14 – 18 show that farms with ≥ 750 dairy cows can be economically feasible in B.C. if they build a biogas plant without nutrient recovery equipment. If nutrient recovery equipment is required, farms with ≤ 750 dairy cows cannot be economically feasible in B.C.

Farm Scenario #19 and 20 assess the economic feasibility of chicken farms digesting 100% poultry manure. Unlike Farm Scenario #1 – 18, which assess required renewable natural gas sale price, Farm Scenario #19 and 20 assess the maximum affordable cost of digestate stripping equipment (this equipment is needed to remove nutrients from digestate prior to it being recirculated to dilute incoming poultry manure). This was done because the number of poultry manure biogas plants around the world is very small and the cost/performance of digestate stripping equipment for poultry manure biogas plants is relatively unknown. As such, it wasn't possible to estimate digestate stripping equipment costs for the B.C. On-Farm Biogas Benchmark Study (Version 2) based on industry-wide experience.

Results from Farm Scenario #19 and 20 show that farms with 2.5 million chickens can spend up to \$1.24 million, and farms with 5 million chickens can spend up to \$4.8 million on digestate stripping equipment and still be economically feasible in B.C. However, as mentioned, the cost/performance of digestate stripping equipment for poultry manure biogas plants is relatively unknown. As such, further research with a key focus on digestate stripping equipment is required to better understand the economic feasibility of poultry manure biogas plants in B.C.

1

Introduction

1. Introduction

The B.C. On-Farm Biogas Benchmark Study, Version 2 (herein referred to as the B.C. Benchmark Study), was created to provide B.C. farmers with updated, detailed information about the economic feasibility of building biogas plants on a variety of different farms. B.C. farmers can use information provided in the B.C. Benchmark Study to perform a preliminary feasibility assessments for building a biogas plant on their own farm, without first paying the cost of a feasibility study that may return a foreseeable negative verdict.

For B.C. Government, the B.C. Benchmark Study provides a better understanding of the economic feasibility of on-farm biogas plant technology. Furthermore, it provides important information pertaining to the costs, benefits, and necessary government support required to enable economically feasible biogas plants to be built on a variety of different B.C. farms.

The B.C. Benchmark Study is not intended to provide detailed information about on-farm biogas plant equipment, or the development steps required to take an on-farm biogas plant from idea to operation. For this and other information about on-farm biogas plants, please read the On-Farm Biogas Development Handbook for B.C. Farmers.



2

**How To Use
This Study**

2. How To Use This Study

For those with limited biogas knowledge, it is suggested to start with Chapters 3 and 4. Chapter 3 provides a brief introduction to on-farm biogas plants, including how they work and the different technologies available. Chapter 4 provides basic information about on-farm biogas plant costs and revenues, and explains how biogas plants on similar size/type of farms can be different.

For those familiar with biogas, it is suggested to start with Chapters 5 and 6. Chapter 5 provides information on the different scenarios (i.e., farm size and type, feedstock availability, equipment choice, etc.) assessed in the B.C. Benchmark Study. Chapter 6 lists all of the assumptions used to assess on-farm biogas plant economic feasibility. Read these chapters to know which scenario is most similar to the farm or type of on-farm biogas plant you are interested in.

Chapter 7 presents the economic feasibility for building on-farm biogas plants for each scenario, while Chapter 8 summarises the economic feasibility of building on-farm biogas plants across all scenarios. Finally, Chapter 9 provides information on the greenhouse gas emission reductions that would result from building on-farm biogas plants.

It should be noted that while biogas can produce renewable heat, renewable electricity or Renewable Natural Gas (RNG), the B.C. Benchmark Study focuses solely on RNG. This is because RNG can be sold to B.C. utilities throughout B.C. Converting biogas into renewable heat is rarely profitable unless there is a large, year-round demand for the heat nearby. Converting biogas into renewable electricity is economically challenging because as of 2019, B.C. Hydro isn't purchasing renewable electricity. This looks unlikely to change soon.



3

Introduction To Biogas

3. Introduction To Biogas

The basic concept of an on-farm biogas plant is simple; place organic material into a warmed, airtight tank and let naturally occurring microorganisms convert this material (called 'feedstock') into biogas. Biogas contains methane (typically 60% – 65%), carbon dioxide (typically 30% – 40%), small amounts of water, hydrogen sulphide and other trace gases. Biogas is upgraded to Renewable Natural Gas (RNG) by removing carbon dioxide and water. RNG is sold to local utilities as a replacement for natural gas.

Digestate is the material removed from the digester tank after microorganisms have finished converting most of the feedstock into biogas. Digestate, which is typically 92% – 96% water, contains almost all of the nitrogen, phosphorus and potassium of the input feedstock. While digestate is a good fertilizer and can be land applied using the same equipment as used for liquid manure, finding farmland near to a biogas plant to spread digestate on can be challenging.

Feedstock suitable for on-farm biogas plants can be agricultural (i.e., those produced on a farm, such as manure, spoiled silage and crop residues) and non-agricultural (i.e., unwanted organic material produced by non-farm sources, including food and beverage processing, grocery stores, restaurants, hotels and homes). Throughout the B.C. Benchmark Study, non-agricultural feedstock is referred to as 'mixed food waste'.

There are two types of biogas plant. These are wet biogas plants and dry biogas plants. A biogas plant is defined as 'wet' when all feedstock mixed together is pumpable and can be stirred inside tanks. Wet biogas plants are sometime referred to as complete mix or continuous stirred biogas plants. A biogas plant is defined as 'dry' when all feedstock mixed together is too dry to pump, and therefore must be shovelled or augured. Throughout the B.C. Benchmark Study, the term 'biogas plant' refers to wet biogas plants unless otherwise stated.

Digester tanks can operate at one of three temperature ranges; psychrophilic (below 25°C), mesophilic (35 – 40°C) or thermophilic (above 50°C). As temperature increases, biogas yield per tonne of feedstock typically increases. However, as temperature increases the microorganisms inside digester tanks typically become less stable, requiring greater supervision. Most on-farm biogas plants in Canada and elsewhere are mesophilic (35 – 40°C). Throughout the B.C. Benchmark Study, biogas plants are mesophilic unless otherwise stated.

4

Biogas Plant Costs & Revenues

4. Biogas Plant Costs & Revenues

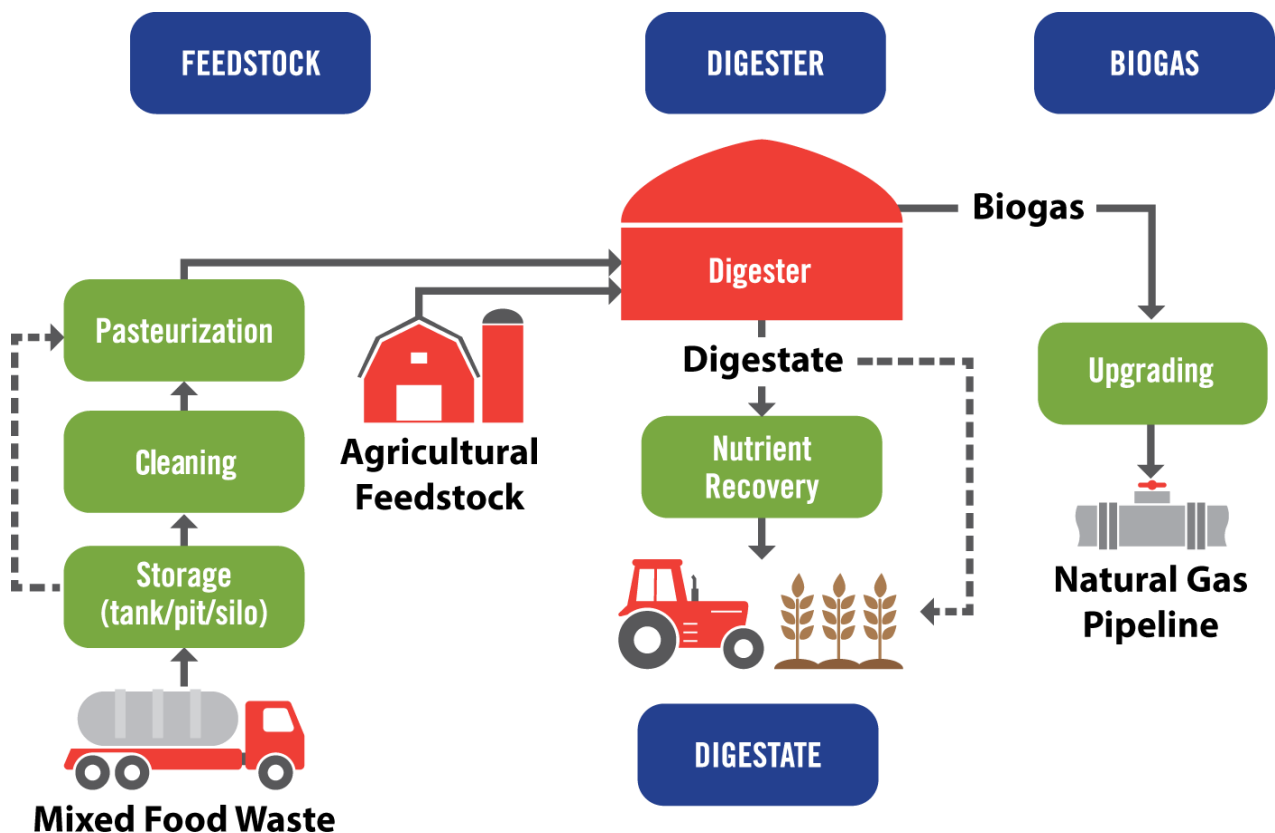
On-farm biogas plants consist of four key components (Figure 1). These are:

1. Feedstock;
2. Digester;
3. Biogas; and
4. Digestate.

On-farm biogas plants come in a variety of shapes and sizes, from small and technologically simple, to large and technologically complex. This variability is because feedstock availability and the type of biogas plant equipment required can vary greatly. For example:

- Feedstock: some biogas plants will require feedstock pre-treatment equipment (i.e., cleaning and pasteurization) and may receive a tip fee, others will not;
- Digester: some biogas plants will produce more biogas than others;
- Biogas: some biogas plants will require Renewable Natural Gas (RNG) compression and transportation equipment, others will not; and
- Digestate: some biogas plants will require nutrient recovery equipment, others will not.

Figure 1: Typical On-Farm Biogas Plant



4.1 Feedstock Cost & Revenue Differences

Most mixed food waste must be heated (pasteurized) to kill bacteria. Pasteurization is typically carried out using insulated tanks that are filled, heated to temperature, and then emptied. For biogas plants that only digest agricultural feedstock (i.e., manure), pasteurization isn't required.

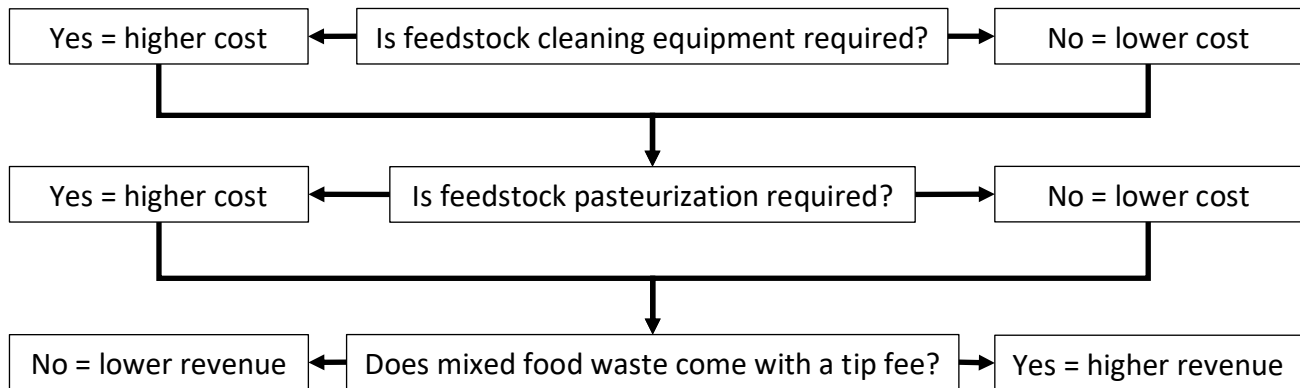
If mixed food waste contains contaminants (e.g., bits of plastic, metal, etc.), feedstock cleaning equipment, such as a de-packer, may be necessary to remove these contaminants. This equipment must be housed inside a building to protect it from the elements. For clean mixed food waste, a simple, low cost macerator or chopper pump to cut/mash the feedstock may be all that is required.

Once received, and if necessary cleaned of contaminants, feedstock is stored before being delivered into digester tanks. Dry agricultural feedstock, such as poultry and cattle manure, is stored in bins, bunkers, etc., and requires dry feeding equipment, such as a hopper with auger or belt feeder, to deliver this feedstock into digester tanks. Wet agricultural feedstock, such as dairy manure and mixed food waste, is stored in tanks. A pump is required to deliver this feedstock into digester tanks.

Some feedstock, typically mixed food waste, comes with a tip fee. This is the price paid for accepting the feedstock. Feedstock that is sought after because of its high biogas yield and low levels of contaminants typically comes with a low or no tip fee. Feedstock with low biogas yield and high levels of contaminants typically comes with a high tip fee.

Feedstock pre-treatment equipment and tip fees can significantly impact the economic feasibility of on-farm biogas plants. For example, an on-farm biogas plant that requires no feedstock pre-treatment equipment and receives a high tip fee for mixed food waste will have lower capital and operating costs and higher revenue than if it requires feedstock pre-treatment equipment and receives a low tip fee (Figure 2).

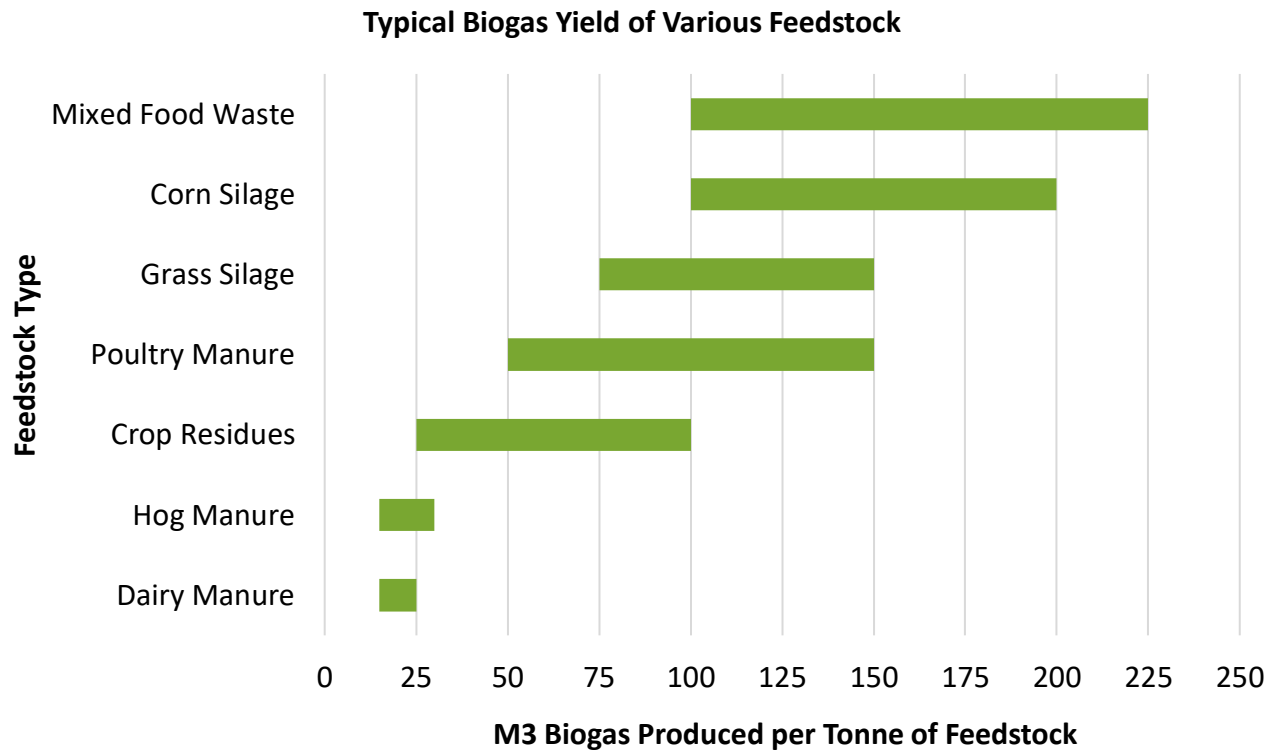
Figure 2: Feedstock Cost & Revenue Differences



4.2 Digester Revenue Differences

Different feedstocks have different biogas yields (Figure 3). Biogas yield is important as it is the sale of biogas, once upgraded to renewable natural gas, which makes on-farm biogas plants economically feasible. Manure has a relatively low biogas yield, which is why manure only biogas plants must be technologically simple and low cost to be economically feasible. Mixed food waste has a biogas yield several times greater than manure. Therefore, mixed food waste is often sought after as a feedstock for on-farm biogas plants.

Figure 3: Feedstock Biogas Yield



4.3 Biogas Cost Differences

Once biogas is upgraded to RNG it can be injected into the natural gas grid. However, grid injection is only possible if the biogas plant is located near a gas pipeline. If a biogas plant is located far from a gas pipeline, if there are obstacles between the biogas plant and the gas pipeline that prevents pipeline extension (such as a major road, railway line or body of water), or if the gas pipeline is unable to accept RNG due to pressure constraints, size, etc., the RNG must be compressed. Once compressed, RNG can be transported elsewhere for injection into the natural gas grid, or for sale directly to an end user.

The ability to inject RNG into a gas pipeline can significantly impact the economic feasibility of on-farm biogas plants. For example, an on-farm biogas plant that can inject RNG directly into the local gas pipeline will have lower capital and operating costs than if it must compress and transport the RNG for injection into the gas grid elsewhere.

4.4 Digestate Cost Differences

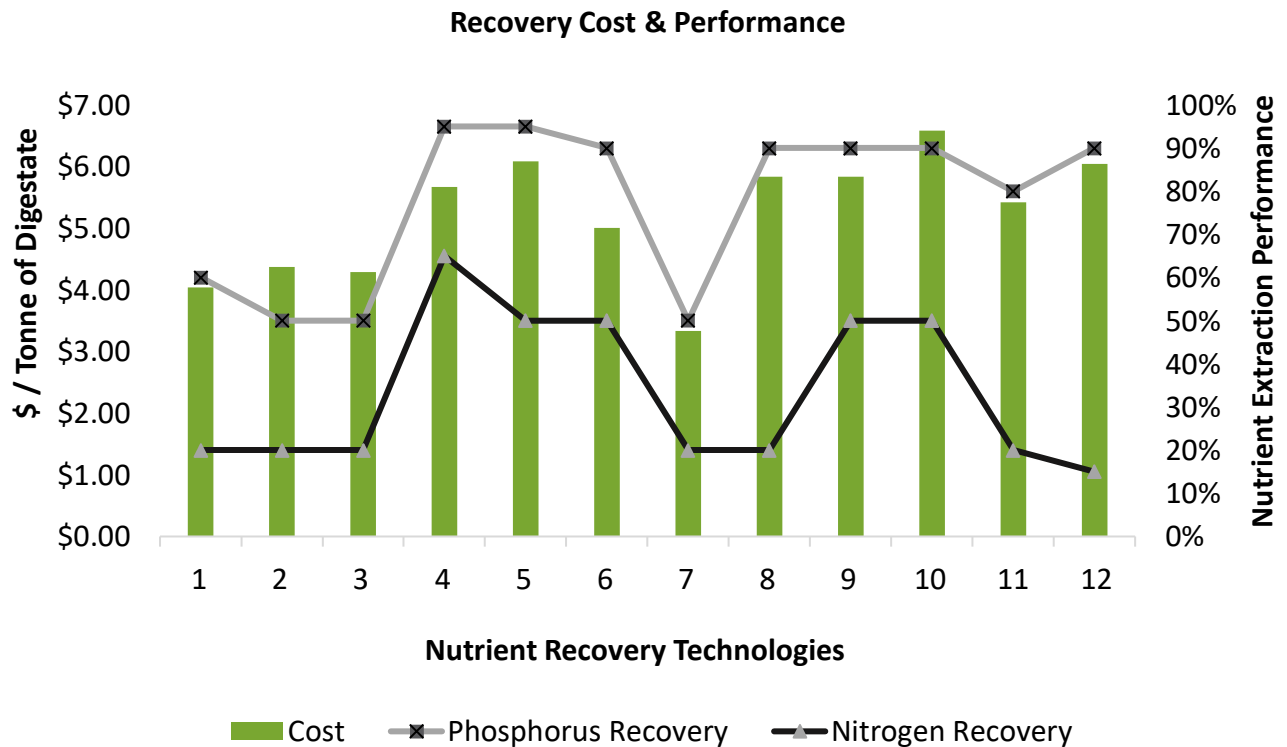
With a typical dry matter of 4% – 8%, digestate is watery. Ideally, digestate is spread on farmland surrounding the biogas plant (typically within a few kilometers), as this is often the most cost effective way to deal with it. For farms with access to insufficient agricultural land this may not be possible. If digestate cannot be spread on farmland surrounding the biogas plant, nutrient recovery equipment is typically required.

Nutrient recovery equipment extracts some of the nutrients from digestate into a more concentrated form (dry matter typically >20%). The extracted nutrients can be transported off farm and out of the area much more cheaply than digestate, while the remaining, nutrient-depleted liquid digestate can be spread on farmland surrounding the biogas plant.

When choosing nutrient recovery equipment, it is important to determine the level of nutrient extraction required. There is little point extracting more nutrients than necessary, as these nutrients can be spread on farmland surrounding the biogas plant. Furthermore, the cost of nutrient recovery equipment typically increases with extraction performance (Figure 4). For example, nutrient recovery equipment capable of extracting <50% of phosphorus from digestate is typically less expensive than equipment capable of extracting >50%.

Nutrient recovery can significantly impact the economic feasibility of on-farm biogas plants. For example, an on-farm biogas plant that must extract nutrients from digestate for transportation elsewhere will have higher capital and operating costs than an on-farm biogas plant that can apply all digestate on surrounding farmland.

Figure 4: Nutrient Recovery Technology Cost & Performance



Note: Nutrient recovery technology #1 – #3 = centrifuges, #4 – #6 = membrane filtration, #7 = dryer, #8 – #10 = flocculation, and #11 and #12 = struvite crystallization. For more info about digestate nutrient recovery technology, see the B.C. Ministry of Agriculture’s 2016 Evaluation of Nutrient Recovery Technologies for Dairy Manure and Digestate Study.

5

**Farm Choice,
Scenarios &
Technology
Options**

5. Farm Choice, Scenarios & Technology Options

5.1 Farm Choice

The B.C. Benchmark Study was created to provide B.C. farmers and government with economic feasibility estimations for building on-farm biogas plants across as wide a range of B.C. farms as possible. Farm Choice for the B.C. Benchmark Study was made using the following process:

1. A list of B.C. farms deemed most likely to build an on-farm biogas plant, based on farm type, size and feedstock availability, was created; and
2. An array of farms from this list were chosen to provide as broad a representative sample of farms across B.C.'s agricultural sector as possible.

This two-step process resulted in the following Farm Choices:

- | | | |
|-----------------------|-------------------------|-------------------------------|
| - 100 dairy cow farm; | - 500 dairy cow farm; | - 1,000 head cattle feedlot; |
| - 150 dairy cow farm; | - 750 dairy cow farm | - 2,500 head cattle feedlot; |
| - 200 dairy cow farm; | - 1,000 dairy cow farm; | - 2,500,000 chicken farm; and |
| - 300 dairy cow farm; | - 2,000 dairy cow farm; | - 5,000,000 chicken farm. |
| - 400 dairy cow farm; | - 2,500 dairy cow farm; | |

Note: Fifty dairy cow farms are considered too small to build economically feasible biogas plants. Cattle manure only biogas plants are not considered to be economically feasible because of the large volume of water required to make cattle manure pumpable.

While the above Farm Choices do not include pig farms, the B.C. Benchmark Study can be used to assess the economic feasibility of building biogas plants on pig farms. To assess the economic feasibility of building a biogas plant on a pig farm simply determine the amount of manure available and select the dairy farm choice (i.e., 100 cows, 200 cows, 300 cows, etc.) with the most similar amount of manure. This is possible because hog and dairy manure are very similar in both their composition (i.e., liquid) and biogas potential.

5.2 Farm Scenarios

Assessing the economic feasibility for building biogas plants on the Farm Choices above is limiting because farms of the same type (i.e., dairy) and size (i.e., 300 milk cows) may not have access to the same feedstock. For example, while two farms with 300 dairy cows will have roughly the same amount of dairy manure, they may have access to different amounts of other feedstock (Figure 5).

To provide B.C. farmers and government with economic feasibility estimations for building on-farm biogas plants across as wide a range of B.C. farms as possible, the Farm Choices were assessed under twenty different Farm Scenarios (Figure 6).

Figure 5: Feedstock Differences between Similar Farms

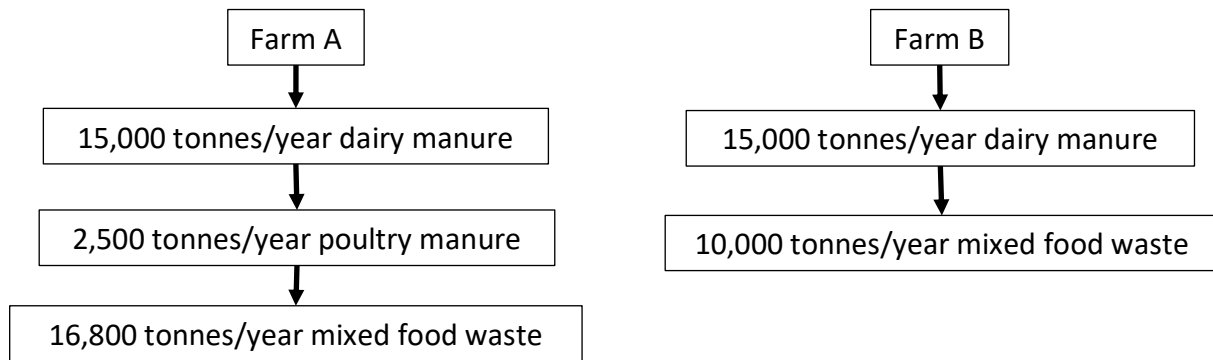


Figure 6: Farm Scenarios

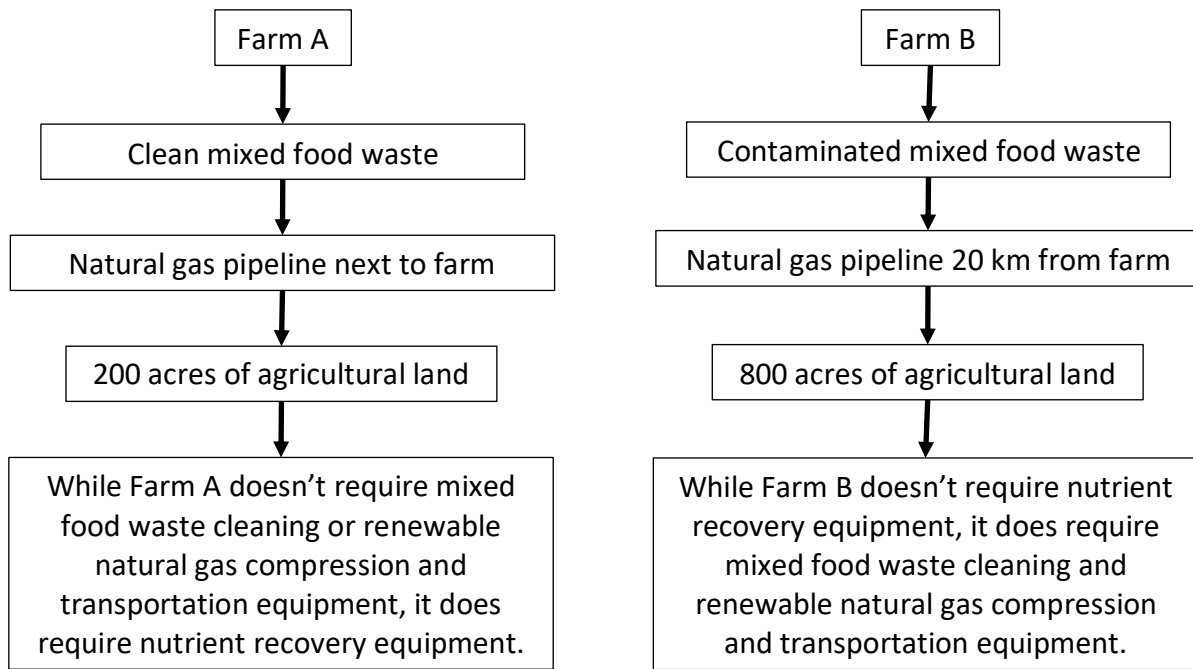
Farm Scenario	Farm Choice	Feedstock
#1	100 dairy cows	51% dairy manure + 49% mixed food waste
#2	150 dairy cows	
#3	200 dairy cows	
#4	300 dairy cows	
#5	400 dairy cows	
#6	500 dairy cows	51% cattle manure + 49% mixed food waste
#7	1,000 cattle	
#8	2,500 cattle	80% dairy manure + 20% poultry manure*
#9	500 dairy cows	
#10	750 dairy cows	
#11	1,000 dairy cows	
#12	2,000 dairy cows	100% dairy manure
#13	2,500 dairy cows	
#14	200 dairy cows	
#15	300 dairy cows	
#16	400 dairy cows	
#17	500 dairy cows	80% dairy manure + 20% poultry manure*
#18	750 dairy cows	
#19	2,500,000 chickens	
#20	5,000,000 chickens	

* Farm Scenarios #9 - 12 are different from #14 – 18 due to the technology scenario (see below).

5.3 Equipment Choice

Assessing the economic feasibility for building biogas plants under the Farm Scenarios is also limiting. This is because farms of the same type (i.e., dairy), size (i.e., 300 milk cows) and with access to the same feedstock (i.e., 51% dairy manure and 49% mixed food waste) may require different equipment. For example, while two farms with 300 dairy cows may have roughly the same feedstock (i.e., 15,000 tonnes/year of dairy manure and 14,400 tonnes/year of mixed food waste), they may or may not require mixed food waste cleaning, Renewable Natural Gas (RNG) compression and transportation, and nutrient recovery equipment (Figure 7).

Figure 7: Equipment Differences between Similar Farms



To provide B.C. farmers and government with economic feasibility estimations for building on-farm biogas plants across as wide a range of B.C. farms as possible, the Farm Scenarios were assessed with and without key pieces of equipment (Figure 8).

Figure 8: Equipment Options

Farm Scenario	Equipment Choice		
	Food Waste Cleaning	RNG Compression	Nutrient Recovery
#1 - #8	Assessed with and without mixed food waste cleaning equipment	Assessed with and without RNG compression and transportation equipment	Assessed with and without nutrient recovery equipment
#9 - #20	N/A	N/A	

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For example, Farm Scenario #1 (100 dairy cows co-digesting 49% mixed food waste) was assessed eight times based on the need for mixed food waste cleaning, RNG compression and transportation, and nutrient recovery equipment. Furthermore, and because biogas production and mixed food waste tip fees can impact economic feasibility, the eight different Equipment Choice options were also assessed under a range of biogas production levels and mixed food waste tip fees (Figure 9).

Figure 9: Farm Scenario #1 Equipment Options

Farm Scenario	Equipment Choice Options				
	Food Waste Cleaning	Renewable Natural Gas Compression	Nutrient Recovery	Tip Fee	Biogas Production
#1				\$0 - \$50 tonne	+/- 25%
	✓				
		✓			
			✓		
	✓	✓			
	✓		✓		
		✓	✓		
	✓	✓	✓		

5.4 Technology Scenario

There may be situations where mixed food waste is unavailable, or where farmers don't want to co-digest mixed food waste with manure. In Europe, for example, there are a growing number of manure only biogas plants. To provide B.C. farmers and government with economic feasibility estimations for building on-farm biogas plants across as wide a range of B.C. farms as possible, the Farm Scenarios were also assessed under two different Technology Scenarios (Figure 10).

Figure 10: Technology Scenarios

Farm Scenario	Technology Scenario
#1 - #13	Traditional on-farm biogas technology
#14 - #20	Modular or poultry manure biogas technology

5.4.1 Modular Biogas Technology

Traditionally, on-farm biogas plants are specifically designed for the local situation. This results in a significant amount of engineering and construction costs, as each biogas plant is unique. Although modular biogas plants use the same components as traditional on-farm biogas plants, they are highly standardised. This keeps costs down. Furthermore, modular biogas plants are

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constructed at the factory, and delivered for on-site assembly. This means little engineering is required, and assembly is quick and easy, without the need for advanced equipment, tools, or digester construction knowledge.

Prior to delivery, all that is required is a simple concrete slab. Once delivered, modular biogas plants are assembled following an easy step-by-step guide. Digester tanks typically consist of stainless steel plates. All mixing equipment, along with safety and monitoring devices are also delivered. Piping and cables are sourced locally to reduce costs. Because of their design and assembly, modular biogas plants are sometimes referred to as IKEA biogas plants.

While the assembly of modular biogas plants will vary by company and between sites, a typical assembly timeline (after a concrete slab is poured and cured) is as follows:

- Day 1: Equipment container is installed;
- Day 2 - 3: Digester tank installed;
- Day 4: Heat lines installed inside digester tank;
- Day 5 - 6: Digester tank roof installed;
- Day 7 – 8: Piping and cables installed;
- Day 9: Electrical connection; and
- Day 10: Construction complete.

The potential downside of modular biogas plants is that they are often designed for one specific size. For example, if a company builds modular biogas plants for 10,000 tonnes/year of feedstock, anyone with 12,000 tonnes/year of feedstock will require two biogas plants (at almost twice the price), even though they only require a slightly larger biogas plant. Because of this it is important to find the right supplier for the volume of feedstock available.

Figure 11: Examples of Two Modular Biogas Plants



Example of Bioelectric modular biogas plant. Source www.bioelectric.be/en



Example of a PlanET Biogas modular biogas plant. Source www.planet-biogas.ca

Conventional biogas to RNG upgrading technology can be scaled down. However, small upgraders cost almost as much as larger upgraders (and much more per m³ of biogas capacity). As with modular biogas plants, small-scale biogas to RNG upgraders are being developed. Today, there are a handful of small-scale biogas to RNG upgraders in the range of 20 – 150 m³/hour of biogas capacity, each at a different technology readiness level. Several of these biogas to RNG upgraders were identified by Record Biomap Network¹.

5.4.2 Poultry Manure Biogas Technology

The use of poultry manure in traditional on-farm biogas plants is challenging because of poultry manure's high nitrogen; high nitrogen inhibits the digestion process. To overcome the nitrogen issue, poultry manure is traditionally co-digested in biogas plants with low nitrogen feedstock, such as dairy manure. As such, poultry manure typically accounts for no more than 20% of an on-farm biogas plant's total feedstock.

Poultry manure only biogas plants have recently been developed and built. These plants solve the nitrogen issue by using nitrogen removal/stripping technology. This technology reduces nitrogen levels so that poultry manure can be used as the only feedstock. While poultry manure only biogas plants differ in design and set-up, their basic premise is somewhat similar (Figure 12).

Nitrogen may or may not be stripped from the poultry manure. The poultry manure is then fed into mixing tanks for dilution with water and/or recirculated digestate liquid. Dilution lowers both the dry matter and nitrogen content of poultry manure, making it pumpable and safe to digest.

The ratio of poultry manure, water and recirculated digestate liquid ultimately depends upon the poultry manure's dry matter and nitrogen content, and the recirculated digestate liquid's nitrogen levels. For example, higher dry matter poultry manure will require more water and/or recirculated digestate liquid to make it pumpable, while poultry manure that has had nitrogen stripped will require less water and/or recirculated digestate liquid to lower nitrogen levels.

After dilution, poultry manure is pumped into a traditional biogas plant. Following digestion, digestate is removed and separated into a solid and liquid fraction by use of a slope screen, centrifuge, belt press, etc. The solid fraction can be used as a fertilizer. The value of this fertilizer will depend upon if any further processing (e.g., drying, composting, etc.) is undertaken.

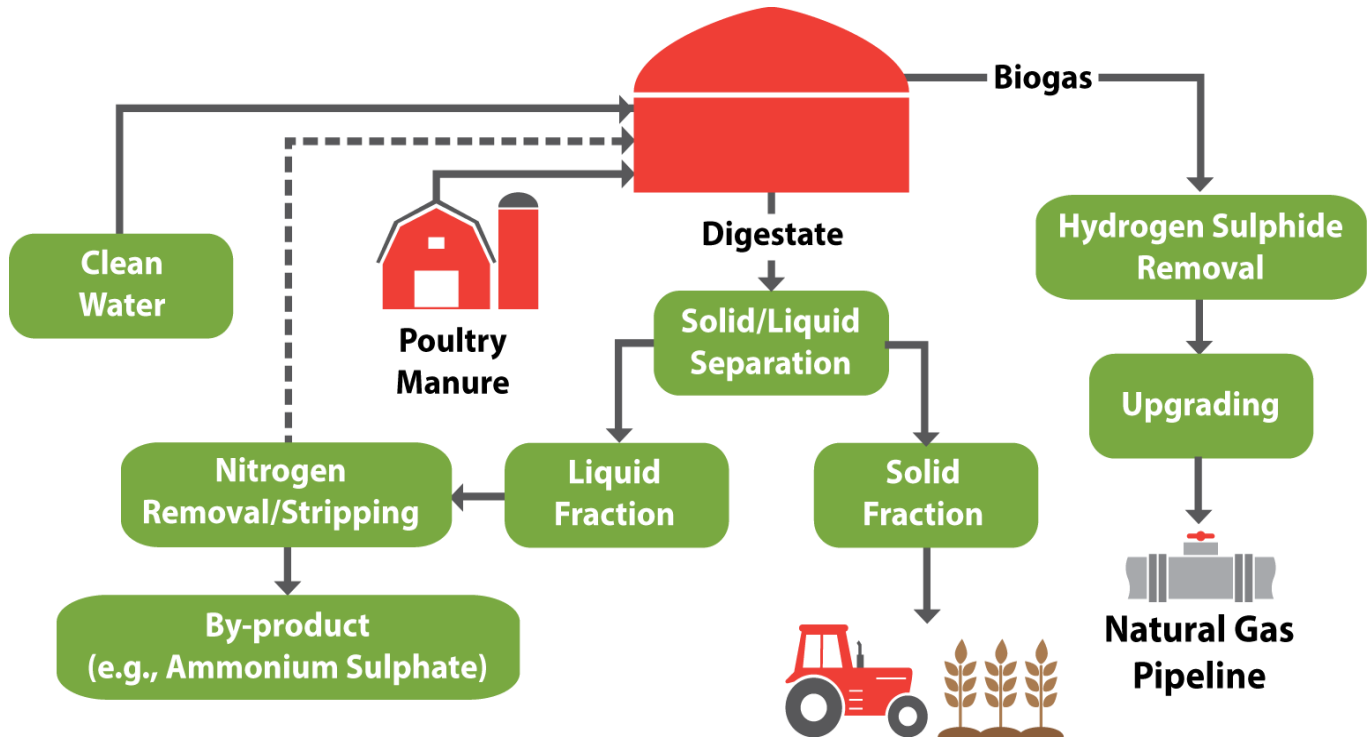
Nitrogen from the liquid fraction is removed with nitrogen removal/stripping technology. Once stripped of nitrogen, liquid digestate is recirculated to dilute incoming poultry manure. The by-product of nitrogen removal/stripping, often an ammonium sulphate solution, but dependent upon removal/stripping technology used, may or may not have value as a fertilizer input.

Biogas from poultry manure biogas plants is high in hydrogen sulphide levels. These levels can be up to ten times higher than traditional on-farm biogas plants. Hydrogen sulphide is highly corrosive

¹ Research Coordination for a Low-Cost Biomethane Production at Small and Medium Scale Applications. Available at https://biomethane-map.eu/fileadmin/downloads/deliverables/D1.9_final_-_for_website.pdf

and must be removed from the biogas prior to upgrading. The cost of hydrogen sulphide removal can be expensive.

Figure 12: Example of Poultry Manure On-Farm Biogas Plant



6

Benchmark Assumptions

6. Benchmarking Assumptions

6.1 Feedstock Assumptions

Knowing the type and volume of feedstock is essential to determining the economic feasibility of any on-farm biogas plant. As a general rule of thumb, on-farm biogas plants in B.C. accept up to 49% mixed food waste (the other 51% being agricultural feedstock, such as manure). As such, it is important to accurately estimate the availability of agricultural feedstock, as this dictates the amount of mixed food waste to be accepted.

Dairy Manure

While a 100 dairy cow farm has 100 milk cows, the number of dry cows and heifers can vary greatly; some farms may have a high number of dry cows, others may raise their heifers on satellite farms or purchase them from elsewhere. The length of time cows spend in pasture also varies between farms. Cow numbers and the time these cows spend in pasture affect manure availability.

It is estimated that for every 100 dairy cows, there are 20 dry cows and 60 heifers (because calves produce so little manure, they aren't included in the manure calculations). It is also estimated that for each dairy cow, 50 tonnes/year (13,200 gallons/year) of liquid manure and wash water are produced. For example, a 100 dairy cow farm is estimated to produce 5,000 tonnes/year (1,300,000 gallons) of liquid manure. Finally, it is assumed that cows spend little time in pasture, meaning all of the manure is available for a biogas plant. One tonne of dairy manure is estimated to produce 14 m³ of biogas (9 m³ of methane). The B.C. Nutrient Management Calculator can be used to estimate manure and milking centre wash water (<https://nmp.apps.nrs.gov.bc.ca/>).

Hog Manure

Manure production at pig farms varies greatly depending upon animal type. For example, according to the B.C. Nutrient Management Calculator (<https://nmp.apps.nrs.gov.bc.ca/>) dry sows, boars, or gilts produce 5.8 tonnes/year (1,524 gallons/year) of liquid manure, finishers produce 4.4 tonnes/year (1,157 gallons/year) and growers produce 2.3 tonnes/year (607 gallons/year). As with dairy manure, one tonne of hog manure is estimated to produce 14 m³ of biogas (9 m³ of methane).

Poultry Manure

It is assumed that for every 100,000 chicken spaces on a farm, 1,200 tonnes/year of manure is produced. Poultry manure is assumed to be 60% dry matter. One tonne of poultry manure is estimated to produce 129 m³ of biogas (84 m³ of methane).

Beef Manure

In B.C. there are two types of cattle operations; cow-calf farms and feedlots. Cattle at cow-calf farms spend a large portion of the year (>5 months) pasture grazing. This means a large portion of manure at cow-calf farms cannot be used in biogas plants. Feedlot cattle are kept in pens, meaning all manure at feedlots can be used in biogas plants. For this reason, only cattle feedlots are considered in the B.C. Benchmark Study.

The amount of manure produced by a B.C. cattle feedlot varies depending upon how often the manure is removed from the pens, and the number of months that cattle are raised at the feedlot.

It is assumed that feedlots raise cattle year-round and collect manure weekly. Therefore, each cow at a feedlot is assumed to produce 7 tonnes/year of manure. One tonne of beef manure is estimated to produce 80 m³ of biogas (52 m³ of methane).

Mixed Food Waste

Mixed food waste is considered to be any food waste produced by non-farm sources, including food and beverage processing, grocery stores, restaurants, hotels and homes. Because mixed food waste produces much more biogas than manure, whenever mixed food waste is digested in an on-farm biogas plant, it is assumed to be at the maximum allowable amount or 49%. One tonne of mixed food waste is estimated to produce 190 m³ of biogas (124 m³ of methane).

6.2 Cost & Revenue Assumptions

The economic feasibility of an on-farm biogas plant depends upon capital costs, operating costs and revenues. The following assumptions, based upon industry experience and quotes from local businesses, were used in all economic feasibility assessments.

Capital Cost Assumptions

- Equipment for injecting Renewable Natural Gas (RNG) at the gas pipeline location is provided by the gas utility;
- Biogas plants are built on farms where land is available at no cost;
- Building for housing equipment, control system, boiler, etc. costs \$550/m³ (51/ft²);²
- Covered digestate storage costs \$70 – 105/m³ (\$0.26 – \$0.40/gallon) depending upon size;
- Site preparation, including civil works and utility upgrades account for 2.5% of capital costs (this cost can vary greatly between locations and shouldn't be underestimated);
- Project development, including approvals, negotiations and other activities accounts for 2% of capital costs (this cost varies depending on project complexity and site-specific details);
- Engineering and project management accounts for 5% of capital costs; and
- Risk management to cover unforeseen costs and/or delays is 5% of total capital costs.

Operating Cost Assumptions

- Feedstock is available year-round, removing the need for long-term feedstock storage;
- Poultry manure costs \$10/tonne delivered;
- Electricity required to power pumps, mixing, control panels, etc. is equal to 5% of biogas production;
- Natural gas required for heating tanks and pasteurization is equal to 10% and 5% of biogas production respectively;

² Estimating building size for on-farm biogas plants is difficult. However, this cost shouldn't be ignored as a structure will be needed to house pasteurization, food waste cleaning and nutrient recovery equipment.

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- Transporting unwanted digestate nutrients off-farm costs \$30/tonne;
- Electricity costs \$0.10/kWh, natural gas costs \$7/GJ, and labour costs \$45/hour;
- Reinvestments in equipment (pumps, mixers, etc.) is equal to 2% of CAPEX; and
- Contingency to cover unforeseen operating costs is 10% of total operating costs.

Revenue & Other Assumptions

- Operational up-time is 97% (8,322 hours/year);
- Biogas contains 65% methane;
- Methane slip (methane lost during upgrading) is 2%;
- RNG contracts are for 20 years and include a 1%/year price increase (up to a maximum RNG sale price of \$30/GJ);
- Mixed food waste comes with a \$25/tonne tip fee for 20 years;
- Digestate fibre used for bedding saves \$200/milk cow/year or \$50/feedlot cow/year;
- Biogas plants are 100% debt financed;
- Inflation is 2%/year; and
- An unlevered, pre-tax Internal Rate of Return (IRR) of 12% is deemed an acceptable return on investment.





Economic Feasibility Assessment

7. Economic Feasibility Assessment

The following are economic feasibility assessments for the Farm Scenarios. Before reading this section, determine which Farm Scenario (#1 - #20) is most similar to your farm, or the type of on-farm biogas plant you are interested in. This choice should be based on the type (i.e., dairy manure, mixed food waste, etc.) and amount (i.e., tonnes/year) of available feedstock.

Once the Farm Scenario has been identified, determine which pieces of equipment are needed for your farm, or the type of on-farm biogas plant you are interested in. This should be based on the following:

- If mixed food waste contain contaminants (e.g., plastic, metal, etc.), food waste cleaning equipment will be required;
- If there isn't a gas pipeline near the biogas plant site, or if RNG cannot be injected into the gas pipeline, RNG compression and transportation equipment will be required; and
- If there isn't sufficient land surrounding the biogas plant site to apply all digestate nutrients, nutrient recovery equipment will be required.

If unsure which equipment will be needed, view all Equipment Choices under the chosen Farm Scenario. Doing so will provide a good understanding of how each piece of equipment impacts cost and biogas plant economic feasibility.

7.1

Farm Scenario #1: 100 Dairy Cows + Mixed Food Waste

Farm Scenario #1 is a 100 dairy cow farm co-digesting dairy manure and mixed food waste. Farm Scenario #1 assumes the use of traditional on-farm biogas plant technology. Estimated feedstock volumes and Renewable Natural Gas (RNG) production for Farm Scenario #1 are as follows:

Feedstock	Tonnes/Year	Percentage	RNG Production (GJ/Year)
Dairy manure	5,004	51%	1,615 GJ
Mixed food waste	4,808	49%	23,365 GJ
<i>Total</i>	<i>9,812</i>	<i>100%</i>	<i>24,980 GJ</i>

The following Equipment Choices were assessed for Farm Scenario #1:

- Option A: No additional equipment;
- Option B: Mixed food waste cleaning equipment;
- Option C: RNG compression equipment;
- Option D: Nutrient recovery equipment;
- Option E: Mixed food waste cleaning and RNG compression equipment;
- Option F: Mixed food waste cleaning and nutrient recovery equipment;
- Option G: RNG compression and nutrient recovery equipment; and
- Option H: Mixed food waste cleaning, RNG compression and nutrient recovery equipment.

For full capital and operating costs for Farm Scenario #1 Options A – H, see Appendix A.

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Farm Scenario #1 - Option A: No Additional Equipment

This biogas plant is estimated to cost \$4.4 million to build. Operating costs are estimated to average \$541,006/year. At an RNG sale price of \$30/GJ, average revenue is estimated to be \$856,925/year. This biogas plant requires \$1.8 million funding (41% of CAPEX) for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$315,919/year; equal to 58% of operating costs. Operating income should be sufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (e.g., broken equipment, unexpected downtime, etc.).

Option A: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>	<u>Revenue</u>		<u>Investment</u>	
Digester	\$1,658,475		RNG/GJ =	\$30.00	Farm Investment =	\$2,616,166
Upgrader	\$2,008,800		Avg RNG Sales/Yr =	\$712,427	Funding Amount =	\$1,815,105
Nutrient Recovery	\$186,842		Tip Fee/Yr =	\$120,200	Funding % of CAPEX =	41%
Other	\$577,154		Bedding Savings/Yr* =	\$24,297		
Total	<u>\$4,431,272</u>	<u>\$541,006</u>	Total =	<u>\$856,925</u>	<i>Inflation =</i>	<i>2%</i>

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$853	\$853	\$853	\$854	\$854	\$855	\$855	\$856	\$856	\$857
OPEX (000s)	\$445	\$454	\$463	\$473	\$482	\$492	\$502	\$512	\$522	\$532
Income (000s)	\$407	\$399	\$390	\$381	\$372	\$363	\$354	\$344	\$334	\$324

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$857	\$857	\$858	\$858	\$859	\$860	\$860	\$861	\$861	\$862
OPEX (000s)	\$543	\$554	\$565	\$576	\$588	\$599	\$611	\$624	\$636	\$649
Income (000s)	\$314	\$304	\$293	\$282	\$271	\$260	\$249	\$237	\$225	\$213

Unlevered, Pre-Tax IRR =	12%	Average Operating Income* =	\$315,919	% of OPEX	58%
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* Averaged over twenty years to account for inflation

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RNG sales account for 83% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, with 41% funding, if RNG production is 10% or 20% higher than anticipated (due to the availability of high biogas-potential mixed food waste), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$26/GJ and <\$24/GJ respectively. Alternately, with 41% funding, if RNG production is 5% or 10% lower than anticipated, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 10.2% and 8.2% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Mixed food waste tip fee accounts for 14% of biogas plant revenue. Therefore, although less important than RNG sales, food waste tip fee can have a significant impact on biogas plant economic feasibility. For example, with 41% funding, if mixed food waste tip fee is \$35/tonne or \$50/tonne instead of \$25/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$27/GJ and <\$24/GJ respectively. Alternately, with 41% funding, if mixed food waste tip fee is only \$20/tonne or \$15/tonne, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 10.8% and 9.5% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option A: Sensitivity Analysis – RNG Production & Mixed Food Waste Tip Fee

		Change in RNG Production Amount						
		-10%	-5%	0%	5%	10%	15%	20%
\$/GJ RNG	\$16	---	---	---	---	---	---	---
	\$17	---	---	---	---	---	---	0.5%
	\$18	---	---	---	---	---	1.1%	2.8%
	\$19	---	---	---	---	1.5%	3.2%	4.8%
	\$20	---	---	---	1.7%	3.5%	5.1%	6.6%
	\$21	---	---	1.7%	3.6%	5.2%	6.8%	8.2%
	\$22	---	1.5%	3.5%	5.2%	6.9%	8.4%	9.8%
	\$23	1.1%	3.2%	5.1%	6.8%	8.4%	9.9%	11.3%
	\$24	2.8%	4.8%	6.6%	8.2%	9.8%	11.3%	12.7%
	\$25	4.3%	6.2%	8.0%	9.6%	11.2%	12.6%	14.1%
	\$26	5.5%	7.4%	9.2%	10.8%	12.4%	13.9%	15.3%
	\$27	6.6%	8.5%	10.2%	11.9%	13.5%	15.0%	16.5%
	\$28	7.4%	9.3%	11.1%	12.8%	14.4%	16.0%	17.5%
	\$29	7.9%	9.9%	11.7%	13.5%	15.1%	16.8%	18.3%
\$30	8.2%	10.2%	12.0%	13.8%	15.5%	17.1%	18.7%	

		Mixed Food Waste Tip Fee (\$/Tonne)							
		\$15	\$20	\$25	\$30	\$35	\$40	\$45	\$50
\$/GJ RNG	\$16	---	---	---	---	---	---	---	0.9%
	\$17	---	---	---	---	---	---	1.1%	2.9%
	\$18	---	---	---	---	---	1.2%	3.0%	4.6%
	\$19	---	---	---	---	1.4%	3.1%	4.7%	6.1%
	\$20	---	---	---	1.5%	3.2%	4.8%	6.2%	7.6%
	\$21	---	---	1.7%	3.4%	4.9%	6.3%	7.7%	8.9%
	\$22	0.0%	1.8%	3.5%	5.0%	6.4%	7.7%	9.0%	10.2%
	\$23	2.0%	3.6%	5.1%	6.5%	7.8%	9.1%	10.3%	11.5%
	\$24	3.7%	5.2%	6.6%	7.9%	9.2%	10.4%	11.5%	12.7%
	\$25	5.3%	6.7%	8.0%	9.2%	10.4%	11.6%	12.7%	13.8%
	\$26	6.6%	7.9%	9.2%	10.4%	11.6%	12.7%	13.8%	14.9%
	\$27	7.7%	9.0%	10.2%	11.4%	12.6%	13.7%	14.8%	15.9%
	\$28	8.6%	9.9%	11.1%	12.3%	13.4%	14.6%	15.7%	16.7%
	\$29	9.2%	10.5%	11.7%	12.9%	14.1%	15.2%	16.3%	17.4%
\$30	9.5%	10.8%	12.0%	13.2%	14.4%	15.5%	16.6%	17.7%	

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #1 - Option B: Mixed Food Waste Cleaning Equipment

This biogas plant is estimated to cost \$5.3 million to build. Operating costs are estimated to average \$622,847/year. At an RNG sale price of \$30/GJ, average revenue is estimated to be \$856,925/year. This biogas plant requires \$3.2 million funding (61% of CAPEX) for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$234,077/year; equal to 38% of operating costs. Operating income may or may not be sufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (e.g., broken equipment, unexpected downtime, etc.).

Option B: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>		<u>Revenue</u>		<u>Investment</u>	
Digester	\$2,385,600			RNG/GJ =	\$30.00	Farm Investment =	\$2,047,340
Upgrader	\$2,008,800			Avg RNG Sales/Yr =	\$712,427	Funding Amount =	\$3,219,944
Nutrient Recovery	\$186,842			Tip Fee/Yr =	\$120,200	Funding % of CAPEX =	61%
Other	\$686,041			Bedding Savings/Yr* =	\$24,297		
Total	<u>\$5,267,283</u>	<u>\$622,847</u>		Total =	<u>\$856,925</u>	Inflation =	2%

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$853	\$853	\$853	\$854	\$854	\$855	\$855	\$856	\$856	\$857
OPEX (000s)	\$513	\$523	\$533	\$544	\$555	\$566	\$577	\$589	\$601	\$613
<i>Income (000s)</i>	\$340	\$330	\$320	\$310	\$299	\$289	\$278	\$267	\$255	\$244

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$857	\$857	\$858	\$858	\$859	\$860	\$860	\$861	\$861	\$862
OPEX (000s)	\$625	\$637	\$650	\$663	\$676	\$690	\$704	\$718	\$732	\$747
<i>Income (000s)</i>	\$232	\$220	\$208	\$195	\$183	\$170	\$156	\$143	\$129	\$115

Unlevered, Pre-Tax IRR =	12%
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Average Operating Income* =	\$234,077
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% of OPEX	38%
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* Averaged over twenty years to account for inflation

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 83% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, with 61% funding, if RNG production is 10% or 20% higher than anticipated (due to the availability of high biogas-potential mixed food waste), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$26/GJ and <\$24/GJ respectively. Alternately, with 61% funding, if RNG production is 5% or 10% lower than anticipated, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 9.5% and 6.6% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Mixed food waste tip fee accounts for 14% of biogas plant revenue. Therefore, although less important than RNG sales, food waste tip fee can have a significant impact on biogas plant economic feasibility. For example, with 61% funding, if mixed food waste tip fee is \$35/tonne or \$50/tonne instead of \$25/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$27/GJ and <\$24/GJ respectively. Alternately, with 61% funding, if mixed food waste tip fee is only \$20/tonne or \$15/tonne, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 10.3% and 8.5% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option B: Sensitivity Analysis – RNG Production & Mixed Food Waste Tip Fee

		Change in RNG Production Amount						
		-10%	-5%	0%	5%	10%	15%	20%
\$/GJ RNG	\$16	---	---	---	---	---	---	---
	\$17	---	---	---	---	---	---	---
	\$18	---	---	---	---	---	---	---
	\$19	---	---	---	---	---	---	1.6%
	\$20	---	---	---	---	---	2.2%	4.5%
	\$21	---	---	---	---	2.4%	4.8%	6.9%
	\$22	---	---	---	2.4%	4.9%	7.1%	9.1%
	\$23	---	---	2.2%	4.8%	7.1%	9.1%	11.0%
	\$24	---	1.6%	4.5%	6.9%	9.1%	11.0%	12.9%
	\$25	0.8%	3.9%	6.5%	8.8%	10.9%	12.8%	14.7%
	\$26	2.8%	5.7%	8.2%	10.4%	12.5%	14.5%	16.3%
	\$27	4.3%	7.2%	9.6%	11.9%	14.0%	15.9%	17.9%
	\$28	5.5%	8.3%	10.8%	13.1%	15.2%	17.2%	19.2%
\$29	6.2%	9.1%	11.6%	14.0%	16.1%	18.2%	20.3%	
\$30	6.6%	9.5%	12.0%	14.4%	16.6%	18.7%	20.8%	

		Mixed Food Waste Tip Fee (\$/Tonne)							
		\$15	\$20	\$25	\$30	\$35	\$40	\$45	\$50
\$/GJ RNG	\$16	---	---	---	---	---	---	---	---
	\$17	---	---	---	---	---	---	---	---
	\$18	---	---	---	---	---	---	---	1.2%
	\$19	---	---	---	---	---	---	1.4%	3.7%
	\$20	---	---	---	---	---	1.6%	3.9%	5.9%
	\$21	---	---	---	---	1.8%	4.0%	6.0%	7.8%
	\$22	---	---	---	2.0%	4.2%	6.1%	7.9%	9.6%
	\$23	---	---	2.2%	4.3%	6.3%	8.0%	9.7%	11.3%
	\$24	---	2.3%	4.5%	6.4%	8.2%	9.8%	11.4%	12.9%
	\$25	2.5%	4.6%	6.5%	8.2%	9.9%	11.4%	12.9%	14.4%
	\$26	4.5%	6.4%	8.2%	9.9%	11.4%	12.9%	14.4%	15.8%
	\$27	6.1%	7.9%	9.6%	11.2%	12.8%	14.2%	15.7%	17.1%
	\$28	7.3%	9.1%	10.8%	12.4%	13.9%	15.4%	16.8%	18.2%
\$29	8.1%	9.9%	11.6%	13.2%	14.8%	16.2%	17.7%	19.1%	
\$30	8.5%	10.3%	12.0%	13.6%	15.2%	16.7%	18.1%	19.5%	

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #1 - Option C: RNG Compression Equipment

This biogas plant is estimated to cost \$5.2 million to build. Operating costs are estimated to average \$715,569/year. At an RNG sale price of \$30/GJ, average revenue is estimated to be \$856,925/year. This biogas plant requires \$3.8 million of funding (73% of CAPEX) for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$141,355/year; equal to 20% of operating costs. Operating income is likely insufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (i.e., broken equipment, unexpected downtime, etc.). This is because farm investment (i.e., debt) is only 27%. Low investment means that even with an unlevered, pre-tax IRR of 12%, operating income can be too low.

Option C: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>	<u>Revenue</u>		<u>Investment</u>	
Digester	\$1,658,475		RNG/GJ =	\$30.00	Farm Investment =	\$1,403,183
Upgrader	\$2,649,383		Avg RNG Sales/Yr =	\$712,427	Funding Amount =	\$3,764,598
Nutrient Recovery	\$186,842		Tip Fee/Yr =	\$120,200	Funding % of CAPEX =	73%
Other	\$673,081		Bedding Savings/Yr* =	\$24,297		
Total	<u>\$5,167,782</u>	<u>\$715,569</u>	Total =	<u>\$856,925</u>	<i>Inflation =</i>	<i>2%</i>

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$853	\$853	\$853	\$854	\$854	\$855	\$855	\$856	\$856	\$857
OPEX (000s)	\$589	\$601	\$613	\$625	\$638	\$650	\$663	\$677	\$690	\$704
<i>Income (000s)</i>	<i>\$264</i>	<i>\$252</i>	<i>\$241</i>	<i>\$229</i>	<i>\$217</i>	<i>\$204</i>	<i>\$192</i>	<i>\$179</i>	<i>\$166</i>	<i>\$153</i>

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$857	\$857	\$858	\$858	\$859	\$860	\$860	\$861	\$861	\$862
OPEX (000s)	\$718	\$732	\$747	\$762	\$777	\$793	\$809	\$825	\$841	\$858
<i>Income (000s)</i>	<i>\$139</i>	<i>\$125</i>	<i>\$111</i>	<i>\$97</i>	<i>\$82</i>	<i>\$67</i>	<i>\$51</i>	<i>\$36</i>	<i>\$20</i>	<i>\$4</i>

Unlevered, Pre-Tax IRR =	12%	Average Operating Income* =	\$141,355	% of OPEX	20%
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* Averaged over twenty years to account for inflation

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 83% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, with 73% funding, if RNG production is 10% or 20% higher than anticipated (due to the availability of high biogas-potential mixed food waste), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$26/GJ and <\$24/GJ respectively. Alternately, with 73% funding, if RNG production is 5% lower than anticipated, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 7.4%. An unlevered, pre-tax IRR <12% isn't economically feasible.

Mixed food waste tip fee accounts for 14% of biogas plant revenue. Therefore, although less important than RNG sales, food waste tip fee can have a significant impact on biogas plant economic feasibility. For example, with 73% funding, if mixed food waste tip fee is \$35/tonne or \$50/tonne instead of \$25/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$27/GJ and <\$24/GJ respectively. Alternately, with 73% funding, if mixed food waste tip fee is only \$20/tonne or \$15/tonne, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 9.0% and 5.4% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option C: Sensitivity Analysis – RNG Production & Mixed Food Waste Tip Fee

		Change in RNG Production Amount						
		-10%	-5%	0%	5%	10%	15%	20%
\$/GJ RNG	\$16	---	---	---	---	---	---	---
	\$17	---	---	---	---	---	---	---
	\$18	---	---	---	---	---	---	---
	\$19	---	---	---	---	---	---	---
	\$20	---	---	---	---	---	---	---
	\$21	---	---	---	---	---	---	3.1%
	\$22	---	---	---	---	---	3.4%	7.2%
	\$23	---	---	---	---	3.4%	7.3%	10.5%
	\$24	---	---	---	3.1%	7.2%	10.5%	13.4%
	\$25	---	---	2.2%	6.7%	10.2%	13.3%	16.1%
	\$26	---	0.0%	5.5%	9.5%	12.8%	15.8%	18.5%
	\$27	---	3.1%	8.0%	11.8%	15.0%	18.0%	20.8%
	\$28	---	5.3%	10.0%	13.7%	17.0%	20.0%	22.8%
\$29	---	6.8%	11.4%	15.1%	18.5%	21.6%	24.5%	
\$30	---	7.4%	12.0%	15.8%	19.2%	22.4%	25.4%	

		Mixed Food Waste Tip Fee (\$/Tonne)							
		\$15	\$20	\$25	\$30	\$35	\$40	\$45	\$50
\$/GJ RNG	\$16	---	---	---	---	---	---	---	---
	\$17	---	---	---	---	---	---	---	---
	\$18	---	---	---	---	---	---	---	---
	\$19	---	---	---	---	---	---	---	---
	\$20	---	---	---	---	---	---	---	0.4%
	\$21	---	---	---	---	---	---	0.8%	4.8%
	\$22	---	---	---	---	---	1.2%	5.0%	8.1%
	\$23	---	---	---	---	1.6%	5.3%	8.2%	10.9%
	\$24	---	---	---	1.9%	5.5%	8.4%	11.0%	13.3%
	\$25	---	---	2.2%	5.7%	8.6%	11.1%	13.4%	15.7%
	\$26	---	1.9%	5.5%	8.5%	11.1%	13.4%	15.7%	17.8%
	\$27	0.5%	4.8%	8.0%	10.8%	13.2%	15.5%	17.6%	19.7%
	\$28	3.1%	6.9%	10.0%	12.6%	15.0%	17.2%	19.4%	21.4%
\$29	4.7%	8.4%	11.4%	14.0%	16.4%	18.6%	20.7%	22.8%	
\$30	5.4%	9.0%	12.0%	14.6%	17.0%	19.3%	21.5%	23.5%	

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #1 - Option D: Nutrient Recovery Equipment

This biogas plant is estimated to cost \$5.5 million to build. Operating costs are estimated to average \$747,771/year. At an RNG sale price of \$30/GJ, average revenue is estimated to be \$856,925/year. This biogas plant requires \$4.3 million funding (78% of CAPEX) for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$109,153/year; equal to 15% of operating costs. Operating income is likely insufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (i.e., broken equipment, unexpected downtime, etc.). This is because farm investment (i.e., debt) is only 22%. Low investment means that even with an unlevered, pre-tax IRR of 12%, operating income can be too low.

Option D: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>	<u>Revenue</u>		<u>Investment</u>	
Digester	\$1,889,475		RNG/GJ =	\$30.00	Farm Investment =	\$1,182,983
Upgrader	\$2,008,800		Avg RNG Sales/Yr =	\$712,427	Funding Amount =	\$4,289,962
Nutrient Recovery	\$861,842		Tip Fee/Yr =	\$120,200	Funding % of CAPEX =	78%
Other	\$712,828		Bedding Savings/Yr* =	\$24,297		
Total	<u>\$5,472,945</u>	<u>\$747,771</u>	Total =	<u>\$856,925</u>	<i>Inflation =</i>	<i>2%</i>

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$853	\$853	\$853	\$854	\$854	\$855	\$855	\$856	\$856	\$857
OPEX (000s)	\$616	\$628	\$640	\$653	\$666	\$680	\$693	\$707	\$721	\$736
<i>Income (000s)</i>	<i>\$237</i>	<i>\$225</i>	<i>\$213</i>	<i>\$201</i>	<i>\$188</i>	<i>\$175</i>	<i>\$162</i>	<i>\$149</i>	<i>\$135</i>	<i>\$121</i>

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$857	\$857	\$858	\$858	\$859	\$860	\$860	\$861	\$861	\$862
OPEX (000s)	\$750	\$765	\$781	\$796	\$812	\$828	\$845	\$862	\$879	\$897
<i>Income (000s)</i>	<i>\$107</i>	<i>\$92</i>	<i>\$77</i>	<i>\$62</i>	<i>\$47</i>	<i>\$31</i>	<i>\$15</i>	<i>-\$1</i>	<i>-\$18</i>	<i>-\$35</i>

Unlevered, Pre-Tax IRR =	12%	Average Operating Income* =	\$109,153	% of OPEX	15%
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* Averaged over twenty years to account for inflation

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 83% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, with 78% funding, if RNG production is 10% or 20% higher than anticipated (due to the availability of high biogas-potential mixed food waste), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$26/GJ and <\$24/GJ respectively. Alternately, with 78% funding, if RNG production is 5% lower than anticipated, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 5.3%. An unlevered, pre-tax IRR <12% isn't economically feasible.

Mixed food waste tip fee accounts for 14% of biogas plant revenue. Therefore, although less important than RNG sales, food waste tip fee can have a significant impact on biogas plant economic feasibility. For example, with 78% funding, if mixed food waste tip fee is \$35/tonne or \$50/tonne instead of \$25/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$27/GJ and <\$24/GJ respectively. Alternately, with 78% funding, if mixed food waste tip fee is only \$20/tonne or \$15/tonne, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 7.9% and 1.1% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option D: Sensitivity Analysis – RNG Production & Mixed Food Waste Tip Fee

		Change in RNG Production Amount						
		-10%	-5%	0%	5%	10%	15%	20%
\$/GJ RNG	\$16	---	---	---	---	---	---	---
	\$17	---	---	---	---	---	---	---
	\$18	---	---	---	---	---	---	---
	\$19	---	---	---	---	---	---	---
	\$20	---	---	---	---	---	---	---
	\$21	---	---	---	---	---	---	---
	\$22	---	---	---	---	---	---	5.6%
	\$23	---	---	---	---	---	5.8%	10.0%
	\$24	---	---	---	---	5.6%	10.0%	13.7%
	\$25	---	---	---	5.0%	9.7%	13.5%	16.9%
	\$26	---	---	3.1%	8.7%	12.9%	16.5%	19.9%
	\$27	---	---	6.7%	11.7%	15.7%	19.2%	22.6%
	\$28	---	2.0%	9.3%	14.0%	18.0%	21.6%	25.0%
\$29	---	4.4%	11.1%	15.8%	19.9%	23.6%	27.1%	
\$30	---	5.3%	12.0%	16.7%	20.9%	24.6%	28.2%	

		Mixed Food Waste Tip Fee (\$/Tonne)							
		\$15	\$20	\$25	\$30	\$35	\$40	\$45	\$50
\$/GJ RNG	\$16	---	---	---	---	---	---	---	---
	\$17	---	---	---	---	---	---	---	---
	\$18	---	---	---	---	---	---	---	---
	\$19	---	---	---	---	---	---	---	---
	\$20	---	---	---	---	---	---	---	---
	\$21	---	---	---	---	---	---	---	1.9%
	\$22	---	---	---	---	---	---	2.3%	6.8%
	\$23	---	---	---	---	---	2.7%	7.1%	10.5%
	\$24	---	---	---	---	3.1%	7.3%	10.7%	13.6%
	\$25	---	---	---	3.5%	7.5%	10.8%	13.7%	16.4%
	\$26	---	---	3.1%	7.4%	10.8%	13.7%	16.4%	18.9%
	\$27	---	1.6%	6.7%	10.3%	13.4%	16.2%	18.8%	21.3%
	\$28	---	4.9%	9.3%	12.7%	15.7%	18.4%	20.9%	23.4%
\$29	---	7.0%	11.1%	14.4%	17.4%	20.1%	22.6%	25.1%	
\$30	1.1%	7.9%	12.0%	15.3%	18.2%	20.9%	23.5%	26.0%	

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #1 - Option E: Mixed Food Waste Cleaning & RNG Compression Equipment

This biogas plant is estimated to cost \$6.0 million to build. Operating costs are estimated to average \$797,411/year. At an RNG sale price of \$30/GJ, average revenue is estimated to be \$856,925/year. This biogas plant requires \$5.2 million funding (86% of CAPEX) for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$59,514/year; equal to 7% of operating costs. Operating income is likely insufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (i.e., broken equipment, unexpected downtime, etc.). This is because farm investment (i.e., debt) is only 14%. Low investment means that even with an unlevered, pre-tax IRR of 12%, operating income can be too low.

Option E: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>	<u>Revenue</u>		<u>Investment</u>	
Digester	\$2,385,600		RNG/GJ =	\$30.00	Farm Investment =	\$835,994
Upgrader	\$2,649,383		Avg RNG Sales/Yr =	\$712,427	Funding Amount =	\$5,167,800
Nutrient Recovery	\$186,842		Tip Fee/Yr =	\$120,200	Funding % of CAPEX =	86%
Other	\$781,968		Bedding Savings/Yr* =	\$24,297		
<u>Total</u>	<u>\$6,003,794</u>	<u>\$797,411</u>	<u>Total =</u>	<u>\$856,925</u>	Inflation =	2%

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$853	\$853	\$853	\$854	\$854	\$855	\$855	\$856	\$856	\$857
OPEX (000s)	\$656	\$670	\$683	\$697	\$710	\$725	\$739	\$754	\$769	\$784
<i>Income (000s)</i>	\$196	\$184	\$171	\$157	\$144	\$130	\$116	\$102	\$87	\$72

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$857	\$857	\$858	\$858	\$859	\$860	\$860	\$861	\$861	\$862
OPEX (000s)	\$800	\$816	\$832	\$849	\$866	\$883	\$901	\$919	\$937	\$956
<i>Income (000s)</i>	\$57	\$41	\$26	\$9	-\$7	-\$24	-\$41	-\$58	-\$76	-\$94

Unlevered, Pre-Tax IRR =	12%	Average Operating Income* =	\$59,514	% of OPEX	7%
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* Averaged over twenty years to account for inflation

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 83% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, with 86% funding, if RNG production is 10% or 20% higher than anticipated (due to the availability of high biogas-potential mixed food waste), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$26/GJ and <\$24/GJ respectively. Alternately, with 86% funding, if RNG production is 5% lower than anticipated, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR is negative.

Mixed food waste tip fee accounts for 14% of biogas plant revenue. Therefore, although less important than RNG sales, food waste tip fee can have a significant impact on biogas plant economic feasibility. For example, with 86% funding, if mixed food waste tip fee is \$35/tonne or \$50/tonne instead of \$25/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$27/GJ and <\$24/GJ respectively. Alternately, with 86% funding, if mixed food waste tip fee is only \$20/tonne, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR is negative.

Option E: Sensitivity Analysis – RNG Production & Mixed Food Waste Tip Fee

		Change in RNG Production Amount						
		-10%	-5%	0%	5%	10%	15%	20%
\$/GJ RNG	\$16	---	---	---	---	---	---	---
	\$17	---	---	---	---	---	---	---
	\$18	---	---	---	---	---	---	---
	\$19	---	---	---	---	---	---	---
	\$20	---	---	---	---	---	---	---
	\$21	---	---	---	---	---	---	---
	\$22	---	---	---	---	---	---	---
	\$23	---	---	---	---	---	---	8.7%
	\$24	---	---	---	---	---	8.7%	14.6%
	\$25	---	---	---	---	8.1%	14.4%	19.4%
	\$26	---	---	---	6.1%	13.5%	18.9%	23.6%
	\$27	---	---	---	11.5%	17.7%	22.9%	27.5%
	\$28	---	---	6.6%	15.4%	21.3%	26.4%	31.1%
\$29	---	---	10.4%	18.3%	24.1%	29.3%	34.2%	
\$30	---	---	12.0%	19.7%	25.7%	31.0%	36.0%	

		Mixed Food Waste Tip Fee (\$/Tonne)							
		\$15	\$20	\$25	\$30	\$35	\$40	\$45	\$50
\$/GJ RNG	\$16	---	---	---	---	---	---	---	---
	\$17	---	---	---	---	---	---	---	---
	\$18	---	---	---	---	---	---	---	---
	\$19	---	---	---	---	---	---	---	---
	\$20	---	---	---	---	---	---	---	---
	\$21	---	---	---	---	---	---	---	---
	\$22	---	---	---	---	---	---	---	0.5%
	\$23	---	---	---	---	---	---	1.8%	9.5%
	\$24	---	---	---	---	---	2.7%	9.8%	14.6%
	\$25	---	---	---	---	3.4%	10.1%	14.8%	18.7%
	\$26	---	---	---	2.7%	10.0%	14.7%	18.8%	22.4%
	\$27	---	---	---	9.1%	14.4%	18.6%	22.3%	25.8%
	\$28	---	---	6.6%	13.2%	17.9%	21.8%	25.4%	28.8%
\$29	---	---	10.4%	16.1%	20.5%	24.4%	28.0%	31.4%	
\$30	---	---	12.0%	17.5%	21.9%	25.8%	29.5%	32.9%	

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #1 - Option F: Mixed Food Waste Cleaning & Nutrient Recovery Equipment

This biogas plant is estimated to cost \$6.3 million to build. Operating costs are estimated to average \$829,613/year. At an RNG sale price of \$30/GJ, average revenue is estimated to be \$856,925/year. This biogas plant requires \$5.8 million funding (91% of CAPEX) for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$27,311/year; equal to 3% of operating costs. Operating income is likely insufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (i.e., broken equipment, unexpected downtime, etc.). This is because farm investment (i.e., debt) is only 9%. Low investment means that even with an unlevered, pre-tax IRR of 12%, operating income can be too low.

Option F: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>	<u>Revenue</u>		<u>Investment</u>	
Digester	\$2,616,600		RNG/GJ =	\$30.00	Farm Investment =	\$546,226
Upgrader	\$2,008,800		Avg RNG Sales/Yr =	\$712,427	Funding Amount =	\$5,762,731
Nutrient Recovery	\$861,842		Tip Fee/Yr =	\$120,200	Funding % of CAPEX =	91%
Other	\$821,715		Bedding Savings/Yr* =	\$24,297		
Total	<u>\$6,308,957</u>	<u>\$829,613</u>	Total =	<u>\$856,925</u>	Inflation =	2%

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$853	\$853	\$853	\$854	\$854	\$855	\$855	\$856	\$856	\$857
OPEX (000s)	\$683	\$697	\$710	\$725	\$739	\$754	\$769	\$784	\$800	\$816
<i>Income (000s)</i>	<i>\$170</i>	<i>\$156</i>	<i>\$143</i>	<i>\$129</i>	<i>\$115</i>	<i>\$101</i>	<i>\$86</i>	<i>\$71</i>	<i>\$56</i>	<i>\$40</i>

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$857	\$857	\$858	\$858	\$859	\$860	\$860	\$861	\$861	\$862
OPEX (000s)	\$832	\$849	\$866	\$883	\$901	\$919	\$937	\$956	\$975	\$995
<i>Income (000s)</i>	<i>\$25</i>	<i>\$8</i>	<i>-\$8</i>	<i>-\$25</i>	<i>-\$42</i>	<i>-\$60</i>	<i>-\$77</i>	<i>-\$96</i>	<i>-\$114</i>	<i>-\$133</i>

Unlevered, Pre-Tax IRR =	12%	Average Operating Income* =	\$27,311	% of OPEX	3%
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* Averaged over twenty years to account for inflation

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 83% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, with 91% funding, if RNG production is 10% or 20% higher than anticipated (due to the availability of high biogas-potential mixed food waste), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$27/GJ and <\$25/GJ respectively. Alternately, with 91% funding, if RNG production is 5% lower than anticipated, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR is negative.

Mixed food waste tip fee accounts for 14% of biogas plant revenue. Therefore, although less important than RNG sales, food waste tip fee can have a significant impact on biogas plant economic feasibility. For example, with 91% funding, if mixed food waste tip fee is \$35/tonne or \$50/tonne instead of \$25/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$28/GJ and <\$25/GJ respectively. Alternately, with 91% funding, if mixed food waste tip fee is only \$20/tonne, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR is negative.

Option F: Sensitivity Analysis – RNG Production & Mixed Food Waste Tip Fee

		Change in RNG Production Amount						
		-10%	-5%	0%	5%	10%	15%	20%
\$/GJ RNG	\$16	---	---	---	---	---	---	---
	\$17	---	---	---	---	---	---	---
	\$18	---	---	---	---	---	---	---
	\$19	---	---	---	---	---	---	---
	\$20	---	---	---	---	---	---	---
	\$21	---	---	---	---	---	---	---
	\$22	---	---	---	---	---	---	---
	\$23	---	---	---	---	---	---	5.5%
	\$24	---	---	---	---	---	5.5%	11.4%
	\$25	---	---	---	---	4.9%	11.2%	16.2%
	\$26	---	---	---	2.9%	10.3%	15.7%	20.4%
	\$27	---	---	---	8.3%	14.5%	19.7%	24.3%
	\$28	---	---	3.4%	12.2%	18.0%	23.2%	27.9%
\$29	---	---	7.2%	15.1%	20.9%	26.1%	31.0%	
\$30	---	---	12.0%	16.5%	22.5%	27.8%	32.8%	

		Mixed Food Waste Tip Fee (\$/Tonne)							
		\$15	\$20	\$25	\$30	\$35	\$40	\$45	\$50
\$/GJ RNG	\$16	---	---	---	---	---	---	---	---
	\$17	---	---	---	---	---	---	---	---
	\$18	---	---	---	---	---	---	---	---
	\$19	---	---	---	---	---	---	---	---
	\$20	---	---	---	---	---	---	---	---
	\$21	---	---	---	---	---	---	---	---
	\$22	---	---	---	---	---	---	---	---
	\$23	---	---	---	---	---	---	---	6.2%
	\$24	---	---	---	---	---	---	6.6%	11.4%
	\$25	---	---	---	---	0.2%	6.9%	11.6%	15.5%
	\$26	---	---	---	---	6.8%	11.5%	15.6%	19.2%
	\$27	---	---	---	5.9%	11.2%	15.4%	19.1%	22.6%
	\$28	---	---	3.4%	10.0%	14.7%	18.6%	22.2%	25.5%
\$29	---	---	7.2%	12.9%	17.3%	21.2%	24.8%	28.1%	
\$30	---	---	12.0%	14.3%	18.7%	22.6%	26.3%	29.7%	

Farm Scenario #1 - Option G: RNG Compression & Nutrient Recovery Equipment

This biogas plant is estimated to cost \$6.2 million to build. Operating costs are estimated to average \$922,335/year. At an RNG sale price of \$30/GJ, average revenue is estimated to be \$856,925/year. Because operating costs are greater than revenue, this biogas plant requires >100% funding for an unlevered, pre-tax IRR of 12%. For this reason, an economic assessment was not completed.

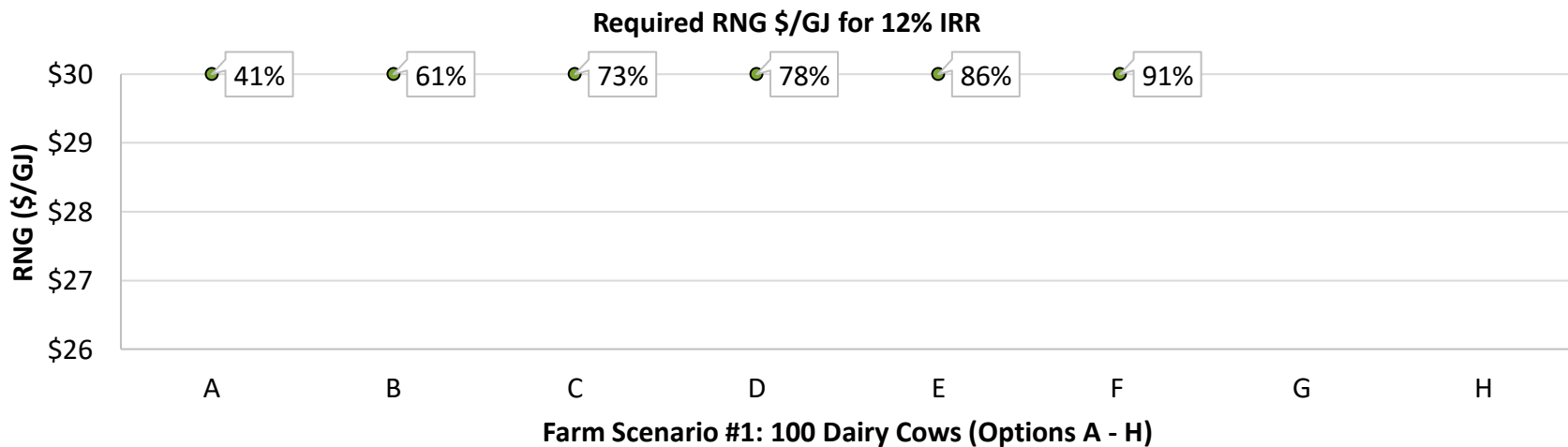
Farm Scenario #1 - Option H: Mixed Food Waste Cleaning, RNG Compression & Nutrient Recovery Equipment

This biogas plant is estimated to cost \$7.0 million to build. Operating costs are estimated to average \$1,004,177/year. At an RNG sale price of \$30/GJ, average revenue is estimated to be \$856,925/year. Because operating costs are greater than revenue, this biogas plant requires >100% funding for an unlevered, pre-tax IRR of 12%. For this reason, an economic assessment was not completed.

Farm Scenario #1: Summary

Figure 13 shows the required RNG \$/GJ sale price for Farm Scenario #1 Options A – G for an unlevered, pre-tax IRR of 12%. Where required RNG sale price is >\$30/GJ, percentage of required funding is shown. All Farm Scenario #1 Options A – H require funding. Funding increases from 41% (for Option A) to 91% (for Option F). Options G and H aren't shown because they require >100% funding. Figure 13 shows that even under the best circumstances (i.e., Option A - needing the least equipment), 100 dairy cow farms co-digesting dairy manure and mixed food waste cannot be economically feasible in B.C. without funding.

Figure 13: Farm Scenario #1 - Required RNG Sale Price for 100 Dairy Cows + Mixed Food Waste



7.2

Farm Scenario #2: 150 Dairy Cows + Mixed Food Waste

Farm Scenario #2 is a 150 dairy cow farm co-digesting dairy manure and mixed food waste. Farm Scenario #2 assumes the use of traditional on-farm biogas plant technology. Estimated feedstock volume and Renewable Natural Gas (RNG) production for Farm Scenario #2 are as follows:

Feedstock	Tonnes/Year	Percentage	RNG Production (GJ/Year)
Dairy manure	7,506	51%	2,422
Mixed food waste	7,212	49%	35,047
<i>Total</i>	<i>14,718</i>	<i>100%</i>	<i>37,470</i>

The following Equipment Choices were assessed for Farm Scenario #2:

- Option A: No additional equipment;
- Option B: Mixed food waste cleaning equipment;
- Option C: RNG compression equipment;
- Option D: Nutrient recovery equipment;
- Option E: Mixed food waste cleaning and RNG compression equipment;
- Option F: Mixed food waste cleaning and nutrient recovery equipment;
- Option G: RNG compression and nutrient recovery equipment; and
- Option H: Mixed food waste cleaning, RNG compression and nutrient recovery equipment.

For full capital and operating costs for Farm Scenario #2 Options A – H, see Appendix B.

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #2 - Option A: No Additional Equipment

This biogas plant is estimated to cost \$4.8 million to build. Operating costs are estimated to average \$620,136/year. At an RNG sale price of \$26.80/GJ, average revenue is estimated to be \$1,249,588/year. This biogas plant doesn't require funding for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$629,452/year; equal to 102% of operating costs. Operating income should be sufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (i.e., broken equipment, unexpected downtime, etc.).

Option A: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>	<u>Revenue</u>		<u>Investment</u>	
Digester	\$1,794,975		RNG/GJ [†] =	\$26.80	Farm Investment =	\$4,814,048
Upgrader	\$2,111,800		Avg RNG Sales/Yr =	\$1,032,843	Funding Amount =	\$0
Nutrient Recovery	\$280,264		Tip Fee/Yr =	\$180,300	Funding % of CAPEX =	0%
Other	\$627,009		Bedding Savings/Yr* =	\$36,446		
Total	<u>\$4,814,048</u>	<u>\$620,136</u>	Total =	<u>\$1,249,588</u>	Inflation =	2%

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$1,165	\$1,175	\$1,185	\$1,196	\$1,206	\$1,217	\$1,227	\$1,238	\$1,249	\$1,260
OPEX (000s)	\$510	\$521	\$531	\$542	\$553	\$564	\$575	\$586	\$598	\$610
Income (000s)	\$654	\$654	\$654	\$654	\$654	\$653	\$653	\$652	\$651	\$650

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$1,271	\$1,283	\$1,287	\$1,288	\$1,289	\$1,289	\$1,290	\$1,291	\$1,292	\$1,293
OPEX (000s)	\$622	\$635	\$647	\$660	\$674	\$687	\$701	\$715	\$729	\$744
Income (000s)	\$649	\$648	\$640	\$627	\$615	\$602	\$589	\$576	\$563	\$549

Unlevered, Pre-Tax IRR =	12%
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Average Operating Income* =	\$629,452
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% of OPEX	102%
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* Averaged over twenty years to account for inflation

[†] Base price (1%/year increase up to \$30/GJ max)

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 83% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, if RNG production is 10% or 20% higher than anticipated (due to the availability of high biogas-potential mixed food waste), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$26.80/GJ to <\$25/GJ and <\$23/GJ respectively. Alternately, if RNG production is 10% or 15% lower than anticipated, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 10.7% and 9.2% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Mixed food waste tip fee accounts for 14% of biogas plant revenue. Therefore, although less important than RNG sales, food waste tip fee can have a significant impact on biogas plant economic feasibility. For example, if mixed food waste tip fee is \$35/tonne or \$50/tonne instead of \$25/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$26.80/GJ to <\$25/GJ and <\$22/GJ respectively. Alternately, if mixed food waste tip fee is only \$15/tonne or \$10/tonne, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 11.7% and 10.7% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option A: Sensitivity Analysis – RNG Production & Mixed Food Waste Tip Fee

		Change in RNG Production Amount							
		-15%	-10%	-5%	0%	5%	10%	15%	20%
\$/GJ RNG	\$16	---	---	---	---	0.6%	1.8%	3.0%	4.0%
	\$17	---	---	---	0.9%	2.2%	3.4%	4.5%	5.5%
	\$18	---	---	1.1%	2.4%	3.6%	4.8%	5.8%	6.9%
	\$19	---	1.1%	2.5%	3.8%	5.0%	6.1%	7.2%	8.2%
	\$20	0.9%	2.4%	3.8%	5.0%	6.2%	7.3%	8.4%	9.4%
	\$21	2.2%	3.6%	5.0%	6.2%	7.4%	8.5%	9.6%	10.6%
	\$22	3.4%	4.8%	6.1%	7.3%	8.5%	9.6%	10.7%	11.8%
	\$23	4.5%	5.8%	7.2%	8.4%	9.6%	10.7%	11.8%	12.9%
	\$24	5.5%	6.9%	8.2%	9.4%	10.6%	11.8%	12.9%	14.0%
	\$25	6.5%	7.9%	9.2%	10.4%	11.6%	12.8%	13.9%	15.1%
	\$26	7.3%	8.7%	10.1%	11.3%	12.6%	13.8%	14.9%	16.1%
	\$27	8.1%	9.5%	10.8%	12.1%	13.4%	14.6%	15.8%	17.0%
	\$28	8.7%	10.1%	11.5%	12.8%	14.1%	15.4%	16.6%	17.8%
	\$29	9.1%	10.5%	12.0%	13.3%	14.6%	15.9%	17.2%	18.4%
\$30	9.2%	10.7%	12.2%	13.6%	14.9%	16.2%	17.5%	18.8%	

		Mixed Food Waste Tip Fee (\$/Tonne)								
		\$10	\$15	\$20	\$25	\$30	\$35	\$40	\$45	\$50
\$/GJ RNG	\$16			---	---	0.8%	2.2%	3.5%	4.7%	5.8%
	\$17			---	0.9%	2.3%	3.6%	4.8%	5.9%	7.0%
	\$18			1.0%	2.4%	3.7%	4.9%	6.0%	7.1%	8.1%
	\$19	-0.3%	1.2%	2.5%	3.8%	4.9%	6.1%	7.1%	8.2%	9.1%
	\$20	1.3%	2.6%	3.8%	5.0%	6.1%	7.2%	8.2%	9.2%	10.2%
	\$21	2.7%	3.9%	5.1%	6.2%	7.3%	8.3%	9.3%	10.2%	11.2%
	\$22	4.0%	5.2%	6.3%	7.3%	8.3%	9.3%	10.3%	11.2%	12.1%
	\$23	5.3%	6.3%	7.4%	8.4%	9.4%	10.3%	11.3%	12.2%	13.1%
	\$24	6.4%	7.4%	8.5%	9.4%	10.4%	11.3%	12.2%	13.1%	14.0%
	\$25	7.5%	8.5%	9.5%	10.4%	11.3%	12.2%	13.1%	14.0%	14.9%
	\$26	8.5%	9.5%	10.4%	11.3%	12.2%	13.1%	14.0%	14.9%	15.7%
	\$27	9.3%	10.3%	11.2%	12.1%	13.0%	13.9%	14.8%	15.7%	16.5%
	\$28	10.0%	11.0%	11.9%	12.8%	13.7%	14.6%	15.5%	16.3%	17.2%
	\$29	10.5%	11.4%	12.4%	13.3%	14.2%	15.1%	16.0%	16.9%	17.7%
\$30	10.7%	11.7%	12.6%	13.6%	14.5%	15.4%	16.2%	17.1%	18.0%	

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #2 - Option B: Mixed Food Waste Cleaning Equipment

This biogas plant is estimated to cost \$5.7 million to build. Operating costs are estimated to average \$701,978/year. At an RNG sale price of \$30/GJ, average revenue is estimated to be \$1,285,387/year. This biogas plant requires \$1.0 million funding (17% of CAPEX) for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$583,409/year; equal to 83% of operating costs. Operating income should be sufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (i.e., broken equipment, unexpected downtime, etc.).

Option B: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>		<u>Revenue</u>		<u>Investment</u>
Digester	\$2,522,100			RNG/GJ =	\$30.00	Farm Investment = \$4,679,980
Upgrader	\$2,111,800			Avg RNG Sales/Yr =	\$1,068,641	Funding Amount = \$970,080
Nutrient Recovery	\$280,264			Tip Fee/Yr =	\$180,300	Funding % of CAPEX = 17%
Other	\$735,896			Bedding Savings/Yr* =	\$36,446	
Total	<u>\$5,650,060</u>	<u>\$701,978</u>		Total =	<u>\$1,285,387</u>	Inflation = 2%

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$1,279	\$1,280	\$1,280	\$1,281	\$1,281	\$1,282	\$1,283	\$1,283	\$1,284	\$1,285
OPEX (000s)	\$578	\$589	\$601	\$613	\$625	\$638	\$651	\$664	\$677	\$691
<i>Income (000s)</i>	\$701	\$690	\$679	\$668	\$656	\$644	\$632	\$620	\$607	\$594

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$1,286	\$1,286	\$1,287	\$1,288	\$1,289	\$1,289	\$1,290	\$1,291	\$1,292	\$1,293
OPEX (000s)	\$704	\$718	\$733	\$747	\$762	\$778	\$793	\$809	\$825	\$842
<i>Income (000s)</i>	\$581	\$568	\$554	\$540	\$526	\$512	\$497	\$482	\$467	\$451

Unlevered, Pre-Tax IRR =	12%	Average Operating Income* =	\$583,409	% of OPEX	83%
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* Averaged over twenty years to account for inflation

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 83% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, with 17% funding, if RNG production is 10% or 20% higher than anticipated (due to the availability of high biogas-potential mixed food waste), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$26/GJ and <\$24/GJ respectively. Alternately, with 17% funding, if RNG production is 5% or 10% lower than anticipated, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 10.5% and 9.0% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Mixed food waste tip fee accounts for 14% of biogas plant revenue. Therefore, although less important than RNG sales, food waste tip fee can have a significant impact on biogas plant economic feasibility. For example, with 17% funding, if mixed food waste tip fee is \$35/tonne or \$50/tonne instead of \$25/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$27/GJ and <\$24/GJ respectively. Alternately, with 17% funding, if mixed food waste tip fee is only \$20/tonne or \$15/tonne, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 11.0% and 10.0% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option B: Sensitivity Analysis – RNG Production & Mixed Food Waste Tip Fee

		Change in RNG Production Amount						
		-10%	-5%	0%	5%	10%	15%	20%
\$/GJ RNG	\$16	---	---	---	---	---	0.1%	1.4%
	\$17	---	---	---	---	0.6%	2.0%	3.2%
	\$18	---	---	---	0.9%	2.3%	3.6%	4.8%
	\$19	---	---	1.1%	2.5%	3.9%	5.1%	6.3%
	\$20	---	1.1%	2.6%	4.0%	5.3%	6.5%	7.7%
	\$21	0.9%	2.5%	4.0%	5.4%	6.6%	7.8%	9.0%
	\$22	2.3%	3.9%	5.3%	6.6%	7.9%	9.1%	10.2%
	\$23	3.6%	5.1%	6.5%	7.8%	9.1%	10.3%	11.4%
	\$24	4.8%	6.3%	7.7%	9.0%	10.2%	11.4%	12.6%
	\$25	5.9%	7.4%	8.8%	10.1%	11.3%	12.6%	13.7%
	\$26	6.9%	8.3%	9.7%	11.1%	12.3%	13.6%	14.8%
	\$27	7.7%	9.2%	10.6%	11.9%	13.3%	14.5%	15.8%
	\$28	8.3%	9.8%	11.3%	12.7%	14.0%	15.3%	16.6%
\$29	8.8%	10.3%	11.8%	13.2%	14.6%	15.9%	17.3%	
\$30	9.0%	10.5%	12.0%	13.5%	14.9%	16.2%	17.6%	

		Mixed Food Waste Tip Fee (\$/Tonne)							
		\$15	\$20	\$25	\$30	\$35	\$40	\$45	\$50
\$/GJ RNG	\$16			---	---	---	0.7%	2.2%	3.5%
	\$17			---	---	0.8%	2.3%	3.6%	4.9%
	\$18			---	1.0%	2.4%	3.7%	5.0%	6.1%
	\$19			1.1%	2.5%	3.8%	5.1%	6.2%	7.3%
	\$20	-0.3%	1.2%	2.6%	3.9%	5.1%	6.3%	7.4%	8.5%
	\$21	1.3%	2.7%	4.0%	5.2%	6.4%	7.5%	8.5%	9.5%
	\$22	2.8%	4.1%	5.3%	6.4%	7.5%	8.6%	9.6%	10.6%
	\$23	4.2%	5.4%	6.5%	7.6%	8.6%	9.6%	10.6%	11.6%
	\$24	5.5%	6.6%	7.7%	8.7%	9.7%	10.7%	11.6%	12.6%
	\$25	6.6%	7.7%	8.8%	9.8%	10.7%	11.7%	12.6%	13.5%
	\$26	7.7%	8.7%	9.7%	10.7%	11.7%	12.6%	13.5%	14.4%
	\$27	8.6%	9.6%	10.6%	11.6%	12.5%	13.4%	14.3%	15.2%
	\$28	9.3%	10.3%	11.3%	12.3%	13.2%	14.1%	15.0%	15.9%
\$29	9.8%	10.8%	11.8%	12.8%	13.7%	14.7%	15.6%	16.5%	
\$30	10.0%	11.0%	12.0%	13.0%	14.0%	14.9%	15.8%	16.7%	

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #2 - Option C: RNG Compression Equipment

This biogas plant is estimated to cost \$5.6 million to build. Operating costs are estimated to average \$808,858/year. At an RNG sale price of \$30/GJ, average revenue is estimated to be \$1,285,387/year. This biogas plant requires \$1.6 million funding (29% of CAPEX) for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$476,529/year; equal to 59% of operating costs. Operating income should be sufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (i.e., broken equipment, unexpected downtime, etc.).

Option C: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>		<u>Revenue</u>		<u>Investment</u>	
Digester	\$1,794,975			RNG/GJ =	\$30.00	Farm Investment =	\$3,949,812
Upgrader	\$2,779,817			Avg RNG Sales/Yr =	\$1,068,641	Funding Amount =	\$1,632,288
Nutrient Recovery	\$280,264			Tip Fee/Yr =	\$180,300	Funding % of CAPEX =	29%
Other	\$727,045			Bedding Savings/Yr* =	\$36,446		
Total	<u>\$5,582,101</u>	<u>\$808,858</u>		Total =	<u>\$1,285,387</u>	Inflation =	2%

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$1,279	\$1,280	\$1,280	\$1,281	\$1,281	\$1,282	\$1,283	\$1,283	\$1,284	\$1,285
OPEX (000s)	\$666	\$679	\$693	\$707	\$721	\$735	\$750	\$765	\$780	\$796
<i>Income (000s)</i>	\$613	\$600	\$587	\$574	\$561	\$547	\$533	\$519	\$504	\$489

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$1,286	\$1,286	\$1,287	\$1,288	\$1,289	\$1,289	\$1,290	\$1,291	\$1,292	\$1,293
OPEX (000s)	\$812	\$828	\$844	\$861	\$879	\$896	\$914	\$932	\$951	\$970
<i>Income (000s)</i>	\$474	\$458	\$443	\$426	\$410	\$393	\$376	\$359	\$341	\$323

Unlevered, Pre-Tax IRR =	12%
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Average Operating Income* =	\$476,529
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% of OPEX	59%
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* Averaged over twenty years to account for inflation

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 83% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, with 29% funding, if RNG production is 10% or 20% higher than anticipated (due to the availability of high biogas-potential mixed food waste), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$26/GJ and <\$24/GJ respectively. Alternately, with 29% funding, if RNG production is 5% or 10% lower than anticipated, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 10.1% and 8.2% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Mixed food waste tip fee accounts for 14% of biogas plant revenue. Therefore, although less important than RNG sales, food waste tip fee can have a significant impact on biogas plant economic feasibility. For example, with 29% funding, if mixed food waste tip fee is \$35/tonne or \$50/tonne instead of \$25/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$27/GJ and <\$24/GJ respectively. Alternately, with 29% funding, if mixed food waste tip fee is only \$20/tonne or \$15/tonne, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 10.8% and 9.5% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option C: Sensitivity Analysis – RNG Production & Mixed Food Waste Tip Fee

		Change in RNG Production Amount						
		-10%	-5%	0%	5%	10%	15%	20%
\$/GJ RNG	\$16	---	---	---	---	---	---	---
	\$17	---	---	---	---	---	---	0.6%
	\$18	---	---	---	---	---	1.2%	2.8%
	\$19	---	---	---	---	1.5%	3.3%	4.8%
	\$20	---	---	---	1.7%	3.5%	5.1%	6.6%
	\$21	---	---	1.7%	3.6%	5.3%	6.8%	8.2%
	\$22	---	1.5%	3.5%	5.3%	6.9%	8.4%	9.8%
	\$23	1.2%	3.3%	5.1%	6.8%	8.4%	9.9%	11.3%
	\$24	2.8%	4.8%	6.6%	8.2%	9.8%	11.3%	12.7%
	\$25	4.3%	6.2%	8.0%	9.6%	11.1%	12.6%	14.0%
	\$26	5.6%	7.4%	9.2%	10.8%	12.4%	13.9%	15.3%
	\$27	6.6%	8.5%	10.2%	11.9%	13.5%	15.0%	16.5%
	\$28	7.4%	9.3%	11.1%	12.8%	14.4%	16.0%	17.5%
\$29	7.9%	9.9%	11.7%	13.4%	15.1%	16.7%	18.3%	
\$30	8.2%	10.1%	12.0%	13.7%	15.4%	17.1%	18.7%	

		Mixed Food Waste Tip Fee (\$/Tonne)							
		\$15	\$20	\$25	\$30	\$35	\$40	\$45	\$50
\$/GJ RNG	\$16	---	---	---	---	---	---	---	1.0%
	\$17	---	---	---	---	---	---	1.1%	2.9%
	\$18	---	---	---	---	---	1.3%	3.0%	4.6%
	\$19	---	---	---	---	1.4%	3.1%	4.7%	6.1%
	\$20	---	---	---	1.6%	3.3%	4.8%	6.2%	7.6%
	\$21	---	---	1.7%	3.4%	4.9%	6.3%	7.7%	8.9%
	\$22	0.1%	1.9%	3.5%	5.0%	6.4%	7.7%	9.0%	10.2%
	\$23	2.0%	3.6%	5.1%	6.5%	7.8%	9.1%	10.3%	11.4%
	\$24	3.7%	5.2%	6.6%	7.9%	9.1%	10.3%	11.5%	12.6%
	\$25	5.3%	6.7%	8.0%	9.2%	10.4%	11.6%	12.7%	13.8%
	\$26	6.6%	7.9%	9.2%	10.4%	11.5%	12.7%	13.8%	14.9%
	\$27	7.7%	9.0%	10.2%	11.4%	12.6%	13.7%	14.8%	15.8%
	\$28	8.6%	9.9%	11.1%	12.3%	13.4%	14.5%	15.6%	16.7%
\$29	9.2%	10.5%	11.7%	12.9%	14.0%	15.2%	16.3%	17.3%	
\$30	9.5%	10.8%	12.0%	13.2%	14.3%	15.5%	16.6%	17.7%	

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #2 - Option D: Nutrient Recovery Equipment

This biogas plant is estimated to cost \$5.9 million to build. Operating costs are estimated to average \$852,649/year. At an RNG sale price of \$30/GJ, average revenue is estimated to be \$1,285,387/year. This biogas plant requires \$2.2 million funding (38% of CAPEX) for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$432,738/year; equal to 51% of operating costs. Operating income should be sufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (i.e., broken equipment, unexpected downtime, etc.).

Option D: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>	<u>Revenue</u>		<u>Investment</u>	
Digester	\$2,025,975		RNG/GJ =	\$30.00	Farm Investment =	\$3,636,161
Upgrader	\$2,111,800		Avg RNG Sales/Yr =	\$1,068,641	Funding Amount =	\$2,219,561
Nutrient Recovery	\$955,264		Tip Fee/Yr =	\$180,300	Funding % of CAPEX =	38%
Other	\$762,683		Bedding Savings/Yr* =	\$36,446		
Total	<u>\$5,855,721</u>	<u>\$852,649</u>	Total =	<u>\$1,285,387</u>	Inflation =	2%

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$1,279	\$1,280	\$1,280	\$1,281	\$1,281	\$1,282	\$1,283	\$1,283	\$1,284	\$1,285
OPEX (000s)	\$702	\$716	\$730	\$745	\$760	\$775	\$790	\$806	\$822	\$839
<i>Income (000s)</i>	\$577	\$564	\$550	\$536	\$522	\$507	\$492	\$477	\$462	\$446

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$1,286	\$1,286	\$1,287	\$1,288	\$1,289	\$1,289	\$1,290	\$1,291	\$1,292	\$1,293
OPEX (000s)	\$856	\$873	\$890	\$908	\$926	\$945	\$963	\$983	\$1,002	\$1,022
<i>Income (000s)</i>	\$430	\$414	\$397	\$380	\$362	\$345	\$327	\$308	\$289	\$270

Unlevered, Pre-Tax IRR =	12%	Average Operating Income* =	\$432,738	% of OPEX	51%
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* Averaged over twenty years to account for inflation

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 83% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, with 38% funding, if RNG production is 10% or 20% higher than anticipated (due to the availability of high biogas-potential mixed food waste), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$26/GJ and <\$24/GJ respectively. Alternately, with 38% funding, if RNG production is 5% or 10% lower than anticipated, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 10.0% and 7.8% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Mixed food waste tip fee accounts for 14% of biogas plant revenue. Therefore, although less important than RNG sales, food waste tip fee can have a significant impact on biogas plant economic feasibility. For example, with 38% funding, if mixed food waste tip fee is \$35/tonne or \$50/tonne instead of \$25/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$27/GJ and <\$24/GJ respectively. Alternately, with 38% funding, if mixed food waste tip fee is only \$20/tonne or \$15/tonne, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 10.7% and 9.2% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option D: Sensitivity Analysis – RNG Production & Mixed Food Waste Tip Fee

		Change in RNG Production Amount						
		-10%	-5%	0%	5%	10%	15%	20%
\$/GJ RNG	\$16	---	---	---	---	---	---	---
	\$17	---	---	---	---	---	---	---
	\$18	---	---	---	---	---	---	1.7%
	\$19	---	---	---	---	0.1%	2.2%	4.0%
	\$20	---	---	---	0.4%	2.5%	4.4%	6.0%
	\$21	---	---	0.4%	2.6%	4.5%	6.3%	7.9%
	\$22	---	0.1%	2.5%	4.5%	6.4%	8.0%	9.6%
	\$23	---	2.2%	4.4%	6.3%	8.0%	9.7%	11.2%
	\$24	1.7%	4.0%	6.0%	7.9%	9.6%	11.2%	12.8%
	\$25	3.4%	5.6%	7.6%	9.4%	11.1%	12.7%	14.3%
	\$26	4.9%	7.0%	8.9%	10.7%	12.4%	14.1%	15.6%
	\$27	6.0%	8.1%	10.1%	11.9%	13.6%	15.3%	16.9%
	\$28	6.9%	9.0%	11.0%	12.9%	14.7%	16.4%	18.0%
	\$29	7.5%	9.7%	11.7%	13.6%	15.4%	17.2%	18.9%
\$30	7.8%	10.0%	12.0%	14.0%	15.8%	17.6%	19.3%	

		Mixed Food Waste Tip Fee (\$/Tonne)							
		\$15	\$20	\$25	\$30	\$35	\$40	\$45	\$50
\$/GJ RNG	\$16	---	---	---	---	---	---	---	---
	\$17	---	---	---	---	---	---	---	1.7%
	\$18	---	---	---	---	---	---	1.9%	3.7%
	\$19	---	---	---	---	0.0%	2.0%	3.9%	5.5%
	\$20	---	---	---	0.2%	2.2%	4.0%	5.6%	7.1%
	\$21	---	---	0.4%	2.3%	4.1%	5.7%	7.2%	8.6%
	\$22	---	0.5%	2.5%	4.2%	5.8%	7.3%	8.7%	10.1%
	\$23	0.7%	2.6%	4.4%	5.9%	7.4%	8.8%	10.1%	11.4%
	\$24	2.8%	4.5%	6.0%	7.5%	8.9%	10.2%	11.5%	12.7%
	\$25	4.6%	6.1%	7.6%	9.0%	10.3%	11.6%	12.8%	14.0%
	\$26	6.1%	7.5%	8.9%	10.3%	11.5%	12.8%	14.0%	15.2%
	\$27	7.3%	8.7%	10.1%	11.4%	12.6%	13.9%	15.1%	16.2%
	\$28	8.2%	9.7%	11.0%	12.3%	13.6%	14.8%	16.0%	17.2%
	\$29	8.9%	10.4%	11.7%	13.0%	14.3%	15.5%	16.7%	17.9%
\$30	9.2%	10.7%	12.0%	13.3%	14.6%	15.9%	17.1%	18.2%	

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #2 - Option E: Mixed Food Waste Cleaning & RNG Compression Equipment

This biogas plant is estimated to cost \$6.4 million to build. Operating costs are estimated to average \$890,700/year. At an RNG sale price of \$30/GJ, average revenue is estimated to be \$1,285,387/year. This biogas plant requires \$3.0 million funding (47% of CAPEX) for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$394,687/year; equal to 44% of operating costs. Operating income may or may not be sufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (e.g., broken equipment, unexpected downtime, etc.).

Option E: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>	<u>Revenue</u>		<u>Investment</u>	
Digester	\$2,522,100		RNG/GJ =	\$30.00	Farm Investment =	\$3,379,035
Upgrader	\$2,779,817		Avg RNG Sales/Yr =	\$1,068,641	Funding Amount =	\$3,039,078
Nutrient Recovery	\$280,264		Tip Fee/Yr =	\$180,300	Funding % of CAPEX =	47%
Other	\$835,932		Bedding Savings/Yr* =	\$36,446		
Total	<u>\$6,418,113</u>	<u>\$890,700</u>	Total =	<u>\$1,285,387</u>	Inflation =	2%

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$1,279	\$1,280	\$1,280	\$1,281	\$1,281	\$1,282	\$1,283	\$1,283	\$1,284	\$1,285
OPEX (000s)	\$733	\$748	\$763	\$778	\$794	\$809	\$826	\$842	\$859	\$876
<i>Income (000s)</i>	\$546	\$532	\$517	\$503	\$488	\$473	\$457	\$441	\$425	\$409

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$1,286	\$1,286	\$1,287	\$1,288	\$1,289	\$1,289	\$1,290	\$1,291	\$1,292	\$1,293
OPEX (000s)	\$894	\$912	\$930	\$948	\$967	\$987	\$1,006	\$1,027	\$1,047	\$1,068
<i>Income (000s)</i>	\$392	\$375	\$357	\$339	\$321	\$303	\$284	\$264	\$245	\$225

Unlevered, Pre-Tax IRR =	12%	Average Operating Income* =	\$394,687	% of OPEX	44%
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* Averaged over twenty years to account for inflation

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 83% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, with 47% funding, if RNG production is 10% or 20% higher than anticipated (due to the availability of high biogas-potential mixed food waste), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$26/GJ and <\$24/GJ respectively. Alternately, with 47% funding, if RNG production is 5% or 10% lower than anticipated, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 9.7% and 7.3% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Mixed food waste tip fee accounts for 14% of biogas plant revenue. Therefore, although less important than RNG sales, food waste tip fee can have a significant impact on biogas plant economic feasibility. For example, with 47% funding, if mixed food waste tip fee is \$35/tonne or \$50/tonne instead of \$25/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$27/GJ and <\$24/GJ respectively. Alternately, with 47% funding, if mixed food waste tip fee is only \$20/tonne or \$15/tonne, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 10.5% and 8.9% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option E: Sensitivity Analysis – RNG Production & Mixed Food Waste Tip Fee

		Change in RNG Production Amount						
		-10%	-5%	0%	5%	10%	15%	20%
\$/GJ RNG	\$16	---	---	---	---	---	---	---
	\$17	---	---	---	---	---	---	---
	\$18	---	---	---	---	---	---	0.3%
	\$19	---	---	---	---	---	0.9%	3.0%
	\$20	---	---	---	---	1.3%	3.5%	5.4%
	\$21	---	---	---	1.4%	3.7%	5.7%	7.5%
	\$22	---	---	1.3%	3.7%	5.7%	7.6%	9.3%
	\$23	---	0.9%	3.5%	5.7%	7.6%	9.4%	11.1%
	\$24	0.3%	3.0%	5.4%	7.5%	9.3%	11.1%	12.8%
	\$25	2.4%	4.9%	7.1%	9.1%	11.0%	12.7%	14.4%
	\$26	4.0%	6.4%	8.6%	10.6%	12.4%	14.2%	15.9%
	\$27	5.3%	7.7%	9.9%	11.9%	13.7%	15.5%	17.3%
	\$28	6.3%	8.7%	10.9%	12.9%	14.9%	16.7%	18.5%
\$29	7.0%	9.4%	11.6%	13.7%	15.7%	17.6%	19.4%	
\$30	7.3%	9.7%	12.0%	14.1%	16.1%	18.0%	19.9%	

		Mixed Food Waste Tip Fee (\$/Tonne)							
		\$15	\$20	\$25	\$30	\$35	\$40	\$45	\$50
\$/GJ RNG	\$16	---	---	---	---	---	---	---	---
	\$17	---	---	---	---	---	---	---	0.3%
	\$18	---	---	---	---	---	---	0.5%	2.7%
	\$19	---	---	---	---	---	0.7%	2.9%	4.8%
	\$20	---	---	---	---	0.9%	3.0%	4.9%	6.6%
	\$21	---	---	---	1.1%	3.2%	5.0%	6.7%	8.3%
	\$22	---	---	1.3%	3.3%	5.1%	6.8%	8.4%	9.9%
	\$23	---	1.4%	3.5%	5.3%	6.9%	8.5%	9.9%	11.3%
	\$24	1.6%	3.6%	5.4%	7.0%	8.6%	10.0%	11.4%	12.8%
	\$25	3.7%	5.5%	7.1%	8.6%	10.1%	11.5%	12.8%	14.1%
	\$26	5.4%	7.1%	8.6%	10.1%	11.5%	12.8%	14.1%	15.4%
	\$27	6.8%	8.4%	9.9%	11.3%	12.7%	14.0%	15.3%	16.5%
	\$28	7.8%	9.4%	10.9%	12.3%	13.7%	15.0%	16.3%	17.6%
\$29	8.6%	10.1%	11.6%	13.1%	14.4%	15.8%	17.1%	18.3%	
\$30	8.9%	10.5%	12.0%	13.4%	14.8%	16.2%	17.5%	18.7%	

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #2 - Option F: Mixed Food Waste Cleaning & Nutrient Recovery Equipment

This biogas plant is estimated to cost \$6.7 million to build. Operating costs are estimated to average \$934,491/year. At an RNG sale price of \$30/GJ, average revenue is estimated to be \$1,285,387/year. This biogas plant requires \$3.6 million funding (54% of CAPEX) for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$350,896/year; equal to 38% of operating costs. Operating income may or may not be sufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (e.g., broken equipment, unexpected downtime, etc.).

Option F: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>	<u>Revenue</u>		<u>Investment</u>	
Digester	\$2,753,100		RNG/GJ =	\$30.00	Farm Investment =	\$3,076,236
Upgrader	\$2,111,800		Avg RNG Sales/Yr =	\$1,068,641	Funding Amount =	\$3,615,498
Nutrient Recovery	\$955,264		Tip Fee/Yr =	\$180,300	Funding % of CAPEX =	54%
Other	\$871,570		Bedding Savings/Yr* =	\$36,446		
Total	<u>\$6,691,733</u>	<u>\$934,491</u>	Total =	<u>\$1,285,387</u>	<i>Inflation =</i>	<i>2%</i>

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$1,279	\$1,280	\$1,280	\$1,281	\$1,281	\$1,282	\$1,283	\$1,283	\$1,284	\$1,285
OPEX (000s)	\$769	\$785	\$800	\$816	\$833	\$849	\$866	\$884	\$901	\$919
<i>Income (000s)</i>	\$510	\$495	\$480	\$464	\$449	\$433	\$416	\$400	\$383	\$366

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$1,286	\$1,286	\$1,287	\$1,288	\$1,289	\$1,289	\$1,290	\$1,291	\$1,292	\$1,293
OPEX (000s)	\$938	\$956	\$976	\$995	\$1,015	\$1,035	\$1,056	\$1,077	\$1,099	\$1,121
<i>Income (000s)</i>	\$348	\$330	\$311	\$293	\$274	\$254	\$234	\$214	\$193	\$172

Unlevered, Pre-Tax IRR =	12%	Average Operating Income* =	\$350,896	% of OPEX	38%
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** Averaged over twenty years to account for inflation*

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 83% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, with 54% funding, if RNG production is 10% or 20% higher than anticipated (due to the availability of high biogas-potential mixed food waste), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$26/GJ and <\$24/GJ respectively. Alternately, with 54% funding, if RNG production is 5% or 10% lower than anticipated, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 9.4% and 6.5% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Mixed food waste tip fee accounts for 14% of biogas plant revenue. Therefore, although less important than RNG sales, food waste tip fee can have a significant impact on biogas plant economic feasibility. For example, with 54% funding, if mixed food waste tip fee is \$35/tonne or \$50/tonne instead of \$25/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$27/GJ and <\$24/GJ respectively. Alternately, with 54% funding, if mixed food waste tip fee is only \$20/tonne or \$15/tonne, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 10.3% and 8.5% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option F: Sensitivity Analysis – RNG Production & Mixed Food Waste Tip Fee

		Change in RNG Production Amount						
		-10%	-5%	0%	5%	10%	15%	20%
\$/GJ RNG	\$16	---	---	---	---	---	---	---
	\$17	---	---	---	---	---	---	---
	\$18	---	---	---	---	---	---	---
	\$19	---	---	---	---	---	---	1.6%
	\$20	---	---	---	---	---	2.1%	4.4%
	\$21	---	---	---	---	2.4%	4.8%	6.9%
	\$22	---	---	---	2.4%	4.9%	7.0%	9.0%
	\$23	---	---	2.1%	4.8%	7.0%	9.1%	11.0%
	\$24	---	1.6%	4.4%	6.9%	9.0%	11.0%	12.9%
	\$25	0.8%	3.9%	6.5%	8.8%	10.8%	12.8%	14.7%
	\$26	2.8%	5.7%	8.2%	10.4%	12.5%	14.4%	16.3%
	\$27	4.3%	7.1%	9.6%	11.8%	13.9%	15.9%	17.8%
	\$28	5.4%	8.3%	10.7%	13.0%	15.2%	17.2%	19.2%
\$29	6.2%	9.1%	11.6%	13.9%	16.1%	18.2%	20.2%	
\$30	6.5%	9.4%	12.0%	14.3%	16.6%	18.7%	20.8%	

		Mixed Food Waste Tip Fee (\$/Tonne)							
		\$15	\$20	\$25	\$30	\$35	\$40	\$45	\$50
\$/GJ RNG	\$16	---	---	---	---	---	---	---	---
	\$17	---	---	---	---	---	---	---	---
	\$18	---	---	---	---	---	---	---	1.1%
	\$19	---	---	---	---	---	---	1.3%	3.7%
	\$20	---	---	---	---	---	1.5%	3.8%	5.9%
	\$21	---	---	---	---	1.7%	4.0%	6.0%	7.8%
	\$22	---	---	---	1.9%	4.1%	6.1%	7.9%	9.6%
	\$23	---	---	2.1%	4.3%	6.2%	8.0%	9.7%	11.3%
	\$24	---	2.3%	4.4%	6.4%	8.1%	9.8%	11.3%	12.8%
	\$25	2.5%	4.6%	6.5%	8.2%	9.9%	11.4%	12.9%	14.3%
	\$26	4.5%	6.4%	8.2%	9.8%	11.4%	12.9%	14.3%	15.7%
	\$27	6.0%	7.9%	9.6%	11.2%	12.7%	14.2%	15.6%	17.0%
	\$28	7.2%	9.1%	10.7%	12.3%	13.9%	15.3%	16.8%	18.2%
\$29	8.1%	9.9%	11.6%	13.2%	14.7%	16.2%	17.6%	19.0%	
\$30	8.5%	10.3%	12.0%	13.6%	15.1%	16.6%	18.1%	19.5%	

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #2 - Option G: RNG Compression and Nutrient Recovery Equipment

This biogas plant is estimated to cost \$6.6 million to build. Operating costs are estimated to average \$1,041,371/year. At an RNG sale price of \$30/GJ, average revenue is estimated to be \$1,285,387/year. This biogas plant requires \$4.3 million funding (65% of CAPEX) for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$244,016/year; equal to 23% of operating costs. Operating income is likely insufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (i.e., broken equipment, unexpected downtime, etc.). This is because farm investment (i.e., debt) is only 35%. Low investment means that even with an unlevered, pre-tax IRR of 12%, operating income can be too low.

Option G: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>	<u>Revenue</u>		<u>Investment</u>	
Digester	\$2,025,975		RNG/GJ =	\$30.00	Farm Investment =	\$2,334,679
Upgrader	\$2,779,817		Avg RNG Sales/Yr =	\$1,068,641	Funding Amount =	\$4,289,095
Nutrient Recovery	\$955,264		Tip Fee/Yr =	\$180,300	Funding % of CAPEX =	65%
Other	\$862,718		Bedding Savings/Yr* =	\$36,446		
Total	<u>\$6,623,774</u>	<u>\$1,041,371</u>	Total =	<u>\$1,285,387</u>	Inflation =	2%

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$1,279	\$1,280	\$1,280	\$1,281	\$1,281	\$1,282	\$1,283	\$1,283	\$1,284	\$1,285
OPEX (000s)	\$857	\$874	\$892	\$910	\$928	\$946	\$965	\$985	\$1,004	\$1,024
<i>Income (000s)</i>	\$422	\$405	\$388	\$371	\$354	\$336	\$317	\$299	\$280	\$260

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$1,286	\$1,286	\$1,287	\$1,288	\$1,289	\$1,289	\$1,290	\$1,291	\$1,292	\$1,293
OPEX (000s)	\$1,045	\$1,066	\$1,087	\$1,109	\$1,131	\$1,154	\$1,177	\$1,200	\$1,224	\$1,249
<i>Income (000s)</i>	\$241	\$220	\$200	\$179	\$157	\$136	\$113	\$91	\$68	\$44

Unlevered, Pre-Tax IRR =	12%	Average Operating Income* =	\$244,016	% of OPEX	23%
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* Averaged over twenty years to account for inflation

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 83% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, with 65% funding, if RNG production is 10% or 20% higher than anticipated (due to the availability of high biogas-potential mixed food waste), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$26/GJ and <\$24/GJ respectively. Alternately, with 65% funding, if RNG production is 5% or 10% lower than anticipated, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 8.1% and 2.9% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Mixed food waste tip fee accounts for 14% of biogas plant revenue. Therefore, although less important than RNG sales, food waste tip fee can have a significant impact on biogas plant economic feasibility. For example, with 65% funding, if mixed food waste tip fee is \$35/tonne or \$50/tonne instead of \$25/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$27/GJ and <\$24/GJ respectively. Alternately, with 65% funding, if mixed food waste tip fee is only \$20/tonne or \$15/tonne, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 9.4% and 6.5% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option G: Sensitivity Analysis – RNG Production & Mixed Food Waste Tip Fee

		Change in RNG Production Amount						
		-10%	-5%	0%	5%	10%	15%	20%
\$/GJ RNG	\$16	---	---	---	---	---	---	---
	\$17	---	---	---	---	---	---	---
	\$18	---	---	---	---	---	---	---
	\$19	---	---	---	---	---	---	---
	\$20	---	---	---	---	---	---	0.0%
	\$21	---	---	---	---	---	0.6%	4.4%
	\$22	---	---	---	---	0.8%	4.7%	7.7%
	\$23	---	---	---	0.6%	4.7%	7.9%	10.6%
	\$24	---	---	0.0%	4.4%	7.7%	10.6%	13.2%
	\$25	---	---	3.7%	7.3%	10.4%	13.1%	15.6%
	\$26	---	2.2%	6.4%	9.7%	12.6%	15.3%	17.8%
	\$27	---	4.6%	8.5%	11.7%	14.6%	17.3%	19.8%
	\$28	1.1%	6.4%	10.2%	13.4%	16.3%	19.1%	21.6%
\$29	2.4%	7.6%	11.4%	14.7%	17.7%	20.4%	23.1%	
\$30	2.9%	8.1%	12.0%	15.3%	18.3%	21.2%	23.9%	

		Mixed Food Waste Tip Fee (\$/Tonne)							
		\$15	\$20	\$25	\$30	\$35	\$40	\$45	\$50
\$/GJ RNG	\$16	---	---	---	---	---	---	---	---
	\$17	---	---	---	---	---	---	---	---
	\$18	---	---	---	---	---	---	---	---
	\$19	---	---	---	---	---	---	---	---
	\$20	---	---	---	---	---	---	---	2.5%
	\$21	---	---	---	---	---	---	2.8%	5.8%
	\$22	---	---	---	---	---	3.0%	6.0%	8.5%
	\$23	---	---	---	---	3.3%	6.2%	8.7%	10.9%
	\$24	---	---	0.0%	3.5%	6.4%	8.8%	11.1%	13.1%
	\$25	---	0.3%	3.7%	6.5%	8.9%	11.2%	13.2%	15.2%
	\$26	---	3.5%	6.4%	8.9%	11.1%	13.2%	15.2%	17.1%
	\$27	2.7%	5.9%	8.5%	10.9%	13.0%	15.0%	16.9%	18.8%
	\$28	4.6%	7.6%	10.2%	12.5%	14.6%	16.6%	18.5%	20.3%
\$29	5.9%	8.9%	11.4%	13.7%	15.8%	17.8%	19.7%	21.6%	
\$30	6.5%	9.4%	12.0%	14.2%	16.4%	18.4%	20.3%	22.2%	

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #2 - Option H: Mixed Food Waste Cleaning, RNG Compression and Nutrient Recovery Equipment

This biogas plant is estimated to cost \$7.5 million to build. Operating costs are estimated to average \$1,123,213/year. At an RNG sale price of \$30/GJ, average revenue is estimated to be \$1,285,387/year. This biogas plant requires \$5.7 million funding (76% of CAPEX) for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$162,174/year; equal to 14% of operating costs. Operating income is likely insufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (i.e., broken equipment, unexpected downtime, etc.). This is because farm investment (i.e., debt) is only 24%. Low investment means that even with an unlevered, pre-tax IRR of 12%, operating income can be too low.

Option H: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>	<u>Revenue</u>		<u>Investment</u>	
Digester	\$2,753,100		RNG/GJ =	\$30.00	Farm Investment =	\$1,761,819
Upgrader	\$2,779,817		Avg RNG Sales/Yr =	\$1,068,641	Funding Amount =	\$5,697,967
Nutrient Recovery	\$955,264		Tip Fee/Yr =	\$180,300	Funding % of CAPEX =	76%
Other	\$971,605		Bedding Savings/Yr* =	\$36,446		
Total	<u>\$7,459,786</u>	<u>\$1,123,213</u>	Total =	<u>\$1,285,387</u>	Inflation =	2%

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$1,279	\$1,280	\$1,280	\$1,281	\$1,281	\$1,282	\$1,283	\$1,283	\$1,284	\$1,285
OPEX (000s)	\$925	\$943	\$962	\$981	\$1,001	\$1,021	\$1,041	\$1,062	\$1,083	\$1,105
<i>Income (000s)</i>	\$354	\$336	\$318	\$300	\$281	\$261	\$242	\$221	\$201	\$180

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$1,286	\$1,286	\$1,287	\$1,288	\$1,289	\$1,289	\$1,290	\$1,291	\$1,292	\$1,293
OPEX (000s)	\$1,127	\$1,150	\$1,173	\$1,196	\$1,220	\$1,244	\$1,269	\$1,295	\$1,320	\$1,347
<i>Income (000s)</i>	\$158	\$137	\$114	\$92	\$69	\$45	\$21	-\$4	-\$29	-\$54

Unlevered, Pre-Tax IRR =	12%	Average Operating Income* =	\$162,174	% of OPEX	14%
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* Averaged over twenty years to account for inflation

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 83% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, with 76% funding, if RNG production is 10% or 20% higher than anticipated (due to the availability of high biogas-potential mixed food waste), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$26/GJ and <\$24/GJ respectively. Alternately, with 76% funding, if RNG production is 5% lower than anticipated, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 5.2%. An unlevered, pre-tax IRR <12% isn't economically feasible.

Mixed food waste tip fee accounts for 14% of biogas plant revenue. Therefore, although less important than RNG sales, food waste tip fee can have a significant impact on biogas plant economic feasibility. For example, with 76% funding, if mixed food waste tip fee is \$35/tonne or \$50/tonne instead of \$25/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$27/GJ and <\$24/GJ respectively. Alternately, with 76% funding, if mixed food waste tip fee is only \$20/tonne or \$15/tonne, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 7.9% and 0.8% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option H: Sensitivity Analysis – RNG Production & Mixed Food Waste Tip Fee

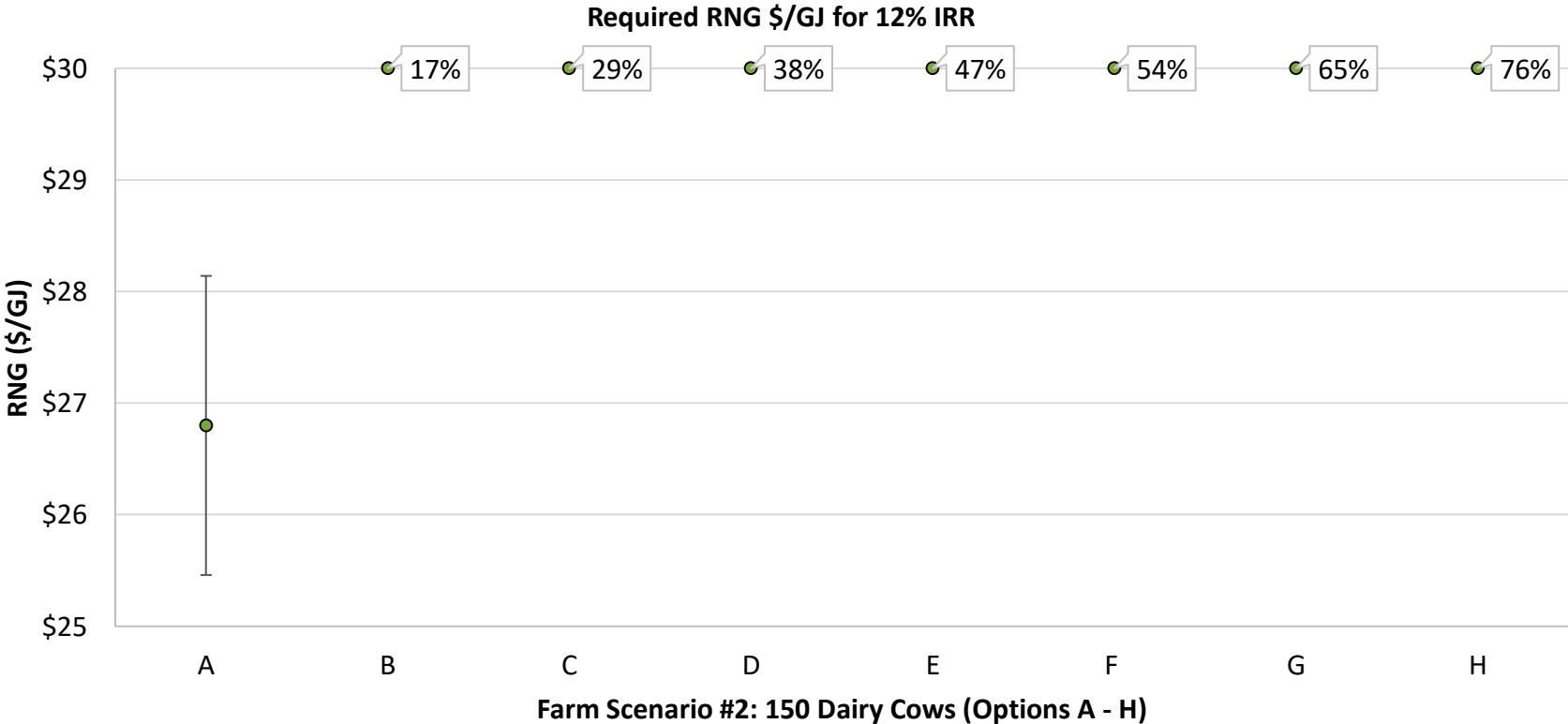
		Change in RNG Production Amount						
		-10%	-5%	0%	5%	10%	15%	20%
\$/GJ RNG	\$16	---	---	---	---	---	---	---
	\$17	---	---	---	---	---	---	---
	\$18	---	---	---	---	---	---	---
	\$19	---	---	---	---	---	---	---
	\$20	---	---	---	---	---	---	---
	\$21	---	---	---	---	---	---	---
	\$22	---	---	---	---	---	---	5.6%
	\$23	---	---	---	---	---	5.8%	10.0%
	\$24	---	---	---	---	5.6%	10.0%	13.7%
	\$25	---	---	---	4.9%	9.7%	13.5%	17.0%
	\$26	---	---	3.0%	8.7%	12.9%	16.6%	19.9%
	\$27	---	---	6.7%	11.7%	15.7%	19.3%	22.7%
	\$28	---	1.9%	9.3%	14.1%	18.1%	21.7%	25.1%
\$29	---	4.3%	11.1%	15.9%	20.0%	23.7%	27.2%	
\$30	---	5.2%	12.0%	16.8%	20.9%	24.8%	28.4%	

		Mixed Food Waste Tip Fee (\$/Tonne)							
		\$15	\$20	\$25	\$30	\$35	\$40	\$45	\$50
\$/GJ RNG	\$16	---	---	---	---	---	---	---	---
	\$17	---	---	---	---	---	---	---	---
	\$18	---	---	---	---	---	---	---	---
	\$19	---	---	---	---	---	---	---	---
	\$20	---	---	---	---	---	---	---	---
	\$21	---	---	---	---	---	---	---	1.7%
	\$22	---	---	---	---	---	---	2.2%	6.8%
	\$23	---	---	---	---	---	2.6%	7.0%	10.5%
	\$24	---	---	---	---	3.0%	7.3%	10.7%	13.6%
	\$25	---	---	---	3.4%	7.5%	10.8%	13.8%	16.5%
	\$26	---	---	3.0%	7.4%	10.8%	13.7%	16.5%	19.0%
	\$27	---	1.4%	6.7%	10.4%	13.5%	16.3%	18.9%	21.4%
	\$28	---	4.8%	9.3%	12.7%	15.7%	18.5%	21.0%	23.5%
\$29	---	6.9%	11.1%	14.5%	17.4%	20.2%	22.7%	25.2%	
\$30	0.8%	7.9%	12.0%	15.3%	18.3%	21.0%	23.6%	26.1%	

Farm Scenario #2: Summary

Figure 14 shows the required RNG \$/GJ sale price for Farm Scenario #2 Options A – G for an unlevered, pre-tax IRR of 12%. Where required RNG sale price is >\$30/GJ, percentage of required funding is also shown. Where required RNG sale price is <\$30/GJ, a bar representing +/- 5% is shown to account for price uncertainty. Only Farm Scenario #2 Option A doesn't require funding. This biogas plant requires \$25.46 - \$28.14/GJ. Farm Scenario #2 Options B – H require funding. Funding increases from 17% (for Option B) to 76% (for Option H). Figure 14 shows that only under the best circumstance (i.e., Option A - needing the least equipment) are 150 dairy cow farms co-digesting dairy manure and mixed food waste economically feasible in B.C. without funding.

Figure 14: Farm Scenario #2 - Required RNG Sale Price for 150 Dairy Cows + Mixed Food Waste



7.3

Farm Scenario #3: 200 Dairy Cows + Mixed Food Waste

Farm Scenario #3 is a 200 dairy cow farm co-digesting dairy manure and mixed food waste. Farm Scenario #3 assumes the use of traditional on-farm biogas plant technology. Estimated feedstock volume and Renewable Natural Gas (RNG) production for Farm Scenario #3 are as follows:

Feedstock	Tonnes/Year	Percentage	RNG Production (GJ/Year)
Dairy manure	10,008	51%	3,229
Mixed food waste	9,616	49%	46,730
<i>Total</i>	<i>19,624</i>	<i>100%</i>	<i>49,959</i>

The following Equipment Choices were assessed for Farm Scenario #3:

- Option A: No additional equipment;
- Option B: Mixed food waste cleaning equipment;
- Option C: RNG compression equipment;
- Option D: Nutrient recovery equipment;
- Option E: Mixed food waste cleaning and RNG compression equipment;
- Option F: Mixed food waste cleaning and nutrient recovery equipment;
- Option G: RNG compression and nutrient recovery equipment; and
- Option H: Mixed food waste cleaning, RNG compression and nutrient recovery equipment.

For full capital and operating costs for Farm Scenario #3 Options A – H, see Appendix C.

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #3 - Option A: No Additional Equipment-

This biogas plant is estimated to cost \$5.7 million to build. Operating costs are estimated to average \$710,923/year. At an RNG sale price of \$22.66/GJ, average revenue is estimated to be \$1,474,199/year. This biogas plant doesn't require funding for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$763,276/year; equal to 107% of operating costs. Operating income should be sufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (i.e., broken equipment, unexpected downtime, etc.).

Option A: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>	<u>Revenue</u>		<u>Investment</u>	
Digester	\$2,207,625		RNG/GJ [†] =	\$22.66	Farm Investment =	\$5,726,801
Upgrader	\$2,399,600		Avg RNG Sales/Yr =	\$1,185,205	Funding Amount =	\$0
Nutrient Recovery	\$373,685		Tip Fee/Yr =	\$240,399	Funding % of CAPEX =	0%
Other	\$745,891		Bedding Savings/Yr* =	\$48,595		
Total	<u>\$5,726,801</u>	<u>\$710,923</u>	Total =	<u>\$1,474,199</u>	Inflation =	2%

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$1,357	\$1,368	\$1,380	\$1,392	\$1,404	\$1,416	\$1,428	\$1,440	\$1,453	\$1,466
OPEX (000s)	\$585	\$597	\$609	\$621	\$633	\$646	\$659	\$672	\$686	\$699
Income (000s)	\$772	\$772	\$771	\$771	\$770	\$770	\$769	\$768	\$767	\$766

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$1,478	\$1,491	\$1,504	\$1,517	\$1,531	\$1,544	\$1,558	\$1,571	\$1,585	\$1,599
OPEX (000s)	\$713	\$728	\$742	\$757	\$772	\$788	\$803	\$819	\$836	\$853
Income (000s)	\$765	\$764	\$762	\$760	\$759	\$757	\$754	\$752	\$749	\$747

Unlevered, Pre-Tax IRR =	12%
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Average Operating Income* =	\$763,276
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% of OPEX	107%
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* Averaged over twenty years to account for inflation

[†] Base price (1%/year increase up to \$30/GJ max)

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 80% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, if RNG production is 10% or 20% higher than anticipated (due to the availability of high biogas-potential mixed food waste), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$22.66/GJ to <\$21/GJ and <\$19/GJ respectively. Alternately, if RNG production is 10% or 15% lower than anticipated, the required RNG sale price for an unlevered, pre-tax IRR increases from \$22.66/GJ to >\$25/GJ and >\$26/GJ respectively. Furthermore, if only 50% of estimated mixed food waste is available (4,808 instead of 9,616 tonnes/year), RNG production will be approximately 45% lower. If RNG production is 45% lower, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 2.7%. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option A: Sensitivity Analysis – RNG Production

		Change in RNG Production Amount														
		-50%	-45%	-40%	-35%	-30%	-25%	-20%	-15%	-10%	-5%	0%	5%	10%	15%	20%
\$/GJ RNG	\$16	---	---	---	---	---	---	---	0.1%	1.5%	2.8%	4.0%	5.1%	6.2%	7.2%	8.1%
	\$17	---	---	---	---	---	---	0.1%	1.6%	2.9%	4.2%	5.4%	6.5%	7.5%	8.6%	9.5%
	\$18	---	---	---	---	---	---	1.5%	2.9%	4.3%	5.5%	6.7%	7.8%	8.8%	9.9%	10.9%
	\$19	---	---	---	---	---	1.3%	2.8%	4.2%	5.5%	6.7%	7.9%	9.0%	10.1%	11.1%	12.1%
	\$20	---	---	---	---	0.8%	2.5%	4.0%	5.4%	6.7%	7.9%	9.1%	10.2%	11.3%	12.4%	13.4%
	\$21	---	---	---	0.2%	2.0%	3.6%	5.1%	6.5%	7.8%	9.0%	10.2%	11.4%	12.5%	13.5%	14.6%
	\$22	---	---	---	1.3%	3.1%	4.7%	6.2%	7.5%	8.8%	10.1%	11.3%	12.5%	13.6%	14.7%	15.8%
	\$23	---	---	0.5%	2.4%	4.1%	5.7%	7.2%	8.6%	9.9%	11.1%	12.4%	13.5%	14.7%	15.8%	16.9%
	\$24	---	---	1.5%	3.4%	5.1%	6.7%	8.1%	9.5%	10.9%	12.1%	13.4%	14.6%	15.8%	16.9%	18.1%
	\$25	---	0.4%	2.5%	4.3%	6.0%	7.6%	9.1%	10.5%	11.8%	13.1%	14.4%	15.6%	16.8%	18.0%	19.2%
	\$26	---	1.2%	3.3%	5.1%	6.8%	8.4%	9.9%	11.3%	12.7%	14.1%	15.3%	16.6%	17.9%	19.1%	20.3%
	\$27	---	1.8%	3.9%	5.8%	7.5%	9.1%	10.7%	12.1%	13.5%	14.9%	16.2%	17.5%	18.8%	20.0%	21.3%
	\$28	---	2.3%	4.4%	6.3%	8.1%	9.7%	11.3%	12.8%	14.2%	15.6%	17.0%	18.3%	19.6%	20.9%	22.2%
	\$29	0.1%	2.5%	4.7%	6.6%	8.4%	10.1%	11.7%	13.2%	14.7%	16.2%	17.6%	18.9%	20.3%	21.6%	22.9%
	\$30	0.2%	2.7%	4.8%	6.8%	8.6%	10.3%	11.9%	13.5%	15.0%	16.4%	17.9%	19.3%	20.6%	22.0%	23.3%

B.C. On-Farm Biogas Benchmark Study, Version 2

Mixed food waste tip fee accounts for 16% of biogas plant revenue. Therefore, although less important than RNG sales, food waste tip fee can have a significant impact on biogas plant economic feasibility. For example, if mixed food waste tip fee is \$35/tonne or \$50/tonne instead of \$25/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$22.66/GJ to <\$21/GJ and <\$18/GJ respectively. Alternately, if mixed food waste tip fee is only \$10/tonne or \$0/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% increases from \$22.66/GJ to >\$25/GJ and >\$27/GJ respectively.

Option A: Sensitivity Analysis – Mixed Food Waste Tip Fee

		Mixed Food Waste Tip Fee (\$/Tonne)										
		\$0	\$5	\$10	\$15	\$20	\$25	\$30	\$35	\$40	\$45	\$50
\$/GJ RNG	\$16	---	---	---	1.1%	2.6%	4.0%	5.3%	6.5%	7.7%	8.8%	9.9%
	\$17	---	---	1.2%	2.7%	4.1%	5.4%	6.6%	7.8%	8.9%	10.0%	11.0%
	\$18	---	1.3%	2.8%	4.2%	5.5%	6.7%	7.8%	8.9%	10.0%	11.1%	12.1%
	\$19	1.5%	2.9%	4.3%	5.5%	6.7%	7.9%	9.0%	10.1%	11.1%	12.2%	13.2%
	\$20	3.0%	4.4%	5.6%	6.8%	8.0%	9.1%	10.1%	11.2%	12.2%	13.2%	14.2%
	\$21	4.5%	5.7%	6.9%	8.0%	9.1%	10.2%	11.2%	12.3%	13.3%	14.2%	15.2%
	\$22	5.8%	7.0%	8.1%	9.2%	10.3%	11.3%	12.3%	13.3%	14.3%	15.2%	16.2%
	\$23	7.0%	8.2%	9.3%	10.3%	11.3%	12.4%	13.3%	14.3%	15.3%	16.2%	17.1%
	\$24	8.2%	9.3%	10.4%	11.4%	12.4%	13.4%	14.4%	15.3%	16.2%	17.2%	18.1%
	\$25	9.4%	10.4%	11.5%	12.5%	13.4%	14.4%	15.3%	16.3%	17.2%	18.1%	19.0%
	\$26	10.4%	11.4%	12.4%	13.4%	14.4%	15.3%	16.3%	17.2%	18.1%	19.0%	19.9%
	\$27	11.3%	12.3%	13.3%	14.3%	15.3%	16.2%	17.2%	18.1%	19.0%	19.9%	20.8%
	\$28	12.1%	13.1%	14.1%	15.1%	16.0%	17.0%	17.9%	18.8%	19.8%	20.7%	21.6%
	\$29	12.6%	13.6%	14.6%	15.6%	16.6%	17.6%	18.5%	19.4%	20.4%	21.3%	22.2%
	\$30	12.9%	13.9%	14.9%	15.9%	16.9%	17.9%	18.8%	19.7%	20.7%	21.6%	22.5%

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #3 - Option B: Mixed Food Waste Cleaning Equipment

This biogas plant is estimated to cost \$6.6 million to build. Operating costs are estimated to average \$792,765/year. At an RNG sale price of \$26.50/GJ, average revenue is estimated to be \$1,656,824/year. This biogas plant doesn't requires funding for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$864,059/year; equal to 109% of operating costs. Operating income should be sufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (i.e., broken equipment, unexpected downtime, etc.).

Option B: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>	<u>Revenue</u>		<u>Investment</u>	
Digester	\$2,934,750		RNG/GJ [†] =	\$26.50	Farm Investment =	\$6,562,813
Upgrader	\$2,399,600		Avg RNG Sales/Yr =	\$1,367,830	Funding Amount =	\$0
Nutrient Recovery	\$373,685		Tip Fee/Yr =	\$240,399	Funding % of CAPEX =	0%
Other	\$854,778		Bedding Savings/Yr* =	\$48,595		
Total	<u>\$6,562,813</u>	<u>\$792,765</u>	Total =	<u>\$1,656,824</u>	Inflation =	2%

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$1,539	\$1,553	\$1,566	\$1,580	\$1,594	\$1,608	\$1,622	\$1,636	\$1,650	\$1,665
OPEX (000s)	\$653	\$666	\$679	\$692	\$706	\$720	\$735	\$750	\$765	\$780
<i>Income (000s)</i>	\$887	\$887	\$887	\$887	\$887	\$887	\$887	\$886	\$886	\$885

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$1,680	\$1,695	\$1,710	\$1,717	\$1,718	\$1,719	\$1,720	\$1,721	\$1,722	\$1,724
OPEX (000s)	\$795	\$811	\$828	\$844	\$861	\$878	\$896	\$914	\$932	\$951
<i>Income (000s)</i>	\$884	\$883	\$882	\$873	\$857	\$841	\$824	\$808	\$790	\$773

Unlevered, Pre-Tax IRR =	12%
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Average Operating Income* =	\$864,059
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% of OPEX	109%
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* Averaged over twenty years to account for inflation

[†] Base price (1%/year increase up to \$30/GJ max)

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 83% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, if RNG production is 10% or 20% higher than anticipated (due to the availability of high biogas-potential mixed food waste), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$26.50/GJ to \$24/GJ and \$22/GJ respectively. Alternately, if RNG production is only 5% lower than anticipated, the required RNG sale price for an unlevered, pre-tax IRR increases from \$26.50/GJ to >\$28/GJ. Furthermore, if only 60% of estimated mixed food waste is available (5,770 instead of 9,616 tonnes/year), RNG production will be approximately 40% lower. If RNG production is 40% lower, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 0.8%. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option B: Sensitivity Analysis – RNG Production

		Change in RNG Production Amount													
		-40%	-35%	-30%	-25%	-20%	-15%	-10%	-5%	0%	5%	10%	15%	20%	
\$/GJ RNG	\$16	---	---	---	---	---	---	---	---	0.1%	1.4%	2.5%	3.6%	4.6%	
	\$17	---	---	---	---	---	---	---	---	1.7%	2.8%	3.9%	5.0%	6.0%	
	\$18	---	---	---	---	---	---	0.5%	1.8%	3.0%	4.2%	5.3%	6.3%	7.3%	
	\$19	---	---	---	---	---	0.4%	1.8%	3.1%	4.3%	5.4%	6.5%	7.5%	8.5%	
	\$20	---	---	---	---	0.1%	1.7%	3.0%	4.3%	5.5%	6.6%	7.7%	8.7%	9.7%	
	\$21	---	---	---	---	1.4%	2.8%	4.2%	5.4%	6.6%	7.8%	8.8%	9.9%	10.9%	
	\$22	---	---	---	0.9%	2.5%	3.9%	5.3%	6.5%	7.7%	8.8%	9.9%	11.0%	12.0%	
	\$23	---	---	0.3%	2.0%	3.6%	5.0%	6.3%	7.5%	8.7%	9.9%	11.0%	12.1%	13.1%	
	\$24	---	---	1.4%	3.0%	4.6%	6.0%	7.3%	8.5%	9.7%	10.9%	12.0%	13.1%	14.2%	
	\$25	---	0.5%	2.4%	4.0%	5.5%	6.9%	8.2%	9.5%	10.7%	11.9%	13.0%	14.1%	15.2%	
	\$26	---	1.4%	3.2%	4.8%	6.3%	7.7%	9.1%	10.3%	11.6%	12.8%	13.9%	15.1%	16.2%	
	\$27	---	2.0%	3.8%	5.5%	7.0%	8.4%	9.8%	11.1%	12.4%	13.6%	14.8%	15.9%	17.1%	
	\$28	0.4%	2.5%	4.3%	6.0%	7.5%	9.0%	10.4%	11.7%	13.0%	14.3%	15.5%	16.7%	17.9%	
	\$29	0.6%	2.8%	4.6%	6.3%	7.9%	9.4%	10.8%	12.2%	13.5%	14.8%	16.1%	17.3%	18.5%	
	\$30	0.8%	2.9%	4.8%	6.5%	8.1%	9.6%	11.0%	12.4%	13.7%	15.1%	16.3%	17.6%	18.8%	

B.C. On-Farm Biogas Benchmark Study, Version 2

Mixed food waste tip fee accounts for 15% of biogas plant revenue. Therefore, although less important than RNG sales, food waste tip fee can have a significant impact on biogas plant economic feasibility. For example, if mixed food waste tip fee is \$35/tonne or \$50/tonne instead of \$25/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$26.50/GJ to <\$25/GJ and <\$22/GJ respectively. Alternately, if mixed food waste tip fee is only \$15/tonne or \$5/tonne, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 11.9% and 10.0% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option B: Sensitivity Analysis – Mixed Food Waste Tip Fee

		Mixed Food Waste Tip Fee (\$/Tonne)										
		\$0	\$5	\$10	\$15	\$20	\$25	\$30	\$35	\$40	\$45	\$50
\$/GJ RNG	\$16	---	---	---	---	---	0.1%	1.6%	2.8%	4.1%	5.2%	6.3%
	\$17	---	---	---	---	0.3%	1.7%	2.9%	4.1%	5.3%	6.4%	7.4%
	\$18	---	---	---	0.4%	1.8%	3.0%	4.2%	5.4%	6.4%	7.5%	8.5%
	\$19	---	---	0.5%	1.9%	3.1%	4.3%	5.4%	6.5%	7.5%	8.5%	9.5%
	\$20	---	0.6%	2.0%	3.2%	4.4%	5.5%	6.6%	7.6%	8.6%	9.5%	10.5%
	\$21	0.8%	2.1%	3.3%	4.5%	5.6%	6.6%	7.6%	8.6%	9.6%	10.5%	11.4%
	\$22	2.2%	3.4%	4.6%	5.6%	6.7%	7.7%	8.7%	9.6%	10.6%	11.5%	12.3%
	\$23	3.5%	4.6%	5.7%	6.8%	7.8%	8.7%	9.7%	10.6%	11.5%	12.4%	13.3%
	\$24	4.7%	5.8%	6.8%	7.8%	8.8%	9.7%	10.7%	11.5%	12.4%	13.3%	14.1%
	\$25	5.9%	6.9%	7.9%	8.8%	9.8%	10.7%	11.6%	12.5%	13.3%	14.2%	15.0%
	\$26	6.9%	7.9%	8.8%	9.8%	10.7%	11.6%	12.5%	13.3%	14.2%	15.0%	15.8%
	\$27	7.7%	8.7%	9.6%	10.6%	11.5%	12.4%	13.2%	14.1%	14.9%	15.8%	16.6%
	\$28	8.4%	9.3%	10.3%	11.2%	12.1%	13.0%	13.9%	14.8%	15.6%	16.4%	17.3%
	\$29	8.8%	9.8%	10.8%	11.7%	12.6%	13.5%	14.4%	15.3%	16.1%	17.0%	17.8%
	\$30	9.0%	10.0%	11.0%	11.9%	12.8%	13.7%	14.6%	15.5%	16.4%	17.2%	18.0%

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #3 - Option C: RNG Compression Equipment

This biogas plant is estimated to cost \$6.6 million to build. Operating costs are estimated to average \$913,803/year. At an RNG sale price of \$30/GJ, average revenue is estimated to be \$1,713,849/year. This biogas plant requires \$0.1 million funding (2% of CAPEX) for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$800,046/year; equal to 88% of operating costs. Operating income should be sufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (i.e., broken equipment, unexpected downtime, etc.).

Option C: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>	<u>Revenue</u>		<u>Investment</u>	
Digester	\$2,207,625		RNG/GJ =	\$30.00	Farm Investment =	\$6,421,540
Upgrader	\$3,095,052		Avg RNG Sales/Yr =	\$1,424,855	Funding Amount =	\$104,856
Nutrient Recovery	\$373,685		Tip Fee/Yr =	\$240,399	Funding % of CAPEX =	2%
Other	\$850,035		Bedding Savings/Yr* =	\$48,595		
Total	<u>\$6,526,397</u>	<u>\$913,803</u>	Total =	<u>\$1,713,849</u>	<i>Inflation =</i>	<i>2%</i>

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$1,705	\$1,706	\$1,707	\$1,708	\$1,709	\$1,709	\$1,710	\$1,711	\$1,712	\$1,713
OPEX (000s)	\$752	\$767	\$783	\$798	\$814	\$830	\$847	\$864	\$881	\$899
<i>Income (000s)</i>	\$953	\$939	\$924	\$909	\$894	\$879	\$863	\$847	\$831	\$814

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$1,714	\$1,715	\$1,716	\$1,717	\$1,718	\$1,719	\$1,720	\$1,721	\$1,722	\$1,724
OPEX (000s)	\$917	\$935	\$954	\$973	\$992	\$1,012	\$1,033	\$1,053	\$1,074	\$1,096
<i>Income (000s)</i>	\$797	\$780	\$762	\$744	\$726	\$707	\$688	\$668	\$648	\$628

Unlevered, Pre-Tax IRR =	12%
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Average Operating Income* =	\$800,046
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% of OPEX	88%
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* Averaged over twenty years to account for inflation

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 83% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, with 2% funding, if RNG production is 10% or 20% higher than anticipated (due to the availability of high biogas-potential mixed food waste), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$26/GJ and <\$24/GJ respectively. Alternately, with 2% funding, if RNG production is 5% or 10% lower than anticipated, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 10.5% and 9.0% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Mixed food waste tip fee accounts for 14% of biogas plant revenue. Therefore, although less important than RNG sales, food waste tip fee can have a significant impact on biogas plant economic feasibility. For example, with 2% funding, if mixed food waste tip fee is \$35/tonne or \$50/tonne instead of \$25/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$27/GJ and <\$24/GJ respectively. Alternately, with 2% funding, if mixed food waste tip fee is only \$20/tonne or \$15/tonne, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 11.0% and 10.0% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option C: Sensitivity Analysis – RNG Production & Mixed Food Waste Tip Fee

		Change in RNG Production Amount						
		-10%	-5%	0%	5%	10%	15%	20%
\$/GJ RNG	\$16	---	---	---	---	---	0.5%	1.7%
	\$17	---	---	---	---	1.0%	2.3%	3.4%
	\$18	---	---	---	1.3%	2.6%	3.8%	5.0%
	\$19	---	---	1.4%	2.8%	4.1%	5.3%	6.4%
	\$20	---	1.4%	2.9%	4.2%	5.4%	6.6%	7.7%
	\$21	1.3%	2.8%	4.2%	5.5%	6.7%	7.9%	9.0%
	\$22	2.6%	4.1%	5.4%	6.7%	7.9%	9.1%	10.2%
	\$23	3.8%	5.3%	6.6%	7.9%	9.1%	10.3%	11.4%
	\$24	5.0%	6.4%	7.7%	9.0%	10.2%	11.4%	12.5%
	\$25	6.0%	7.4%	8.8%	10.1%	11.3%	12.5%	13.6%
	\$26	7.0%	8.4%	9.7%	11.0%	12.3%	13.5%	14.6%
	\$27	7.7%	9.2%	10.6%	11.9%	13.1%	14.4%	15.6%
	\$28	8.4%	9.8%	11.2%	12.6%	13.9%	15.2%	16.4%
\$29	8.8%	10.3%	11.7%	13.1%	14.5%	15.8%	17.0%	
\$30	9.0%	10.5%	12.0%	13.4%	14.7%	16.0%	17.3%	

		Mixed Food Waste Tip Fee (\$/Tonne)							
		\$15	\$20	\$25	\$30	\$35	\$40	\$45	\$50
\$/GJ RNG	\$16	---	---	---	---	---	1.1%	2.5%	3.8%
	\$17	---	---	---	---	1.2%	2.6%	3.9%	5.1%
	\$18	---	---	---	1.3%	2.7%	3.9%	5.1%	6.3%
	\$19	---	0.0%	1.4%	2.8%	4.0%	5.2%	6.3%	7.4%
	\$20	0.1%	1.6%	2.9%	4.1%	5.3%	6.4%	7.5%	8.5%
	\$21	1.7%	3.0%	4.2%	5.4%	6.5%	7.5%	8.6%	9.5%
	\$22	3.1%	4.3%	5.4%	6.5%	7.6%	8.6%	9.6%	10.5%
	\$23	4.4%	5.5%	6.6%	7.7%	8.7%	9.6%	10.6%	11.5%
	\$24	5.6%	6.7%	7.7%	8.7%	9.7%	10.7%	11.6%	12.5%
	\$25	6.7%	7.8%	8.8%	9.8%	10.7%	11.6%	12.5%	13.4%
	\$26	7.8%	8.8%	9.7%	10.7%	11.6%	12.5%	13.4%	14.3%
	\$27	8.6%	9.6%	10.6%	11.5%	12.4%	13.3%	14.2%	15.1%
	\$28	9.3%	10.3%	11.2%	12.2%	13.1%	14.0%	14.9%	15.8%
\$29	9.8%	10.8%	11.7%	12.7%	13.6%	14.5%	15.4%	16.3%	
\$30	10.0%	11.0%	12.0%	12.9%	13.8%	14.8%	15.7%	16.5%	

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #3 - Option D: Nutrient Recovery Equipment

This biogas plant is estimated to cost \$6.8 million to build. Operating costs are estimated to average \$969,184/year. At an RNG sale price of \$30/GJ, average revenue is estimated to be \$1,713,849/year. This biogas plant requires \$0.8 million funding (11% of CAPEX) for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$744,665/year; equal to 77% of operating costs. Operating income should be sufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (i.e., broken equipment, unexpected downtime, etc.).

Option D: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>	<u>Revenue</u>		<u>Investment</u>	
Digester	\$2,438,625		RNG/GJ =	\$30.00	Farm Investment =	\$6,007,167
Upgrader	\$2,399,600		Avg RNG Sales/Yr =	\$1,424,855	Funding Amount =	\$761,308
Nutrient Recovery	\$1,048,685		Tip Fee/Yr =	\$240,399	Funding % of CAPEX =	11%
Other	\$881,565		Bedding Savings/Yr* =	\$48,595		
Total	<u>\$6,768,475</u>	<u>\$969,184</u>	Total =	<u>\$1,713,849</u>	Inflation =	2%

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$1,705	\$1,706	\$1,707	\$1,708	\$1,709	\$1,709	\$1,710	\$1,711	\$1,712	\$1,713
OPEX (000s)	\$798	\$814	\$830	\$847	\$864	\$881	\$898	\$916	\$935	\$953
<i>Income (000s)</i>	\$907	\$892	\$877	\$861	\$845	\$829	\$812	\$795	\$777	\$760

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$1,714	\$1,715	\$1,716	\$1,717	\$1,718	\$1,719	\$1,720	\$1,721	\$1,722	\$1,724
OPEX (000s)	\$972	\$992	\$1,012	\$1,032	\$1,053	\$1,074	\$1,095	\$1,117	\$1,139	\$1,162
<i>Income (000s)</i>	\$742	\$723	\$704	\$685	\$665	\$645	\$625	\$604	\$583	\$561

Unlevered, Pre-Tax IRR =	12%	Average Operating Income* =	\$744,665	% of OPEX	77%
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* Averaged over twenty years to account for inflation

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 83% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, with 11% funding, if RNG production is 10% or 20% higher than anticipated (due to the availability of high biogas-potential mixed food waste), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$26/GJ and <\$24/GJ respectively. Alternately, with 11% funding, if RNG production is 5% or 10% lower than anticipated, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 10.5% and 8.8% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Mixed food waste tip fee accounts for 14% of biogas plant revenue. Therefore, although less important than RNG sales, food waste tip fee can have a significant impact on biogas plant economic feasibility. For example, with 11% funding, if mixed food waste tip fee is \$35/tonne or \$50/tonne instead of \$25/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$27/GJ and <\$24/GJ respectively. Alternately, with 11% funding, if mixed food waste tip fee is only \$20/tonne or \$15/tonne, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 11.0% and 9.9% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option D: Sensitivity Analysis – RNG Production & Mixed Food Waste Tip Fee

		Change in RNG Production Amount						
		-10%	-5%	0%	5%	10%	15%	20%
\$/GJ RNG	\$16			---	---	---	---	0.8%
	\$17			---	---	---	1.4%	2.7%
	\$18			---	0.3%	1.8%	3.2%	4.4%
	\$19			0.4%	2.0%	3.4%	4.8%	6.0%
	\$20	-1.4%	0.4%	2.1%	3.6%	5.0%	6.2%	7.5%
	\$21	0.3%	2.0%	3.6%	5.0%	6.4%	7.6%	8.8%
	\$22	1.8%	3.4%	5.0%	6.4%	7.7%	9.0%	10.2%
	\$23	3.2%	4.8%	6.2%	7.6%	9.0%	10.2%	11.4%
	\$24	4.4%	6.0%	7.5%	8.8%	10.2%	11.4%	12.6%
	\$25	5.6%	7.2%	8.6%	10.0%	11.3%	12.6%	13.8%
	\$26	6.6%	8.2%	9.6%	11.0%	12.4%	13.7%	14.9%
	\$27	7.5%	9.0%	10.5%	11.9%	13.3%	14.6%	15.9%
	\$28	8.2%	9.8%	11.3%	12.7%	14.1%	15.5%	16.8%
\$29	8.6%	10.3%	11.8%	13.3%	14.7%	16.1%	17.5%	
\$30	8.8%	10.5%	12.0%	13.6%	15.0%	16.4%	17.8%	

		Mixed Food Waste Tip Fee (\$/Tonne)							
		\$15	\$20	\$25	\$30	\$35	\$40	\$45	\$50
\$/GJ RNG	\$16			---	---	---	---	1.6%	3.1%
	\$17			---	---	0.2%	1.7%	3.2%	4.5%
	\$18			---	0.3%	1.9%	3.3%	4.6%	5.9%
	\$19			0.4%	2.0%	3.4%	4.7%	5.9%	7.1%
	\$20	-1.1%	0.6%	2.1%	3.5%	4.8%	6.0%	7.2%	8.3%
	\$21	0.7%	2.2%	3.6%	4.9%	6.1%	7.2%	8.4%	9.4%
	\$22	2.3%	3.7%	5.0%	6.2%	7.3%	8.4%	9.5%	10.5%
	\$23	3.8%	5.1%	6.2%	7.4%	8.5%	9.5%	10.6%	11.6%
	\$24	5.1%	6.3%	7.5%	8.6%	9.6%	10.6%	11.6%	12.6%
	\$25	6.4%	7.5%	8.6%	9.7%	10.7%	11.7%	12.6%	13.6%
	\$26	7.5%	8.6%	9.6%	10.7%	11.7%	12.6%	13.6%	14.5%
	\$27	8.4%	9.5%	10.5%	11.5%	12.5%	13.5%	14.4%	15.4%
	\$28	9.2%	10.2%	11.3%	12.3%	13.3%	14.2%	15.2%	16.1%
\$29	9.7%	10.8%	11.8%	12.8%	13.8%	14.8%	15.7%	16.7%	
\$30	9.9%	11.0%	12.0%	13.1%	14.1%	15.0%	16.0%	17.0%	

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #3 - Option E: Mixed Food Waste Cleaning & RNG Compression Equipment

This biogas plant is estimated to cost \$7.4 million to build. Operating costs are estimated to average \$995,645/year. At an RNG sale price of \$30/GJ, average revenue is estimated to be \$1,713,849/year. This biogas plant requires \$1.5 million funding (21% of CAPEX) for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$718,204/year; equal to 72% of operating costs. Operating income should be sufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (i.e., broken equipment, unexpected downtime, etc.).

Option E: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>	<u>Revenue</u>		<u>Investment</u>	
Digester	\$2,934,750		RNG/GJ =	\$30.00	Farm Investment =	\$5,850,406
Upgrader	\$3,095,052		Avg RNG Sales/Yr =	\$1,424,855	Funding Amount =	\$1,512,003
Nutrient Recovery	\$373,685		Tip Fee/Yr =	\$240,399	Funding % of CAPEX =	21%
Other	\$958,922		Bedding Savings/Yr* =	\$48,595		
Total	<u>\$7,362,409</u>	<u>\$995,645</u>	Total =	<u>\$1,713,849</u>	Inflation =	2%

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$1,705	\$1,706	\$1,707	\$1,708	\$1,709	\$1,709	\$1,710	\$1,711	\$1,712	\$1,713
OPEX (000s)	\$820	\$836	\$853	\$870	\$887	\$905	\$923	\$941	\$960	\$979
<i>Income (000s)</i>	\$886	\$870	\$854	\$838	\$821	\$805	\$787	\$770	\$752	\$734

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$1,714	\$1,715	\$1,716	\$1,717	\$1,718	\$1,719	\$1,720	\$1,721	\$1,722	\$1,724
OPEX (000s)	\$999	\$1,019	\$1,039	\$1,060	\$1,081	\$1,103	\$1,125	\$1,148	\$1,171	\$1,194
<i>Income (000s)</i>	\$715	\$696	\$677	\$657	\$637	\$616	\$595	\$574	\$552	\$530

Unlevered, Pre-Tax IRR =	12%
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Average Operating Income* =	\$718,204
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% of OPEX	72%
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* Averaged over twenty years to account for inflation

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 83% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, with 21% funding, if RNG production is 10% or 20% higher than anticipated (due to the availability of high biogas-potential mixed food waste), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$26/GJ and <\$24/GJ respectively. Alternately, with 21% funding, if RNG production is 5% or 10% lower than anticipated, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 10.3% and 8.6% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Mixed food waste tip fee accounts for 14% of biogas plant revenue. Therefore, although less important than RNG sales, food waste tip fee can have a significant impact on biogas plant economic feasibility. For example, with 21% funding, if mixed food waste tip fee is \$35/tonne or \$50/tonne instead of \$25/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$27/GJ and <\$24/GJ respectively. Alternately, with 21% funding, if mixed food waste tip fee is only \$20/tonne or \$15/tonne, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 10.9% and 9.8% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option E: Sensitivity Analysis – RNG Production & Mixed Food Waste Tip Fee

		Change in RNG Production Amount						
		-10%	-5%	0%	5%	10%	15%	20%
\$/GJ RNG	\$16	---	---	---	---	---	---	0.2%
	\$17	---	---	---	---	---	0.8%	2.2%
	\$18	---	---	---	---	1.2%	2.7%	4.1%
	\$19	---	---	---	1.5%	3.0%	4.4%	5.7%
	\$20	---	---	1.6%	3.2%	4.6%	6.0%	7.2%
	\$21	---	1.5%	3.2%	4.7%	6.1%	7.4%	8.7%
	\$22	1.2%	3.0%	4.6%	6.1%	7.5%	8.8%	10.0%
	\$23	2.7%	4.4%	6.0%	7.4%	8.8%	10.1%	11.3%
	\$24	4.1%	5.7%	7.2%	8.7%	10.0%	11.3%	12.6%
	\$25	5.3%	6.9%	8.4%	9.8%	11.2%	12.5%	13.8%
	\$26	6.4%	8.0%	9.5%	10.9%	12.3%	13.6%	14.9%
	\$27	7.2%	8.9%	10.4%	11.9%	13.3%	14.6%	16.0%
	\$28	7.9%	9.6%	11.2%	12.7%	14.1%	15.5%	16.9%
\$29	8.4%	10.1%	11.7%	13.2%	14.7%	16.2%	17.6%	
\$30	8.6%	10.3%	12.0%	13.5%	15.0%	16.5%	17.9%	

		Mixed Food Waste Tip Fee (\$/Tonne)							
		\$15	\$20	\$25	\$30	\$35	\$40	\$45	\$50
\$/GJ RNG	\$16	---	---	-8.6%	-5.2%	-2.7%	-0.7%	1.1%	2.6%
	\$17	---	---	-4.9%	-2.5%	-0.5%	1.2%	2.7%	4.1%
	\$18	---	---	-2.3%	-0.4%	1.3%	2.8%	4.2%	5.5%
	\$19	---	---	-0.2%	1.5%	2.9%	4.3%	5.6%	6.8%
	\$20	---	0.0%	1.6%	3.1%	4.4%	5.7%	6.9%	8.1%
	\$21	0.1%	1.7%	3.2%	4.5%	5.8%	7.0%	8.2%	9.3%
	\$22	1.8%	3.3%	4.6%	5.9%	7.1%	8.2%	9.3%	10.4%
	\$23	3.4%	4.7%	6.0%	7.1%	8.3%	9.4%	10.4%	11.5%
	\$24	4.8%	6.0%	7.2%	8.4%	9.4%	10.5%	11.5%	12.5%
	\$25	6.1%	7.3%	8.4%	9.5%	10.6%	11.6%	12.6%	13.6%
	\$26	7.3%	8.4%	9.5%	10.5%	11.6%	12.6%	13.6%	14.5%
	\$27	8.2%	9.3%	10.4%	11.4%	12.5%	13.5%	14.4%	15.4%
	\$28	9.0%	10.1%	11.2%	12.2%	13.2%	14.2%	15.2%	16.2%
\$29	9.5%	10.6%	11.7%	12.8%	13.8%	14.8%	15.8%	16.7%	
\$30	9.8%	10.9%	12.0%	13.0%	14.1%	15.1%	16.1%	17.0%	

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #3 - Option F: Mixed Food Waste Cleaning & Nutrient Recovery Equipment

This biogas plant is estimated to cost \$7.6 million to build. Operating costs are estimated to average \$1,051,026/year. At an RNG sale price of \$30/GJ, average revenue is estimated to be \$1,713,849/year. This biogas plant requires \$2.2 million funding (28% of CAPEX) for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$662,823/year; equal to 63% of operating costs. Operating income should be sufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (i.e., broken equipment, unexpected downtime, etc.).

Option F: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>	<u>Revenue</u>		<u>Investment</u>	
Digester	\$3,165,750		RNG/GJ =	\$30.00	Farm Investment =	\$5,442,409
Upgrader	\$2,399,600		Avg RNG Sales/Yr =	\$1,424,855	Funding Amount =	\$2,162,078
Nutrient Recovery	\$1,048,685		Tip Fee/Yr =	\$240,399	Funding % of CAPEX =	28%
Other	\$990,452		Bedding Savings/Yr* =	\$48,595		
Total	<u>\$7,604,487</u>	<u>\$1,051,026</u>	Total =	<u>\$1,713,849</u>	<i>Inflation =</i>	<i>2%</i>

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$1,705	\$1,706	\$1,707	\$1,708	\$1,709	\$1,709	\$1,710	\$1,711	\$1,712	\$1,713
OPEX (000s)	\$865	\$882	\$900	\$918	\$936	\$955	\$974	\$994	\$1,014	\$1,034
<i>Income (000s)</i>	\$840	\$824	\$807	\$790	\$772	\$754	\$736	\$717	\$698	\$679

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$1,714	\$1,715	\$1,716	\$1,717	\$1,718	\$1,719	\$1,720	\$1,721	\$1,722	\$1,724
OPEX (000s)	\$1,055	\$1,076	\$1,097	\$1,119	\$1,142	\$1,164	\$1,188	\$1,211	\$1,236	\$1,260
<i>Income (000s)</i>	\$659	\$639	\$619	\$598	\$577	\$555	\$533	\$510	\$487	\$463

Unlevered, Pre-Tax IRR =	12%	Average Operating Income* =	\$662,823	% of OPEX	63%
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* Averaged over twenty years to account for inflation

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 83% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, with 28% funding, if RNG production is 10% or 20% higher than anticipated (due to the availability of high biogas-potential mixed food waste), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$26/GJ and <\$24/GJ respectively. Alternately, with 28% funding, if RNG production is 5% or 10% lower than anticipated, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 10.3% and 8.4% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Mixed food waste tip fee accounts for 14% of biogas plant revenue. Therefore, although less important than RNG sales, food waste tip fee can have a significant impact on biogas plant economic feasibility. For example, with 28% funding, if mixed food waste tip fee is \$35/tonne or \$50/tonne instead of \$25/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$27/GJ and <\$24/GJ respectively. Alternately, with 28% funding, if mixed food waste tip fee is only \$20/tonne or \$15/tonne, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 10.9% and 9.6% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option F: Sensitivity Analysis – RNG Production & Mixed Food Waste Tip Fee

		Change in RNG Production Amount						
		-10%	-5%	0%	5%	10%	15%	20%
\$/GJ RNG	\$16	---	---	---	---	---	---	---
	\$17	---	---	---	---	---	---	1.2%
	\$18	---	---	---	---	0.0%	1.8%	3.3%
	\$19	---	---	---	0.4%	2.1%	3.7%	5.2%
	\$20	---	---	0.5%	2.3%	4.0%	5.5%	6.9%
	\$21	---	0.4%	2.3%	4.0%	5.6%	7.1%	8.4%
	\$22	0.0%	2.1%	4.0%	5.6%	7.1%	8.6%	9.9%
	\$23	1.8%	3.7%	5.5%	7.1%	8.6%	10.0%	11.3%
	\$24	3.3%	5.2%	6.9%	8.4%	9.9%	11.3%	12.7%
	\$25	4.7%	6.5%	8.2%	9.7%	11.2%	12.6%	14.0%
	\$26	5.9%	7.7%	9.3%	10.9%	12.4%	13.8%	15.2%
	\$27	6.9%	8.7%	10.3%	11.9%	13.4%	14.9%	16.3%
	\$28	7.6%	9.5%	11.2%	12.8%	14.3%	15.9%	17.3%
	\$29	8.2%	10.0%	11.8%	13.4%	15.0%	16.6%	18.1%
\$30	8.4%	10.3%	12.0%	13.7%	15.4%	16.9%	18.5%	

		Mixed Food Waste Tip Fee (\$/Tonne)								
		\$15	\$20	\$25	\$30	\$35	\$40	\$45	\$50	
\$/GJ RNG	\$16	---	---	---	---	---	---	---	1.6%	
	\$17	---	---	---	---	---	---	---	1.8%	3.4%
	\$18	---	---	---	---	0.1%	1.9%	3.5%	5.0%	
	\$19	---	---	---	0.3%	2.0%	3.6%	5.1%	6.4%	
	\$20	---	---	0.5%	2.2%	3.7%	5.2%	6.5%	7.8%	
	\$21	---	0.6%	2.3%	3.8%	5.3%	6.6%	7.9%	9.1%	
	\$22	0.8%	2.4%	4.0%	5.4%	6.7%	8.0%	9.2%	10.3%	
	\$23	2.6%	4.1%	5.5%	6.8%	8.0%	9.2%	10.4%	11.5%	
	\$24	4.2%	5.6%	6.9%	8.1%	9.3%	10.5%	11.6%	12.7%	
	\$25	5.6%	6.9%	8.2%	9.4%	10.5%	11.6%	12.7%	13.8%	
	\$26	6.9%	8.1%	9.3%	10.5%	11.6%	12.7%	13.8%	14.8%	
	\$27	7.9%	9.2%	10.3%	11.5%	12.6%	13.7%	14.7%	15.7%	
	\$28	8.8%	10.0%	11.2%	12.3%	13.4%	14.5%	15.5%	16.6%	
	\$29	9.4%	10.6%	11.8%	12.9%	14.0%	15.1%	16.2%	17.2%	
\$30	9.6%	10.9%	12.0%	13.2%	14.3%	15.4%	16.5%	17.5%		

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #3 - Option G: RNG Compression and Nutrient Recovery Equipment

This biogas plant is estimated to cost \$7.6 million to build. Operating costs are estimated to average \$1,172,064/year. At an RNG sale price of \$30/GJ, average revenue is estimated to be \$1,713,849/year. This biogas plant requires \$2.9 million funding (39% of CAPEX) for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$541,785/year; equal to 46% of operating costs. Operating income may or may not be sufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (e.g., broken equipment, unexpected downtime, etc.).

Option G: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>	<u>Revenue</u>		<u>Investment</u>	
Digester	\$2,438,625		RNG/GJ =	\$30.00	Farm Investment =	\$4,619,910
Upgrader	\$3,095,052		Avg RNG Sales/Yr =	\$1,424,855	Funding Amount =	\$2,948,161
Nutrient Recovery	\$1,048,685		Tip Fee/Yr =	\$240,399	Funding % of CAPEX =	39%
Other	\$985,709		Bedding Savings/Yr* =	\$48,595		
Total	<u>\$7,568,070</u>	<u>\$1,172,064</u>	Total =	<u>\$1,713,849</u>	<i>Inflation =</i>	<i>2%</i>

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$1,705	\$1,706	\$1,707	\$1,708	\$1,709	\$1,709	\$1,710	\$1,711	\$1,712	\$1,713
OPEX (000s)	\$965	\$984	\$1,004	\$1,024	\$1,044	\$1,065	\$1,086	\$1,108	\$1,130	\$1,153
<i>Income (000s)</i>	\$740	\$722	\$703	\$684	\$664	\$644	\$624	\$603	\$582	\$560

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$1,714	\$1,715	\$1,716	\$1,717	\$1,718	\$1,719	\$1,720	\$1,721	\$1,722	\$1,724
OPEX (000s)	\$1,176	\$1,200	\$1,224	\$1,248	\$1,273	\$1,298	\$1,324	\$1,351	\$1,378	\$1,405
<i>Income (000s)</i>	\$538	\$515	\$492	\$469	\$445	\$421	\$396	\$370	\$344	\$318

Unlevered, Pre-Tax IRR =	12%	Average Operating Income* =	\$541,785	% of OPEX	46%
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* Averaged over twenty years to account for inflation

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 83% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, with 39% funding, if RNG production is 10% or 20% higher than anticipated (due to the availability of high biogas-potential mixed food waste), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$26/GJ and <\$24/GJ respectively. Alternately, with 39% funding, if RNG production is 5% or 10% lower than anticipated, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 9.8% and 7.4% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Mixed food waste tip fee accounts for 14% of biogas plant revenue. Therefore, although less important than RNG sales, food waste tip fee can have a significant impact on biogas plant economic feasibility. For example, with 39% funding, if mixed food waste tip fee is \$35/tonne or \$50/tonne instead of \$25/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$27/GJ and <\$24/GJ respectively. Alternately, with 39% funding, if mixed food waste tip fee is only \$20/tonne or \$15/tonne, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 10.5% and 9.0% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option G: Sensitivity Analysis – RNG Production & Mixed Food Waste Tip Fee

		Change in RNG Production Amount						
		-10%	-5%	0%	5%	10%	15%	20%
\$/GJ RNG	\$16	---	---	---	---	---	---	---
	\$17	---	---	---	---	---	---	---
	\$18	---	---	---	---	---	---	0.7%
	\$19	---	---	---	---	---	1.3%	3.3%
	\$20	---	---	---	---	1.7%	3.7%	5.6%
	\$21	---	---	---	1.8%	3.9%	5.8%	7.6%
	\$22	---	---	1.7%	3.9%	5.9%	7.7%	9.4%
	\$23	---	1.3%	3.7%	5.8%	7.7%	9.5%	11.1%
	\$24	0.7%	3.3%	5.6%	7.6%	9.4%	11.1%	12.8%
	\$25	2.7%	5.1%	7.2%	9.2%	11.0%	12.7%	14.3%
	\$26	4.3%	6.6%	8.7%	10.6%	12.4%	14.1%	15.8%
	\$27	5.5%	7.8%	9.9%	11.8%	13.7%	15.4%	17.1%
	\$28	6.5%	8.8%	10.9%	12.9%	14.8%	16.5%	18.3%
\$29	7.1%	9.5%	11.6%	13.6%	15.6%	17.4%	19.2%	
\$30	7.4%	9.8%	12.0%	14.0%	16.0%	17.8%	19.7%	

		Mixed Food Waste Tip Fee (\$/Tonne)							
		\$15	\$20	\$25	\$30	\$35	\$40	\$45	\$50
\$/GJ RNG	\$16	---	---	---	---	---	---	---	---
	\$17	---	---	---	---	---	---	---	0.7%
	\$18	---	---	---	---	---	---	0.9%	3.0%
	\$19	---	---	---	---	---	1.1%	3.2%	5.0%
	\$20	---	---	---	---	1.3%	3.3%	5.1%	6.7%
	\$21	---	---	---	1.5%	3.5%	5.2%	6.9%	8.4%
	\$22	---	---	1.7%	3.6%	5.3%	7.0%	8.5%	9.9%
	\$23	---	1.8%	3.7%	5.5%	7.1%	8.5%	10.0%	11.3%
	\$24	2.0%	3.9%	5.6%	7.1%	8.6%	10.0%	11.4%	12.7%
	\$25	4.0%	5.7%	7.2%	8.7%	10.1%	11.5%	12.8%	14.0%
	\$26	5.6%	7.2%	8.7%	10.1%	11.5%	12.8%	14.0%	15.3%
	\$27	6.9%	8.4%	9.9%	11.3%	12.6%	13.9%	15.2%	16.4%
	\$28	7.9%	9.5%	10.9%	12.3%	13.6%	14.9%	16.2%	17.4%
\$29	8.6%	10.2%	11.6%	13.0%	14.4%	15.7%	16.9%	18.1%	
\$30	9.0%	10.5%	12.0%	13.4%	14.7%	16.0%	17.3%	18.5%	

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #3 - Option H: Mixed Food Waste Cleaning, RNG Compression and Nutrient Recovery Equipment

This biogas plant is estimated to cost \$8.4 million to build. Operating costs are estimated to average \$1,253,906/year. At an RNG sale price of \$30/GJ, average revenue is estimated to be \$1,713,849/year. This biogas plant requires \$4.4 million funding (52% of CAPEX) for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$459,943/year; equal to 37% of operating costs. Operating income may or may not be sufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (e.g., broken equipment, unexpected downtime, etc.).

Option H: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>	<u>Revenue</u>		<u>Investment</u>	
Digester	\$3,165,750		RNG/GJ =	\$30.00	Farm Investment =	\$4,045,200
Upgrader	\$3,095,052		Avg RNG Sales/Yr =	\$1,424,855	Funding Amount =	\$4,358,882
Nutrient Recovery	\$1,048,685		Tip Fee/Yr =	\$240,399	Funding % of CAPEX =	52%
Other	\$1,094,596		Bedding Savings/Yr* =	\$48,595		
Total	<u>\$8,404,082</u>	<u>\$1,253,906</u>	Total =	<u>\$1,713,849</u>	<i>Inflation =</i>	<i>2%</i>

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$1,705	\$1,706	\$1,707	\$1,708	\$1,709	\$1,709	\$1,710	\$1,711	\$1,712	\$1,713
OPEX (000s)	\$1,032	\$1,053	\$1,074	\$1,095	\$1,117	\$1,140	\$1,162	\$1,186	\$1,209	\$1,233
<i>Income (000s)</i>	\$673	\$653	\$633	\$612	\$591	\$570	\$548	\$526	\$503	\$480

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$1,714	\$1,715	\$1,716	\$1,717	\$1,718	\$1,719	\$1,720	\$1,721	\$1,722	\$1,724
OPEX (000s)	\$1,258	\$1,283	\$1,309	\$1,335	\$1,362	\$1,389	\$1,417	\$1,445	\$1,474	\$1,504
<i>Income (000s)</i>	\$456	\$432	\$407	\$382	\$356	\$330	\$303	\$276	\$248	\$220

Unlevered, Pre-Tax IRR =	12%
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Average Operating Income* =	\$459,943
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% of OPEX	37%
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* Averaged over twenty years to account for inflation

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 83% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, with 52% funding, if RNG production is 10% or 20% higher than anticipated (due to the availability of high biogas-potential mixed food waste), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$26/GJ and <\$24/GJ respectively. Alternately, with 52% funding, if RNG production is 5% or 10% lower than anticipated, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 9.4% and 6.4% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Mixed food waste tip fee accounts for 14% of biogas plant revenue. Therefore, although less important than RNG sales, food waste tip fee can have a significant impact on biogas plant economic feasibility. For example, with 52% funding, if mixed food waste tip fee is \$35/tonne or \$50/tonne instead of \$25/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$27/GJ and <\$24/GJ respectively. Alternately, with 52% funding, if mixed food waste tip fee is only \$20/tonne or \$15/tonne, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 10.3% and 8.4% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option H: Sensitivity Analysis – RNG Production & Mixed Food Waste Tip Fee

		Change in RNG Production Amount						
		-10%	-5%	0%	5%	10%	15%	20%
\$/GJ RNG	\$16	---	---	---	---	---	---	---
	\$17	---	---	---	---	---	---	---
	\$18	---	---	---	---	---	---	---
	\$19	---	---	---	---	---	---	1.4%
	\$20	---	---	---	---	-1.0%	1.9%	4.3%
	\$21	---	---	---	---	2.2%	4.6%	6.8%
	\$22	---	---	---	2.2%	4.7%	7.0%	9.0%
	\$23	---	---	1.9%	4.6%	7.0%	9.1%	11.0%
	\$24	---	1.4%	4.3%	6.8%	9.0%	11.0%	12.9%
	\$25	0.5%	3.7%	6.4%	8.7%	10.8%	12.8%	14.7%
	\$26	2.6%	5.6%	8.1%	10.4%	12.5%	14.5%	16.4%
	\$27	4.1%	7.0%	9.5%	11.8%	14.0%	16.0%	17.9%
	\$28	5.3%	8.2%	10.7%	13.1%	15.2%	17.3%	19.3%
\$29	6.1%	9.0%	11.6%	14.0%	16.2%	18.3%	20.3%	
\$30	6.4%	9.4%	12.0%	14.4%	16.7%	18.8%	20.9%	

		Mixed Food Waste Tip Fee (\$/Tonne)							
		\$15	\$20	\$25	\$30	\$35	\$40	\$45	\$50
\$/GJ RNG	\$16	---	---	---	---	---	---	---	---
	\$17	---	---	---	---	---	---	---	---
	\$18	---	---	---	---	---	---	---	0.9%
	\$19	---	---	---	---	---	---	1.1%	3.5%
	\$20	---	---	---	---	---	1.3%	3.7%	5.7%
	\$21	---	---	---	---	1.5%	3.8%	5.9%	7.7%
	\$22	---	---	---	1.7%	4.0%	6.0%	7.8%	9.5%
	\$23	---	---	1.9%	4.1%	6.1%	7.9%	9.6%	11.2%
	\$24	---	2.1%	4.3%	6.3%	8.1%	9.7%	11.3%	12.9%
	\$25	2.3%	4.4%	6.4%	8.2%	9.8%	11.4%	12.9%	14.4%
	\$26	4.3%	6.3%	8.1%	9.8%	11.4%	12.9%	14.4%	15.8%
	\$27	5.9%	7.8%	9.5%	11.2%	12.8%	14.2%	15.7%	17.1%
	\$28	7.2%	9.0%	10.7%	12.4%	13.9%	15.4%	16.8%	18.3%
\$29	8.0%	9.9%	11.6%	13.2%	14.8%	16.3%	17.7%	19.1%	
\$30	8.4%	10.3%	12.0%	13.6%	15.2%	16.7%	18.2%	19.6%	

Farm Scenario #3: Summary

Figure 15 shows the required RNG \$/GJ sale price for Farm Scenario #3 Options A – G for an unlevered, pre-tax IRR of 12%. Where required RNG sale price is >\$30/GJ, percentage of required funding is shown. Where required RNG sale price is <\$30/GJ, a bar representing +/- 5% is shown to account for price uncertainty. Only Farm Scenario #3 Options A and B don't require funding. These biogas plants require \$21.53 - \$23.79/GJ and \$25.18 - \$27.83/GJ respectively. Farm Scenario #3 Options C – H require funding. Funding increases from 2% (for Option C) to 52% (for Option H). Figure 15 shows that only under the best circumstances (i.e., Option A - needing the least equipment, or Option B – only needing mixed food waste cleaning equipment) are 200 dairy cow farms co-digesting dairy manure and mixed food waste economically feasible in B.C. without funding.

Figure 15: Farm Scenario #3 - Required RNG Sale Price for 200 Dairy Cows + Mixed Food Waste



7.4

Farm Scenario #4: 300 Dairy Cows + Mixed Food Waste

Farm Scenario #4 is a 300 dairy cow farm co-digesting dairy manure and mixed food waste. Farm Scenario #4 assumes the use of traditional on-farm biogas plant technology. Estimated feedstock volume and Renewable Natural Gas (RNG) production for Farm Scenario #4 are as follows:

Feedstock	Tonnes/Year	Percentage	RNG Production (GJ/Year)
Dairy manure	15,012	51%	4,844
Mixed food waste	14,424	49%	70,095
<i>Total</i>	<i>29,436</i>	<i>100%</i>	<i>74,939</i>

The following Equipment Choices were assessed for Farm Scenario #4:

- Option A: No additional equipment;
- Option B: Mixed food waste cleaning equipment;
- Option C: RNG compression equipment;
- Option D: Nutrient recovery equipment;
- Option E: Mixed food waste cleaning and RNG compression equipment;
- Option F: Mixed food waste cleaning and nutrient recovery equipment;
- Option G: RNG compression and nutrient recovery equipment; and
- Option H: Mixed food waste cleaning, RNG compression and nutrient recovery equipment.

For full capital and operating costs for Farm Scenario #4 Options A – H, see Appendix D.

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #4 - Option A: No Additional Equipment

This biogas plant is estimated to cost \$6.6 million to build. Operating costs are estimated to average \$872,933/year. At an RNG sale price of \$16.86/GJ, average revenue is estimated to be \$1,756,160/year. This biogas plant doesn't require funding for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$883,227/year; equal to 101% of operating costs. Operating income should be sufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (i.e., broken equipment, unexpected downtime, etc.).

Option A: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>	<u>Revenue</u>		<u>Investment</u>	
Digester	\$2,590,875		RNG/GJ [†] =	\$16.86	Farm Investment =	\$6,645,002
Upgrader	\$2,681,500		Avg RNG Sales/Yr =	\$1,322,669	Funding Amount =	\$0
Nutrient Recovery	\$507,144		Tip Fee/Yr =	\$360,599	Funding % of CAPEX =	0%
Other	\$865,483		Bedding Savings/Yr =	\$72,892		
Total	<u>\$6,645,002</u>	<u>\$872,933</u>	Total =	<u>\$1,756,160</u>	Inflation =	2%

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$1,622	\$1,635	\$1,648	\$1,662	\$1,676	\$1,689	\$1,703	\$1,718	\$1,732	\$1,746
OPEX (000s)	\$719	\$733	\$748	\$763	\$778	\$793	\$809	\$825	\$842	\$859
Income (000s)	\$903	\$902	\$901	\$899	\$898	\$896	\$894	\$892	\$890	\$888

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$1,761	\$1,776	\$1,790	\$1,806	\$1,821	\$1,836	\$1,852	\$1,867	\$1,883	\$1,899
OPEX (000s)	\$876	\$893	\$911	\$930	\$948	\$967	\$986	\$1,006	\$1,026	\$1,047
Income (000s)	\$885	\$882	\$879	\$876	\$873	\$869	\$865	\$861	\$857	\$853

Unlevered, Pre-Tax IRR =	12%
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Average Operating Income* =	\$883,227
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% of OPEX	101%
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* Averaged over twenty years to account for inflation

[†] Base price (1%/year increase up to \$30/GJ max)

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 75% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, if RNG production is 10% higher than anticipated (due to the availability of high biogas-potential mixed food waste), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$16.86/GJ to <\$16/GJ. Alternately, if RNG production is 10% or 20% lower than anticipated, the required RNG sale price for an unlevered, pre-tax IRR increases from \$16.86/GJ to >\$18/GJ and >\$21/GJ respectively. Furthermore, if only 50% of estimated mixed food waste is available (7,212 instead of 14,424 tonnes/year), RNG production will be approximately 45% lower. If RNG production is 45% lower, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 10%. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option A: Sensitivity Analysis – RNG Production

		Change in RNG Production Amount														
		-50%	-45%	-40%	-35%	-30%	-25%	-20%	-15%	-10%	-5%	0%	5%	10%	15%	20%
\$/GJ RNG	\$16	---	---	---	1.3%	3.0%	4.5%	5.9%	7.2%	8.5%	9.7%	10.8%	11.9%	13.0%	14.1%	15.1%
	\$17	---	---	0.9%	2.7%	4.3%	5.8%	7.2%	8.6%	9.8%	11.0%	12.2%	13.4%	14.5%	15.6%	16.6%
	\$18	---	0.1%	2.2%	3.9%	5.6%	7.1%	8.5%	9.8%	11.1%	12.4%	13.6%	14.7%	15.9%	17.0%	18.1%
	\$19	---	1.4%	3.4%	5.1%	6.7%	8.3%	9.7%	11.0%	12.4%	13.6%	14.9%	16.1%	17.3%	18.4%	19.6%
	\$20	0.4%	2.6%	4.5%	6.2%	7.9%	9.4%	10.8%	12.2%	13.6%	14.9%	16.1%	17.4%	18.6%	19.8%	21.0%
	\$21	1.5%	3.7%	5.6%	7.3%	8.9%	10.5%	11.9%	13.4%	14.7%	16.1%	17.4%	18.7%	19.9%	21.2%	22.4%
	\$22	2.6%	4.7%	6.6%	8.3%	10.0%	11.5%	13.0%	14.5%	15.9%	17.3%	18.6%	19.9%	21.2%	22.5%	23.8%
	\$23	3.6%	5.7%	7.5%	9.3%	11.0%	12.6%	14.1%	15.6%	17.0%	18.4%	19.8%	21.2%	22.5%	23.8%	25.1%
	\$24	4.5%	6.6%	8.5%	10.3%	11.9%	13.6%	15.1%	16.6%	18.1%	19.6%	21.0%	22.4%	23.8%	25.1%	26.5%
	\$25	5.4%	7.5%	9.4%	11.2%	12.9%	14.5%	16.1%	17.7%	19.2%	20.7%	22.2%	23.6%	25.0%	26.5%	27.9%
	\$26	6.2%	8.3%	10.2%	12.0%	13.8%	15.5%	17.1%	18.7%	20.2%	21.8%	23.3%	24.8%	26.3%	27.7%	29.2%
	\$27	6.8%	8.9%	10.9%	12.8%	14.6%	16.3%	18.0%	19.6%	21.2%	22.8%	24.4%	25.9%	27.5%	29.0%	30.5%
	\$28	7.3%	9.5%	11.5%	13.4%	15.3%	17.0%	18.8%	20.5%	22.1%	23.8%	25.4%	27.0%	28.6%	30.1%	31.7%
	\$29	7.6%	9.9%	11.9%	13.9%	15.8%	17.6%	19.4%	21.1%	22.8%	24.5%	26.2%	27.9%	29.5%	31.1%	32.8%
	\$30	7.8%	10.0%	12.1%	14.1%	16.0%	17.9%	19.7%	21.5%	23.2%	25.0%	26.7%	28.3%	30.0%	31.7%	33.4%

B.C. On-Farm Biogas Benchmark Study, Version 2

Mixed food waste tip fee accounts for 21% of biogas plant revenue. Therefore, although less important than RNG sales, food waste tip fee can have a significant impact on biogas plant economic feasibility. For example, if mixed food waste tip fee is \$30/tonne instead of \$25/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$16.86/GJ to <\$16/GJ. Alternately, if mixed food waste tip fee is only \$10/tonne or \$0/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% increases from \$16.86/GJ to >\$19/GJ and >\$21/GJ respectively.

Option A: Sensitivity Analysis – Mixed Food Waste Tip Fee

		Mixed Food Waste Tip Fee (\$/Tonne)										
		\$0	\$5	\$10	\$15	\$20	\$25	\$30	\$35	\$40	\$45	\$50
\$/GJ RNG	\$16	3.3%	5.0%	6.6%	8.0%	9.5%	10.8%	12.2%	13.4%	14.7%	15.9%	17.1%
	\$17	5.1%	6.7%	8.1%	9.5%	10.9%	12.2%	13.5%	14.8%	16.0%	17.2%	18.4%
	\$18	6.8%	8.2%	9.6%	11.0%	12.3%	13.6%	14.8%	16.0%	17.2%	18.4%	19.6%
	\$19	8.3%	9.7%	11.0%	12.3%	13.6%	14.9%	16.1%	17.3%	18.5%	19.6%	20.8%
	\$20	9.8%	11.1%	12.4%	13.7%	14.9%	16.1%	17.3%	18.5%	19.7%	20.8%	22.0%
	\$21	11.2%	12.5%	13.7%	15.0%	16.2%	17.4%	18.6%	19.7%	20.9%	22.0%	23.2%
	\$22	12.5%	13.8%	15.0%	16.2%	17.4%	18.6%	19.8%	20.9%	22.0%	23.2%	24.3%
	\$23	13.8%	15.1%	16.3%	17.5%	18.6%	19.8%	20.9%	22.1%	23.2%	24.3%	25.5%
	\$24	15.1%	16.3%	17.5%	18.7%	19.8%	21.0%	22.1%	23.2%	24.4%	25.5%	26.6%
	\$25	16.4%	17.6%	18.7%	19.9%	21.0%	22.2%	23.3%	24.4%	25.5%	26.6%	27.7%
	\$26	17.6%	18.7%	19.9%	21.0%	22.2%	23.3%	24.4%	25.5%	26.6%	27.7%	28.8%
	\$27	18.7%	19.8%	21.0%	22.1%	23.3%	24.4%	25.5%	26.6%	27.7%	28.8%	29.9%
	\$28	19.6%	20.8%	22.0%	23.1%	24.3%	25.4%	26.5%	27.6%	28.7%	29.9%	31.0%
\$29	20.4%	21.6%	22.8%	23.9%	25.1%	26.2%	27.3%	28.5%	29.6%	30.7%	31.8%	
\$30	20.8%	22.0%	23.2%	24.4%	25.5%	26.7%	27.8%	28.9%	30.1%	31.2%	32.3%	

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #4 - Option B: Mixed Food Waste Cleaning Equipment

This biogas plant is estimated to cost \$7.8 million to build. Operating costs are estimated to average \$961,790/year. At an RNG sale price of \$19.92/GJ, average revenue is estimated to be \$1,996,038/year. This biogas plant doesn't require funding for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$1,034,248/year; equal to 108% of operating costs. Operating income should be sufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (i.e., broken equipment, unexpected downtime, etc.).

Option B: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>	<u>Revenue</u>	<u>Investment</u>
Digester	\$3,580,500		RNG/GJ [†] =	\$19.92
Upgrader	\$2,681,500		Avg RNG Sales/Yr =	\$1,562,546
Nutrient Recovery	\$507,144		Tip Fee/Yr =	\$360,599
Other	\$1,013,679		Bedding Savings/Yr* =	\$72,892
Total	<u>\$7,782,823</u>	<u>\$961,790</u>	Total =	<u>\$1,996,038</u>
				Farm Investment = \$7,782,823
				Funding Amount = \$0
				Funding % of CAPEX = 0%
				Inflation = 2%

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$1,840	\$1,855	\$1,871	\$1,886	\$1,902	\$1,918	\$1,935	\$1,951	\$1,968	\$1,985
OPEX (000s)	\$792	\$808	\$824	\$840	\$857	\$874	\$892	\$909	\$928	\$946
<i>Income (000s)</i>	<i>\$1,048</i>	<i>\$1,048</i>	<i>\$1,047</i>	<i>\$1,046</i>	<i>\$1,045</i>	<i>\$1,044</i>	<i>\$1,043</i>	<i>\$1,042</i>	<i>\$1,040</i>	<i>\$1,038</i>

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$2,001	\$2,019	\$2,036	\$2,054	\$2,071	\$2,089	\$2,107	\$2,126	\$2,144	\$2,163
OPEX (000s)	\$965	\$984	\$1,004	\$1,024	\$1,045	\$1,066	\$1,087	\$1,109	\$1,131	\$1,153
<i>Income (000s)</i>	<i>\$1,036</i>	<i>\$1,034</i>	<i>\$1,032</i>	<i>\$1,029</i>	<i>\$1,027</i>	<i>\$1,024</i>	<i>\$1,020</i>	<i>\$1,017</i>	<i>\$1,013</i>	<i>\$1,009</i>

Unlevered, Pre-Tax IRR =	12%
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Average Operating Income* =	\$1,034,248
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% of OPEX	108%
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* Averaged over twenty years to account for inflation

[†] Base price (1%/year increase up to \$30/GJ max)

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 78% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, if RNG production is 10% or 20% higher than anticipated (due to the availability of high biogas-potential mixed food waste), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$19.92/GJ to <\$19/GJ and <\$17/GJ respectively. Alternately, if RNG production is 10% or 20% lower than anticipated, the required RNG sale price for an unlevered, pre-tax IRR increases from \$19.92/GJ to >\$22/GJ and >\$24/GJ respectively. Furthermore, if only 50% of estimated mixed food waste is available (7,212 instead of 14,424 tonnes/year), RNG production will be approximately 45% lower. If RNG production is 45% lower, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 6.0%. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option B: Sensitivity Analysis – RNG Production

		Change in RNG Production Amount														
		-50%	-45%	-40%	-35%	-30%	-25%	-20%	-15%	-10%	-5%	0%	5%	10%	15%	20%
\$/GJ RNG	\$16	---	---	---	---	---	0.6%	2.1%	3.5%	4.7%	5.9%	7.0%	8.1%	9.2%	10.2%	11.1%
	\$17	---	---	---	---	0.4%	2.0%	3.5%	4.8%	6.1%	7.3%	8.4%	9.5%	10.5%	11.5%	12.5%
	\$18	---	---	---	0.0%	1.7%	3.3%	4.7%	6.1%	7.3%	8.5%	9.7%	10.8%	11.8%	12.9%	13.9%
	\$19	---	---	---	1.3%	3.0%	4.5%	5.9%	7.3%	8.5%	9.7%	10.9%	12.0%	13.1%	14.2%	15.2%
	\$20	---	---	0.6%	2.5%	4.1%	5.6%	7.0%	8.4%	9.7%	10.9%	12.1%	13.2%	14.3%	15.4%	16.5%
	\$21	---	---	1.7%	3.6%	5.2%	6.7%	8.1%	9.5%	10.8%	12.0%	13.2%	14.4%	15.5%	16.7%	17.8%
	\$22	---	0.8%	2.8%	4.6%	6.2%	7.7%	9.2%	10.5%	11.8%	13.1%	14.3%	15.5%	16.7%	17.9%	19.0%
	\$23	---	1.8%	3.8%	5.6%	7.2%	8.7%	10.2%	11.5%	12.9%	14.2%	15.4%	16.7%	17.9%	19.0%	20.2%
	\$24	0.6%	2.8%	4.7%	6.5%	8.1%	9.7%	11.1%	12.5%	13.9%	15.2%	16.5%	17.8%	19.0%	20.2%	21.4%
	\$25	1.6%	3.7%	5.6%	7.4%	9.0%	10.6%	12.1%	13.5%	14.9%	16.2%	17.5%	18.8%	20.1%	21.4%	22.6%
	\$26	2.3%	4.5%	6.4%	8.2%	9.8%	11.4%	12.9%	14.4%	15.8%	17.2%	18.6%	19.9%	21.2%	22.5%	23.8%
	\$27	2.9%	5.1%	7.1%	8.9%	10.6%	12.2%	13.7%	15.2%	16.7%	18.1%	19.5%	20.9%	22.2%	23.6%	24.9%
	\$28	3.4%	5.6%	7.6%	9.4%	11.1%	12.8%	14.4%	15.9%	17.4%	18.9%	20.3%	21.8%	23.2%	24.5%	25.9%
	\$29	3.7%	5.9%	7.9%	9.8%	11.6%	13.3%	14.9%	16.5%	18.0%	19.5%	21.0%	22.5%	23.9%	25.3%	26.8%
\$30	3.8%	6.0%	8.1%	10.0%	11.8%	13.5%	15.1%	16.7%	18.3%	19.8%	21.4%	22.8%	24.3%	25.8%	27.2%	

B.C. On-Farm Biogas Benchmark Study, Version 2

Mixed food waste tip fee accounts for 18% of biogas plant revenue. Therefore, although less important than RNG sales, food waste tip fee can have a significant impact on biogas plant economic feasibility. For example, if mixed food waste tip fee is \$35/tonne or \$50/tonne instead of \$25/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$19.92/GJ to \$18/GJ and <\$16/GJ respectively. Alternately, if mixed food waste tip fee is only \$10/tonne or \$0/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% increases from \$19.92/GJ to >\$22/GJ and >\$24/GJ respectively.

Option B: Sensitivity Analysis – Mixed Food Waste Tip Fee

		Mixed Food Waste Tip Fee (\$/Tonne)										
		\$0	\$5	\$10	\$15	\$20	\$25	\$30	\$35	\$40	\$45	\$50
\$/GJ RNG	\$16	---	1.2%	2.8%	4.3%	5.7%	7.0%	8.3%	9.5%	10.7%	11.8%	13.0%
	\$17	1.3%	2.9%	4.4%	5.8%	7.1%	8.4%	9.6%	10.8%	11.9%	13.0%	14.1%
	\$18	3.1%	4.5%	5.9%	7.2%	8.5%	9.7%	10.8%	12.0%	13.1%	14.1%	15.2%
	\$19	4.6%	6.0%	7.3%	8.5%	9.7%	10.9%	12.0%	13.1%	14.2%	15.2%	16.3%
	\$20	6.1%	7.4%	8.6%	9.8%	10.9%	12.1%	13.2%	14.2%	15.3%	16.3%	17.4%
	\$21	7.4%	8.7%	9.9%	11.0%	12.1%	13.2%	14.3%	15.3%	16.4%	17.4%	18.4%
	\$22	8.7%	9.9%	11.1%	12.2%	13.3%	14.3%	15.4%	16.4%	17.4%	18.4%	19.4%
	\$23	10.0%	11.1%	12.2%	13.3%	14.4%	15.4%	16.5%	17.5%	18.5%	19.5%	20.5%
	\$24	11.2%	12.3%	13.4%	14.4%	15.5%	16.5%	17.5%	18.5%	19.5%	20.5%	21.5%
	\$25	12.3%	13.4%	14.5%	15.5%	16.5%	17.5%	18.5%	19.5%	20.5%	21.5%	22.5%
	\$26	13.4%	14.5%	15.5%	16.5%	17.6%	18.6%	19.5%	20.5%	21.5%	22.5%	23.4%
	\$27	14.4%	15.4%	16.5%	17.5%	18.5%	19.5%	20.5%	21.5%	22.4%	23.4%	24.4%
	\$28	15.2%	16.3%	17.3%	18.3%	19.3%	20.3%	21.3%	22.3%	23.3%	24.3%	25.2%
	\$29	15.8%	16.9%	17.9%	19.0%	20.0%	21.0%	22.0%	23.0%	24.0%	25.0%	25.9%
\$30	16.1%	17.2%	18.3%	19.3%	20.3%	21.4%	22.4%	23.4%	24.4%	25.3%	26.3%	

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #4 - Option C: RNG Compression Equipment

This biogas plant is estimated to cost \$7.7 million to build. Operating costs are estimated to average \$1,209,617/year. At an RNG sale price of \$22.78/GJ, average revenue is estimated to be \$2,220,268/year. This biogas plant doesn't require funding for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$1,010,650/year; equal to 84% of operating costs. Operating income should be sufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (i.e., broken equipment, unexpected downtime, etc.).

Option C: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>	<u>Revenue</u>		<u>Investment</u>	
Digester	\$2,590,875		RNG/GJ [†] =	\$22.78	Farm Investment =	\$7,680,145
Upgrader	\$3,581,820		Avg RNG Sales/Yr =	\$1,786,777	Funding Amount =	\$0
Nutrient Recovery	\$507,144		Tip Fee/Yr =	\$360,599	Funding % of CAPEX =	0%
Other	\$1,000,306		Bedding Savings/Yr* =	\$72,892		
Total	<u>\$7,680,145</u>	<u>\$1,209,617</u>	Total =	<u>\$2,220,268</u>	Inflation =	2%

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$2,043	\$2,061	\$2,078	\$2,096	\$2,114	\$2,133	\$2,151	\$2,169	\$2,188	\$2,207
OPEX (000s)	\$996	\$1,016	\$1,036	\$1,057	\$1,078	\$1,099	\$1,121	\$1,144	\$1,167	\$1,190
<i>Income (000s)</i>	\$1,048	\$1,045	\$1,043	\$1,040	\$1,037	\$1,033	\$1,030	\$1,026	\$1,022	\$1,017

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$2,226	\$2,246	\$2,266	\$2,285	\$2,305	\$2,326	\$2,346	\$2,367	\$2,388	\$2,409
OPEX (000s)	\$1,214	\$1,238	\$1,263	\$1,288	\$1,314	\$1,340	\$1,367	\$1,394	\$1,422	\$1,451
<i>Income (000s)</i>	\$1,013	\$1,008	\$1,003	\$997	\$992	\$986	\$979	\$973	\$966	\$958

Unlevered, Pre-Tax IRR =	12%
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Average Operating Income* =	\$1,010,650
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% of OPEX	84%
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* Averaged over twenty years to account for inflation

[†] Base price (1%/year increase up to \$30/GJ max)

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 80% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, if RNG production is 10% or 20% higher than anticipated (due to the availability of high biogas-potential mixed food waste), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$22.78/GJ to <\$21/GJ and \$19/GJ respectively. Alternately, if RNG production is 10% or 15% lower than anticipated, the required RNG sale price for an unlevered, pre-tax IRR increases from \$22.78/GJ to >\$25/GJ and >\$27/GJ respectively. Furthermore, if only 50% of estimated mixed food waste is available (7,212 instead of 14,424 tonnes/year), RNG production will be approximately 45% lower. If RNG production is 45% lower, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 0.5%. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option C: Sensitivity Analysis – RNG Production

		Change in RNG Production Amount															
		-50%	-45%	-40%	-35%	-30%	-25%	-20%	-15%	-10%	-5%	0%	5%	10%	15%	20%	
\$/GJ RNG	\$16	---	---	---	---	---	---	---	---	---	0.8%	2.4%	3.8%	5.0%	6.2%	7.4%	
	\$17	---	---	---	---	---	---	---	---	1.0%	2.6%	4.1%	5.4%	6.7%	7.9%	9.0%	
	\$18	---	---	---	---	---	---	---	1.0%	2.7%	4.2%	5.6%	7.0%	8.2%	9.4%	10.5%	
	\$19	---	---	---	---	---	---	0.8%	2.6%	4.2%	5.7%	7.1%	8.4%	9.6%	10.8%	12.0%	
	\$20	---	---	---	---	---	0.4%	2.4%	4.1%	5.6%	7.1%	8.5%	9.8%	11.0%	12.2%	13.4%	
	\$21	---	---	---	---	---	1.9%	3.8%	5.4%	7.0%	8.4%	9.8%	11.1%	12.3%	13.6%	14.8%	
	\$22	---	---	---	---	1.2%	3.2%	5.0%	6.7%	8.2%	9.6%	11.0%	12.3%	13.6%	14.9%	16.1%	
	\$23	---	---	---	0.3%	2.5%	4.5%	6.2%	7.9%	9.4%	10.8%	12.2%	13.6%	14.9%	16.1%	17.4%	
	\$24	---	---	---	1.6%	3.8%	5.6%	7.4%	9.0%	10.5%	12.0%	13.4%	14.8%	16.1%	17.4%	18.6%	
	\$25	---	---	0.4%	2.8%	4.9%	6.7%	8.5%	10.1%	11.6%	13.1%	14.5%	15.9%	17.3%	18.6%	19.9%	
	\$26	---	---	1.4%	3.8%	5.8%	7.7%	9.4%	11.1%	12.6%	14.1%	15.6%	17.0%	18.4%	19.8%	21.1%	
	\$27	---	---	2.2%	4.5%	6.6%	8.5%	10.3%	11.9%	13.5%	15.1%	16.6%	18.0%	19.5%	20.9%	22.2%	
	\$28	---	0.0%	2.8%	5.1%	7.2%	9.2%	11.0%	12.7%	14.3%	15.9%	17.4%	18.9%	20.4%	21.9%	23.3%	
	\$29	---	0.3%	3.1%	5.5%	7.7%	9.6%	11.5%	13.2%	14.9%	16.5%	18.1%	19.6%	21.2%	22.7%	24.1%	
	\$30	---	0.5%	3.3%	5.7%	7.8%	9.8%	11.7%	13.5%	15.2%	16.8%	18.4%	20.0%	21.5%	23.1%	24.6%	

B.C. On-Farm Biogas Benchmark Study, Version 2

Mixed food waste tip fee accounts for 16% of biogas plant revenue. Therefore, although less important than RNG sales, food waste tip fee can have a significant impact on biogas plant economic feasibility. For example, if mixed food waste tip fee is \$35/tonne or \$50/tonne instead of \$25/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$22.78/GJ to <\$21/GJ and <\$19/GJ respectively. Alternately, if mixed food waste tip fee is only \$10/tonne or \$0/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% increases from \$22.78/GJ to >\$25/GJ and >\$28/GJ respectively.

Option C: Sensitivity Analysis – Mixed Food Waste Tip Fee

		Mixed Food Waste Tip Fee (\$/Tonne)										
		\$0	\$5	\$10	\$15	\$20	\$25	\$30	\$35	\$40	\$45	\$50
\$/GJ RNG	\$16	---	---	---	---	0.6%	2.4%	4.0%	5.4%	6.8%	8.2%	9.4%
	\$17	---	---	---	0.8%	2.5%	4.1%	5.5%	6.9%	8.2%	9.5%	10.7%
	\$18	---	---	0.9%	2.6%	4.2%	5.6%	7.0%	8.3%	9.6%	10.8%	11.9%
	\$19	---	1.1%	2.8%	4.3%	5.7%	7.1%	8.4%	9.6%	10.8%	12.0%	13.1%
	\$20	1.2%	2.9%	4.4%	5.8%	7.2%	8.5%	9.7%	10.9%	12.1%	13.2%	14.3%
	\$21	3.0%	4.5%	5.9%	7.3%	8.5%	9.8%	11.0%	12.1%	13.2%	14.3%	15.4%
	\$22	4.6%	6.0%	7.3%	8.6%	9.8%	11.0%	12.2%	13.3%	14.4%	15.5%	16.5%
	\$23	6.1%	7.4%	8.7%	9.9%	11.1%	12.2%	13.3%	14.4%	15.5%	16.6%	17.6%
	\$24	7.5%	8.8%	10.0%	11.1%	12.3%	13.4%	14.5%	15.5%	16.6%	17.6%	18.7%
	\$25	8.8%	10.0%	11.2%	12.3%	13.4%	14.5%	15.6%	16.6%	17.7%	18.7%	19.7%
	\$26	10.0%	11.2%	12.3%	13.4%	14.5%	15.6%	16.6%	17.7%	18.7%	19.7%	20.7%
	\$27	11.0%	12.2%	13.3%	14.4%	15.5%	16.6%	17.6%	18.7%	19.7%	20.7%	21.7%
	\$28	11.9%	13.0%	14.2%	15.3%	16.4%	17.4%	18.5%	19.5%	20.5%	21.6%	22.6%
	\$29	12.5%	13.7%	14.8%	15.9%	17.0%	18.1%	19.2%	20.2%	21.2%	22.3%	23.3%
	\$30	12.8%	14.0%	15.1%	16.2%	17.3%	18.4%	19.5%	20.5%	21.6%	22.6%	23.6%

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #4 - Option D: Nutrient Recovery Equipment

This biogas plant is estimated to cost \$7.7 million to build. Operating costs are estimated to average \$1,182,688/year. At an RNG sale price of \$22.50/GJ, average revenue is estimated to be \$2,198,372/year. This biogas plant doesn't require funding for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$1,015,684/year; equal to 86% of operating costs. Operating income should be sufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (i.e., broken equipment, unexpected downtime, etc.).

Option D: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>	<u>Revenue</u>		<u>Investment</u>	
Digester	\$2,821,875		RNG/GJ [†] =	\$22.50	Farm Investment =	\$7,686,675
Upgrader	\$2,681,500		Avg RNG Sales/Yr =	\$1,764,881	Funding Amount =	\$0
Nutrient Recovery	\$1,182,144		Tip Fee/Yr =	\$360,599	Funding % of CAPEX =	0%
Other	\$1,001,156		Bedding Savings/Yr* =	\$72,892		
Total	<u>\$7,686,675</u>	<u>\$1,182,688</u>	Total =	<u>\$2,198,372</u>	Inflation =	2%

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$2,024	\$2,041	\$2,058	\$2,076	\$2,094	\$2,112	\$2,130	\$2,148	\$2,167	\$2,186
OPEX (000s)	\$974	\$993	\$1,013	\$1,033	\$1,054	\$1,075	\$1,096	\$1,118	\$1,141	\$1,163
<i>Income (000s)</i>	\$1,050	\$1,048	\$1,045	\$1,043	\$1,040	\$1,037	\$1,033	\$1,030	\$1,026	\$1,022

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$2,205	\$2,224	\$2,243	\$2,263	\$2,282	\$2,302	\$2,323	\$2,343	\$2,364	\$2,385
OPEX (000s)	\$1,187	\$1,210	\$1,235	\$1,259	\$1,285	\$1,310	\$1,336	\$1,363	\$1,390	\$1,418
<i>Income (000s)</i>	\$1,018	\$1,013	\$1,008	\$1,003	\$998	\$992	\$986	\$980	\$973	\$967

Unlevered, Pre-Tax IRR =	12%
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Average Operating Income* =	\$1,015,684
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% of OPEX	86%
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* Averaged over twenty years to account for inflation

[†] Base price (1%/year increase up to \$30/GJ max)

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 80% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, if RNG production is 10% or 20% higher than anticipated (due to the availability of high biogas-potential mixed food waste), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$22.50/GJ to <\$21/GJ and <\$19/GJ respectively. Alternately, if RNG production is 10% or 20% lower than anticipated, the required RNG sale price for an unlevered, pre-tax IRR increases from \$22.50/GJ to \$25/GJ and >\$29/GJ respectively. Furthermore, if only 50% of estimated mixed food waste is available (7,212 instead of 14,424 tonnes/year), RNG production will be approximately 45% lower. If RNG production is 45% lower, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 1.2%. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option D: Sensitivity Analysis – RNG Production

		Change in RNG Production Amount														
		-50%	-45%	-40%	-35%	-30%	-25%	-20%	-15%	-10%	-5%	0%	5%	10%	15%	20%
\$/GJ RNG	\$16	---	---	---	---	---	---	---	---	-0.1%	1.5%	3.0%	4.3%	5.5%	6.7%	7.8%
	\$17	---	---	---	---	---	---	---	0.0%	1.7%	3.2%	4.6%	5.9%	7.1%	8.3%	9.4%
	\$18	---	---	---	---	---	---	-0.1%	1.7%	3.3%	4.8%	6.1%	7.4%	8.6%	9.8%	10.9%
	\$19	---	---	---	---	---	-0.4%	1.5%	3.2%	4.8%	6.2%	7.6%	8.8%	10.1%	11.2%	12.4%
	\$20	---	---	---	---	---	1.1%	3.0%	4.6%	6.1%	7.6%	8.9%	10.2%	11.4%	12.6%	13.8%
	\$21	---	---	---	---	0.5%	2.5%	4.3%	5.9%	7.4%	8.8%	10.2%	11.5%	12.7%	13.9%	15.1%
	\$22	---	---	---	---	1.9%	3.8%	5.5%	7.1%	8.6%	10.1%	11.4%	12.7%	14.0%	15.2%	16.4%
	\$23	---	---	---	1.0%	3.1%	5.0%	6.7%	8.3%	9.8%	11.2%	12.6%	13.9%	15.2%	16.5%	17.7%
	\$24	---	---	---	2.3%	4.3%	6.1%	7.8%	9.4%	10.9%	12.4%	13.8%	15.1%	16.4%	17.7%	19.0%
	\$25	---	---	1.1%	3.4%	5.4%	7.2%	8.9%	10.5%	12.0%	13.5%	14.9%	16.3%	17.6%	18.9%	20.2%
	\$26	---	---	2.1%	4.3%	6.3%	8.1%	9.8%	11.5%	13.0%	14.5%	15.9%	17.3%	18.7%	20.1%	21.4%
	\$27	---	0.2%	2.8%	5.1%	7.1%	8.9%	10.7%	12.3%	13.9%	15.4%	16.9%	18.4%	19.8%	21.2%	22.6%
	\$28	---	0.7%	3.4%	5.7%	7.7%	9.6%	11.4%	13.1%	14.7%	16.2%	17.8%	19.3%	20.7%	22.2%	23.6%
	\$29	---	1.1%	3.7%	6.1%	8.1%	10.1%	11.9%	13.6%	15.3%	16.9%	18.4%	20.0%	21.5%	23.0%	24.4%
	\$30	---	1.2%	3.9%	6.2%	8.3%	10.3%	12.1%	13.9%	15.5%	17.2%	18.8%	20.3%	21.9%	23.4%	24.9%

B.C. On-Farm Biogas Benchmark Study, Version 2

Mixed food waste tip fee accounts for 16% of biogas plant revenue. Therefore, although less important than RNG sales, food waste tip fee can have a significant impact on biogas plant economic feasibility. For example, if mixed food waste tip fee is \$35/tonne or \$50/tonne instead of \$25/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$22.50/GJ to <\$21/GJ and <\$18/GJ respectively. Alternately, if mixed food waste tip fee is only \$10/tonne or \$0/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% increases from \$22.50/GJ to >\$25/GJ and >\$27/GJ respectively.

Option D: Sensitivity Analysis – Mixed Food Waste Tip Fee

		Mixed Food Waste Tip Fee (\$/Tonne)										
		\$0	\$5	\$10	\$15	\$20	\$25	\$30	\$35	\$40	\$45	\$50
\$/GJ RNG	\$16	---	---	---	---	1.3%	3.0%	4.5%	5.9%	7.3%	8.6%	9.8%
	\$17	---	---	---	1.4%	3.1%	4.6%	6.0%	7.4%	8.7%	9.9%	11.1%
	\$18	---	---	1.6%	3.2%	4.7%	6.1%	7.5%	8.7%	10.0%	11.2%	12.3%
	\$19	---	1.7%	3.3%	4.8%	6.2%	7.6%	8.8%	10.0%	11.2%	12.4%	13.5%
	\$20	1.8%	3.4%	4.9%	6.3%	7.6%	8.9%	10.1%	11.3%	12.4%	13.5%	14.6%
	\$21	3.6%	5.0%	6.4%	7.7%	9.0%	10.2%	11.3%	12.5%	13.6%	14.7%	15.8%
	\$22	5.1%	6.5%	7.8%	9.0%	10.2%	11.4%	12.5%	13.7%	14.7%	15.8%	16.9%
	\$23	6.6%	7.9%	9.1%	10.3%	11.5%	12.6%	13.7%	14.8%	15.9%	16.9%	17.9%
	\$24	7.9%	9.2%	10.4%	11.5%	12.7%	13.8%	14.8%	15.9%	16.9%	18.0%	19.0%
	\$25	9.2%	10.4%	11.6%	12.7%	13.8%	14.9%	15.9%	17.0%	18.0%	19.0%	20.0%
	\$26	10.4%	11.6%	12.7%	13.8%	14.9%	15.9%	17.0%	18.0%	19.0%	20.1%	21.1%
	\$27	11.4%	12.6%	13.7%	14.8%	15.9%	16.9%	18.0%	19.0%	20.0%	21.0%	22.0%
	\$28	12.3%	13.4%	14.5%	15.6%	16.7%	17.8%	18.8%	19.8%	20.9%	21.9%	22.9%
	\$29	12.9%	14.1%	15.2%	16.3%	17.4%	18.4%	19.5%	20.5%	21.6%	22.6%	23.6%
	\$30	13.2%	14.4%	15.5%	16.6%	17.7%	18.8%	19.8%	20.9%	21.9%	22.9%	24.0%

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #4 - Option E: Mixed Food Waste Cleaning & RNG Compression Equipment

This biogas plant is estimated to cost \$8.8 million to build. Operating costs are estimated to average \$1,298,475/year. At an RNG sale price of \$25.95/GJ, average revenue is estimated to be \$2,455,827/year. This biogas plant doesn't require funding for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$1,157,352/year; equal to 89% of operating costs. Operating income should be sufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (i.e., broken equipment, unexpected downtime, etc.).

Option E: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>	<u>Revenue</u>		<u>Investment</u>	
Digester	\$3,580,500		RNG/GJ [†] =	\$25.95	Farm Investment =	\$8,817,966
Upgrader	\$3,581,820		Avg RNG Sales/Yr =	\$2,022,335	Funding Amount =	\$0
Nutrient Recovery	\$507,144		Tip Fee/Yr =	\$360,599	Funding % of CAPEX =	0%
Other	\$1,148,502		Bedding Savings/Yr* =	\$72,892		
Total	<u>\$8,817,966</u>	<u>\$1,298,475</u>	Total =	<u>\$2,455,827</u>	Inflation =	2%

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$2,269	\$2,289	\$2,309	\$2,329	\$2,349	\$2,370	\$2,391	\$2,412	\$2,433	\$2,454
OPEX (000s)	\$1,069	\$1,090	\$1,112	\$1,134	\$1,157	\$1,180	\$1,204	\$1,228	\$1,252	\$1,277
<i>Income (000s)</i>	\$1,201	\$1,199	\$1,197	\$1,195	\$1,192	\$1,190	\$1,187	\$1,184	\$1,181	\$1,177

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$2,476	\$2,498	\$2,520	\$2,542	\$2,565	\$2,579	\$2,580	\$2,582	\$2,584	\$2,585
OPEX (000s)	\$1,303	\$1,329	\$1,356	\$1,383	\$1,410	\$1,438	\$1,467	\$1,497	\$1,527	\$1,557
<i>Income (000s)</i>	\$1,173	\$1,169	\$1,165	\$1,160	\$1,155	\$1,140	\$1,113	\$1,085	\$1,057	\$1,028

Unlevered, Pre-Tax IRR =	12%
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Average Operating Income* =	\$1,157,352
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% of OPEX	89%
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* Averaged over twenty years to account for inflation

[†] Base price (1%/year increase up to \$30/GJ max)

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 82% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, if RNG production is 10% or 20% higher than anticipated (due to the availability of high biogas-potential mixed food waste), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$25.95/GJ to <\$24/GJ and <\$22/GJ respectively. Alternately, if RNG production is only 5% lower than anticipated, the required RNG sale price for an unlevered, pre-tax IRR increases from \$25.95/GJ to >\$27/GJ. Furthermore, if only 60% of estimated mixed food waste is available (8,654 instead of 14,424 tonnes/year), RNG production will be approximately 35% lower. If RNG production is 35% lower, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 2.0%. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option E: Sensitivity Analysis – RNG Production

		Change in RNG Production Amount														
		-50%	-45%	-40%	-35%	-30%	-25%	-20%	-15%	-10%	-5%	0%	5%	10%	15%	20%
\$/GJ RNG	\$16	---	---	---	---	---	---	---	---	---	---	---	0.3%	1.6%	2.9%	4.1%
	\$17	---	---	---	---	---	---	---	---	---	---	0.6%	2.1%	3.4%	4.6%	5.7%
	\$18	---	---	---	---	---	---	---	---	---	0.8%	2.3%	3.6%	4.9%	6.1%	7.2%
	\$19	---	---	---	---	---	---	---	---	0.8%	2.4%	3.8%	5.1%	6.3%	7.5%	8.6%
	\$20	---	---	---	---	---	---	---	0.6%	2.3%	3.8%	5.2%	6.5%	7.7%	8.8%	10.0%
	\$21	---	---	---	---	---	---	0.3%	2.1%	3.6%	5.1%	6.5%	7.7%	9.0%	10.1%	11.2%
	\$22	---	---	---	---	---	---	1.6%	3.4%	4.9%	6.3%	7.7%	9.0%	10.2%	11.4%	12.5%
	\$23	---	---	---	---	---	1.1%	2.9%	4.6%	6.1%	7.5%	8.8%	10.1%	11.4%	12.5%	13.7%
	\$24	---	---	---	---	0.3%	2.3%	4.1%	5.7%	7.2%	8.6%	10.0%	11.2%	12.5%	13.7%	14.9%
	\$25	---	---	---	---	1.5%	3.4%	5.2%	6.8%	8.3%	9.7%	11.0%	12.3%	13.6%	14.8%	16.0%
	\$26	---	---	---	0.2%	2.4%	4.4%	6.1%	7.7%	9.2%	10.6%	12.0%	13.3%	14.6%	15.9%	17.1%
	\$27	---	---	---	1.0%	3.2%	5.1%	6.9%	8.5%	10.0%	11.5%	12.9%	14.3%	15.6%	16.9%	18.1%
	\$28	---	---	---	1.5%	3.7%	5.7%	7.5%	9.1%	10.7%	12.2%	13.6%	15.0%	16.4%	17.7%	19.0%
	\$29	---	---	---	1.9%	4.1%	6.1%	7.9%	9.6%	11.2%	12.7%	14.2%	15.6%	17.0%	18.4%	19.7%
	\$30	---	---	---	2.0%	4.3%	6.3%	8.1%	9.8%	11.4%	13.0%	14.5%	15.9%	17.3%	18.7%	20.1%

B.C. On-Farm Biogas Benchmark Study, Version 2

Mixed food waste tip fee accounts for 15% of biogas plant revenue. Therefore, although less important than RNG sales, food waste tip fee can have a significant impact on biogas plant economic feasibility. For example, if mixed food waste tip fee is \$35/tonne or \$50/tonne instead of \$25/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$25.95/GJ to \$24/GJ and <\$22/GJ respectively. Alternately, if mixed food waste tip fee is only \$10/tonne or \$0/tonne, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 11.4% and 9.2% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option E: Sensitivity Analysis – Mixed Food Waste Tip Fee

		Mixed Food Waste Tip Fee (\$/Tonne)										
		\$0	\$5	\$10	\$15	\$20	\$25	\$30	\$35	\$40	\$45	\$50
\$/GJ RNG	\$16	---	---	---	---	---	---	0.5%	2.1%	3.5%	4.8%	6.1%
	\$17	---	---	---	---	---	0.6%	2.2%	3.6%	4.9%	6.1%	7.3%
	\$18	---	---	---	---	0.8%	2.3%	3.7%	5.0%	6.2%	7.4%	8.5%
	\$19	---	---	---	0.9%	2.4%	3.8%	5.1%	6.3%	7.5%	8.6%	9.7%
	\$20	---	---	1.0%	2.5%	3.9%	5.2%	6.4%	7.5%	8.6%	9.7%	10.8%
	\$21	---	1.2%	2.6%	4.0%	5.3%	6.5%	7.6%	8.7%	9.8%	10.8%	11.8%
	\$22	1.3%	2.7%	4.1%	5.3%	6.5%	7.7%	8.8%	9.8%	10.9%	11.9%	12.9%
	\$23	2.8%	4.2%	5.4%	6.6%	7.7%	8.8%	9.9%	10.9%	11.9%	12.9%	13.9%
	\$24	4.3%	5.5%	6.7%	7.8%	8.9%	10.0%	11.0%	12.0%	13.0%	13.9%	14.9%
	\$25	5.6%	6.8%	7.9%	9.0%	10.0%	11.0%	12.0%	13.0%	14.0%	14.9%	15.8%
	\$26	6.7%	7.8%	8.9%	10.0%	11.0%	12.0%	13.0%	14.0%	14.9%	15.8%	16.8%
	\$27	7.7%	8.8%	9.8%	10.9%	11.9%	12.9%	13.9%	14.8%	15.8%	16.7%	17.6%
	\$28	8.4%	9.5%	10.6%	11.6%	12.7%	13.6%	14.6%	15.6%	16.5%	17.4%	18.4%
	\$29	8.9%	10.0%	11.1%	12.2%	13.2%	14.2%	15.2%	16.1%	17.1%	18.0%	18.9%
	\$30	9.2%	10.3%	11.4%	12.4%	13.5%	14.5%	15.4%	16.4%	17.4%	18.3%	19.2%

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #4 - Option F: Mixed Food Waste Cleaning & Nutrient Recovery Equipment

This biogas plant is estimated to cost \$8.8 million to build. Operating costs are estimated to average \$1,271,546/year. At an RNG sale price of \$25.62/GJ, average revenue is estimated to be \$2,435,964/year. This biogas plant doesn't require funding for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$1,164,419/year; equal to 92% of operating costs. Operating income should be sufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (i.e., broken equipment, unexpected downtime, etc.).

Option F: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>	<u>Revenue</u>		<u>Investment</u>	
Digester	\$3,811,500		RNG/GJ [†] =	\$25.62	Farm Investment =	\$8,824,497
Upgrader	\$2,681,500		Avg RNG Sales/Yr =	\$2,002,473	Funding Amount =	\$0
Nutrient Recovery	\$1,182,144		Tip Fee/Yr =	\$360,599	Funding % of CAPEX =	0%
Other	\$1,149,353		Bedding Savings/Yr* =	\$72,892		
Total	<u>\$8,824,497</u>	<u>\$1,271,546</u>	Total =	<u>\$2,435,964</u>	Inflation =	2%

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$2,246	\$2,265	\$2,285	\$2,305	\$2,325	\$2,345	\$2,366	\$2,386	\$2,407	\$2,429
OPEX (000s)	\$1,047	\$1,068	\$1,089	\$1,111	\$1,133	\$1,156	\$1,179	\$1,202	\$1,226	\$1,251
<i>Income (000s)</i>	\$1,199	\$1,198	\$1,196	\$1,194	\$1,192	\$1,190	\$1,187	\$1,184	\$1,181	\$1,178

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$2,450	\$2,472	\$2,494	\$2,516	\$2,538	\$2,561	\$2,580	\$2,582	\$2,584	\$2,585
OPEX (000s)	\$1,276	\$1,301	\$1,327	\$1,354	\$1,381	\$1,409	\$1,437	\$1,466	\$1,495	\$1,525
<i>Income (000s)</i>	\$1,174	\$1,170	\$1,166	\$1,162	\$1,157	\$1,152	\$1,143	\$1,116	\$1,089	\$1,061

Unlevered, Pre-Tax IRR =	12%
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Average Operating Income* =	\$1,164,419
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% of OPEX	92%
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* Averaged over twenty years to account for inflation

[†] Base price (1%/year increase up to \$30/GJ max)

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 82% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, if RNG production is 10% or 20% higher than anticipated (due to the availability of high biogas-potential mixed food waste), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$25.62/GJ to <\$24/GJ and <\$22/GJ respectively. Alternately, if RNG production is only 5% lower than anticipated, the required RNG sale price for an unlevered, pre-tax IRR increases from \$25.62/GJ to >\$27/GJ. Furthermore, if only 60% of estimated mixed food waste is available (8,654 instead of 14,424 tonnes/year), RNG production will be approximately 35% lower. If RNG production is 35% lower, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 2.6%. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option F: Sensitivity Analysis – RNG Production

		Change in RNG Production Amount														
		-50%	-45%	-40%	-35%	-30%	-25%	-20%	-15%	-10%	-5%	0%	5%	10%	15%	20%
\$/GJ RNG	\$16	---	---	---	---	---	---	---	---	---	---	---	0.9%	2.2%	3.4%	4.5%
	\$17	---	---	---	---	---	---	---	---	---	---	1.2%	2.6%	3.8%	5.0%	6.1%
	\$18	---	---	---	---	---	---	---	---	---	1.4%	2.8%	4.1%	5.3%	6.5%	7.6%
	\$19	---	---	---	---	---	---	---	---	1.4%	2.9%	4.3%	5.5%	6.7%	7.9%	9.0%
	\$20	---	---	---	---	---	---	---	1.2%	2.8%	4.3%	5.6%	6.9%	8.1%	9.2%	10.3%
	\$21	---	---	---	---	---	---	0.9%	2.6%	4.1%	5.5%	6.9%	8.1%	9.3%	10.5%	11.6%
	\$22	---	---	---	---	---	0.3%	2.2%	3.8%	5.3%	6.7%	8.1%	9.3%	10.5%	11.7%	12.8%
	\$23	---	---	---	---	---	1.6%	3.4%	5.0%	6.5%	7.9%	9.2%	10.5%	11.7%	12.9%	14.0%
	\$24	---	---	---	---	0.9%	2.8%	4.5%	6.1%	7.6%	9.0%	10.3%	11.6%	12.8%	14.0%	15.2%
	\$25	---	---	---	---	2.0%	3.9%	5.6%	7.2%	8.6%	10.0%	11.4%	12.7%	13.9%	15.1%	16.3%
	\$26	---	---	---	0.9%	3.0%	4.8%	6.5%	8.1%	9.6%	11.0%	12.4%	13.7%	14.9%	16.2%	17.4%
	\$27	---	---	-0.9%	1.6%	3.7%	5.6%	7.3%	8.9%	10.4%	11.8%	13.2%	14.6%	15.9%	17.2%	18.4%
	\$28	---	---	-0.4%	2.1%	4.2%	6.1%	7.9%	9.5%	11.1%	12.5%	14.0%	15.4%	16.7%	18.0%	19.3%
	\$29	---	---	0.0%	2.5%	4.6%	6.5%	8.3%	10.0%	11.5%	13.1%	14.5%	15.9%	17.3%	18.7%	20.0%
	\$30	---	---	0.1%	2.6%	4.8%	6.7%	8.5%	10.2%	11.8%	13.3%	14.8%	16.2%	17.6%	19.0%	20.4%

B.C. On-Farm Biogas Benchmark Study, Version 2

Mixed food waste tip fee accounts for 15% of biogas plant revenue. Therefore, although less important than RNG sales, food waste tip fee can have a significant impact on biogas plant economic feasibility. For example, if mixed food waste tip fee is \$35/tonne or \$50/tonne instead of \$25/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$25.62/GJ to <\$24/GJ and <\$21/GJ respectively. Alternately, if mixed food waste tip fee is only \$10/tonne or \$0/tonne, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 11.7% and 9.6% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option F: Sensitivity Analysis – Mixed Food Waste Tip Fee

		Mixed Food Waste Tip Fee (\$/Tonne)										
		\$0	\$5	\$10	\$15	\$20	\$25	\$30	\$35	\$40	\$45	\$50
\$/GJ RNG	\$16	---	---	---	---	---	---	1.1%	2.6%	4.0%	5.3%	6.5%
	\$17	---	---	---	---	---	1.2%	2.7%	4.1%	5.3%	6.6%	7.7%
	\$18	---	---	---	---	1.3%	2.8%	4.2%	5.4%	6.6%	7.8%	8.9%
	\$19	---	---	---	1.5%	2.9%	4.3%	5.5%	6.7%	7.9%	9.0%	10.0%
	\$20	---	0.0%	1.6%	3.0%	4.3%	5.6%	6.8%	7.9%	9.0%	10.1%	11.1%
	\$21	0.2%	1.7%	3.1%	4.4%	5.7%	6.9%	8.0%	9.1%	10.1%	11.2%	12.2%
	\$22	1.8%	3.2%	4.5%	5.8%	6.9%	8.1%	9.1%	10.2%	11.2%	12.2%	13.2%
	\$23	3.3%	4.6%	5.8%	7.0%	8.1%	9.2%	10.3%	11.3%	12.3%	13.2%	14.2%
	\$24	4.7%	5.9%	7.1%	8.2%	9.3%	10.3%	11.3%	12.3%	13.3%	14.2%	15.2%
	\$25	6.0%	7.1%	8.3%	9.3%	10.4%	11.4%	12.4%	13.3%	14.3%	15.2%	16.1%
	\$26	7.1%	8.2%	9.3%	10.3%	11.4%	12.4%	13.3%	14.3%	15.2%	16.1%	17.1%
	\$27	8.0%	9.1%	10.2%	11.2%	12.2%	13.2%	14.2%	15.1%	16.1%	17.0%	17.9%
	\$28	8.8%	9.9%	10.9%	12.0%	13.0%	14.0%	14.9%	15.9%	16.8%	17.7%	18.6%
	\$29	9.3%	10.4%	11.5%	12.5%	13.5%	14.5%	15.5%	16.4%	17.4%	18.3%	19.2%
	\$30	9.6%	10.7%	11.7%	12.8%	13.8%	14.8%	15.8%	16.7%	17.7%	18.6%	19.5%

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #4 - Option G: RNG Compression and Nutrient Recovery Equipment

This biogas plant is estimated to cost \$8.7 million to build. Operating costs are estimated to average \$1,519,373/year. At an RNG sale price of \$30/GJ, average revenue is estimated to be \$2,570,774/year. This biogas plant requires \$0.1 million funding (1% of CAPEX) for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$1,051,401/year; equal to 69% of operating costs. Operating income should be sufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (i.e., broken equipment, unexpected downtime, etc.).

Option G: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>	<u>Revenue</u>		<u>Investment</u>	
Digester	\$2,821,875		RNG/GJ =	\$30.00	Farm Investment =	\$8,596,837
Upgrader	\$3,581,820		Avg RNG Sales/Yr =	\$2,137,282	Funding Amount =	\$124,982
Nutrient Recovery	\$1,182,144		Tip Fee/Yr =	\$360,599	Funding % of CAPEX =	1%
Other	\$1,135,979		Bedding Savings/Yr* =	\$72,892		
Total	<u>\$8,721,818</u>	<u>\$1,519,373</u>	Total =	<u>\$2,570,774</u>	Inflation =	2%

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$2,558	\$2,559	\$2,560	\$2,562	\$2,563	\$2,564	\$2,565	\$2,567	\$2,568	\$2,570
OPEX (000s)	\$1,251	\$1,276	\$1,301	\$1,327	\$1,354	\$1,381	\$1,408	\$1,437	\$1,465	\$1,495
<i>Income (000s)</i>	\$1,307	\$1,283	\$1,259	\$1,234	\$1,209	\$1,183	\$1,157	\$1,130	\$1,103	\$1,075

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$2,571	\$2,572	\$2,574	\$2,575	\$2,577	\$2,579	\$2,580	\$2,582	\$2,584	\$2,585
OPEX (000s)	\$1,525	\$1,555	\$1,586	\$1,618	\$1,650	\$1,683	\$1,717	\$1,751	\$1,786	\$1,822
<i>Income (000s)</i>	\$1,046	\$1,017	\$988	\$958	\$927	\$895	\$863	\$831	\$797	\$763

Unlevered, Pre-Tax IRR =	12%	Average Operating Income* =	\$1,051,401	% of OPEX	69%
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* Averaged over twenty years to account for inflation

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 83% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, with 1% funding, if RNG production is 10% or 20% higher than anticipated (due to the availability of high biogas-potential mixed food waste), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$26/GJ and <\$24/GJ respectively. Alternately, with 1% funding, if RNG production is 5% or 10% lower than anticipated, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 10.3% and 8.5% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Mixed food waste tip fee accounts for 14% of biogas plant revenue. Therefore, although less important than RNG sales, food waste tip fee can have a significant impact on biogas plant economic feasibility. For example, with 1% funding, if mixed food waste tip fee is \$35/tonne or \$50/tonne instead of \$25/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 1% falls from \$30/GJ to <\$27/GJ and <\$24/GJ respectively. Alternately, with 1% funding, if mixed food waste tip fee is only \$20/tonne or \$15/tonne, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 10.9% and 9.7% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option G: Sensitivity Analysis – RNG Production & Mixed Food Waste Tip Fee

		Change in RNG Production Amount						
		-10%	-5%	0%	5%	10%	15%	20%
\$/GJ RNG	\$16	---	---	---	---	---	---	---
	\$17	---	---	---	---	---	0.4%	1.9%
	\$18	---	---	---	---	0.9%	2.4%	3.8%
	\$19	---	---	---	1.2%	2.7%	4.2%	5.5%
	\$20	---	---	1.2%	2.9%	4.4%	5.8%	7.1%
	\$21	---	1.2%	2.9%	4.5%	5.9%	7.3%	8.6%
	\$22	0.9%	2.7%	4.4%	5.9%	7.3%	8.7%	10.0%
	\$23	2.4%	4.2%	5.8%	7.3%	8.7%	10.0%	11.3%
	\$24	3.8%	5.5%	7.1%	8.6%	10.0%	11.3%	12.6%
	\$25	5.1%	6.8%	8.3%	9.8%	11.2%	12.5%	13.8%
	\$26	6.2%	7.9%	9.4%	10.9%	12.3%	13.7%	15.0%
	\$27	7.1%	8.8%	10.4%	11.9%	13.3%	14.7%	16.0%
	\$28	7.8%	9.5%	11.1%	12.7%	14.2%	15.6%	17.0%
\$29	8.3%	10.1%	11.7%	13.3%	14.8%	16.3%	17.7%	
\$30	8.5%	10.3%	12.0%	13.6%	15.1%	16.6%	18.0%	

		Mixed Food Waste Tip Fee (\$/Tonne)							
		\$15	\$20	\$25	\$30	\$35	\$40	\$45	\$50
\$/GJ RNG	\$16	---	---	---	---	---	---	0.7%	2.3%
	\$17	---	---	---	---	---	0.8%	2.4%	3.9%
	\$18	---	---	---	---	1.0%	2.6%	4.0%	5.4%
	\$19	---	---	---	1.1%	2.7%	4.1%	5.4%	6.7%
	\$20	---	---	1.2%	2.8%	4.2%	5.5%	6.8%	8.0%
	\$21	---	1.4%	2.9%	4.3%	5.6%	6.9%	8.1%	9.2%
	\$22	1.5%	3.0%	4.4%	5.7%	6.9%	8.1%	9.3%	10.4%
	\$23	3.1%	4.5%	5.8%	7.0%	8.2%	9.3%	10.4%	11.5%
	\$24	4.6%	5.9%	7.1%	8.3%	9.4%	10.5%	11.5%	12.6%
	\$25	6.0%	7.2%	8.3%	9.4%	10.5%	11.6%	12.6%	13.6%
	\$26	7.1%	8.3%	9.4%	10.5%	11.6%	12.6%	13.6%	14.6%
	\$27	8.1%	9.3%	10.4%	11.4%	12.5%	13.5%	14.5%	15.5%
	\$28	8.9%	10.0%	11.1%	12.2%	13.3%	14.3%	15.3%	16.3%
\$29	9.4%	10.6%	11.7%	12.8%	13.8%	14.9%	15.9%	16.8%	
\$30	9.7%	10.9%	12.0%	13.0%	14.1%	15.1%	16.1%	17.1%	

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #4 - Option H: Mixed Food Waste Cleaning, RNG Compression and Nutrient Recovery Equipment

This biogas plant is estimated to cost \$9.9 million to build. Operating costs are estimated to average \$1,608,230/year. At an RNG sale price of \$30/GJ, average revenue is estimated to be \$2,570,774/year. This biogas plant requires \$1.9 million funding (19% of CAPEX) for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$962,543/year; equal to 60% of operating costs. Operating income should be sufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (i.e., broken equipment, unexpected downtime, etc.).

Option H: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>	<u>Revenue</u>		<u>Investment</u>	
Digester	\$3,811,500		RNG/GJ =	\$30.00	Farm Investment =	\$7,942,351
Upgrader	\$3,581,820		Avg RNG Sales/Yr =	\$2,137,282	Funding Amount =	\$1,917,288
Nutrient Recovery	\$1,182,144		Tip Fee/Yr =	\$360,599	Funding % of CAPEX =	19%
Other	\$1,284,176		Bedding Savings/Yr* =	\$72,892		
Total	<u>\$9,859,640</u>	<u>\$1,608,230</u>	Total =	<u>\$2,570,774</u>	<i>Inflation =</i>	<i>2%</i>

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$2,558	\$2,559	\$2,560	\$2,562	\$2,563	\$2,564	\$2,565	\$2,567	\$2,568	\$2,570
OPEX (000s)	\$1,324	\$1,350	\$1,377	\$1,405	\$1,433	\$1,462	\$1,491	\$1,521	\$1,551	\$1,582
<i>Income (000s)</i>	<i>\$1,234</i>	<i>\$1,209</i>	<i>\$1,183</i>	<i>\$1,157</i>	<i>\$1,130</i>	<i>\$1,103</i>	<i>\$1,075</i>	<i>\$1,046</i>	<i>\$1,017</i>	<i>\$988</i>

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$2,571	\$2,572	\$2,574	\$2,575	\$2,577	\$2,579	\$2,580	\$2,582	\$2,584	\$2,585
OPEX (000s)	\$1,614	\$1,646	\$1,679	\$1,712	\$1,747	\$1,782	\$1,817	\$1,854	\$1,891	\$1,929
<i>Income (000s)</i>	<i>\$957</i>	<i>\$927</i>	<i>\$895</i>	<i>\$863</i>	<i>\$830</i>	<i>\$797</i>	<i>\$763</i>	<i>\$728</i>	<i>\$693</i>	<i>\$657</i>

Unlevered, Pre-Tax IRR =	12%	Average Operating Income* =	\$962,543	% of OPEX	60%
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** Averaged over twenty years to account for inflation*

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 83% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, with 19% funding, if RNG production is 10% or 20% higher than anticipated (due to the availability of high biogas-potential mixed food waste), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$26/GJ and <\$24/GJ respectively. Alternately, with 19% funding, if RNG production is 5% or 10% lower than anticipated, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 10.2% and 8.3% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Mixed food waste tip fee accounts for 14% of biogas plant revenue. Therefore, although less important than RNG sales, food waste tip fee can have a significant impact on biogas plant economic feasibility. For example, with 19% funding, if mixed food waste tip fee is \$35/tonne or \$50/tonne instead of \$25/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$27/GJ and <\$24/GJ respectively. Alternately, with 19% funding, if mixed food waste tip fee is only \$20/tonne or \$15/tonne, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 10.8% and 9.5% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option H: Sensitivity Analysis – RNG Production & Mixed Food Waste Tip Fee

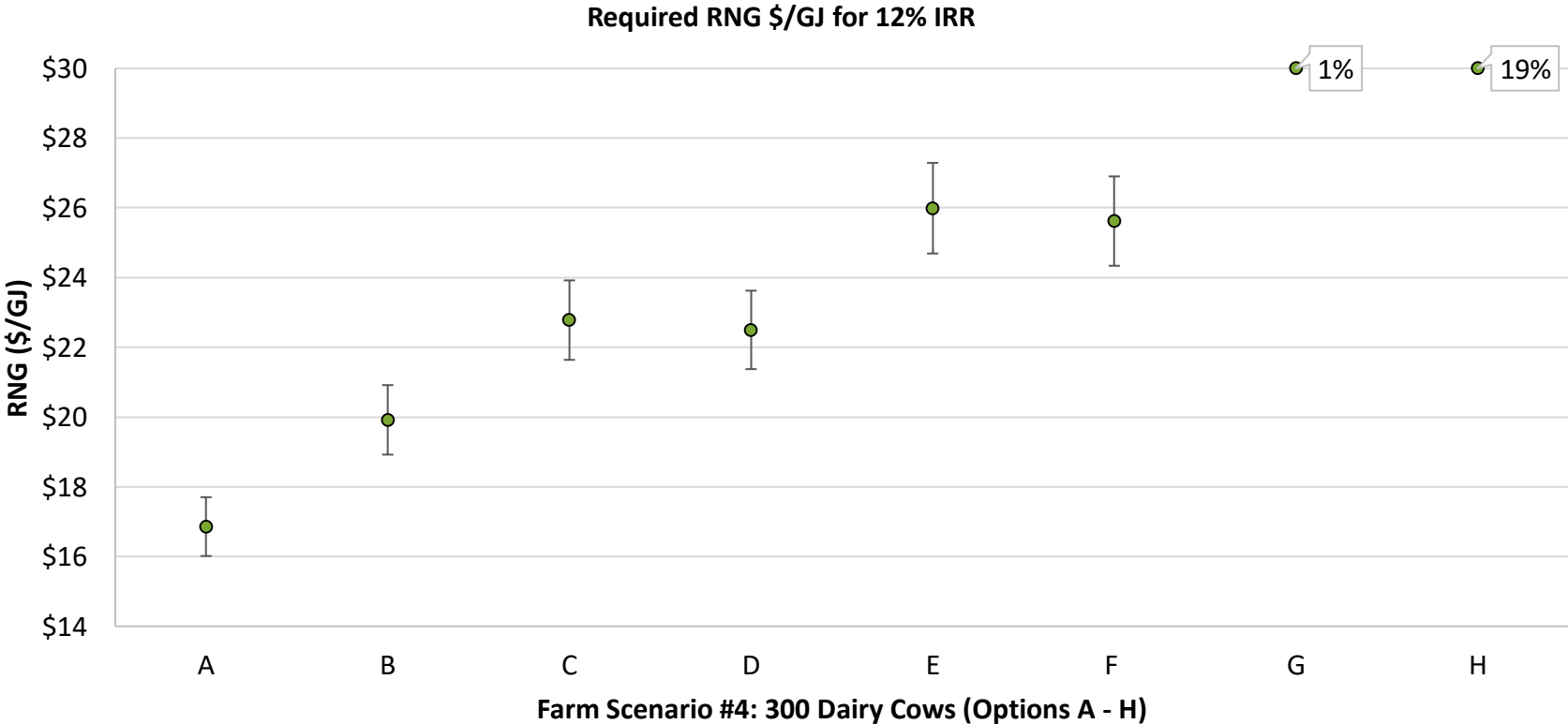
		Change in RNG Production Amount						
		-10%	-5%	0%	5%	10%	15%	20%
\$/GJ RNG	\$16	---	---	---	---	---	---	---
	\$17	---	---	---	---	---	---	0.7%
	\$18	---	---	---	---	---	1.3%	3.0%
	\$19	---	---	---	---	1.7%	3.4%	4.9%
	\$20	---	---	---	1.9%	3.6%	5.2%	6.7%
	\$21	---	---	1.9%	3.7%	5.4%	6.9%	8.3%
	\$22	---	1.7%	3.6%	5.4%	7.0%	8.4%	9.9%
	\$23	1.3%	3.4%	5.2%	6.9%	8.4%	9.9%	11.3%
	\$24	3.0%	4.9%	6.7%	8.3%	9.9%	11.3%	12.7%
	\$25	4.4%	6.3%	8.0%	9.7%	11.2%	12.7%	14.1%
	\$26	5.7%	7.5%	9.2%	10.9%	12.4%	13.9%	15.3%
	\$27	6.7%	8.5%	10.3%	11.9%	13.5%	15.0%	16.5%
	\$28	7.5%	9.4%	11.1%	12.8%	14.4%	16.0%	17.5%
	\$29	8.0%	9.9%	11.8%	13.5%	15.1%	16.7%	18.3%
\$30	8.3%	10.2%	12.0%	13.8%	15.5%	17.1%	18.7%	

		Mixed Food Waste Tip Fee (\$/Tonne)							
		\$15	\$20	\$25	\$30	\$35	\$40	\$45	\$50
\$/GJ RNG	\$16	---	---	---	---	---	---	---	1.2%
	\$17	---	---	---	---	---	---	1.3%	3.0%
	\$18	---	---	---	---	---	1.5%	3.2%	4.7%
	\$19	---	---	---	---	1.6%	3.3%	4.8%	6.2%
	\$20	---	---	---	1.8%	3.4%	4.9%	6.3%	7.7%
	\$21	---	0.1%	1.9%	3.5%	5.0%	6.4%	7.7%	9.0%
	\$22	0.3%	2.0%	3.6%	5.1%	6.5%	7.8%	9.1%	10.3%
	\$23	2.2%	3.8%	5.2%	6.6%	7.9%	9.1%	10.3%	11.5%
	\$24	3.9%	5.3%	6.7%	8.0%	9.2%	10.4%	11.6%	12.7%
	\$25	5.4%	6.8%	8.0%	9.3%	10.5%	11.6%	12.7%	13.8%
	\$26	6.7%	8.0%	9.2%	10.4%	11.6%	12.7%	13.8%	14.9%
	\$27	7.8%	9.1%	10.3%	11.5%	12.6%	13.7%	14.8%	15.9%
	\$28	8.7%	9.9%	11.1%	12.3%	13.4%	14.6%	15.6%	16.7%
	\$29	9.3%	10.5%	11.8%	12.9%	14.1%	15.2%	16.3%	17.4%
\$30	9.5%	10.8%	12.0%	13.2%	14.4%	15.5%	16.6%	17.7%	

Farm Scenario #4: Summary

Figure 16 shows the required RNG \$/GJ sale price for Farm Scenario #4 Options A – G for an unlevered, pre-tax IRR of 12%. Where required RNG sale price is >\$30/GJ, percentage of required funding is shown. Where required RNG sale price is <\$30/GJ, a bar representing +/- 5% is shown to account for price uncertainty. Farm Scenario #4 Options A – F don't require funding. These biogas plants require an RNG sale price from \$16.02 - \$27.29/GJ. Farm Scenario #4 Options G and H require funding. Funding is low at 1% (for Option G) to 19% (for Option H). Figure 16 shows that even with mixed food waste cleaning, RNG compression or nutrient recovery equipment, 300 dairy cow farms co-digesting dairy manure and mixed food waste can be economically feasible in B.C. without funding.

Figure 16: Farm Scenario #4 - Required RNG Sale Price for 300 Dairy Cows + Mixed Food Waste



7.5

Farm Scenario #5: 400 Dairy Cows + Mixed Food Waste

Farm Scenario #5 is a 400 dairy cow farm co-digesting dairy manure and mixed food waste. Farm Scenario #5 assumes the use of traditional on-farm biogas plant technology. Estimated feedstock volume and Renewable Natural Gas (RNG) production for Farm Scenario #5 are as follows:

Feedstock	Tonnes/Year	Percentage	RNG Production (GJ/Year)
Dairy manure	20,017	51%	6,459
Mixed food waste	19,232	49%	93,460
<i>Total</i>	<i>39,249</i>	<i>100%</i>	<i>99,919</i>

The following Equipment Choices were assessed for Farm Scenario #5:

- Option A: No additional equipment;
- Option B: Mixed food waste cleaning equipment;
- Option C: RNG compression equipment;
- Option D: Nutrient recovery equipment;
- Option E: Mixed food waste cleaning and RNG compression equipment;
- Option F: Mixed food waste cleaning and nutrient recovery equipment;
- Option G: RNG compression and nutrient recovery equipment; and
- Option H: Mixed food waste cleaning, RNG compression and nutrient recovery equipment.

For full capital and operating costs for Farm Scenario #5 Options A – H, see Appendix E.

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #5 - Option A: No Additional Equipment

This biogas plant is estimated to cost \$8.0 million to build. Operating costs are estimated to average \$1,044,537/year. At an RNG sale price of \$14.58/GJ, average revenue is estimated to be \$2,102,846/year. This biogas plant doesn't require funding for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$1,058,309/year; equal to 101% of operating costs. Operating income should be sufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (i.e., broken equipment, unexpected downtime, etc.).

Option A: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>	<u>Revenue</u>		<u>Investment</u>	
Digester	\$3,163,125		RNG/GJ [†] =	\$14.58	Farm Investment =	\$7,971,006
Upgrader	\$3,093,500		Avg RNG Sales/Yr =	\$1,524,857	Funding Amount =	\$0
Nutrient Recovery	\$676,192		Tip Fee/Yr =	\$480,799	Funding % of CAPEX =	0%
Other	\$1,038,189		Bedding Savings/Yr* =	\$97,189		
Total	<u>\$7,971,006</u>	<u>\$1,044,537</u>	Total =	<u>\$2,102,846</u>	Inflation =	2%

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$1,946	\$1,961	\$1,977	\$1,993	\$2,009	\$2,025	\$2,041	\$2,058	\$2,074	\$2,091
OPEX (000s)	\$860	\$877	\$895	\$912	\$931	\$949	\$968	\$988	\$1,007	\$1,028
Income (000s)	\$1,086	\$1,084	\$1,082	\$1,080	\$1,078	\$1,075	\$1,073	\$1,070	\$1,067	\$1,064

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$2,108	\$2,126	\$2,143	\$2,161	\$2,178	\$2,196	\$2,215	\$2,233	\$2,252	\$2,271
OPEX (000s)	\$1,048	\$1,069	\$1,090	\$1,112	\$1,134	\$1,157	\$1,180	\$1,204	\$1,228	\$1,253
Income (000s)	\$1,060	\$1,056	\$1,053	\$1,048	\$1,044	\$1,039	\$1,034	\$1,029	\$1,024	\$1,018

Unlevered, Pre-Tax IRR =	12%
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Average Operating Income* =	\$1,058,309
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% of OPEX	101%
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* Averaged over twenty years to account for inflation

[†] Base price (1%/year increase up to \$30/GJ max)

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 73% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, if RNG production is 10% or 20% higher than anticipated (due to the availability of high biogas-potential mixed food waste), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$14.58/GJ to <\$14/GJ and <\$13/GJ respectively. Alternately, if RNG production is 10% or 20% lower than anticipated, the required RNG sale price for an unlevered, pre-tax IRR increases from \$14.58/GJ to >\$16/GJ and >\$18/GJ respectively. Furthermore, if only 50% of estimated mixed food waste is available (9,616 instead of 19,232 tonnes/year), RNG production will be approximately 45% lower. If RNG production is 45% lower, the required RNG sale price for an unlevered, pre-tax IRR of 12% increases from \$14.58/GJ to >\$26/GJ.

Option A: Sensitivity Analysis – RNG Production

		Change in RNG Production Amount														
		-50%	-45%	-40%	-35%	-30%	-25%	-20%	-15%	-10%	-5%	0%	5%	10%	15%	20%
\$/GJ RNG	\$12	---	---	---	---	0.3%	1.8%	3.2%	4.5%	5.7%	6.8%	7.9%	8.9%	9.9%	10.8%	11.8%
	\$13	---	---	---	0.5%	2.1%	3.5%	4.9%	6.1%	7.3%	8.5%	9.5%	10.6%	11.6%	12.6%	13.6%
	\$14	---	---	0.3%	2.1%	3.6%	5.1%	6.4%	7.7%	8.9%	10.0%	11.1%	12.2%	13.3%	14.3%	15.3%
	\$15	---	---	1.8%	3.5%	5.1%	6.5%	7.9%	9.1%	10.3%	11.5%	12.7%	13.8%	14.9%	15.9%	17.0%
	\$16	---	1.4%	3.2%	4.9%	6.4%	7.9%	9.2%	10.5%	11.8%	13.0%	14.1%	15.3%	16.4%	17.5%	18.6%
	\$17	0.6%	2.7%	4.5%	6.1%	7.7%	9.1%	10.5%	11.8%	13.1%	14.4%	15.6%	16.8%	17.9%	19.1%	20.2%
	\$18	1.8%	3.9%	5.7%	7.3%	8.9%	10.3%	11.8%	13.1%	14.4%	15.7%	17.0%	18.2%	19.4%	20.6%	21.8%
	\$19	3.0%	5.0%	6.8%	8.5%	10.0%	11.5%	13.0%	14.4%	15.7%	17.0%	18.3%	19.6%	20.9%	22.1%	23.3%
	\$20	4.1%	6.0%	7.9%	9.5%	11.1%	12.7%	14.1%	15.6%	17.0%	18.3%	19.7%	21.0%	22.3%	23.6%	24.9%
	\$21	5.1%	7.1%	8.9%	10.6%	12.2%	13.8%	15.3%	16.8%	18.2%	19.6%	21.0%	22.4%	23.7%	25.0%	26.4%
	\$22	6.0%	8.0%	9.9%	11.6%	13.3%	14.9%	16.4%	17.9%	19.4%	20.9%	22.3%	23.7%	25.1%	26.5%	27.9%
	\$23	7.0%	9.0%	10.8%	12.6%	14.3%	15.9%	17.5%	19.1%	20.6%	22.1%	23.6%	25.0%	26.5%	27.9%	29.4%
	\$24	7.9%	9.9%	11.8%	13.6%	15.3%	17.0%	18.6%	20.2%	21.8%	23.3%	24.9%	26.4%	27.9%	29.4%	30.9%
	\$25	8.7%	10.7%	12.7%	14.5%	16.3%	18.0%	19.7%	21.3%	22.9%	24.5%	26.1%	27.7%	29.2%	30.8%	32.3%
	\$26	9.5%	11.6%	13.5%	15.4%	17.2%	19.0%	20.7%	22.4%	24.1%	25.7%	27.4%	29.0%	30.6%	32.2%	33.8%
	\$27	10.1%	12.3%	14.3%	16.2%	18.1%	19.9%	21.7%	23.4%	25.2%	26.9%	28.6%	30.2%	31.9%	33.6%	35.2%
	\$28	10.7%	12.9%	14.9%	16.9%	18.8%	20.7%	22.6%	24.4%	26.2%	27.9%	29.7%	31.4%	33.2%	34.9%	36.6%
\$29	11.1%	13.3%	15.4%	17.5%	19.4%	21.4%	23.3%	25.1%	27.0%	28.8%	30.6%	32.4%	34.2%	36.0%	37.8%	
\$30	11.3%	13.5%	15.7%	17.7%	19.8%	21.7%	23.7%	25.6%	27.5%	29.3%	31.2%	33.0%	34.9%	36.7%	38.5%	

B.C. On-Farm Biogas Benchmark Study, Version 2

Mixed food waste tip fee accounts for 23% of biogas plant revenue. Therefore, although less important than RNG sales, food waste tip fee can have a significant impact on biogas plant economic feasibility. For example, if mixed food waste tip fee is \$35/tonne or \$40/tonne instead of \$25/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$14.58/GJ to <\$13/GJ and <\$12/GJ respectively. Alternately, if mixed food waste tip fee is only \$10/tonne or \$0/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% increases from \$14.58/GJ to >\$17/GJ and >\$19/GJ respectively.

Option A: Sensitivity Analysis – Mixed Food Waste Tip Fee

		Mixed Food Waste Tip Fee (\$/Tonne)										
		\$0	\$5	\$10	\$15	\$20	\$25	\$30	\$35	\$40	\$45	\$50
\$/GJ RNG	\$12	---	0.1%	2.4%	4.3%	6.2%	7.9%	9.5%	11.0%	12.5%	13.9%	15.3%
	\$13	0.3%	2.5%	4.5%	6.3%	8.0%	9.5%	11.1%	12.5%	14.0%	15.3%	16.7%
	\$14	2.7%	4.6%	6.4%	8.1%	9.6%	11.1%	12.6%	14.0%	15.4%	16.8%	18.1%
	\$15	4.7%	6.5%	8.1%	9.7%	11.2%	12.7%	14.1%	15.5%	16.8%	18.1%	19.4%
	\$16	6.6%	8.2%	9.8%	11.3%	12.7%	14.1%	15.5%	16.9%	18.2%	19.5%	20.8%
	\$17	8.3%	9.9%	11.4%	12.8%	14.2%	15.6%	16.9%	18.2%	19.5%	20.8%	22.1%
	\$18	10.0%	11.4%	12.9%	14.3%	15.6%	17.0%	18.3%	19.6%	20.9%	22.1%	23.4%
	\$19	11.5%	12.9%	14.3%	15.7%	17.0%	18.3%	19.6%	20.9%	22.2%	23.4%	24.7%
	\$20	13.0%	14.4%	15.7%	17.1%	18.4%	19.7%	20.9%	22.2%	23.5%	24.7%	26.0%
	\$21	14.5%	15.8%	17.1%	18.4%	19.7%	21.0%	22.3%	23.5%	24.8%	26.0%	27.2%
	\$22	15.9%	17.2%	18.5%	19.8%	21.0%	22.3%	23.5%	24.8%	26.0%	27.3%	28.5%
	\$23	17.2%	18.5%	19.8%	21.1%	22.3%	23.6%	24.8%	26.1%	27.3%	28.5%	29.7%
	\$24	18.6%	19.8%	21.1%	22.4%	23.6%	24.9%	26.1%	27.3%	28.5%	29.8%	31.0%
	\$25	19.9%	21.2%	22.4%	23.6%	24.9%	26.1%	27.3%	28.6%	29.8%	31.0%	32.2%
	\$26	21.2%	22.4%	23.7%	24.9%	26.1%	27.4%	28.6%	29.8%	31.0%	32.2%	33.4%
	\$27	22.4%	23.6%	24.9%	26.1%	27.3%	28.6%	29.8%	31.0%	32.2%	33.4%	34.6%
	\$28	23.5%	24.7%	26.0%	27.2%	28.5%	29.7%	30.9%	32.1%	33.4%	34.6%	35.8%
\$29	24.4%	25.6%	26.9%	28.2%	29.4%	30.6%	31.9%	33.1%	34.3%	35.6%	36.8%	
\$30	24.9%	26.1%	27.4%	28.7%	29.9%	31.2%	32.4%	33.7%	34.9%	36.1%	37.4%	

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #5 - Option B: Mixed Food Waste Cleaning Equipment

This biogas plant is estimated to cost \$9.1 million to build. Operating costs are estimated to average \$1,133,394/year. At an RNG sale price of \$16.86/GJ, average revenue is estimated to be \$2,341,019/year. This biogas plant doesn't require funding for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$1,207,625/year; equal to 107% of operating costs. Operating income should be sufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (i.e., broken equipment, unexpected downtime, etc.).

Option B: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>	<u>Revenue</u>		<u>Investment</u>	
Digester	\$4,152,750		RNG/GJ [†] =	\$16.86	Farm Investment =	\$9,108,827
Upgrader	\$3,093,500		Avg RNG Sales/Yr =	\$1,763,031	Funding Amount =	\$0
Nutrient Recovery	\$676,192		Tip Fee/Yr =	\$480,799	Funding % of CAPEX =	0%
Other	\$1,186,386		Bedding Savings/Yr* =	\$97,189		
Total	<u>\$9,108,827</u>	<u>\$1,133,394</u>	Total =	<u>\$2,341,019</u>	Inflation =	2%

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$2,162	\$2,180	\$2,197	\$2,215	\$2,234	\$2,252	\$2,271	\$2,290	\$2,309	\$2,328
OPEX (000s)	\$933	\$952	\$971	\$990	\$1,010	\$1,030	\$1,051	\$1,072	\$1,093	\$1,115
<i>Income (000s)</i>	\$1,229	\$1,228	\$1,227	\$1,225	\$1,224	\$1,222	\$1,220	\$1,218	\$1,216	\$1,213

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$2,347	\$2,367	\$2,387	\$2,407	\$2,427	\$2,448	\$2,468	\$2,489	\$2,511	\$2,532
OPEX (000s)	\$1,137	\$1,160	\$1,183	\$1,207	\$1,231	\$1,256	\$1,281	\$1,306	\$1,332	\$1,359
<i>Income (000s)</i>	\$1,210	\$1,207	\$1,204	\$1,200	\$1,196	\$1,192	\$1,188	\$1,183	\$1,178	\$1,173

Unlevered, Pre-Tax IRR =	12%
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Average Operating Income* =	\$1,207,625
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% of OPEX	107%
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* Averaged over twenty years to account for inflation

[†] Base price (1%/year increase up to \$30/GJ max)

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 75% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, if RNG production is 10% or 20% higher than anticipated (due to the availability of high biogas-potential mixed food waste), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$16.86/GJ to <\$16/GJ and <\$15/GJ respectively. Alternately, if RNG production is 10% or 20% lower than anticipated, the required RNG sale price for an unlevered, pre-tax IRR increases from \$16.86/GJ to >\$18/GJ and >\$21/GJ respectively. Furthermore, if only 50% of estimated mixed food waste is available (9,616 instead of 19,232 tonnes/year), RNG production will be approximately 45% lower. If RNG production is 45% lower, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 10%. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option B: Sensitivity Analysis – RNG Production

		Change in RNG Production Amount														
		-50%	-45%	-40%	-35%	-30%	-25%	-20%	-15%	-10%	-5%	0%	5%	10%	15%	20%
\$/GJ RNG	\$12	---	---	---	---	---	---	---	1.2%	2.4%	3.6%	4.7%	5.7%	6.7%	7.6%	8.5%
	\$13	---	---	---	---	---	0.2%	1.6%	2.9%	4.1%	5.3%	6.4%	7.4%	8.4%	9.3%	10.2%
	\$14	---	---	---	---	0.3%	1.8%	3.2%	4.5%	5.7%	6.8%	7.9%	9.0%	10.0%	10.9%	11.9%
	\$15	---	---	---	0.2%	1.8%	3.3%	4.7%	6.0%	7.2%	8.3%	9.4%	10.5%	11.5%	12.5%	13.5%
	\$16	---	---	---	1.6%	3.2%	4.7%	6.0%	7.3%	8.5%	9.7%	10.8%	11.9%	12.9%	14.0%	15.0%
	\$17	---	---	1.2%	2.9%	4.5%	6.0%	7.3%	8.6%	9.8%	11.0%	12.1%	13.3%	14.3%	15.4%	16.4%
	\$18	---	0.5%	2.4%	4.1%	5.7%	7.2%	8.5%	9.8%	11.1%	12.3%	13.5%	14.6%	15.7%	16.8%	17.9%
	\$19	---	1.7%	3.6%	5.3%	6.8%	8.3%	9.7%	11.0%	12.3%	13.5%	14.7%	15.9%	17.0%	18.2%	19.3%
	\$20	0.8%	2.8%	4.7%	6.4%	7.9%	9.4%	10.8%	12.1%	13.5%	14.7%	16.0%	17.2%	18.4%	19.5%	20.7%
	\$21	1.8%	3.9%	5.7%	7.4%	9.0%	10.5%	11.9%	13.3%	14.6%	15.9%	17.2%	18.4%	19.6%	20.9%	22.1%
	\$22	2.8%	4.9%	6.7%	8.4%	10.0%	11.5%	12.9%	14.3%	15.7%	17.0%	18.4%	19.6%	20.9%	22.2%	23.4%
	\$23	3.8%	5.8%	7.6%	9.3%	10.9%	12.5%	14.0%	15.4%	16.8%	18.2%	19.5%	20.9%	22.2%	23.5%	24.7%
	\$24	4.7%	6.7%	8.5%	10.2%	11.9%	13.5%	15.0%	16.4%	17.9%	19.3%	20.7%	22.1%	23.4%	24.7%	26.1%
	\$25	5.5%	7.5%	9.4%	11.1%	12.8%	14.4%	16.0%	17.5%	18.9%	20.4%	21.8%	23.2%	24.6%	26.0%	27.4%
	\$26	6.3%	8.3%	10.2%	12.0%	13.7%	15.3%	16.9%	18.4%	20.0%	21.5%	22.9%	24.4%	25.8%	27.3%	28.7%
	\$27	6.9%	9.0%	10.9%	12.7%	14.4%	16.1%	17.8%	19.4%	20.9%	22.5%	24.0%	25.5%	27.0%	28.5%	29.9%
\$28	7.4%	9.5%	11.5%	13.3%	15.1%	16.8%	18.5%	20.2%	21.8%	23.4%	25.0%	26.5%	28.1%	29.6%	31.1%	
\$29	7.7%	9.9%	11.9%	13.8%	15.6%	17.4%	19.1%	20.8%	22.5%	24.1%	25.8%	27.4%	29.0%	30.6%	32.1%	
\$30	7.9%	10.0%	12.1%	14.0%	15.9%	17.7%	19.4%	21.2%	22.9%	24.5%	26.2%	27.8%	29.5%	31.1%	32.7%	

B.C. On-Farm Biogas Benchmark Study, Version 2

Mixed food waste tip fee accounts for 21% of biogas plant revenue. Therefore, although less important than RNG sales, food waste tip fee can have a significant impact on biogas plant economic feasibility. For example, if mixed food waste tip fee is \$35/tonne or \$50/tonne instead of \$25/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$16.86/GJ to <\$15/GJ and <\$13/GJ respectively. Alternately, if mixed food waste tip fee is only \$10/tonne or \$0/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% increases from \$16.86/GJ to >\$19/GJ and >\$21/GJ respectively.

Option B: Sensitivity Analysis – Mixed Food Waste Tip Fee

		Mixed Food Waste Tip Fee (\$/Tonne)										
		\$0	\$5	\$10	\$15	\$20	\$25	\$30	\$35	\$40	\$45	\$50
\$/GJ RNG	\$12	---	---	---	1.1%	3.0%	4.7%	6.3%	7.7%	9.2%	10.5%	11.8%
	\$13	---	---	1.3%	3.1%	4.8%	6.4%	7.8%	9.2%	10.6%	11.9%	13.2%
	\$14	---	1.4%	3.2%	4.9%	6.5%	7.9%	9.3%	10.7%	12.0%	13.2%	14.5%
	\$15	1.6%	3.4%	5.0%	6.6%	8.0%	9.4%	10.7%	12.0%	13.3%	14.5%	15.7%
	\$16	3.5%	5.1%	6.7%	8.1%	9.5%	10.8%	12.1%	13.3%	14.6%	15.8%	16.9%
	\$17	5.2%	6.8%	8.2%	9.5%	10.9%	12.1%	13.4%	14.6%	15.8%	17.0%	18.1%
	\$18	6.8%	8.3%	9.6%	10.9%	12.2%	13.5%	14.7%	15.9%	17.0%	18.2%	19.3%
	\$19	8.3%	9.7%	11.0%	12.3%	13.5%	14.7%	15.9%	17.1%	18.2%	19.4%	20.5%
	\$20	9.8%	11.1%	12.3%	13.6%	14.8%	16.0%	17.1%	18.3%	19.4%	20.5%	21.7%
	\$21	11.1%	12.4%	13.6%	14.8%	16.0%	17.2%	18.3%	19.4%	20.6%	21.7%	22.8%
	\$22	12.5%	13.7%	14.9%	16.1%	17.2%	18.4%	19.5%	20.6%	21.7%	22.8%	23.9%
	\$23	13.7%	14.9%	16.1%	17.3%	18.4%	19.5%	20.6%	21.8%	22.9%	24.0%	25.0%
	\$24	15.0%	16.1%	17.3%	18.4%	19.6%	20.7%	21.8%	22.9%	24.0%	25.1%	26.2%
	\$25	16.2%	17.3%	18.5%	19.6%	20.7%	21.8%	22.9%	24.0%	25.1%	26.2%	27.3%
	\$26	17.3%	18.5%	19.6%	20.7%	21.8%	22.9%	24.0%	25.1%	26.2%	27.3%	28.3%
	\$27	18.4%	19.6%	20.7%	21.8%	22.9%	24.0%	25.1%	26.2%	27.2%	28.3%	29.4%
	\$28	19.4%	20.5%	21.6%	22.8%	23.9%	25.0%	26.1%	27.1%	28.2%	29.3%	30.4%
\$29	20.1%	21.3%	22.4%	23.5%	24.7%	25.8%	26.9%	28.0%	29.1%	30.1%	31.2%	
\$30	20.5%	21.7%	22.8%	23.9%	25.1%	26.2%	27.3%	28.4%	29.5%	30.6%	31.7%	

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #5 - Option C: RNG Compression Equipment

This biogas plant is estimated to cost \$9.1 million to build. Operating costs are estimated to average \$1,409,538/year. At an RNG sale price of \$19.35/GJ, average revenue is estimated to be \$2,601,824/year. This biogas plant doesn't require funding for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$1,192,287/year; equal to 85% of operating costs. Operating income should be sufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (i.e., broken equipment, unexpected downtime, etc.).

Option C: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>	<u>Revenue</u>		<u>Investment</u>	
Digester	\$3,163,125		RNG/GJ [†] =	\$19.35	Farm Investment =	\$9,069,234
Upgrader	\$4,048,689		Avg RNG Sales/Yr =	\$2,023,836	Funding Amount =	\$0
Nutrient Recovery	\$676,192		Tip Fee/Yr =	\$480,799	Funding % of CAPEX =	0%
Other	\$1,181,229		Bedding Savings/Yr* =	\$97,189		
Total	<u>\$9,069,234</u>	<u>\$1,409,538</u>	Total =	<u>\$2,601,824</u>	Inflation =	2%

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$2,399	\$2,419	\$2,439	\$2,460	\$2,480	\$2,501	\$2,522	\$2,544	\$2,565	\$2,587
OPEX (000s)	\$1,160	\$1,183	\$1,207	\$1,231	\$1,256	\$1,281	\$1,307	\$1,333	\$1,359	\$1,387
<i>Income (000s)</i>	\$1,239	\$1,235	\$1,232	\$1,228	\$1,224	\$1,220	\$1,216	\$1,211	\$1,206	\$1,200

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$2,609	\$2,631	\$2,654	\$2,676	\$2,699	\$2,723	\$2,746	\$2,770	\$2,794	\$2,818
OPEX (000s)	\$1,414	\$1,443	\$1,471	\$1,501	\$1,531	\$1,562	\$1,593	\$1,625	\$1,657	\$1,690
<i>Income (000s)</i>	\$1,195	\$1,189	\$1,182	\$1,176	\$1,169	\$1,161	\$1,153	\$1,145	\$1,137	\$1,128

Unlevered, Pre-Tax IRR =	12%
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Average Operating Income* =	\$1,192,287
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% of OPEX	85%
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* Averaged over twenty years to account for inflation

[†] Base price (1%/year increase up to \$30/GJ max)

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 78% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, if RNG production is 10% or 20% higher than anticipated (due to the availability of high biogas-potential mixed food waste), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$19.35/GJ to <\$18/GJ and <\$17/GJ respectively. Alternately, if RNG production is 10% or 20% lower than anticipated, the required RNG sale price for an unlevered, pre-tax IRR increases from \$19.35/GJ to >\$21/GJ and >\$24/GJ respectively. Furthermore, if only 50% of estimated mixed food waste is available (9,616 instead of 19,232 tonnes/year), RNG production will be approximately 45% lower. If RNG production is 45% lower, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 5.9%. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option C: Sensitivity Analysis – RNG Production

		Change in RNG Production Amount														
		-50%	-45%	-40%	-35%	-30%	-25%	-20%	-15%	-10%	-5%	0%	5%	10%	15%	20%
\$/GJ RNG	\$12	---	---	---	---	---	---	---	---	---	---	---	0.7%	2.0%	3.2%	4.4%
	\$13	---	---	---	---	---	---	---	---	---	0.2%	1.6%	3.0%	4.2%	5.3%	6.4%
	\$14	---	---	---	---	---	---	---	---	0.7%	2.3%	3.6%	4.9%	6.1%	7.2%	8.3%
	\$15	---	---	---	---	---	---	---	1.1%	2.7%	4.1%	5.4%	6.7%	7.9%	9.0%	10.1%
	\$16	---	---	---	---	---	---	1.2%	2.9%	4.4%	5.8%	7.1%	8.3%	9.5%	10.6%	11.8%
	\$17	---	---	---	---	---	1.1%	2.9%	4.5%	5.9%	7.3%	8.6%	9.9%	11.1%	12.2%	13.3%
	\$18	---	---	---	---	0.7%	2.7%	4.4%	5.9%	7.4%	8.8%	10.1%	11.3%	12.6%	13.7%	14.9%
	\$19	---	---	---	0.2%	2.3%	4.1%	5.8%	7.3%	8.8%	10.2%	11.5%	12.8%	14.0%	15.2%	16.4%
	\$20	---	---	---	1.6%	3.6%	5.4%	7.1%	8.6%	10.1%	11.5%	12.8%	14.1%	15.4%	16.6%	17.8%
	\$21	---	---	0.7%	3.0%	4.9%	6.7%	8.3%	9.9%	11.3%	12.8%	14.1%	15.4%	16.7%	18.0%	19.3%
	\$22	---	---	2.0%	4.2%	6.1%	7.9%	9.5%	11.1%	12.6%	14.0%	15.4%	16.7%	18.1%	19.4%	20.7%
	\$23	---	0.8%	3.2%	5.3%	7.2%	9.0%	10.6%	12.2%	13.7%	15.2%	16.6%	18.0%	19.4%	20.7%	22.0%
	\$24	---	2.0%	4.4%	6.4%	8.3%	10.1%	11.8%	13.3%	14.9%	16.4%	17.8%	19.3%	20.7%	22.0%	23.4%
	\$25	0.5%	3.1%	5.4%	7.5%	9.4%	11.1%	12.8%	14.4%	16.0%	17.5%	19.0%	20.5%	21.9%	23.3%	24.8%
	\$26	1.4%	4.1%	6.3%	8.4%	10.3%	12.1%	13.8%	15.5%	17.1%	18.6%	20.2%	21.7%	23.2%	24.6%	26.1%
	\$27	2.2%	4.8%	7.1%	9.2%	11.1%	13.0%	14.7%	16.4%	18.1%	19.7%	21.2%	22.8%	24.3%	25.8%	27.3%
	\$28	2.7%	5.4%	7.7%	9.8%	11.8%	13.7%	15.5%	17.2%	18.9%	20.6%	22.2%	23.8%	25.4%	27.0%	28.5%
\$29	3.0%	5.7%	8.1%	10.3%	12.3%	14.2%	16.1%	17.9%	19.6%	21.3%	23.0%	24.7%	26.3%	27.9%	29.5%	
\$30	3.2%	5.9%	8.3%	10.5%	12.5%	14.5%	16.4%	18.2%	20.0%	21.7%	23.4%	25.1%	26.8%	28.4%	30.1%	

B.C. On-Farm Biogas Benchmark Study, Version 2

Mixed food waste tip fee accounts for 18% of biogas plant revenue. Therefore, although less important than RNG sales, food waste tip fee can have a significant impact on biogas plant economic feasibility. For example, if mixed food waste tip fee is \$35/tonne or \$50/tonne instead of \$25/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$19.35/GJ to <\$18/GJ and <\$15/GJ respectively. Alternately, if mixed food waste tip fee is only \$10/tonne or \$0/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% increases from \$19.35/GJ to >\$22/GJ and >\$24/GJ respectively.

Option C: Sensitivity Analysis – Mixed Food Waste Tip Fee

		Mixed Food Waste Tip Fee (\$/Tonne)										
		\$0	\$5	\$10	\$15	\$20	\$25	\$30	\$35	\$40	\$45	\$50
\$/GJ RNG	\$12	---	---	---	---	---	---	1.5%	3.4%	5.1%	6.7%	8.2%
	\$13	---	---	---	---	---	1.6%	3.5%	5.2%	6.8%	8.3%	9.7%
	\$14	---	---	---	---	1.8%	3.6%	5.3%	6.9%	8.4%	9.8%	11.1%
	\$15	---	---	---	1.9%	3.8%	5.4%	7.0%	8.5%	9.9%	11.2%	12.5%
	\$16	---	0.1%	2.1%	3.9%	5.5%	7.1%	8.5%	9.9%	11.3%	12.6%	13.8%
	\$17	0.3%	2.2%	4.0%	5.6%	7.2%	8.6%	10.0%	11.3%	12.6%	13.9%	15.1%
	\$18	2.4%	4.1%	5.8%	7.3%	8.7%	10.1%	11.4%	12.7%	14.0%	15.2%	16.4%
	\$19	4.3%	5.9%	7.4%	8.8%	10.2%	11.5%	12.8%	14.0%	15.2%	16.4%	17.6%
	\$20	6.0%	7.5%	8.9%	10.2%	11.5%	12.8%	14.1%	15.3%	16.5%	17.7%	18.8%
	\$21	7.5%	9.0%	10.3%	11.6%	12.9%	14.1%	15.3%	16.5%	17.7%	18.9%	20.0%
	\$22	9.0%	10.4%	11.7%	12.9%	14.2%	15.4%	16.6%	17.7%	18.9%	20.0%	21.2%
	\$23	10.4%	11.7%	13.0%	14.2%	15.4%	16.6%	17.8%	18.9%	20.1%	21.2%	22.3%
	\$24	11.8%	13.1%	14.3%	15.5%	16.7%	17.8%	19.0%	20.1%	21.2%	22.4%	23.5%
	\$25	13.1%	14.3%	15.5%	16.7%	17.9%	19.0%	20.2%	21.3%	22.4%	23.5%	24.6%
	\$26	14.3%	15.5%	16.7%	17.9%	19.0%	20.2%	21.3%	22.4%	23.5%	24.6%	25.7%
	\$27	15.4%	16.6%	17.8%	19.0%	20.1%	21.2%	22.4%	23.5%	24.6%	25.7%	26.8%
	\$28	16.4%	17.6%	18.8%	19.9%	21.1%	22.2%	23.3%	24.5%	25.6%	26.7%	27.8%
\$29	17.1%	18.3%	19.5%	20.7%	21.9%	23.0%	24.1%	25.3%	26.4%	27.5%	28.6%	
\$30	17.5%	18.7%	19.9%	21.1%	22.3%	23.4%	24.6%	25.7%	26.8%	27.9%	29.1%	

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #5 - Option D: Nutrient Recovery Equipment

This biogas plant is estimated to cost \$9.4 million to build. Operating costs are estimated to average \$1,433,850/year. At an RNG sale price of \$19.99/GJ, average revenue is estimated to be \$2,668,236/year. This biogas plant doesn't require funding for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$1,234,386/year; equal to 86% of operating costs. Operating income should be sufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (i.e., broken equipment, unexpected downtime, etc.).

Option D: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>	<u>Revenue</u>		<u>Investment</u>	
Digester	\$3,394,125		RNG/GJ [†] =	\$19.99	Farm Investment =	\$9,357,604
Upgrader	\$3,093,500		Avg RNG Sales/Yr =	\$2,090,248	Funding Amount =	\$0
Nutrient Recovery	\$1,651,192		Tip Fee/Yr =	\$480,799	Funding % of CAPEX =	0%
Other	\$1,218,788		Bedding Savings/Yr* =	\$97,189		
Total	<u>\$9,357,604</u>	<u>\$1,433,850</u>	Total =	<u>\$2,668,236</u>	Inflation =	2%

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$2,459	\$2,480	\$2,501	\$2,522	\$2,543	\$2,564	\$2,586	\$2,608	\$2,630	\$2,653
OPEX (000s)	\$1,180	\$1,204	\$1,228	\$1,252	\$1,278	\$1,303	\$1,329	\$1,356	\$1,383	\$1,411
<i>Income (000s)</i>	\$1,279	\$1,276	\$1,273	\$1,269	\$1,265	\$1,261	\$1,257	\$1,252	\$1,248	\$1,242

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$2,676	\$2,698	\$2,722	\$2,745	\$2,769	\$2,793	\$2,817	\$2,841	\$2,866	\$2,891
OPEX (000s)	\$1,439	\$1,467	\$1,497	\$1,527	\$1,557	\$1,588	\$1,620	\$1,653	\$1,686	\$1,719
<i>Income (000s)</i>	\$1,237	\$1,231	\$1,225	\$1,218	\$1,211	\$1,204	\$1,197	\$1,189	\$1,180	\$1,172

Unlevered, Pre-Tax IRR =	12%
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Average Operating Income* =	\$1,234,386
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% of OPEX	86%
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* Averaged over twenty years to account for inflation

[†] Base price (1%/year increase up to \$30/GJ max)

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 78% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, if RNG production is 10% or 20% higher than anticipated (due to the availability of high biogas-potential mixed food waste), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$19.99/GJ to <\$19/GJ and <\$17/GJ respectively. Alternately, if RNG production is 10% or 20% lower than anticipated, the required RNG sale price for an unlevered, pre-tax IRR increases from \$19.99/GJ to >\$22/GJ and >\$24/GJ respectively. Furthermore, if only 50% of estimated mixed food waste is available (9,616 instead of 19,232 tonnes/year), RNG production will be approximately 45% lower. If RNG production is 45% lower, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 5%. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option D: Sensitivity Analysis – RNG Production

		Change in RNG Production Amount														
		-50%	-45%	-40%	-35%	-30%	-25%	-20%	-15%	-10%	-5%	0%	5%	10%	15%	20%
\$/GJ RNG	\$12	---	---	---	---	---	---	---	---	---	---	---	---	1.2%	2.4%	3.6%
	\$13	---	---	---	---	---	---	---	---	---	---	0.8%	2.1%	3.4%	4.6%	5.7%
	\$14	---	---	---	---	---	---	---	---	---	1.4%	2.8%	4.1%	5.3%	6.5%	7.5%
	\$15	---	---	---	---	---	---	---	0.2%	1.8%	3.3%	4.6%	5.9%	7.1%	8.2%	9.3%
	\$16	---	---	---	---	---	---	0.3%	2.0%	3.6%	5.0%	6.3%	7.5%	8.7%	9.9%	11.0%
	\$17	---	---	---	---	---	0.2%	2.0%	3.7%	5.2%	6.5%	7.8%	9.1%	10.3%	11.4%	12.5%
	\$18	---	---	---	---	---	1.8%	3.6%	5.2%	6.6%	8.0%	9.3%	10.5%	11.7%	12.9%	14.0%
	\$19	---	---	---	---	1.4%	3.3%	5.0%	6.5%	8.0%	9.4%	10.7%	11.9%	13.2%	14.4%	15.5%
	\$20	---	---	---	0.8%	2.8%	4.6%	6.3%	7.8%	9.3%	10.7%	12.0%	13.3%	14.5%	15.8%	16.9%
	\$21	---	---	---	2.1%	4.1%	5.9%	7.5%	9.1%	10.5%	11.9%	13.3%	14.6%	15.9%	17.1%	18.3%
	\$22	---	---	1.2%	3.4%	5.3%	7.1%	8.7%	10.3%	11.7%	13.2%	14.5%	15.9%	17.2%	18.5%	19.7%
	\$23	---	0.0%	2.4%	4.6%	6.5%	8.2%	9.9%	11.4%	12.9%	14.4%	15.8%	17.1%	18.5%	19.8%	21.1%
	\$24	---	1.2%	3.6%	5.7%	7.5%	9.3%	11.0%	12.5%	14.0%	15.5%	16.9%	18.3%	19.7%	21.1%	22.4%
	\$25	---	2.3%	4.6%	6.7%	8.6%	10.3%	12.0%	13.6%	15.1%	16.6%	18.1%	19.5%	21.0%	22.3%	23.7%
	\$26	0.6%	3.3%	5.5%	7.6%	9.5%	11.3%	13.0%	14.6%	16.2%	17.7%	19.2%	20.7%	22.2%	23.6%	25.0%
	\$27	1.3%	4.0%	6.3%	8.4%	10.3%	12.1%	13.9%	15.5%	17.2%	18.7%	20.3%	21.8%	23.3%	24.8%	26.2%
	\$28	1.8%	4.5%	6.9%	9.0%	11.0%	12.8%	14.6%	16.3%	18.0%	19.6%	21.2%	22.8%	24.3%	25.9%	27.4%
\$29	2.2%	4.9%	7.3%	9.4%	11.4%	13.4%	15.2%	16.9%	18.7%	20.3%	22.0%	23.6%	25.2%	26.8%	28.3%	
\$30	2.3%	5.0%	7.4%	9.6%	11.7%	13.6%	15.5%	17.2%	19.0%	20.7%	22.4%	24.0%	25.7%	27.3%	28.9%	

B.C. On-Farm Biogas Benchmark Study, Version 2

Mixed food waste tip fee accounts for 18% of biogas plant revenue. Therefore, although less important than RNG sales, food waste tip fee can have a significant impact on biogas plant economic feasibility. For example, if mixed food waste tip fee is \$35/tonne or \$50/tonne instead of \$25/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$19.99/GJ to <\$19/GJ and <\$16/GJ respectively. Alternately, if mixed food waste tip fee is only \$10/tonne or \$0/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% increases from \$19.99/GJ to >\$22/GJ and >\$24/GJ respectively.

Option D: Sensitivity Analysis – Mixed Food Waste Tip Fee

		Mixed Food Waste Tip Fee (\$/Tonne)										
		\$0	\$5	\$10	\$15	\$20	\$25	\$30	\$35	\$40	\$45	\$50
\$/GJ RNG	\$12	---	---	---	---	---	---	0.6%	2.5%	4.3%	5.9%	7.4%
	\$13	---	---	---	---	---	0.8%	2.7%	4.4%	6.0%	7.5%	8.9%
	\$14	---	---	---	---	0.9%	2.8%	4.5%	6.1%	7.6%	9.0%	10.3%
	\$15	---	---	---	1.1%	3.0%	4.6%	6.2%	7.7%	9.1%	10.4%	11.7%
	\$16	---	---	1.3%	3.1%	4.8%	6.3%	7.8%	9.1%	10.5%	11.8%	13.0%
	\$17	---	1.4%	3.2%	4.9%	6.4%	7.8%	9.2%	10.5%	11.8%	13.1%	14.3%
	\$18	1.6%	3.4%	5.0%	6.5%	7.9%	9.3%	10.6%	11.9%	13.1%	14.3%	15.5%
	\$19	3.5%	5.1%	6.6%	8.0%	9.4%	10.7%	11.9%	13.2%	14.4%	15.6%	16.7%
	\$20	5.2%	6.7%	8.1%	9.5%	10.8%	12.0%	13.2%	14.4%	15.6%	16.8%	17.9%
	\$21	6.8%	8.2%	9.5%	10.8%	12.1%	13.3%	14.5%	15.7%	16.8%	17.9%	19.1%
	\$22	8.3%	9.6%	10.9%	12.1%	13.4%	14.5%	15.7%	16.9%	18.0%	19.1%	20.2%
	\$23	9.7%	11.0%	12.2%	13.4%	14.6%	15.8%	16.9%	18.0%	19.1%	20.2%	21.3%
	\$24	11.0%	12.3%	13.5%	14.6%	15.8%	16.9%	18.1%	19.2%	20.3%	21.4%	22.5%
	\$25	12.3%	13.5%	14.7%	15.8%	17.0%	18.1%	19.2%	20.3%	21.4%	22.5%	23.6%
	\$26	13.5%	14.7%	15.9%	17.0%	18.1%	19.2%	20.3%	21.4%	22.5%	23.6%	24.6%
	\$27	14.6%	15.8%	16.9%	18.0%	19.2%	20.3%	21.4%	22.5%	23.5%	24.6%	25.7%
	\$28	15.5%	16.7%	17.8%	19.0%	20.1%	21.2%	22.3%	23.4%	24.5%	25.6%	26.6%
\$29	16.2%	17.4%	18.6%	19.7%	20.9%	22.0%	23.1%	24.2%	25.3%	26.4%	27.4%	
\$30	16.6%	17.8%	18.9%	20.1%	21.2%	22.4%	23.5%	24.6%	25.7%	26.8%	27.9%	

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #5 - Option E: Mixed Food Waste Cleaning & RNG Compression Equipment

This biogas plant is estimated to cost \$10.2 million to build. Operating costs are estimated to average \$1,498,395/year. At an RNG sale price of \$21.70/GJ, average revenue is estimated to be \$2,847,070/year. This biogas plant doesn't require funding for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$1,348,674/year; equal to 90% of operating costs. Operating income should be sufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (i.e., broken equipment, unexpected downtime, etc.).

Option E: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>	<u>Revenue</u>		<u>Investment</u>	
Digester	\$4,152,750		RNG/GJ [†] =	\$21.70	Farm Investment =	\$10,207,056
Upgrader	\$4,048,689		Avg RNG Sales/Yr =	\$2,269,082	Funding Amount =	\$0
Nutrient Recover	\$676,192		Tip Fee/Yr =	\$480,799	Funding % of CAPEX =	0%
Other	\$1,329,425		Bedding Saving/Yr* =	\$97,189		
Total	\$10,207,056	\$1,498,395	Total =	\$2,847,070	Inflation =	2%

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$2,622	\$2,644	\$2,666	\$2,689	\$2,712	\$2,735	\$2,759	\$2,782	\$2,806	\$2,831
OPEX (000s)	\$1,233	\$1,258	\$1,283	\$1,309	\$1,335	\$1,362	\$1,389	\$1,417	\$1,445	\$1,474
<i>Income (000s)</i>	\$1,388	\$1,386	\$1,383	\$1,380	\$1,377	\$1,373	\$1,370	\$1,366	\$1,361	\$1,357

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$2,855	\$2,880	\$2,905	\$2,930	\$2,956	\$2,981	\$3,007	\$3,034	\$3,060	\$3,087
OPEX (000s)	\$1,503	\$1,534	\$1,564	\$1,596	\$1,627	\$1,660	\$1,693	\$1,727	\$1,762	\$1,797
<i>Income (000s)</i>	\$1,351	\$1,346	\$1,341	\$1,334	\$1,328	\$1,321	\$1,314	\$1,307	\$1,299	\$1,291

Unlevered, Pre-Tax IRR =	12%
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Average Operating Income* =	\$1,348,674
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% of OPEX	90%
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* Averaged over twenty years to account for inflation

† Base price (1%/year increase up to \$30/GJ max)

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 80% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, if RNG production is 10% or 20% higher than anticipated (due to the availability of high biogas-potential mixed food waste), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$21.70/GJ to <\$20/GJ and <\$19/GJ respectively. Alternately, if RNG production is 10% or 20% lower than anticipated, the required RNG sale price for an unlevered, pre-tax IRR increases from \$21.70/GJ to >\$24/GJ and >\$27/GJ respectively. Furthermore, if only 50% of estimated mixed food waste is available (9,616 instead of 19,232 tonnes/year), RNG production will be approximately 45% lower. If RNG production is 45% lower, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 2.8%. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option E: Sensitivity Analysis – RNG Production

		Change in RNG Production Amount														
		-50%	-45%	-40%	-35%	-30%	-25%	-20%	-15%	-10%	-5%	0%	5%	10%	15%	20%
\$/GJ RNG	\$12	---	---	---	---	---	---	---	---	---	---	---	---	---	0.3%	1.5%
	\$13	---	---	---	---	---	---	---	---	---	---	---	---	1.3%	2.5%	3.6%
	\$14	---	---	---	---	---	---	---	---	---	---	0.7%	2.0%	3.3%	4.4%	5.5%
	\$15	---	---	---	---	---	---	---	---	---	1.2%	2.6%	3.8%	5.0%	6.2%	7.2%
	\$16	---	---	---	---	---	---	---	---	1.5%	2.9%	4.2%	5.5%	6.7%	7.8%	8.9%
	\$17	---	---	---	---	---	---	---	1.5%	3.1%	4.5%	5.8%	7.0%	8.2%	9.3%	10.4%
	\$18	---	---	---	---	---	---	1.5%	3.1%	4.6%	5.9%	7.2%	8.5%	9.6%	10.8%	11.9%
	\$19	---	---	---	---	---	1.2%	2.9%	4.5%	5.9%	7.3%	8.6%	9.8%	11.0%	12.2%	13.3%
	\$20	---	---	---	---	0.7%	2.6%	4.2%	5.8%	7.2%	8.6%	9.9%	11.1%	12.3%	13.5%	14.6%
	\$21	---	---	---	---	2.0%	3.8%	5.5%	7.0%	8.5%	9.8%	11.1%	12.4%	13.6%	14.8%	16.0%
	\$22	---	---	---	1.3%	3.3%	5.0%	6.7%	8.2%	9.6%	11.0%	12.3%	13.6%	14.9%	16.1%	17.3%
	\$23	---	---	0.3%	2.5%	4.4%	6.2%	7.8%	9.3%	10.8%	12.2%	13.5%	14.8%	16.1%	17.3%	18.5%
	\$24	---	---	1.5%	3.6%	5.5%	7.2%	8.9%	10.4%	11.9%	13.3%	14.6%	16.0%	17.3%	18.5%	19.8%
	\$25	---	0.1%	2.5%	4.6%	6.5%	8.3%	9.9%	11.4%	12.9%	14.4%	15.7%	17.1%	18.4%	19.7%	21.0%
	\$26	---	1.1%	3.5%	5.5%	7.4%	9.2%	10.8%	12.4%	13.9%	15.4%	16.8%	18.2%	19.6%	20.9%	22.2%
	\$27	---	1.8%	4.2%	6.3%	8.2%	10.0%	11.6%	13.3%	14.8%	16.3%	17.8%	19.2%	20.6%	22.0%	23.4%
	\$28	---	2.3%	4.7%	6.8%	8.8%	10.6%	12.3%	14.0%	15.6%	17.1%	18.6%	20.1%	21.6%	23.0%	24.4%
\$29	---	2.6%	5.1%	7.2%	9.2%	11.1%	12.8%	14.5%	16.2%	17.8%	19.3%	20.8%	22.3%	23.8%	25.3%	
\$30	---	2.8%	5.2%	7.4%	9.4%	11.3%	13.1%	14.8%	16.5%	18.1%	19.6%	21.2%	22.7%	24.2%	25.7%	

B.C. On-Farm Biogas Benchmark Study, Version 2

Mixed food waste tip fee accounts for 17% of biogas plant revenue. Therefore, although less important than RNG sales, food waste tip fee can have a significant impact on biogas plant economic feasibility. For example, if mixed food waste tip fee is \$35/tonne or \$50/tonne instead of \$25/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$21.70/GJ to <\$20/GJ and <\$17/GJ respectively. Alternately, if mixed food waste tip fee is only \$10/tonne or \$0/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% increases from \$21.70/GJ to >\$24/GJ and >\$26/GJ respectively.

Option E: Sensitivity Analysis – Mixed Food Waste Tip Fee

		Mixed Food Waste Tip Fee (\$/Tonne)										
		\$0	\$5	\$10	\$15	\$20	\$25	\$30	\$35	\$40	\$45	\$50
\$/GJ RNG	\$12	---	---	---	---	---	---	---	0.3%	2.2%	3.8%	5.3%
	\$13	---	---	---	---	---	---	0.5%	2.3%	3.9%	5.4%	6.8%
	\$14	---	---	---	---	---	0.7%	2.4%	4.0%	5.5%	6.9%	8.2%
	\$15	---	---	---	---	0.8%	2.6%	4.1%	5.6%	7.0%	8.3%	9.6%
	\$16	---	---	---	1.0%	2.7%	4.2%	5.7%	7.1%	8.4%	9.6%	10.8%
	\$17	---	---	1.1%	2.8%	4.4%	5.8%	7.2%	8.4%	9.7%	10.9%	12.1%
	\$18	---	1.3%	2.9%	4.5%	5.9%	7.2%	8.5%	9.8%	11.0%	12.1%	13.2%
	\$19	1.4%	3.1%	4.6%	6.0%	7.3%	8.6%	9.8%	11.0%	12.2%	13.3%	14.4%
	\$20	3.2%	4.7%	6.1%	7.4%	8.7%	9.9%	11.1%	12.2%	13.4%	14.4%	15.5%
	\$21	4.8%	6.2%	7.5%	8.7%	10.0%	11.1%	12.3%	13.4%	14.5%	15.6%	16.6%
	\$22	6.3%	7.6%	8.8%	10.0%	11.2%	12.3%	13.5%	14.5%	15.6%	16.7%	17.7%
	\$23	7.6%	8.9%	10.1%	11.3%	12.4%	13.5%	14.6%	15.7%	16.7%	17.8%	18.8%
	\$24	9.0%	10.2%	11.3%	12.5%	13.6%	14.6%	15.7%	16.8%	17.8%	18.8%	19.8%
	\$25	10.2%	11.4%	12.5%	13.6%	14.7%	15.7%	16.8%	17.8%	18.9%	19.9%	20.9%
	\$26	11.4%	12.5%	13.6%	14.7%	15.8%	16.8%	17.8%	18.9%	19.9%	20.9%	21.9%
	\$27	12.4%	13.5%	14.6%	15.7%	16.7%	17.8%	18.8%	19.8%	20.8%	21.8%	22.8%
	\$28	13.2%	14.3%	15.4%	16.5%	17.6%	18.6%	19.7%	20.7%	21.7%	22.7%	23.7%
\$29	13.9%	15.0%	16.1%	17.2%	18.2%	19.3%	20.3%	21.4%	22.4%	23.4%	24.4%	
\$30	14.2%	15.3%	16.4%	17.5%	18.6%	19.6%	20.7%	21.7%	22.8%	23.8%	24.8%	

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #5 - Option F: Mixed Food Waste Cleaning & Nutrient Recovery Equipment

This biogas plant is estimated to cost \$10.5 million to build. Operating costs are estimated to average \$1,522,708/year. At an RNG sale price of \$22.32/GJ, average revenue is estimated to be \$2,912,003/year. This biogas plant doesn't require funding for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$1,389,295/year; equal to 91% of operating costs. Operating income should be sufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (i.e., broken equipment, unexpected downtime, etc.).

Option F: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>	<u>Revenue</u>		<u>Investment</u>	
Digester	\$4,383,750		RNG/GJ [†] =	\$22.32	Farm Investment =	\$10,495,426
Upgrader	\$3,093,500		Avg RNG Sales/Yr =	\$2,334,015	Funding Amount =	\$0
Nutrient Recover	\$1,651,192		Tip Fee/Yr =	\$480,799	Funding % of CAPEX =	0%
Other	\$1,366,984		Bedding Saving/Yr* =	\$97,189		
Total	<u>\$10,495,426</u>	<u>\$1,522,708</u>	Total =	<u>\$2,912,003</u>	Inflation =	2%

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$2,681	\$2,703	\$2,727	\$2,750	\$2,773	\$2,797	\$2,821	\$2,846	\$2,870	\$2,895
OPEX (000s)	\$1,253	\$1,278	\$1,304	\$1,330	\$1,357	\$1,384	\$1,412	\$1,440	\$1,469	\$1,498
<i>Income (000s)</i>	\$1,427	\$1,425	\$1,422	\$1,420	\$1,417	\$1,413	\$1,410	\$1,406	\$1,402	\$1,397

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$2,920	\$2,945	\$2,971	\$2,997	\$3,023	\$3,050	\$3,077	\$3,104	\$3,131	\$3,159
OPEX (000s)	\$1,528	\$1,558	\$1,590	\$1,621	\$1,654	\$1,687	\$1,721	\$1,755	\$1,790	\$1,826
<i>Income (000s)</i>	\$1,392	\$1,387	\$1,382	\$1,376	\$1,369	\$1,363	\$1,356	\$1,349	\$1,341	\$1,333

Unlevered, Pre-Tax IRR =	12%
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Average Operating Income* =	\$1,389,295
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% of OPEX	91%
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* Averaged over twenty years to account for inflation

† Base price (1%/year increase up to \$30/GJ max)

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 80% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, if RNG production is 10% or 20% higher than anticipated (due to the availability of high biogas-potential mixed food waste), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$22.32/GJ to <\$21/GJ and <\$19/GJ respectively. Alternately, if RNG production is 10% or 20% lower than anticipated, the required RNG sale price for an unlevered, pre-tax IRR increases from \$22.32/GJ to >\$24/GJ and >\$28/GJ respectively. Furthermore, if only 50% of estimated mixed food waste is available (9,616 instead of 19,232 tonnes/year), RNG production will be approximately 45% lower. If RNG production is 45% lower, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 2.0%. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option F: Sensitivity Analysis – RNG Production

		Change in RNG Production Amount														
		-50%	-45%	-40%	-35%	-30%	-25%	-20%	-15%	-10%	-5%	0%	5%	10%	15%	20%
\$/GJ RNG	\$12	---	---	---	---	---	---	---	---	---	---	---	---	---	---	0.7%
	\$13	---	---	---	---	---	---	---	---	---	---	---	---	0.5%	1.7%	2.9%
	\$14	---	---	---	---	---	---	---	---	---	---	---	1.3%	2.5%	3.7%	4.8%
	\$15	---	---	---	---	---	---	---	---	---	0.4%	1.8%	3.1%	4.3%	5.5%	6.6%
	\$16	---	---	---	---	---	---	---	---	0.7%	2.2%	3.5%	4.8%	6.0%	7.1%	8.2%
	\$17	---	---	---	---	---	---	---	0.8%	2.4%	3.8%	5.1%	6.3%	7.5%	8.6%	9.7%
	\$18	---	---	---	---	---	---	0.7%	2.4%	3.9%	5.3%	6.6%	7.8%	8.9%	10.1%	11.2%
	\$19	---	---	---	---	---	0.4%	2.2%	3.8%	5.3%	6.6%	7.9%	9.1%	10.3%	11.5%	12.6%
	\$20	---	---	---	---	---	1.8%	3.5%	5.1%	6.6%	7.9%	9.2%	10.4%	11.6%	12.8%	13.9%
	\$21	---	---	---	---	1.3%	3.1%	4.8%	6.3%	7.8%	9.1%	10.4%	11.7%	12.9%	14.1%	15.2%
	\$22	---	---	---	0.5%	2.5%	4.3%	6.0%	7.5%	8.9%	10.3%	11.6%	12.9%	14.1%	15.3%	16.5%
	\$23	---	---	---	1.7%	3.7%	5.5%	7.1%	8.6%	10.1%	11.5%	12.8%	14.1%	15.3%	16.5%	17.7%
	\$24	---	---	0.7%	2.9%	4.8%	6.6%	8.2%	9.7%	11.2%	12.6%	13.9%	15.2%	16.5%	17.7%	19.0%
	\$25	---	---	1.8%	3.9%	5.8%	7.6%	9.2%	10.7%	12.2%	13.6%	15.0%	16.3%	17.6%	18.9%	20.2%
	\$26	---	0.3%	2.7%	4.8%	6.7%	8.5%	10.1%	11.7%	13.2%	14.6%	16.0%	17.4%	18.7%	20.1%	21.4%
	\$27	---	1.0%	3.4%	5.6%	7.5%	9.3%	10.9%	12.5%	14.1%	15.5%	17.0%	18.4%	19.8%	21.1%	22.5%
	\$28	---	1.5%	4.0%	6.1%	8.1%	9.9%	11.6%	13.2%	14.8%	16.3%	17.8%	19.3%	20.7%	22.1%	23.5%
\$29	---	1.9%	4.3%	6.5%	8.5%	10.3%	12.1%	13.8%	15.4%	16.9%	18.5%	20.0%	21.4%	22.9%	24.3%	
\$30	---	2.0%	4.5%	6.7%	8.7%	10.5%	12.3%	14.0%	15.6%	17.2%	18.8%	20.3%	21.8%	23.3%	24.7%	

B.C. On-Farm Biogas Benchmark Study, Version 2

Mixed food waste tip fee accounts for 17% of biogas plant revenue. Therefore, although less important than RNG sales, food waste tip fee can have a significant impact on biogas plant economic feasibility. For example, if mixed food waste tip fee is \$35/tonne or \$50/tonne instead of \$25/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$22.32/GJ to <\$21/GJ and <\$18/GJ respectively. Alternately, if mixed food waste tip fee is only \$10/tonne or \$0/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% increases from \$22.32/GJ to >\$25/GJ and >\$27/GJ respectively.

Option F: Sensitivity Analysis – Mixed Food Waste Tip Fee

		Mixed Food Waste Tip Fee (\$/Tonne)										
		\$0	\$5	\$10	\$15	\$20	\$25	\$30	\$35	\$40	\$45	\$50
\$/GJ RNG	\$12	---	---	---	---	---	---	---	---	1.4%	3.1%	4.6%
	\$13	---	---	---	---	---	---	---	1.6%	3.2%	4.7%	6.1%
	\$14	---	---	---	---	---	---	1.7%	3.3%	4.8%	6.2%	7.5%
	\$15	---	---	---	---	0.1%	1.8%	3.4%	4.9%	6.3%	7.6%	8.8%
	\$16	---	---	---	0.2%	2.0%	3.5%	5.0%	6.4%	7.7%	8.9%	10.1%
	\$17	---	---	0.4%	2.1%	3.7%	5.1%	6.5%	7.8%	9.0%	10.2%	11.3%
	\$18	---	0.5%	2.2%	3.8%	5.2%	6.6%	7.8%	9.1%	10.2%	11.4%	12.5%
	\$19	0.7%	2.4%	3.9%	5.3%	6.6%	7.9%	9.1%	10.3%	11.5%	12.6%	13.7%
	\$20	2.5%	4.0%	5.4%	6.7%	8.0%	9.2%	10.4%	11.5%	12.6%	13.7%	14.8%
	\$21	4.1%	5.5%	6.8%	8.1%	9.3%	10.4%	11.6%	12.7%	13.8%	14.8%	15.9%
	\$22	5.6%	6.9%	8.1%	9.3%	10.5%	11.6%	12.7%	13.8%	14.9%	15.9%	16.9%
	\$23	7.0%	8.2%	9.4%	10.6%	11.7%	12.8%	13.9%	14.9%	15.9%	17.0%	18.0%
	\$24	8.3%	9.5%	10.6%	11.7%	12.8%	13.9%	15.0%	16.0%	17.0%	18.0%	19.0%
	\$25	9.5%	10.7%	11.8%	12.9%	13.9%	15.0%	16.0%	17.0%	18.0%	19.0%	20.0%
	\$26	10.7%	11.8%	12.9%	13.9%	15.0%	16.0%	17.0%	18.1%	19.0%	20.0%	21.0%
	\$27	11.6%	12.8%	13.8%	14.9%	15.9%	17.0%	18.0%	19.0%	20.0%	21.0%	21.9%
	\$28	12.5%	13.6%	14.7%	15.7%	16.8%	17.8%	18.8%	19.8%	20.8%	21.8%	22.8%
\$29	13.1%	14.2%	15.3%	16.4%	17.4%	18.5%	19.5%	20.5%	21.5%	22.5%	23.5%	
\$30	13.4%	14.5%	15.6%	16.7%	17.7%	18.8%	19.8%	20.8%	21.8%	22.8%	23.8%	

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #5 - Option G: RNG Compression and Nutrient Recovery Equipment

This biogas plant is estimated to cost \$10.5 million to build. Operating costs are estimated to average \$1,798,852/year. At an RNG sale price of \$24.81/GJ, average revenue is estimated to be \$3,173,065/year. This biogas plant doesn't require funding for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$1,374,213/year; equal to 76% of operating costs. Operating income should be sufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (i.e., broken equipment, unexpected downtime, etc.).

Option G: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>	<u>Revenue</u>	<u>Investment</u>
Digester	\$3,394,125		RNG/GJ [†] = \$24.81	Farm Investment = \$10,455,833
Upgrader	\$4,048,689		Avg RNG Sales/Yr = \$2,595,076	Funding Amount = \$0
Nutrient Recover	\$1,651,192		Tip Fee/Yr = \$480,799	Funding % of CAPEX = 0%
Other	\$1,361,827		Bedding Saving/Yr* = \$97,189	
Total	<u>\$10,455,833</u>	<u>\$1,798,852</u>	Total = <u>\$3,173,065</u>	<i>Inflation = 2%</i>

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$2,918	\$2,943	\$2,968	\$2,994	\$3,020	\$3,046	\$3,073	\$3,100	\$3,127	\$3,154
OPEX (000s)	\$1,481	\$1,510	\$1,541	\$1,571	\$1,603	\$1,635	\$1,668	\$1,701	\$1,735	\$1,770
<i>Income (000s)</i>	\$1,437	\$1,433	\$1,428	\$1,423	\$1,417	\$1,412	\$1,405	\$1,399	\$1,392	\$1,385

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$3,182	\$3,210	\$3,238	\$3,267	\$3,296	\$3,325	\$3,355	\$3,385	\$3,415	\$3,445
OPEX (000s)	\$1,805	\$1,841	\$1,878	\$1,915	\$1,954	\$1,993	\$2,033	\$2,073	\$2,115	\$2,157
<i>Income (000s)</i>	\$1,377	\$1,369	\$1,361	\$1,352	\$1,342	\$1,332	\$1,322	\$1,311	\$1,300	\$1,288

Unlevered, Pre-Tax IRR =	12%
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Average Operating Income* =	\$1,374,213
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% of OPEX	76%
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* Averaged over twenty years to account for inflation

† Base price (1%/year increase up to \$30/GJ max)

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 82% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, if RNG production is 10% or 20% higher than anticipated (due to the availability of high biogas-potential mixed food waste), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$24.81/GJ to <\$23/GJ and <\$21/GJ respectively. Alternately, if RNG production is 10% lower than anticipated, the required RNG sale price for an unlevered, pre-tax IRR increases from \$24.81/GJ to >\$28/GJ. Furthermore, if only 60% of estimated mixed food waste is available (11,539 instead of 19,232 tonnes/year), RNG production will be approximately 35% lower. If RNG production is 35% lower, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 2.3%. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option G: Sensitivity Analysis – RNG Production

		Change in RNG Production Amount														
		-50%	-45%	-40%	-35%	-30%	-25%	-20%	-15%	-10%	-5%	0%	5%	10%	15%	20%
\$/GJ RNG	\$14	---	---	---	---	---	---	---	---	---	---	---	---	---	---	0.3%
	\$15	---	---	---	---	---	---	---	---	---	---	---	---	---	1.2%	2.6%
	\$16	---	---	---	---	---	---	---	---	---	---	---	0.3%	1.8%	3.2%	4.5%
	\$17	---	---	---	---	---	---	---	---	---	---	0.7%	2.3%	3.7%	5.1%	6.3%
	\$18	---	---	---	---	---	---	---	---	0.9%	2.6%	4.1%	5.5%	6.8%	8.0%	
	\$19	---	---	---	---	---	---	---	0.9%	2.6%	4.2%	5.7%	7.0%	8.3%	9.6%	
	\$20	---	---	---	---	---	---	0.7%	2.6%	4.2%	5.8%	7.2%	8.5%	9.8%	11.0%	
	\$21	---	---	---	---	---	0.3%	2.3%	4.1%	5.7%	7.2%	8.6%	9.9%	11.2%	12.4%	
	\$22	---	---	---	---	---	1.8%	3.7%	5.5%	7.0%	8.5%	9.9%	11.3%	12.6%	13.8%	
	\$23	---	---	---	---	1.2%	3.2%	5.1%	6.8%	8.3%	9.8%	11.2%	12.6%	13.9%	15.1%	
	\$24	---	---	---	0.3%	2.6%	4.5%	6.3%	8.0%	9.6%	11.0%	12.4%	13.8%	15.1%	16.4%	
	\$25	---	---	---	1.6%	3.8%	5.7%	7.5%	9.2%	10.7%	12.2%	13.6%	15.0%	16.4%	17.7%	
	\$26	---	---	0.2%	2.7%	4.9%	6.8%	8.6%	10.2%	11.8%	13.3%	14.8%	16.2%	17.6%	18.9%	
	\$27	---	---	1.1%	3.6%	5.7%	7.7%	9.5%	11.1%	12.7%	14.3%	15.8%	17.2%	18.6%	20.0%	
	\$28	---	---	1.7%	4.2%	6.4%	8.4%	10.2%	11.9%	13.5%	15.1%	16.7%	18.2%	19.6%	21.1%	
\$29	---	---	2.1%	4.6%	6.8%	8.8%	10.7%	12.5%	14.1%	15.8%	17.3%	18.9%	20.4%	21.9%		
\$30	---	---	2.3%	4.8%	7.0%	9.1%	10.9%	12.7%	14.4%	16.1%	17.7%	19.2%	20.8%	22.3%		

B.C. On-Farm Biogas Benchmark Study, Version 2

Mixed food waste tip fee accounts for 15% of biogas plant revenue. Therefore, although less important than RNG sales, food waste tip fee can have a significant impact on biogas plant economic feasibility. For example, if mixed food waste tip fee is \$35/tonne or \$50/tonne instead of \$25/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$24.81/GJ to <\$23/GJ and <\$21/GJ respectively. Alternately, if mixed food waste tip fee is only \$10/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% increases from \$24.81/GJ to >\$28/GJ. If mixed food waste tip fee is \$0/tonne, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 10.2%. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option G: Sensitivity Analysis – Mixed Food Waste Tip Fee

		Mixed Food Waste Tip Fee (\$/Tonne)										
		\$0	\$5	\$10	\$15	\$20	\$25	\$30	\$35	\$40	\$45	\$50
\$/GJ RNG	\$12	---	---	---	---	---	---	---	---	---	---	---
	\$13	---	---	---	---	---	---	---	---	---	0.0%	1.9%
	\$14	---	---	---	---	---	---	---	---	0.2%	2.0%	3.7%
	\$15	---	---	---	---	---	---	---	0.4%	2.2%	3.8%	5.3%
	\$16	---	---	---	---	---	---	0.5%	2.3%	3.9%	5.4%	6.8%
	\$17	---	---	---	---	---	0.7%	2.4%	4.0%	5.5%	6.8%	8.1%
	\$18	---	---	---	---	0.8%	2.6%	4.1%	5.6%	6.9%	8.2%	9.5%
	\$19	---	---	---	1.0%	2.7%	4.2%	5.7%	7.0%	8.3%	9.5%	10.7%
	\$20	---	---	1.1%	2.8%	4.3%	5.8%	7.1%	8.4%	9.6%	10.8%	11.9%
	\$21	---	1.3%	2.9%	4.4%	5.8%	7.2%	8.4%	9.7%	10.8%	12.0%	13.1%
	\$22	1.4%	3.0%	4.5%	5.9%	7.3%	8.5%	9.7%	10.9%	12.0%	13.2%	14.2%
	\$23	3.2%	4.6%	6.0%	7.3%	8.6%	9.8%	11.0%	12.1%	13.2%	14.3%	15.4%
	\$24	4.7%	6.1%	7.4%	8.7%	9.9%	11.0%	12.2%	13.3%	14.3%	15.4%	16.4%
	\$25	6.2%	7.5%	8.7%	9.9%	11.1%	12.2%	13.3%	14.4%	15.4%	16.5%	17.5%
	\$26	7.5%	8.7%	9.9%	11.1%	12.2%	13.3%	14.4%	15.4%	16.5%	17.5%	18.5%
	\$27	8.5%	9.7%	10.9%	12.1%	13.2%	14.3%	15.4%	16.4%	17.4%	18.5%	19.5%
	\$28	9.4%	10.6%	11.8%	12.9%	14.0%	15.1%	16.2%	17.3%	18.3%	19.3%	20.3%
\$29	10.0%	11.2%	12.4%	13.5%	14.7%	15.8%	16.8%	17.9%	19.0%	20.0%	21.0%	
\$30	10.2%	11.5%	12.7%	13.8%	15.0%	16.1%	17.2%	18.2%	19.3%	20.3%	21.3%	

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #5 - Option H: Mixed Food Waste Cleaning, RNG Compression and Nutrient Recovery Equipment

This biogas plant is estimated to cost \$11.6 million to build. Operating costs are estimated to average \$1,887,709/year. At an RNG sale price of \$27.45/GJ, average revenue is estimated to be \$3,366,766/year. This biogas plant doesn't require funding for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$1,479,057/year; equal to 78% of operating costs. Operating income should be sufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (i.e., broken equipment, unexpected downtime, etc.).

Option H: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>	<u>Revenue</u>		<u>Investment</u>	
Digester	\$4,383,750		RNG/GJ [†] =	\$27.45	Farm Investment =	\$11,593,654
Upgrader	\$4,048,689		Avg RNG Sales/Yr =	\$2,788,778	Funding Amount =	\$0
Nutrient Rec.	\$1,651,192		Tip Fee/Yr =	\$480,799	Funding % of CAPEX =	0%
Other	\$1,510,024		Bedding Savings/Yr* =	\$97,189		
Total	<u>\$11,593,654</u>	<u>\$1,887,709</u>	Total =	<u>\$3,366,766</u>	Inflation =	2%

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$3,168	\$3,196	\$3,224	\$3,252	\$3,281	\$3,310	\$3,339	\$3,368	\$3,398	\$3,426
OPEX (000s)	\$1,554	\$1,585	\$1,617	\$1,649	\$1,682	\$1,716	\$1,750	\$1,785	\$1,821	\$1,857
<i>Income (000s)</i>	\$1,614	\$1,611	\$1,607	\$1,603	\$1,599	\$1,594	\$1,589	\$1,583	\$1,578	\$1,569

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$3,428	\$3,430	\$3,432	\$3,434	\$3,436	\$3,438	\$3,440	\$3,443	\$3,445	\$3,447
OPEX (000s)	\$1,894	\$1,932	\$1,971	\$2,010	\$2,050	\$2,091	\$2,133	\$2,176	\$2,219	\$2,264
<i>Income (000s)</i>	\$1,534	\$1,498	\$1,461	\$1,424	\$1,386	\$1,347	\$1,307	\$1,267	\$1,226	\$1,183

Unlevered, Pre-Tax IRR =	12%
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Average Operating Income* =	\$1,479,057
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% of OPEX	78%
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* Averaged over twenty years to account for inflation

† Base price (1%/year increase up to \$30/GJ max)

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 83% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, if RNG production is 10% or 20% higher than anticipated (due to the availability of high biogas-potential mixed food waste), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$27.45/GJ to <\$25/GJ and <\$23/GJ respectively. Alternately, if RNG production is 10% or 20% lower than anticipated, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 10.0 and 6.4% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option H: Sensitivity Analysis – RNG Production

		Change in RNG Production Amount														
		-50%	-45%	-40%	-35%	-30%	-25%	-20%	-15%	-10%	-5%	0%	5%	10%	15%	20%
\$/GJ RNG	\$16	---	---	---	---	---	---	---	---	---	---	---	---	---	0.6%	2.0%
	\$17	---	---	---	---	---	---	---	---	---	---	---	---	1.1%	2.6%	3.8%
	\$18	---	---	---	---	---	---	---	---	---	---	---	1.5%	2.9%	4.3%	5.5%
	\$19	---	---	---	---	---	---	---	---	---	0.0%	1.7%	3.2%	4.6%	5.8%	7.1%
	\$20	---	---	---	---	---	---	---	---	---	1.7%	3.2%	4.7%	6.0%	7.3%	8.5%
	\$21	---	---	---	---	---	---	---	---	1.5%	3.2%	4.7%	6.1%	7.4%	8.7%	9.9%
	\$22	---	---	---	---	---	---	---	1.1%	2.9%	4.6%	6.0%	7.4%	8.7%	10.0%	11.2%
	\$23	---	---	---	---	---	---	0.6%	2.6%	4.3%	5.8%	7.3%	8.7%	10.0%	11.3%	12.5%
	\$24	---	---	---	---	---	---	2.0%	3.8%	5.5%	7.1%	8.5%	9.9%	11.2%	12.5%	13.7%
	\$25	---	---	---	---	---	1.2%	3.2%	5.0%	6.7%	8.2%	9.7%	11.0%	12.4%	13.7%	14.9%
	\$26	---	---	---	---	0.0%	2.3%	4.3%	6.1%	7.7%	9.2%	10.7%	12.1%	13.4%	14.8%	16.0%
	\$27	---	---	---	---	0.9%	3.1%	5.1%	6.9%	8.6%	10.1%	11.6%	13.0%	14.4%	15.8%	17.1%
	\$28	---	---	---	---	1.5%	3.7%	5.7%	7.6%	9.3%	10.8%	12.4%	13.8%	15.2%	16.6%	18.0%
	\$29	---	---	---	---	1.8%	4.1%	6.2%	8.0%	9.7%	11.4%	12.9%	14.4%	15.9%	17.3%	18.7%
	\$30	---	---	---	---	2.0%	4.3%	6.4%	8.2%	10.0%	11.6%	13.2%	14.7%	16.2%	17.6%	19.0%

B.C. On-Farm Biogas Benchmark Study, Version 2

Mixed food waste tip fee accounts for 14% of biogas plant revenue. Therefore, although less important than RNG sales, food waste tip fee can have a significant impact on biogas plant economic feasibility. For example, if mixed food waste tip fee is \$35/tonne or \$50/tonne instead of \$25/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$27.45/GJ to <\$26/GJ and <\$23/GJ respectively. Alternately, if mixed food waste tip fee is only \$10/tonne or \$0/tonne, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 9.9% and 7.5% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

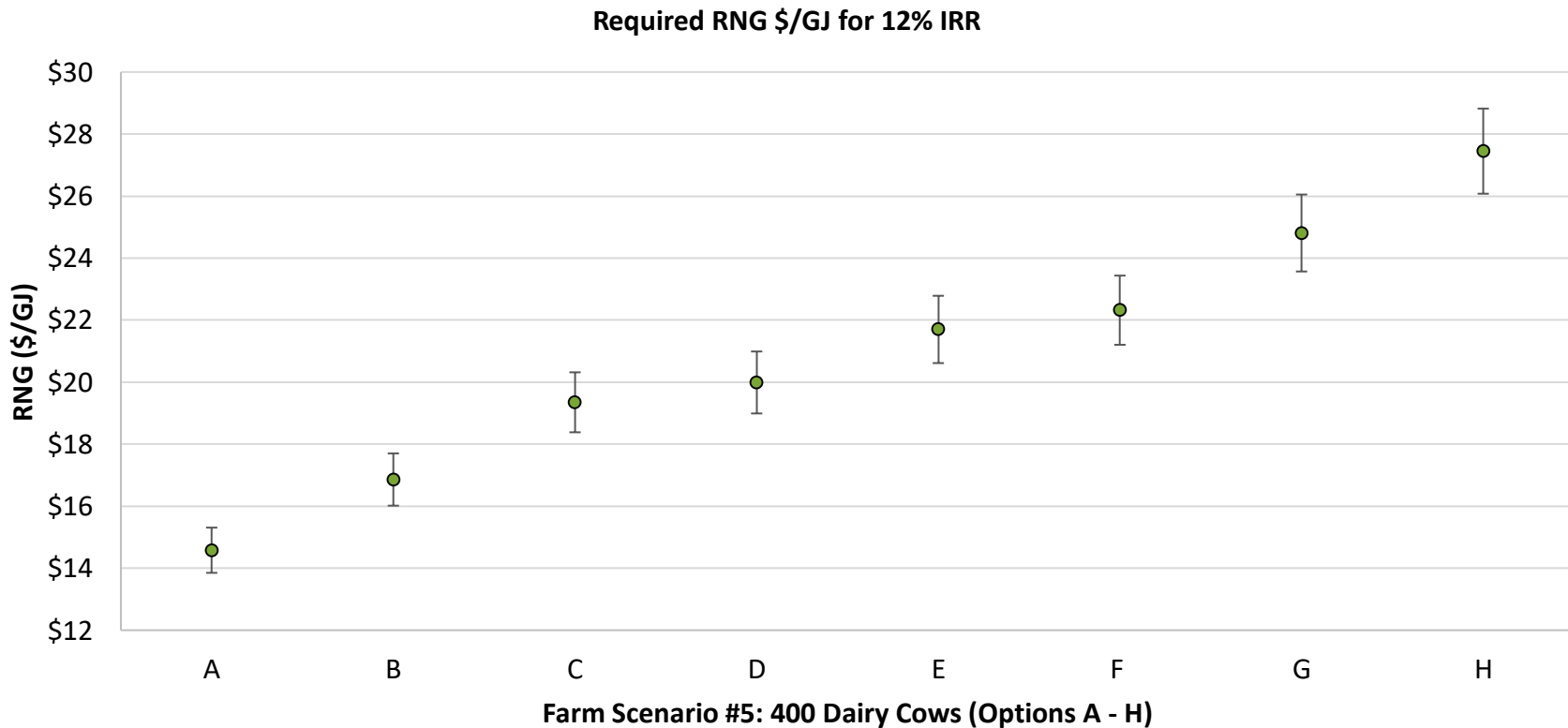
Option H: Sensitivity Analysis – Mixed Food Waste Tip Fee

		Mixed Food Waste Tip Fee (\$/Tonne)										
		\$0	\$5	\$10	\$15	\$20	\$25	\$30	\$35	\$40	\$45	\$50
\$/GJ RNG	\$16	---	---	---	---	---	---	---	---	1.3%	2.8%	4.2%
	\$17	---	---	---	---	---	---	---	1.4%	2.9%	4.3%	5.6%
	\$18	---	---	---	---	---	---	1.5%	3.0%	4.4%	5.7%	6.9%
	\$19	---	---	---	---	0.0%	1.7%	3.1%	4.5%	5.8%	7.0%	8.2%
	\$20	---	---	---	0.2%	1.8%	3.2%	4.6%	5.9%	7.1%	8.2%	9.4%
	\$21	---	---	0.3%	1.9%	3.4%	4.7%	6.0%	7.2%	8.3%	9.4%	10.5%
	\$22	---	0.5%	2.0%	3.5%	4.8%	6.0%	7.2%	8.4%	9.5%	10.5%	11.6%
	\$23	0.6%	2.1%	3.6%	4.9%	6.1%	7.3%	8.4%	9.5%	10.6%	11.6%	12.6%
	\$24	2.3%	3.7%	5.0%	6.2%	7.4%	8.5%	9.6%	10.7%	11.7%	12.7%	13.7%
	\$25	3.8%	5.0%	6.3%	7.4%	8.6%	9.7%	10.7%	11.7%	12.7%	13.7%	14.7%
	\$26	5.0%	6.2%	7.4%	8.5%	9.6%	10.7%	11.7%	12.7%	13.7%	14.7%	15.6%
	\$27	6.0%	7.2%	8.4%	9.5%	10.6%	11.6%	12.6%	13.6%	14.6%	15.6%	16.5%
	\$28	6.8%	8.0%	9.1%	10.2%	11.3%	12.4%	13.4%	14.4%	15.4%	16.3%	17.3%
	\$29	7.3%	8.5%	9.7%	10.8%	11.9%	12.9%	14.0%	15.0%	15.9%	16.9%	17.9%
	\$30	7.5%	8.8%	9.9%	11.0%	12.1%	13.2%	14.2%	15.2%	16.2%	17.2%	18.2%

Farm Scenario #5: Summary

Figure 17 shows the required RNG \$/GJ sale price for Farm Scenario #5 Options A – G for an unlevered, pre-tax IRR of 12%. Where required RNG sale price is <\$30/GJ, a bar representing +/- 5% is shown to account for price uncertainty. Farm Scenario #5 Options A – H don't require funding. These biogas plants require an RNG sale price from as low as \$13.85/GJ to as high as \$28.82/GJ. Figure 17 shows that even with mixed food waste cleaning, RNG compression and nutrient recovery equipment, 400 dairy cow farms co-digesting dairy manure and mixed food waste are economically feasible in B.C. without funding.

Figure 17: Farm Scenario #5 - Required RNG Sale Price for 400 Dairy Cows + Mixed Food Waste



7.6

Farm Scenario #6: 500 Dairy Cows + Mixed Food Waste

Farm Scenario #6 is a 500 dairy cow farm co-digesting dairy manure and mixed food waste. Farm Scenario #6 assumes the use of traditional on-farm biogas plant technology. Estimated feedstock volume and Renewable Natural Gas (RNG) production for Farm Scenario #6 are as follows:

Feedstock	Tonnes/Year	Percentage	RNG Production (GJ/Year)
Dairy manure	25,021	51%	8,074
Mixed food waste	24,040	49%	116,825
<i>Total</i>	<i>49,061</i>	<i>100%</i>	<i>124,898</i>

The following Equipment Choices were assessed for Farm Scenario #6:

- Option A: No additional equipment;
- Option B: Mixed food waste cleaning equipment;
- Option C: RNG compression equipment;
- Option D: Nutrient recovery equipment;
- Option E: Mixed food waste cleaning and RNG compression equipment;
- Option F: Mixed food waste cleaning and nutrient recovery equipment;
- Option G: RNG compression and nutrient recovery equipment; and
- Option H: Mixed food waste cleaning, RNG compression and nutrient recovery equipment.

For full capital and operating costs for Farm Scenario #6 Options A – H, see Appendix F.

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #6 - Option A: No Additional Equipment

This biogas plant is estimated to cost \$8.7 million to build. Operating costs are estimated to average \$1,204,735/year. At an RNG sale price of \$12.48/GJ, average revenue is estimated to be \$2,353,753/year. This biogas plant doesn't require funding for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$1,149,018/year; equal to 95% of operating costs. Operating income should be sufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (i.e., broken equipment, unexpected downtime, etc.).

Option A: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>	<u>Revenue</u>		<u>Investment</u>	
Digester	\$3,278,625		RNG/GJ [†] =	\$12.48	Farm Investment =	\$8,705,093
Upgrader	\$3,536,400		Avg RNG Sales/Yr =	\$1,631,268	Funding Amount =	\$0
Nutrient Recovery	\$756,267		Tip Fee/Yr =	\$600,998	Funding % of CAPEX =	0%
Other	\$1,133,801		Bedding Savings/Yr* =	\$121,487		
Total	<u>\$8,705,093</u>	<u>\$1,204,735</u>	Total =	<u>\$2,353,753</u>	Inflation =	2%

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$2,183	\$2,199	\$2,216	\$2,234	\$2,251	\$2,269	\$2,286	\$2,304	\$2,323	\$2,341
OPEX (000s)	\$992	\$1,011	\$1,032	\$1,052	\$1,073	\$1,095	\$1,117	\$1,139	\$1,162	\$1,185
<i>Income (000s)</i>	<i>\$1,191</i>	<i>\$1,188</i>	<i>\$1,185</i>	<i>\$1,181</i>	<i>\$1,178</i>	<i>\$1,174</i>	<i>\$1,170</i>	<i>\$1,165</i>	<i>\$1,161</i>	<i>\$1,156</i>

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$2,360	\$2,378	\$2,397	\$2,417	\$2,436	\$2,456	\$2,476	\$2,496	\$2,516	\$2,537
OPEX (000s)	\$1,209	\$1,233	\$1,258	\$1,283	\$1,308	\$1,335	\$1,361	\$1,389	\$1,416	\$1,445
<i>Income (000s)</i>	<i>\$1,151</i>	<i>\$1,145</i>	<i>\$1,140</i>	<i>\$1,134</i>	<i>\$1,128</i>	<i>\$1,121</i>	<i>\$1,114</i>	<i>\$1,107</i>	<i>\$1,100</i>	<i>\$1,092</i>

Unlevered, Pre-Tax IRR =	12%	Average Operating Income* =	\$1,149,018	% of OPEX	95%
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* Averaged over twenty years to account for inflation

[†] Base price (1%/year increase up to \$30/GJ max)

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 69% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, if RNG production is 5% higher than anticipated (due to the availability of high biogas-potential mixed food waste), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$12.48/GJ to <\$12/GJ. Alternately, if RNG production is 10% or 20% lower than anticipated, the required RNG sale price for an unlevered, pre-tax IRR increases from \$12.48/GJ to >\$13/GJ and >\$15/GJ respectively. Furthermore, if only 50% of estimated mixed food waste is available (12,020 instead of 24,040 tonnes/year), RNG production will be approximately 45% lower. If RNG production is 45% lower, the required RNG sale price for an unlevered, pre-tax IRR increases from \$12.48/GJ to >\$22/GJ.

Option A: Sensitivity Analysis – RNG Production

		Change in RNG Production Amount														
		-50%	-45%	-40%	-35%	-30%	-25%	-20%	-15%	-10%	-5%	0%	5%	10%	15%	20%
\$/GJ RNG	\$12	---	---	0.6%	2.3%	3.8%	5.2%	6.5%	7.7%	8.9%	10.1%	11.2%	12.2%	13.2%	14.3%	15.2%
	\$13	---	0.4%	2.3%	3.9%	5.4%	6.8%	8.1%	9.4%	10.6%	11.8%	12.9%	14.0%	15.1%	16.1%	17.2%
	\$14	---	2.0%	3.8%	5.4%	6.9%	8.3%	9.7%	11.0%	12.2%	13.4%	14.6%	15.7%	16.8%	17.9%	19.0%
	\$15	1.4%	3.4%	5.2%	6.8%	8.3%	9.8%	11.2%	12.5%	13.8%	15.0%	16.2%	17.4%	18.6%	19.7%	20.9%
	\$16	2.8%	4.7%	6.5%	8.1%	9.7%	11.2%	12.6%	13.9%	15.2%	16.5%	17.8%	19.0%	20.3%	21.5%	22.6%
	\$17	4.0%	6.0%	7.7%	9.4%	11.0%	12.5%	13.9%	15.3%	16.7%	18.0%	19.3%	20.6%	21.9%	23.2%	24.4%
	\$18	5.2%	7.1%	8.9%	10.6%	12.2%	13.8%	15.2%	16.7%	18.1%	19.5%	20.9%	22.2%	23.5%	24.8%	26.2%
	\$19	6.3%	8.2%	10.1%	11.8%	13.4%	15.0%	16.5%	18.0%	19.5%	20.9%	22.4%	23.8%	25.1%	26.5%	27.9%
	\$20	7.3%	9.3%	11.2%	12.9%	14.6%	16.2%	17.8%	19.3%	20.9%	22.4%	23.8%	25.3%	26.7%	28.2%	29.6%
	\$21	8.3%	10.3%	12.2%	14.0%	15.7%	17.4%	19.0%	20.6%	22.2%	23.8%	25.3%	26.8%	28.3%	29.8%	31.3%
	\$22	9.3%	11.3%	13.2%	15.1%	16.8%	18.6%	20.3%	21.9%	23.5%	25.1%	26.7%	28.3%	29.9%	31.4%	33.0%
	\$23	10.2%	12.3%	14.3%	16.1%	17.9%	19.7%	21.5%	23.2%	24.8%	26.5%	28.2%	29.8%	31.4%	33.0%	34.7%
	\$24	11.2%	13.2%	15.2%	17.2%	19.0%	20.9%	22.6%	24.4%	26.2%	27.9%	29.6%	31.3%	33.0%	34.7%	36.3%
	\$25	12.0%	14.2%	16.2%	18.2%	20.1%	22.0%	23.8%	25.6%	27.4%	29.2%	31.0%	32.8%	34.5%	36.3%	38.0%
	\$26	12.9%	15.0%	17.1%	19.2%	21.1%	23.1%	25.0%	26.9%	28.7%	30.6%	32.4%	34.2%	36.0%	37.9%	39.7%
	\$27	13.6%	15.8%	18.0%	20.1%	22.1%	24.1%	26.1%	28.0%	30.0%	31.9%	33.8%	35.7%	37.6%	39.4%	41.3%
\$28	14.2%	16.5%	18.7%	20.9%	23.0%	25.1%	27.1%	29.1%	31.1%	33.1%	35.1%	37.1%	39.0%	41.0%	42.9%	
\$29	14.7%	17.1%	19.3%	21.6%	23.7%	25.9%	28.0%	30.1%	32.1%	34.2%	36.2%	38.3%	40.3%	42.3%	44.3%	
\$30	14.9%	17.3%	19.6%	21.9%	24.1%	26.3%	28.4%	30.6%	32.7%	34.8%	36.9%	39.0%	41.1%	43.1%	45.2%	

B.C. On-Farm Biogas Benchmark Study, Version 2

Mixed food waste tip fee accounts for 26% of biogas plant revenue. Therefore, although less important than RNG sales, food waste tip fee can have a significant impact on biogas plant economic feasibility. For example, if mixed food waste tip fee is \$30/tonne instead of \$25/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$12.48/GJ to <\$12/GJ. Alternately, if mixed food waste tip fee is only \$10/tonne or \$0/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% increases from \$12.48/GJ to >\$15/GJ and >\$17/GJ respectively.

Option A: Sensitivity Analysis – Mixed Food Waste Tip Fee

		Mixed Food Waste Tip Fee (\$/Tonne)										
		\$0	\$5	\$10	\$15	\$20	\$25	\$30	\$35	\$40	\$45	\$50
\$/GJ RNG	\$12	1.1%	3.5%	5.6%	7.6%	9.4%	11.2%	12.8%	14.4%	16.0%	17.6%	19.1%
	\$13	3.7%	5.8%	7.7%	9.5%	11.2%	12.9%	14.5%	16.1%	17.6%	19.1%	20.6%
	\$14	5.9%	7.8%	9.6%	11.3%	13.0%	14.6%	16.1%	17.7%	19.2%	20.7%	22.1%
	\$15	7.9%	9.7%	11.4%	13.1%	14.7%	16.2%	17.7%	19.2%	20.7%	22.2%	23.6%
	\$16	9.8%	11.5%	13.1%	14.7%	16.3%	17.8%	19.3%	20.8%	22.2%	23.7%	25.1%
	\$17	11.6%	13.2%	14.8%	16.3%	17.9%	19.3%	20.8%	22.3%	23.7%	25.1%	26.6%
	\$18	13.3%	14.9%	16.4%	17.9%	19.4%	20.9%	22.3%	23.7%	25.2%	26.6%	28.0%
	\$19	14.9%	16.5%	18.0%	19.4%	20.9%	22.4%	23.8%	25.2%	26.6%	28.0%	29.4%
	\$20	16.5%	18.0%	19.5%	21.0%	22.4%	23.8%	25.2%	26.7%	28.1%	29.5%	30.9%
	\$21	18.1%	19.5%	21.0%	22.4%	23.9%	25.3%	26.7%	28.1%	29.5%	30.9%	32.3%
	\$22	19.6%	21.0%	22.5%	23.9%	25.3%	26.7%	28.1%	29.5%	30.9%	32.3%	33.7%
	\$23	21.1%	22.5%	23.9%	25.4%	26.8%	28.2%	29.6%	31.0%	32.3%	33.7%	35.1%
	\$24	22.6%	24.0%	25.4%	26.8%	28.2%	29.6%	31.0%	32.4%	33.7%	35.1%	36.5%
	\$25	24.0%	25.4%	26.8%	28.2%	29.6%	31.0%	32.4%	33.8%	35.2%	36.5%	37.9%
	\$26	25.4%	26.8%	28.2%	29.6%	31.0%	32.4%	33.8%	35.2%	36.5%	37.9%	39.3%
	\$27	26.8%	28.2%	29.6%	31.0%	32.4%	33.8%	35.2%	36.5%	37.9%	39.3%	40.7%
	\$28	28.1%	29.5%	30.9%	32.3%	33.7%	35.1%	36.5%	37.9%	39.2%	40.6%	42.0%
\$29	29.2%	30.6%	32.0%	33.4%	34.8%	36.2%	37.6%	39.0%	40.4%	41.8%	43.2%	
\$30	29.8%	31.2%	32.6%	34.1%	35.5%	36.9%	38.3%	39.7%	41.1%	42.5%	43.9%	

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #6 - Option B: Mixed Food Waste Cleaning Equipment

This biogas plant is estimated to cost \$9.8 million to build. Operating costs are estimated to average \$1,293,593/year. At an RNG sale price of \$14.32/GJ, average revenue is estimated to be \$2,594,693/year. This biogas plant doesn't require funding for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$1,301,100/year; equal to 101% of operating costs. Operating income should be sufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (i.e., broken equipment, unexpected downtime, etc.).

Option B: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>	<u>Revenue</u>		<u>Investment</u>	
Digester	\$4,268,250		RNG/GJ [†] =	\$14.32	Farm Investment =	\$9,842,914
Upgrader	\$3,536,400		Avg RNG Sales/Yr =	\$1,872,208	Funding Amount =	\$0
Nutrient Recovery	\$756,267		Tip Fee/Yr =	\$600,998	Funding % of CAPEX =	0%
Other	\$1,281,997		Bedding Savings/Yr* =	\$121,487		
Total	<u>\$9,842,914</u>	<u>\$1,293,593</u>	Total =	<u>\$2,594,693</u>	Inflation =	2%

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$2,401	\$2,420	\$2,440	\$2,459	\$2,479	\$2,499	\$2,519	\$2,539	\$2,560	\$2,580
OPEX (000s)	\$1,065	\$1,086	\$1,108	\$1,130	\$1,153	\$1,176	\$1,199	\$1,223	\$1,248	\$1,273
<i>Income (000s)</i>	\$1,337	\$1,334	\$1,332	\$1,329	\$1,326	\$1,323	\$1,320	\$1,316	\$1,312	\$1,308

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$2,601	\$2,623	\$2,644	\$2,666	\$2,688	\$2,710	\$2,732	\$2,755	\$2,778	\$2,801
OPEX (000s)	\$1,298	\$1,324	\$1,350	\$1,377	\$1,405	\$1,433	\$1,462	\$1,491	\$1,521	\$1,551
<i>Income (000s)</i>	\$1,303	\$1,299	\$1,294	\$1,288	\$1,283	\$1,277	\$1,271	\$1,264	\$1,257	\$1,250

Unlevered, Pre-Tax IRR =	12%
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Average Operating Income* =	\$1,301,100
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% of OPEX	101%
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* Averaged over twenty years to account for inflation

[†] Base price (1%/year increase up to \$30/GJ max)

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 72% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, if RNG production is 10% or 20% higher than anticipated (due to the availability of high biogas-potential mixed food waste), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$14.32/GJ to <\$13/GJ and <12/GJ respectively. Alternately, if RNG production is 10% or 20% lower than anticipated, the required RNG sale price for an unlevered, pre-tax IRR increases from \$14.32/GJ to >\$15/GJ and >\$17/GJ respectively. Furthermore, if only 50% of estimated mixed food waste is available (12,020 instead of 24,040 tonnes/year), RNG production will be approximately 45% lower. If RNG production is 45% lower, the required RNG sale price for an unlevered, pre-tax IRR increases from \$14.32/GJ to >\$26/GJ.

Option B: Sensitivity Analysis – RNG Production

		Change in RNG Production Amount														
		-50%	-45%	-40%	-35%	-30%	-25%	-20%	-15%	-10%	-5%	0%	5%	10%	15%	20%
\$/GJ RNG	\$12	---	---	---	---	0.7%	2.2%	3.6%	4.8%	6.0%	7.1%	8.2%	9.2%	10.2%	11.2%	12.1%
	\$13	---	---	---	0.8%	2.4%	3.9%	5.2%	6.5%	7.6%	8.8%	9.9%	10.9%	11.9%	12.9%	13.9%
	\$14	---	---	0.7%	2.4%	4.0%	5.4%	6.7%	8.0%	9.2%	10.4%	11.5%	12.6%	13.6%	14.6%	15.6%
	\$15	---	0.3%	2.2%	3.9%	5.4%	6.8%	8.2%	9.5%	10.7%	11.9%	13.0%	14.1%	15.2%	16.3%	17.3%
	\$16	---	1.7%	3.6%	5.2%	6.7%	8.2%	9.5%	10.8%	12.1%	13.3%	14.5%	15.6%	16.8%	17.9%	19.0%
	\$17	1.0%	3.0%	4.8%	6.5%	8.0%	9.5%	10.8%	12.2%	13.5%	14.7%	15.9%	17.1%	18.3%	19.4%	20.6%
	\$18	2.2%	4.2%	6.0%	7.6%	9.2%	10.7%	12.1%	13.5%	14.8%	16.1%	17.3%	18.6%	19.8%	21.0%	22.2%
	\$19	3.3%	5.3%	7.1%	8.8%	10.4%	11.9%	13.3%	14.7%	16.1%	17.4%	18.7%	20.0%	21.3%	22.5%	23.7%
	\$20	4.4%	6.4%	8.2%	9.9%	11.5%	13.0%	14.5%	15.9%	17.3%	18.7%	20.1%	21.4%	22.7%	24.0%	25.3%
	\$21	5.4%	7.4%	9.2%	10.9%	12.6%	14.1%	15.6%	17.1%	18.6%	20.0%	21.4%	22.8%	24.1%	25.5%	26.8%
	\$22	6.4%	8.4%	10.2%	11.9%	13.6%	15.2%	16.8%	18.3%	19.8%	21.3%	22.7%	24.1%	25.5%	26.9%	28.3%
	\$23	7.3%	9.3%	11.2%	12.9%	14.6%	16.3%	17.9%	19.4%	21.0%	22.5%	24.0%	25.5%	26.9%	28.4%	29.8%
	\$24	8.2%	10.2%	12.1%	13.9%	15.6%	17.3%	19.0%	20.6%	22.2%	23.7%	25.3%	26.8%	28.3%	29.8%	31.3%
	\$25	9.0%	11.1%	13.0%	14.8%	16.6%	18.4%	20.1%	21.7%	23.3%	25.0%	26.6%	28.1%	29.7%	31.3%	32.8%
	\$26	9.8%	11.9%	13.9%	15.7%	17.6%	19.4%	21.1%	22.8%	24.5%	26.2%	27.8%	29.5%	31.1%	32.7%	34.3%
	\$27	10.5%	12.6%	14.6%	16.6%	18.4%	20.3%	22.1%	23.8%	25.6%	27.3%	29.0%	30.7%	32.4%	34.1%	35.8%
\$28	11.0%	13.2%	15.3%	17.3%	19.2%	21.1%	23.0%	24.8%	26.6%	28.4%	30.2%	31.9%	33.7%	35.4%	37.2%	
\$29	11.4%	13.7%	15.8%	17.8%	19.8%	21.8%	23.7%	25.6%	27.5%	29.3%	31.1%	33.0%	34.8%	36.6%	38.4%	
\$30	11.6%	13.9%	16.0%	18.1%	20.2%	22.1%	24.1%	26.0%	27.9%	29.8%	31.7%	33.6%	35.4%	37.3%	39.1%	

B.C. On-Farm Biogas Benchmark Study, Version 2

Mixed food waste tip fee accounts for 23% of biogas plant revenue. Therefore, although less important than RNG sales, food waste tip fee can have a significant impact on biogas plant economic feasibility. For example, if mixed food waste tip fee is \$35/tonne or \$40/tonne instead of \$25/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$14.32/GJ to <\$13/GJ and <\$12/GJ respectively. Alternately, if mixed food waste tip fee is only \$10/tonne or \$0/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% increases from \$14.32/GJ to >\$17/GJ and >\$19/GJ respectively.

Option B: Sensitivity Analysis – Mixed Food Waste Tip Fee

		Mixed Food Waste Tip Fee (\$/Tonne)										
		\$0	\$5	\$10	\$15	\$20	\$25	\$30	\$35	\$40	\$45	\$50
\$/GJ RNG	\$12	---	0.5%	2.7%	4.7%	6.5%	8.2%	9.8%	11.3%	12.8%	14.2%	15.6%
	\$13	0.7%	2.9%	4.8%	6.6%	8.3%	9.9%	11.4%	12.9%	14.3%	15.7%	17.1%
	\$14	3.0%	4.9%	6.7%	8.4%	10.0%	11.5%	12.9%	14.4%	15.8%	17.1%	18.5%
	\$15	5.1%	6.8%	8.5%	10.0%	11.5%	13.0%	14.4%	15.8%	17.2%	18.5%	19.8%
	\$16	6.9%	8.6%	10.1%	11.6%	13.1%	14.5%	15.9%	17.2%	18.6%	19.9%	21.2%
	\$17	8.7%	10.2%	11.7%	13.1%	14.5%	15.9%	17.3%	18.6%	19.9%	21.2%	22.5%
	\$18	10.3%	11.8%	13.2%	14.6%	16.0%	17.3%	18.7%	20.0%	21.3%	22.5%	23.8%
	\$19	11.8%	13.3%	14.7%	16.0%	17.4%	18.7%	20.0%	21.3%	22.6%	23.9%	25.1%
	\$20	13.3%	14.7%	16.1%	17.4%	18.7%	20.1%	21.3%	22.6%	23.9%	25.2%	26.4%
	\$21	14.8%	16.1%	17.5%	18.8%	20.1%	21.4%	22.7%	23.9%	25.2%	26.4%	27.7%
	\$22	16.2%	17.5%	18.8%	20.1%	21.4%	22.7%	24.0%	25.2%	26.5%	27.7%	29.0%
	\$23	17.6%	18.9%	20.2%	21.5%	22.7%	24.0%	25.3%	26.5%	27.7%	29.0%	30.2%
	\$24	18.9%	20.2%	21.5%	22.8%	24.0%	25.3%	26.5%	27.8%	29.0%	30.2%	31.5%
	\$25	20.3%	21.5%	22.8%	24.1%	25.3%	26.6%	27.8%	29.0%	30.3%	31.5%	32.7%
	\$26	21.6%	22.8%	24.1%	25.3%	26.6%	27.8%	29.0%	30.3%	31.5%	32.7%	34.0%
	\$27	22.8%	24.0%	25.3%	26.5%	27.8%	29.0%	30.3%	31.5%	32.7%	34.0%	35.2%
	\$28	23.9%	25.2%	26.4%	27.7%	28.9%	30.2%	31.4%	32.7%	33.9%	35.1%	36.3%
\$29	24.8%	26.1%	27.4%	28.6%	29.9%	31.1%	32.4%	33.6%	34.9%	36.1%	37.4%	
\$30	25.3%	26.6%	27.9%	29.2%	30.4%	31.7%	33.0%	34.2%	35.5%	36.7%	38.0%	

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #6 - Option C: RNG Compression Equipment

This biogas plant is estimated to cost \$10.0 million to build. Operating costs are estimated to average \$1,612,084/year. At an RNG sale price of \$16.90/GJ, average revenue is estimated to be \$2,931,755/year. This biogas plant doesn't require funding for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$1,319,671/year; equal to 82% of operating costs. Operating income should be sufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (i.e., broken equipment, unexpected downtime, etc.).

Option C: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>	<u>Revenue</u>	<u>Investment</u>
Digester	\$3,278,625		RNG/GJ [†] = \$16.90	Farm Investment = \$10,038,869
Upgrader	\$4,696,458		Avg RNG Sales/Yr = \$2,209,270	Funding Amount = \$0
Nutrient Recover	\$756,267		Tip Fee/Yr = \$600,998	Funding % of CAPEX = 0%
Other	\$1,307,520		Bedding Saving/Yr* = \$121,487	
Total	<u>\$10,038,869</u>	<u>\$1,612,084</u>	Total = <u>\$2,931,755</u>	<i>Inflation = 2%</i>

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$2,708	\$2,730	\$2,752	\$2,775	\$2,797	\$2,820	\$2,844	\$2,867	\$2,891	\$2,915
OPEX (000s)	\$1,327	\$1,354	\$1,381	\$1,408	\$1,436	\$1,465	\$1,494	\$1,524	\$1,555	\$1,586
<i>Income (000s)</i>	\$1,381	\$1,376	\$1,371	\$1,366	\$1,361	\$1,355	\$1,349	\$1,343	\$1,336	\$1,329

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$2,940	\$2,964	\$2,989	\$3,014	\$3,040	\$3,065	\$3,091	\$3,118	\$3,144	\$3,171
OPEX (000s)	\$1,618	\$1,650	\$1,683	\$1,717	\$1,751	\$1,786	\$1,822	\$1,858	\$1,895	\$1,933
<i>Income (000s)</i>	\$1,322	\$1,314	\$1,306	\$1,298	\$1,289	\$1,279	\$1,270	\$1,260	\$1,249	\$1,238

Unlevered, Pre-Tax IRR =	12%
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Average Operating Income* =	\$1,319,671
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% of OPEX	82%
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* Averaged over twenty years to account for inflation

[†] Base price (1%/year increase up to \$30/GJ max)

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 75% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, if RNG production is 10% or 20% higher than anticipated (due to the availability of high biogas-potential mixed food waste), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$16.90/GJ to <\$16/GJ and <15/GJ respectively. Alternately, if RNG production is 10% or 20% lower than anticipated, the required RNG sale price for an unlevered, pre-tax IRR increases from \$16.90/GJ to >\$18/GJ and >\$21/GJ respectively. Furthermore, if only 50% of estimated mixed food waste is available (12,020 instead of 24,040 tonnes/year), RNG production will be approximately 45% lower. If RNG production is 45% lower, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 9.7%. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option C: Sensitivity Analysis – RNG Production

		Change in RNG Production Amount															
		-50%	-45%	-40%	-35%	-30%	-25%	-20%	-15%	-10%	-5%	0%	5%	10%	15%	20%	
\$/GJ RNG	\$12	---	---	---	---	---	---	---	---	0.4%	1.9%	3.3%	4.6%	5.8%	6.9%	7.9%	
	\$13	---	---	---	---	---	---	---	1.1%	2.6%	4.1%	5.4%	6.6%	7.8%	8.9%	10.0%	
	\$14	---	---	---	---	---	---	1.4%	3.1%	4.6%	5.9%	7.2%	8.5%	9.6%	10.8%	11.8%	
	\$15	---	---	---	---	---	1.6%	3.3%	4.9%	6.3%	7.7%	9.0%	10.2%	11.4%	12.5%	13.6%	
	\$16	---	---	---	---	1.4%	3.3%	5.0%	6.5%	7.9%	9.3%	10.6%	11.8%	13.1%	14.2%	15.4%	
	\$17	---	---	---	1.1%	3.1%	4.9%	6.5%	8.0%	9.5%	10.8%	12.2%	13.4%	14.7%	15.9%	17.0%	
	\$18	---	---	0.4%	2.6%	4.6%	6.3%	7.9%	9.5%	10.9%	12.3%	13.6%	14.9%	16.2%	17.5%	18.7%	
	\$19	---	---	1.9%	4.1%	5.9%	7.7%	9.3%	10.8%	12.3%	13.7%	15.1%	16.4%	17.7%	19.0%	20.3%	
	\$20	---	0.9%	3.3%	5.4%	7.2%	9.0%	10.6%	12.2%	13.6%	15.1%	16.5%	17.9%	19.2%	20.5%	21.8%	
	\$21	---	2.3%	4.6%	6.6%	8.5%	10.2%	11.8%	13.4%	14.9%	16.4%	17.9%	19.3%	20.7%	22.0%	23.4%	
	\$22	0.9%	3.5%	5.8%	7.8%	9.6%	11.4%	13.1%	14.7%	16.2%	17.7%	19.2%	20.7%	22.1%	23.5%	24.9%	
	\$23	2.2%	4.7%	6.9%	8.9%	10.8%	12.5%	14.2%	15.9%	17.5%	19.0%	20.5%	22.0%	23.5%	25.0%	26.4%	
	\$24	3.3%	5.8%	7.9%	10.0%	11.8%	13.6%	15.4%	17.0%	18.7%	20.3%	21.8%	23.4%	24.9%	26.4%	27.9%	
	\$25	4.4%	6.8%	9.0%	11.0%	12.9%	14.7%	16.5%	18.2%	19.9%	21.5%	23.1%	24.7%	26.3%	27.8%	29.4%	
	\$26	5.3%	7.7%	9.9%	11.9%	13.9%	15.7%	17.6%	19.3%	21.0%	22.7%	24.4%	26.0%	27.6%	29.3%	30.9%	
	\$27	6.0%	8.4%	10.7%	12.8%	14.8%	16.7%	18.5%	20.3%	22.1%	23.9%	25.6%	27.3%	29.0%	30.6%	32.3%	
	\$28	6.6%	9.1%	11.3%	13.5%	15.5%	17.5%	19.4%	21.3%	23.1%	24.9%	26.7%	28.5%	30.2%	31.9%	33.6%	
	\$29	6.9%	9.5%	11.8%	14.0%	16.1%	18.1%	20.1%	22.0%	23.9%	25.8%	27.6%	29.4%	31.2%	33.0%	34.8%	
\$30	7.1%	9.7%	12.0%	14.3%	16.4%	18.5%	20.5%	22.4%	24.4%	26.3%	28.1%	30.0%	31.8%	33.7%	35.5%		

B.C. On-Farm Biogas Benchmark Study, Version 2

Mixed food waste tip fee accounts for 20% of biogas plant revenue. Therefore, although less important than RNG sales, food waste tip fee can have a significant impact on biogas plant economic feasibility. For example, if mixed food waste tip fee is \$35/tonne or \$50/tonne instead of \$25/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$16.90/GJ to \$15/GJ and <\$13/GJ respectively. Alternately, if mixed food waste tip fee is only \$10/tonne or \$0/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% increases from \$16.90/GJ to >\$19/GJ and >\$21/GJ respectively.

Option C: Sensitivity Analysis – Mixed Food Waste Tip Fee

		Mixed Food Waste Tip Fee (\$/Tonne)										
		\$0	\$5	\$10	\$15	\$20	\$25	\$30	\$35	\$40	\$45	\$50
\$/GJ RNG	\$12	---	---	---	---	1.1%	3.3%	5.2%	7.0%	8.7%	10.3%	11.8%
	\$13	---	---	---	1.3%	3.5%	5.4%	7.1%	8.8%	10.4%	11.9%	13.3%
	\$14	---	---	1.5%	3.6%	5.5%	7.2%	8.9%	10.4%	11.9%	13.4%	14.8%
	\$15	---	1.7%	3.8%	5.6%	7.3%	9.0%	10.5%	12.0%	13.4%	14.8%	16.2%
	\$16	1.9%	3.9%	5.7%	7.4%	9.1%	10.6%	12.1%	13.5%	14.9%	16.3%	17.6%
	\$17	4.0%	5.9%	7.6%	9.2%	10.7%	12.2%	13.6%	15.0%	16.3%	17.7%	19.0%
	\$18	6.0%	7.7%	9.2%	10.8%	12.2%	13.6%	15.0%	16.4%	17.7%	19.0%	20.3%
	\$19	7.8%	9.3%	10.8%	12.3%	13.7%	15.1%	16.4%	17.8%	19.1%	20.4%	21.6%
	\$20	9.4%	10.9%	12.4%	13.8%	15.1%	16.5%	17.8%	19.1%	20.4%	21.7%	22.9%
	\$21	11.0%	12.4%	13.8%	15.2%	16.5%	17.9%	19.2%	20.4%	21.7%	23.0%	24.2%
	\$22	12.5%	13.9%	15.3%	16.6%	17.9%	19.2%	20.5%	21.8%	23.0%	24.3%	25.5%
	\$23	14.0%	15.3%	16.6%	18.0%	19.3%	20.5%	21.8%	23.0%	24.3%	25.5%	26.8%
	\$24	15.4%	16.7%	18.0%	19.3%	20.6%	21.8%	23.1%	24.3%	25.6%	26.8%	28.0%
	\$25	16.8%	18.1%	19.3%	20.6%	21.9%	23.1%	24.4%	25.6%	26.8%	28.0%	29.3%
	\$26	18.1%	19.3%	20.6%	21.9%	23.1%	24.4%	25.6%	26.8%	28.1%	29.3%	30.5%
	\$27	19.3%	20.6%	21.8%	23.1%	24.3%	25.6%	26.8%	28.0%	29.3%	30.5%	31.7%
	\$28	20.4%	21.7%	22.9%	24.2%	25.4%	26.7%	27.9%	29.2%	30.4%	31.6%	32.8%
\$29	21.2%	22.5%	23.8%	25.1%	26.4%	27.6%	28.9%	30.1%	31.3%	32.6%	33.8%	
\$30	21.7%	23.0%	24.3%	25.6%	26.9%	28.1%	29.4%	30.6%	31.9%	33.1%	34.4%	

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #6 - Option D: Nutrient Recovery Equipment

This biogas plant is estimated to cost \$10.4 million to build. Operating costs are estimated to average \$1,715,422/year. At an RNG sale price of \$17.97/GJ, average revenue is estimated to be \$3,071,965/year. This biogas plant doesn't require funding for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$1,356,544/year; equal to 79% of operating costs. Operating income should be sufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (i.e., broken equipment, unexpected downtime, etc.).

Option D: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>	<u>Revenue</u>		<u>Investment</u>	
Digester	\$3,509,625		RNG/GJ [†] =	\$17.97	Farm Investment =	\$10,350,385
Upgrader	\$3,536,400		Avg RNG Sales/Yr =	\$2,349,480	Funding Amount =	\$0
Nutrient Recover	\$1,956,267		Tip Fee/Yr =	\$600,998	Funding % of CAPEX =	0%
Other	\$1,348,093		Bedding Saving/Yr* =	\$121,487		
Total	<u>\$10,350,385</u>	<u>\$1,715,422</u>	Total =	<u>\$3,071,965</u>	Inflation =	2%

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$2,835	\$2,858	\$2,882	\$2,906	\$2,930	\$2,954	\$2,979	\$3,004	\$3,029	\$3,054
OPEX (000s)	\$1,412	\$1,440	\$1,469	\$1,498	\$1,528	\$1,559	\$1,590	\$1,622	\$1,654	\$1,687
<i>Income (000s)</i>	\$1,423	\$1,418	\$1,413	\$1,407	\$1,401	\$1,395	\$1,389	\$1,382	\$1,375	\$1,367

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$3,080	\$3,106	\$3,133	\$3,159	\$3,186	\$3,213	\$3,241	\$3,269	\$3,297	\$3,325
OPEX (000s)	\$1,721	\$1,756	\$1,791	\$1,827	\$1,863	\$1,900	\$1,938	\$1,977	\$2,017	\$2,057
<i>Income (000s)</i>	\$1,359	\$1,351	\$1,342	\$1,333	\$1,323	\$1,313	\$1,302	\$1,291	\$1,280	\$1,268

Unlevered, Pre-Tax IRR =	12%
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Average Operating Income* =	\$1,356,544
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% of OPEX	79%
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* Averaged over twenty years to account for inflation

† Base price (1%/year increase up to \$30/GJ max)

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 76% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, if RNG production is 10% or 20% higher than anticipated (due to the availability of high biogas-potential mixed food waste), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$17.97/GJ to <\$17/GJ and <15/GJ respectively. Alternately, if RNG production is 10% or 20% lower than anticipated, the required RNG sale price for an unlevered, pre-tax IRR increases from \$17.97/GJ to >\$19/GJ and >\$22/GJ respectively. Furthermore, if only 50% of estimated mixed food waste is available (12,020 instead of 24,040 tonnes/year), RNG production will be approximately 45% lower. If RNG production is 45% lower, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 7.8%. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option D: Sensitivity Analysis – RNG Production

		Change in RNG Production Amount														
		-50%	-45%	-40%	-35%	-30%	-25%	-20%	-15%	-10%	-5%	0%	5%	10%	15%	20%
\$/GJ RNG	\$12	---	---	---	---	---	---	---	---	---	---	1.1%	2.5%	3.8%	5.0%	6.2%
	\$13	---	---	---	---	---	---	---	---	0.4%	2.0%	3.4%	4.7%	6.0%	7.1%	8.2%
	\$14	---	---	---	---	---	---	---	0.9%	2.5%	4.0%	5.4%	6.7%	7.9%	9.1%	10.2%
	\$15	---	---	---	---	---	---	1.1%	2.9%	4.4%	5.9%	7.2%	8.5%	9.7%	10.9%	12.0%
	\$16	---	---	---	---	---	1.1%	3.0%	4.6%	6.2%	7.6%	8.9%	10.2%	11.4%	12.6%	13.7%
	\$17	---	---	---	---	0.9%	2.9%	4.6%	6.2%	7.7%	9.2%	10.5%	11.8%	13.0%	14.2%	15.4%
	\$18	---	---	---	0.4%	2.5%	4.4%	6.2%	7.7%	9.2%	10.7%	12.0%	13.3%	14.6%	15.8%	17.0%
	\$19	---	---	---	2.0%	4.0%	5.9%	7.6%	9.2%	10.7%	12.1%	13.5%	14.8%	16.1%	17.4%	18.6%
	\$20	---	---	1.1%	3.4%	5.4%	7.2%	8.9%	10.5%	12.0%	13.5%	14.9%	16.2%	17.6%	18.9%	20.2%
	\$21	---	0.0%	2.5%	4.7%	6.7%	8.5%	10.2%	11.8%	13.3%	14.8%	16.2%	17.6%	19.0%	20.4%	21.7%
	\$22	---	1.4%	3.8%	6.0%	7.9%	9.7%	11.4%	13.0%	14.6%	16.1%	17.6%	19.0%	20.4%	21.8%	23.2%
	\$23	---	2.7%	5.0%	7.1%	9.1%	10.9%	12.6%	14.2%	15.8%	17.4%	18.9%	20.4%	21.8%	23.3%	24.7%
	\$24	1.1%	3.8%	6.2%	8.2%	10.2%	12.0%	13.7%	15.4%	17.0%	18.6%	20.2%	21.7%	23.2%	24.7%	26.1%
	\$25	2.3%	4.9%	7.2%	9.3%	11.3%	13.1%	14.9%	16.6%	18.2%	19.9%	21.4%	23.0%	24.6%	26.1%	27.6%
	\$26	3.3%	5.9%	8.2%	10.3%	12.2%	14.1%	15.9%	17.7%	19.4%	21.0%	22.7%	24.3%	25.9%	27.5%	29.0%
	\$27	4.0%	6.6%	9.0%	11.1%	13.1%	15.0%	16.9%	18.7%	20.4%	22.2%	23.8%	25.5%	27.2%	28.8%	30.4%
	\$28	4.6%	7.2%	9.6%	11.8%	13.9%	15.8%	17.7%	19.6%	21.4%	23.2%	24.9%	26.7%	28.4%	30.1%	31.7%
\$29	5.0%	7.6%	10.1%	12.3%	14.4%	16.4%	18.4%	20.3%	22.2%	24.0%	25.8%	27.6%	29.4%	31.1%	32.9%	
\$30	5.1%	7.8%	10.3%	12.5%	14.7%	16.7%	18.7%	20.7%	22.6%	24.4%	26.3%	28.1%	29.9%	31.7%	33.5%	

B.C. On-Farm Biogas Benchmark Study, Version 2

Mixed food waste tip fee accounts for 20% of biogas plant revenue. Therefore, although less important than RNG sales, food waste tip fee can have a significant impact on biogas plant economic feasibility. For example, if mixed food waste tip fee is \$35/tonne or \$50/tonne instead of \$25/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$17.97/GJ to <\$17/GJ and <\$14/GJ respectively. Alternately, if mixed food waste tip fee is only \$10/tonne or \$0/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% increases from \$17.97/GJ to >\$20/GJ and >\$22/GJ respectively.

Option D: Sensitivity Analysis – Mixed Food Waste Tip Fee

		Mixed Food Waste Tip Fee (\$/Tonne)										
		\$0	\$5	\$10	\$15	\$20	\$25	\$30	\$35	\$40	\$45	\$50
\$/GJ RNG	\$12	---	---	---	---	---	1.1%	3.3%	5.2%	6.9%	8.5%	10.1%
	\$13	---	---	---	---	1.3%	3.4%	5.3%	7.0%	8.6%	10.2%	11.6%
	\$14	---	---	---	1.5%	3.6%	5.4%	7.1%	8.7%	10.3%	11.7%	13.1%
	\$15	---	---	1.7%	3.7%	5.5%	7.2%	8.8%	10.3%	11.8%	13.2%	14.6%
	\$16	---	1.9%	3.8%	5.6%	7.3%	8.9%	10.4%	11.9%	13.3%	14.6%	16.0%
	\$17	2.0%	4.0%	5.8%	7.4%	9.0%	10.5%	11.9%	13.3%	14.7%	16.0%	17.3%
	\$18	4.1%	5.9%	7.5%	9.1%	10.6%	12.0%	13.4%	14.8%	16.1%	17.4%	18.7%
	\$19	6.0%	7.6%	9.2%	10.7%	12.1%	13.5%	14.8%	16.1%	17.4%	18.7%	20.0%
	\$20	7.7%	9.3%	10.7%	12.1%	13.5%	14.9%	16.2%	17.5%	18.7%	20.0%	21.2%
	\$21	9.3%	10.8%	12.2%	13.6%	14.9%	16.2%	17.5%	18.8%	20.0%	21.3%	22.5%
	\$22	10.9%	12.3%	13.7%	15.0%	16.3%	17.6%	18.8%	20.1%	21.3%	22.6%	23.8%
	\$23	12.4%	13.7%	15.0%	16.3%	17.6%	18.9%	20.1%	21.4%	22.6%	23.8%	25.0%
	\$24	13.8%	15.1%	16.4%	17.7%	18.9%	20.2%	21.4%	22.6%	23.8%	25.0%	26.2%
	\$25	15.2%	16.4%	17.7%	19.0%	20.2%	21.4%	22.7%	23.9%	25.1%	26.3%	27.5%
	\$26	16.4%	17.7%	19.0%	20.2%	21.5%	22.7%	23.9%	25.1%	26.3%	27.5%	28.7%
	\$27	17.6%	18.9%	20.2%	21.4%	22.6%	23.8%	25.1%	26.3%	27.5%	28.6%	29.8%
	\$28	18.7%	20.0%	21.2%	22.5%	23.7%	24.9%	26.1%	27.3%	28.5%	29.7%	30.9%
\$29	19.5%	20.8%	22.1%	23.3%	24.6%	25.8%	27.0%	28.2%	29.5%	30.7%	31.9%	
\$30	20.0%	21.3%	22.5%	23.8%	25.0%	26.3%	27.5%	28.7%	30.0%	31.2%	32.4%	

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #6 - Option E: Mixed Food Waste Cleaning & RNG Compression Equipment

This biogas plant is estimated to cost \$11.2 million to build. Operating costs are estimated to average \$1,700,942/year. At an RNG sale price of \$18.75/GJ, average revenue is estimated to be \$3,174,342/year. This biogas plant doesn't require funding for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$1,473,400/year; equal to 87% of operating costs. Operating income should be sufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (i.e., broken equipment, unexpected downtime, etc.).

Option E: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>	<u>Revenue</u>	<u>Investment</u>
Digester	\$4,268,250		RNG/GJ [†] = \$18.75	Farm Investment = \$11,176,691
Upgrader	\$4,696,458		Avg RNG Sales/Yr = \$2,451,857	Funding Amount = \$0
Nutrient Recover	\$756,267		Tip Fee/Yr = \$600,998	Funding % of CAPEX = 0%
Other	\$1,455,716		Bedding Saving/Yr* = \$121,487	
Total	<u>\$11,176,691</u>	<u>\$1,700,942</u>	Total = <u>\$3,174,342</u>	<i>Inflation = 2%</i>

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$2,928	\$2,952	\$2,977	\$3,002	\$3,027	\$3,052	\$3,078	\$3,103	\$3,130	\$3,156
OPEX (000s)	\$1,400	\$1,428	\$1,457	\$1,486	\$1,516	\$1,546	\$1,577	\$1,608	\$1,640	\$1,673
<i>Income (000s)</i>	\$1,528	\$1,524	\$1,520	\$1,516	\$1,511	\$1,506	\$1,501	\$1,495	\$1,489	\$1,483

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$3,183	\$3,210	\$3,237	\$3,265	\$3,293	\$3,321	\$3,350	\$3,379	\$3,408	\$3,437
OPEX (000s)	\$1,707	\$1,741	\$1,776	\$1,811	\$1,847	\$1,884	\$1,922	\$1,960	\$2,000	\$2,040
<i>Income (000s)</i>	\$1,476	\$1,469	\$1,462	\$1,454	\$1,446	\$1,437	\$1,428	\$1,418	\$1,408	\$1,398

Unlevered, Pre-Tax IRR =	12%
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Average Operating Income* =	\$1,473,400
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% of OPEX	87%
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* Averaged over twenty years to account for inflation

[†] Base price (1%/year increase up to \$30/GJ max)

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 77% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, if RNG production is 10% or 20% higher than anticipated (due to the availability of high biogas-potential mixed food waste), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$18.75/GJ to <\$17/GJ and <\$16/GJ respectively. Alternately, if RNG production is 10% or 20% lower than anticipated, the required RNG sale price for an unlevered, pre-tax IRR increases from \$18.75/GJ to >\$20/GJ and >\$23/GJ respectively. Furthermore, if only 50% of estimated mixed food waste is available (12,020 instead of 24,040 tonnes/year), RNG production will be approximately 45% lower. If RNG production is 45% lower, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 6.9%. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option E: Sensitivity Analysis – RNG Production

		Change in RNG Production Amount														
		-50%	-45%	-40%	-35%	-30%	-25%	-20%	-15%	-10%	-5%	0%	5%	10%	15%	20%
\$/GJ RNG	\$12	---	---	---	---	---	---	---	---	---	---	0.6%	1.9%	3.1%	4.3%	5.4%
	\$13	---	---	---	---	---	---	---	---	---	1.4%	2.7%	4.0%	5.2%	6.3%	7.4%
	\$14	---	---	---	---	---	---	---	0.3%	1.9%	3.3%	4.7%	5.9%	7.0%	8.1%	9.2%
	\$15	---	---	---	---	---	---	0.6%	2.2%	3.7%	5.1%	6.4%	7.6%	8.8%	9.9%	10.9%
	\$16	---	---	---	---	---	0.6%	2.3%	3.9%	5.4%	6.7%	8.0%	9.2%	10.4%	11.5%	12.6%
	\$17	---	---	---	---	0.3%	2.2%	3.9%	5.5%	6.9%	8.2%	9.5%	10.7%	11.9%	13.1%	14.2%
	\$18	---	---	---	---	1.9%	3.7%	5.4%	6.9%	8.3%	9.7%	10.9%	12.2%	13.4%	14.6%	15.7%
	\$19	---	---	---	1.4%	3.3%	5.1%	6.7%	8.2%	9.7%	11.0%	12.3%	13.6%	14.8%	16.0%	17.2%
	\$20	---	---	0.6%	2.7%	4.7%	6.4%	8.0%	9.5%	10.9%	12.3%	13.7%	14.9%	16.2%	17.4%	18.7%
	\$21	---	---	1.9%	4.0%	5.9%	7.6%	9.2%	10.7%	12.2%	13.6%	14.9%	16.3%	17.6%	18.8%	20.1%
	\$22	---	0.8%	3.1%	5.2%	7.0%	8.8%	10.4%	11.9%	13.4%	14.8%	16.2%	17.6%	18.9%	20.2%	21.5%
	\$23	---	2.0%	4.3%	6.3%	8.1%	9.9%	11.5%	13.1%	14.6%	16.0%	17.4%	18.8%	20.2%	21.6%	22.9%
	\$24	0.6%	3.1%	5.4%	7.4%	9.2%	10.9%	12.6%	14.2%	15.7%	17.2%	18.7%	20.1%	21.5%	22.9%	24.3%
	\$25	1.7%	4.2%	6.4%	8.4%	10.2%	12.0%	13.7%	15.3%	16.8%	18.4%	19.8%	21.3%	22.8%	24.2%	25.6%
	\$26	2.6%	5.1%	7.3%	9.3%	11.2%	12.9%	14.6%	16.3%	17.9%	19.5%	21.0%	22.5%	24.0%	25.5%	26.9%
	\$27	3.3%	5.8%	8.0%	10.1%	12.0%	13.8%	15.5%	17.2%	18.9%	20.5%	22.1%	23.7%	25.2%	26.7%	28.2%
	\$28	3.8%	6.4%	8.6%	10.7%	12.7%	14.5%	16.3%	18.1%	19.8%	21.4%	23.1%	24.7%	26.3%	27.9%	29.4%
\$29	4.2%	6.7%	9.0%	11.2%	13.2%	15.1%	16.9%	18.7%	20.5%	22.2%	23.9%	25.6%	27.2%	28.8%	30.5%	
\$30	4.3%	6.9%	9.2%	11.4%	13.4%	15.4%	17.2%	19.1%	20.8%	22.6%	24.3%	26.0%	27.7%	29.4%	31.0%	

B.C. On-Farm Biogas Benchmark Study, Version 2

Mixed food waste tip fee accounts for 19% of biogas plant revenue. Therefore, although less important than RNG sales, food waste tip fee can have a significant impact on biogas plant economic feasibility. For example, if mixed food waste tip fee is \$35/tonne or \$50/tonne instead of \$25/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$18.75/GJ to <\$17/GJ and <\$14/GJ respectively. Alternately, if mixed food waste tip fee is only \$10/tonne or \$0/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% increases from \$18.75/GJ to >\$21/GJ and >\$23/GJ respectively.

Option E: Sensitivity Analysis – Mixed Food Waste Tip Fee

		Mixed Food Waste Tip Fee (\$/Tonne)										
		\$0	\$5	\$10	\$15	\$20	\$25	\$30	\$35	\$40	\$45	\$50
\$/GJ RNG	\$12	---	---	---	---	---	0.6%	2.6%	4.4%	6.1%	7.6%	9.1%
	\$13	---	---	---	---	0.8%	2.7%	4.5%	6.2%	7.7%	9.2%	10.6%
	\$14	---	---	---	0.9%	2.9%	4.7%	6.3%	7.8%	9.3%	10.7%	12.0%
	\$15	---	---	1.1%	3.0%	4.8%	6.4%	7.9%	9.3%	10.7%	12.1%	13.4%
	\$16	---	1.3%	3.2%	4.9%	6.5%	8.0%	9.4%	10.8%	12.1%	13.4%	14.7%
	\$17	1.4%	3.3%	5.0%	6.6%	8.1%	9.5%	10.9%	12.2%	13.5%	14.7%	16.0%
	\$18	3.4%	5.1%	6.7%	8.2%	9.6%	10.9%	12.3%	13.5%	14.8%	16.0%	17.2%
	\$19	5.2%	6.8%	8.3%	9.7%	11.0%	12.3%	13.6%	14.8%	16.1%	17.3%	18.4%
	\$20	6.9%	8.3%	9.7%	11.1%	12.4%	13.7%	14.9%	16.1%	17.3%	18.5%	19.7%
	\$21	8.4%	9.8%	11.2%	12.4%	13.7%	14.9%	16.2%	17.4%	18.5%	19.7%	20.8%
	\$22	9.9%	11.2%	12.5%	13.8%	15.0%	16.2%	17.4%	18.6%	19.7%	20.9%	22.0%
	\$23	11.3%	12.6%	13.8%	15.1%	16.3%	17.4%	18.6%	19.8%	20.9%	22.1%	23.2%
	\$24	12.6%	13.9%	15.1%	16.3%	17.5%	18.7%	19.8%	21.0%	22.1%	23.2%	24.3%
	\$25	13.9%	15.2%	16.4%	17.5%	18.7%	19.8%	21.0%	22.1%	23.2%	24.4%	25.5%
	\$26	15.2%	16.4%	17.5%	18.7%	19.9%	21.0%	22.1%	23.3%	24.4%	25.5%	26.6%
	\$27	16.3%	17.5%	18.6%	19.8%	21.0%	22.1%	23.2%	24.3%	25.5%	26.6%	27.7%
	\$28	17.2%	18.4%	19.6%	20.8%	21.9%	23.1%	24.2%	25.3%	26.5%	27.6%	28.7%
\$29	18.0%	19.2%	20.4%	21.6%	22.7%	23.9%	25.0%	26.2%	27.3%	28.4%	29.5%	
\$30	18.4%	19.6%	20.8%	22.0%	23.2%	24.3%	25.5%	26.6%	27.7%	28.9%	30.0%	

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #6 - Option F: Mixed Food Waste Cleaning & Nutrient Recovery Equipment

This biogas plant is estimated to cost \$11.5 million to build. Operating costs are estimated to average \$1,804,279/year. At an RNG sale price of \$19.84/GJ, average revenue is estimated to be \$3,315,981/year. This biogas plant doesn't require funding for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$1,511,702/year; equal to 84% of operating costs. Operating income should be sufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (i.e., broken equipment, unexpected downtime, etc.).

Option F: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>	<u>Revenue</u>		<u>Investment</u>	
Digester	\$4,499,250		RNG/GJ [†] =	\$19.84	Farm Investment =	\$11,488,207
Upgrader	\$3,536,400		Avg RNG Sales/Yr =	\$2,593,496	Funding Amount =	\$0
Nutrient Recover	\$1,956,267		Tip Fee/Yr =	\$600,998	Funding % of CAPEX =	0%
Other	\$1,496,290		Bedding Saving/Yr* =	\$121,487		
Total	<u>\$11,488,207</u>	<u>\$1,804,279</u>	Total =	<u>\$3,315,981</u>	Inflation =	2%

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$3,057	\$3,082	\$3,108	\$3,134	\$3,161	\$3,187	\$3,214	\$3,241	\$3,269	\$3,297
OPEX (000s)	\$1,485	\$1,515	\$1,545	\$1,576	\$1,608	\$1,640	\$1,673	\$1,706	\$1,740	\$1,775
<i>Income (000s)</i>	\$1,571	\$1,567	\$1,563	\$1,558	\$1,553	\$1,547	\$1,542	\$1,535	\$1,529	\$1,522

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$3,325	\$3,353	\$3,382	\$3,411	\$3,441	\$3,471	\$3,501	\$3,531	\$3,562	\$3,593
OPEX (000s)	\$1,810	\$1,847	\$1,884	\$1,921	\$1,960	\$1,999	\$2,039	\$2,080	\$2,121	\$2,164
<i>Income (000s)</i>	\$1,515	\$1,507	\$1,499	\$1,490	\$1,481	\$1,472	\$1,462	\$1,451	\$1,441	\$1,429

Unlevered, Pre-Tax IRR =	12%
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Average Operating Income* =	\$1,511,702
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% of OPEX	84%
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* Averaged over twenty years to account for inflation

† Base price (1%/year increase up to \$30/GJ max)

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 78% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, if RNG production is 10% or 20% higher than anticipated (due to the availability of high biogas-potential mixed food waste), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$19.84/GJ to <\$18/GJ and <\$17/GJ respectively. Alternately, if RNG production is 10% or 20% lower than anticipated, the required RNG sale price for an unlevered, pre-tax IRR increases from \$19.84/GJ to >\$21/GJ and >\$24/GJ respectively. Furthermore, if only 50% of estimated mixed food waste is available (12,020 instead of 24,040 tonnes/year), RNG production will be approximately 45% lower. If RNG production is 45% lower, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 5.1%. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option F: Sensitivity Analysis – RNG Production

		Change in RNG Production Amount														
		-50%	-45%	-40%	-35%	-30%	-25%	-20%	-15%	-10%	-5%	0%	5%	10%	15%	20%
\$/GJ RNG	\$12	---	---	---	---	---	---	---	---	---	---	---	---	1.2%	2.5%	3.6%
	\$13	---	---	---	---	---	---	---	---	---	---	0.8%	2.2%	3.4%	4.6%	5.7%
	\$14	---	---	---	---	---	---	---	---	---	1.4%	2.9%	4.2%	5.4%	6.6%	7.7%
	\$15	---	---	---	---	---	---	---	0.2%	1.9%	3.3%	4.7%	6.0%	7.2%	8.3%	9.4%
	\$16	---	---	---	---	---	---	0.3%	2.1%	3.6%	5.1%	6.4%	7.7%	8.9%	10.0%	11.1%
	\$17	---	---	---	---	---	0.2%	2.1%	3.7%	5.2%	6.6%	8.0%	9.2%	10.4%	11.6%	12.7%
	\$18	---	---	---	---	---	1.9%	3.6%	5.2%	6.7%	8.1%	9.4%	10.7%	11.9%	13.1%	14.3%
	\$19	---	---	---	---	1.4%	3.3%	5.1%	6.6%	8.1%	9.5%	10.8%	12.1%	13.4%	14.6%	15.7%
	\$20	---	---	---	0.8%	2.9%	4.7%	6.4%	8.0%	9.4%	10.8%	12.2%	13.5%	14.8%	16.0%	17.2%
	\$21	---	---	---	2.2%	4.2%	6.0%	7.7%	9.2%	10.7%	12.1%	13.5%	14.8%	16.1%	17.4%	18.6%
	\$22	---	---	1.2%	3.4%	5.4%	7.2%	8.9%	10.4%	11.9%	13.4%	14.8%	16.1%	17.4%	18.7%	20.0%
	\$23	---	0.0%	2.5%	4.6%	6.6%	8.3%	10.0%	11.6%	13.1%	14.6%	16.0%	17.4%	18.7%	20.1%	21.4%
	\$24	---	1.2%	3.6%	5.7%	7.7%	9.4%	11.1%	12.7%	14.3%	15.7%	17.2%	18.6%	20.0%	21.4%	22.7%
	\$25	---	2.4%	4.7%	6.8%	8.7%	10.5%	12.2%	13.8%	15.4%	16.9%	18.4%	19.8%	21.3%	22.7%	24.1%
	\$26	0.6%	3.3%	5.6%	7.7%	9.6%	11.5%	13.2%	14.8%	16.4%	18.0%	19.5%	21.0%	22.5%	23.9%	25.4%
	\$27	1.3%	4.0%	6.4%	8.5%	10.5%	12.3%	14.1%	15.8%	17.4%	19.0%	20.6%	22.1%	23.6%	25.1%	26.6%
	\$28	1.8%	4.6%	7.0%	9.1%	11.1%	13.0%	14.8%	16.6%	18.3%	19.9%	21.5%	23.1%	24.7%	26.3%	27.8%
\$29	2.2%	5.0%	7.4%	9.6%	11.6%	13.6%	15.4%	17.2%	18.9%	20.6%	22.3%	24.0%	25.6%	27.2%	28.8%	
\$30	2.3%	5.1%	7.6%	9.8%	11.9%	13.8%	15.7%	17.5%	19.3%	21.0%	22.7%	24.4%	26.1%	27.7%	29.3%	

B.C. On-Farm Biogas Benchmark Study, Version 2

Mixed food waste tip fee accounts for 18% of biogas plant revenue. Therefore, although less important than RNG sales, food waste tip fee can have a significant impact on biogas plant economic feasibility. For example, if mixed food waste tip fee is \$35/tonne or \$50/tonne instead of \$25/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$19.84/GJ to <\$18/GJ and <\$16/GJ respectively. Alternately, if mixed food waste tip fee is only \$10/tonne or \$0/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% increases from \$19.84/GJ to >\$22/GJ and >\$24/GJ respectively.

Option F: Sensitivity Analysis – Mixed Food Waste Tip Fee

		Mixed Food Waste Tip Fee (\$/Tonne)										
		\$0	\$5	\$10	\$15	\$20	\$25	\$30	\$35	\$40	\$45	\$50
\$/GJ RNG	\$12	---	---	---	---	---	---	0.6%	2.6%	4.4%	6.0%	7.5%
	\$13	---	---	---	---	---	0.8%	2.7%	4.5%	6.1%	7.6%	9.0%
	\$14	---	---	---	---	0.9%	2.9%	4.6%	6.2%	7.7%	9.1%	10.5%
	\$15	---	---	---	1.1%	3.0%	4.7%	6.3%	7.8%	9.2%	10.6%	11.9%
	\$16	---	---	1.3%	3.1%	4.8%	6.4%	7.9%	9.3%	10.6%	11.9%	13.2%
	\$17	---	1.4%	3.3%	4.9%	6.5%	8.0%	9.4%	10.7%	12.0%	13.3%	14.5%
	\$18	1.6%	3.4%	5.1%	6.6%	8.0%	9.4%	10.8%	12.1%	13.3%	14.5%	15.7%
	\$19	3.5%	5.2%	6.7%	8.1%	9.5%	10.8%	12.1%	13.4%	14.6%	15.8%	17.0%
	\$20	5.3%	6.8%	8.2%	9.6%	10.9%	12.2%	13.4%	14.6%	15.8%	17.0%	18.2%
	\$21	6.9%	8.3%	9.7%	11.0%	12.3%	13.5%	14.7%	15.9%	17.1%	18.2%	19.4%
	\$22	8.4%	9.7%	11.0%	12.3%	13.5%	14.8%	15.9%	17.1%	18.3%	19.4%	20.5%
	\$23	9.8%	11.1%	12.4%	13.6%	14.8%	16.0%	17.2%	18.3%	19.4%	20.6%	21.7%
	\$24	11.2%	12.4%	13.7%	14.9%	16.0%	17.2%	18.3%	19.5%	20.6%	21.7%	22.8%
	\$25	12.5%	13.7%	14.9%	16.1%	17.2%	18.4%	19.5%	20.6%	21.7%	22.8%	23.9%
	\$26	13.7%	14.9%	16.1%	17.2%	18.4%	19.5%	20.6%	21.7%	22.8%	23.9%	25.0%
	\$27	14.8%	16.0%	17.2%	18.3%	19.5%	20.6%	21.7%	22.8%	23.9%	25.0%	26.1%
	\$28	15.8%	16.9%	18.1%	19.3%	20.4%	21.5%	22.7%	23.8%	24.9%	26.0%	27.1%
\$29	16.5%	17.7%	18.9%	20.0%	21.2%	22.3%	23.4%	24.6%	25.7%	26.8%	27.9%	
\$30	16.8%	18.0%	19.2%	20.4%	21.6%	22.7%	23.9%	25.0%	26.1%	27.2%	28.3%	

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #6 - Option G: RNG Compression and Nutrient Recovery Equipment

This biogas plant is estimated to cost \$11.7 million to build. Operating costs are estimated to average \$2,122,771/year. At an RNG sale price of \$22.40/GJ, average revenue is estimated to be \$3,650,685/year. This biogas plant doesn't require funding for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$1,527,914/year; equal to 72% of operating costs. Operating income should be sufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (i.e., broken equipment, unexpected downtime, etc.).

Option G: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>	<u>Revenue</u>	<u>Investment</u>
Digester	\$3,509,625		RNG/GJ [†] = \$22.40	Farm Investment = \$11,684,161
Upgrader	\$4,696,458		Avg RNG Sales/Yr = \$2,928,200	Funding Amount = \$0
Nutrient Recover	\$1,956,267		Tip Fee/Yr = \$600,998	Funding % of CAPEX = 0%
Other	\$1,521,812		Bedding Saving/Yr* = \$121,487	
Total	<u>\$11,684,161</u>	<u>\$2,122,771</u>	Total = <u>\$3,650,685</u>	<i>Inflation = 2%</i>

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$3,361	\$3,389	\$3,418	\$3,447	\$3,477	\$3,507	\$3,537	\$3,567	\$3,598	\$3,629
OPEX (000s)	\$1,747	\$1,782	\$1,818	\$1,854	\$1,891	\$1,929	\$1,968	\$2,007	\$2,047	\$2,088
<i>Income (000s)</i>	\$1,613	\$1,607	\$1,600	\$1,593	\$1,585	\$1,578	\$1,569	\$1,560	\$1,551	\$1,541

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$3,661	\$3,693	\$3,725	\$3,757	\$3,790	\$3,823	\$3,857	\$3,891	\$3,925	\$3,960
OPEX (000s)	\$2,130	\$2,173	\$2,216	\$2,260	\$2,306	\$2,352	\$2,399	\$2,447	\$2,496	\$2,546
<i>Income (000s)</i>	\$1,531	\$1,520	\$1,509	\$1,497	\$1,485	\$1,472	\$1,458	\$1,444	\$1,430	\$1,415

Unlevered, Pre-Tax IRR =	12%
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Average Operating Income* =	\$1,527,914
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% of OPEX	72%
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* Averaged over twenty years to account for inflation

† Base price (1%/year increase up to \$30/GJ max)

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 80% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, if RNG production is 10% or 20% higher than anticipated (due to the availability of high biogas-potential mixed food waste), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$22.40/GJ to <\$21/GJ and <\$19/GJ respectively. Alternately, if RNG production is 10% or 20% lower than anticipated, the required RNG sale price for an unlevered, pre-tax IRR increases from \$22.40/GJ to >\$24/GJ and >\$28/GJ respectively. Furthermore, if only 60% of estimated mixed food waste is available (14,424 instead of 24,040 tonnes/year), RNG production will be approximately 35% lower. If RNG production is 35% lower, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 5.6%. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option G: Sensitivity Analysis – RNG Production

		Change in RNG Production Amount														
		-50%	-45%	-40%	-35%	-30%	-25%	-20%	-15%	-10%	-5%	0%	5%	10%	15%	20%
\$/GJ RNG	\$12	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	\$13	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1.0%
	\$14	---	---	---	---	---	---	---	---	---	---	---	---	0.5%	2.0%	3.4%
	\$15	---	---	---	---	---	---	---	---	---	---	-0.4%	1.3%	2.8%	4.2%	5.5%
	\$16	---	---	---	---	---	---	---	---	---	0.0%	1.8%	3.4%	4.9%	6.2%	7.5%
	\$17	---	---	---	---	---	---	---	---	0.3%	2.1%	3.8%	5.3%	6.7%	8.0%	9.2%
	\$18	---	---	---	---	---	---	---	0.3%	2.2%	4.0%	5.5%	7.0%	8.4%	9.7%	10.9%
	\$19	---	---	---	---	---	---	0.0%	2.1%	4.0%	5.6%	7.1%	8.6%	9.9%	11.2%	12.5%
	\$20	---	---	---	---	---	---	1.8%	3.8%	5.5%	7.1%	8.7%	10.1%	11.4%	12.8%	14.0%
	\$21	---	---	---	---	---	1.3%	3.4%	5.3%	7.0%	8.6%	10.1%	11.5%	12.9%	14.2%	15.5%
	\$22	---	---	---	---	0.5%	2.8%	4.9%	6.7%	8.4%	9.9%	11.4%	12.9%	14.3%	15.6%	16.9%
	\$23	---	---	---	---	2.0%	4.2%	6.2%	8.0%	9.7%	11.2%	12.8%	14.2%	15.6%	17.0%	18.4%
	\$24	---	---	---	1.0%	3.4%	5.5%	7.5%	9.2%	10.9%	12.5%	14.0%	15.5%	16.9%	18.4%	19.7%
	\$25	---	---	---	2.3%	4.7%	6.7%	8.7%	10.4%	12.1%	13.7%	15.3%	16.8%	18.2%	19.7%	21.1%
	\$26	---	---	0.7%	3.4%	5.7%	7.8%	9.7%	11.5%	13.2%	14.8%	16.4%	18.0%	19.5%	21.0%	22.4%
	\$27	---	---	1.6%	4.3%	6.6%	8.7%	10.6%	12.5%	14.2%	15.9%	17.5%	19.1%	20.6%	22.2%	23.7%
	\$28	---	---	2.3%	5.0%	7.3%	9.4%	11.4%	13.3%	15.1%	16.8%	18.4%	20.1%	21.7%	23.3%	24.8%
\$29	---	---	2.7%	5.4%	7.8%	9.9%	12.0%	13.9%	15.7%	17.5%	19.2%	20.9%	22.5%	24.1%	25.7%	
\$30	---	---	2.8%	5.6%	8.0%	10.2%	12.2%	14.2%	16.0%	17.8%	19.6%	21.3%	23.0%	24.6%	26.3%	

B.C. On-Farm Biogas Benchmark Study, Version 2

Mixed food waste tip fee accounts for 16% of biogas plant revenue. Therefore, although less important than RNG sales, food waste tip fee can have a significant impact on biogas plant economic feasibility. For example, if mixed food waste tip fee is \$35/tonne or \$50/tonne instead of \$25/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$22.40/GJ to <\$21/GJ and <\$18/GJ respectively. Alternately, if mixed food waste tip fee is only \$10/tonne or \$0/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% increases from \$22.40/GJ to >\$25/GJ and >\$27/GJ respectively.

Option G: Sensitivity Analysis – Mixed Food Waste Tip Fee

		Mixed Food Waste Tip Fee (\$/Tonne)										
		\$0	\$5	\$10	\$15	\$20	\$25	\$30	\$35	\$40	\$45	\$50
\$/GJ RNG	\$12	---	---	---	---	---	---	---	---	---	1.2%	3.1%
	\$13	---	---	---	---	---	---	---	---	1.3%	3.2%	5.0%
	\$14	---	---	---	---	---	---	---	1.5%	3.4%	5.1%	6.7%
	\$15	---	---	---	---	---	---	1.7%	3.5%	5.2%	6.8%	8.2%
	\$16	---	---	---	---	---	1.8%	3.7%	5.3%	6.9%	8.3%	9.7%
	\$17	---	---	---	0.0%	2.0%	3.8%	5.4%	7.0%	8.4%	9.8%	11.1%
	\$18	---	---	0.1%	2.1%	3.9%	5.5%	7.1%	8.5%	9.9%	11.2%	12.5%
	\$19	---	0.3%	2.3%	4.0%	5.6%	7.1%	8.6%	9.9%	11.2%	12.5%	13.8%
	\$20	0.5%	2.4%	4.2%	5.7%	7.2%	8.7%	10.0%	11.3%	12.6%	13.8%	15.0%
	\$21	2.6%	4.3%	5.9%	7.3%	8.7%	10.1%	11.4%	12.6%	13.9%	15.1%	16.2%
	\$22	4.4%	6.0%	7.4%	8.8%	10.2%	11.4%	12.7%	13.9%	15.1%	16.3%	17.4%
	\$23	6.1%	7.5%	8.9%	10.2%	11.5%	12.8%	14.0%	15.2%	16.3%	17.5%	18.6%
	\$24	7.6%	9.0%	10.3%	11.6%	12.8%	14.0%	15.2%	16.4%	17.5%	18.7%	19.8%
	\$25	9.0%	10.4%	11.6%	12.9%	14.1%	15.3%	16.4%	17.6%	18.7%	19.8%	20.9%
	\$26	10.3%	11.6%	12.9%	14.1%	15.3%	16.4%	17.6%	18.7%	19.8%	20.9%	22.0%
	\$27	11.5%	12.7%	14.0%	15.2%	16.3%	17.5%	18.6%	19.8%	20.9%	22.0%	23.1%
	\$28	12.4%	13.7%	14.9%	16.1%	17.3%	18.4%	19.6%	20.7%	21.8%	22.9%	24.0%
\$29	13.1%	14.4%	15.6%	16.8%	18.0%	19.2%	20.3%	21.5%	22.6%	23.7%	24.8%	
\$30	13.4%	14.7%	16.0%	17.2%	18.4%	19.6%	20.7%	21.9%	23.0%	24.1%	25.2%	

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #6 - Option H: Mixed Food Waste Cleaning, RNG Compression and Nutrient Recovery Equipment

This biogas plant is estimated to cost \$12.8 million to build. Operating costs are estimated to average \$2,211,628/year. At an RNG sale price of \$24.28/GJ, average revenue is estimated to be \$3,897,036/year. This biogas plant doesn't require funding for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$1,685,407/year; equal to 76% of operating costs. Operating income should be sufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (i.e., broken equipment, unexpected downtime, etc.).

Option H: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>	<u>Revenue</u>		<u>Investment</u>	
Digester	\$4,499,250		RNG/GJ [†] =	\$24.28	Farm Investment =	\$12,821,983
Upgrader	\$4,696,458		Avg RNG Sales/Yr =	\$3,174,550	Funding Amount =	\$0
Nutrient Recover	\$1,956,267		Tip Fee/Yr =	\$600,998	Funding % of CAPEX =	0%
Other	\$1,670,008		Bedding Saving/Yr* =	\$121,487		
Total	<u>\$12,821,983</u>	<u>\$2,211,628</u>	Total =	<u>\$3,897,036</u>	Inflation =	2%

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$3,584	\$3,615	\$3,646	\$3,678	\$3,710	\$3,742	\$3,774	\$3,807	\$3,841	\$3,874
OPEX (000s)	\$1,820	\$1,857	\$1,894	\$1,932	\$1,971	\$2,010	\$2,050	\$2,091	\$2,133	\$2,176
<i>Income (000s)</i>	\$1,764	\$1,758	\$1,752	\$1,746	\$1,739	\$1,732	\$1,724	\$1,716	\$1,708	\$1,698

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$3,908	\$3,942	\$3,977	\$4,012	\$4,047	\$4,083	\$4,120	\$4,156	\$4,193	\$4,230
OPEX (000s)	\$2,219	\$2,264	\$2,309	\$2,355	\$2,402	\$2,450	\$2,499	\$2,549	\$2,600	\$2,652
<i>Income (000s)</i>	\$1,689	\$1,679	\$1,668	\$1,657	\$1,645	\$1,633	\$1,620	\$1,607	\$1,593	\$1,578

Unlevered, Pre-Tax IRR =	12%
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Average Operating Income* =	\$1,685,407
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% of OPEX	76%
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* Averaged over twenty years to account for inflation

† Base price (1%/year increase up to \$30/GJ max)

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 81% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, if RNG production is 10% or 20% higher than anticipated (due to the availability of high biogas-potential mixed food waste), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$24.48/GJ to <\$23/GJ and <\$21/GJ respectively. Alternately, if RNG production is 10% lower than anticipated, the required RNG sale price for an unlevered, pre-tax IRR increases from \$24.48/GJ to >\$27/GJ. Furthermore, if only 60% of estimated mixed food waste is available (14,424 instead of 24,040 tonnes/year), RNG production will be approximately 35% lower. If RNG production is 35% lower, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 3.1%. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option H: Sensitivity Analysis – RNG Production

		Change in RNG Production Amount														
		-50%	-45%	-40%	-35%	-30%	-25%	-20%	-15%	-10%	-5%	0%	5%	10%	15%	20%
\$/GJ RNG	\$16	---	---	---	---	---	---	---	---	---	---	---	1.0%	2.6%	3.9%	5.2%
	\$17	---	---	---	---	---	---	---	---	---	---	1.4%	3.0%	4.4%	5.7%	7.0%
	\$18	---	---	---	---	---	---	---	---	---	1.6%	3.3%	4.7%	6.1%	7.4%	8.6%
	\$19	---	---	---	---	---	---	---	---	1.6%	3.3%	4.9%	6.3%	7.7%	9.0%	10.2%
	\$20	---	---	---	---	---	---	---	1.4%	3.3%	4.9%	6.4%	7.8%	9.2%	10.4%	11.7%
	\$21	---	---	---	---	---	---	1.0%	3.0%	4.7%	6.3%	7.8%	9.2%	10.6%	11.8%	13.1%
	\$22	---	---	---	---	---	0.4%	2.6%	4.4%	6.1%	7.7%	9.2%	10.6%	11.9%	13.2%	14.5%
	\$23	---	---	---	---	---	1.9%	3.9%	5.7%	7.4%	9.0%	10.4%	11.8%	13.2%	14.5%	15.8%
	\$24	---	---	---	---	1.0%	3.3%	5.2%	7.0%	8.6%	10.2%	11.7%	13.1%	14.5%	15.8%	17.1%
	\$25	---	---	---	---	2.4%	4.5%	6.4%	8.2%	9.8%	11.4%	12.8%	14.3%	15.7%	17.0%	18.4%
	\$26	---	---	---	1.0%	3.4%	5.5%	7.4%	9.2%	10.9%	12.4%	13.9%	15.4%	16.8%	18.2%	19.6%
	\$27	---	---	---	1.9%	4.3%	6.4%	8.3%	10.1%	11.8%	13.4%	14.9%	16.4%	17.9%	19.3%	20.7%
	\$28	---	---	---	2.5%	4.9%	7.1%	9.0%	10.8%	12.6%	14.2%	15.8%	17.3%	18.9%	20.3%	21.8%
	\$29	---	---	0.0%	2.9%	5.4%	7.5%	9.5%	11.4%	13.1%	14.8%	16.5%	18.0%	19.6%	21.1%	22.6%
	\$30	---	---	0.1%	3.1%	5.5%	7.7%	9.7%	11.6%	13.4%	15.1%	16.8%	18.4%	20.0%	21.5%	23.1%

B.C. On-Farm Biogas Benchmark Study, Version 2

Mixed food waste tip fee accounts for 15% of biogas plant revenue. Therefore, although less important than RNG sales, food waste tip fee can have a significant impact on biogas plant economic feasibility. For example, if mixed food waste tip fee is \$35/tonne or \$50/tonne instead of \$25/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$24.48/GJ to <\$23/GJ and <\$20/GJ respectively. Alternately, if mixed food waste tip fee is only \$10/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% increases from \$24.48/GJ to >\$27/GJ. If mixed food waste tip fee is \$0/tonne, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 10.9%. An unlevered, pre-tax IRR <12% isn't economically feasible.

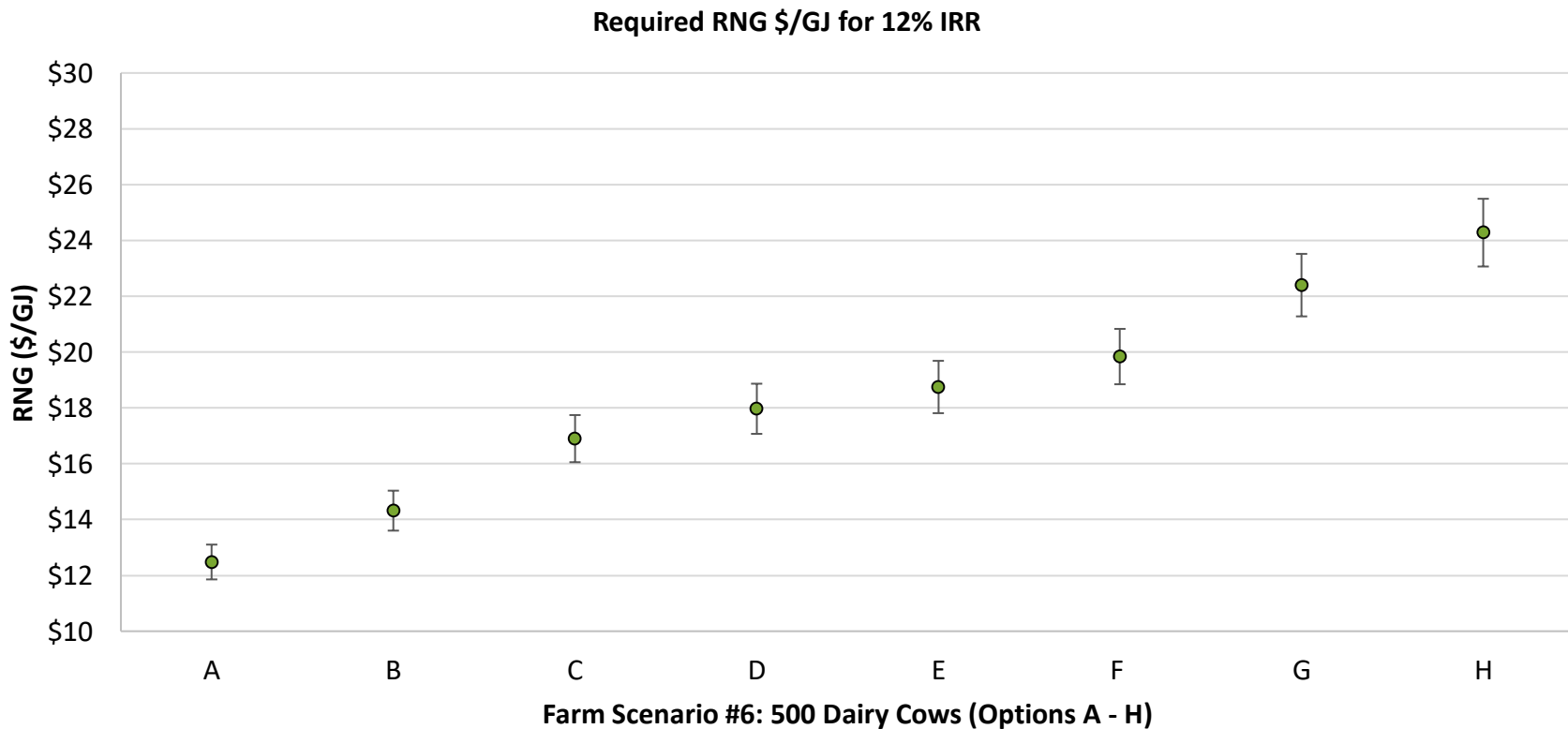
Option H: Sensitivity Analysis – Mixed Food Waste Tip Fee

		Mixed Food Waste Tip Fee (\$/Tonne)										
		\$0	\$5	\$10	\$15	\$20	\$25	\$30	\$35	\$40	\$45	\$50
\$/GJ RNG	\$16	---	---	---	---	---	---	1.3%	3.0%	4.6%	6.0%	7.4%
	\$17	---	---	---	---	---	1.4%	3.1%	4.7%	6.1%	7.5%	8.8%
	\$18	---	---	---	---	1.6%	3.3%	4.8%	6.2%	7.6%	8.9%	10.1%
	\$19	---	---	---	1.7%	3.4%	4.9%	6.3%	7.7%	8.9%	10.2%	11.4%
	\$20	---	0.1%	1.9%	3.5%	5.0%	6.4%	7.7%	9.0%	10.2%	11.4%	12.6%
	\$21	0.2%	2.0%	3.6%	5.1%	6.5%	7.8%	9.1%	10.3%	11.5%	12.6%	13.8%
	\$22	2.1%	3.7%	5.2%	6.6%	7.9%	9.2%	10.4%	11.5%	12.7%	13.8%	14.9%
	\$23	3.8%	5.3%	6.7%	8.0%	9.2%	10.4%	11.6%	12.7%	13.9%	14.9%	16.0%
	\$24	5.4%	6.8%	8.1%	9.3%	10.5%	11.7%	12.8%	13.9%	15.0%	16.1%	17.1%
	\$25	6.8%	8.1%	9.4%	10.6%	11.7%	12.8%	14.0%	15.0%	16.1%	17.1%	18.2%
	\$26	8.1%	9.3%	10.5%	11.7%	12.8%	13.9%	15.0%	16.1%	17.2%	18.2%	19.2%
	\$27	9.2%	10.4%	11.6%	12.7%	13.8%	14.9%	16.0%	17.1%	18.1%	19.2%	20.2%
	\$28	10.0%	11.2%	12.4%	13.6%	14.7%	15.8%	16.9%	17.9%	19.0%	20.0%	21.1%
	\$29	10.6%	11.9%	13.1%	14.2%	15.3%	16.5%	17.5%	18.6%	19.7%	20.7%	21.7%
\$30	10.9%	12.2%	13.4%	14.5%	15.7%	16.8%	17.9%	19.0%	20.0%	21.1%	22.1%	

Farm Scenario #6: Summary

Figure 18 shows the required RNG \$/GJ sale price for Farm Scenario #6 Options A – G for an unlevered, pre-tax IRR of 12%. Where required RNG sale price is <\$30/GJ, a bar representing +/- 5% is shown to account for price uncertainty. Farm Scenario #6 Options A – H don't require funding. These biogas plants require an RNG sale price from as low as \$11.86/GJ to as high as \$25.49/GJ. Figure 18 shows that even with mixed food waste cleaning, RNG compression and nutrient recovery equipment, 500 dairy cow farms co-digesting dairy manure and mixed food waste are economically feasible in B.C. without funding.

Figure 18: Farm Scenario #6 - Required RNG Sale Price for 500 Dairy Cows + Mixed Food Waste



7.7

Farm Scenario #7: 1,000 Feedlot Cattle + Mixed Food Waste

Farm Scenario #7 is a 1,000 feedlot cattle co-digesting cattle manure and mixed food waste. Farm Scenario #7 assumes the use of traditional on-farm biogas plant technology. Estimated feedstock volumes and Renewable Natural Gas (RNG) production for Farm Scenario #7 are as follows:

Feedstock	Tonnes/Year	Percentage	RNG Production (GJ/Year)
Cattle manure	7,000	51%	13,153 GJ
Mixed food waste	6,726	49%	32,684 GJ
<i>Total</i>	<i>13,726</i>	<i>100%</i>	<i>45,837 GJ</i>

The following Equipment Choices were assessed for Farm Scenario #7:

- Option A: No additional equipment;
- Option B: Mixed food waste cleaning equipment;
- Option C: RNG compression equipment;
- Option D: Nutrient recovery equipment;
- Option E: Mixed food waste cleaning and RNG compression equipment;
- Option F: Mixed food waste cleaning and nutrient recovery equipment;
- Option G: RNG compression and nutrient recovery equipment; and
- Option H: Mixed food waste cleaning, RNG compression and nutrient recovery equipment.

For full capital and operating costs for Farm Scenario #7 Options A – H, see Appendix G.

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #7 - Option A: No Additional Equipment-

This biogas plant is estimated to cost \$5.9 million to build. Operating costs are estimated to average \$685,406/year. At an RNG sale price of \$25.90/GJ, average revenue is estimated to be \$1,464,117/year. This biogas plant doesn't require funding for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$778,711/year; equal to 114% of operating costs. Operating income should be sufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (i.e., broken equipment, unexpected downtime, etc.).

Option A: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>	<u>Revenue</u>		<u>Investment</u>	
Digester	\$2,151,975		RNG/GJ [†] =	\$25.90	Farm Investment =	\$5,857,596
Upgrader	\$2,399,600		Avg RNG Sales/Yr =	\$1,235,233	Funding Amount =	\$0
Nutrient Recovery	\$543,094		Tip Fee/Yr =	\$168,140	Funding % of CAPEX =	0%
Other	\$762,927		Bedding Savings/Yr* =	\$60,743		
Total	<u>\$5,857,596</u>	<u>\$685,406</u>	Total =	<u>\$1,464,117</u>	Inflation =	2%

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$1,347	\$1,359	\$1,371	\$1,384	\$1,397	\$1,410	\$1,423	\$1,436	\$1,449	\$1,462
OPEX (000s)	\$564	\$575	\$587	\$599	\$611	\$623	\$635	\$648	\$661	\$674
Income (000s)	\$783	\$784	\$785	\$785	\$786	\$787	\$787	\$788	\$788	\$788

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$1,476	\$1,490	\$1,503	\$1,517	\$1,532	\$1,543	\$1,544	\$1,545	\$1,547	\$1,548
OPEX (000s)	\$688	\$701	\$716	\$730	\$744	\$759	\$774	\$790	\$806	\$822
Income (000s)	\$788	\$788	\$788	\$788	\$787	\$783	\$770	\$755	\$741	\$726

Unlevered, Pre-Tax IRR =	12%
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Average Operating Income* =	\$778,711
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% of OPEX	114%
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* Averaged over twenty years to account for inflation

† Base price (1%/year increase up to \$30/GJ max)

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 84% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, if RNG production is 10% or 20% higher than anticipated (due to the availability of high biogas-potential mixed food waste), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$25.90/GJ to <\$24/GJ and <\$22/GJ respectively. Alternately, if RNG production is 10% or 20% lower than anticipated, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 11.5% and 8.5% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option A: Sensitivity Analysis – RNG Production

		Change in RNG Production Amount														
		-50%	-45%	-40%	-35%	-30%	-25%	-20%	-15%	-10%	-5%	0%	5%	10%	15%	20%
\$/GJ RNG	\$16	---	---	---	---	---	---	---	---	---	---	0.6%	1.8%	2.9%	4.0%	5.0%
	\$17	---	---	---	---	---	---	---	---	---	0.8%	2.1%	3.3%	4.4%	5.4%	6.4%
	\$18	---	---	---	---	---	---	---	---	0.9%	2.2%	3.5%	4.6%	5.7%	6.7%	7.7%
	\$19	---	---	---	---	---	---	---	0.8%	2.2%	3.5%	4.7%	5.9%	7.0%	8.0%	9.0%
	\$20	---	---	---	---	---	---	0.6%	2.1%	3.5%	4.7%	5.9%	7.1%	8.1%	9.2%	10.2%
	\$21	---	---	---	---	---	0.2%	1.8%	3.3%	4.6%	5.9%	7.1%	8.2%	9.3%	10.3%	11.4%
	\$22	---	---	---	---	---	1.4%	2.9%	4.4%	5.7%	7.0%	8.1%	9.3%	10.4%	11.5%	12.5%
	\$23	---	---	---	---	0.8%	2.5%	4.0%	5.4%	6.7%	8.0%	9.2%	10.3%	11.5%	12.5%	13.6%
	\$24	---	---	---	0.0%	1.8%	3.5%	5.0%	6.4%	7.7%	9.0%	10.2%	11.4%	12.5%	13.6%	14.7%
	\$25	---	---	---	1.0%	2.8%	4.4%	5.9%	7.3%	8.7%	9.9%	11.2%	12.3%	13.5%	14.6%	15.7%
	\$26	---	---	---	1.8%	3.6%	5.2%	6.8%	8.2%	9.5%	10.8%	12.1%	13.3%	14.4%	15.6%	16.7%
	\$27	---	---	0.4%	2.5%	4.3%	5.9%	7.4%	8.9%	10.3%	11.6%	12.9%	14.1%	15.3%	16.5%	17.6%
	\$28	---	---	0.9%	2.9%	4.8%	6.4%	8.0%	9.5%	10.9%	12.2%	13.5%	14.8%	16.0%	17.3%	18.5%
	\$29	---	---	1.1%	3.2%	5.1%	6.8%	8.4%	9.9%	11.3%	12.7%	14.0%	15.3%	16.6%	17.9%	19.1%
\$30	---	---	1.3%	3.3%	5.2%	6.9%	8.5%	10.1%	11.5%	12.9%	14.3%	15.6%	16.9%	18.2%	19.4%	

B.C. On-Farm Biogas Benchmark Study, Version 2

Mixed food waste tip fee accounts for 11% of biogas plant revenue. Therefore, although less important than RNG sales, food waste tip fee can have a significant impact on biogas plant economic feasibility. For example, if mixed food waste tip fee is \$35/tonne or \$50/tonne instead of \$25/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$25.90/GJ to <\$25/GJ and <\$23/GJ respectively. Alternately, if mixed food waste tip fee is only \$10/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% increases from \$25.90/GJ to >\$29/GJ. If mixed food waste tip fee is \$0/tonne, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 10.7%. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option A: Sensitivity Analysis – Mixed Food Waste Tip Fee

		Mixed Food Waste Tip Fee (\$/Tonne)										
		\$0	\$5	\$10	\$15	\$20	\$25	\$30	\$35	\$40	\$45	\$50
\$/GJ RNG	\$16	---	---	---	---	---	0.6%	1.7%	2.7%	3.6%	4.6%	5.4%
	\$17	---	---	---	0.0%	1.1%	2.1%	3.1%	4.0%	4.9%	5.8%	6.6%
	\$18	---	---	0.4%	1.5%	2.5%	3.5%	4.4%	5.3%	6.1%	6.9%	7.7%
	\$19	---	0.9%	1.9%	2.9%	3.9%	4.7%	5.6%	6.4%	7.2%	8.0%	8.8%
	\$20	1.3%	2.4%	3.3%	4.2%	5.1%	5.9%	6.7%	7.5%	8.3%	9.1%	9.8%
	\$21	2.8%	3.7%	4.6%	5.4%	6.3%	7.1%	7.8%	8.6%	9.4%	10.1%	10.8%
	\$22	4.1%	4.9%	5.8%	6.6%	7.4%	8.1%	8.9%	9.6%	10.4%	11.1%	11.8%
	\$23	5.3%	6.1%	6.9%	7.7%	8.4%	9.2%	9.9%	10.6%	11.3%	12.0%	12.7%
	\$24	6.4%	7.2%	8.0%	8.7%	9.5%	10.2%	10.9%	11.6%	12.3%	13.0%	13.6%
	\$25	7.5%	8.3%	9.0%	9.7%	10.5%	11.2%	11.9%	12.5%	13.2%	13.9%	14.5%
	\$26	8.5%	9.2%	10.0%	10.7%	11.4%	12.1%	12.7%	13.4%	14.1%	14.7%	15.4%
	\$27	9.3%	10.0%	10.8%	11.5%	12.2%	12.9%	13.5%	14.2%	14.9%	15.5%	16.2%
	\$28	10.0%	10.7%	11.4%	12.2%	12.8%	13.5%	14.2%	14.9%	15.5%	16.2%	16.8%
	\$29	10.5%	11.2%	11.9%	12.6%	13.3%	14.0%	14.7%	15.4%	16.1%	16.7%	17.4%
	\$30	10.7%	11.4%	12.2%	12.9%	13.6%	14.3%	15.0%	15.6%	16.3%	17.0%	17.6%

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #7 - Option B: Mixed Food Waste Cleaning Equipment

This biogas plant is estimated to cost \$6.7 million to build. Operating costs are estimated to average \$767,247/year. At an RNG sale price of \$30/GJ, average revenue is estimated to be \$1,536,172/year. This biogas plant requires \$0.6 million funding (9% of CAPEX) for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$768,924/year; equal to 100% of operating costs. Operating income should be sufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (i.e., broken equipment, unexpected downtime, etc.).

Option B: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>		<u>Revenue</u>		<u>Investment</u>	
Digester	\$2,879,100			RNG/GJ =	\$30.00	Farm Investment =	\$6,087,588
Upgrader	\$2,399,600			Avg RNG Sales/Yr =	\$1,307,288	Funding Amount =	\$606,020
Nutrient Recovery	\$543,094			Tip Fee/Yr =	\$168,140	Funding % of CAPEX =	9%
Other	\$871,814			Bedding Savings/Yr* =	\$60,743		
Total	<u>\$6,693,608</u>	<u>\$767,247</u>		Total =	<u>\$1,536,172</u>	Inflation =	2%

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$1,525	\$1,526	\$1,527	\$1,528	\$1,530	\$1,531	\$1,532	\$1,533	\$1,534	\$1,535
OPEX (000s)	\$632	\$644	\$657	\$670	\$684	\$697	\$711	\$725	\$740	\$755
<i>Income (000s)</i>	\$894	\$882	\$870	\$858	\$846	\$833	\$821	\$807	\$794	\$780

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$1,536	\$1,538	\$1,539	\$1,540	\$1,541	\$1,543	\$1,544	\$1,545	\$1,547	\$1,548
OPEX (000s)	\$770	\$785	\$801	\$817	\$833	\$850	\$867	\$884	\$902	\$920
<i>Income (000s)</i>	\$767	\$752	\$738	\$723	\$708	\$693	\$677	\$661	\$645	\$628

Unlevered, Pre-Tax IRR =	12%
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Average Operating Income* =	\$768,924
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% of OPEX	100%
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* Averaged over twenty years to account for inflation

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 85% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, with 9% funding, if RNG production is 10% or 20% higher than anticipated (due to the availability of high biogas-potential mixed food waste), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$26/GJ and <\$24/GJ respectively. Alternately, with 9% funding, if RNG production is 5% or 10% lower than anticipated, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 10.6% and 9.2% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Mixed food waste tip fee accounts for 11% of biogas plant revenue. Therefore, although less important than RNG sales, food waste tip fee can have a significant impact on biogas plant economic feasibility. For example, with 9% funding, if mixed food waste tip fee is \$35/tonne or \$50/tonne instead of \$25/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$27/GJ and <\$25/GJ respectively. Alternately, with 9% funding, if mixed food waste tip fee is only \$20/tonne or \$15/tonne, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 11.3% and 10.6% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option B: Sensitivity Analysis – RNG Production & Mixed Food Waste Tip Fee

		Change in RNG Production Amount						
		-10%	-5%	0%	5%	10%	15%	20%
\$/GJ RNG	\$16	---	---	---	---	0.1%	1.3%	2.4%
	\$17	---	---	---	0.4%	1.7%	2.9%	3.9%
	\$18	---	---	0.7%	2.0%	3.2%	4.3%	5.4%
	\$19	---	0.8%	2.1%	3.4%	4.5%	5.7%	6.7%
	\$20	0.7%	2.1%	3.4%	4.7%	5.8%	6.9%	8.0%
	\$21	2.0%	3.4%	4.7%	5.9%	7.0%	8.1%	9.2%
	\$22	3.2%	4.5%	5.8%	7.0%	8.2%	9.3%	10.3%
	\$23	4.3%	5.7%	6.9%	8.1%	9.3%	10.4%	11.5%
	\$24	5.4%	6.7%	8.0%	9.2%	10.3%	11.5%	12.5%
	\$25	6.4%	7.7%	9.0%	10.2%	11.4%	12.5%	13.6%
	\$26	7.3%	8.6%	9.9%	11.1%	12.3%	13.5%	14.6%
	\$27	8.0%	9.4%	10.7%	11.9%	13.2%	14.3%	15.5%
	\$28	8.6%	10.0%	11.3%	12.6%	13.9%	15.1%	16.3%
\$29	9.0%	10.4%	11.8%	13.1%	14.4%	15.7%	16.9%	
\$30	9.2%	10.6%	12.0%	13.4%	14.7%	15.9%	17.2%	

		Mixed Food Waste Tip Fee (\$/Tonne)							
		\$15	\$20	\$25	\$30	\$35	\$40	\$45	\$50
\$/GJ RNG	\$16	---	---	---	---	---	0.8%	1.9%	2.8%
	\$17	---	---	---	0.2%	1.3%	2.3%	3.2%	4.1%
	\$18	---	---	0.7%	1.7%	2.7%	3.6%	4.5%	5.3%
	\$19	0.1%	1.1%	2.1%	3.1%	4.0%	4.8%	5.7%	6.5%
	\$20	1.5%	2.5%	3.4%	4.3%	5.2%	6.0%	6.8%	7.5%
	\$21	2.9%	3.8%	4.7%	5.5%	6.3%	7.1%	7.8%	8.6%
	\$22	4.2%	5.0%	5.8%	6.6%	7.4%	8.1%	8.9%	9.6%
	\$23	5.3%	6.1%	6.9%	7.7%	8.4%	9.1%	9.8%	10.5%
	\$24	6.5%	7.2%	8.0%	8.7%	9.4%	10.1%	10.8%	11.5%
	\$25	7.5%	8.3%	9.0%	9.7%	10.4%	11.1%	11.7%	12.4%
	\$26	8.5%	9.2%	9.9%	10.6%	11.3%	11.9%	12.6%	13.2%
	\$27	9.3%	10.0%	10.7%	11.4%	12.0%	12.7%	13.4%	14.0%
	\$28	9.9%	10.6%	11.3%	12.0%	12.7%	13.4%	14.0%	14.7%
\$29	10.4%	11.1%	11.8%	12.5%	13.2%	13.8%	14.5%	15.2%	
\$30	10.6%	11.3%	12.0%	12.7%	13.4%	14.1%	14.7%	15.4%	

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #7 - Option C: RNG Compression Equipment

This biogas plant is estimated to cost \$6.6 million to build. Operating costs are estimated to average \$883,613/year. At an RNG sale price of \$30/GJ, average revenue is estimated to be \$1,536,172/year. This biogas plant requires \$1.4 million funding (21% of CAPEX) for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$652,559/year; equal to 74% of operating costs. Operating income should be sufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (i.e., broken equipment, unexpected downtime, etc.).

Option C: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>		<u>Revenue</u>		<u>Investment</u>	
Digester	\$2,151,975			RNG/GJ =	\$30.00	Farm Investment =	\$5,272,211
Upgrader	\$3,085,997			Avg RNG Sales/Yr =	\$1,307,288	Funding Amount =	\$1,374,569
Nutrient Recovery	\$543,094			Tip Fee/Yr =	\$168,140	Funding % of CAPEX =	21%
Other	\$865,715			Bedding Savings/Yr* =	\$60,743		
Total	<u>\$6,646,781</u>	<u>\$883,613</u>		Total =	<u>\$1,536,172</u>	Inflation =	2%

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$1,525	\$1,526	\$1,527	\$1,528	\$1,530	\$1,531	\$1,532	\$1,533	\$1,534	\$1,535
OPEX (000s)	\$727	\$742	\$757	\$772	\$787	\$803	\$819	\$835	\$852	\$869
<i>Income (000s)</i>	\$798	\$785	\$771	\$757	\$742	\$728	\$713	\$697	\$682	\$666

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$1,536	\$1,538	\$1,539	\$1,540	\$1,541	\$1,543	\$1,544	\$1,545	\$1,547	\$1,548
OPEX (000s)	\$887	\$904	\$922	\$941	\$960	\$979	\$998	\$1,018	\$1,039	\$1,060
<i>Income (000s)</i>	\$650	\$633	\$616	\$599	\$582	\$564	\$546	\$527	\$508	\$489

Unlevered, Pre-Tax IRR =	12%	Average Operating Income* =	\$652,559	% of OPEX	74%
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* Averaged over twenty years to account for inflation

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 85% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, with 21% funding, if RNG production is 10% or 20% higher than anticipated (due to the availability of high biogas-potential mixed food waste), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$26/GJ and <\$24/GJ respectively. Alternately, with 21% funding, if RNG production is 5% or 10% lower than anticipated, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 10.4% and 8.7% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Mixed food waste tip fee accounts for 11% of biogas plant revenue. Therefore, although less important than RNG sales, food waste tip fee can have a significant impact on biogas plant economic feasibility. For example, with 21% funding, if mixed food waste tip fee is \$35/tonne or \$50/tonne instead of \$25/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$27/GJ and <\$25/GJ respectively. Alternately, with 21% funding, if mixed food waste tip fee is only \$20/tonne or \$15/tonne, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 11.2% and 10.4% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option C: Sensitivity Analysis – RNG Production & Mixed Food Waste Tip Fee

		Change in RNG Production Amount						
		-10%	-5%	0%	5%	10%	15%	20%
\$/GJ RNG	\$16	---	---	---	---	---	---	0.1%
	\$17	---	---	---	---	---	0.8%	2.2%
	\$18	---	---	---	---	1.2%	2.7%	4.0%
	\$19	---	---	---	1.5%	3.0%	4.4%	5.7%
	\$20	---	---	1.5%	3.1%	4.6%	6.0%	7.2%
	\$21	---	1.5%	3.1%	4.7%	6.1%	7.4%	8.7%
	\$22	1.2%	3.0%	4.6%	6.1%	7.5%	8.8%	10.1%
	\$23	2.7%	4.4%	6.0%	7.4%	8.8%	10.1%	11.4%
	\$24	4.0%	5.7%	7.2%	8.7%	10.1%	11.4%	12.7%
	\$25	5.3%	6.9%	8.5%	9.9%	11.3%	12.6%	13.9%
	\$26	6.4%	8.0%	9.5%	11.0%	12.4%	13.7%	15.0%
	\$27	7.3%	8.9%	10.5%	11.9%	13.4%	14.7%	16.1%
	\$28	8.0%	9.6%	11.2%	12.7%	14.2%	15.6%	17.0%
\$29	8.5%	10.2%	11.8%	13.3%	14.8%	16.3%	17.7%	
\$30	8.7%	10.4%	12.0%	13.6%	15.1%	16.6%	18.1%	

		Mixed Food Waste Tip Fee (\$/Tonne)							
		\$15	\$20	\$25	\$30	\$35	\$40	\$45	\$50
\$/GJ RNG	\$16	---	---	---	---	---	---	---	0.7%
	\$17	---	---	---	---	---	---	1.2%	2.4%
	\$18	---	---	---	---	0.5%	1.7%	2.9%	4.0%
	\$19	---	---	---	1.0%	2.2%	3.3%	4.4%	5.4%
	\$20	---	0.3%	1.5%	2.7%	3.8%	4.8%	5.8%	6.7%
	\$21	0.8%	2.0%	3.1%	4.2%	5.2%	6.2%	7.1%	8.0%
	\$22	2.5%	3.6%	4.6%	5.6%	6.5%	7.4%	8.3%	9.2%
	\$23	4.0%	5.0%	6.0%	6.9%	7.8%	8.6%	9.5%	10.3%
	\$24	5.4%	6.3%	7.2%	8.1%	9.0%	9.8%	10.6%	11.4%
	\$25	6.7%	7.6%	8.5%	9.3%	10.1%	10.9%	11.7%	12.5%
	\$26	7.8%	8.7%	9.5%	10.3%	11.2%	11.9%	12.7%	13.5%
	\$27	8.8%	9.6%	10.5%	11.3%	12.1%	12.8%	13.6%	14.4%
	\$28	9.6%	10.4%	11.2%	12.0%	12.8%	13.6%	14.4%	15.1%
\$29	10.1%	11.0%	11.8%	12.6%	13.4%	14.2%	15.0%	15.7%	
\$30	10.4%	11.2%	12.0%	12.9%	13.7%	14.5%	15.2%	16.0%	

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #7 - Option D: Nutrient Recovery Equipment

This biogas plant is estimated to cost \$6.9 million to build. Operating costs are estimated to average \$909,434/year. At an RNG sale price of \$30/GJ, average revenue is estimated to be \$1,536,172/year. This biogas plant requires \$1.8 million funding (26% of CAPEX) for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$626,738/year; equal to 69% of operating costs. Operating income should be sufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (i.e., broken equipment, unexpected downtime, etc.).

Option D: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>	<u>Revenue</u>		<u>Investment</u>	
Digester	\$2,382,975		RNG/GJ =	\$30.00	Farm Investment =	\$5,098,584
Upgrader	\$2,399,600		Avg RNG Sales/Yr =	\$1,307,288	Funding Amount =	\$1,800,686
Nutrient Recovery	\$1,218,094		Tip Fee/Yr =	\$168,140	Funding % of CAPEX =	26%
Other	\$898,600		Bedding Savings/Yr* =	\$60,743		
Total	<u>\$6,899,269</u>	<u>\$909,434</u>	Total =	<u>\$1,536,172</u>	Inflation =	2%

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$1,525	\$1,526	\$1,527	\$1,528	\$1,530	\$1,531	\$1,532	\$1,533	\$1,534	\$1,535
OPEX (000s)	\$749	\$764	\$779	\$794	\$810	\$826	\$843	\$860	\$877	\$895
<i>Income (000s)</i>	\$777	\$763	\$749	\$734	\$719	\$704	\$689	\$673	\$657	\$641

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$1,536	\$1,538	\$1,539	\$1,540	\$1,541	\$1,543	\$1,544	\$1,545	\$1,547	\$1,548
OPEX (000s)	\$913	\$931	\$949	\$968	\$988	\$1,007	\$1,028	\$1,048	\$1,069	\$1,091
<i>Income (000s)</i>	\$624	\$607	\$589	\$572	\$554	\$535	\$516	\$497	\$478	\$458

Unlevered, Pre-Tax IRR =	12%
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Average Operating Income* =	\$626,738
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% of OPEX	69%
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* Averaged over twenty years to account for inflation

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 85% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, with 26% funding, if RNG production is 10% or 20% higher than anticipated (due to the availability of high biogas-potential mixed food waste), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$26/GJ and <\$24/GJ respectively. Alternately, with 26% funding, if RNG production is 5% or 10% lower than anticipated, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 10.3% and 8.5% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Mixed food waste tip fee accounts for 11% of biogas plant revenue. Therefore, although less important than RNG sales, food waste tip fee can have a significant impact on biogas plant economic feasibility. For example, with 26% funding, if mixed food waste tip fee is \$35/tonne or \$50/tonne instead of \$25/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$27/GJ and <\$25/GJ respectively. Alternately, with 26% funding, if mixed food waste tip fee is only \$20/tonne or \$15/tonne, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 11.2% and 10.3% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option D: Sensitivity Analysis – RNG Production & Mixed Food Waste Tip Fee

		Change in RNG Production Amount						
		-10%	-5%	0%	5%	10%	15%	20%
\$/GJ RNG	\$16	---	---	---	---	---	---	---
	\$17	---	---	---	---	---	0.1%	1.7%
	\$18	---	---	---	---	0.6%	2.2%	3.6%
	\$19	---	---	---	0.9%	2.5%	4.0%	5.4%
	\$20	---	---	1.0%	2.7%	4.2%	5.7%	7.0%
	\$21	---	0.9%	2.7%	4.3%	5.8%	7.2%	8.5%
	\$22	0.6%	2.5%	4.2%	5.8%	7.3%	8.7%	10.0%
	\$23	2.2%	4.0%	5.7%	7.2%	8.7%	10.0%	11.3%
	\$24	3.6%	5.4%	7.0%	8.5%	10.0%	11.3%	12.7%
	\$25	5.0%	6.7%	8.3%	9.8%	11.2%	12.6%	13.9%
	\$26	6.1%	7.8%	9.4%	10.9%	12.4%	13.8%	15.1%
	\$27	7.0%	8.8%	10.4%	11.9%	13.4%	14.8%	16.2%
	\$28	7.8%	9.5%	11.2%	12.8%	14.3%	15.7%	17.2%
\$29	8.3%	10.1%	11.8%	13.4%	14.9%	16.4%	17.9%	
\$30	8.5%	10.3%	12.0%	13.7%	15.2%	16.8%	18.3%	

		Mixed Food Waste Tip Fee (\$/Tonne)							
		\$15	\$20	\$25	\$30	\$35	\$40	\$45	\$50
\$/GJ RNG	\$16	---	---	---	---	---	---	---	0.0%
	\$17	---	---	---	---	---	---	0.6%	1.9%
	\$18	---	---	---	---	---	1.2%	2.4%	3.6%
	\$19	---	---	---	0.4%	1.7%	2.9%	4.0%	5.1%
	\$20	---	---	1.0%	2.2%	3.4%	4.4%	5.5%	6.5%
	\$21	0.2%	1.5%	2.7%	3.8%	4.9%	5.9%	6.8%	7.8%
	\$22	2.0%	3.2%	4.2%	5.3%	6.3%	7.2%	8.1%	9.0%
	\$23	3.6%	4.7%	5.7%	6.6%	7.6%	8.5%	9.4%	10.2%
	\$24	5.1%	6.1%	7.0%	7.9%	8.8%	9.7%	10.5%	11.4%
	\$25	6.4%	7.4%	8.3%	9.2%	10.0%	10.9%	11.7%	12.5%
	\$26	7.6%	8.5%	9.4%	10.3%	11.1%	11.9%	12.7%	13.5%
	\$27	8.6%	9.5%	10.4%	11.2%	12.0%	12.9%	13.7%	14.4%
	\$28	9.4%	10.3%	11.2%	12.0%	12.8%	13.7%	14.5%	15.2%
\$29	10.0%	10.9%	11.8%	12.6%	13.4%	14.2%	15.0%	15.8%	
\$30	10.3%	11.2%	12.0%	12.9%	13.7%	14.5%	15.3%	16.1%	

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #7 - Option E: Mixed Food Waste Cleaning & RNG Compression Equipment

This biogas plant is estimated to cost \$7.5 million to build. Operating costs are estimated to average \$965,454/year. At an RNG sale price of \$30/GJ, average revenue is estimated to be \$1,536,172/year. This biogas plant requires \$2.8 million funding (37% of CAPEX) for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$570,717/year; equal to 59% of operating costs. Operating income should be sufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (i.e., broken equipment, unexpected downtime, etc.).

Option E: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>	<u>Revenue</u>		<u>Investment</u>	
Digester	\$2,879,100		RNG/GJ =	\$30.00	Farm Investment =	\$4,721,971
Upgrader	\$3,085,997		Avg RNG Sales/Yr =	\$1,307,288	Funding Amount =	\$2,760,822
Nutrient Recovery	\$543,094		Tip Fee/Yr =	\$168,140	Funding % of CAPEX =	37%
Other	\$974,602		Bedding Savings/Yr* =	\$60,743		
Total	<u>\$7,482,793</u>	<u>\$965,454</u>	Total =	<u>\$1,536,172</u>	<i>Inflation =</i>	<i>2%</i>

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$1,525	\$1,526	\$1,527	\$1,528	\$1,530	\$1,531	\$1,532	\$1,533	\$1,534	\$1,535
OPEX (000s)	\$795	\$811	\$827	\$843	\$860	\$877	\$895	\$913	\$931	\$950
<i>Income (000s)</i>	\$731	\$716	\$701	\$685	\$669	\$653	\$637	\$620	\$603	\$585

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$1,536	\$1,538	\$1,539	\$1,540	\$1,541	\$1,543	\$1,544	\$1,545	\$1,547	\$1,548
OPEX (000s)	\$969	\$988	\$1,008	\$1,028	\$1,049	\$1,070	\$1,091	\$1,113	\$1,135	\$1,158
<i>Income (000s)</i>	\$568	\$549	\$531	\$512	\$493	\$473	\$453	\$433	\$412	\$391

Unlevered, Pre-Tax IRR =	12%
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Average Operating Income* =	\$570,717
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% of OPEX	59%
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** Averaged over twenty years to account for inflation*

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 85% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, with 37% funding, if RNG production is 10% or 20% higher than anticipated (due to the availability of high biogas-potential mixed food waste), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$26/GJ and <\$24/GJ respectively. Alternately, with 37% funding, if RNG production is 5% or 10% lower than anticipated, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 10.1% and 8.1% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Mixed food waste tip fee accounts for 11% of biogas plant revenue. Therefore, although less important than RNG sales, food waste tip fee can have a significant impact on biogas plant economic feasibility. For example, with 37% funding, if mixed food waste tip fee is \$35/tonne or \$50/tonne instead of \$25/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$27/GJ and <\$25/GJ respectively. Alternately, with 37% funding, if mixed food waste tip fee is only \$20/tonne or \$15/tonne, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 11.0% and 10.0% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option E: Sensitivity Analysis – RNG Production & Mixed Food Waste Tip Fee

		Change in RNG Production Amount						
		-10%	-5%	0%	5%	10%	15%	20%
\$/GJ RNG	\$16	---	---	---	---	---	---	---
	\$17	---	---	---	---	---	---	0.3%
	\$18	---	---	---	---	---	0.9%	2.6%
	\$19	---	---	---	---	1.3%	3.1%	4.6%
	\$20	---	---	---	1.5%	3.3%	5.0%	6.5%
	\$21	---	---	1.5%	3.4%	5.1%	6.7%	8.2%
	\$22	---	1.3%	3.3%	5.1%	6.8%	8.3%	9.7%
	\$23	0.9%	3.1%	5.0%	6.7%	8.3%	9.8%	11.2%
	\$24	2.6%	4.6%	6.5%	8.2%	9.7%	11.2%	12.7%
	\$25	4.1%	6.1%	7.9%	9.5%	11.1%	12.6%	14.1%
	\$26	5.4%	7.3%	9.1%	10.8%	12.4%	13.9%	15.4%
	\$27	6.5%	8.4%	10.2%	11.9%	13.5%	15.0%	16.5%
	\$28	7.3%	9.2%	11.1%	12.8%	14.4%	16.0%	17.6%
\$29	7.8%	9.8%	11.7%	13.5%	15.1%	16.8%	18.4%	
\$30	8.1%	10.1%	12.0%	13.8%	15.5%	17.2%	18.8%	

		Mixed Food Waste Tip Fee (\$/Tonne)							
		\$15	\$20	\$25	\$30	\$35	\$40	\$45	\$50
\$/GJ RNG	\$16	---	---	---	---	---	---	---	---
	\$17	---	---	---	---	---	---	---	0.5%
	\$18	---	---	---	---	---	---	1.1%	2.5%
	\$19	---	---	---	---	0.3%	1.7%	3.0%	4.2%
	\$20	---	---	---	0.9%	2.3%	3.5%	4.7%	5.8%
	\$21	---	0.1%	1.5%	2.8%	4.0%	5.2%	6.3%	7.3%
	\$22	0.7%	2.1%	3.3%	4.5%	5.6%	6.7%	7.7%	8.7%
	\$23	2.6%	3.8%	5.0%	6.1%	7.1%	8.1%	9.1%	10.0%
	\$24	4.3%	5.4%	6.5%	7.5%	8.5%	9.4%	10.4%	11.3%
	\$25	5.8%	6.9%	7.9%	8.8%	9.8%	10.7%	11.6%	12.5%
	\$26	7.1%	8.1%	9.1%	10.1%	11.0%	11.9%	12.7%	13.6%
	\$27	8.2%	9.2%	10.2%	11.1%	12.0%	12.9%	13.8%	14.6%
	\$28	9.1%	10.1%	11.1%	12.0%	12.9%	13.8%	14.6%	15.5%
\$29	9.8%	10.7%	11.7%	12.6%	13.5%	14.4%	15.3%	16.1%	
\$30	10.0%	11.0%	12.0%	12.9%	13.8%	14.7%	15.6%	16.5%	

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #7 - Option F: Mixed Food Waste Cleaning & Nutrient Recovery Equipment

This biogas plant is estimated to cost \$7.7 million to build. Operating costs are estimated to average \$991,275/year. At an RNG sale price of \$30/GJ, average revenue is estimated to be \$1,536,172/year. This biogas plant requires \$3.2 million funding (41% of CAPEX) for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$544,897/year; equal to 55% of operating costs. Operating income should be sufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (i.e., broken equipment, unexpected downtime, etc.).

Option F: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>	<u>Revenue</u>		<u>Investment</u>	
Digester	\$3,110,100		RNG/GJ [†] =	\$30.00	Farm Investment =	\$4,528,007
Upgrader	\$2,399,600		Avg RNG Sales/Yr =	\$1,307,288	Funding Amount =	\$3,207,274
Nutrient Recovery	\$1,218,094		Tip Fee/Yr =	\$168,140	Funding % of CAPEX =	41%
Other	\$1,007,487		Bedding Savings/Yr* =	\$60,743		
Total	<u>\$7,735,281</u>	<u>\$991,275</u>	Total =	<u>\$1,536,172</u>	Inflation =	2%

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$1,525	\$1,526	\$1,527	\$1,528	\$1,530	\$1,531	\$1,532	\$1,533	\$1,534	\$1,535
OPEX (000s)	\$816	\$832	\$849	\$866	\$883	\$901	\$919	\$937	\$956	\$975
<i>Income (000s)</i>	\$709	\$694	\$679	\$663	\$646	\$630	\$613	\$596	\$578	\$560

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$1,536	\$1,538	\$1,539	\$1,540	\$1,541	\$1,543	\$1,544	\$1,545	\$1,547	\$1,548
OPEX (000s)	\$995	\$1,015	\$1,035	\$1,056	\$1,077	\$1,098	\$1,120	\$1,143	\$1,165	\$1,189
<i>Income (000s)</i>	\$542	\$523	\$504	\$485	\$465	\$445	\$424	\$403	\$381	\$360

Unlevered, Pre-Tax IRR =	12%
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Average Operating Income* =	\$544,897
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% of OPEX	55%
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* Averaged over twenty years to account for inflation

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 85% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, with 41% funding, if RNG production is 10% or 20% higher than anticipated (due to the availability of high biogas-potential mixed food waste), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$26/GJ and <\$24/GJ respectively. Alternately, with 41% funding, if RNG production is 5% or 10% lower than anticipated, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 10.1% and 7.9% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Mixed food waste tip fee accounts for 11% of biogas plant revenue. Therefore, although less important than RNG sales, food waste tip fee can have a significant impact on biogas plant economic feasibility. For example, with 41% funding, if mixed food waste tip fee is \$35/tonne or \$50/tonne instead of \$25/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$27/GJ and <\$25/GJ respectively. Alternately, with 41% funding, if mixed food waste tip fee is only \$20/tonne or \$15/tonne, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 11.0% and 10.0% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option F: Sensitivity Analysis – RNG Production & Mixed Food Waste Tip Fee

		Change in RNG Production Amount						
		-10%	-5%	0%	5%	10%	15%	20%
\$/GJ RNG	\$16	---	---	---	---	---	---	---
	\$17	---	---	---	---	---	---	---
	\$18	---	---	---	---	---	0.2%	2.1%
	\$19	---	---	---	---	0.6%	2.6%	4.3%
	\$20	---	---	---	0.9%	2.9%	4.6%	6.2%
	\$21	---	---	0.9%	3.0%	4.8%	6.5%	8.0%
	\$22	---	0.6%	2.9%	4.8%	6.5%	8.2%	9.7%
	\$23	0.2%	2.6%	4.6%	6.5%	8.2%	9.7%	11.3%
	\$24	2.1%	4.3%	6.2%	8.0%	9.7%	11.3%	12.8%
	\$25	3.8%	5.8%	7.7%	9.5%	11.1%	12.7%	14.2%
	\$26	5.1%	7.2%	9.0%	10.8%	12.4%	14.0%	15.6%
	\$27	6.2%	8.3%	10.1%	11.9%	13.6%	15.2%	16.8%
	\$28	7.1%	9.1%	11.1%	12.9%	14.6%	16.3%	17.9%
\$29	7.7%	9.8%	11.7%	13.6%	15.3%	17.1%	18.7%	
\$30	7.9%	10.1%	12.0%	13.9%	15.7%	17.5%	19.1%	

		Mixed Food Waste Tip Fee (\$/Tonne)							
		\$15	\$20	\$25	\$30	\$35	\$40	\$45	\$50
\$/GJ RNG	\$16	---	---	---	---	---	---	---	---
	\$17	---	---	---	---	---	---	---	---
	\$18	---	---	---	---	---	---	0.4%	1.9%
	\$19	---	---	---	---	---	1.1%	2.5%	3.8%
	\$20	---	---	---	0.2%	1.7%	3.1%	4.4%	5.6%
	\$21	---	---	0.9%	2.3%	3.6%	4.9%	6.0%	7.1%
	\$22	0.0%	1.5%	2.9%	4.1%	5.3%	6.5%	7.5%	8.6%
	\$23	2.1%	3.4%	4.6%	5.8%	6.9%	8.0%	9.0%	10.0%
	\$24	3.9%	5.1%	6.2%	7.3%	8.4%	9.4%	10.3%	11.3%
	\$25	5.6%	6.7%	7.7%	8.7%	9.7%	10.7%	11.6%	12.6%
	\$26	6.9%	8.0%	9.0%	10.0%	11.0%	11.9%	12.8%	13.7%
	\$27	8.1%	9.1%	10.1%	11.1%	12.1%	13.0%	13.9%	14.8%
	\$28	9.0%	10.1%	11.1%	12.0%	13.0%	13.9%	14.8%	15.7%
\$29	9.7%	10.7%	11.7%	12.7%	13.6%	14.6%	15.5%	16.4%	
\$30	10.0%	11.0%	12.0%	13.0%	14.0%	14.9%	15.8%	16.7%	

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #7 - Option G: RNG Compression and Nutrient Recovery Equipment

This biogas plant is estimated to cost \$7.7 million to build. Operating costs are estimated to average \$1,107,641/year. At an RNG sale price of \$30/GJ, average revenue is estimated to be \$1,536,172/year. This biogas plant requires \$4.0 million funding (51% of CAPEX) for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$428,531/year; equal to 39% of operating costs. Operating income may or may not be sufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (e.g., broken equipment, unexpected downtime, etc.).

Option G: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>	<u>Revenue</u>		<u>Investment</u>	
Digester	\$2,382,975		RNG/GJ =	\$30.00	Farm Investment =	\$3,731,567
Upgrader	\$3,085,997		Avg RNG Sales/Yr =	\$1,307,288	Funding Amount =	\$3,956,887
Nutrient Recovery	\$1,218,094		Tip Fee/Yr =	\$168,140	Funding % of CAPEX =	51%
Other	\$1,001,388		Bedding Savings/Yr* =	\$60,743		
Total	<u>\$7,688,454</u>	<u>\$1,107,641</u>	Total =	<u>\$1,536,172</u>	Inflation =	2%

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$1,525	\$1,526	\$1,527	\$1,528	\$1,530	\$1,531	\$1,532	\$1,533	\$1,534	\$1,535
OPEX (000s)	\$912	\$930	\$949	\$968	\$987	\$1,007	\$1,027	\$1,047	\$1,068	\$1,090
<i>Income (000s)</i>	\$614	\$596	\$579	\$561	\$543	\$524	\$505	\$486	\$466	\$446

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$1,536	\$1,538	\$1,539	\$1,540	\$1,541	\$1,543	\$1,544	\$1,545	\$1,547	\$1,548
OPEX (000s)	\$1,111	\$1,134	\$1,156	\$1,179	\$1,203	\$1,227	\$1,252	\$1,277	\$1,302	\$1,328
<i>Income (000s)</i>	\$425	\$404	\$383	\$361	\$338	\$316	\$292	\$269	\$245	\$220

Unlevered, Pre-Tax IRR =	12%	Average Operating Income* =	\$428,531	% of OPEX	39%
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* Averaged over twenty years to account for inflation

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 85% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, with 51% funding, if RNG production is 10% or 20% higher than anticipated (due to the availability of high biogas-potential mixed food waste), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$26/GJ and <\$24/GJ respectively. Alternately, with 51% funding, if RNG production is 5% or 10% lower than anticipated, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 9.4% and 6.5% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Mixed food waste tip fee accounts for 11% of biogas plant revenue. Therefore, although less important than RNG sales, food waste tip fee can have a significant impact on biogas plant economic feasibility. For example, with 51% funding, if mixed food waste tip fee is \$35/tonne or \$50/tonne instead of \$25/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$27/GJ and <\$25/GJ respectively. Alternately, with 51% funding, if mixed food waste tip fee is only \$20/tonne or \$15/tonne, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 10.7% and 9.3% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option G: Sensitivity Analysis – RNG Production & Mixed Food Waste Tip Fee

		Change in RNG Production Amount						
		-10%	-5%	0%	5%	10%	15%	20%
\$/GJ RNG	\$16	---	---	---	---	---	---	---
	\$17	---	---	---	---	---	---	---
	\$18	---	---	---	---	---	---	---
	\$19	---	---	---	---	---	---	1.6%
	\$20	---	---	---	---	---	2.1%	4.5%
	\$21	---	---	---	---	2.4%	4.8%	6.9%
	\$22	---	---	---	2.4%	4.9%	7.0%	9.0%
	\$23	---	---	2.1%	4.8%	7.0%	9.1%	11.0%
	\$24	---	1.6%	4.5%	6.9%	9.0%	11.0%	12.9%
	\$25	0.8%	3.9%	6.5%	8.8%	10.8%	12.8%	14.7%
	\$26	2.8%	5.7%	8.2%	10.4%	12.5%	14.4%	16.3%
	\$27	4.3%	7.1%	9.6%	11.8%	13.9%	15.9%	17.8%
	\$28	5.4%	8.3%	10.7%	13.0%	15.2%	17.2%	19.2%
\$29	6.2%	9.1%	11.6%	13.9%	16.1%	18.2%	20.2%	
\$30	6.5%	9.4%	12.0%	14.4%	16.6%	18.7%	20.8%	

		Mixed Food Waste Tip Fee (\$/Tonne)							
		\$15	\$20	\$25	\$30	\$35	\$40	\$45	\$50
\$/GJ RNG	\$16	---	---	---	---	---	---	---	---
	\$17	---	---	---	---	---	---	---	---
	\$18	---	---	---	---	---	---	---	---
	\$19	---	---	---	---	---	---	---	0.9%
	\$20	---	---	---	---	---	---	1.7%	3.4%
	\$21	---	---	---	---	0.6%	2.4%	4.1%	5.6%
	\$22	---	---	---	1.4%	3.2%	4.7%	6.2%	7.6%
	\$23	---	0.3%	2.1%	3.8%	5.3%	6.8%	8.1%	9.4%
	\$24	1.1%	2.9%	4.5%	5.9%	7.3%	8.6%	9.8%	11.0%
	\$25	3.5%	5.0%	6.5%	7.8%	9.1%	10.3%	11.5%	12.6%
	\$26	5.4%	6.8%	8.2%	9.4%	10.7%	11.8%	13.0%	14.1%
	\$27	6.9%	8.3%	9.6%	10.8%	12.0%	13.2%	14.3%	15.4%
	\$28	8.1%	9.5%	10.7%	12.0%	13.2%	14.3%	15.4%	16.5%
\$29	9.0%	10.3%	11.6%	12.8%	14.0%	15.2%	16.3%	17.4%	
\$30	9.3%	10.7%	12.0%	13.2%	14.4%	15.6%	16.7%	17.8%	

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #7 - Option H: Mixed Food Waste Cleaning, RNG Compression and Nutrient Recovery Equipment

This biogas plant is estimated to cost \$8.5 million to build. Operating costs are estimated to average \$1,189,482/year. At an RNG sale price of \$30/GJ, average revenue is estimated to be \$1,536,172/year. This biogas plant requires \$5.4 million funding (63% of CAPEX) for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$346,689/year; equal to 29% of operating costs. Operating income is likely insufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (i.e., broken equipment, unexpected downtime, etc.). This is because farm investment (i.e., debt) is only 47%. Low investment means that even with an unlevered, pre-tax IRR of 12%, operating income can be too low.

Option H: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>	<u>Revenue</u>		<u>Investment</u>	
Digester	\$3,110,100		RNG/GJ =	\$30.00	Farm Investment =	\$3,161,397
Upgrader	\$3,085,997		Avg RNG Sales/Yr =	\$1,307,288	Funding Amount =	\$5,363,069
Nutrient Recovery	\$1,218,094		Tip Fee/Yr =	\$168,140	Funding % of CAPEX =	63%
Other	\$1,110,275		Bedding Savings/Yr* =	\$60,743		
Total	<u>\$8,524,466</u>	<u>\$1,189,482</u>	Total =	<u>\$1,536,172</u>	<i>Inflation =</i>	<i>2%</i>

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$1,525	\$1,526	\$1,527	\$1,528	\$1,530	\$1,531	\$1,532	\$1,533	\$1,534	\$1,535
OPEX (000s)	\$979	\$999	\$1,019	\$1,039	\$1,060	\$1,081	\$1,103	\$1,125	\$1,147	\$1,170
<i>Income (000s)</i>	<i>\$546</i>	<i>\$528</i>	<i>\$509</i>	<i>\$489</i>	<i>\$470</i>	<i>\$450</i>	<i>\$429</i>	<i>\$408</i>	<i>\$387</i>	<i>\$365</i>

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$1,536	\$1,538	\$1,539	\$1,540	\$1,541	\$1,543	\$1,544	\$1,545	\$1,547	\$1,548
OPEX (000s)	\$1,194	\$1,217	\$1,242	\$1,267	\$1,292	\$1,318	\$1,344	\$1,371	\$1,398	\$1,426
<i>Income (000s)</i>	<i>\$343</i>	<i>\$320</i>	<i>\$297</i>	<i>\$274</i>	<i>\$249</i>	<i>\$225</i>	<i>\$200</i>	<i>\$174</i>	<i>\$148</i>	<i>\$122</i>

Unlevered, Pre-Tax IRR =	12%	Average Operating Income* =	\$346,689	% of OPEX	29%
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** Averaged over twenty years to account for inflation*

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 83% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, with 63% funding, if RNG production is 10% or 20% higher than anticipated (due to the availability of high biogas-potential mixed food waste), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$26/GJ and <\$24/GJ respectively. Alternately, with 63% funding, if RNG production is 5% or 10% lower than anticipated, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 8.7% and 4.8% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Mixed food waste tip fee accounts for 14% of biogas plant revenue. Therefore, although less important than RNG sales, food waste tip fee can have a significant impact on biogas plant economic feasibility. For example, with 63% funding, if mixed food waste tip fee is \$35/tonne or \$50/tonne instead of \$25/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$27/GJ and <\$25/GJ respectively. Alternately, with 63% funding, if mixed food waste tip fee is only \$20/tonne or \$15/tonne, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 10.4% and 8.6% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option H: Sensitivity Analysis – RNG Production & Mixed Food Waste Tip Fee

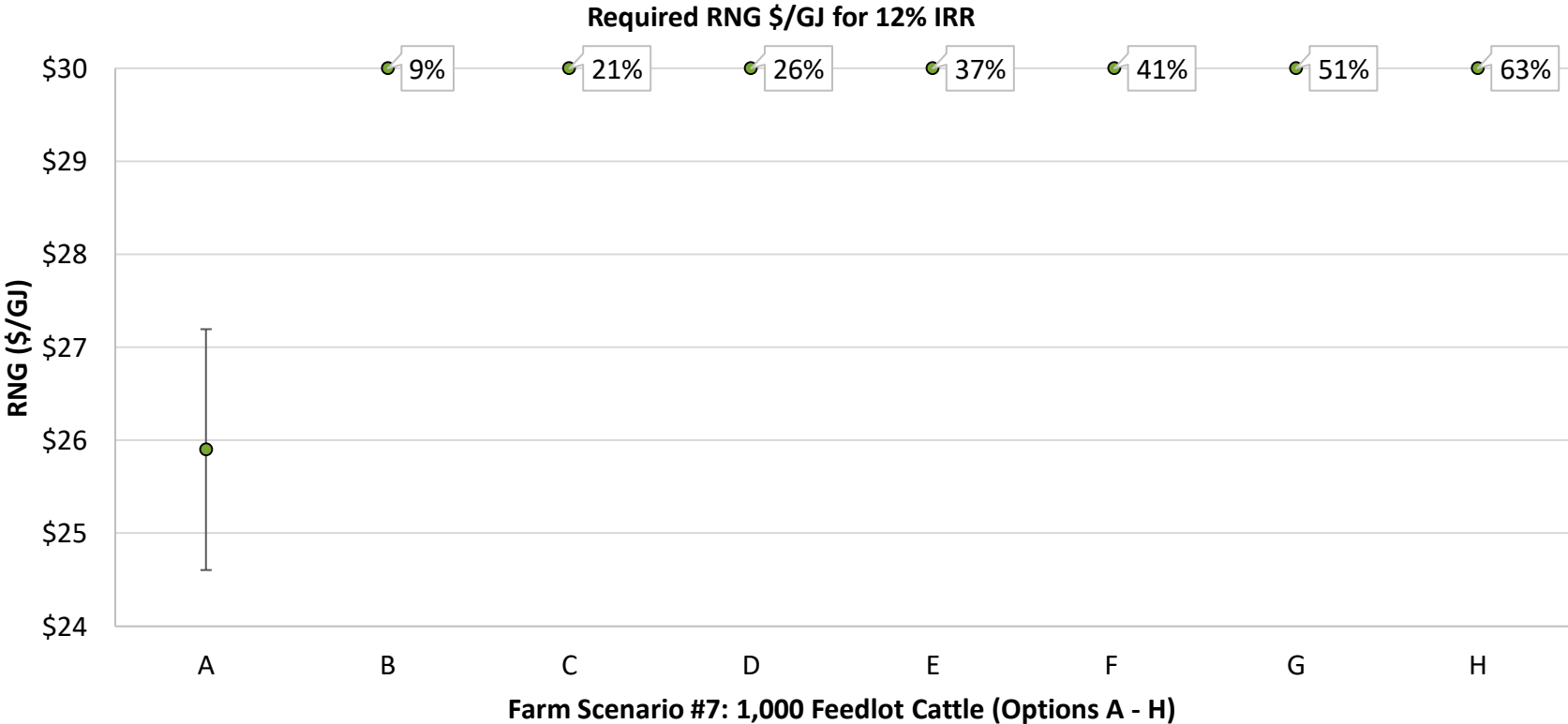
		Change in RNG Production Amount						
		-10%	-5%	0%	5%	10%	15%	20%
\$/GJ RNG	\$16	---	---	---	---	---	---	---
	\$17	---	---	---	---	---	---	---
	\$18	---	---	---	---	---	---	---
	\$19	---	---	---	---	---	---	---
	\$20	---	---	---	---	---	---	2.3%
	\$21	---	---	---	---	---	2.8%	5.6%
	\$22	---	---	---	---	2.9%	5.8%	8.3%
	\$23	---	---	---	2.8%	5.8%	8.4%	10.8%
	\$24	---	---	2.3%	5.6%	8.3%	10.8%	13.1%
	\$25	---	1.5%	5.1%	8.0%	10.6%	13.0%	15.2%
	\$26	---	4.0%	7.2%	10.1%	12.6%	14.9%	17.2%
	\$27	1.9%	5.8%	9.0%	11.8%	14.3%	16.7%	19.0%
	\$28	3.4%	7.3%	10.5%	13.3%	15.8%	18.3%	20.6%
\$29	4.4%	8.3%	11.5%	14.3%	17.0%	19.5%	21.9%	
\$30	4.8%	8.7%	12.0%	14.9%	17.6%	20.1%	22.6%	

		Mixed Food Waste Tip Fee (\$/Tonne)							
		\$15	\$20	\$25	\$30	\$35	\$40	\$45	\$50
\$/GJ RNG	\$16	---	---	---	---	---	---	---	---
	\$17	---	---	---	---	---	---	---	---
	\$18	---	---	---	---	---	---	---	---
	\$19	---	---	---	---	---	---	---	---
	\$20	---	---	---	---	---	---	---	0.7%
	\$21	---	---	---	---	---	---	1.7%	3.9%
	\$22	---	---	---	---	0.3%	2.7%	4.7%	6.5%
	\$23	---	---	---	1.4%	3.5%	5.4%	7.2%	8.8%
	\$24	---	---	2.3%	4.3%	6.1%	7.8%	9.4%	10.8%
	\$25	1.0%	3.1%	5.1%	6.8%	8.4%	9.9%	11.4%	12.8%
	\$26	3.6%	5.5%	7.2%	8.8%	10.4%	11.8%	13.2%	14.5%
	\$27	5.6%	7.4%	9.0%	10.6%	12.0%	13.4%	14.8%	16.1%
	\$28	7.1%	8.8%	10.5%	12.0%	13.4%	14.8%	16.1%	17.4%
\$29	8.2%	9.9%	11.5%	13.0%	14.5%	15.8%	17.2%	18.5%	
\$30	8.6%	10.4%	12.0%	13.5%	15.0%	16.4%	17.7%	19.0%	

Farm Scenario #7: Summary

Figure 19 shows the required RNG \$/GJ sale price for Farm Scenario #7 Options A – G for an unlevered, pre-tax IRR of 12%. Where required RNG sale price is >\$30/GJ, percentage of required funding is shown. Where required RNG sale price is <\$30/GJ, a bar representing +/- 5% is shown to account for price uncertainty. Only Farm Scenario #7 Option A doesn't require funding. This biogas plant requires \$24.61 - \$27.20/GJ. Farm Scenario #7 Options B – H require funding. Funding increases from 9% (for Option B) to 63% (for Option H). Figure 19 shows that only under the best circumstance (i.e., Option A - needing the least equipment) are 1,000 cattle feedlots co-digesting cattle manure and mixed food waste economically feasible in B.C. without funding.

Figure 19: Farm Scenario #7 - Required RNG Sale Price for 1,000 Feedlot Cattle + Mixed Food Waste



7.8

Farm Scenario #8: 2,500 Feedlot Cattle + Mixed Food Waste

Farm Scenario #8 is a 2,500 feedlot cattle co-digesting cattle manure and mixed food waste. Farm Scenario #8 assumes the use of traditional on-farm biogas plant technology. Estimated feedstock volumes and Renewable Natural Gas (RNG) production for Farm Scenario #8 are as follows:

Feedstock	Tonnes/Year	Percentage	RNG Production (GJ/Year)
Cattle manure	17,500	51%	32,883 GJ
Mixed food waste	16,814	49%	81,710 GJ
<i>Total</i>	<i>34,314</i>	<i>100%</i>	<i>114,593 GJ</i>

The following Equipment Choices were assessed for Farm Scenario #8:

- Option A: No additional equipment;
- Option B: Mixed food waste cleaning equipment;
- Option C: RNG compression equipment;
- Option D: Nutrient recovery equipment;
- Option E: Mixed food waste cleaning and RNG compression equipment;
- Option F: Mixed food waste cleaning and nutrient recovery equipment;
- Option G: RNG compression and nutrient recovery equipment; and
- Option H: Mixed food waste cleaning, RNG compression and nutrient recovery equipment.

For full capital and operating costs for Farm Scenario #8 Options A – H, see Appendix H.

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #8 - Option A: No Additional Equipment

This biogas plant is estimated to cost \$9.0 million to build. Operating costs are estimated to average \$1,142,835/year. At an RNG sale price of \$14.74/GJ, average revenue is estimated to be \$2,340,562/year. This biogas plant doesn't require funding for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$1,197,727/year; equal to 105% of operating costs. Operating income should be sufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (i.e., broken equipment, unexpected downtime, etc.).

Option A: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>	<u>Revenue</u>		<u>Investment</u>	
Digester	\$3,210,375		RNG/GJ [†] =	\$14.74	Farm Investment =	\$8,989,517
Upgrader	\$3,536,400		Avg RNG Sales/Yr =	\$1,768,353	Funding Amount =	\$0
Nutrient Recovery	\$1,071,896		Tip Fee/Yr =	\$420,350	Funding % of CAPEX =	0%
Other	\$1,170,846		Bedding Savings/Yr* =	\$151,859		
Total	<u>\$8,989,517</u>	<u>\$1,142,835</u>	Total =	<u>\$2,340,562</u>	Inflation =	2%

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$2,151	\$2,170	\$2,189	\$2,208	\$2,227	\$2,246	\$2,266	\$2,286	\$2,306	\$2,326
OPEX (000s)	\$941	\$960	\$979	\$998	\$1,018	\$1,039	\$1,059	\$1,081	\$1,102	\$1,124
Income (000s)	\$1,211	\$1,211	\$1,210	\$1,209	\$1,209	\$1,208	\$1,207	\$1,205	\$1,204	\$1,202

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$2,347	\$2,368	\$2,389	\$2,410	\$2,432	\$2,453	\$2,475	\$2,498	\$2,520	\$2,543
OPEX (000s)	\$1,147	\$1,170	\$1,193	\$1,217	\$1,241	\$1,266	\$1,291	\$1,317	\$1,344	\$1,370
Income (000s)	\$1,200	\$1,198	\$1,196	\$1,193	\$1,190	\$1,187	\$1,184	\$1,181	\$1,177	\$1,173

Unlevered, Pre-Tax IRR =	12%
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Average Operating Income* =	\$1,197,727
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% of OPEX	105%
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* Averaged over twenty years to account for inflation

† Base price (1%/year increase up to \$30/GJ max)

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 76% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, if RNG production is 10% or 20% higher than anticipated (due to the availability of high biogas-potential mixed food waste), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$14.74/GJ to <\$14/GJ and <\$13/GJ respectively. Alternately, if RNG production is 10% or 20% lower than anticipated, the required RNG sale price for an unlevered, pre-tax IRR increases from \$14.74/GJ to >\$16/GJ and >\$18/GJ respectively. Furthermore, if only 50% of estimated mixed food waste is available (8,407 instead of 16,814 tonnes/year), RNG production will be approximately 35% lower. If RNG production is 35% lower, the required RNG sale price for an unlevered, pre-tax IRR of 12% increases from \$14.74/GJ to >\$22/GJ.

Option A: Sensitivity Analysis – RNG Production

		Change in RNG Production Amount														
		-50%	-45%	-40%	-35%	-30%	-25%	-20%	-15%	-10%	-5%	0%	5%	10%	15%	20%
\$/GJ RNG	\$12	---	---	---	---	---	1.3%	2.7%	4.0%	5.2%	6.4%	7.5%	8.5%	9.5%	10.5%	11.5%
	\$13	---	---	---	---	1.5%	3.0%	4.4%	5.7%	6.9%	8.1%	9.2%	10.3%	11.3%	12.3%	13.3%
	\$14	---	---	---	1.5%	3.2%	4.6%	6.0%	7.3%	8.5%	9.7%	10.8%	11.9%	13.0%	14.0%	15.1%
	\$15	---	---	1.3%	3.0%	4.6%	6.1%	7.5%	8.8%	10.0%	11.2%	12.4%	13.5%	14.6%	15.7%	16.8%
	\$16	---	0.8%	2.7%	4.4%	6.0%	7.5%	8.9%	10.2%	11.5%	12.7%	13.9%	15.1%	16.2%	17.3%	18.4%
	\$17	0.0%	2.1%	4.0%	5.7%	7.3%	8.8%	10.2%	11.5%	12.8%	14.1%	15.3%	16.5%	17.7%	18.9%	20.0%
	\$18	1.3%	3.4%	5.2%	6.9%	8.5%	10.0%	11.5%	12.8%	14.2%	15.5%	16.8%	18.0%	19.2%	20.4%	21.6%
	\$19	2.5%	4.5%	6.4%	8.1%	9.7%	11.2%	12.7%	14.1%	15.5%	16.8%	18.1%	19.4%	20.7%	22.0%	23.2%
	\$20	3.6%	5.6%	7.5%	9.2%	10.8%	12.4%	13.9%	15.3%	16.8%	18.1%	19.5%	20.8%	22.2%	23.5%	24.8%
	\$21	4.6%	6.7%	8.5%	10.3%	11.9%	13.5%	15.1%	16.5%	18.0%	19.4%	20.8%	22.2%	23.6%	25.0%	26.3%
	\$22	5.6%	7.7%	9.5%	11.3%	13.0%	14.6%	16.2%	17.7%	19.2%	20.7%	22.2%	23.6%	25.0%	26.4%	27.8%
	\$23	6.6%	8.6%	10.5%	12.3%	14.0%	15.7%	17.3%	18.9%	20.4%	22.0%	23.5%	25.0%	26.4%	27.9%	29.3%
	\$24	7.5%	9.5%	11.5%	13.3%	15.1%	16.8%	18.4%	20.0%	21.6%	23.2%	24.8%	26.3%	27.8%	29.3%	30.9%
	\$25	8.3%	10.4%	12.4%	14.3%	16.1%	17.8%	19.5%	21.2%	22.8%	24.4%	26.0%	27.6%	29.2%	30.8%	32.4%
	\$26	9.1%	11.3%	13.2%	15.2%	17.0%	18.8%	20.6%	22.3%	24.0%	25.6%	27.3%	29.0%	30.6%	32.2%	33.8%
	\$27	9.8%	12.0%	14.0%	16.0%	17.9%	19.7%	21.5%	23.3%	25.1%	26.8%	28.5%	30.2%	31.9%	33.6%	35.3%
	\$28	10.4%	12.6%	14.7%	16.7%	18.7%	20.6%	22.4%	24.3%	26.1%	27.9%	29.7%	31.4%	33.2%	34.9%	36.7%
\$29	10.8%	13.0%	15.2%	17.3%	19.3%	21.2%	23.2%	25.1%	26.9%	28.8%	30.6%	32.5%	34.3%	36.1%	37.9%	
\$30	11.0%	13.2%	15.4%	17.5%	19.6%	21.6%	23.5%	25.5%	27.4%	29.3%	31.2%	33.1%	34.9%	36.8%	38.6%	

B.C. On-Farm Biogas Benchmark Study, Version 2

Mixed food waste tip fee accounts for 18% of biogas plant revenue. Therefore, although less important than RNG sales, food waste tip fee can have a significant impact on biogas plant economic feasibility. For example, if mixed food waste tip fee is \$35/tonne or \$45/tonne instead of \$25/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$14.74/GJ to <\$14/GJ and <\$12/GJ respectively. Alternately, if mixed food waste tip fee is only \$10/tonne or \$0/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% increases from \$14.74/GJ to >\$16/GJ and >\$18/GJ respectively.

Option A: Sensitivity Analysis – Mixed Food Waste Tip Fee

		Mixed Food Waste Tip Fee (\$/Tonne)										
		\$0	\$5	\$10	\$15	\$20	\$25	\$30	\$35	\$40	\$45	\$50
\$/GJ RNG	\$12	0.0%	1.7%	3.3%	4.8%	6.2%	7.5%	8.7%	9.9%	11.1%	12.2%	13.4%
	\$13	2.4%	3.9%	5.4%	6.7%	8.0%	9.2%	10.4%	11.5%	12.7%	13.8%	14.8%
	\$14	4.5%	5.9%	7.2%	8.5%	9.7%	10.8%	12.0%	13.1%	14.2%	15.2%	16.3%
	\$15	6.4%	7.7%	8.9%	10.1%	11.3%	12.4%	13.5%	14.6%	15.6%	16.7%	17.7%
	\$16	8.2%	9.4%	10.6%	11.7%	12.8%	13.9%	15.0%	16.0%	17.0%	18.1%	19.1%
	\$17	9.8%	11.0%	12.1%	13.2%	14.3%	15.3%	16.4%	17.4%	18.4%	19.4%	20.4%
	\$18	11.4%	12.5%	13.6%	14.7%	15.7%	16.8%	17.8%	18.8%	19.8%	20.8%	21.8%
	\$19	12.9%	14.0%	15.1%	16.1%	17.1%	18.1%	19.1%	20.1%	21.1%	22.1%	23.1%
	\$20	14.4%	15.5%	16.5%	17.5%	18.5%	19.5%	20.5%	21.5%	22.5%	23.4%	24.4%
	\$21	15.8%	16.9%	17.9%	18.9%	19.9%	20.8%	21.8%	22.8%	23.8%	24.7%	25.7%
	\$22	17.2%	18.2%	19.2%	20.2%	21.2%	22.2%	23.1%	24.1%	25.1%	26.0%	27.0%
	\$23	18.6%	19.6%	20.6%	21.5%	22.5%	23.5%	24.4%	25.4%	26.3%	27.3%	28.2%
	\$24	19.9%	20.9%	21.9%	22.8%	23.8%	24.8%	25.7%	26.7%	27.6%	28.6%	29.5%
	\$25	21.2%	22.2%	23.2%	24.1%	25.1%	26.0%	27.0%	27.9%	28.9%	29.8%	30.8%
	\$26	22.5%	23.5%	24.5%	25.4%	26.4%	27.3%	28.3%	29.2%	30.1%	31.1%	32.0%
	\$27	23.8%	24.7%	25.7%	26.6%	27.6%	28.5%	29.5%	30.4%	31.4%	32.3%	33.2%
	\$28	24.9%	25.8%	26.8%	27.8%	28.7%	29.7%	30.6%	31.6%	32.5%	33.5%	34.4%
\$29	25.8%	26.8%	27.7%	28.7%	29.7%	30.6%	31.6%	32.6%	33.5%	34.5%	35.4%	
\$30	26.3%	27.3%	28.3%	29.2%	30.2%	31.2%	32.2%	33.1%	34.1%	35.0%	36.0%	

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #8 - Option B: Mixed Food Waste Cleaning Equipment

This biogas plant is estimated to cost \$10.1 million to build. Operating costs are estimated to average \$1,231,693/year. At an RNG sale price of \$16.76/GJ, average revenue is estimated to be \$2,582,617/year. This biogas plant doesn't require funding for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$1,350,924/year; equal to 110% of operating costs. Operating income should be sufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (i.e., broken equipment, unexpected downtime, etc.).

Option B: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>	<u>Revenue</u>	<u>Investment</u>
Digester	\$4,200,000		RNG/GJ [†] = \$16.76	Farm Investment = \$10,127,339
Upgrader	\$3,536,400		Avg RNG Sales/Yr = \$2,010,408	Funding Amount = \$0
Nutrient Rec.	\$1,071,896		Tip Fee/Yr = \$420,350	Funding % of CAPEX = 0%
Other	\$1,319,042		Bedding Savings/Yr* = \$151,859	
Total	<u>\$10,127,339</u>	<u>\$1,231,693</u>	Total = <u>\$2,582,617</u>	Inflation = 2%

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$2,371	\$2,392	\$2,413	\$2,434	\$2,456	\$2,478	\$2,499	\$2,522	\$2,544	\$2,567
OPEX (000s)	\$1,014	\$1,034	\$1,055	\$1,076	\$1,097	\$1,119	\$1,142	\$1,165	\$1,188	\$1,212
Income (000s)	\$1,357	\$1,358	\$1,358	\$1,358	\$1,358	\$1,358	\$1,358	\$1,357	\$1,356	\$1,355

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$2,590	\$2,613	\$2,637	\$2,660	\$2,684	\$2,709	\$2,733	\$2,758	\$2,783	\$2,809
OPEX (000s)	\$1,236	\$1,261	\$1,286	\$1,312	\$1,338	\$1,365	\$1,392	\$1,420	\$1,448	\$1,477
Income (000s)	\$1,354	\$1,352	\$1,351	\$1,349	\$1,347	\$1,344	\$1,341	\$1,338	\$1,335	\$1,332

Unlevered, Pre-Tax IRR =	12%
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Average Operating Income* =	\$1,350,924
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% of OPEX	110%
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* Averaged over twenty years to account for inflation

† Base price (1%/year increase up to \$30/GJ max)

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 78% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, if RNG production is 10% or 20% higher than anticipated (due to the availability of high biogas-potential mixed food waste), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$16.76/GJ to <\$16/GJ and <\$14/GJ respectively. Alternately, if RNG production is 10% or 20% lower than anticipated, the required RNG sale price for an unlevered, pre-tax IRR increases from \$16.76/GJ to >\$18/GJ and >\$20/GJ respectively. Furthermore, if only 50% of estimated mixed food waste is available (8,407 instead of 16,814 tonnes/year), RNG production will be approximately 35% lower. If RNG production is 35% lower, the required RNG sale price for an unlevered, pre-tax IRR of 12% increases from \$16.76/GJ to >\$25/GJ.

Option B: Sensitivity Analysis – RNG Production

		Change in RNG Production Amount														
		-50%	-45%	-40%	-35%	-30%	-25%	-20%	-15%	-10%	-5%	0%	5%	10%	15%	20%
\$/GJ RNG	\$12	---	---	---	---	---	---	---	1.1%	2.4%	3.6%	4.7%	5.7%	6.7%	7.7%	8.6%
	\$13	---	---	---	---	---	0.1%	1.5%	2.9%	4.1%	5.3%	6.4%	7.4%	8.4%	9.4%	10.4%
	\$14	---	---	---	---	0.2%	1.8%	3.2%	4.5%	5.7%	6.9%	8.0%	9.0%	10.1%	11.1%	12.0%
	\$15	---	---	---	0.1%	1.8%	3.3%	4.7%	6.0%	7.2%	8.4%	9.5%	10.6%	11.6%	12.6%	13.6%
	\$16	---	---	---	1.5%	3.2%	4.7%	6.1%	7.4%	8.6%	9.8%	10.9%	12.0%	13.1%	14.2%	15.2%
	\$17	---	---	1.1%	2.9%	4.5%	6.0%	7.4%	8.7%	9.9%	11.1%	12.3%	13.4%	14.5%	15.6%	16.7%
	\$18	---	0.4%	2.4%	4.1%	5.7%	7.2%	8.6%	9.9%	11.2%	12.4%	13.6%	14.8%	15.9%	17.1%	18.2%
	\$19	---	1.7%	3.6%	5.3%	6.9%	8.4%	9.8%	11.1%	12.4%	13.7%	14.9%	16.1%	17.3%	18.5%	19.6%
	\$20	0.7%	2.8%	4.7%	6.4%	8.0%	9.5%	10.9%	12.3%	13.6%	14.9%	16.2%	17.4%	18.7%	19.9%	21.0%
	\$21	1.8%	3.8%	5.7%	7.4%	9.0%	10.6%	12.0%	13.4%	14.8%	16.1%	17.4%	18.7%	20.0%	21.2%	22.4%
	\$22	2.8%	4.8%	6.7%	8.4%	10.1%	11.6%	13.1%	14.5%	15.9%	17.3%	18.7%	20.0%	21.3%	22.6%	23.8%
	\$23	3.8%	5.8%	7.7%	9.4%	11.1%	12.6%	14.2%	15.6%	17.1%	18.5%	19.9%	21.2%	22.6%	23.9%	25.2%
	\$24	4.7%	6.7%	8.6%	10.4%	12.0%	13.6%	15.2%	16.7%	18.2%	19.6%	21.0%	22.4%	23.8%	25.2%	26.6%
	\$25	5.5%	7.6%	9.5%	11.3%	13.0%	14.6%	16.2%	17.7%	19.3%	20.7%	22.2%	23.7%	25.1%	26.5%	27.9%
	\$26	6.3%	8.4%	10.3%	12.1%	13.9%	15.5%	17.2%	18.7%	20.3%	21.8%	23.3%	24.8%	26.3%	27.8%	29.2%
	\$27	6.9%	9.0%	11.0%	12.9%	14.7%	16.4%	18.0%	19.7%	21.3%	22.9%	24.4%	26.0%	27.5%	29.0%	30.5%
\$28	7.4%	9.6%	11.6%	13.5%	15.3%	17.1%	18.8%	20.5%	22.2%	23.8%	25.4%	27.0%	28.6%	30.2%	31.8%	
\$29	7.8%	10.0%	12.0%	14.0%	15.9%	17.7%	19.5%	21.2%	22.9%	24.6%	26.3%	27.9%	29.6%	31.2%	32.8%	
\$30	7.9%	10.1%	12.2%	14.2%	16.1%	18.0%	19.8%	21.5%	23.3%	25.0%	26.7%	28.4%	30.1%	31.8%	33.4%	

B.C. On-Farm Biogas Benchmark Study, Version 2

Mixed food waste tip fee accounts for 16% of biogas plant revenue. Therefore, although less important than RNG sales, food waste tip fee can have a significant impact on biogas plant economic feasibility. For example, if mixed food waste tip fee is \$35/tonne or \$50/tonne instead of \$25/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$16.76/GJ to <\$16/GJ and <\$14/GJ respectively. Alternately, if mixed food waste tip fee is only \$10/tonne or \$0/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% increases from \$16.76/GJ to >\$18/GJ and >\$20/GJ respectively.

Option B: Sensitivity Analysis – Mixed Food Waste Tip Fee

		Mixed Food Waste Tip Fee (\$/Tonne)										
		\$0	\$5	\$10	\$15	\$20	\$25	\$30	\$35	\$40	\$45	\$50
\$/GJ RNG	\$12	---	---	0.4%	1.9%	3.4%	4.7%	5.9%	7.1%	8.2%	9.3%	10.4%
	\$13	---	1.1%	2.5%	3.9%	5.2%	6.4%	7.5%	8.7%	9.7%	10.8%	11.8%
	\$14	1.7%	3.1%	4.4%	5.7%	6.9%	8.0%	9.1%	10.1%	11.2%	12.2%	13.2%
	\$15	3.7%	4.9%	6.1%	7.3%	8.4%	9.5%	10.5%	11.6%	12.5%	13.5%	14.5%
	\$16	5.4%	6.6%	7.7%	8.8%	9.9%	10.9%	11.9%	12.9%	13.9%	14.8%	15.8%
	\$17	7.1%	8.2%	9.3%	10.3%	11.3%	12.3%	13.3%	14.2%	15.2%	16.1%	17.0%
	\$18	8.6%	9.7%	10.7%	11.7%	12.7%	13.6%	14.6%	15.5%	16.4%	17.4%	18.3%
	\$19	10.1%	11.1%	12.1%	13.0%	14.0%	14.9%	15.9%	16.8%	17.7%	18.6%	19.5%
	\$20	11.4%	12.4%	13.4%	14.3%	15.3%	16.2%	17.1%	18.0%	18.9%	19.8%	20.7%
	\$21	12.8%	13.7%	14.7%	15.6%	16.5%	17.4%	18.3%	19.2%	20.1%	21.0%	21.9%
	\$22	14.1%	15.0%	16.0%	16.9%	17.8%	18.7%	19.5%	20.4%	21.3%	22.2%	23.0%
	\$23	15.4%	16.3%	17.2%	18.1%	19.0%	19.9%	20.7%	21.6%	22.5%	23.3%	24.2%
	\$24	16.6%	17.5%	18.4%	19.3%	20.2%	21.0%	21.9%	22.8%	23.6%	24.5%	25.3%
	\$25	17.8%	18.7%	19.6%	20.5%	21.3%	22.2%	23.1%	23.9%	24.8%	25.6%	26.5%
	\$26	19.0%	19.9%	20.8%	21.6%	22.5%	23.3%	24.2%	25.1%	25.9%	26.7%	27.6%
	\$27	20.1%	21.0%	21.8%	22.7%	23.6%	24.4%	25.3%	26.1%	27.0%	27.8%	28.7%
	\$28	21.1%	22.0%	22.8%	23.7%	24.6%	25.4%	26.3%	27.1%	28.0%	28.8%	29.7%
\$29	21.9%	22.8%	23.6%	24.5%	25.4%	26.3%	27.1%	28.0%	28.8%	29.7%	30.6%	
\$30	22.3%	23.2%	24.1%	25.0%	25.8%	26.7%	27.6%	28.5%	29.3%	30.2%	31.0%	

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #8 - Option C: RNG Compression Equipment

This biogas plant is estimated to cost \$10.1 million to build. Operating costs are estimated to average \$1,524,470/year. At an RNG sale price of \$19.11/GJ, average revenue is estimated to be \$2,863,868/year. This biogas plant doesn't require funding for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$1,339,397/year; equal to 88% of operating costs. Operating income should be sufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (i.e., broken equipment, unexpected downtime, etc.).

Option C: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>	<u>Revenue</u>		<u>Investment</u>	
Digester	\$3,210,375		RNG/GJ [†] =	\$19.11	Farm Investment =	\$10,124,805
Upgrader	\$4,523,821		Avg RNG Sales/Yr =	\$2,291,659	Funding Amount =	\$0
Nutrient Rec.	\$1,071,896		Tip Fee/Yr =	\$420,350	Funding % of CAPEX =	0%
Other	\$1,318,712		Bedding Savings/Yr* =	\$151,859		
Total	<u>\$10,124,805</u>	<u>\$1,524,470</u>	Total =	<u>\$2,863,868</u>	Inflation =	2%

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$2,627	\$2,650	\$2,674	\$2,697	\$2,722	\$2,746	\$2,771	\$2,796	\$2,821	\$2,846
OPEX (000s)	\$1,255	\$1,280	\$1,306	\$1,332	\$1,358	\$1,385	\$1,413	\$1,441	\$1,470	\$1,500
<i>Income (000s)</i>	\$1,372	\$1,370	\$1,368	\$1,366	\$1,363	\$1,361	\$1,357	\$1,354	\$1,351	\$1,347

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$2,872	\$2,898	\$2,924	\$2,951	\$2,978	\$3,005	\$3,033	\$3,061	\$3,089	\$3,117
OPEX (000s)	\$1,530	\$1,560	\$1,591	\$1,623	\$1,656	\$1,689	\$1,723	\$1,757	\$1,792	\$1,828
<i>Income (000s)</i>	\$1,342	\$1,338	\$1,333	\$1,328	\$1,322	\$1,316	\$1,310	\$1,304	\$1,297	\$1,289

Unlevered, Pre-Tax IRR =	12%
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Average Operating Income* =	\$1,339,397
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% of OPEX	88%
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* Averaged over twenty years to account for inflation

† Base price (1%/year increase up to \$30/GJ max)

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 80% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, if RNG production is 10% or 20% higher than anticipated (due to the availability of high biogas-potential mixed food waste), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$19.11/GJ to <\$18/GJ and <\$16/GJ respectively. Alternately, if RNG production is 10% or 20% lower than anticipated, the required RNG sale price for an unlevered, pre-tax IRR increases from \$19.11/GJ to >\$21/GJ and >\$23/GJ respectively. Furthermore, if only 50% of estimated mixed food waste is available (8,407 instead of 16,814 tonnes/year), RNG production will be approximately 35% lower. If RNG production is 35% lower, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 10.8%. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option C: Sensitivity Analysis – RNG Production

		Change in RNG Production Amount														
		-50%	-45%	-40%	-35%	-30%	-25%	-20%	-15%	-10%	-5%	0%	5%	10%	15%	20%
\$/GJ RNG	\$12	---	---	---	---	---	---	---	---	---	---	---	1.0%	2.3%	3.5%	4.7%
	\$13	---	---	---	---	---	---	---	---	---	0.5%	1.9%	3.2%	4.5%	5.6%	6.7%
	\$14	---	---	---	---	---	---	---	---	1.0%	2.5%	3.9%	5.2%	6.4%	7.5%	8.6%
	\$15	---	---	---	---	---	---	---	1.4%	2.9%	4.4%	5.7%	7.0%	8.2%	9.3%	10.4%
	\$16	---	---	---	---	---	---	1.5%	3.1%	4.7%	6.1%	7.4%	8.6%	9.8%	11.0%	12.1%
	\$17	---	---	---	---	---	1.4%	3.1%	4.8%	6.2%	7.6%	8.9%	10.2%	11.4%	12.6%	13.7%
	\$18	---	---	---	---	1.0%	2.9%	4.7%	6.2%	7.7%	9.1%	10.4%	11.7%	12.9%	14.1%	15.3%
	\$19	---	---	---	0.5%	2.5%	4.4%	6.1%	7.6%	9.1%	10.5%	11.8%	13.1%	14.4%	15.6%	16.8%
	\$20	---	---	---	1.9%	3.9%	5.7%	7.4%	8.9%	10.4%	11.8%	13.2%	14.5%	15.8%	17.0%	18.3%
	\$21	---	---	1.0%	3.2%	5.2%	7.0%	8.6%	10.2%	11.7%	13.1%	14.5%	15.8%	17.2%	18.4%	19.7%
	\$22	---	---	2.3%	4.5%	6.4%	8.2%	9.8%	11.4%	12.9%	14.4%	15.8%	17.2%	18.5%	19.8%	21.1%
	\$23	---	1.1%	3.5%	5.6%	7.5%	9.3%	11.0%	12.6%	14.1%	15.6%	17.0%	18.4%	19.8%	21.2%	22.6%
	\$24	---	2.3%	4.7%	6.7%	8.6%	10.4%	12.1%	13.7%	15.3%	16.8%	18.3%	19.7%	21.1%	22.6%	23.9%
	\$25	0.8%	3.4%	5.7%	7.8%	9.7%	11.5%	13.2%	14.8%	16.4%	18.0%	19.5%	21.0%	22.4%	23.9%	25.3%
	\$26	1.7%	4.4%	6.6%	8.7%	10.6%	12.4%	14.2%	15.9%	17.5%	19.1%	20.6%	22.2%	23.7%	25.2%	26.7%
	\$27	2.5%	5.1%	7.4%	9.5%	11.5%	13.3%	15.1%	16.8%	18.5%	20.1%	21.7%	23.3%	24.9%	26.4%	28.0%
	\$28	3.0%	5.7%	8.0%	10.1%	12.2%	14.1%	15.9%	17.7%	19.4%	21.1%	22.7%	24.4%	26.0%	27.6%	29.2%
\$29	3.4%	6.0%	8.4%	10.6%	12.7%	14.6%	16.5%	18.3%	20.1%	21.8%	23.6%	25.2%	26.9%	28.6%	30.2%	
\$30	3.5%	6.2%	8.6%	10.8%	12.9%	14.9%	16.8%	18.6%	20.5%	22.2%	24.0%	25.7%	27.4%	29.1%	30.8%	

B.C. On-Farm Biogas Benchmark Study, Version 2

Mixed food waste tip fee accounts for 15% of biogas plant revenue. Therefore, although less important than RNG sales, food waste tip fee can have a significant impact on biogas plant economic feasibility. For example, if mixed food waste tip fee is \$35/tonne or \$50/tonne instead of \$25/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$19.11/GJ to <\$18/GJ and <\$16/GJ respectively. Alternately, if mixed food waste tip fee is only \$10/tonne or \$0/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% increases from \$19.11/GJ to >\$21/GJ and >\$22/GJ respectively.

Option C: Sensitivity Analysis – Mixed Food Waste Tip Fee

		Mixed Food Waste Tip Fee (\$/Tonne)										
		\$0	\$5	\$10	\$15	\$20	\$25	\$30	\$35	\$40	\$45	\$50
\$/GJ RNG	\$12	---	---	---	---	---	---	1.3%	2.8%	4.2%	5.5%	6.7%
	\$13	---	---	---	---	0.3%	1.9%	3.4%	4.7%	6.0%	7.2%	8.3%
	\$14	---	---	---	1.0%	2.5%	3.9%	5.2%	6.5%	7.6%	8.8%	9.8%
	\$15	---	0.1%	1.7%	3.1%	4.5%	5.7%	6.9%	8.1%	9.2%	10.3%	11.3%
	\$16	0.8%	2.3%	3.7%	5.0%	6.2%	7.4%	8.5%	9.6%	10.7%	11.7%	12.7%
	\$17	2.9%	4.2%	5.5%	6.7%	7.8%	8.9%	10.0%	11.1%	12.1%	13.1%	14.0%
	\$18	4.7%	6.0%	7.1%	8.3%	9.4%	10.4%	11.4%	12.4%	13.4%	14.4%	15.3%
	\$19	6.4%	7.6%	8.7%	9.8%	10.8%	11.8%	12.8%	13.8%	14.7%	15.7%	16.6%
	\$20	8.0%	9.1%	10.2%	11.2%	12.2%	13.2%	14.1%	15.1%	16.0%	17.0%	17.9%
	\$21	9.5%	10.6%	11.6%	12.6%	13.5%	14.5%	15.4%	16.4%	17.3%	18.2%	19.1%
	\$22	11.0%	12.0%	12.9%	13.9%	14.8%	15.8%	16.7%	17.6%	18.5%	19.4%	20.3%
	\$23	12.3%	13.3%	14.3%	15.2%	16.1%	17.0%	17.9%	18.8%	19.7%	20.6%	21.5%
	\$24	13.7%	14.6%	15.5%	16.5%	17.4%	18.3%	19.2%	20.0%	20.9%	21.8%	22.7%
	\$25	14.9%	15.9%	16.8%	17.7%	18.6%	19.5%	20.4%	21.2%	22.1%	23.0%	23.8%
	\$26	16.2%	17.1%	18.0%	18.9%	19.8%	20.6%	21.5%	22.4%	23.3%	24.1%	25.0%
	\$27	17.3%	18.2%	19.1%	20.0%	20.9%	21.7%	22.6%	23.5%	24.4%	25.2%	26.1%
	\$28	18.3%	19.2%	20.1%	21.0%	21.9%	22.7%	23.6%	24.5%	25.4%	26.2%	27.1%
\$29	19.0%	20.0%	20.9%	21.8%	22.7%	23.6%	24.4%	25.3%	26.2%	27.1%	27.9%	
\$30	19.4%	20.4%	21.3%	22.2%	23.1%	24.0%	24.9%	25.8%	26.6%	27.5%	28.4%	

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #8 - Option D: Nutrient Recovery Equipment

This biogas plant is estimated to cost \$10.0 million to build. Operating costs are estimated to average \$1,469,998/year. At an RNG sale price of \$18.58/GJ, average revenue is estimated to be \$2,800,419/year. This biogas plant doesn't require funding for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$1,330,421/year; equal to 91% of operating costs. Operating income should be sufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (i.e., broken equipment, unexpected downtime, etc.).

Option D: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>	<u>Revenue</u>		<u>Investment</u>	
Digester	\$3,441,375		RNG/GJ [†] =	\$18.58	Farm Investment =	\$10,031,191
Upgrader	\$3,536,400		Avg RNG Sales/Yr =	\$2,228,210	Funding Amount =	\$0
Nutrient Rec.	\$1,746,896		Tip Fee/Yr =	\$420,350	Funding % of CAPEX =	0%
Other	\$1,306,520		Bedding Savings/Yr* =	\$151,859		
Total	<u>\$10,031,191</u>	<u>\$1,469,998</u>	Total =	<u>\$2,800,419</u>	Inflation =	2%

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$2,569	\$2,592	\$2,615	\$2,638	\$2,662	\$2,685	\$2,709	\$2,734	\$2,758	\$2,783
OPEX (000s)	\$1,210	\$1,234	\$1,259	\$1,284	\$1,310	\$1,336	\$1,363	\$1,390	\$1,418	\$1,446
<i>Income (000s)</i>	\$1,359	\$1,358	\$1,356	\$1,354	\$1,352	\$1,349	\$1,347	\$1,344	\$1,341	\$1,337

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$2,808	\$2,834	\$2,860	\$2,885	\$2,912	\$2,938	\$2,965	\$2,992	\$3,020	\$3,048
OPEX (000s)	\$1,475	\$1,504	\$1,535	\$1,565	\$1,597	\$1,629	\$1,661	\$1,694	\$1,728	\$1,763
<i>Income (000s)</i>	\$1,333	\$1,329	\$1,325	\$1,320	\$1,315	\$1,310	\$1,304	\$1,298	\$1,292	\$1,285

Unlevered, Pre-Tax IRR =	12%
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Average Operating Income* =	\$1,330,421
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% of OPEX	91%
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* Averaged over twenty years to account for inflation

† Base price (1%/year increase up to \$30/GJ max)

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 80% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, if RNG production is 10% or 20% higher than anticipated (due to the availability of high biogas-potential mixed food waste), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$18.58/GJ to <\$17/GJ and <\$16/GJ respectively. Alternately, if RNG production is 10% or 20% lower than anticipated, the required RNG sale price for an unlevered, pre-tax IRR increases from \$18.58/GJ to >\$20/GJ and >\$23/GJ respectively. Furthermore, if only 50% of estimated mixed food waste is available (8,407 instead of 16,814 tonnes/year), RNG production will be approximately 35% lower. If RNG production is 35% lower, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 11.6%. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option D: Sensitivity Analysis – RNG Production

		Change in RNG Production Amount														
		-50%	-45%	-40%	-35%	-30%	-25%	-20%	-15%	-10%	-5%	0%	5%	10%	15%	20%
\$/GJ RNG	\$12	---	---	---	---	---	---	---	---	---	---	0.8%	2.1%	3.4%	4.5%	5.6%
	\$13	---	---	---	---	---	---	---	---	0.1%	1.6%	3.0%	4.2%	5.4%	6.5%	7.6%
	\$14	---	---	---	---	---	---	---	0.6%	2.1%	3.5%	4.9%	6.1%	7.3%	8.4%	9.4%
	\$15	---	---	---	---	---	---	0.8%	2.4%	3.9%	5.3%	6.6%	7.8%	9.0%	10.1%	11.2%
	\$16	---	---	---	---	---	0.8%	2.5%	4.1%	5.6%	6.9%	8.2%	9.4%	10.6%	11.7%	12.8%
	\$17	---	---	---	---	0.6%	2.4%	4.1%	5.7%	7.1%	8.4%	9.7%	11.0%	12.2%	13.3%	14.4%
	\$18	---	---	---	0.1%	2.1%	3.9%	5.6%	7.1%	8.5%	9.9%	11.2%	12.4%	13.7%	14.8%	16.0%
	\$19	---	---	---	1.6%	3.5%	5.3%	6.9%	8.4%	9.9%	11.3%	12.6%	13.9%	15.1%	16.3%	17.5%
	\$20	---	---	0.8%	3.0%	4.9%	6.6%	8.2%	9.7%	11.2%	12.6%	13.9%	15.2%	16.5%	17.8%	19.0%
	\$21	---	---	2.1%	4.2%	6.1%	7.8%	9.4%	11.0%	12.4%	13.9%	15.2%	16.6%	17.9%	19.2%	20.4%
	\$22	---	1.0%	3.4%	5.4%	7.3%	9.0%	10.6%	12.2%	13.7%	15.1%	16.5%	17.9%	19.2%	20.6%	21.9%
	\$23	---	2.2%	4.5%	6.5%	8.4%	10.1%	11.7%	13.3%	14.8%	16.3%	17.8%	19.2%	20.6%	21.9%	23.3%
	\$24	0.8%	3.4%	5.6%	7.6%	9.4%	11.2%	12.8%	14.4%	16.0%	17.5%	19.0%	20.4%	21.9%	23.3%	24.7%
	\$25	1.9%	4.4%	6.6%	8.6%	10.5%	12.2%	13.9%	15.5%	17.1%	18.7%	20.2%	21.7%	23.2%	24.6%	26.1%
	\$26	2.8%	5.3%	7.5%	9.5%	11.4%	13.2%	14.9%	16.6%	18.2%	19.8%	21.4%	22.9%	24.4%	25.9%	27.4%
	\$27	3.5%	6.0%	8.2%	10.3%	12.2%	14.1%	15.8%	17.6%	19.2%	20.9%	22.5%	24.1%	25.6%	27.2%	28.7%
	\$28	4.0%	6.6%	8.9%	11.0%	12.9%	14.8%	16.6%	18.4%	20.1%	21.8%	23.5%	25.1%	26.8%	28.4%	30.0%
\$29	4.4%	7.0%	9.3%	11.4%	13.4%	15.4%	17.3%	19.1%	20.8%	22.6%	24.3%	26.0%	27.7%	29.4%	31.0%	
\$30	4.5%	7.1%	9.5%	11.6%	13.7%	15.7%	17.6%	19.4%	21.2%	23.0%	24.7%	26.5%	28.2%	29.9%	31.6%	

B.C. On-Farm Biogas Benchmark Study, Version 2

Mixed food waste tip fee accounts for 15% of biogas plant revenue. Therefore, although less important than RNG sales, food waste tip fee can have a significant impact on biogas plant economic feasibility. For example, if mixed food waste tip fee is \$35/tonne or \$50/tonne instead of \$25/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$18.58/GJ to <\$18/GJ and <\$15/GJ respectively. Alternately, if mixed food waste tip fee is only \$10/tonne or \$0/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% increases from \$18.58/GJ to >\$20/GJ and >\$22/GJ respectively.

Option D: Sensitivity Analysis – Mixed Food Waste Tip Fee

		Mixed Food Waste Tip Fee (\$/Tonne)										
		\$0	\$5	\$10	\$15	\$20	\$25	\$30	\$35	\$40	\$45	\$50
\$/GJ RNG	\$12	---	---	---	---	---	0.8%	2.4%	3.8%	5.1%	6.4%	7.6%
	\$13	---	---	---	---	1.5%	3.0%	4.3%	5.6%	6.8%	8.0%	9.1%
	\$14	---	---	0.5%	2.1%	3.5%	4.9%	6.1%	7.3%	8.5%	9.6%	10.6%
	\$15	---	1.2%	2.7%	4.1%	5.4%	6.6%	7.8%	8.9%	10.0%	11.0%	12.1%
	\$16	1.9%	3.3%	4.6%	5.9%	7.1%	8.2%	9.3%	10.4%	11.4%	12.4%	13.4%
	\$17	3.8%	5.1%	6.4%	7.5%	8.6%	9.7%	10.8%	11.8%	12.8%	13.8%	14.8%
	\$18	5.6%	6.8%	8.0%	9.1%	10.1%	11.2%	12.2%	13.2%	14.2%	15.1%	16.1%
	\$19	7.3%	8.4%	9.5%	10.5%	11.6%	12.6%	13.6%	14.5%	15.5%	16.4%	17.3%
	\$20	8.8%	9.9%	10.9%	12.0%	12.9%	13.9%	14.9%	15.8%	16.8%	17.7%	18.6%
	\$21	10.3%	11.3%	12.3%	13.3%	14.3%	15.2%	16.2%	17.1%	18.0%	18.9%	19.8%
	\$22	11.7%	12.7%	13.7%	14.6%	15.6%	16.5%	17.4%	18.3%	19.2%	20.1%	21.0%
	\$23	13.1%	14.0%	15.0%	15.9%	16.8%	17.8%	18.7%	19.6%	20.5%	21.3%	22.2%
	\$24	14.4%	15.3%	16.3%	17.2%	18.1%	19.0%	19.9%	20.8%	21.7%	22.5%	23.4%
	\$25	15.7%	16.6%	17.5%	18.4%	19.3%	20.2%	21.1%	22.0%	22.8%	23.7%	24.6%
	\$26	16.9%	17.8%	18.7%	19.6%	20.5%	21.4%	22.2%	23.1%	24.0%	24.9%	25.7%
	\$27	18.0%	18.9%	19.8%	20.7%	21.6%	22.5%	23.4%	24.2%	25.1%	26.0%	26.8%
	\$28	19.0%	19.9%	20.8%	21.7%	22.6%	23.5%	24.4%	25.2%	26.1%	27.0%	27.8%
\$29	19.8%	20.7%	21.6%	22.5%	23.4%	24.3%	25.2%	26.1%	27.0%	27.8%	28.7%	
\$30	20.2%	21.1%	22.0%	22.9%	23.8%	24.7%	25.6%	26.5%	27.4%	28.3%	29.2%	

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #8 - Option E: Mixed Food Waste Cleaning & RNG Compression Equipment

This biogas plant is estimated to cost \$11.3 million to build. Operating costs are estimated to average \$1,613,328/year. At an RNG sale price of \$21.14/GJ, average revenue is estimated to be \$3,107,533/year. This biogas plant doesn't require funding for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$1,494,205/year; equal to 93% of operating costs. Operating income should be sufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (i.e., broken equipment, unexpected downtime, etc.).

Option E: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>	<u>Revenue</u>		<u>Investment</u>	
Digester	\$4,200,000		RNG/GJ [†] =	\$21.14	Farm Investment =	\$11,262,626
Upgrader	\$4,523,821		Avg RNG Sales/Yr =	\$2,535,324	Funding Amount =	\$0
Nutrient Rec.	\$1,071,896		Tip Fee/Yr =	\$420,350	Funding % of CAPEX =	0%
Other	\$1,466,909		Bedding Savings/Yr* =	\$151,859		
Total	<u>\$11,262,626</u>	<u>\$1,613,328</u>	Total =	<u>\$3,107,533</u>	Inflation =	2%

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$2,848	\$2,874	\$2,899	\$2,925	\$2,952	\$2,979	\$3,006	\$3,033	\$3,060	\$3,088
OPEX (000s)	\$1,328	\$1,355	\$1,382	\$1,409	\$1,437	\$1,466	\$1,496	\$1,525	\$1,556	\$1,587
<i>Income (000s)</i>	\$1,520	\$1,519	\$1,518	\$1,516	\$1,514	\$1,512	\$1,510	\$1,507	\$1,505	\$1,501

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$3,116	\$3,145	\$3,174	\$3,203	\$3,232	\$3,262	\$3,292	\$3,323	\$3,354	\$3,385
OPEX (000s)	\$1,619	\$1,651	\$1,684	\$1,718	\$1,752	\$1,787	\$1,823	\$1,860	\$1,897	\$1,935
<i>Income (000s)</i>	\$1,498	\$1,494	\$1,490	\$1,485	\$1,480	\$1,475	\$1,469	\$1,463	\$1,457	\$1,450

Unlevered, Pre-Tax IRR =	12%
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Average Operating Income* =	\$1,494,205
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% of OPEX	93%
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* Averaged over twenty years to account for inflation

† Base price (1%/year increase up to \$30/GJ max)

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 82% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, if RNG production is 10% or 20% higher than anticipated (due to the availability of high biogas-potential mixed food waste), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$21.14/GJ to <\$20/GJ and <\$18/GJ respectively. Alternately, if RNG production is 10% or 20% lower than anticipated, the required RNG sale price for an unlevered, pre-tax IRR increases from \$21.14/GJ to >\$23/GJ and >\$26/GJ respectively. Furthermore, if only 50% of estimated mixed food waste is available (8,407 instead of 16,814 tonnes/year), RNG production will be approximately 35% lower. If RNG production is 35% lower, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 8.1%. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option E: Sensitivity Analysis – RNG Production

		Change in RNG Production Amount															
		-50%	-45%	-40%	-35%	-30%	-25%	-20%	-15%	-10%	-5%	0%	5%	10%	15%	20%	
\$/GJ RNG	\$12	---	---	---	---	---	---	---	---	---	---	---	---	---	0.9%	2.1%	
	\$13	---	---	---	---	---	---	---	---	---	---	---	0.6%	1.9%	3.1%	4.2%	
	\$14	---	---	---	---	---	---	---	---	---	---	1.3%	2.6%	3.9%	5.0%	6.1%	
	\$15	---	---	---	---	---	---	---	---	0.3%	1.8%	3.2%	4.4%	5.6%	6.8%	7.9%	
	\$16	---	---	---	---	---	---	---	0.5%	2.1%	3.5%	4.9%	6.1%	7.3%	8.4%	9.5%	
	\$17	---	---	---	---	---	---	0.5%	2.2%	3.7%	5.1%	6.4%	7.6%	8.8%	10.0%	11.0%	
	\$18	---	---	---	---	---	0.3%	2.1%	3.7%	5.2%	6.6%	7.9%	9.1%	10.3%	11.4%	12.5%	
	\$19	---	---	---	---	---	1.8%	3.5%	5.1%	6.6%	7.9%	9.2%	10.5%	11.7%	12.8%	14.0%	
	\$20	---	---	---	---	1.3%	3.2%	4.9%	6.4%	7.9%	9.2%	10.5%	11.8%	13.0%	14.2%	15.4%	
	\$21	---	---	---	0.6%	2.6%	4.4%	6.1%	7.6%	9.1%	10.5%	11.8%	13.1%	14.3%	15.5%	16.7%	
	\$22	---	---	---	1.9%	3.9%	5.6%	7.3%	8.8%	10.3%	11.7%	13.0%	14.3%	15.6%	16.8%	18.1%	
	\$23	---	---	0.9%	3.1%	5.0%	6.8%	8.4%	10.0%	11.4%	12.8%	14.2%	15.5%	16.8%	18.1%	19.4%	
	\$24	---	---	2.1%	4.2%	6.1%	7.9%	9.5%	11.0%	12.5%	14.0%	15.4%	16.7%	18.1%	19.4%	20.7%	
	\$25	---	0.8%	3.2%	5.2%	7.1%	8.9%	10.5%	12.1%	13.6%	15.1%	16.5%	17.9%	19.3%	20.6%	21.9%	
	\$26	---	1.7%	4.1%	6.2%	8.0%	9.8%	11.5%	13.1%	14.6%	16.1%	17.6%	19.0%	20.4%	21.8%	23.2%	
	\$27	---	2.4%	4.8%	6.9%	8.8%	10.6%	12.3%	14.0%	15.5%	17.1%	18.6%	20.1%	21.5%	22.9%	24.3%	
	\$28	0.2%	3.0%	5.4%	7.5%	9.5%	11.3%	13.0%	14.7%	16.3%	17.9%	19.5%	21.0%	22.5%	24.0%	25.4%	
	\$29	0.5%	3.3%	5.7%	7.9%	9.9%	11.8%	13.6%	15.3%	17.0%	18.6%	20.2%	21.7%	23.3%	24.8%	26.3%	
\$30	0.6%	3.4%	5.9%	8.1%	10.1%	12.0%	13.8%	15.6%	17.3%	18.9%	20.5%	22.1%	23.7%	25.3%	26.8%		

B.C. On-Farm Biogas Benchmark Study, Version 2

Mixed food waste tip fee accounts for 14% of biogas plant revenue. Therefore, although less important than RNG sales, food waste tip fee can have a significant impact on biogas plant economic feasibility. For example, if mixed food waste tip fee is \$35/tonne or \$50/tonne instead of \$25/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$21.14/GJ to <\$20/GJ and <\$18/GJ respectively. Alternately, if mixed food waste tip fee is only \$10/tonne or \$0/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% increases from \$21.14/GJ to >\$23/GJ and >\$24/GJ respectively.

Option E: Sensitivity Analysis – Mixed Food Waste Tip Fee

		Mixed Food Waste Tip Fee (\$/Tonne)										
		\$0	\$5	\$10	\$15	\$20	\$25	\$30	\$35	\$40	\$45	\$50
\$/GJ RNG	\$12	---	---	---	---	---	---	---	0.1%	1.5%	2.9%	4.1%
	\$13	---	---	---	---	---	---	0.7%	2.1%	3.4%	4.6%	5.8%
	\$14	---	---	---	---	---	1.3%	2.6%	3.9%	5.1%	6.2%	7.3%
	\$15	---	---	---	0.5%	1.9%	3.2%	4.4%	5.5%	6.6%	7.7%	8.7%
	\$16	---	---	1.1%	2.4%	3.7%	4.9%	6.0%	7.0%	8.1%	9.1%	10.0%
	\$17	0.3%	1.7%	3.0%	4.2%	5.3%	6.4%	7.5%	8.5%	9.4%	10.4%	11.3%
	\$18	2.2%	3.5%	4.6%	5.8%	6.8%	7.9%	8.9%	9.8%	10.8%	11.7%	12.6%
	\$19	3.9%	5.1%	6.2%	7.2%	8.2%	9.2%	10.2%	11.1%	12.0%	12.9%	13.8%
	\$20	5.5%	6.6%	7.6%	8.6%	9.6%	10.5%	11.5%	12.4%	13.2%	14.1%	15.0%
	\$21	7.0%	8.0%	9.0%	10.0%	10.9%	11.8%	12.7%	13.6%	14.4%	15.3%	16.1%
	\$22	8.4%	9.4%	10.3%	11.2%	12.1%	13.0%	13.9%	14.7%	15.6%	16.4%	17.3%
	\$23	9.7%	10.7%	11.6%	12.5%	13.3%	14.2%	15.1%	15.9%	16.7%	17.5%	18.4%
	\$24	11.0%	11.9%	12.8%	13.7%	14.5%	15.4%	16.2%	17.0%	17.8%	18.7%	19.5%
	\$25	12.3%	13.1%	14.0%	14.8%	15.7%	16.5%	17.3%	18.1%	18.9%	19.7%	20.5%
	\$26	13.4%	14.2%	15.1%	15.9%	16.8%	17.6%	18.4%	19.2%	20.0%	20.8%	21.6%
	\$27	14.4%	15.3%	16.1%	16.9%	17.8%	18.6%	19.4%	20.2%	21.0%	21.8%	22.6%
	\$28	15.3%	16.2%	17.0%	17.8%	18.7%	19.5%	20.3%	21.1%	21.9%	22.7%	23.5%
\$29	16.0%	16.8%	17.7%	18.5%	19.4%	20.2%	21.0%	21.8%	22.6%	23.4%	24.2%	
\$30	16.3%	17.2%	18.0%	18.9%	19.7%	20.5%	21.4%	22.2%	23.0%	23.8%	24.6%	

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #8 - Option F: Mixed Food Waste Cleaning & Nutrient Recovery Equipment

This biogas plant is estimated to cost \$11.2 million to build. Operating costs are estimated to average \$1,558,856/year. At an RNG sale price of \$20.61/GJ, average revenue is estimated to be \$3,044,126/year. This biogas plant doesn't require funding for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$1,485,270/year; equal to 95% of operating costs. Operating income should be sufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (i.e., broken equipment, unexpected downtime, etc.).

Option F: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>	<u>Revenue</u>		<u>Investment</u>	
Digester	\$4,431,000		RNG/GJ [†] =	\$20.61	Farm Investment =	\$11,169,012
Upgrader	\$3,536,400		Avg RNG Sales/Yr =	\$2,471,918	Funding Amount =	\$0
Nutrient Rec.	\$1,746,896		Tip Fee/Yr =	\$420,350	Funding % of CAPEX =	0%
Other	\$1,454,716		Bedding Savings/Yr* =	\$151,859		
Total	<u>\$11,169,012</u>	<u>\$1,558,856</u>	Total =	<u>\$3,044,126</u>	Inflation =	2%

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$2,790	\$2,815	\$2,841	\$2,866	\$2,892	\$2,918	\$2,944	\$2,971	\$2,998	\$3,025
OPEX (000s)	\$1,283	\$1,309	\$1,335	\$1,362	\$1,389	\$1,417	\$1,445	\$1,474	\$1,503	\$1,533
<i>Income (000s)</i>	\$1,507	\$1,507	\$1,506	\$1,504	\$1,503	\$1,501	\$1,499	\$1,497	\$1,495	\$1,492

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$3,053	\$3,081	\$3,109	\$3,137	\$3,166	\$3,195	\$3,225	\$3,255	\$3,285	\$3,315
OPEX (000s)	\$1,564	\$1,595	\$1,627	\$1,660	\$1,693	\$1,727	\$1,761	\$1,797	\$1,833	\$1,869
<i>Income (000s)</i>	\$1,489	\$1,485	\$1,482	\$1,478	\$1,473	\$1,468	\$1,463	\$1,458	\$1,452	\$1,446

Unlevered, Pre-Tax IRR =	12%
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Average Operating Income* =	\$1,485,270
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% of OPEX	95%
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* Averaged over twenty years to account for inflation

† Base price (1%/year increase up to \$30/GJ max)

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 81% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, if RNG production is 10% or 20% higher than anticipated (due to the availability of high biogas-potential mixed food waste), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$20.61/GJ to <\$19/GJ and <\$18/GJ respectively. Alternately, if RNG production is 10% or 20% lower than anticipated, the required RNG sale price for an unlevered, pre-tax IRR increases from \$20.61/GJ to >\$22/GJ and >\$25/GJ respectively. Furthermore, if only 50% of estimated mixed food waste is available (8,407 instead of 16,814 tonnes/year), RNG production will be approximately 35% lower. If RNG production is 35% lower, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 8.9%. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option F: Sensitivity Analysis – RNG Production

		Change in RNG Production Amount														
		-50%	-45%	-40%	-35%	-30%	-25%	-20%	-15%	-10%	-5%	0%	5%	10%	15%	20%
\$/GJ RNG	\$12	---	---	---	---	---	---	---	---	---	---	---	---	0.7%	1.9%	3.0%
	\$13	---	---	---	---	---	---	---	---	---	---	0.3%	1.6%	2.8%	4.0%	5.0%
	\$14	---	---	---	---	---	---	---	---	---	0.9%	2.3%	3.5%	4.7%	5.8%	6.9%
	\$15	---	---	---	---	---	---	---	---	1.3%	2.7%	4.0%	5.3%	6.4%	7.5%	8.6%
	\$16	---	---	---	---	---	---	---	1.5%	3.0%	4.4%	5.7%	6.9%	8.0%	9.1%	10.2%
	\$17	---	---	---	---	---	---	1.5%	3.1%	4.5%	5.9%	7.2%	8.4%	9.5%	10.7%	11.7%
	\$18	---	---	---	---	---	1.3%	3.0%	4.5%	6.0%	7.3%	8.6%	9.8%	11.0%	12.1%	13.2%
	\$19	---	---	---	---	0.9%	2.7%	4.4%	5.9%	7.3%	8.7%	9.9%	11.2%	12.4%	13.5%	14.6%
	\$20	---	---	---	0.3%	2.3%	4.0%	5.7%	7.2%	8.6%	9.9%	11.2%	12.5%	13.7%	14.9%	16.0%
	\$21	---	---	---	1.6%	3.5%	5.3%	6.9%	8.4%	9.8%	11.2%	12.5%	13.7%	15.0%	16.2%	17.4%
	\$22	---	---	0.7%	2.8%	4.7%	6.4%	8.0%	9.5%	11.0%	12.4%	13.7%	15.0%	16.2%	17.5%	18.7%
	\$23	---	---	1.9%	4.0%	5.8%	7.5%	9.1%	10.7%	12.1%	13.5%	14.9%	16.2%	17.5%	18.8%	20.0%
	\$24	---	0.7%	3.0%	5.0%	6.9%	8.6%	10.2%	11.7%	13.2%	14.6%	16.0%	17.4%	18.7%	20.0%	21.3%
	\$25	---	1.8%	4.0%	6.0%	7.9%	9.6%	11.2%	12.8%	14.3%	15.7%	17.1%	18.5%	19.9%	21.2%	22.6%
	\$26	0.1%	2.7%	4.9%	6.9%	8.8%	10.5%	12.2%	13.8%	15.3%	16.8%	18.2%	19.7%	21.1%	22.4%	23.8%
	\$27	0.8%	3.4%	5.6%	7.7%	9.6%	11.3%	13.0%	14.6%	16.2%	17.7%	19.2%	20.7%	22.2%	23.6%	25.0%
	\$28	1.3%	3.9%	6.2%	8.3%	10.2%	12.0%	13.7%	15.4%	17.0%	18.6%	20.1%	21.7%	23.1%	24.6%	26.1%
\$29	1.6%	4.2%	6.6%	8.7%	10.6%	12.5%	14.3%	16.0%	17.6%	19.3%	20.8%	22.4%	24.0%	25.5%	27.0%	
\$30	1.7%	4.4%	6.7%	8.9%	10.8%	12.7%	14.5%	16.3%	17.9%	19.6%	21.2%	22.8%	24.4%	25.9%	27.5%	

B.C. On-Farm Biogas Benchmark Study, Version 2

Mixed food waste tip fee accounts for 14% of biogas plant revenue. Therefore, although less important than RNG sales, food waste tip fee can have a significant impact on biogas plant economic feasibility. For example, if mixed food waste tip fee is \$35/tonne or \$50/tonne instead of \$25/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$20.61/GJ to <\$20/GJ and \$17/GJ respectively. Alternately, if mixed food waste tip fee is only \$10/tonne or \$0/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% increases from \$20.61/GJ to >\$22/GJ and >\$24/GJ respectively.

Option F: Sensitivity Analysis – Mixed Food Waste Tip Fee

		Mixed Food Waste Tip Fee (\$/Tonne)										
		\$0	\$5	\$10	\$15	\$20	\$25	\$30	\$35	\$40	\$45	\$50
\$/GJ RNG	\$12	---	---	---	---	---	---	---	1.1%	2.5%	3.8%	5.0%
	\$13	---	---	---	---	---	0.3%	1.7%	3.0%	4.3%	5.4%	6.5%
	\$14	---	---	---	---	0.9%	2.3%	3.5%	4.7%	5.9%	7.0%	8.0%
	\$15	---	---	0.0%	1.5%	2.8%	4.0%	5.2%	6.3%	7.4%	8.4%	9.4%
	\$16	---	0.7%	2.0%	3.3%	4.5%	5.7%	6.8%	7.8%	8.8%	9.8%	10.7%
	\$17	1.3%	2.6%	3.8%	5.0%	6.1%	7.2%	8.2%	9.2%	10.2%	11.1%	12.0%
	\$18	3.1%	4.3%	5.4%	6.5%	7.6%	8.6%	9.6%	10.5%	11.4%	12.4%	13.3%
	\$19	4.8%	5.9%	7.0%	8.0%	9.0%	9.9%	10.9%	11.8%	12.7%	13.6%	14.5%
	\$20	6.3%	7.4%	8.4%	9.3%	10.3%	11.2%	12.1%	13.0%	13.9%	14.8%	15.6%
	\$21	7.8%	8.8%	9.7%	10.7%	11.6%	12.5%	13.4%	14.2%	15.1%	15.9%	16.8%
	\$22	9.1%	10.1%	11.0%	11.9%	12.8%	13.7%	14.6%	15.4%	16.2%	17.1%	17.9%
	\$23	10.4%	11.4%	12.3%	13.1%	14.0%	14.9%	15.7%	16.5%	17.4%	18.2%	19.0%
	\$24	11.7%	12.6%	13.5%	14.3%	15.2%	16.0%	16.9%	17.7%	18.5%	19.3%	20.1%
	\$25	12.9%	13.8%	14.6%	15.5%	16.3%	17.1%	18.0%	18.8%	19.6%	20.4%	21.2%
	\$26	14.0%	14.9%	15.7%	16.6%	17.4%	18.2%	19.0%	19.8%	20.6%	21.4%	22.2%
	\$27	15.1%	15.9%	16.8%	17.6%	18.4%	19.2%	20.0%	20.8%	21.6%	22.4%	23.2%
	\$28	16.0%	16.8%	17.7%	18.5%	19.3%	20.1%	20.9%	21.8%	22.6%	23.3%	24.1%
\$29	16.6%	17.5%	18.4%	19.2%	20.0%	20.8%	21.7%	22.5%	23.3%	24.1%	24.9%	
\$30	17.0%	17.8%	18.7%	19.5%	20.4%	21.2%	22.0%	22.9%	23.7%	24.5%	25.3%	

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #8 - Option G: RNG Compression and Nutrient Recovery Equipment

This biogas plant is estimated to cost \$11.2 million to build. Operating costs are estimated to average \$1,851,634/year. At an RNG sale price of \$22.98/GJ, average revenue is estimated to be \$3,328,946/year. This biogas plant doesn't require funding for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$1,477,312/year; equal to 80% of operating costs. Operating income should be sufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (i.e., broken equipment, unexpected downtime, etc.).

Option G: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>	<u>Revenue</u>	<u>Investment</u>
Digester	\$3,441,375		RNG/GJ [†] = \$22.98	Farm Investment = \$11,166,478
Upgrader	\$4,523,821		Avg RNG Sales/Yr = \$2,756,737	Funding Amount = \$0
Nutrient Rec.	\$1,746,896		Tip Fee/Yr = \$420,350	Funding % of CAPEX = 0%
Other	\$1,454,386		Bedding Savings/Yr* = \$151,859	
Total	<u>\$11,166,478</u>	<u>\$1,851,634</u>	Total = <u>\$3,328,946</u>	Inflation = 2%

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$3,049	\$3,077	\$3,105	\$3,133	\$3,161	\$3,190	\$3,219	\$3,248	\$3,278	\$3,308
OPEX (000s)	\$1,524	\$1,555	\$1,586	\$1,617	\$1,650	\$1,683	\$1,716	\$1,751	\$1,786	\$1,821
<i>Income (000s)</i>	\$1,525	\$1,522	\$1,519	\$1,515	\$1,511	\$1,507	\$1,503	\$1,498	\$1,492	\$1,487

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$3,339	\$3,369	\$3,400	\$3,432	\$3,464	\$3,496	\$3,528	\$3,561	\$3,594	\$3,628
OPEX (000s)	\$1,858	\$1,895	\$1,933	\$1,972	\$2,011	\$2,051	\$2,092	\$2,134	\$2,177	\$2,220
<i>Income (000s)</i>	\$1,481	\$1,474	\$1,467	\$1,460	\$1,453	\$1,444	\$1,436	\$1,427	\$1,417	\$1,407

Unlevered, Pre-Tax IRR =	12%
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Average Operating Income* =	\$1,477,312
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% of OPEX	80%
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* Averaged over twenty years to account for inflation

† Base price (1%/year increase up to \$30/GJ max)

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 83% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, if RNG production is 10% or 20% higher than anticipated (due to the availability of high biogas-potential mixed food waste), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$22.98/GJ to <\$21/GJ and <\$20/GJ respectively. Alternately, if RNG production is 10% lower than anticipated, the required RNG sale price for an unlevered, pre-tax IRR increases from \$22.98/GJ to >\$25/GJ. If RNG production is 20% lower than anticipated, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 10.7%. Furthermore, if only 50% of estimated mixed food waste is available (8,407 instead of 16,814 tonnes/year), RNG production will be approximately 35% lower. If RNG production is 35% lower, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 5.0%. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option G: Sensitivity Analysis – RNG Production

		Change in RNG Production Amount														
		-50%	-45%	-40%	-35%	-30%	-25%	-20%	-15%	-10%	-5%	0%	5%	10%	15%	20%
\$/GJ RNG	\$14	---	---	---	---	---	---	---	---	---	---	---	---	0.2%	1.6%	3.0%
	\$15	---	---	---	---	---	---	---	---	---	---	---	0.9%	2.4%	3.8%	5.0%
	\$16	---	---	---	---	---	---	---	---	---	---	1.4%	3.0%	4.4%	5.7%	6.9%
	\$17	---	---	---	---	---	---	---	---	0.0%	1.7%	3.3%	4.8%	6.1%	7.4%	8.6%
	\$18	---	---	---	---	---	---	---	0.0%	1.8%	3.5%	5.0%	6.4%	7.8%	9.0%	10.2%
	\$19	---	---	---	---	---	---	---	1.7%	3.5%	5.1%	6.6%	8.0%	9.3%	10.6%	11.8%
	\$20	---	---	---	---	---	---	1.4%	3.3%	5.0%	6.6%	8.1%	9.4%	10.8%	12.0%	13.3%
	\$21	---	---	---	---	---	0.9%	3.0%	4.8%	6.4%	8.0%	9.4%	10.8%	12.2%	13.5%	14.7%
	\$22	---	---	---	---	0.2%	2.4%	4.4%	6.1%	7.8%	9.3%	10.8%	12.2%	13.5%	14.8%	16.1%
	\$23	---	---	---	---	1.6%	3.8%	5.7%	7.4%	9.0%	10.6%	12.0%	13.5%	14.8%	16.2%	17.5%
	\$24	---	---	---	0.6%	3.0%	5.0%	6.9%	8.6%	10.2%	11.8%	13.3%	14.7%	16.1%	17.5%	18.8%
	\$25	---	---	---	1.9%	4.2%	6.2%	8.1%	9.8%	11.4%	13.0%	14.5%	15.9%	17.3%	18.7%	20.1%
	\$26	---	---	0.4%	3.0%	5.2%	7.2%	9.1%	10.8%	12.5%	14.1%	15.6%	17.1%	18.5%	20.0%	21.4%
	\$27	---	---	1.2%	3.8%	6.1%	8.1%	10.0%	11.7%	13.4%	15.0%	16.6%	18.1%	19.6%	21.1%	22.6%
	\$28	---	---	1.8%	4.4%	6.7%	8.8%	10.7%	12.5%	14.2%	15.9%	17.5%	19.1%	20.6%	22.2%	23.7%
	\$29	---	---	2.2%	4.9%	7.2%	9.3%	11.2%	13.1%	14.8%	16.6%	18.2%	19.8%	21.4%	23.0%	24.6%
\$30	---	---	2.4%	5.0%	7.4%	9.5%	11.5%	13.3%	15.1%	16.9%	18.6%	20.2%	21.9%	23.4%	25.0%	

B.C. On-Farm Biogas Benchmark Study, Version 2

Mixed food waste tip fee accounts for 13% of biogas plant revenue. Therefore, although less important than RNG sales, food waste tip fee can have a significant impact on biogas plant economic feasibility. For example, if mixed food waste tip fee is \$35/tonne or \$50/tonne instead of \$25/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$22.98/GJ to <\$22/GJ and <\$20/GJ respectively. Alternately, if mixed food waste tip fee is only \$10/tonne or \$0/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% increases from \$22.98/GJ to >\$25/GJ and >\$26/GJ respectively.

Option G: Sensitivity Analysis – Mixed Food Waste Tip Fee

		Mixed Food Waste Tip Fee (\$/Tonne)										
		\$0	\$5	\$10	\$15	\$20	\$25	\$30	\$35	\$40	\$45	\$50
\$/GJ RNG	\$12	---	---	---	---	---	---	---	---	---	---	0.4%
	\$13	---	---	---	---	---	---	---	---	---	1.1%	2.5%
	\$14	---	---	---	---	---	---	---	0.2%	1.7%	3.0%	4.3%
	\$15	---	---	---	---	---	---	0.8%	2.2%	3.6%	4.8%	5.9%
	\$16	---	---	---	---	---	1.4%	2.8%	4.1%	5.3%	6.4%	7.5%
	\$17	---	---	---	0.6%	2.0%	3.3%	4.6%	5.7%	6.8%	7.9%	8.9%
	\$18	---	---	1.2%	2.6%	3.8%	5.0%	6.2%	7.2%	8.3%	9.3%	10.3%
	\$19	0.4%	1.8%	3.1%	4.3%	5.5%	6.6%	7.7%	8.7%	9.7%	10.6%	11.6%
	\$20	2.4%	3.6%	4.8%	5.9%	7.0%	8.1%	9.1%	10.0%	11.0%	11.9%	12.8%
	\$21	4.1%	5.3%	6.4%	7.4%	8.5%	9.4%	10.4%	11.3%	12.3%	13.2%	14.0%
	\$22	5.7%	6.8%	7.8%	8.8%	9.8%	10.8%	11.7%	12.6%	13.5%	14.4%	15.2%
	\$23	7.2%	8.2%	9.2%	10.2%	11.1%	12.0%	12.9%	13.8%	14.7%	15.6%	16.4%
	\$24	8.6%	9.6%	10.5%	11.5%	12.4%	13.3%	14.1%	15.0%	15.9%	16.7%	17.5%
	\$25	10.0%	10.9%	11.8%	12.7%	13.6%	14.5%	15.3%	16.2%	17.0%	17.8%	18.7%
	\$26	11.2%	12.1%	13.0%	13.9%	14.7%	15.6%	16.4%	17.3%	18.1%	18.9%	19.7%
	\$27	12.2%	13.1%	14.0%	14.9%	15.8%	16.6%	17.5%	18.3%	19.1%	19.9%	20.7%
	\$28	13.1%	14.0%	14.9%	15.8%	16.7%	17.5%	18.4%	19.2%	20.0%	20.8%	21.7%
\$29	13.8%	14.7%	15.6%	16.5%	17.4%	18.2%	19.1%	19.9%	20.7%	21.6%	22.4%	
\$30	14.1%	15.0%	15.9%	16.8%	17.7%	18.6%	19.4%	20.3%	21.1%	21.9%	22.8%	

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #8 - Option H: Mixed Food Waste Cleaning, RNG Compression and Nutrient Recovery Equipment

This biogas plant is estimated to cost \$12.3 million to build. Operating costs are estimated to average \$1,940,491/year. At an RNG sale price of \$25.04/GJ, average revenue is estimated to be \$3,574,202/year. This biogas plant doesn't require funding for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$1,633,710/year; equal to 84% of operating costs. Operating income should be sufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (i.e., broken equipment, unexpected downtime, etc.).

Option H: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>	<u>Revenue</u>		<u>Investment</u>	
Digester	\$4,431,000		RNG/GJ [†] =	\$25.04	Farm Investment =	\$12,304,300
Upgrader	\$4,523,821		Avg RNG Sales/Yr =	\$3,001,993	Funding Amount =	\$0
Nutrient Rec.	\$1,746,896		Tip Fee/Yr =	\$420,350	Funding % of CAPEX =	0%
Other	\$1,602,582		Bedding Savings/Yr* =	\$151,859		
Total	<u>\$12,304,300</u>	<u>\$1,940,491</u>	Total =	<u>\$3,574,202</u>	Inflation =	2%

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$3,273	\$3,303	\$3,333	\$3,363	\$3,394	\$3,425	\$3,457	\$3,489	\$3,521	\$3,553
OPEX (000s)	\$1,597	\$1,629	\$1,662	\$1,695	\$1,729	\$1,764	\$1,799	\$1,835	\$1,871	\$1,909
<i>Income (000s)</i>	\$1,676	\$1,674	\$1,671	\$1,668	\$1,665	\$1,662	\$1,658	\$1,654	\$1,649	\$1,644

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$3,586	\$3,619	\$3,653	\$3,687	\$3,721	\$3,756	\$3,791	\$3,826	\$3,862	\$3,871
OPEX (000s)	\$1,947	\$1,986	\$2,026	\$2,066	\$2,108	\$2,150	\$2,193	\$2,237	\$2,281	\$2,327
<i>Income (000s)</i>	\$1,639	\$1,633	\$1,627	\$1,621	\$1,614	\$1,606	\$1,598	\$1,590	\$1,581	\$1,544

Unlevered, Pre-Tax IRR =	12%
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Average Operating Income* =	\$1,633,710
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% of OPEX	84%
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* Averaged over twenty years to account for inflation

† Base price (1%/year increase up to \$30/GJ max)

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 84% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, if RNG production is 10% or 20% higher than anticipated (due to the availability of high biogas-potential mixed food waste), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$25.04/GJ to <\$23/GJ and <\$21/GJ respectively. Alternately, if RNG production is 10% lower than anticipated, the required RNG sale price for an unlevered, pre-tax IRR increases from \$25.04/GJ to >\$28/GJ. If RNG production is 20% lower than anticipated, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 8.9%. Furthermore, if only 50% of estimated mixed food waste is available (8,407 instead of 16,814 tonnes/year), RNG production will be approximately 35% lower. If RNG production is 35% lower, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 2.4%. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option H: Sensitivity Analysis – RNG Production

		Change in RNG Production Amount														
		-50%	-45%	-40%	-35%	-30%	-25%	-20%	-15%	-10%	-5%	0%	5%	10%	15%	20%
\$/GJ RNG	\$16	---	---	---	---	---	---	---	---	---	---	---	0.5%	2.0%	3.3%	4.6%
	\$17	---	---	---	---	---	---	---	---	---	---	0.9%	2.4%	3.8%	5.1%	6.3%
	\$18	---	---	---	---	---	---	---	---	---	1.1%	2.7%	4.1%	5.5%	6.7%	7.9%
	\$19	---	---	---	---	---	---	---	---	1.1%	2.8%	4.3%	5.7%	7.0%	8.2%	9.4%
	\$20	---	---	---	---	---	---	---	0.9%	2.7%	4.3%	5.7%	7.1%	8.4%	9.7%	10.9%
	\$21	---	---	---	---	---	---	0.5%	2.4%	4.1%	5.7%	7.1%	8.5%	9.8%	11.0%	12.2%
	\$22	---	---	---	---	---	---	2.0%	3.8%	5.5%	7.0%	8.4%	9.8%	11.1%	12.3%	13.6%
	\$23	---	---	---	---	---	1.4%	3.3%	5.1%	6.7%	8.2%	9.7%	11.0%	12.3%	13.6%	14.8%
	\$24	---	---	---	---	0.5%	2.7%	4.6%	6.3%	7.9%	9.4%	10.9%	12.2%	13.6%	14.8%	16.1%
	\$25	---	---	---	---	1.8%	3.9%	5.7%	7.4%	9.0%	10.6%	12.0%	13.4%	14.7%	16.1%	17.3%
	\$26	---	---	---	0.5%	2.8%	4.9%	6.7%	8.5%	10.1%	11.6%	13.1%	14.5%	15.9%	17.2%	18.5%
	\$27	---	---	---	1.3%	3.7%	5.7%	7.6%	9.3%	11.0%	12.5%	14.0%	15.5%	16.9%	18.3%	19.6%
	\$28	---	---	---	1.9%	4.3%	6.3%	8.2%	10.0%	11.7%	13.3%	14.8%	16.3%	17.8%	19.2%	20.6%
	\$29	---	---	---	2.3%	4.7%	6.8%	8.7%	10.5%	12.2%	13.9%	15.4%	17.0%	18.5%	19.9%	21.4%
\$30	---	---	---	2.4%	4.8%	7.0%	8.9%	10.7%	12.5%	14.1%	15.7%	17.3%	18.8%	20.3%	21.8%	

B.C. On-Farm Biogas Benchmark Study, Version 2

Mixed food waste tip fee accounts for 12% of biogas plant revenue. Therefore, although less important than RNG sales, food waste tip fee can have a significant impact on biogas plant economic feasibility. For example, if mixed food waste tip fee is \$35/tonne or \$50/tonne instead of \$25/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$25.04/GJ to <\$24/GJ and <\$22/GJ respectively. Alternately, if mixed food waste tip fee is only \$10/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% increases from \$25.04/GJ to >\$27/GJ. If mixed food waste tip fee is \$0/tonne, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 11.5%. An unlevered, pre-tax IRR <12% isn't economically feasible.

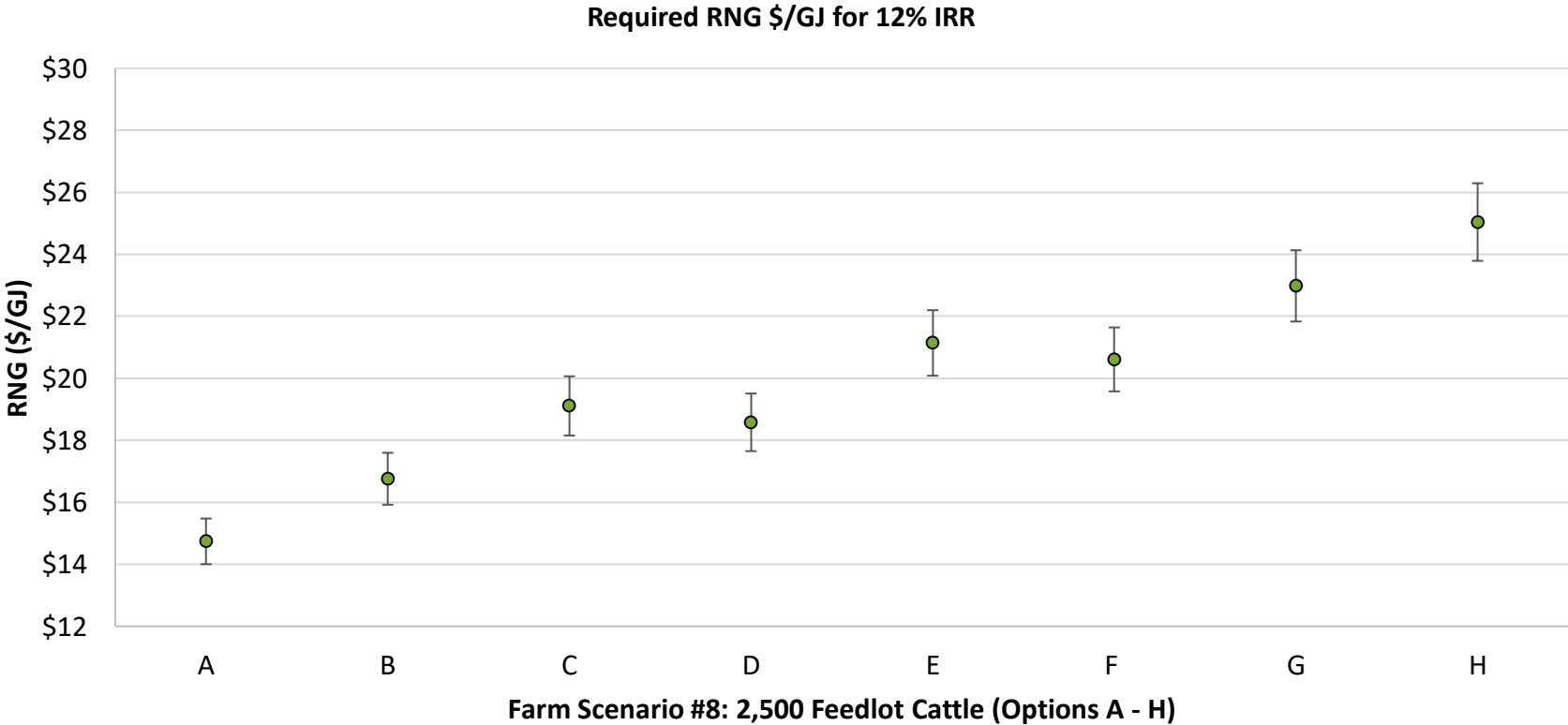
Option H: Sensitivity Analysis – Mixed Food Waste Tip Fee

		Mixed Food Waste Tip Fee (\$/Tonne)										
		\$0	\$5	\$10	\$15	\$20	\$25	\$30	\$35	\$40	\$45	\$50
\$/GJ RNG	\$16	---	---	---	---	---	---	0.3%	1.7%	2.9%	4.0%	5.1%
	\$17	---	---	---	---	---	0.9%	2.2%	3.4%	4.5%	5.5%	6.6%
	\$18	---	---	---	0.1%	1.5%	2.7%	3.8%	4.9%	5.9%	6.9%	7.9%
	\$19	---	---	0.7%	2.0%	3.2%	4.3%	5.3%	6.3%	7.3%	8.3%	9.2%
	\$20	---	1.2%	2.5%	3.6%	4.7%	5.7%	6.7%	7.7%	8.6%	9.5%	10.4%
	\$21	1.8%	3.0%	4.1%	5.1%	6.1%	7.1%	8.1%	9.0%	9.9%	10.7%	11.6%
	\$22	3.4%	4.5%	5.5%	6.5%	7.5%	8.4%	9.3%	10.2%	11.1%	11.9%	12.7%
	\$23	4.9%	5.9%	6.9%	7.9%	8.8%	9.7%	10.5%	11.4%	12.2%	13.0%	13.8%
	\$24	6.3%	7.3%	8.2%	9.1%	10.0%	10.9%	11.7%	12.5%	13.3%	14.1%	14.9%
	\$25	7.7%	8.6%	9.5%	10.3%	11.2%	12.0%	12.8%	13.6%	14.4%	15.2%	16.0%
	\$26	8.8%	9.7%	10.6%	11.4%	12.2%	13.1%	13.9%	14.7%	15.4%	16.2%	17.0%
	\$27	9.8%	10.7%	11.5%	12.4%	13.2%	14.0%	14.8%	15.6%	16.4%	17.1%	17.9%
	\$28	10.6%	11.5%	12.4%	13.2%	14.0%	14.8%	15.6%	16.4%	17.2%	18.0%	18.7%
	\$29	11.2%	12.1%	13.0%	13.8%	14.6%	15.4%	16.2%	17.0%	17.8%	18.6%	19.4%
\$30	11.5%	12.4%	13.2%	14.1%	14.9%	15.7%	16.6%	17.3%	18.1%	18.9%	19.7%	

Farm Scenario #8: Summary

Figure 20 shows the required RNG \$/GJ sale price for Farm Scenario #8 Options A – G for an unlevered, pre-tax IRR of 12%. Where required RNG sale price is <\$30/GJ, a bar representing +/- 5% is shown to account for price uncertainty. Farm Scenario #8 Options A – H don't require funding. These biogas plants require an RNG sale price from as low as \$14.00/GJ to as high as \$26.29/GJ. Figure 20 shows that even with mixed food waste cleaning, RNG compression and nutrient recovery equipment, 2,500 cattle feedlots co-digesting cattle manure and mixed food waste are economically feasible in B.C. without any funding.

Figure 20: Farm Scenario #8 - Required RNG Sale Price for 2,500 Feedlot Cattle + Mixed Food Waste



7.9

Farm Scenario #9: 500 Dairy Cows + Poultry Manure

Farm Scenario #9 is a 500 dairy cow farm co-digesting dairy and poultry manure. Farm Scenario #9 assumes the use of traditional on-farm biogas plant technology. Estimated feedstock volumes and Renewable Natural Gas (RNG) production for Farm Scenario #9 are as follows:

Feedstock	Tonnes/Year	Percentage	RNG Production (GJ/Year)
Dairy manure	25,021	80%	8,074 GJ
Poultry manure	6,236	20%	18,775 GJ
<i>Total</i>	<i>31,257</i>	<i>100%</i>	<i>26,848 GJ</i>

The following Equipment Choices were assessed for Farm Scenario #9:

- Option A: No additional equipment;
- Option B: RNG compression equipment;
- Option C: Nutrient recovery equipment; and
- Option D: RNG compression and nutrient recovery equipment.

For full capital and operating costs for Farm Scenario #9 Options A – D, see Appendix I.

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #9 - Option A: No Additional Equipment

This biogas plant is estimated to cost \$5.3 million to build. Operating costs are estimated to average \$617,297/year. At an RNG sale price of \$30/GJ, average revenue is estimated to be \$887,211/year. This biogas plant requires \$3.0 million funding (57% of CAPEX) for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$269,913/year; equal to 44% of operating costs. Operating income may or may not be sufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (e.g., broken equipment, unexpected downtime, etc.).

Option A: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>	<u>Revenue</u>		<u>Investment</u>	
Digester	\$2,325,750		RNG/GJ =	\$30.00	Farm Investment =	\$2,265,425
Upgrader	\$2,008,800		Avg RNG Sales/Yr =	\$765,724	Funding Amount =	\$3,013,591
Nutrient Recovery	\$256,897		Bedding Savings/Yr* =	\$121,487	Funding % of CAPEX =	57%
Other	\$687,569					
<u>Total</u>	<u>\$5,279,016</u>	<u>\$617,297</u>	<u>Total =</u>	<u>\$887,211</u>	<u>Inflation =</u>	<u>2%</u>

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$866	\$868	\$870	\$872	\$874	\$876	\$878	\$881	\$883	\$885
OPEX (000s)	\$508	\$518	\$529	\$539	\$550	\$561	\$572	\$584	\$595	\$607
<i>Operate Income</i>	\$358	\$349	\$341	\$333	\$324	\$315	\$306	\$297	\$288	\$278

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$888	\$890	\$893	\$895	\$898	\$900	\$903	\$906	\$909	\$911
OPEX (000s)	\$619	\$632	\$644	\$657	\$670	\$684	\$698	\$711	\$726	\$740
<i>Operate Income</i>	\$268	\$258	\$248	\$238	\$227	\$216	\$205	\$194	\$183	\$171

Unlevered, Pre-Tax IRR =	12%	Average Operating Income* =	\$269,913	% of OPEX	44%
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* Averaged over twenty years to account for inflation

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 86% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, with 57% funding, if RNG production is 10% or 20% higher than anticipated (due to the better than expected biogas production from the feedstock), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$26/GJ and <\$24/GJ respectively. Alternately, with 57% funding, if RNG production is 5% or 10% lower than anticipated, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 9.6% and 7.0% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Poultry manure accounts for 12% of biogas plant operating costs. Therefore, although less important than RNG sales, poultry manure tip fee can have an impact on biogas plant economic feasibility. For example, with 57% funding, if poultry manure tip fee is only \$5/tonne or \$0/tonne instead of \$10/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$28/GJ and <\$26/GJ respectively. Alternately, with 57% funding, if poultry manure tip fee is \$15/tonne or \$20/tonne, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 9.8% and 7.3% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option A: Sensitivity Analysis – RNG Production & Poultry Manure Tip Fee

		Change in RNG Production Amount						
		-10%	-5%	0%	5%	10%	15%	20%
\$/GJ RNG	\$16	---	---	---	---	---	---	---
	\$17	---	---	---	---	---	---	---
	\$18	---	---	---	---	---	---	---
	\$19	---	---	---	---	---	0.5%	2.7%
	\$20	---	---	---	---	0.8%	3.1%	5.1%
	\$21	---	---	---	1.0%	3.3%	5.4%	7.3%
	\$22	---	---	0.8%	3.3%	5.5%	7.4%	9.2%
	\$23	---	0.5%	3.1%	5.4%	7.4%	9.3%	11.1%
	\$24	---	2.7%	5.1%	7.3%	9.2%	11.1%	12.8%
	\$25	2.0%	4.6%	6.9%	9.0%	10.9%	12.8%	14.5%
	\$26	3.7%	6.2%	8.5%	10.5%	12.5%	14.3%	16.1%
	\$27	5.0%	7.5%	9.8%	11.9%	13.8%	15.7%	17.5%
	\$28	6.0%	8.6%	10.9%	13.0%	15.0%	16.9%	18.8%
	\$29	6.7%	9.3%	11.6%	13.8%	15.9%	17.9%	19.8%
\$30	7.0%	9.6%	12.0%	14.2%	16.3%	18.3%	20.3%	

		Poultry Manure Tip Fee (\$/Tonne)				
		\$0	\$5	\$10	\$15	\$20
\$/GJ RNG	\$16	---	---	---	---	---
	\$17	---	---	---	---	---
	\$18	---	---	---	---	---
	\$19	0.1%	---	---	---	---
	\$20	2.4%	---	---	---	---
	\$21	4.5%	1.7%	---	---	---
	\$22	6.3%	3.8%	0.8%	---	---
	\$23	8.0%	5.7%	3.1%	---	---
	\$24	9.6%	7.5%	5.1%	2.4%	---
	\$25	11.1%	9.1%	6.9%	4.5%	1.6%
	\$26	12.5%	10.5%	8.5%	6.2%	3.5%
	\$27	13.7%	11.8%	9.8%	7.6%	5.0%
	\$28	14.7%	12.9%	10.9%	8.7%	6.2%
	\$29	15.5%	13.6%	11.6%	9.4%	7.0%
\$30	15.9%	14.0%	12.0%	9.8%	7.3%	

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #9 - Option B: RNG Compression Equipment

This biogas plant is estimated to cost \$6.0 million to build. Operating costs are estimated to average \$750,903/year. At an RNG sale price of \$30/GJ, average revenue is estimated to be \$887,211/year. This biogas plant requires \$4.7 million funding (78% of CAPEX) for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$136,308/year; equal to 18% of operating costs. Operating income is likely insufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (i.e., broken equipment, unexpected downtime, etc.). This is because farm investment (i.e., debt) is only 22%. Low investment means that even with an unlevered, pre-tax IRR of 12%, operating income can be too low.

Option B: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>	<u>Revenue</u>		<u>Investment</u>	
Digester	\$2,325,750		RNG/GJ =	\$30.00	Farm Investment =	\$1,336,454
Upgrader	\$2,653,488		Avg RNG Sales/Yr =	\$765,724	Funding Amount =	\$4,683,791
Nutrient Recovery	\$256,897		Bedding Savings/Yr* =	\$121,487	Funding % of CAPEX =	78%
Other	\$784,111					
<u>Total</u>	<u>\$6,020,246</u>	<u>\$750,903</u>	<u>Total =</u>	<u>\$887,211</u>	<u>Inflation =</u>	<u>2%</u>

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$866	\$868	\$870	\$872	\$874	\$876	\$878	\$881	\$883	\$885
OPEX (000s)	\$618	\$630	\$643	\$656	\$669	\$682	\$696	\$710	\$724	\$739
<i>Operate Income</i>	\$248	\$237	\$227	\$216	\$205	\$194	\$182	\$171	\$159	\$147

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$888	\$890	\$893	\$895	\$898	\$900	\$903	\$906	\$909	\$911
OPEX (000s)	\$753	\$769	\$784	\$800	\$816	\$832	\$849	\$865	\$883	\$900
<i>Operate Income</i>	\$134	\$122	\$109	\$96	\$82	\$68	\$54	\$40	\$26	\$11

Unlevered, Pre-Tax IRR =	12%	Average Operating Income* =	\$136,308	% of OPEX	18%
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* Averaged over twenty years to account for inflation

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 86% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, with 78% funding, if RNG production is 10% or 20% higher than anticipated (due to the better than expected biogas production from the feedstock), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$26/GJ and <\$24/GJ respectively. Alternately, with 78% funding, if RNG production is 5% lower than anticipated, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 6.8%. An unlevered, pre-tax IRR <12% isn't economically feasible.

Poultry manure accounts for 10% of biogas plant operating costs. Therefore, although less important than RNG sales, poultry manure tip fee can have an impact on biogas plant economic feasibility. For example, with 78% funding, if poultry manure tip fee is only \$5/tonne or \$0/tonne instead of \$10/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$28/GJ and <\$26/GJ respectively. Alternately, with 78% funding, if poultry manure tip fee is \$15/tonne, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 7.1%. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option B: Sensitivity Analysis – RNG Production & Poultry Manure Tip Fee

		Change in RNG Production Amount						
		-10%	-5%	0%	5%	10%	15%	20%
\$/GJ RNG	\$16	---	---	---	---	---	---	---
	\$17	---	---	---	---	---	---	---
	\$18	---	---	---	---	---	---	---
	\$19	---	---	---	---	---	---	---
	\$20	---	---	---	---	---	---	---
	\$21	---	---	---	---	---	---	2.1%
	\$22	---	---	---	---	---	2.5%	6.7%
	\$23	---	---	---	---	2.5%	6.8%	10.3%
	\$24	---	---	---	2.1%	6.7%	10.3%	13.5%
	\$25	---	---	1.1%	6.1%	10.0%	13.4%	16.4%
	\$26	---	---	4.8%	9.2%	12.8%	16.1%	19.1%
	\$27	---	2.1%	7.6%	11.7%	15.3%	18.5%	21.6%
	\$28	---	4.5%	9.7%	13.8%	17.4%	20.7%	23.9%
\$29	---	6.1%	11.3%	15.4%	19.1%	22.5%	25.7%	
\$30	---	6.8%	12.0%	16.2%	19.9%	23.4%	26.8%	

		Poultry Manure Tip Fee (\$/Tonne)				
		\$0	\$5	\$10	\$15	\$20
\$/GJ RNG	\$16	---	---	---	---	---
	\$17	---	---	---	---	---
	\$18	---	---	---	---	---
	\$19	---	---	---	---	---
	\$20	---	---	---	---	---
	\$21	---	---	---	---	---
	\$22	---	---	---	---	---
	\$23	4.0%	---	---	---	---
	\$24	7.4%	2.7%	---	---	---
	\$25	10.3%	6.4%	1.1%	---	---
	\$26	12.8%	9.2%	4.8%	---	---
	\$27	15.0%	11.6%	7.6%	2.0%	---
	\$28	16.9%	13.6%	9.7%	4.6%	---
\$29	18.4%	15.1%	11.3%	6.4%	---	
\$30	19.2%	15.8%	12.0%	7.1%	---	

Farm Scenario #9 - Option C: Nutrient Recovery Equipment

This biogas plant is estimated to cost \$6.3 million to build. Operating costs are estimated to average \$996,893/year. At an RNG sale price of \$30/GJ, average revenue is estimated to be \$887,211/year. Because operating costs are greater than revenue, this biogas plant requires >100% funding for an unlevered, pre-tax IRR of 12%. For this reason, an economic assessment was not completed.

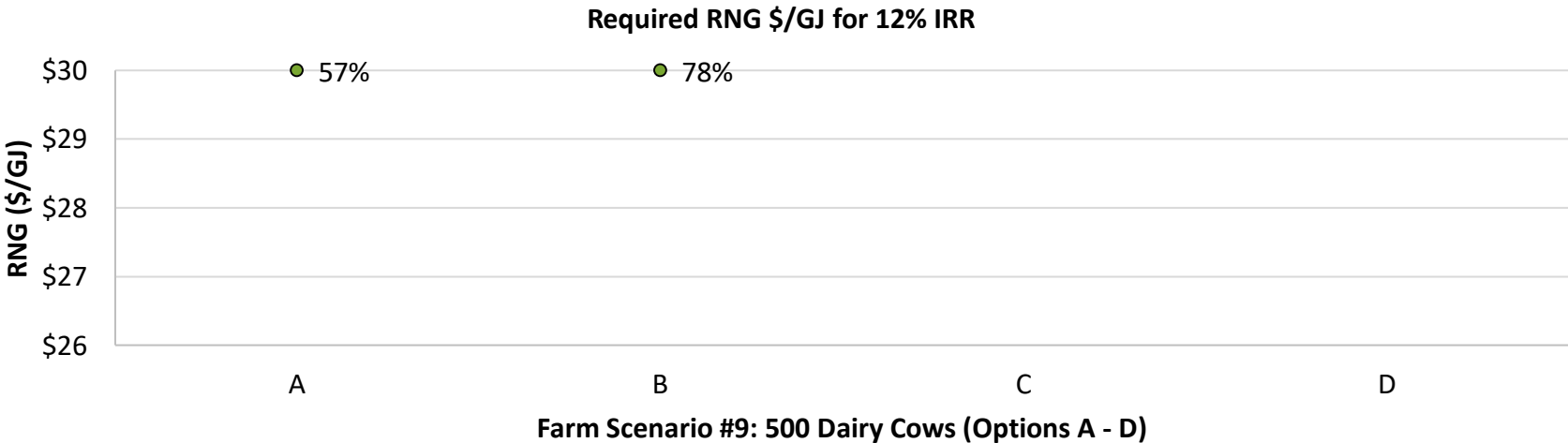
Farm Scenario #9 - Option D: RNG Compression and Nutrient Recovery Equipment

This biogas plant is estimated to cost \$7.0 million to build. Operating costs are estimated to average \$1,130,499/year. At an RNG sale price of \$30/GJ, average revenue is estimated to be \$887,211/year. Because operating costs are greater than revenue, this biogas plant requires >100% funding for an unlevered, pre-tax IRR of 12%. For this reason, an economic assessment was not completed.

Farm Scenario #9: Summary

Figure 21 shows the required RNG \$/GJ sale price for Farm Scenario #9 Options A – D for an unlevered, pre-tax IRR of 12%. Where required RNG sale price is >\$30/GJ, percentage of required funding is shown. All Farm Scenario #9 Options A – D require funding. Funding increases from 57% (for Option A) to 78% (for Option B). Options C and D aren't shown because they require >100% funding. Figure 21 shows that even under the best circumstances (i.e., Option A - needing the least equipment), 500 dairy cow farms co-digesting dairy and poultry manure cannot be economically feasible in B.C. without funding.

Figure 21: Farm Scenario #9 - Required RNG Sale Price for 500 Dairy Cows + Poultry Manure



7.10

Farm Scenario #10: 750 Dairy Cows + Poultry Manure

Farm Scenario #10 is a 750 dairy cow farm co-digesting dairy and poultry manure. Farm Scenario #10 assumes the use of traditional on-farm biogas plant technology. Estimated feedstock volumes and Renewable Natural Gas (RNG) production for Farm Scenario #10 are as follows:

Feedstock	Tonnes/Year	Percentage	RNG Production (GJ/Year)
Dairy manure	37,531	80%	12,110 GJ
Poultry manure	9,354	20%	28,162 GJ
<i>Total</i>	<i>46,885</i>	<i>100%</i>	<i>40,273 GJ</i>

The following Equipment Choices were assessed for Farm Scenario #10:

- Option A: No additional equipment;
- Option B: RNG compression equipment;
- Option C: Nutrient recovery equipment; and
- Option D: RNG compression and nutrient recovery equipment.

For full capital and operating costs for Farm Scenario #10 Options A – D, see Appendix J.

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #10 - Option A: No Additional Equipment

This biogas plant is estimated to cost \$6.1 million to build. Operating costs are estimated to average \$743,717/year. At an RNG sale price of \$30/GJ, average revenue is estimated to be \$1,330,816/year. This biogas plant requires \$1.5 million funding (24% of CAPEX) for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$587,099/year; equal to 79% of operating costs. Operating income should be sufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (e.g., broken equipment, unexpected downtime, etc.).

Option A: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>	<u>Revenue</u>		<u>Investment</u>	
Digester	\$2,845,500		RNG/GJ =	\$30.00	Farm Investment =	\$4,662,430
Upgrader	\$2,111,800		Avg RNG Sales/Yr =	\$1,148,586	Funding Amount =	\$1,480,277
Nutrient Recovery	\$385,345		Bedding Savings/Yr* =	\$182,230	Funding % of CAPEX =	24%
Other	\$800,061					
<u>Total</u>	<u>\$6,142,706</u>	<u>\$743,717</u>	<u>Total =</u>	<u>\$1,330,816</u>	<u>Inflation =</u>	<u>2%</u>

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$1,299	\$1,302	\$1,305	\$1,308	\$1,311	\$1,314	\$1,318	\$1,321	\$1,324	\$1,328
OPEX (000s)	\$612	\$624	\$637	\$650	\$663	\$676	\$689	\$703	\$717	\$732
<i>Operate Income</i>	\$686	\$677	\$668	\$658	\$648	\$638	\$628	\$618	\$607	\$596

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$1,331	\$1,335	\$1,339	\$1,343	\$1,347	\$1,350	\$1,355	\$1,359	\$1,363	\$1,367
OPEX (000s)	\$746	\$761	\$776	\$792	\$808	\$824	\$840	\$857	\$874	\$892
<i>Operate Income</i>	\$585	\$574	\$562	\$551	\$539	\$527	\$514	\$501	\$488	\$475

Unlevered, Pre-Tax IRR =	12%	Average Operating Income* =	\$587,099	% of OPEX	79%
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* Averaged over twenty years to account for inflation

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 86% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, with 24% funding, if RNG production is 10% or 20% higher than anticipated (due to the better than expected biogas production from the feedstock), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$26/GJ and <\$24/GJ respectively. Alternately, with 24% funding, if RNG production is 5% or 10% lower than anticipated, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 10.4% and 8.7% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Poultry manure accounts for 15% of biogas plant operating costs. Therefore, although less important than RNG sales, poultry manure tip fee can have an impact on biogas plant economic feasibility. For example, with 24% funding, if poultry manure tip fee is only \$5/tonne or \$0/tonne instead of \$10/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$28/GJ and <\$26/GJ respectively. Alternately, with 24% funding, if poultry manure tip fee is \$15/tonne or \$20/tonne, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 10.5% and 9.0% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option A: Sensitivity Analysis – RNG Production & Poultry Manure Tip Fee

		Change in RNG Production Amount						
		-10%	-5%	0%	5%	10%	15%	20%
\$/GJ RNG	\$16	---	---	---	---	---	---	0.6%
	\$17	---	---	---	---	---	1.2%	2.5%
	\$18	---	---	---	0.1%	1.6%	3.0%	4.3%
	\$19	---	---	0.3%	1.9%	3.3%	4.6%	5.9%
	\$20	---	0.3%	1.9%	3.4%	4.8%	6.1%	7.4%
	\$21	0.1%	1.9%	3.4%	4.9%	6.2%	7.5%	8.8%
	\$22	1.6%	3.3%	4.8%	6.2%	7.6%	8.9%	10.1%
	\$23	3.0%	4.6%	6.1%	7.5%	8.9%	10.1%	11.4%
	\$24	4.3%	5.9%	7.4%	8.8%	10.1%	11.4%	12.6%
	\$25	5.5%	7.0%	8.5%	9.9%	11.3%	12.6%	13.8%
	\$26	6.5%	8.1%	9.6%	11.0%	12.3%	13.7%	14.9%
	\$27	7.4%	9.0%	10.5%	11.9%	13.3%	14.7%	16.0%
	\$28	8.0%	9.7%	11.2%	12.7%	14.1%	15.5%	16.9%
	\$29	8.5%	10.2%	11.8%	13.3%	14.7%	16.2%	17.6%
\$30	8.7%	10.4%	12.0%	13.6%	15.0%	16.5%	17.9%	

		Poultry Manure Tip Fee (\$/Tonne)				
		\$0	\$5	\$10	\$15	\$20
\$/GJ RNG	\$16	---	---	---	---	---
	\$17	1.4%	---	---	---	---
	\$18	3.0%	0.9%	---	---	---
	\$19	4.4%	2.5%	0.3%	---	---
	\$20	5.7%	3.9%	1.9%	---	---
	\$21	6.9%	5.3%	3.4%	1.4%	---
	\$22	8.1%	6.5%	4.8%	2.9%	0.8%
	\$23	9.2%	7.7%	6.1%	4.4%	2.4%
	\$24	10.3%	8.9%	7.4%	5.7%	3.9%
	\$25	11.4%	10.0%	8.5%	7.0%	5.3%
	\$26	12.3%	11.0%	9.6%	8.1%	6.4%
	\$27	13.2%	11.9%	10.5%	9.0%	7.4%
	\$28	14.0%	12.6%	11.2%	9.7%	8.2%
	\$29	14.5%	13.2%	11.8%	10.3%	8.7%
\$30	14.8%	13.4%	12.0%	10.5%	9.0%	

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #10 - Option B: RNG Compression Equipment

This biogas plant is estimated to cost \$6.9 million to build. Operating costs are estimated to average \$890,570/year. At an RNG sale price of \$30/GJ, average revenue is estimated to be \$1,330,816/year. This biogas plant requires \$3.3 million funding (47% of CAPEX) for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$440,246/year; equal to 49% of operating costs. Operating income may or may not be sufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (e.g., broken equipment, unexpected downtime, etc.).

Option B: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>		<u>Revenue</u>		<u>Investment</u>	
Digester	\$2,845,500			RNG/GJ =	\$30.00	Farm Investment =	\$3,646,639
Upgrader	\$2,785,974			Avg RNG Sales/Yr =	\$1,148,586	Funding Amount =	\$3,271,199
Nutrient Recovery	\$385,345			Bedding Savings/Yr* =	\$182,230	Funding % of CAPEX =	47%
Other	\$901,019						
<u>Total</u>	<u>\$6,917,838</u>	<u>\$890,570</u>		<u>Total =</u>	<u>\$1,330,816</u>	<u>Inflation =</u>	<u>2%</u>

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$1,299	\$1,302	\$1,305	\$1,308	\$1,311	\$1,314	\$1,318	\$1,321	\$1,324	\$1,328
OPEX (000s)	\$733	\$748	\$763	\$778	\$793	\$809	\$826	\$842	\$859	\$876
<i>Operate Income</i>	\$566	\$554	\$542	\$530	\$517	\$505	\$492	\$479	\$465	\$452

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$1,331	\$1,335	\$1,339	\$1,343	\$1,347	\$1,350	\$1,355	\$1,359	\$1,363	\$1,367
OPEX (000s)	\$894	\$911	\$930	\$948	\$967	\$987	\$1,006	\$1,026	\$1,047	\$1,068
<i>Operate Income</i>	\$438	\$424	\$409	\$394	\$379	\$364	\$348	\$332	\$316	\$299

Unlevered, Pre-Tax IRR =	12%
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Average Operating Income* =	\$440,246
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% of OPEX	49%
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* Averaged over twenty years to account for inflation

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 86% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, with 47% funding, if RNG production is 10% or 20% higher than anticipated (due to the better than expected biogas production from the feedstock), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$26/GJ and <\$24/GJ respectively. Alternately, with 47% funding, if RNG production is 5% or 10% lower than anticipated, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 9.8% and 7.5% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible

Poultry manure accounts for 13% of biogas plant operating costs. Therefore, although less important than RNG sales, poultry manure tip fee can have an impact on biogas plant economic feasibility. For example, with 47% funding, if poultry manure tip fee is only \$5/tonne or \$0/tonne instead of \$10/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$28/GJ and <\$26/GJ respectively. Alternately, with 47% funding, if poultry manure tip fee is \$15/tonne or \$20/tonne, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 10.0% and 7.8% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option B: Sensitivity Analysis – RNG Production & Poultry Manure Tip Fee

		Change in RNG Production Amount						
		-10%	-5%	0%	5%	10%	15%	20%
\$/GJ RNG	\$16	---	---	---	---	---	---	---
	\$17	---	---	---	---	---	---	---
	\$18	---	---	---	---	---	---	1.1%
	\$19	---	---	---	---	---	1.6%	3.6%
	\$20	---	---	---	---	2.0%	3.9%	5.7%
	\$21	---	---	---	2.1%	4.1%	6.0%	7.6%
	\$22	---	---	2.0%	4.1%	6.0%	7.8%	9.4%
	\$23	---	1.6%	3.9%	6.0%	7.8%	9.5%	11.1%
	\$24	1.1%	3.6%	5.7%	7.6%	9.4%	11.1%	12.8%
	\$25	3.0%	5.3%	7.3%	9.2%	11.0%	12.7%	14.3%
	\$26	4.5%	6.7%	8.7%	10.6%	12.4%	14.1%	15.8%
	\$27	5.6%	7.9%	9.9%	11.9%	13.7%	15.4%	17.1%
	\$28	6.6%	8.8%	10.9%	12.9%	14.8%	16.5%	18.3%
	\$29	7.2%	9.5%	11.7%	13.7%	15.6%	17.4%	19.2%
\$30	7.5%	9.8%	12.0%	14.0%	16.0%	17.8%	19.7%	

		Poultry Manure Tip Fee (\$/Tonne)				
		\$0	\$5	\$10	\$15	\$20
\$/GJ RNG	\$16	---	---	---	---	---
	\$17	---	---	---	---	---
	\$18	---	---	---	---	---
	\$19	1.3%	---	---	---	---
	\$20	3.3%	0.5%	---	---	---
	\$21	5.1%	2.6%	---	---	---
	\$22	6.8%	4.5%	2.0%	---	---
	\$23	8.3%	6.2%	3.9%	1.2%	---
	\$24	9.8%	7.8%	5.7%	3.3%	0.4%
	\$25	11.2%	9.3%	7.3%	5.1%	2.6%
	\$26	12.4%	10.6%	8.7%	6.7%	4.3%
	\$27	13.6%	11.8%	9.9%	7.9%	5.7%
	\$28	14.5%	12.8%	10.9%	8.9%	6.7%
	\$29	15.3%	13.5%	11.7%	9.7%	7.4%
\$30	15.6%	13.9%	12.0%	10.0%	7.8%	

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #10 - Option C: Nutrient Recovery Equipment

This biogas plant is estimated to cost \$7.3 million to build. Operating costs are estimated to average \$1,276,121/year. At an RNG sale price of \$30/GJ, average revenue is estimated to be \$1,330,816/year. This biogas plant requires \$6.4 million funding (87% of CAPEX) for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$54,695/year; equal to 4% of operating costs. Operating income is likely insufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (i.e., broken equipment, unexpected downtime, etc.). This is because farm investment (i.e., debt) is only 13%. Low investment means that even with an unlevered, pre-tax IRR of 12%, operating income can be too low.

Option C: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>	<u>Revenue</u>		<u>Investment</u>	
Digester	\$3,076,500		RNG/GJ =	\$30.00	Farm Investment =	\$961,773
Upgrader	\$2,111,800		Avg RNG Sales/Yr =	\$1,148,586	Funding Amount =	\$6,366,325
Nutrient Recovery	\$1,185,345		Bedding Savings/Yr* =	\$182,230	Funding % of CAPEX =	87%
Other	\$954,453					
<u>Total</u>	<u>\$7,328,099</u>	<u>\$1,276,121</u>	<u>Total =</u>	<u>\$1,330,816</u>	<u>Inflation =</u>	<u>2%</u>

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$1,299	\$1,302	\$1,305	\$1,308	\$1,311	\$1,314	\$1,318	\$1,321	\$1,324	\$1,328
OPEX (000s)	\$1,050	\$1,071	\$1,093	\$1,115	\$1,137	\$1,160	\$1,183	\$1,207	\$1,231	\$1,255
<i>Operate Income</i>	\$248	\$230	\$212	\$193	\$174	\$154	\$135	\$114	\$94	\$73

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$1,331	\$1,335	\$1,339	\$1,343	\$1,347	\$1,350	\$1,355	\$1,359	\$1,363	\$1,367
OPEX (000s)	\$1,280	\$1,306	\$1,332	\$1,359	\$1,386	\$1,414	\$1,442	\$1,471	\$1,500	\$1,530
<i>Operate Income</i>	\$51	\$29	\$7	-\$16	-\$39	-\$63	-\$87	-\$112	-\$137	-\$163

Unlevered, Pre-Tax IRR =	12%
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Average Operating Income* =	\$54,695
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% of OPEX	4%
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* Averaged over twenty years to account for inflation

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 86% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, with 87% funding, if RNG production is 10% or 20% higher than anticipated (due to the better than expected biogas production from the feedstock), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$26/GJ and <\$24/GJ respectively. Alternately, with 87% funding, if RNG production is 5% lower than anticipated, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR is negative.

Poultry manure accounts for 9% of biogas plant operating costs. Therefore, although less important than RNG sales, poultry manure tip fee can have an impact on biogas plant economic feasibility. For example, with 87% funding, if poultry manure tip fee is only \$5/tonne or \$0/tonne instead of \$10/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$28/GJ and <\$26/GJ respectively. Alternately, with 87% funding, if poultry manure tip fee is \$15/tonne, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR is negative.

Option C: Sensitivity Analysis – RNG Production & Poultry Manure Tip Fee

Change in RNG Production Amount									
\$/GJ RNG		-10%	-5%	0%	5%	10%	15%	20%	
	\$16	---	---	---	---	---	---	---	---
	\$17	---	---	---	---	---	---	---	
	\$18	---	---	---	---	---	---	---	
	\$19	---	---	---	---	---	---	---	
	\$20	---	---	---	---	---	---	---	
	\$21	---	---	---	---	---	---	---	
	\$22	---	---	---	---	---	---	---	
	\$23	---	---	---	---	---	---	7.1%	
	\$24	---	---	---	---	---	7.1%	15.7%	
	\$25	---	---	---	---	6.0%	15.4%	22.1%	
	\$26	---	---	---	0.7%	14.2%	21.5%	27.8%	
	\$27	---	---	---	11.2%	20.0%	26.9%	33.1%	
	\$28	---	---	---	17.0%	25.0%	31.8%	38.1%	
\$29	---	---	8.8%	21.2%	29.1%	36.0%	42.5%		
\$30	---	---	12.0%	23.4%	31.4%	38.6%	45.3%		

Poultry Manure Tip Fee (\$/Tonne)						
\$/GJ RNG		\$0	\$5	\$10	\$15	\$20
	\$16	---	---	---	---	---
	\$17	---	---	---	---	---
	\$18	---	---	---	---	---
	\$19	---	---	---	---	---
	\$20	---	---	---	---	---
	\$21	---	---	---	---	---
	\$22	---	---	---	---	---
	\$23	---	---	---	---	---
	\$24	---	---	---	---	---
	\$25	7.4%	---	---	---	---
	\$26	14.1%	2.0%	---	---	---
	\$27	19.3%	10.9%	---	---	---
	\$28	23.8%	16.4%	---	---	---
\$29	27.4%	20.3%	8.8%	---	---	
\$30	29.5%	22.4%	12.0%	---	---	

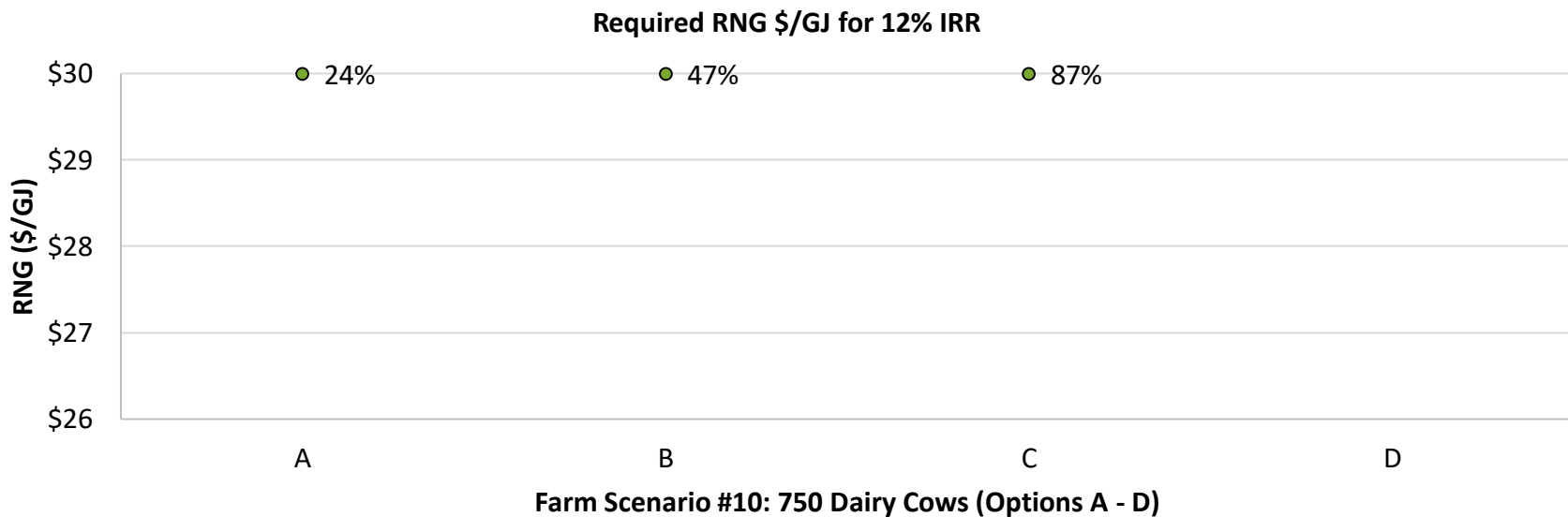
Farm Scenario #10 - Option D: RNG Compression and Nutrient Recovery Equipment

This biogas plant is estimated to cost \$8.1 million to build. Operating costs are estimated to average \$1,422,973/year. At an RNG sale price of \$30/GJ, average revenue is estimated to be \$1,330,816/year. Because operating costs are greater than revenue, this biogas plant requires >100% funding for an unlevered, pre-tax IRR of 12%. For this reason, an economic assessment was not completed.

Farm Scenario #10: Summary

Figure 22 shows the required RNG \$/GJ sale price for Farm Scenario #10 Options A – D for an unlevered, pre-tax IRR of 12%. Where required RNG sale price is >\$30/GJ, percentage of required funding is shown. All Farm Scenario #10 Options A – D require funding. Funding increases from 24% (for Option A) to 87% (for Option C). Option D isn't shown because it requires >100% funding. Figure 22 shows that even under the best circumstances (i.e., Option A - needing the least equipment), 500 dairy cow farms co-digesting dairy and poultry manure cannot be economically feasible in B.C. without funding.

Figure 22: Farm Scenario #10 - Required RNG Sale Price for 750 Dairy Cows + Poultry Manure



7.11

Farm Scenario #11: 1,000 Dairy Cows + Poultry Manure

Farm Scenario #11 is a 1,000 dairy cow farm co-digesting dairy and poultry manure. Farm Scenario #11 assumes the use of traditional on-farm biogas plant technology. Estimated feedstock volumes and Renewable Natural Gas (RNG) production for Farm Scenario #11 are as follows:

Feedstock	Tonnes/Year	Percentage	RNG Production (GJ/Year)
Dairy manure	50,042	80%	16,147 GJ
Poultry manure	12,472	20%	37,549 GJ
<i>Total</i>	<i>62,513</i>	<i>100%</i>	<i>53,697 GJ</i>

The following Equipment Choices were assessed for Farm Scenario #11:

- Option A: No additional equipment;
- Option B: RNG compression equipment;
- Option C: Nutrient recovery equipment; and
- Option D: RNG compression and nutrient recovery equipment.

For full capital and operating costs for Farm Scenario #11 Options A – D, see Appendix K.

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #11 - Option A: No Additional Equipment

This biogas plant is estimated to cost \$8.5 million to build. Operating costs are estimated to average \$905,257/year. At an RNG sale price of \$30/GJ, average revenue is estimated to be \$1,774,421/year. This biogas plant requires \$1.7 million funding (20% of CAPEX) for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$869,165/year; equal to 96% of operating costs. Operating income should be sufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (e.g., broken equipment, unexpected downtime, etc.).

Option A: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>	<u>Revenue</u>		<u>Investment</u>	
Digester	\$4,289,250		RNG/GJ =	\$30.00	Farm Investment =	\$6,818,045
Upgrader	\$2,636,500		Avg RNG Sales/Yr =	\$1,531,447	Funding Amount =	\$1,679,310
Nutrient Recovery	\$464,861		Bedding Savings/Yr* =	\$242,974	Funding % of CAPEX =	20%
Other	\$1,106,744					
<u>Total</u>	<u>\$8,497,355</u>	<u>\$905,257</u>	<u>Total =</u>	<u>\$1,774,421</u>	<u>Inflation =</u>	<u>2%</u>

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$1,731	\$1,735	\$1,740	\$1,744	\$1,748	\$1,752	\$1,757	\$1,761	\$1,766	\$1,770
OPEX (000s)	\$745	\$760	\$775	\$791	\$807	\$823	\$839	\$856	\$873	\$891
<i>Operate Income</i>	\$986	\$975	\$964	\$953	\$941	\$930	\$918	\$905	\$893	\$880

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$1,775	\$1,780	\$1,785	\$1,790	\$1,795	\$1,801	\$1,806	\$1,811	\$1,817	\$1,823
OPEX (000s)	\$908	\$926	\$945	\$964	\$983	\$1,003	\$1,023	\$1,043	\$1,064	\$1,086
<i>Operate Income</i>	\$867	\$854	\$840	\$826	\$812	\$798	\$783	\$768	\$753	\$737

Unlevered, Pre-Tax IRR =	12%	Average Operating Income* =	\$869,165	% of OPEX	96%
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* Averaged over twenty years to account for inflation

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 86% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, with 20% funding, if RNG production is 10% or 20% higher than anticipated (due to the better than expected biogas production from the feedstock), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$26/GJ and <\$24/GJ respectively. Alternately, with 20% funding, if RNG production is 5% or 10% lower than anticipated, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 10.6% and 9.1% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Poultry manure accounts for 17% of biogas plant operating costs. Therefore, although less important than RNG sales, poultry manure tip fee can have an impact on biogas plant economic feasibility. For example, with 20% funding, if poultry manure tip fee is only \$5/tonne or \$0/tonne instead of \$10/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$28/GJ and <\$26/GJ respectively. Alternately, with 20% funding, if poultry manure tip fee is \$15/tonne or \$20/tonne, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 10.7% and 9.3% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option A: Sensitivity Analysis – RNG Production & Poultry Manure Tip Fee

		Change in RNG Production Amount						
		-10%	-5%	0%	5%	10%	15%	20%
\$/GJ RNG	\$16	---	---	---	---	---	0.9%	2.0%
	\$17	---	---	---	0.0%	1.3%	2.5%	3.6%
	\$18	---	---	0.2%	1.6%	2.9%	4.0%	5.1%
	\$19	---	0.3%	1.7%	3.1%	4.3%	5.4%	6.5%
	\$20	0.2%	1.7%	3.1%	4.4%	5.6%	6.7%	7.8%
	\$21	1.6%	3.1%	4.4%	5.7%	6.8%	8.0%	9.1%
	\$22	2.9%	4.3%	5.6%	6.8%	8.0%	9.2%	10.3%
	\$23	4.0%	5.4%	6.7%	8.0%	9.2%	10.3%	11.4%
	\$24	5.1%	6.5%	7.8%	9.1%	10.3%	11.4%	12.6%
	\$25	6.2%	7.6%	8.9%	10.1%	11.3%	12.5%	13.6%
	\$26	7.1%	8.5%	9.8%	11.1%	12.3%	13.5%	14.7%
	\$27	7.8%	9.3%	10.6%	11.9%	13.2%	14.4%	15.6%
	\$28	8.5%	9.9%	11.3%	12.6%	13.9%	15.2%	16.4%
	\$29	8.9%	10.4%	11.8%	13.2%	14.5%	15.8%	17.0%
\$30	9.1%	10.6%	12.0%	13.4%	14.7%	16.1%	17.4%	

		Poultry Manure Tip Fee (\$/Tonne)				
		\$0	\$5	\$10	\$15	\$20
\$/GJ RNG	\$16	1.3%	---	---	---	---
	\$17	2.7%	0.8%	---	---	---
	\$18	4.0%	2.2%	0.2%	---	---
	\$19	5.2%	3.6%	1.7%	---	---
	\$20	6.3%	4.8%	3.1%	1.3%	---
	\$21	7.4%	6.0%	4.4%	2.7%	0.7%
	\$22	8.5%	7.1%	5.6%	4.0%	2.2%
	\$23	9.5%	8.2%	6.7%	5.2%	3.6%
	\$24	10.5%	9.2%	7.8%	6.4%	4.8%
	\$25	11.4%	10.2%	8.9%	7.5%	6.0%
	\$26	12.3%	11.1%	9.8%	8.5%	7.0%
	\$27	13.1%	11.9%	10.6%	9.3%	7.9%
	\$28	13.8%	12.6%	11.3%	10.0%	8.6%
	\$29	14.3%	13.1%	11.8%	10.5%	9.1%
\$30	14.5%	13.3%	12.0%	10.7%	9.3%	

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #11 - Option B: RNG Compression Equipment

This biogas plant is estimated to cost \$9.3 million to build. Operating costs are estimated to average \$1,065,356/year. At an RNG sale price of \$30/GJ, average revenue is estimated to be \$1,774,421/year. This biogas plant requires \$3.6 million funding (39% of CAPEX) for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$709,065/year; equal to 67% of operating costs. Operating income is likely sufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (i.e., broken equipment, unexpected downtime, etc.).

Option B: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>	<u>Revenue</u>		<u>Investment</u>	
Digester	\$4,289,250		RNG/GJ =	\$30.00	Farm Investment =	\$5,710,698
Upgrader	\$3,340,161		Avg RNG Sales/Yr =	\$1,531,447	Funding Amount =	\$3,595,691
Nutrient Recovery	\$464,861		Bedding Savings/Yr* =	\$242,974	Funding % of CAPEX =	39%
Other	\$1,212,117					
<u>Total</u>	<u>\$9,306,389</u>	<u>\$1,065,356</u>	<u>Total =</u>	<u>\$1,774,421</u>	<u>Inflation =</u>	<u>2%</u>

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$1,731	\$1,735	\$1,740	\$1,744	\$1,748	\$1,752	\$1,757	\$1,761	\$1,766	\$1,770
OPEX (000s)	\$877	\$894	\$912	\$931	\$949	\$968	\$988	\$1,007	\$1,027	\$1,048
<i>Operate Income</i>	\$855	\$841	\$827	\$813	\$799	\$784	\$769	\$754	\$738	\$722

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$1,775	\$1,780	\$1,785	\$1,790	\$1,795	\$1,801	\$1,806	\$1,811	\$1,817	\$1,823
OPEX (000s)	\$1,069	\$1,090	\$1,112	\$1,134	\$1,157	\$1,180	\$1,204	\$1,228	\$1,252	\$1,278
<i>Operate Income</i>	\$706	\$690	\$673	\$656	\$638	\$620	\$602	\$584	\$565	\$545

Unlevered, Pre-Tax IRR =	12%	Average Operating Income* =	\$709,065	% of OPEX	67%
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* Averaged over twenty years to account for inflation

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 86% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, with 39% funding, if RNG production is 10% or 20% higher than anticipated (due to the better than expected biogas production from the feedstock), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$26/GJ and <\$24/GJ respectively. Alternately, with 39% funding, if RNG production is 10% or 5% lower than anticipated, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 10.2% and 8.3% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Poultry manure accounts for 14% of biogas plant operating costs. Therefore, although less important than RNG sales, poultry manure tip fee can have an impact on biogas plant economic feasibility. For example, with 39% funding, if poultry manure tip fee is only \$5/tonne or \$0/tonne instead of \$10/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$28/GJ and <\$26/GJ respectively. Alternately, with 39% funding, if poultry manure tip fee is \$15/tonne or \$20/tonne, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 10.4% and 8.6% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option B: Sensitivity Analysis – RNG Production & Poultry Manure Tip Fee

		Change in RNG Production Amount						
		-10%	-5%	0%	5%	10%	15%	20%
\$/GJ RNG	\$16	---	---	---	---	---	---	---
	\$17	---	---	---	---	---	---	1.3%
	\$18	---	---	---	---	0.2%	1.8%	3.3%
	\$19	---	---	---	0.5%	2.2%	3.7%	5.2%
	\$20	---	---	0.6%	2.4%	4.0%	5.5%	6.8%
	\$21	---	0.5%	2.4%	4.0%	5.6%	7.0%	8.4%
	\$22	0.2%	2.2%	4.0%	5.6%	7.1%	8.5%	9.9%
	\$23	1.8%	3.7%	5.5%	7.0%	8.5%	9.9%	11.3%
	\$24	3.3%	5.2%	6.8%	8.4%	9.9%	11.3%	12.6%
	\$25	4.7%	6.5%	8.1%	9.7%	11.2%	12.6%	14.0%
	\$26	5.9%	7.6%	9.3%	10.9%	12.4%	13.8%	15.2%
	\$27	6.8%	8.6%	10.3%	11.9%	13.4%	14.9%	16.3%
	\$28	7.6%	9.4%	11.1%	12.7%	14.3%	15.8%	17.3%
	\$29	8.1%	10.0%	11.7%	13.4%	15.0%	16.5%	18.1%
\$30	8.3%	10.2%	12.0%	13.7%	15.3%	16.9%	18.5%	

		Poultry Manure Tip Fee (\$/Tonne)				
		\$0	\$5	\$10	\$15	\$20
\$/GJ RNG	\$16	---	---	---	---	---
	\$17	0.0%	---	---	---	---
	\$18	1.8%	---	---	---	---
	\$19	3.4%	1.2%	---	---	---
	\$20	4.9%	2.9%	0.6%	---	---
	\$21	6.3%	4.5%	2.4%	---	---
	\$22	7.7%	5.9%	4.0%	1.8%	---
	\$23	8.9%	7.3%	5.5%	3.4%	1.1%
	\$24	10.1%	8.5%	6.8%	5.0%	2.9%
	\$25	11.3%	9.8%	8.1%	6.4%	4.5%
	\$26	12.4%	10.9%	9.3%	7.6%	5.8%
	\$27	13.3%	11.8%	10.3%	8.6%	6.9%
	\$28	14.1%	12.7%	11.1%	9.5%	7.7%
	\$29	14.7%	13.3%	11.7%	10.1%	8.3%
\$30	15.0%	13.5%	12.0%	10.4%	8.6%	

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #11 - Option C: Nutrient Recovery Equipment

This biogas plant is estimated to cost \$10.1 million to build. Operating costs are estimated to average \$1,565,023/year. At an RNG sale price of \$30/GJ, average revenue is estimated to be \$1,774,421/year. This biogas plant requires \$7.9 million funding (78% of CAPEX) for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$203,398/year; equal to 13% of operating costs. Operating income is likely insufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (i.e., broken equipment, unexpected downtime, etc.). This is because farm investment (i.e., debt) is only 22%. Low investment means that even with an unlevered, pre-tax IRR of 12%, operating income can be too low.

Option C: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>	<u>Revenue</u>		<u>Investment</u>	
Digester	\$4,520,250		RNG/GJ =	\$30.00	Farm Investment =	\$2,232,519
Upgrader	\$2,636,500		Avg RNG Sales/Yr =	\$1,531,447	Funding Amount =	\$7,910,128
Nutrient Recovery	\$1,664,861		Bedding Savings/Yr* =	\$242,974	Funding % of CAPEX =	78%
Other	\$1,321,036					
<u>Total</u>	<u>\$10,142,647</u>	<u>\$1,565,023</u>	<u>Total =</u>	<u>\$1,774,421</u>	<u>Inflation =</u>	<u>2%</u>

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$1,731	\$1,735	\$1,740	\$1,744	\$1,748	\$1,752	\$1,757	\$1,761	\$1,766	\$1,770
OPEX (000s)	\$1,288	\$1,314	\$1,340	\$1,367	\$1,394	\$1,422	\$1,451	\$1,480	\$1,509	\$1,540
<i>Operate Income</i>	\$443	\$421	\$399	\$377	\$354	\$330	\$306	\$281	\$256	\$231

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$1,775	\$1,780	\$1,785	\$1,790	\$1,795	\$1,801	\$1,806	\$1,811	\$1,817	\$1,823
OPEX (000s)	\$1,570	\$1,602	\$1,634	\$1,666	\$1,700	\$1,734	\$1,768	\$1,804	\$1,840	\$1,877
<i>Operate Income</i>	\$205	\$178	\$151	\$124	\$96	\$67	\$38	\$8	-\$23	-\$54

Unlevered, Pre-Tax IRR =	12%	Average Operating Income* =	\$209,398	% of OPEX	13%
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* Averaged over twenty years to account for inflation

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 86% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, with 78% funding, if RNG production is 10% or 20% higher than anticipated (due to the better than expected biogas production from the feedstock), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$26/GJ and <\$24/GJ respectively. Alternately, with 78% funding, if RNG production is 5% lower than anticipated, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 4.3%. An unlevered, pre-tax IRR <12% isn't economically feasible.

Poultry manure accounts for 10% of biogas plant operating costs. Therefore, although less important than RNG sales, poultry manure tip fee can have an impact on biogas plant economic feasibility. For example, with 78% funding, if poultry manure tip fee is only \$5/tonne or \$0/tonne instead of \$10/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$28/GJ and <\$26/GJ respectively. Alternately, with 78% funding, if poultry manure tip fee is \$15/tonne, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 4.7%. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option C: Sensitivity Analysis – RNG Production & Poultry Manure Tip Fee

		Change in RNG Production Amount						
		-10%	-5%	0%	5%	10%	15%	20%
\$/GJ RNG	\$16	---	---	---	---	---	---	---
	\$17	---	---	---	---	---	---	---
	\$18	---	---	---	---	---	---	---
	\$19	---	---	---	---	---	---	---
	\$20	---	---	---	---	---	---	---
	\$21	---	---	---	---	---	---	---
	\$22	---	---	---	---	---	---	5.0%
	\$23	---	---	---	---	---	5.3%	9.9%
	\$24	---	---	---	---	5.0%	9.9%	13.9%
	\$25	---	---	---	4.3%	9.5%	13.7%	17.4%
	\$26	---	---	2.2%	8.4%	13.0%	17.0%	20.7%
	\$27	---	---	6.1%	11.7%	16.1%	20.0%	23.7%
	\$28	---	0.4%	9.0%	14.3%	18.7%	22.7%	26.4%
\$29	---	3.2%	11.0%	16.3%	20.8%	24.9%	28.7%	
\$30	---	4.3%	12.0%	17.3%	21.9%	26.1%	30.0%	

		Poultry Manure Tip Fee (\$/Tonne)				
		\$0	\$5	\$10	\$15	\$20
\$/GJ RNG	\$16	---	---	---	---	---
	\$17	---	---	---	---	---
	\$18	---	---	---	---	---
	\$19	---	---	---	---	---
	\$20	---	---	---	---	---
	\$21	---	---	---	---	---
	\$22	---	---	---	---	---
	\$23	1.2%	---	---	---	---
	\$24	6.1%	---	---	---	---
	\$25	9.9%	4.7%	---	---	---
	\$26	13.0%	8.5%	2.2%	---	---
	\$27	15.7%	11.5%	6.1%	---	---
	\$28	18.1%	14.0%	9.0%	0.4%	---
\$29	19.9%	15.9%	11.0%	3.5%	---	
\$30	20.9%	16.8%	12.0%	4.7%	---	

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #11 - Option D: RNG Compression and Nutrient Recovery Equipment

This biogas plant is estimated to cost \$11.0 million to build. Operating costs are estimated to average \$1,725,123/year. At an RNG sale price of \$30/GJ, average revenue is estimated to be \$1,774,421/year. This biogas plant requires \$10.0 million funding (91% of CAPEX) for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$49,298/year; equal to 3% of operating costs. Operating income is likely insufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (i.e., broken equipment, unexpected downtime, etc.). This is because farm investment (i.e., debt) is only 9%. Low investment means that even with an unlevered, pre-tax IRR of 12%, operating income can be too low.

Option D: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>	<u>Revenue</u>		<u>Investment</u>	
Digester	\$4,520,250		RNG/GJ =	\$30.00	Farm Investment =	\$985,911
Upgrader	\$3,340,161		Avg RNG Sales/Yr =	\$1,531,447	Funding Amount =	\$9,965,770
Nutrient Recovery	\$1,664,861		Bedding Savings/Yr* =	\$242,974	Funding % of CAPEX =	91%
Other	\$1,426,409					
<u>Total</u>	<u>\$10,951,681</u>	<u>\$1,725,123</u>	<u>Total =</u>	<u>\$1,774,421</u>	<u>Inflation =</u>	<u>2%</u>

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$1,731	\$1,735	\$1,740	\$1,744	\$1,748	\$1,752	\$1,757	\$1,761	\$1,766	\$1,770
OPEX (000s)	\$1,420	\$1,448	\$1,477	\$1,507	\$1,537	\$1,568	\$1,599	\$1,631	\$1,664	\$1,697
<i>Operate Income</i>	\$311	\$287	\$262	\$237	\$211	\$184	\$158	\$130	\$102	\$73

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$1,775	\$1,780	\$1,785	\$1,790	\$1,795	\$1,801	\$1,806	\$1,811	\$1,817	\$1,823
OPEX (000s)	\$1,731	\$1,766	\$1,801	\$1,837	\$1,874	\$1,911	\$1,949	\$1,988	\$2,028	\$2,069
<i>Operate Income</i>	\$44	\$15	-\$16	-\$47	-\$78	-\$111	-\$143	-\$177	-\$211	-\$246

Unlevered, Pre-Tax IRR =	12%	Average Operating Income* =	\$49,298	% of OPEX	3%
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* Averaged over twenty years to account for inflation

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 86% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, with 91% funding, if RNG production is 10% or 20% higher than anticipated (due to the better than expected biogas production from the feedstock), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$27/GJ and <\$24/GJ respectively. Alternately, with 91% funding, if RNG production is 5% lower than anticipated, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR is negative.

Poultry manure accounts for 9% of biogas plant operating costs. Therefore, although less important than RNG sales, poultry manure tip fee can have an impact on biogas plant economic feasibility. For example, with 91% funding, if poultry manure tip fee is only \$5/tonne or \$0/tonne instead of \$10/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$28/GJ and <\$27/GJ respectively. Alternately, with 87% funding, if poultry manure tip fee is \$15/tonne, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR is negative.

Option D: Sensitivity Analysis – RNG Production & Poultry Manure Tip Fee

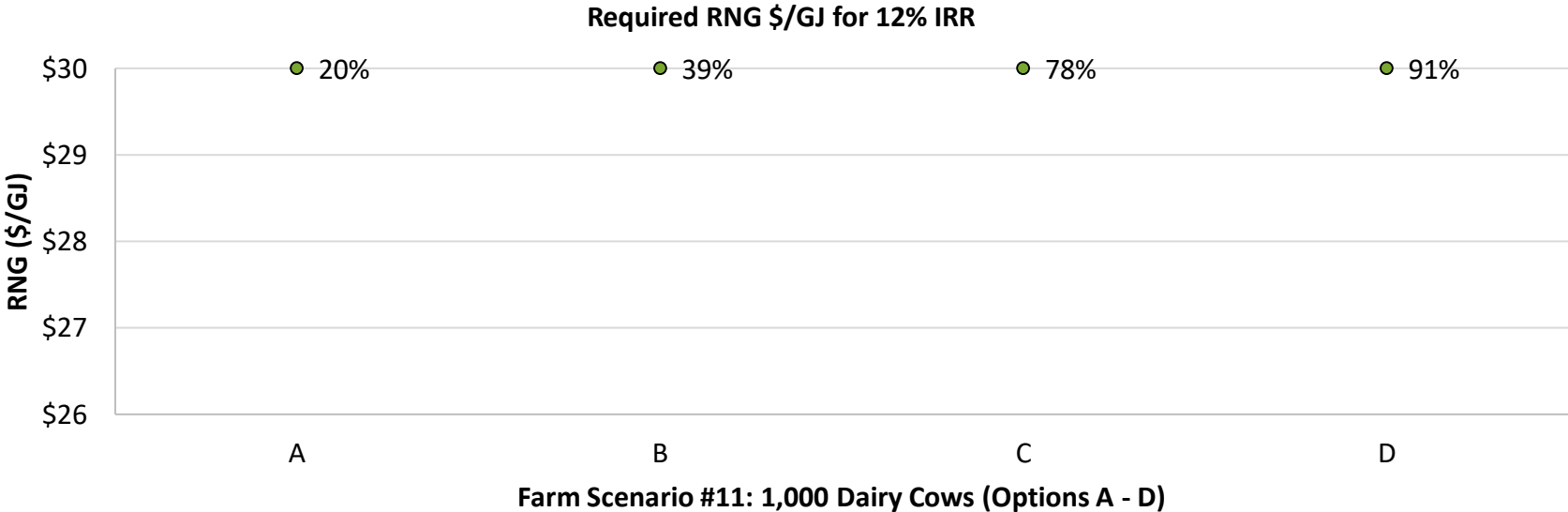
		Change in RNG Production Amount						
		-10%	-5%	0%	5%	10%	15%	20%
\$/GJ RNG	\$16	---	---	---	---	---	---	---
	\$17	---	---	---	---	---	---	---
	\$18	---	---	---	---	---	---	---
	\$19	---	---	---	---	---	---	---
	\$20	---	---	---	---	---	---	---
	\$21	---	---	---	---	---	---	---
	\$22	---	---	---	---	---	---	---
	\$23	---	---	---	---	---	---	2.6%
	\$24	---	---	---	---	---	2.6%	13.7%
	\$25	---	---	---	---	1.0%	13.3%	21.8%
	\$26	---	---	---	---	11.9%	21.1%	29.0%
	\$27	---	---	---	8.7%	19.4%	27.9%	35.7%
	\$28	---	---	---	16.2%	25.9%	34.3%	42.2%
\$29	---	---	---	21.8%	31.4%	40.0%	48.2%	
\$30	---	---	12.0%	24.9%	34.7%	43.6%	52.2%	

		Poultry Manure Tip Fee (\$/Tonne)				
		\$0	\$5	\$10	\$15	\$20
\$/GJ RNG	\$16	---	---	---	---	---
	\$17	---	---	---	---	---
	\$18	---	---	---	---	---
	\$19	---	---	---	---	---
	\$20	---	---	---	---	---
	\$21	---	---	---	---	---
	\$22	---	---	---	---	---
	\$23	---	---	---	---	---
	\$24	---	---	---	---	---
	\$25	2.8%	---	---	---	---
	\$26	11.7%	---	---	---	---
	\$27	18.4%	8.2%	---	---	---
	\$28	24.2%	15.3%	---	---	---
\$29	29.1%	20.6%	---	---	---	
\$30	32.1%	23.5%	12.0%	---	---	

Farm Scenario #11: Summary

Figure 23 shows the required RNG \$/GJ sale price for Farm Scenario #11 Options A – D for an unlevered, pre-tax IRR of 12%. Where required RNG sale price is >\$30/GJ, percentage of required funding is shown. All Farm Scenario #11 Options A – D require funding. Funding increases from 20% (for Option A) to 91% (for Option D). Figure 23 shows that even under the best circumstances (i.e., Option A - needing the least equipment), 1,000 dairy cow farms co-digesting dairy and poultry manure cannot be economically feasible in B.C. without funding.

Figure 23: Farm Scenario #11 - Required RNG Sale Price for 1,000 Dairy Cows + Poultry Manure



7.12

Farm Scenario #12: 2,000 Dairy Cows + Poultry Manure

Farm Scenario #12 is a 2,000 dairy cow farm co-digesting dairy and poultry manure. Farm Scenario #12 assumes the use of traditional on-farm biogas plant technology. Estimated feedstock volumes and Renewable Natural Gas (RNG) production for Farm Scenario #12 are as follows:

Feedstock	Tonnes/Year	Percentage	RNG Production (GJ/Year)
Dairy manure	100,083	80%	32,295 GJ
Poultry manure	24,943	20%	75,099 GJ
<i>Total</i>	<i>125,026</i>	<i>100%</i>	<i>107,394 GJ</i>

The following Equipment Choices were assessed for Farm Scenario #12:

- Option A: No additional equipment;
- Option B: RNG compression equipment;
- Option C: Nutrient recovery equipment; and
- Option D: RNG compression and nutrient recovery equipment.

For full capital and operating costs for Farm Scenario #12 Options A – D, see Appendix L.

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #12 - Option A: No Additional Equipment

This biogas plant is estimated to cost \$10.5 million to build. Operating costs are estimated to average \$1,380,347/year. At an RNG sale price of \$20.70/GJ, average revenue is estimated to be \$2,812,825/year. This biogas plant doesn't require funding for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$1,432,478/year; equal to 104% of operating costs. Operating income should be sufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (e.g., broken equipment, unexpected downtime, etc.).

Option A: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>	<u>Revenue</u>		<u>Investment</u>	
Digester	\$5,223,750		RNG/GJ [†] =	\$20.70	Farm Investment =	\$10,519,185
Upgrader	\$3,093,500		Avg RNG Sales/Yr =	\$2,326,877	Funding Amount =	\$0
Nutrient Rec.	\$831,856		Bedding Savings/Yr* =	\$485,947	Funding % of CAPEX =	0%
Other	\$1,370,079					
<u>Total</u>	<u>\$10,519,185</u>	<u>\$1,380,347</u>	<u>Total =</u>	<u>\$2,812,825</u>	<u>Inflation =</u>	<u>2%</u>

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$2,513	\$2,543	\$2,572	\$2,602	\$2,632	\$2,663	\$2,694	\$2,725	\$2,757	\$2,790
OPEX (000s)	\$1,136	\$1,159	\$1,182	\$1,206	\$1,230	\$1,254	\$1,280	\$1,305	\$1,331	\$1,358
Operate Income	\$1,377	\$1,384	\$1,390	\$1,396	\$1,402	\$1,408	\$1,414	\$1,420	\$1,426	\$1,432

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$2,822	\$2,855	\$2,889	\$2,923	\$2,957	\$2,992	\$3,028	\$3,063	\$3,100	\$3,136
OPEX (000s)	\$1,385	\$1,413	\$1,441	\$1,470	\$1,499	\$1,529	\$1,560	\$1,591	\$1,623	\$1,655
Operate Income	\$1,437	\$1,443	\$1,448	\$1,453	\$1,458	\$1,463	\$1,468	\$1,472	\$1,477	\$1,481

Unlevered, Pre-Tax IRR =	12%	Average Operating Income* =	\$1,432,478	% of OPEX	104%
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* Averaged over twenty years to account for inflation

† Base price (1%/year increase up to \$30/GJ max)

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 83% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, if RNG production is 10% or 20% higher than anticipated (due to the better than expected biogas production from the feedstock), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$20.70/GJ to <\$19/GJ and <\$18/GJ respectively. Alternately, if RNG production is 10% or 20% lower than anticipated, the required RNG sale price for an unlevered, pre-tax IRR increases from \$20.70/GJ to \$23/GJ and >\$25/GJ respectively. Furthermore, if only 50% of estimated poultry manure is available (12,472 instead of 24,943 tonnes/year), RNG production will be approximately 35% lower. If RNG production is 35% lower, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 8.9%. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option A: Sensitivity Analysis – RNG Production

		Change in RNG Production Amount														
		-50%	-45%	-40%	-35%	-30%	-25%	-20%	-15%	-10%	-5%	0%	5%	10%	15%	20%
\$/GJ RNG	\$16	---	---	---	---	---	---	0.3%	1.9%	3.3%	4.6%	5.8%	7.0%	8.1%	9.2%	10.2%
	\$17	---	---	---	---	---	0.2%	1.9%	3.4%	4.7%	6.0%	7.3%	8.4%	9.5%	10.6%	11.7%
	\$18	---	---	---	---	---	1.7%	3.3%	4.7%	6.1%	7.4%	8.6%	9.8%	10.9%	12.0%	13.1%
	\$19	---	---	---	---	1.3%	3.0%	4.6%	6.0%	7.4%	8.7%	9.9%	11.1%	12.3%	13.4%	14.5%
	\$20	---	---	---	0.7%	2.6%	4.3%	5.8%	7.3%	8.6%	9.9%	11.2%	12.4%	13.6%	14.7%	15.9%
	\$21	---	---	---	2.0%	3.8%	5.4%	7.0%	8.4%	9.8%	11.1%	12.4%	13.6%	14.9%	16.0%	17.2%
	\$22	---	---	1.1%	3.1%	4.9%	6.5%	8.1%	9.5%	10.9%	12.3%	13.6%	14.9%	16.1%	17.3%	18.5%
	\$23	---	0.0%	2.2%	4.2%	6.0%	7.6%	9.2%	10.6%	12.0%	13.4%	14.7%	16.0%	17.3%	18.6%	19.8%
	\$24	---	1.1%	3.3%	5.2%	7.0%	8.6%	10.2%	11.7%	13.1%	14.5%	15.9%	17.2%	18.5%	19.8%	21.1%
	\$25	---	2.1%	4.3%	6.2%	7.9%	9.6%	11.2%	12.7%	14.2%	15.6%	17.0%	18.3%	19.7%	21.0%	22.3%
	\$26	0.6%	3.0%	5.1%	7.0%	8.8%	10.5%	12.1%	13.7%	15.2%	16.6%	18.0%	19.4%	20.8%	22.2%	23.5%
	\$27	1.2%	3.6%	5.8%	7.7%	9.6%	11.3%	12.9%	14.5%	16.1%	17.6%	19.0%	20.5%	21.9%	23.3%	24.7%
	\$28	1.7%	4.1%	6.3%	8.3%	10.2%	11.9%	13.6%	15.3%	16.8%	18.4%	19.9%	21.4%	22.9%	24.3%	25.8%
	\$29	2.0%	4.5%	6.7%	8.7%	10.6%	12.4%	14.1%	15.8%	17.4%	19.0%	20.6%	22.2%	23.7%	25.2%	26.7%
\$30	2.1%	4.6%	6.8%	8.9%	10.8%	12.6%	14.4%	16.1%	17.8%	19.4%	21.0%	22.5%	24.1%	25.6%	27.2%	

B.C. On-Farm Biogas Benchmark Study, Version 2

Poultry manure accounts for 22% of biogas plant operating costs. Therefore, although less important than RNG sales, poultry manure tip fee can have an impact on biogas plant economic feasibility. For example, if poultry manure tip fee is only \$5/tonne or \$0/tonne instead of \$10/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$20.70/GJ to <\$20/GJ and <\$19/GJ respectively. Alternately, if poultry manure tip fee is \$15/tonne or \$20/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% increases from \$20.70/GJ to \$22/GJ and >\$23/GJ respectively.

Option A: Sensitivity Analysis – Poultry Manure Tip Fee

		Poultry Manure Tip Fee (\$/Tonne)				
		\$0	\$5	\$10	\$15	\$20
\$/GJ RNG	\$16	9.4%	7.7%	5.8%	3.7%	1.3%
	\$17	10.7%	9.0%	7.3%	5.3%	3.2%
	\$18	11.9%	10.3%	8.6%	6.8%	4.8%
	\$19	13.1%	11.6%	9.9%	8.2%	6.3%
	\$20	14.3%	12.8%	11.2%	9.5%	7.8%
	\$21	15.4%	13.9%	12.4%	10.8%	9.1%
	\$22	16.5%	15.1%	13.6%	12.0%	10.4%
	\$23	17.6%	16.2%	14.7%	13.2%	11.7%
	\$24	18.7%	17.3%	15.9%	14.4%	12.9%
	\$25	19.8%	18.4%	17.0%	15.5%	14.1%
	\$26	20.8%	19.4%	18.0%	16.6%	15.2%
	\$27	21.8%	20.4%	19.0%	17.6%	16.2%
	\$28	22.6%	21.3%	19.9%	18.5%	17.1%
	\$29	23.4%	22.0%	20.6%	19.2%	17.7%
	\$30	23.7%	22.4%	21.0%	19.5%	18.1%

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #12 - Option B: RNG Compression Equipment

This biogas plant is estimated to cost \$11.6 million to build. Operating costs are estimated to average \$1,688,901/year. At an RNG sale price of \$24.69/GJ, average revenue is estimated to be \$3,261,409/year. This biogas plant doesn't require funding for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$1,572,508/year; equal to 93% of operating costs. Operating income should be sufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (i.e., broken equipment, unexpected downtime, etc.).

Option B: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>	<u>Revenue</u>	<u>Investment</u>
Digester	\$5,223,750		RNG/GJ [†] = \$24.69	Farm Investment = \$11,636,291
Upgrader	\$4,065,108		Avg RNG Sales/Yr = \$2,775,461	Funding Amount = \$0
Nutrient Rec.	\$831,856		Bedding Savings/Yr* = \$485,947	Funding % of CAPEX = 0%
Other	\$1,515,577			
<u>Total</u>	<u>\$11,636,291</u>	<u>\$1,688,901</u>	<u>Total = \$3,261,409</u>	<u>Inflation = 2%</u>

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$2,921	\$2,954	\$2,988	\$3,022	\$3,056	\$3,091	\$3,126	\$3,162	\$3,199	\$3,235
OPEX (000s)	\$1,390	\$1,418	\$1,446	\$1,475	\$1,505	\$1,535	\$1,566	\$1,597	\$1,629	\$1,661
<i>Operate Income</i>	\$1,531	\$1,536	\$1,541	\$1,546	\$1,551	\$1,556	\$1,561	\$1,565	\$1,570	\$1,574

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$3,272	\$3,310	\$3,348	\$3,387	\$3,426	\$3,465	\$3,505	\$3,546	\$3,587	\$3,628
OPEX (000s)	\$1,695	\$1,729	\$1,763	\$1,798	\$1,834	\$1,871	\$1,908	\$1,947	\$1,986	\$2,025
<i>Operate Income</i>	\$1,578	\$1,581	\$1,585	\$1,588	\$1,591	\$1,594	\$1,597	\$1,599	\$1,601	\$1,603

Unlevered, Pre-Tax IRR =	12%
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Average Operating Income* =	\$1,572,508
------------------------------------	--------------------

% of OPEX	93%
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* Averaged over twenty years to account for inflation

† Base price (1%/year increase up to \$30/GJ max)

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 85% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, if RNG production is 10% or 20% higher than anticipated (due to the better than expected biogas production from the feedstock), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$24.69/GJ to <\$23/GJ and <\$21/GJ respectively. Alternately, if RNG production is 10% lower than anticipated, the required RNG sale price for an unlevered, pre-tax IRR increases from \$24.69/GJ to \$28/GJ. Furthermore, if only 50% of estimated poultry manure is available (12,472 instead of 24,943 tonnes/year), RNG production will be approximately 35% lower. If RNG production is 35% lower, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 3.4%. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option B: Sensitivity Analysis – RNG Production

		Change in RNG Production Amount														
		-50%	-45%	-40%	-35%	-30%	-25%	-20%	-15%	-10%	-5%	0%	5%	10%	15%	20%
\$/GJ RNG	\$16	---	---	---	---	---	---	---	---	---	---	0.2%	1.7%	3.0%	4.2%	5.3%
	\$17	---	---	---	---	---	---	---	---	---	0.5%	2.0%	3.3%	4.6%	5.8%	6.9%
	\$18	---	---	---	---	---	---	---	---	0.6%	2.2%	3.6%	4.9%	6.1%	7.3%	8.4%
	\$19	---	---	---	---	---	---	---	0.5%	2.2%	3.7%	5.0%	6.3%	7.6%	8.7%	9.9%
	\$20	---	---	---	---	---	---	0.2%	2.0%	3.6%	5.0%	6.4%	7.7%	8.9%	10.1%	11.2%
	\$21	---	---	---	---	---	---	1.7%	3.3%	4.9%	6.3%	7.7%	9.0%	10.2%	11.4%	12.6%
	\$22	---	---	---	---	---	1.1%	3.0%	4.6%	6.1%	7.6%	8.9%	10.2%	11.5%	12.7%	13.8%
	\$23	---	---	---	---	0.4%	2.4%	4.2%	5.8%	7.3%	8.7%	10.1%	11.4%	12.7%	13.9%	15.1%
	\$24	---	---	---	---	1.7%	3.6%	5.3%	6.9%	8.4%	9.9%	11.2%	12.6%	13.8%	15.1%	16.3%
	\$25	---	---	---	0.7%	2.8%	4.7%	6.4%	8.0%	9.5%	10.9%	12.3%	13.7%	15.0%	16.3%	17.5%
	\$26	---	---	---	1.6%	3.7%	5.6%	7.3%	8.9%	10.5%	11.9%	13.4%	14.7%	16.1%	17.4%	18.7%
	\$27	---	---	0.0%	2.4%	4.5%	6.4%	8.1%	9.8%	11.3%	12.8%	14.3%	15.7%	17.1%	18.4%	19.7%
	\$28	---	---	0.5%	2.9%	5.1%	7.0%	8.8%	10.5%	12.0%	13.6%	15.1%	16.5%	17.9%	19.3%	20.7%
	\$29	---	---	0.8%	3.3%	5.4%	7.4%	9.2%	10.9%	12.6%	14.1%	15.7%	17.2%	18.6%	20.1%	21.5%
	\$30	---	---	1.0%	3.4%	5.6%	7.6%	9.4%	11.2%	12.8%	14.4%	16.0%	17.5%	19.0%	20.4%	21.9%

B.C. On-Farm Biogas Benchmark Study, Version 2

Poultry manure accounts for 18% of biogas plant operating costs. Therefore, although less important than RNG sales, poultry manure tip fee can have an impact on biogas plant economic feasibility. For example, if poultry manure tip fee is only \$5/tonne or \$0/tonne instead of \$10/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$24.69/GJ to <\$24/GJ and <\$23/GJ respectively. Alternately, if poultry manure tip fee is \$15/tonne or \$20/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% increases from \$24.69/GJ to >\$26/GJ and >\$27/GJ respectively.

Option B: Sensitivity Analysis –Poultry Manure Tip Fee

		Poultry Manure Tip Fee (\$/Tonne)				
		\$0	\$5	\$10	\$15	\$20
\$/GJ RNG	\$16	4.5%	2.5%	0.2%	-2.6%	-6.5%
	\$17	5.9%	4.1%	2.0%	-0.4%	-3.5%
	\$18	7.2%	5.5%	3.6%	1.4%	-1.2%
	\$19	8.5%	6.8%	5.0%	3.1%	0.8%
	\$20	9.6%	8.1%	6.4%	4.6%	2.5%
	\$21	10.8%	9.3%	7.7%	6.0%	4.1%
	\$22	11.9%	10.4%	8.9%	7.3%	5.5%
	\$23	13.0%	11.6%	10.1%	8.5%	6.9%
	\$24	14.0%	12.7%	11.2%	9.7%	8.1%
	\$25	15.1%	13.7%	12.3%	10.9%	9.4%
	\$26	16.0%	14.7%	13.4%	11.9%	10.5%
	\$27	16.9%	15.6%	14.3%	12.9%	11.4%
	\$28	17.7%	16.4%	15.1%	13.7%	12.2%
	\$29	18.4%	17.0%	15.7%	14.3%	12.8%
	\$30	18.7%	17.3%	16.0%	14.6%	13.1%

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #12 - Option C: Nutrient Recovery Equipment

This biogas plant is estimated to cost \$12.2 million to build. Operating costs are estimated to average \$2,442,873/year. At an RNG sale price of \$30.00/GJ, average revenue is estimated to be \$3,548,842/year. This biogas plant requires \$2.9 million funding (24% of CAPEX) for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$1,105,969/year; equal to 45% of operating costs. Operating income may or may not be sufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (i.e., broken equipment, unexpected downtime, etc.).

Option C: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>	<u>Revenue</u>		<u>Investment</u>	
Digester	\$5,454,750		RNG/GJ =	\$30.00	Farm Investment =	\$9,232,445
Upgrader	\$3,093,500		Avg RNG Sales/Yr =	\$3,062,895	Funding Amount =	\$2,932,033
Nutrient Recovery	\$2,031,856		Bedding Saving/Yr* =	\$485,947	Funding % of CAPEX =	24%
Other	\$1,584,371					
<u>Total</u>	<u>\$12,164,477</u>	<u>\$2,442,873</u>	<u>Total =</u>	<u>\$3,548,842</u>	<u>Inflation =</u>	<u>2%</u>

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$3,463	\$3,471	\$3,479	\$3,487	\$3,496	\$3,505	\$3,513	\$3,522	\$3,532	\$3,541
OPEX (000s)	\$2,011	\$2,051	\$2,092	\$2,134	\$2,177	\$2,220	\$2,265	\$2,310	\$2,356	\$2,403
<i>Operate Income</i>	\$1,452	\$1,420	\$1,387	\$1,353	\$1,319	\$1,284	\$1,249	\$1,213	\$1,176	\$1,138

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$3,550	\$3,560	\$3,570	\$3,580	\$3,591	\$3,601	\$3,612	\$3,623	\$3,634	\$3,646
OPEX (000s)	\$2,451	\$2,500	\$2,550	\$2,601	\$2,653	\$2,706	\$2,760	\$2,816	\$2,872	\$2,929
<i>Operate Income</i>	\$1,099	\$1,060	\$1,020	\$979	\$937	\$895	\$852	\$807	\$762	\$716

Unlevered, Pre-Tax IRR =	12%	Average Operating Income* =	\$1,105,969	% of OPEX	45%
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* Averaged over twenty years to account for inflation

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 86% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, with 24% funding, if RNG production is 10% or 20% higher than anticipated (due to the better than expected biogas production from the feedstock), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$26/GJ and <\$24/GJ respectively. Alternately, with 24% funding, if RNG production is 5% or 10% lower than anticipated, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 9.7% and 7.2% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Poultry manure accounts for 12% of biogas plant operating costs. Therefore, although less important than RNG sales, poultry manure tip fee can have an impact on biogas plant economic feasibility. For example, with 24% funding, if poultry manure tip fee is only \$5/tonne or \$0/tonne instead of \$10/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$28/GJ and <\$26/GJ respectively. Alternately, with 24% funding, if poultry manure tip fee is \$15/tonne or \$20/tonne, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 9.9% and 7.5% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option C: Sensitivity Analysis – RNG Production & Poultry Manure Tip Fee

		Change in RNG Production Amount						
		-10%	-5%	0%	5%	10%	15%	20%
\$/GJ RNG	\$16	---	---	---	---	---	---	---
	\$17	---	---	---	---	---	---	---
	\$18	---	---	---	---	---	---	0.2%
	\$19	---	---	---	---	---	0.8%	3.0%
	\$20	---	---	---	---	1.2%	3.4%	5.3%
	\$21	---	---	---	1.3%	3.6%	5.6%	7.4%
	\$22	---	---	1.2%	3.6%	5.7%	7.6%	9.3%
	\$23	---	0.8%	3.4%	5.6%	7.6%	9.4%	11.1%
	\$24	0.2%	3.0%	5.3%	7.4%	9.3%	11.1%	12.8%
	\$25	2.3%	4.8%	7.1%	9.1%	11.0%	12.8%	14.5%
	\$26	3.9%	6.4%	8.6%	10.6%	12.5%	14.3%	16.0%
	\$27	5.2%	7.7%	9.8%	11.9%	13.8%	15.6%	17.4%
	\$28	6.2%	8.7%	10.9%	13.0%	14.9%	16.8%	18.7%
	\$29	6.9%	9.4%	11.7%	13.8%	15.8%	17.8%	19.6%
\$30	7.2%	9.7%	12.0%	14.2%	16.2%	18.2%	20.1%	

		Poultry Manure Tip Fee (\$/Tonne)				
		\$0	\$5	\$10	\$15	\$20
\$/GJ RNG	\$16	---	---	---	---	---
	\$17	---	---	---	---	---
	\$18	---	---	---	---	---
	\$19	0.4%	---	---	---	---
	\$20	2.7%	---	---	---	---
	\$21	4.7%	2.0%	---	---	---
	\$22	6.5%	4.0%	1.2%	---	---
	\$23	8.1%	5.9%	3.4%	0.4%	---
	\$24	9.7%	7.6%	5.3%	2.7%	---
	\$25	11.1%	9.2%	7.1%	4.7%	1.9%
	\$26	12.5%	10.6%	8.6%	6.3%	3.8%
	\$27	13.7%	11.8%	9.8%	7.7%	5.3%
	\$28	14.7%	12.9%	10.9%	8.8%	6.4%
	\$29	15.5%	13.6%	11.7%	9.5%	7.2%
\$30	15.9%	14.0%	12.0%	9.9%	7.5%	

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #12 - Option D: RNG Compression and Nutrient Recovery Equipment

This biogas plant is estimated to cost \$13.3 million to build. Operating costs are estimated to average \$2,751,427/year. At an RNG sale price of \$30.00/GJ, average revenue is estimated to be \$3,548,842/year. This biogas plant requires \$6.2 million funding (47% of CAPEX) for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$797,415/year; equal to 29% of operating costs. Operating income is likely insufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (i.e., broken equipment, unexpected downtime, etc.). This is because farm investment (i.e., debt) is only 53%. Low investment means that even with an unlevered, pre-tax IRR of 12%, operating income can be too low.

Option D: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>	<u>Revenue</u>	<u>Investment</u>
Digester	\$5,454,750		RNG/GJ = \$30.00	Farm Investment = \$7,100,458
Upgrader	\$4,065,108		Avg RNG Sales/Yr = \$3,062,895	Funding Amount = \$6,181,125
Nutrient Recovery	\$2,031,856		Bedding Savings/Yr* = \$485,947	Funding % of CAPEX = 47%
Other	\$1,729,869			
<u>Total</u>	<u>\$13,281,583</u>	<u>\$2,751,427</u>	<u>Total = \$3,548,842</u>	<u>Inflation = 2%</u>

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$3,463	\$3,471	\$3,479	\$3,487	\$3,496	\$3,505	\$3,513	\$3,522	\$3,532	\$3,541
OPEX (000s)	\$2,265	\$2,310	\$2,356	\$2,403	\$2,451	\$2,501	\$2,551	\$2,602	\$2,654	\$2,707
<i>Operate Income</i>	\$1,198	\$1,161	\$1,123	\$1,084	\$1,044	\$1,004	\$963	\$921	\$878	\$834

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$3,550	\$3,560	\$3,570	\$3,580	\$3,591	\$3,601	\$3,612	\$3,623	\$3,634	\$3,646
OPEX (000s)	\$2,761	\$2,816	\$2,872	\$2,930	\$2,988	\$3,048	\$3,109	\$3,171	\$3,235	\$3,299
<i>Operate Income</i>	\$790	\$744	\$698	\$651	\$602	\$553	\$503	\$452	\$400	\$346

Unlevered, Pre-Tax IRR =	12%	Average Operating Income* =	\$797,415	% of OPEX	29%
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* Averaged over twenty years to account for inflation

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 86% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, with 47% funding, if RNG production is 10% or 20% higher than anticipated (due to the better than expected biogas production from the feedstock), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$26/GJ and <\$24/GJ respectively. Alternately, with 47% funding, if RNG production is 5% or 10% lower than anticipated, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 8.7% and 4.8% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Poultry manure accounts for 11% of biogas plant operating costs. Therefore, although less important than RNG sales, poultry manure tip fee can have an impact on biogas plant economic feasibility. For example, with 47% funding, if poultry manure tip fee is only \$5/tonne or \$0/tonne instead of \$10/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$28/GJ and <\$26/GJ respectively. Alternately, with 47% funding, if poultry manure tip fee is \$15/tonne or \$20/tonne, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 8.9% and 5.1% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option D: Sensitivity Analysis – RNG Production & Poultry Manure Tip Fee

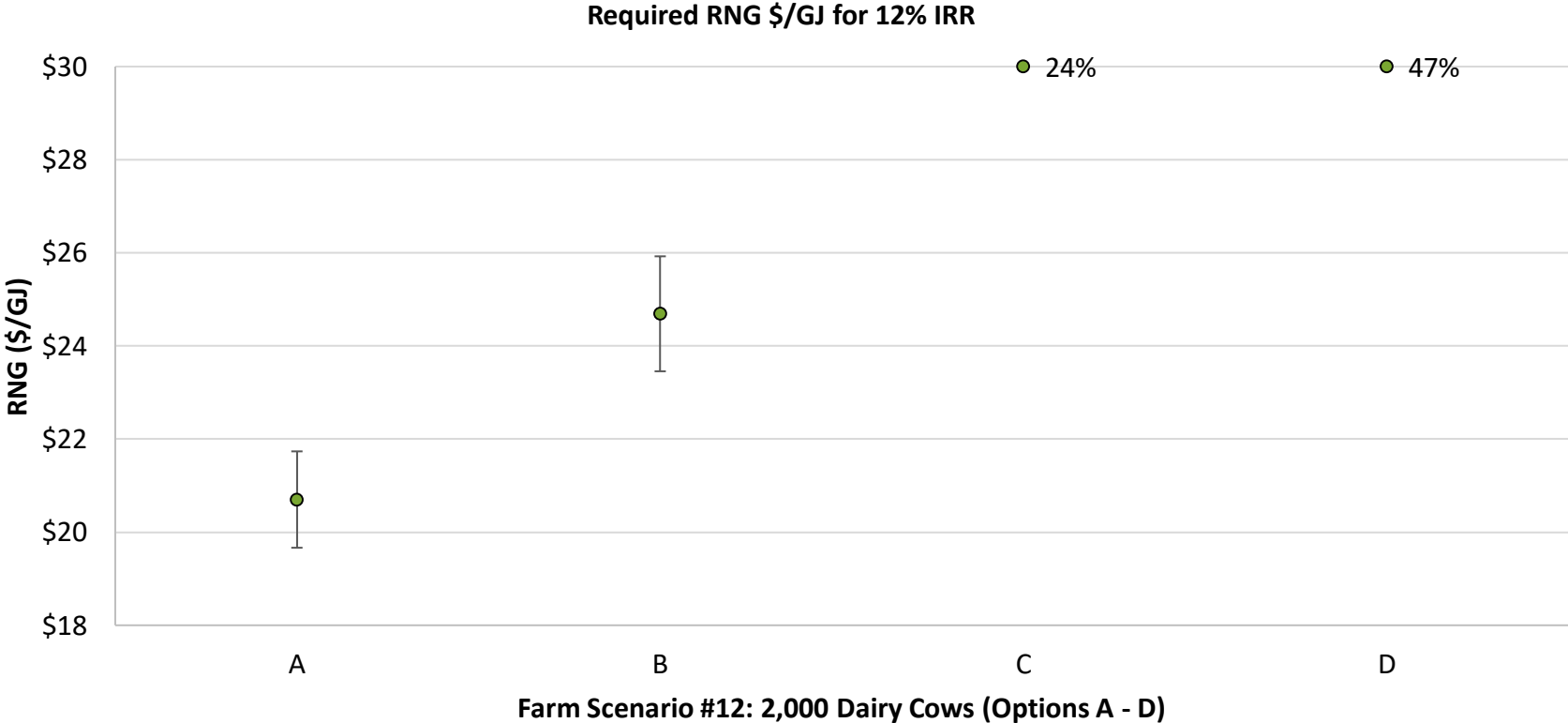
		Change in RNG Production Amount						
		-10%	-5%	0%	5%	10%	15%	20%
\$/GJ RNG	\$16	---	---	---	---	---	---	---
	\$17	---	---	---	---	---	---	---
	\$18	---	---	---	---	---	---	---
	\$19	---	---	---	---	---	---	---
	\$20	---	---	---	---	---	---	2.3%
	\$21	---	---	---	---	---	2.7%	5.5%
	\$22	---	---	---	---	2.9%	5.8%	8.3%
	\$23	---	---	---	2.7%	5.8%	8.4%	10.8%
	\$24	---	---	2.3%	5.5%	8.3%	10.8%	13.1%
	\$25	---	1.5%	5.0%	8.0%	10.6%	13.0%	15.3%
	\$26	---	3.9%	7.2%	10.0%	12.6%	15.0%	17.3%
	\$27	1.8%	5.8%	9.0%	11.8%	14.4%	16.8%	19.1%
	\$28	3.4%	7.2%	10.4%	13.3%	15.9%	18.4%	20.8%
\$29	4.3%	8.2%	11.5%	14.4%	17.1%	19.7%	22.1%	
\$30	4.8%	8.7%	12.0%	14.9%	17.7%	20.3%	22.8%	

		Poultry Manure Tip Fee (\$/Tonne)				
		\$0	\$5	\$10	\$15	\$20
\$/GJ RNG	\$16	---	---	---	---	---
	\$17	---	---	---	---	---
	\$18	---	---	---	---	---
	\$19	---	---	---	---	---
	\$20	---	---	---	---	---
	\$21	1.3%	---	---	---	---
	\$22	4.1%	0.1%	---	---	---
	\$23	6.6%	3.2%	---	---	---
	\$24	8.8%	5.8%	2.3%	---	---
	\$25	10.8%	8.1%	5.0%	1.2%	---
	\$26	12.6%	10.1%	7.2%	3.8%	---
	\$27	14.2%	11.7%	9.0%	5.8%	1.7%
	\$28	15.6%	13.1%	10.4%	7.4%	3.5%
\$29	16.6%	14.2%	11.5%	8.4%	4.7%	
\$30	17.2%	14.7%	12.0%	8.9%	5.1%	

Farm Scenario #12: Summary

Figure 24 shows the required RNG \$/GJ sale price for Farm Scenario #12 Options A – D for an unlevered, pre-tax IRR of 12%. Where required RNG sale price is >\$30/GJ, percentage of required funding is shown. Where required RNG sale price is <\$30/GJ, a bar representing +/- 5% is shown to account for price uncertainty. Farm Scenario #12 Options A – B don’t require funding. These biogas plant requires \$19.67 - \$25.92/GJ. Farm Scenario #12 Options C and D require funding. Funding increases from 24% (for Option C) to 47% (for Option D). Figure 24 shows that only under the best circumstances (i.e., Option A - needing the least equipment, or Option B – only needing RNG compression equipment) are 2,000 dairy cow farms co-digesting dairy and poultry manure economically feasible in B.C. without funding.

Figure 24: Farm Scenario #12 - Required RNG Sale Price for 2,000 Dairy Cows + Poultry Manure



7.13

Farm Scenario #13: 2,500 Dairy Cows

Farm Scenario #13 is a 2,500 dairy cow farm digesting dairy manure. Farm Scenario #13 assumes the use of traditional on-farm biogas plant technology. Estimated feedstock volumes and Renewable Natural Gas (RNG) production for Farm Scenario #13 are as follows:

Feedstock	Tonnes/Year	Percentage	RNG Production (GJ/Year)
Dairy manure	125,104	100%	40,386 GJ
<i>Total</i>	<i>125,026</i>	<i>100%</i>	<i>40,368 GJ</i>

The following Equipment Choices were assessed for Farm Scenario #13:

- Option A: No additional equipment;
- Option B: RNG compression equipment;
- Option C: Nutrient recovery equipment; and
- Option D: RNG compression and nutrient recovery equipment.

For full capital and operating costs for Farm Scenario #13 Options A – D, see Appendix M.

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #13 - Option A: No Additional Equipment

This biogas plant is estimated to cost \$7.7 million to build. Operating costs are estimated to average \$676,058/year. At an RNG sale price of \$26.92/GJ, average revenue is estimated to be \$1,723,033/year. This biogas plant doesn't require funding for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$1,046,975/year; equal to 155% of operating costs. Operating income should be sufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (e.g., broken equipment, unexpected downtime, etc.).

Option A: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>	<u>Revenue</u>		<u>Investment</u>	
Digester	\$4,546,500		RNG/GJ [†] =	\$26.92	Farm Investment =	\$7,655,380
Upgrader	\$2,111,800		Avg RNG Sales/Yr =	\$1,115,598	Funding Amount =	\$0
Nutrient Recovery	\$0		Bedding Savings/Yr* =	\$607,434	Funding % of CAPEX =	0%
Other	\$997,080					
<u>Total</u>	<u>\$7,655,380</u>	<u>\$676,058</u>	<u>Total =</u>	<u>\$1,723,033</u>	<u>Inflation =</u>	<u>2%</u>

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$1,533	\$1,553	\$1,574	\$1,595	\$1,616	\$1,638	\$1,660	\$1,682	\$1,705	\$1,728
OPEX (000s)	\$556	\$568	\$579	\$591	\$602	\$614	\$627	\$639	\$652	\$665
Operate Income	\$977	\$986	\$995	\$1,004	\$1,014	\$1,023	\$1,033	\$1,043	\$1,053	\$1,062

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$1,751	\$1,773	\$1,785	\$1,798	\$1,811	\$1,824	\$1,838	\$1,851	\$1,865	\$1,880
OPEX (000s)	\$678	\$692	\$706	\$720	\$734	\$749	\$764	\$779	\$795	\$811
Operate Income	\$1,072	\$1,081	\$1,080	\$1,078	\$1,077	\$1,075	\$1,074	\$1,072	\$1,071	\$1,069

Unlevered, Pre-Tax IRR =	12%
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Average Operating Income* =	\$1,046,975
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% of OPEX	155%
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* Averaged over twenty years to account for inflation

† Base price (1%/year increase up to \$30/GJ max)

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 65% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, if RNG production is 10% or 20% higher than anticipated (due to the better than expected biogas production from the feedstock), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$26.92/GJ to <\$25/GJ and <\$23/GJ respectively. Alternately, if RNG production is 10%, 20% or 30% lower than anticipated, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 11.2%, 9.3% and 7.3% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option A: Sensitivity Analysis – RNG Production

		Change in RNG Production Amount														
		-50%	-45%	-40%	-35%	-30%	-25%	-20%	-15%	-10%	-5%	0%	5%	10%	15%	20%
\$/GJ RNG	\$16	---	---	---	---	0.5%	1.3%	2.0%	2.7%	3.4%	4.1%	4.7%	5.3%	5.9%	6.5%	7.1%
	\$17	---	---	---	0.4%	1.2%	2.0%	2.7%	3.5%	4.2%	4.8%	5.5%	6.1%	6.7%	7.3%	7.9%
	\$18	---	---	0.1%	1.0%	1.8%	2.6%	3.4%	4.2%	4.9%	5.6%	6.2%	6.9%	7.5%	8.1%	8.7%
	\$19	---	---	0.7%	1.6%	2.5%	3.3%	4.1%	4.8%	5.6%	6.3%	6.9%	7.6%	8.3%	8.9%	9.5%
	\$20	---	0.3%	1.3%	2.2%	3.1%	3.9%	4.7%	5.5%	6.2%	6.9%	7.6%	8.3%	9.0%	9.7%	10.3%
	\$21	---	0.9%	1.8%	2.8%	3.7%	4.5%	5.3%	6.1%	6.9%	7.6%	8.3%	9.0%	9.7%	10.4%	11.1%
	\$22	0.3%	1.4%	2.4%	3.3%	4.2%	5.1%	5.9%	6.7%	7.5%	8.3%	9.0%	9.7%	10.4%	11.1%	11.8%
	\$23	0.8%	1.9%	2.9%	3.9%	4.8%	5.7%	6.5%	7.3%	8.1%	8.9%	9.7%	10.4%	11.1%	11.8%	12.5%
	\$24	1.3%	2.4%	3.4%	4.4%	5.3%	6.2%	7.1%	7.9%	8.7%	9.5%	10.3%	11.1%	11.8%	12.5%	13.3%
	\$25	1.8%	2.9%	3.9%	4.9%	5.8%	6.8%	7.6%	8.5%	9.3%	10.1%	10.9%	11.7%	12.5%	13.2%	14.0%
	\$26	2.1%	3.3%	4.3%	5.3%	6.3%	7.2%	8.2%	9.0%	9.9%	10.7%	11.5%	12.3%	13.1%	13.9%	14.6%
	\$27	2.4%	3.6%	4.7%	5.7%	6.7%	7.7%	8.6%	9.5%	10.4%	11.2%	12.0%	12.9%	13.7%	14.5%	15.3%
	\$28	2.7%	3.8%	4.9%	6.0%	7.0%	8.0%	8.9%	9.9%	10.7%	11.6%	12.5%	13.3%	14.2%	15.0%	15.8%
	\$29	2.8%	4.0%	5.1%	6.2%	7.2%	8.2%	9.2%	10.1%	11.0%	11.9%	12.8%	13.7%	14.5%	15.4%	16.2%
\$30	2.9%	4.1%	5.2%	6.3%	7.3%	8.3%	9.3%	10.2%	11.2%	12.1%	13.0%	13.8%	14.7%	15.5%	16.4%	

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #13 - Option B: RNG Compression Equipment

This biogas plant is estimated to cost \$8.4 million to build. Operating costs are estimated to average \$823,005/year. At an RNG sale price of \$30.00/GJ, average revenue is estimated to be \$1,758,748/year. This biogas plant requires \$1.3 million funding (16% of CAPEX) for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$935,743/year; equal to 114% of operating costs. Operating income should be sufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (i.e., broken equipment, unexpected downtime, etc.).

Option B: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>		<u>Revenue</u>		<u>Investment</u>	
Digester	\$4,546,500			RNG/GJ =	\$30.00	Farm Investment =	\$6,995,984
Upgrader	\$2,786,184			Avg RNG Sales/Yr =	\$1,151,314	Funding Amount =	\$1,333,781
Nutrient Recovery	\$0			Bedding Savings/Yr* =	\$607,434	Funding % of CAPEX =	16%
Other	\$1,098,069						
<u>Total</u>	<u>\$8,430,754</u>	<u>\$823,005</u>		<u>Total =</u>	<u>\$1,758,748</u>	<u>Inflation =</u>	<u>2%</u>

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$1,651	\$1,661	\$1,672	\$1,682	\$1,693	\$1,703	\$1,714	\$1,726	\$1,737	\$1,749
OPEX (000s)	\$677	\$691	\$705	\$719	\$733	\$748	\$763	\$778	\$794	\$810
<i>Operate Income</i>	\$974	\$970	\$967	\$963	\$959	\$955	\$951	\$947	\$943	\$939

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$1,761	\$1,773	\$1,785	\$1,798	\$1,811	\$1,824	\$1,838	\$1,851	\$1,865	\$1,880
OPEX (000s)	\$826	\$842	\$859	\$876	\$894	\$912	\$930	\$949	\$968	\$987
<i>Operate Income</i>	\$935	\$931	\$926	\$922	\$917	\$912	\$908	\$903	\$898	\$893

Unlevered, Pre-Tax IRR =	12%
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Average Operating Income* =	\$935,743
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% of OPEX	114%
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* Averaged over twenty years to account for inflation

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 65% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, with 16% funding, if RNG production is 10% or 20% higher than anticipated (due to the better than expected biogas production from the feedstock), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$26/GJ and <\$24/GJ respectively. Alternately, with 16% funding, if RNG production is 10%, 20% or 30% lower than anticipated, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 10.0%, 7.9% and 5.6% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option B: Sensitivity Analysis – RNG Production

		Change in RNG Production Amount														
		-50%	-45%	-40%	-35%	-30%	-25%	-20%	-15%	-10%	-5%	0%	5%	10%	15%	20%
\$/GJ RNG	\$16	---	---	---	---	---	---	---	0.1%	1.0%	1.8%	2.6%	3.3%	4.0%	4.7%	5.4%
	\$17	---	---	---	---	---	---	0.1%	1.0%	1.9%	2.7%	3.5%	4.3%	5.0%	5.7%	6.4%
	\$18	---	---	---	---	---	0.0%	1.0%	1.9%	2.8%	3.6%	4.4%	5.2%	5.9%	6.6%	7.3%
	\$19	---	---	---	---	---	0.8%	1.8%	2.7%	3.6%	4.4%	5.2%	6.0%	6.8%	7.5%	8.2%
	\$20	---	---	---	---	0.5%	1.6%	2.6%	3.5%	4.4%	5.2%	6.1%	6.8%	7.6%	8.4%	9.1%
	\$21	---	---	---	0.2%	1.3%	2.3%	3.3%	4.3%	5.2%	6.0%	6.8%	7.6%	8.4%	9.2%	9.9%
	\$22	---	---	---	0.9%	2.0%	3.0%	4.0%	5.0%	5.9%	6.8%	7.6%	8.4%	9.2%	10.0%	10.8%
	\$23	---	---	0.3%	1.5%	2.7%	3.7%	4.7%	5.7%	6.6%	7.5%	8.4%	9.2%	10.0%	10.8%	11.6%
	\$24	---	---	1.0%	2.2%	3.3%	4.4%	5.4%	6.4%	7.3%	8.2%	9.1%	9.9%	10.8%	11.6%	12.4%
	\$25	---	0.3%	1.6%	2.8%	3.9%	5.0%	6.0%	7.0%	8.0%	8.9%	9.8%	10.7%	11.5%	12.3%	13.2%
	\$26	---	0.8%	2.1%	3.3%	4.5%	5.6%	6.6%	7.6%	8.6%	9.5%	10.4%	11.3%	12.2%	13.1%	13.9%
	\$27	---	1.1%	2.5%	3.7%	4.9%	6.0%	7.1%	8.1%	9.1%	10.1%	11.0%	11.9%	12.8%	13.7%	14.6%
	\$28	---	1.4%	2.8%	4.1%	5.3%	6.4%	7.5%	8.5%	9.5%	10.5%	11.5%	12.4%	13.3%	14.2%	15.1%
	\$29	0.1%	1.6%	3.0%	4.3%	5.5%	6.6%	7.7%	8.8%	9.8%	10.9%	11.8%	12.8%	13.7%	14.7%	15.6%
	\$30	0.1%	1.7%	3.1%	4.4%	5.6%	6.7%	7.9%	8.9%	10.0%	11.0%	12.0%	13.0%	13.9%	14.9%	15.8%

Farm Scenario #13 - Option C: Nutrient Recovery Equipment

This biogas plant is estimated to cost \$9.3 million to build. Operating costs are estimated to average \$1,759,205/year. At an RNG sale price of \$30/GJ, average revenue is estimated to be \$1,758,748/year. Because operating costs are greater than revenue, this biogas plant requires >100% funding for an unlevered, pre-tax IRR of 12%. For this reason, an economic assessment was not completed.

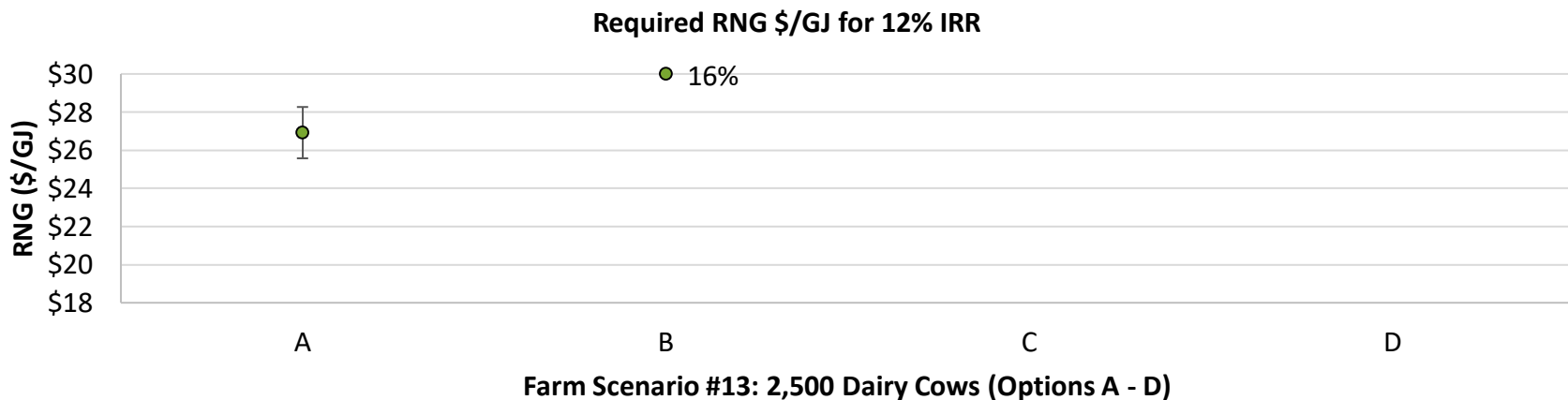
Farm Scenario #13 - Option D: RNG Compression and Nutrient Recovery Equipment

This biogas plant is estimated to cost \$10.1 million to build. Operating costs are estimated to average \$1,906,152/year. At an RNG sale price of \$30/GJ, average revenue is estimated to be \$1,758,748/year. Because operating costs are greater than revenue, this biogas plant requires >100% funding for an unlevered, pre-tax IRR of 12%. For this reason, an economic assessment was not completed.

Farm Scenario #13: Summary

Figure 25 shows the required RNG \$/GJ sale price for Farm Scenario #13 Options A – D for an unlevered, pre-tax IRR of 12%. Where required RNG sale price is >\$30/GJ, percentage of required funding is shown. Where required RNG sale price is <\$30/GJ, a bar representing +/- 5% is shown to account for price uncertainty. Farm Scenario #13 Option A doesn't require funding. This biogas plant requires \$25.57 - \$28.27/GJ. Farm Scenario #13 Options B requires 16% funding. Option C and D aren't shown because they require >100% funding. Figure 25 shows that only under the best circumstance (i.e., Option A - needing the least equipment) are 2,500 dairy cow farms digesting dairy manure economically feasible in B.C. without funding.

Figure 25: Farm Scenario #13 - Required RNG Sale Price for 2,500 Dairy Cows



7.14

Farm Scenario #14: 200 Dairy Cows + Poultry Manure

Farm Scenario #14 is a 200 dairy cow farm co-digesting dairy manure and poultry manure. Farm Scenario #14 assumes the use of modular biogas plant technology. Estimated feedstock volume and Renewable Natural Gas (RNG) production for Farm Scenario #14 are as follows:

Feedstock	Tonnes/Year	Percentage	RNG Production (GJ/Year)
Dairy manure	10,008	80%	3,229
Poultry manure	2,494	20%	7,510
<i>Total</i>	<i>12,503</i>	<i>100%</i>	<i>10,739</i>

The following Equipment Choices were assessed for Farm Scenario #14:

- Option A: No additional equipment; and
- Option B: Nutrient recovery equipment.

For full capital and operating costs for Farm Scenario #14 Options A and B, see Appendix N.

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #14 - Option A: No Additional Equipment

This biogas plant is estimated to cost \$1.8 million to build. Operating costs are estimated to average \$315,232/year. At an RNG sale price of \$30/GJ, average revenue is estimated to be \$354,884/year. This biogas plant requires \$1.4 million funding (76% of CAPEX) for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$39,652/year; equal to 13% of operating costs. Operating income is likely insufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (i.e., broken equipment, unexpected downtime, etc.). This is because farm investment (i.e., debt) is only 24%. Low investment means that even with an unlevered, pre-tax IRR of 12%, operating income can be too low.

Option A: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>	<u>Revenue</u>		<u>Investment</u>	
Digester	\$545,475		RNG/GJ =	\$30.00	Farm Investment =	\$431,914
Upgrader	\$1,084,160		Avg RNG Sales/Yr =	\$306,289	Funding Amount =	\$1,405,290
Nutrient Recovery	\$102,759		Bedding Savings/Yr* =	\$48,595	Funding % of CAPEX =	76%
Other	\$104,810					
<u>Total</u>	<u>\$1,837,204</u>	<u>\$315,232</u>	<u>Total =</u>	<u>\$354,884</u>	<u>Inflation =</u>	<u>2%</u>

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$346	\$347	\$348	\$349	\$350	\$350	\$351	\$352	\$353	\$354
OPEX (000s)	\$259	\$265	\$270	\$275	\$281	\$286	\$292	\$298	\$304	\$310
<i>Operate Income</i>	\$87	\$82	\$78	\$73	\$69	\$64	\$59	\$54	\$49	\$44

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$355	\$356	\$357	\$358	\$359	\$360	\$361	\$362	\$363	\$365
OPEX (000s)	\$316	\$323	\$329	\$336	\$342	\$349	\$356	\$363	\$371	\$378
<i>Operate Income</i>	\$39	\$33	\$28	\$22	\$17	\$11	\$5	-\$1	-\$7	-\$13

Unlevered, Pre-Tax IRR =	12%
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Average Operating Income* =	\$39,652
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% of OPEX	13%
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* Averaged over twenty years to account for inflation

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 86% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, with 76% funding, if RNG production is 10% or 20% higher than anticipated (due to the better than expected biogas production from the feedstock), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$26/GJ and <\$24/GJ respectively. Alternately, with 86% funding, if RNG production is 5% lower than anticipated, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 3.4%. An unlevered, pre-tax IRR <12% isn't economically feasible.

Poultry manure accounts for 10% of biogas plant operating costs. Therefore, although less important than RNG sales, poultry manure tip fee can have an impact on biogas plant economic feasibility. For example, with 76% funding, if poultry manure tip fee is only \$5/tonne or \$0/tonne instead of \$10/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$28/GJ and <\$26/GJ respectively. Alternately, with 76% funding, if poultry manure tip fee is \$15/tonne, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 3.9%. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option A: Sensitivity Analysis – RNG Production & Poultry Manure Tip Fee

		Change in RNG Production Amount						
		-10%	-5%	0%	5%	10%	15%	20%
\$/GJ RNG	\$16	---	---	---	---	---	---	---
	\$17	---	---	---	---	---	---	---
	\$18	---	---	---	---	---	---	---
	\$19	---	---	---	---	---	---	---
	\$20	---	---	---	---	---	---	---
	\$21	---	---	---	---	---	---	-4.4%
	\$22	---	---	---	---	---	-3.2%	4.6%
	\$23	---	---	---	---	-3.2%	4.9%	9.7%
	\$24	---	---	---	-4.4%	4.6%	9.7%	13.9%
	\$25	---	---	---	3.8%	9.3%	13.7%	17.6%
	\$26	---	---	1.4%	8.2%	13.0%	17.2%	20.9%
	\$27	---	---	5.7%	11.6%	16.2%	20.3%	24.0%
	\$28	---	---	8.8%	14.4%	18.9%	23.0%	26.9%
\$29	---	2.1%	10.9%	16.4%	21.1%	25.3%	29.3%	
\$30	---	3.4%	12.0%	17.5%	22.2%	26.6%	30.7%	

		Poultry Manure Tip Fee (\$/Tonne)				
		\$0	\$5	\$10	\$15	\$20
\$/GJ RNG	\$16	---	---	---	---	---
	\$17	---	---	---	---	---
	\$18	---	---	---	---	---
	\$19	---	---	---	---	---
	\$20	---	---	---	---	---
	\$21	---	---	---	---	---
	\$22	---	---	---	---	---
	\$23	0.4%	---	---	---	---
	\$24	5.8%	-2.5%	---	---	---
	\$25	9.8%	4.2%	---	---	---
	\$26	13.0%	8.3%	1.4%	---	---
	\$27	15.9%	11.5%	5.7%	---	---
	\$28	18.3%	14.1%	8.8%	---	---
\$29	20.2%	16.0%	10.9%	2.4%	---	
\$30	21.2%	17.0%	12.0%	3.9%	---	

Farm Scenario #14 - Option B: Nutrient Recovery Equipment

This biogas plant is estimated to cost \$2.4 million to build. Operating costs are estimated to average \$487,054/year. At an RNG sale price of \$30/GJ, average revenue is estimated to be \$354,884/year. Because operating costs are greater than revenue, this biogas plant requires >100% funding for an unlevered, pre-tax IRR of 12%. For this reason, an economic assessment was not completed.

7.15

Farm Scenario #15: 300 Dairy Cows + Poultry Manure

Farm Scenario #15 is a 300 dairy cow farm co-digesting dairy manure and poultry manure. Farm Scenario #15 assumes the use of modular biogas plant technology. Estimated feedstock volume and Renewable Natural Gas (RNG) production for Farm Scenario #15 are as follows:

Feedstock	Tonnes/Year	Percentage	RNG Production (GJ/Year)
Dairy manure	15,012	80%	4,844
Poultry manure	3,741	20%	11,265
<i>Total</i>	<i>18,754</i>	<i>100%</i>	<i>16,109</i>

The following Equipment Choices were assessed for Farm Scenario #15:

- Option A: No additional equipment; and
- Option B: Nutrient recovery equipment.

For full capital and operating costs for Farm Scenario #15 Options A and B, see Appendix O.

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #15 - Option A: No Additional Equipment

This biogas plant is estimated to cost \$2.6 million to build. Operating costs are estimated to average \$390,937/year. At an RNG sale price of \$30/GJ, average revenue is estimated to be \$532,326/year. This biogas plant requires \$1.3 million funding (53% of CAPEX) for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$141,389/year; equal to 36% of operating costs. Operating income may or may not be sufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (i.e., broken equipment, unexpected downtime, etc.). This is because farm investment (i.e., debt) is only 47%. Low investment means that even with an unlevered, pre-tax IRR of 12%, operating income can be too low.

Option A: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>	<u>Revenue</u>		<u>Investment</u>	
Digester	\$1,018,500		RNG/GJ =	\$30.00	Farm Investment =	\$1,218,491
Upgrader	\$1,247,115		Avg RNG Sales/Yr =	\$459,434	Funding Amount =	\$1,347,657
Nutrient Recovery	\$154,138		Bedding Savings/Yr* =	\$72,892	Funding % of CAPEX =	53%
Other	\$146,395					
<u>Total</u>	<u>\$2,566,148</u>	<u>\$390,937</u>	<u>Total =</u>	<u>\$532,326</u>	<u>Inflation =</u>	<u>2%</u>

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$519	\$521	\$522	\$523	\$524	\$526	\$527	\$528	\$530	\$531
OPEX (000s)	\$322	\$328	\$335	\$341	\$348	\$355	\$362	\$370	\$377	\$385
<i>Operate Income</i>	\$198	\$192	\$187	\$182	\$176	\$170	\$165	\$159	\$153	\$147

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$533	\$534	\$536	\$537	\$539	\$540	\$542	\$543	\$545	\$547
OPEX (000s)	\$392	\$400	\$408	\$416	\$425	\$433	\$442	\$451	\$460	\$469
<i>Operate Income</i>	\$140	\$134	\$127	\$121	\$114	\$107	\$100	\$93	\$86	\$78

Unlevered, Pre-Tax IRR =	12%	Average Operating Income* =	\$141,389	% of OPEX	36%
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* Averaged over twenty years to account for inflation

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 86% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, with 53% funding, if RNG production is 10% or 20% higher than anticipated (due to the better than expected biogas production from the feedstock), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$26/GJ and <\$24/GJ respectively. Alternately, with 53% funding, if RNG production is 5% or 10% lower than anticipated, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 9.2% and 6.1% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Poultry manure accounts for 12% of biogas plant operating costs. Therefore, although less important than RNG sales, poultry manure tip fee can have an impact on biogas plant economic feasibility. For example, with 53% funding, if poultry manure tip fee is only \$5/tonne or \$0/tonne instead of \$10/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$28/GJ and <\$26/GJ respectively. Alternately, with 53% funding, if poultry manure tip fee is \$15/tonne or \$20/tonne, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 9.4% and 6.5% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option A: Sensitivity Analysis – RNG Production & Poultry Manure Tip Fee

		Change in RNG Production Amount						
		-10%	-5%	0%	5%	10%	15%	20%
\$/GJ RNG	\$16	---	---	---	---	---	---	---
	\$17	---	---	---	---	---	---	---
	\$18	---	---	---	---	---	-7.7%	-3.0%
	\$19	---	---	---	---	-6.4%	-2.1%	0.9%
	\$20	---	---	---	-5.8%	-1.5%	1.5%	4.0%
	\$21	---	---	-5.8%	-1.4%	1.8%	4.3%	6.5%
	\$22	---	-6.4%	-1.5%	1.8%	4.4%	6.7%	8.8%
	\$23	-7.7%	-2.1%	1.5%	4.3%	6.7%	8.9%	10.9%
	\$24	-3.0%	0.9%	4.0%	6.5%	8.8%	10.9%	12.9%
	\$25	0.0%	3.4%	6.1%	8.5%	10.8%	12.8%	14.8%
	\$26	2.2%	5.3%	7.9%	10.3%	12.5%	14.6%	16.5%
	\$27	3.8%	6.8%	9.4%	11.8%	14.0%	16.1%	18.1%
	\$28	5.0%	8.0%	10.7%	13.1%	15.3%	17.5%	19.6%
\$29	5.8%	8.8%	11.5%	14.0%	16.3%	18.6%	20.7%	
\$30	6.1%	9.2%	12.0%	14.5%	16.9%	19.1%	21.3%	

		Poultry Manure Tip Fee (\$/Tonne)				
		\$0	\$5	\$10	\$15	\$20
\$/GJ RNG	\$16	---	---	---	---	---
	\$17	---	---	---	---	---
	\$18	-7.3%	---	---	---	---
	\$19	-2.6%	-10.4%	---	---	---
	\$20	0.6%	-4.0%	---	---	---
	\$21	3.2%	-0.4%	-5.8%	---	---
	\$22	5.4%	2.4%	-1.5%	-8.3%	---
	\$23	7.4%	4.7%	1.5%	-2.9%	---
	\$24	9.2%	6.8%	4.0%	0.5%	-4.5%
	\$25	10.9%	8.7%	6.1%	3.2%	-0.6%
	\$26	12.5%	10.3%	7.9%	5.2%	1.9%
	\$27	13.9%	11.7%	9.4%	6.8%	3.8%
	\$28	15.1%	12.9%	10.7%	8.1%	5.1%
\$29	16.0%	13.8%	11.5%	9.0%	6.1%	
\$30	16.4%	14.3%	12.0%	9.4%	6.5%	

Farm Scenario #15 - Option B: Nutrient Recovery Equipment

This biogas plant is estimated to cost \$3.2 million to build. Operating costs are estimated to average \$487,054/year. At an RNG sale price of \$30/GJ, average revenue is estimated to be \$598,738/year. Because operating costs are greater than revenue, this biogas plant requires >100% funding for an unlevered, pre-tax IRR of 12%. For this reason, an economic assessment was not completed.

7.16

Farm Scenario #16: 400 Dairy Cows + Poultry Manure

Farm Scenario #16 is a 400 dairy cow farm co-digesting dairy manure and poultry manure. Farm Scenario #16 assumes the use of modular biogas plant technology. Estimated feedstock volume and Renewable Natural Gas (RNG) production for Farm Scenario #16 are as follows:

Feedstock	Tonnes/Year	Percentage	RNG Production (GJ/Year)
Dairy manure	15,012	80%	4,844
Poultry manure	3,741	20%	11,265
<i>Total</i>	<i>18,754</i>	<i>100%</i>	<i>16,109</i>

The following Equipment Choices were assessed for Farm Scenario #16:

- Option A: No additional equipment; and
- Option B: Nutrient recovery equipment.

For full capital and operating costs for Farm Scenario #16 Options A and B, see Appendix P.

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #16 - Option A: No Additional Equipment

This biogas plant is estimated to cost \$2.9 million to build. Operating costs are estimated to average \$456,352/year. At an RNG sale price of \$30/GJ, average revenue is estimated to be \$709,768/year. This biogas plant requires \$0.8 million funding (28% of CAPEX) for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$253,416/year; equal to 56% of operating costs. Operating income should be sufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (i.e., broken equipment, unexpected downtime, etc.).

Option A: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>	<u>Revenue</u>		<u>Investment</u>	
Digester	\$1,018,500		RNG/GJ =	\$30.00	Farm Investment =	\$2,072,261
Upgrader	\$1,490,710		Avg RNG Sales/Yr =	\$612,579	Funding Amount =	\$806,707
Nutrient Recovery	\$205,517		Bedding Savings/Yr* =	\$97,189	Funding % of CAPEX =	28%
Other	\$164,241					
<u>Total</u>	<u>\$2,878,968</u>	<u>\$456,352</u>	<u>Total =</u>	<u>\$709,768</u>	<u>Inflation =</u>	<u>2%</u>

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$693	\$694	\$696	\$697	\$699	\$701	\$703	\$704	\$706	\$708
OPEX (000s)	\$376	\$383	\$391	\$399	\$407	\$415	\$423	\$431	\$440	\$449
Operate Income	\$317	\$311	\$305	\$299	\$293	\$286	\$280	\$273	\$266	\$259

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$710	\$712	\$714	\$716	\$718	\$720	\$722	\$725	\$727	\$729
OPEX (000s)	\$458	\$467	\$476	\$486	\$496	\$506	\$516	\$526	\$537	\$547
Operate Income	\$252	\$245	\$238	\$230	\$222	\$215	\$207	\$199	\$190	\$182

Unlevered, Pre-Tax IRR =	12%
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Average Operating Income* =	\$253,416
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% of OPEX	56%
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* Averaged over twenty years to account for inflation

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 86% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, with 28% funding, if RNG production is 10% or 20% higher than anticipated (due to the better than expected biogas production from the feedstock), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$26/GJ and <\$24/GJ respectively. Alternately, with 28% funding, if RNG production is 5% or 10% lower than anticipated, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 10.0% and 7.9% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Poultry manure accounts for 13% of biogas plant operating costs. Therefore, although less important than RNG sales, poultry manure tip fee can have an impact on biogas plant economic feasibility. For example, with 28% funding, if poultry manure tip fee is only \$5/tonne or \$0/tonne instead of \$10/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$28/GJ and <\$26/GJ respectively. Alternately, with 28% funding, if poultry manure tip fee is \$15/tonne or \$20/tonne, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 10.2% and 8.1% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option A: Sensitivity Analysis – RNG Production & Poultry Manure Tip Fee

		Change in RNG Production Amount						
		-10%	-5%	0%	5%	10%	15%	20%
\$/GJ RNG	\$16	---	---	---	---	-10.8%	-6.4%	-3.6%
	\$17	---	---	---	-9.1%	-5.2%	-2.6%	-0.4%
	\$18	---	---	-8.3%	-4.5%	-1.9%	0.3%	2.1%
	\$19	---	-8.0%	-4.2%	-1.5%	0.7%	2.6%	4.3%
	\$20	-8.3%	-4.2%	-1.4%	0.9%	2.9%	4.6%	6.2%
	\$21	-4.5%	-1.5%	0.9%	2.9%	4.8%	6.4%	8.0%
	\$22	-1.9%	0.7%	2.9%	4.8%	6.5%	8.1%	9.6%
	\$23	0.3%	2.6%	4.6%	6.4%	8.1%	9.7%	11.2%
	\$24	2.1%	4.3%	6.2%	8.0%	9.6%	11.2%	12.7%
	\$25	3.7%	5.8%	7.7%	9.4%	11.1%	12.7%	14.2%
	\$26	5.1%	7.1%	9.0%	10.7%	12.4%	14.0%	15.5%
	\$27	6.2%	8.2%	10.1%	11.9%	13.6%	15.2%	16.8%
	\$28	7.0%	9.1%	11.0%	12.8%	14.6%	16.3%	17.9%
	\$29	7.6%	9.7%	11.7%	13.6%	15.3%	17.1%	18.7%
\$30	7.9%	10.0%	12.0%	13.9%	15.7%	17.5%	19.2%	

		Poultry Manure Tip Fee (\$/Tonne)				
		\$0	\$5	\$10	\$15	\$20
\$/GJ RNG	\$16	-5.1%	-12.6%	---	---	---
	\$17	-2.1%	-6.5%	---	---	---
	\$18	0.2%	-3.1%	-8.3%	---	---
	\$19	2.2%	-0.5%	-4.2%	-10.8%	---
	\$20	4.0%	1.6%	-1.4%	-5.5%	---
	\$21	5.7%	3.5%	0.9%	-2.3%	-7.1%
	\$22	7.2%	5.1%	2.9%	0.2%	-3.4%
	\$23	8.6%	6.7%	4.6%	2.2%	-0.7%
	\$24	9.9%	8.1%	6.2%	4.0%	1.5%
	\$25	11.2%	9.5%	7.7%	5.7%	3.4%
	\$26	12.4%	10.8%	9.0%	7.1%	5.0%
	\$27	13.5%	11.8%	10.1%	8.2%	6.2%
	\$28	14.4%	12.7%	11.0%	9.2%	7.2%
	\$29	15.1%	13.4%	11.7%	9.9%	7.8%
\$30	15.4%	13.7%	12.0%	10.2%	8.1%	

Farm Scenario #16 - Option B: Nutrient Recovery Equipment

This biogas plant is estimated to cost \$3.5 million to build. Operating costs are estimated to average \$700,131/year. At an RNG sale price of \$30/GJ, average revenue is estimated to be \$709,768/year. Because operating costs are almost equal to revenue, this biogas plant requires 100% funding for an unlevered, pre-tax IRR of 12%. For this reason, an economic assessment was not completed.

7.17

Farm Scenario #17: 500 Dairy Cows + Poultry Manure

Farm Scenario #17 is a 500 dairy cow farm co-digesting dairy manure and poultry manure. Farm Scenario #17 assumes the use of modular biogas plant technology. Estimated feedstock volume and Renewable Natural Gas (RNG) production for Farm Scenario #17 are as follows:

Feedstock	Tonnes/Year	Percentage	RNG Production (GJ/Year)
Dairy manure	25,021	80%	8,074
Poultry manure	6,236	20%	18,775
<i>Total</i>	<i>31,257</i>	<i>100%</i>	<i>26,848</i>

The following Equipment Choices were assessed for Farm Scenario #17:

- Option A: No additional equipment; and
- Option B: Nutrient recovery equipment.

For full capital and operating costs for Farm Scenario #17 Options A and B, see Appendix Q.

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #17 - Option A: No Additional Equipment

This biogas plant is estimated to cost \$3.6 million to build. Operating costs are estimated to average \$532,524/year. At an RNG sale price of \$30/GJ, average revenue is estimated to be \$877,211/year. This biogas plant requires \$0.8 million funding (21% of CAPEX) for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$354,686/year; equal to 67% of operating costs. Operating income should be sufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (i.e., broken equipment, unexpected downtime, etc.).

Option A: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>	<u>Revenue</u>		<u>Investment</u>	
Digester	\$1,459,500		RNG/GJ =	\$30.00	Farm Investment =	\$2,853,145
Upgrader	\$1,694,650		Avg RNG Sales/Yr =	\$765,724	Funding Amount =	\$764,270
Nutrient Recovery	\$256,897		Bedding Savings/Yr* =	\$121,487	Funding % of CAPEX =	21%
Other	\$206,368					
<u>Total</u>	<u>\$3,617,415</u>	<u>\$532,524</u>	<u>Total =</u>	<u>\$887,211</u>	<u>Inflation =</u>	<u>2%</u>

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$866	\$868	\$870	\$872	\$874	\$876	\$878	\$881	\$883	\$885
OPEX (000s)	\$438	\$447	\$456	\$465	\$474	\$484	\$494	\$504	\$514	\$524
<i>Operate Income</i>	\$427	\$421	\$414	\$407	\$399	\$392	\$385	\$377	\$369	\$361

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$888	\$890	\$893	\$895	\$898	\$900	\$903	\$906	\$909	\$911
OPEX (000s)	\$534	\$545	\$556	\$567	\$578	\$590	\$602	\$614	\$626	\$639
<i>Operate Income</i>	\$353	\$345	\$337	\$328	\$319	\$310	\$301	\$292	\$282	\$273

Unlevered, Pre-Tax IRR =	12%	Average Operating Income* =	\$354,686	% of OPEX	67%
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* Averaged over twenty years to account for inflation

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 86% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, with 21% funding, if RNG production is 10% or 20% higher than anticipated (due to the better than expected biogas production from the feedstock), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$26/GJ and <\$24/GJ respectively. Alternately, with 21% funding, if RNG production is 5% or 10% lower than anticipated, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 10.2% and 8.4% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Poultry manure accounts for 14% of biogas plant operating costs. Therefore, although less important than RNG sales, poultry manure tip fee can have an impact on biogas plant economic feasibility. For example, with 21% funding, if poultry manure tip fee is only \$5/tonne or \$0/tonne instead of \$10/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$28/GJ and <\$26/GJ respectively. Alternately, with 21% funding, if poultry manure tip fee is \$15/tonne or \$20/tonne, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 10.4% and 8.6% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option A: Sensitivity Analysis – RNG Production & Poultry Manure Tip Fee

		Change in RNG Production Amount						
		-10%	-5%	0%	5%	10%	15%	20%
\$/GJ RNG	\$16	---	---	-13.4%	-8.2%	-5.2%	-2.9%	-1.0%
	\$17	---	-12.0%	-7.3%	-4.4%	-2.2%	-0.3%	1.3%
	\$18	-11.7%	-6.9%	-4.0%	-1.7%	0.2%	1.9%	3.4%
	\$19	-6.9%	-3.8%	-1.5%	0.5%	2.2%	3.8%	5.2%
	\$20	-4.0%	-1.5%	0.6%	2.4%	4.0%	5.5%	6.9%
	\$21	-1.7%	0.5%	2.4%	4.1%	5.6%	7.1%	8.4%
	\$22	0.2%	2.2%	4.0%	5.6%	7.1%	8.5%	9.9%
	\$23	1.9%	3.8%	5.5%	7.1%	8.5%	10.0%	11.3%
	\$24	3.4%	5.2%	6.9%	8.4%	9.9%	11.3%	12.7%
	\$25	4.7%	6.5%	8.2%	9.7%	11.2%	12.6%	14.0%
	\$26	5.9%	7.7%	9.3%	10.9%	12.4%	13.8%	15.2%
	\$27	6.9%	8.6%	10.3%	11.9%	13.4%	14.9%	16.3%
	\$28	7.6%	9.4%	11.1%	12.8%	14.3%	15.8%	17.3%
	\$29	8.1%	10.0%	11.7%	13.4%	15.0%	16.6%	18.1%
\$30	8.4%	10.2%	12.0%	13.7%	15.3%	16.9%	18.5%	

		Poultry Manure Tip Fee (\$/Tonne)				
		\$0	\$5	\$10	\$15	\$20
\$/GJ RNG	\$16	-2.1%	-5.9%	-13.4%	---	---
	\$17	0.0%	-3.0%	-7.3%	---	---
	\$18	1.8%	-0.7%	-4.0%	-9.1%	---
	\$19	3.5%	1.2%	-1.5%	-5.1%	-11.6%
	\$20	5.0%	2.9%	0.6%	-2.3%	-6.4%
	\$21	6.4%	4.5%	2.4%	-0.1%	-3.2%
	\$22	7.7%	5.9%	4.0%	1.8%	-0.8%
	\$23	8.9%	7.3%	5.5%	3.5%	1.2%
	\$24	10.2%	8.6%	6.9%	5.0%	2.9%
	\$25	11.3%	9.8%	8.2%	6.4%	4.5%
	\$26	12.4%	10.9%	9.3%	7.6%	5.8%
	\$27	13.3%	11.9%	10.3%	8.7%	6.9%
	\$28	14.1%	12.7%	11.1%	9.5%	7.7%
	\$29	14.8%	13.3%	11.7%	10.1%	8.3%
\$30	15.0%	13.6%	12.0%	10.4%	8.6%	

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #17 - Option B: Nutrient Recovery Equipment

This biogas plant is estimated to cost \$4.4 million to build. Operating costs are estimated to average \$830,990/year. At an RNG sale price of \$30/GJ, average revenue is estimated to be \$877,211/year. This biogas plant requires \$3.7 million funding (82% of CAPEX) for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$56,220/year; equal to 7% of operating costs. Operating income is likely insufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (i.e., broken equipment, unexpected downtime, etc.). This is because farm investment (i.e., debt) is only 18%. Low investment means that even with an unlevered, pre-tax IRR of 12%, operating income can be too low.

Option B: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>	<u>Revenue</u>		<u>Investment</u>	
Digester	\$1,575,000		RNG/GJ =	\$30.00	Farm Investment =	\$778,510
Upgrader	\$1,694,650		Avg RNG Sales/Yr =	\$765,724	Funding Amount =	\$3,650,718
Nutrient Recovery	\$906,897		Bedding Savings/Yr* =	\$121,487	Funding % of CAPEX =	82%
Other	\$252,681					
<u>Total</u>	<u>\$4,429,228</u>	<u>\$830,990</u>	<u>Total =</u>	<u>\$887,211</u>	<u>Inflation =</u>	<u>2%</u>

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$866	\$868	\$870	\$872	\$874	\$876	\$878	\$881	\$883	\$885
OPEX (000s)	\$684	\$698	\$712	\$726	\$740	\$755	\$770	\$786	\$801	\$817
<i>Operate Income</i>	\$182	\$170	\$158	\$146	\$134	\$121	\$108	\$95	\$81	\$68

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$888	\$890	\$893	\$895	\$898	\$900	\$903	\$906	\$909	\$911
OPEX (000s)	\$834	\$850	\$867	\$885	\$903	\$921	\$939	\$958	\$977	\$996
<i>Operate Income</i>	\$54	\$40	\$25	\$10	-\$5	-\$20	-\$36	-\$52	-\$68	-\$85

Unlevered, Pre-Tax IRR =	12%
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Average Operating Income* =	\$56,220
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% of OPEX	7%
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* Averaged over twenty years to account for inflation

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 86% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, with 82% funding, if RNG production is 10% or 20% higher than anticipated (due to the better than expected biogas production from the feedstock), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$26/GJ and <\$24/GJ respectively. Alternately, with 82% funding, if RNG production is 5% lower than anticipated, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR is negative

Poultry manure accounts for 9% of biogas plant operating costs. Therefore, although less important than RNG sales, poultry manure tip fee can have an impact on biogas plant economic feasibility. For example, with 82% funding, if poultry manure tip fee is only \$5/tonne or \$0/tonne instead of \$10/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$28/GJ and <\$26/GJ respectively. Alternately, with 82% funding, if poultry manure tip fee is \$15/tonne, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR is negative.

Option B: Sensitivity Analysis – RNG Production & Poultry Manure Tip Fee

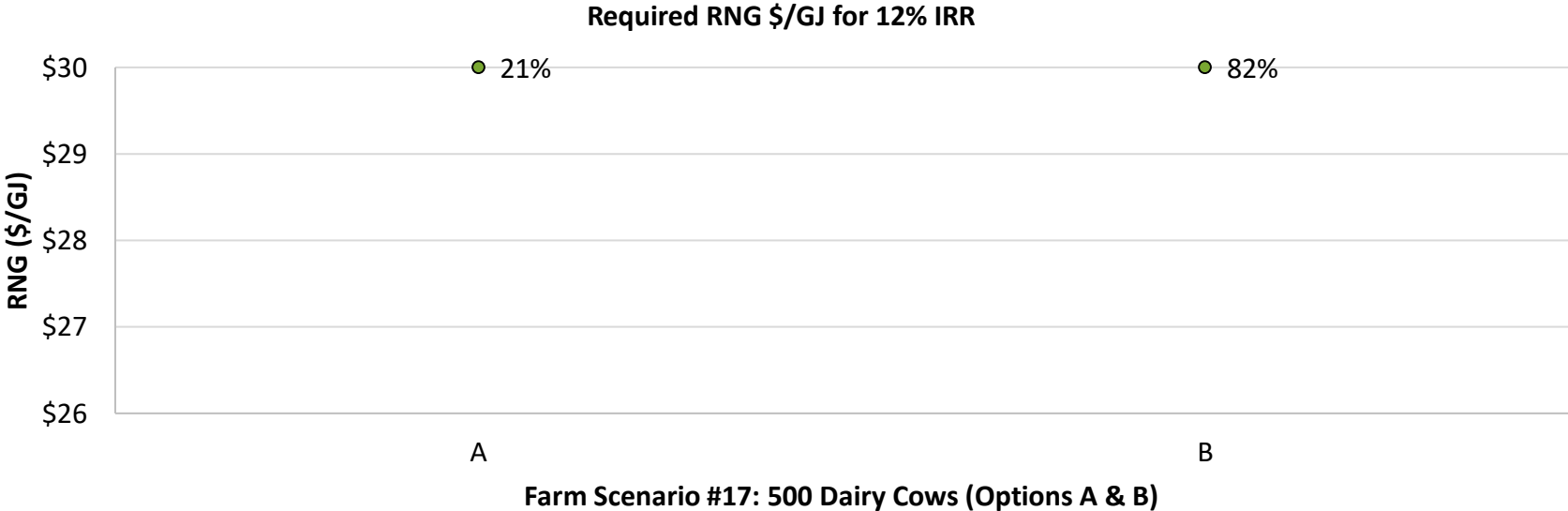
Change in RNG Production Amount									
\$/GJ RNG		-10%	-5%	0%	5%	10%	15%	20%	
	\$16	---	---	---	---	---	---	---	---
	\$17	---	---	---	---	---	---	---	
	\$18	---	---	---	---	---	---	---	
	\$19	---	---	---	---	---	---	---	
	\$20	---	---	---	---	---	---	---	
	\$21	---	---	---	---	---	---	---	
	\$22	---	---	---	---	---	---	---	
	\$23	---	---	---	---	---	-3.8%	8.5%	
	\$24	---	---	---	---	---	8.5%	14.9%	
	\$25	---	---	---	---	7.8%	14.6%	20.1%	
	\$26	---	---	---	5.6%	13.7%	19.6%	24.8%	
	\$27	---	---	---	11.4%	18.3%	24.0%	29.2%	
	\$28	---	---	5.8%	15.8%	22.3%	28.0%	33.2%	
\$29	---	---	10.2%	19.0%	25.5%	31.3%	36.8%		
\$30	---	---	12.0%	20.7%	27.3%	33.3%	38.9%		

Poultry Manure Tip Fee (\$/Tonne)						
\$/GJ RNG		\$0	\$5	\$10	\$15	\$20
	\$16	---	---	---	---	---
	\$17	---	---	---	---	---
	\$18	---	---	---	---	---
	\$19	---	---	---	---	---
	\$20	---	---	---	---	---
	\$21	---	---	---	---	---
	\$22	---	---	---	---	---
	\$23	---	---	---	---	---
	\$24	0.8%	---	---	---	---
	\$25	8.6%	---	---	---	---
	\$26	13.6%	5.8%	---	---	---
	\$27	17.8%	11.2%	---	---	---
	\$28	21.3%	15.3%	5.8%	---	---
\$29	24.2%	18.3%	10.2%	---	---	
\$30	25.8%	19.9%	12.0%	---	---	

Farm Scenario #17: Summary

Figure 26 shows the required RNG \$/GJ sale price for Farm Scenario #17 Options A and B for an unlevered, pre-tax IRR of 12%. Where required RNG sale price is >\$30/GJ, percentage of required funding is shown. Both Farm Scenario #9 Options A and B require funding. Funding is 21% (for Option A) and 82% (for Option B). Figure 26 shows that even under the best circumstances (i.e., Option A - needing the least equipment), 500 dairy cow farms co-digesting dairy and poultry manure in modular biogas plants cannot be economically feasible in B.C. without funding.

Figure 26: Farm Scenario #17 - Required RNG Sale Price for 500 Dairy Cows + Poultry Manure



7.18

Farm Scenario #18: 750 Dairy Cows + Poultry Manure

Farm Scenario #18 is a 750 dairy cow farm co-digesting dairy manure and poultry manure. Farm Scenario #18 assumes the use of modular biogas plant technology. Estimated feedstock volume and Renewable Natural Gas (RNG) production for Farm Scenario #18 are as follows:

Feedstock	Tonnes/Year	Percentage	RNG Production (GJ/Year)
Dairy manure	37,531	80%	12,110
Poultry manure	9,354	20%	28,162
<i>Total</i>	<i>46,885</i>	<i>100%</i>	<i>40,273</i>

The following Equipment Choices were assessed for Farm Scenario #18:

- Option A: No additional equipment; and
- Option B: Nutrient recovery equipment.

For full capital and operating costs for Farm Scenario #18 Options A and B, see Appendix R.

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #18 - Option A: No Additional Equipment

This biogas plant is estimated to cost \$4.7 million to build. Operating costs are estimated to average \$702,922/year. At an RNG sale price of \$27.70/GJ, average revenue is estimated to be \$1,310,794/year. This biogas plant doesn't require funding for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$607,871/year; equal to 86% of operating costs. Operating income should be sufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (i.e., broken equipment, unexpected downtime, etc.).

Option A: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>	<u>Revenue</u>		<u>Investment</u>	
Digester	\$2,004,975		RNG/GJ [†] =	\$27.70	Farm Investment =	\$4,662,536
Upgrader	\$2,006,225		Avg RNG Sales/Yr =	\$1,128,564	Funding Amount =	\$0
Nutrient Recovery	\$385,345		Bedding Savings/Yr* =	\$182,230	Funding % of CAPEX =	0%
Other	\$265,991					
<u>Total</u>	<u>\$4,662,536</u>	<u>\$702,922</u>	<u>Total =</u>	<u>\$1,310,794</u>	<u>Inflation =</u>	<u>2%</u>

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$1,211	\$1,224	\$1,238	\$1,252	\$1,266	\$1,280	\$1,295	\$1,309	\$1,324	\$1,328
OPEX (000s)	\$579	\$590	\$602	\$614	\$626	\$639	\$652	\$665	\$678	\$691
Operate Income	\$632	\$634	\$636	\$638	\$640	\$642	\$643	\$645	\$646	\$636

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$1,331	\$1,335	\$1,339	\$1,343	\$1,347	\$1,350	\$1,355	\$1,359	\$1,363	\$1,367
OPEX (000s)	\$705	\$719	\$734	\$748	\$763	\$779	\$794	\$810	\$826	\$843
Operate Income	\$626	\$616	\$605	\$594	\$583	\$572	\$560	\$548	\$536	\$524

Unlevered, Pre-Tax IRR =	12%
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Average Operating Income* =	\$607,871
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% of OPEX	86%
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* Averaged over twenty years to account for inflation

[†] Base price (1%/year increase up to \$30/GJ max)

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 86% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, if RNG production is 10% or 20% higher than anticipated (due to the better than expected biogas production from the feedstock), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$27.70/GJ to <\$25/GJ and <\$23/GJ respectively. Alternately, if RNG production is 5% or 10% lower than anticipated, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 11.5% and 9.9% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Poultry manure accounts for 16% of biogas plant operating costs. Therefore, although less important than RNG sales, poultry manure tip fee can have an impact on biogas plant economic feasibility. For example, if poultry manure tip fee is only \$5/tonne or \$0/tonne instead of \$10/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$27.70/GJ to <\$27/GJ and <\$25/GJ respectively. Alternately, if poultry manure tip fee is \$15/tonne or \$20/tonne, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 11.6% and 10.1% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option A: Sensitivity Analysis – RNG Production & Poultry Manure Tip Fee

		Change in RNG Production Amount						
		-10%	-5%	0%	5%	10%	15%	20%
\$/GJ RNG	\$16	-9.2%	-6.2%	-3.9%	-2.1%	-0.5%	0.9%	2.2%
	\$17	-5.8%	-3.6%	-1.7%	-0.1%	1.4%	2.7%	3.9%
	\$18	-3.4%	-1.5%	0.2%	1.7%	3.1%	4.4%	5.5%
	\$19	-1.5%	0.3%	1.9%	3.3%	4.6%	5.9%	7.0%
	\$20	0.2%	1.9%	3.4%	4.8%	6.1%	7.3%	8.5%
	\$21	1.7%	3.3%	4.8%	6.1%	7.4%	8.6%	9.8%
	\$22	3.1%	4.6%	6.1%	7.4%	8.7%	9.9%	11.1%
	\$23	4.4%	5.9%	7.3%	8.6%	9.9%	11.1%	12.3%
	\$24	5.5%	7.0%	8.5%	9.8%	11.1%	12.3%	13.5%
	\$25	6.7%	8.2%	9.6%	10.9%	12.2%	13.5%	14.7%
	\$26	7.7%	9.2%	10.6%	11.9%	13.3%	14.6%	15.8%
	\$27	8.5%	10.0%	11.5%	12.9%	14.2%	15.6%	16.9%
	\$28	9.2%	10.7%	12.2%	13.7%	15.1%	16.4%	17.8%
\$29	9.7%	11.2%	12.8%	14.3%	15.7%	17.1%	18.5%	
\$30	9.9%	11.5%	13.0%	14.5%	16.0%	17.4%	18.8%	

		Poultry Manure Tip Fee (\$/Tonne)				
		\$0	\$5	\$10	\$15	\$20
\$/GJ RNG	\$16	1.4%	-1.0%	-3.9%	-8.2%	---
	\$17	2.9%	0.8%	-1.7%	-4.9%	-10.0%
	\$18	4.3%	2.4%	0.2%	-2.4%	-6.0%
	\$19	5.6%	3.8%	1.9%	-0.4%	-3.3%
	\$20	6.9%	5.2%	3.4%	1.3%	-1.1%
	\$21	8.0%	6.5%	4.8%	2.9%	0.7%
	\$22	9.2%	7.7%	6.1%	4.3%	2.4%
	\$23	10.3%	8.8%	7.3%	5.6%	3.9%
	\$24	11.3%	9.9%	8.5%	6.9%	5.2%
	\$25	12.3%	11.0%	9.6%	8.1%	6.5%
	\$26	13.3%	11.9%	10.6%	9.1%	7.6%
	\$27	14.2%	12.8%	11.5%	10.1%	8.6%
	\$28	14.9%	13.6%	12.2%	10.8%	9.3%
\$29	15.4%	14.1%	12.8%	11.4%	9.9%	
\$30	15.7%	14.4%	13.0%	11.6%	10.1%	

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #18 - Option B: Nutrient Recovery Equipment

This biogas plant is estimated to cost \$5.7 million to build. Operating costs are estimated to average \$1,110,043/year. At an RNG sale price of \$30/GJ, average revenue is estimated to be \$1,330,816/year. This biogas plant requires \$3.6 million funding (63% of CAPEX) for an unlevered, pre-tax IRR of 12%. Average operating income for this biogas plant is \$220,773/year; equal to 20% of operating costs. Operating income is likely insufficient, depending upon debt term and interest rate, to cover both debt repayments and any unforeseen negative circumstances with the biogas plant (i.e., broken equipment, unexpected downtime, etc.). This is because farm investment (i.e., debt) is only 37%. Low investment means that even with an unlevered, pre-tax IRR of 12%, operating income can be too low.

Option B: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>	<u>Revenue</u>		<u>Investment</u>	
Digester	\$2,120,475		RNG/GJ =	\$30.00	Farm Investment =	\$2,114,568
Upgrader	\$2,006,225		Avg RNG Sales/Yr =	\$1,148,586	Funding Amount =	\$3,571,881
Nutrient Recovery	\$1,235,345		Bedding Savings/Yr* =	\$182,230	Funding % of CAPEX =	63%
Other	\$324,404					
<u>Total</u>	<u>\$5,686,449</u>	<u>\$1,110,043</u>	<u>Total =</u>	<u>\$1,330,816</u>	<u>Inflation =</u>	<u>2%</u>

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$1,299	\$1,302	\$1,305	\$1,308	\$1,311	\$1,314	\$1,318	\$1,321	\$1,324	\$1,328
OPEX (000s)	\$914	\$932	\$951	\$970	\$989	\$1,009	\$1,029	\$1,050	\$1,071	\$1,092
<i>Operate Income</i>	\$385	\$370	\$354	\$338	\$322	\$305	\$289	\$271	\$254	\$236

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$1,331	\$1,335	\$1,339	\$1,343	\$1,347	\$1,350	\$1,355	\$1,359	\$1,363	\$1,367
OPEX (000s)	\$1,114	\$1,136	\$1,159	\$1,182	\$1,206	\$1,230	\$1,254	\$1,279	\$1,305	\$1,331
<i>Operate Income</i>	\$218	\$199	\$180	\$161	\$141	\$121	\$100	\$79	\$58	\$36

Unlevered, Pre-Tax IRR =	12%	Average Operating Income* =	\$220,773	% of OPEX	20%
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* Averaged over twenty years to account for inflation

B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 86% of biogas plant revenue. This shows the importance of RNG sales on biogas plant economic feasibility. For example, with 63% funding, if RNG production is 10% or 20% higher than anticipated (due to the better than expected biogas production from the feedstock), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$26/GJ and <\$24/GJ respectively. Alternately, with 63% funding, if RNG production is 5% or 10% lower than anticipated, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 7.3% and 0.0% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Poultry manure accounts for 10% of biogas plant operating costs. Therefore, although less important than RNG sales, poultry manure tip fee can have an impact on biogas plant economic feasibility. For example, with 63% funding, if poultry manure tip fee is only \$5/tonne or \$0/tonne instead of \$10/tonne, the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$28/GJ and <\$26/GJ respectively. Alternately, with 63% funding, if poultry manure tip fee is \$15/tonne or \$20/tonne, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 7.6% and 0.3% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option B: Sensitivity Analysis – RNG Production & Poultry Manure Tip Fee

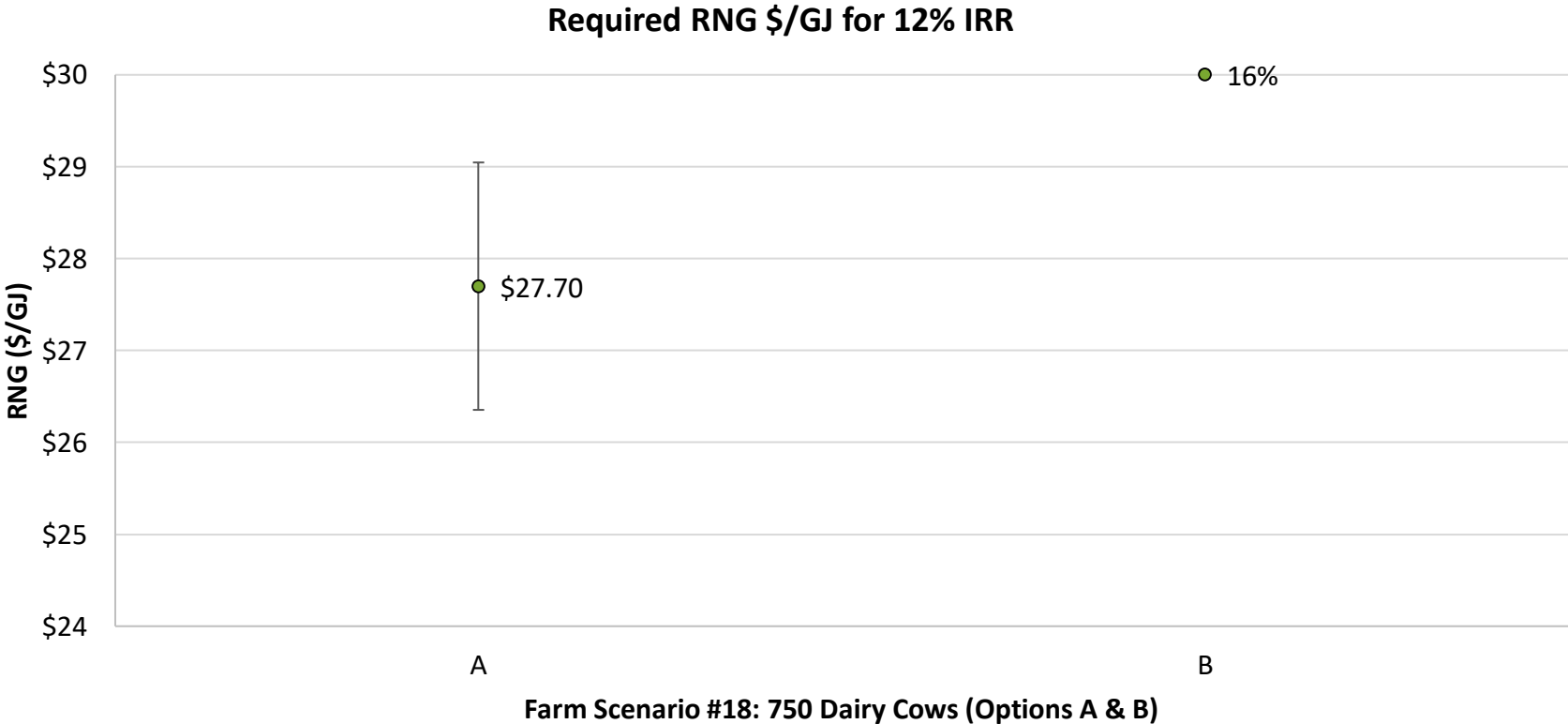
		Change in RNG Production Amount						
		-10%	-5%	0%	5%	10%	15%	20%
\$/GJ RNG	\$16	---	---	---	---	---	---	---
	\$17	---	---	---	---	---	---	---
	\$18	---	---	---	---	---	---	---
	\$19	---	---	---	---	---	---	---
	\$20	---	---	---	---	---	---	-3.0%
	\$21	---	---	---	---	---	-2.0%	3.0%
	\$22	---	---	---	---	-1.7%	3.4%	7.1%
	\$23	---	---	---	-2.0%	3.4%	7.2%	10.4%
	\$24	---	---	-3.0%	3.0%	7.1%	10.4%	13.4%
	\$25	---	-5.1%	2.1%	6.6%	10.2%	13.3%	16.2%
	\$26	---	0.1%	5.4%	9.4%	12.8%	15.9%	18.8%
	\$27	-7.3%	3.1%	7.9%	11.8%	15.1%	18.2%	21.1%
	\$28	-2.7%	5.2%	9.9%	13.7%	17.1%	20.3%	23.2%
\$29	-0.7%	6.7%	11.4%	15.2%	18.7%	21.9%	25.0%	
\$30	0.0%	7.3%	12.0%	16.0%	19.5%	22.8%	26.0%	

		Poultry Manure Tip Fee (\$/Tonne)				
		\$0	\$5	\$10	\$15	\$20
\$/GJ RNG	\$16	---	---	---	---	---
	\$17	---	---	---	---	---
	\$18	---	---	---	---	---
	\$19	---	---	---	---	---
	\$20	---	---	---	---	---
	\$21	-5.1%	---	---	---	---
	\$22	0.8%	-9.7%	---	---	---
	\$23	4.7%	-0.9%	---	---	---
	\$24	7.8%	3.5%	-3.0%	---	---
	\$25	10.5%	6.8%	2.1%	-6.4%	---
	\$26	12.8%	9.5%	5.4%	-0.3%	---
	\$27	14.9%	11.7%	7.9%	3.0%	---
	\$28	16.7%	13.5%	9.9%	5.4%	-3.5%
\$29	18.1%	14.9%	11.4%	6.9%	-0.7%	
\$30	18.8%	15.6%	12.0%	7.6%	0.3%	

Farm Scenario #18: Summary

Figure 27 shows the required RNG \$/GJ sale price for Farm Scenario #18 Options A and B for an unlevered, pre-tax IRR of 12%. Where required RNG sale price is >\$30/GJ, percentage of required funding is shown. Where required RNG sale price is <\$30/GJ, a bar representing +/- 5% is shown to account for price uncertainty. Farm Scenario #18 Option A doesn't require funding. This biogas plant requires \$26.32 - \$29.09/GJ. Farm Scenario #18 Options B requires 16% funding. Figure 27 shows that only under the best circumstance (i.e., Option A - needing the least equipment) are 750 dairy cow farms co-digesting dairy and poultry manure in modular biogas plants cannot be economically feasible in B.C. without funding.

Figure 27: Farm Scenario #18 - Required RNG Sale Price for 750 Dairy Cows + Poultry Manure



7.19

Farm Scenario #19: 2.5 Million Chickens

Farm Scenario #19 is a 2,500,000 chicken farm digesting poultry manure. Farm Scenario #19 assumes the use of poultry manure biogas plant technology. Estimated feedstock volume and Renewable Natural Gas (RNG) production for Farm Scenario #19 are as follows:

Feedstock	Tonnes/Year	Percentage	RNG Production (GJ/Year)
Poultry manure	30,000	100%	90,324
<i>Total</i>	<i>30,000</i>	<i>100%</i>	<i>90,324</i>

Note: Nitrogen removal/stripping technology is required for removing the nitrogen from poultry manure and/or cleaning liquid digestate so that it can be recirculated to dilute incoming poultry manure. However, the potential combination of different technologies to achieve nitrogen removal/stripping is very large. Furthermore, other nitrogen removal/stripping technologies are highly proprietary and their cost is currently unknown. As such, estimating the cost of nitrogen removal/stripping equipment is extremely difficult.

In the following assessment, the maximum affordable cost of nitrogen removal/stripping equipment is estimated. As such, the following assessment shows the maximum amount nitrogen removal/stripping equipment can cost if the biogas plant has an RNG sale price of \$30.00/GJ and receives an unlevered, pre-tax IRR of 12%.

For full capital and operating costs for Farm Scenario #19 Option A see Appendix S.

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #19

This biogas plant is estimated to cost \$9.9 million to build. Operating costs are estimated to average \$1,341,249/year. At an RNG sale price of \$30.00/GJ, average revenue is estimated to be \$2,576,065/year. For this biogas plant to have an unlevered, pre-tax IRR of 12%, **nutrient recovery equipment** (solid/liquid separation and nitrogen removal/stripping) can cost up to **\$1.24 million CAPEX and average \$376,239/year OPEX** (or some combination herein). If the CAPEX or OPEX of the nutrient recovery equipment is higher than this, the unlevered, pre-tax IRR for this biogas plant will be < 12%.

Option A: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>	<u>Revenue</u>		<u>Investment</u>	
Digester	\$4,851,000		RNG/GJ (base price) =	\$30.00	Farm Investment =	\$9,893,352
Upgrader	\$2,676,350		Avg RNG Sales/Yr =	\$2,576,065	Funding Amount =	\$0
Nutrient Recovery	\$1,238,781	\$376,239			Funding % of CAPEX =	0%
Other	\$1,127,221					
<u>Total</u>	<u>\$9,893,352</u>	<u>\$1,341,249</u>	<u>Total =</u>	<u>\$2,576,065</u>	<u>Inflation =</u>	<u>2%</u>

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$2,576	\$2,576	\$2,576	\$2,576	\$2,576	\$2,576	\$2,576	\$2,576	\$2,576	\$2,576
OPEX (000s)	\$1,104	\$1,126	\$1,149	\$1,172	\$1,195	\$1,219	\$1,243	\$1,268	\$1,294	\$1,319
Operate Income	\$1,472	\$1,450	\$1,427	\$1,404	\$1,381	\$1,357	\$1,333	\$1,308	\$1,283	\$1,257

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$2,576	\$2,576	\$2,576	\$2,576	\$2,576	\$2,576	\$2,576	\$2,576	\$2,576	\$2,576
OPEX (000s)	\$1,346	\$1,373	\$1,400	\$1,428	\$1,457	\$1,486	\$1,516	\$1,546	\$1,577	\$1,608
Operate Income	\$1,230	\$1,203	\$1,176	\$1,148	\$1,119	\$1,090	\$1,060	\$1,030	\$999	\$968

Unlevered, Pre-Tax IRR =	12%	Average Operating Income* =	\$1,234,816	% of OPEX	92%
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B.C. On-Farm Biogas Benchmark Study, Version 2

RNG sales account for 100% of biogas plant revenue. If RNG production is 10% or 20% higher than anticipated (due to the better than expected biogas production from the feedstock), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$26/GJ and <\$24/GJ respectively. Alternately, if RNG production is 10% or 20% lower than anticipated, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 8.5% and 4.4% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option A: Sensitivity Analysis – RNG Production

		Change in RNG Production Amount								
		-20%	-15%	-10%	-5%	0%	5%	10%	15%	20%
\$/GJ RNG	\$16	---	---	---	---	-10.2%	-6.6%	-4.1%	-2.1%	-0.4%
	\$17	---	---	---	-9.4%	-5.9%	-3.5%	-1.5%	0.2%	1.8%
	\$18	---	---	-9.1%	-5.6%	-3.1%	-1.0%	0.7%	2.3%	3.7%
	\$19	---	-9.4%	-5.6%	-3.0%	-0.8%	1.0%	2.6%	4.1%	5.4%
	\$20	-10.2%	-5.9%	-3.1%	-0.8%	1.1%	2.8%	4.3%	5.7%	7.0%
	\$21	-6.6%	-3.5%	-1.0%	1.0%	2.8%	4.4%	5.8%	7.2%	8.5%
	\$22	-4.1%	-1.5%	0.7%	2.6%	4.3%	5.8%	7.3%	8.6%	10.0%
	\$23	-2.1%	0.2%	2.3%	4.1%	5.7%	7.2%	8.6%	10.0%	11.3%
	\$24	-0.4%	1.8%	3.7%	5.4%	7.0%	8.5%	10.0%	11.3%	12.6%
	\$25	1.1%	3.1%	5.0%	6.7%	8.3%	9.8%	11.2%	12.6%	13.9%
	\$26	2.2%	4.3%	6.1%	7.8%	9.4%	10.9%	12.3%	13.7%	15.1%
	\$27	3.1%	5.2%	7.0%	8.7%	10.4%	11.9%	13.4%	14.8%	16.2%
	\$28	3.8%	5.9%	7.8%	9.5%	11.2%	12.7%	14.2%	15.7%	17.1%
	\$29	4.3%	6.3%	8.3%	10.0%	11.7%	13.3%	14.9%	16.4%	17.9%
\$30	4.4%	6.6%	8.5%	10.3%	12.0%	13.6%	15.2%	16.8%	18.3%	

Note: Poultry manure only biogas plants are a relatively new and evolving technology. As such, CAPEX and OPEX is much less understood than for traditional on-farm biogas plants that digest manure and food waste. For this reason, estimated CAPEX and OPEX for poultry manure only biogas plants should be seen as ballpark only. Further detailed analysis is recommended to better understand the CAPEX, OPEX and economic feasibility of building poultry manure only biogas plants in B.C.

7.20

Farm Scenario #20: 5 Million Chickens

Farm Scenario #20 is a 5,000,000 chicken farm digesting poultry manure. Farm Scenario #20 assumes the use of poultry manure biogas plant technology. Estimated feedstock volume and Renewable Natural Gas (RNG) production for Farm Scenario #20 are as follows:

Feedstock	Tonnes/Year	Percentage	RNG Production (GJ/Year)
Poultry manure	60,000	100%	180,648
<i>Total</i>	<i>60,000</i>	<i>100%</i>	<i>180,648</i>

Note: Nitrogen removal/stripping technology is required for removing the nitrogen from poultry manure and/or cleaning liquid digestate so that it can be recirculated to dilute incoming poultry manure. However, the potential combination of different technologies to achieve nitrogen removal/stripping is very large. Furthermore, other nitrogen removal/stripping technologies are highly proprietary and their cost is currently unknown. As such, estimating the cost of nitrogen removal/stripping equipment is extremely difficult.

In the following assessment, the maximum affordable cost of nitrogen removal/stripping equipment is estimated. As such, the following assessment shows the maximum amount nitrogen removal/stripping equipment can cost if the biogas plant has an RNG sale price of \$30.00/GJ and receives an unlevered, pre-tax IRR of 12%.

For full capital and operating costs for Farm Scenario #20 Option A see Appendix S.

B.C. On-Farm Biogas Benchmark Study, Version 2

Farm Scenario #20

This biogas plant is estimated to cost \$17.5 million to build. Operating costs are estimated to average \$3,007,073/year. At an RNG sale price of \$30.00/GJ, average revenue is estimated to be \$5,152,130/year. For this biogas plant to have an unlevered, pre-tax IRR of 12%, **nutrient recovery equipment** (solid/liquid separation and nitrogen removal/stripping) can cost up to **\$4.8 million CAPEX and average \$3 million/year OPEX** (or some combination herein). If the CAPEX or OPEX of the nutrient recovery equipment is higher than this, the unlevered, pre-tax IRR for this biogas plant will be < 12%.

Option A: Economic Assessment

	<u>CAPEX</u>	<u>OPEX*</u>	<u>Revenue</u>		<u>Investment</u>	
Digester	\$6,825,000		RNG/GJ (base price) =	\$30.00	Farm Investment =	\$17,537,343
Upgrader	\$4,222,000		Avg RNG Sales/Yr =	\$5,152,130	Funding Amount =	\$0
Nutrient Rec.	\$4,836,055	\$1,468,793			Funding % of CAPEX =	0%
Other	\$1,654,288					
Total	<u>\$17,537,343</u>	<u>\$3,007,073</u>	Total =	<u>\$5,152,130</u>	Inflation =	2%

Year	1	2	3	4	5	6	7	8	9	10
Revenue (000s)	\$5,152	\$5,152	\$5,152	\$5,152	\$5,152	\$5,152	\$5,152	\$5,152	\$5,152	\$5,152
OPEX (000s)	\$2,475	\$2,525	\$2,575	\$2,627	\$2,679	\$2,733	\$2,788	\$2,843	\$2,900	\$2,958
<i>Operate Income</i>	\$2,677	\$2,627	\$2,577	\$2,525	\$2,473	\$2,419	\$2,365	\$2,309	\$2,252	\$2,194

Year	11	12	13	14	15	16	17	18	19	20
Revenue (000s)	\$5,152	\$5,152	\$5,152	\$5,152	\$5,152	\$5,152	\$5,152	\$5,152	\$5,152	\$5,152
OPEX (000s)	\$3,017	\$3,078	\$3,139	\$3,202	\$3,266	\$3,331	\$3,398	\$3,466	\$3,535	\$3,606
<i>Operate Income</i>	\$2,135	\$2,074	\$2,013	\$1,950	\$1,886	\$1,821	\$1,754	\$1,686	\$1,617	\$1,546

Unlevered, Pre-Tax IRR =	12%	Average Operating Income* =	\$2,145,057	% of OPEX	71%
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RNG sales account for 100% of biogas plant revenue. If RNG production is 10% or 20% higher than anticipated (due to the better than expected biogas production from the feedstock), the required RNG sale price for an unlevered, pre-tax IRR of 12% falls from \$30/GJ to <\$26/GJ and <\$24/GJ respectively. Alternately, if RNG production is 10% or 20% lower than anticipated, even with an RNG sale price of \$30/GJ, unlevered, pre-tax IRR falls from 12% to 7.9% and 2.9% respectively. An unlevered, pre-tax IRR <12% isn't economically feasible.

Option A: Sensitivity Analysis – RNG Production

		Change in RNG Production Amount								
		-20%	-15%	-10%	-5%	0%	5%	10%	15%	20%
\$/GJ RNG	\$16	---	---	---	---	---	---	-10.3%	-6.2%	-3.4%
	\$17	---	---	---	---	---	-8.8%	-5.0%	-2.4%	-0.3%
	\$18	---	---	---	---	-8.0%	-4.4%	-1.8%	0.3%	2.2%
	\$19	---	---	---	-7.7%	-4.0%	-1.4%	0.8%	2.6%	4.3%
	\$20	---	---	-8.0%	-4.0%	-1.3%	1.0%	2.9%	4.6%	6.2%
	\$21	---	-8.8%	-4.4%	-1.4%	1.0%	3.0%	4.8%	6.5%	8.0%
	\$22	-10.3%	-5.0%	-1.8%	0.8%	2.9%	4.8%	6.5%	8.1%	9.6%
	\$23	-6.2%	-2.4%	0.3%	2.6%	4.6%	6.5%	8.1%	9.7%	11.2%
	\$24	-3.4%	-0.3%	2.2%	4.3%	6.2%	8.0%	9.6%	11.2%	12.7%
	\$25	-1.3%	1.5%	3.8%	5.8%	7.7%	9.4%	11.1%	12.7%	14.2%
	\$26	0.3%	2.9%	5.1%	7.1%	9.0%	10.7%	12.4%	14.0%	15.5%
	\$27	1.4%	4.0%	6.2%	8.2%	10.1%	11.9%	13.6%	15.2%	16.7%
	\$28	2.2%	4.8%	7.1%	9.1%	11.0%	12.8%	14.6%	16.2%	17.8%
\$29	2.7%	5.3%	7.6%	9.7%	11.7%	13.5%	15.3%	17.0%	18.7%	
\$30	2.9%	5.6%	7.9%	10.0%	12.0%	13.9%	15.7%	17.4%	19.1%	

Note: Poultry manure only biogas plants are a relatively new and evolving technology. As such, CAPEX and OPEX is much less understood than for traditional on-farm biogas plants that digest manure and food waste. For this reason, estimated CAPEX and OPEX for poultry manure only biogas plants should be seen as ballpark only. Further detailed analysis is recommended to better understand the CAPEX, OPEX and economic feasibility of building poultry manure only biogas plants in B.C.

8

Summary of Results

8. Summary of Results

8.1 Farm Scenario #1 – 6: Dairy Manure + Mixed Food Waste

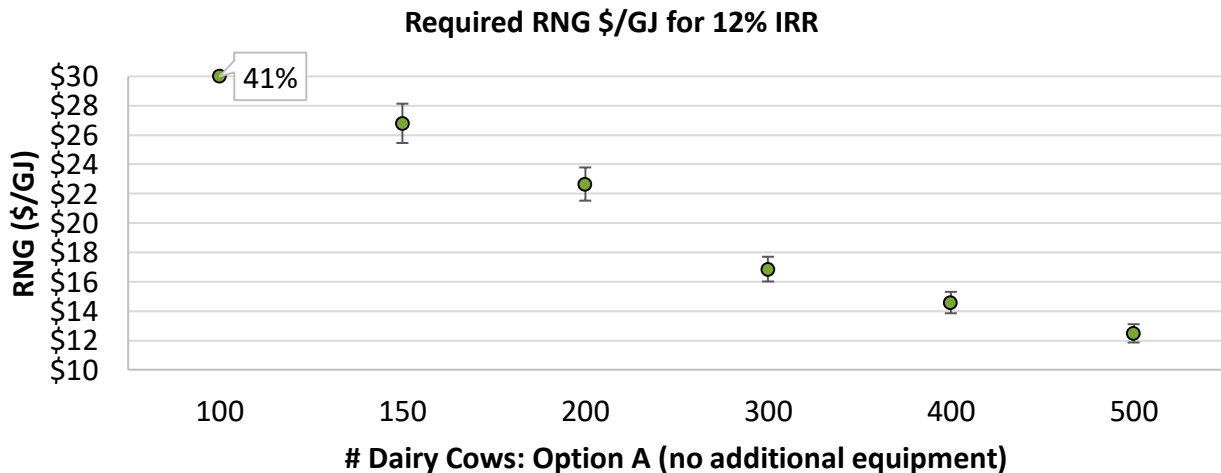
Farm Scenario #1 – 6 assessed the required RNG sale price for different sized dairy farms co-digesting dairy manure and mixed food waste, using traditional biogas plant technology. Results for Farm Scenario #1 – 6, Option A – H are first shown separately based on different equipment choices: mixed food waste cleaning, RNG compression and/or nutrient recovery equipment. Where required RNG sale price is $> \$30/\text{GJ}$, the percentage of required funding is shown. Where required RNG sale price is $< \$30/\text{GJ}$, a bar representing $\pm 5\%$ is shown to account for price uncertainty.

Results for Farm Scenario #1 – 6, Option A – H are then shown collectively. To achieve this, and because many of the Farm Scenarios require an RNG sale price $> \$30/\text{GJ}$, calculations were carried out assuming no RNG sale price limit. While this is not the case in B.C., where maximum RNG sale price is $\$30/\text{GJ}$, this was necessary to show required RNG sale price for every Farm Scenario.

Summary of Results for Option A: No Additional Equipment

Figure 28 shows that without additional equipment, farms with ≥ 150 dairy cows can be economically feasible in B.C. without funding. The required RNG sale price for these farms is as low as $\$11.86/\text{GJ}$ (500 dairy cow farms) to as high as $\$28.14/\text{GJ}$ (150 dairy cow farms). Farms with 100 dairy cows require funding to be economically feasible.

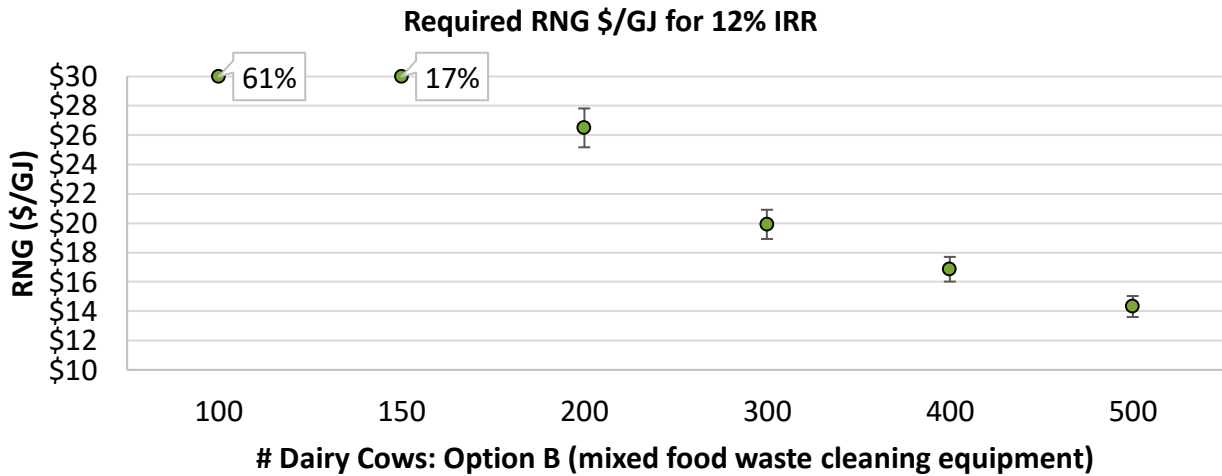
Figure 28: Farm Scenario #1 – 6: Required RNG Sale Price with No Additional Equipment



Summary of Results for Option B: Mixed Food Waste Cleaning Equipment

Figure 29 shows that with mixed food waste cleaning equipment, farms with ≥ 200 dairy cows can be economically feasible in B.C. without funding. The required RNG sale price for these farms is as low as $\$13.60/\text{GJ}$ (500 dairy cow farms) to as high as $\$27.83/\text{GJ}$ (200 dairy cow farms). Farms with ≤ 150 dairy cows require funding to be economically feasible.

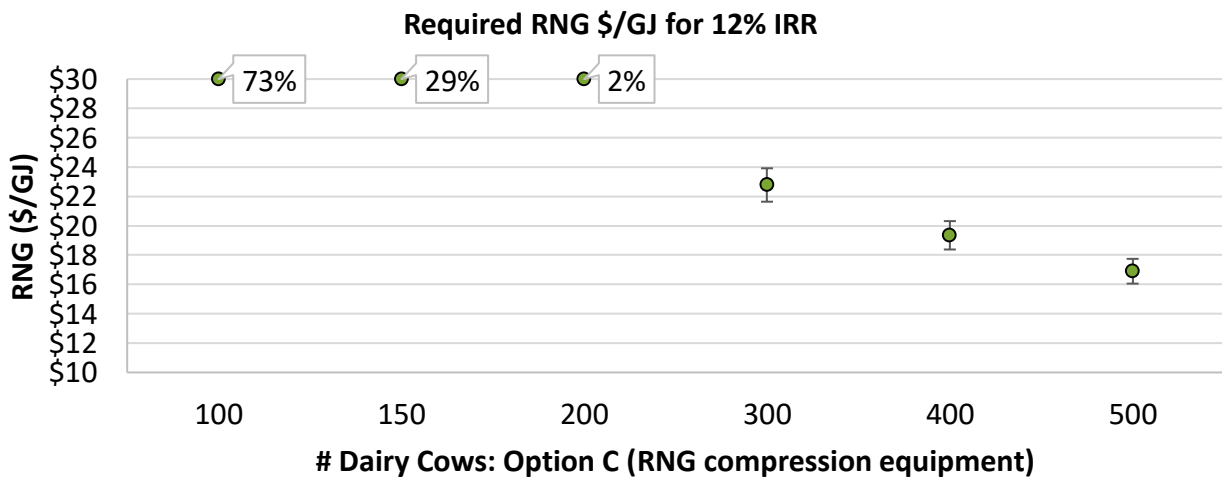
Figure 29: Farm Scenario #1 – 6: Required RNG Sale Price with Mixed Food Waste Cleaning Equipment



Summary of Results for Option C: RNG Compression Equipment

Figure 30 shows that with RNG compression equipment, farms with ≥ 300 dairy cows can be economically feasible in B.C. without funding. The required RNG sale price for these farms is as low as \$16.06/GJ (500 dairy cow farms) to as high as \$23.92/GJ (300 dairy cow farms). Farms with ≤ 200 dairy cows require funding to be economically feasible.

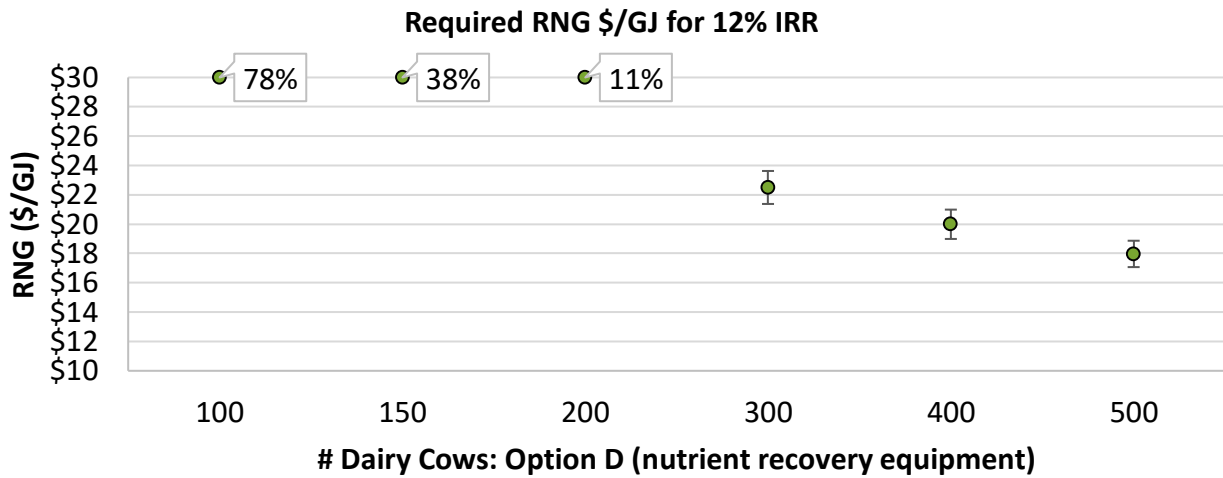
Figure 30: Farm Scenario #1 – 6: Required RNG Sale Price with RNG Compression Equipment



Summary of Results for Option D: Nutrient Recovery Equipment

Figure 31 shows that with nutrient recovery equipment, farms with ≥ 300 dairy cows can be economically feasible in B.C. without funding. The required RNG sale price for these farms as low as \$17.07/GJ (500 dairy cow farms) to as high as \$23.63/GJ (300 dairy cow farms). Farms with ≤ 200 dairy cows require funding to be economically feasible.

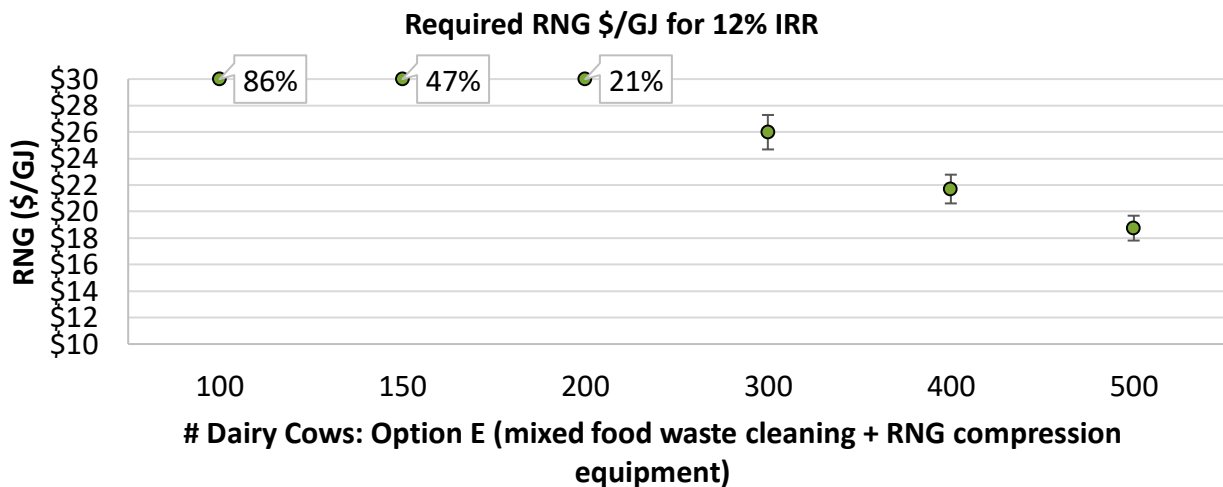
Figure 31: Farm Scenario #1 – 6: Required RNG Sale Price with Nutrient Recovery Equipment



Summary of Results for Option E: Mixed Food Waste Cleaning & RNG Compression Equipment

Figure 32 shows that with mixed food waste and RNG compression equipment, farms with ≥ 300 dairy cows can be economically feasible in B.C. without funding. The required RNG sale price for these farms is as low as \$17.81/GJ (500 dairy cow farms) to as high as \$27.29/GJ (300 dairy cow farms). Farms with ≤ 200 dairy cows require funding to be economically feasible.

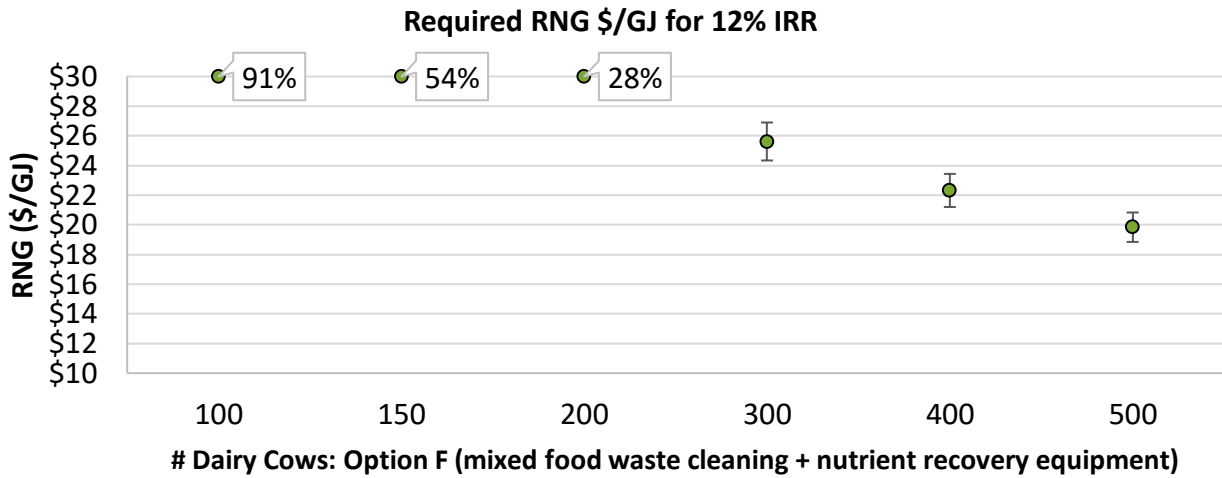
Figure 32: Farm Scenario #1 – 6: Required RNG Sale Price with Mixed Food Waste Cleaning & RNG Compression Equipment



Summary of Results for Option F: Mixed Food Waste Cleaning & Nutrient Recovery Equipment

Figure 33 shows that with mixed food waste cleaning and nutrient recovery equipment, farms with ≥ 300 dairy cows can be economically feasible in B.C. without funding. The required RNG sale price for these farms is as low as \$18.85/GJ (500 dairy cow farms) to as high as \$26.90/GJ (300 dairy cow farms). Farms with ≤ 200 dairy cows require funding to be economically feasible.

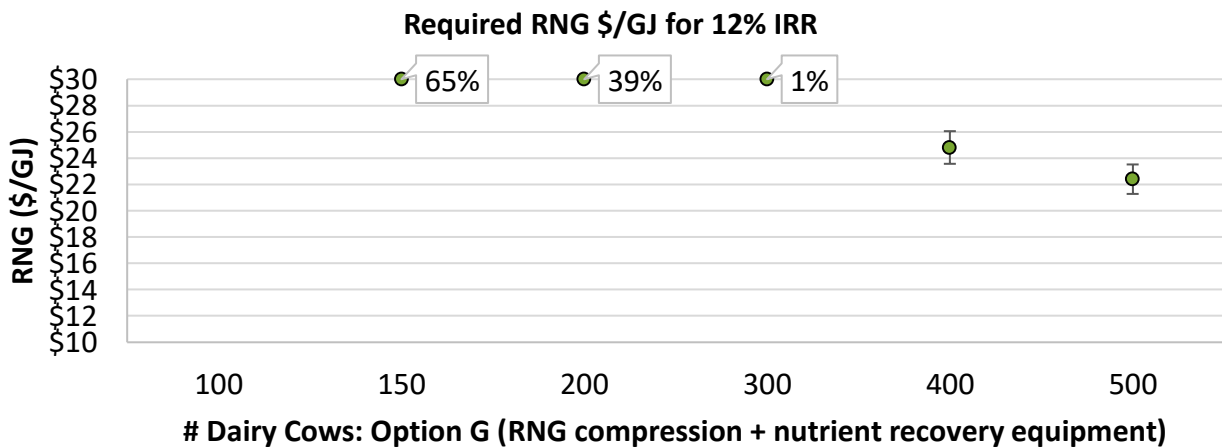
Figure 33: Farm Scenario #1 – 6: Required RNG Sale Price with Mixed Food Waste Cleaning & Nutrient Recovery Equipment



Summary of Results for Option G: RNG Compression & Nutrient Recovery Equipment

Figure 34 shows that with RNG compression and nutrient recovery equipment, farms with ≥ 400 dairy cows can be economically feasible in B.C. without funding. The required RNG sale price for these farms is as low as \$21.28/GJ (500 dairy cow farms) to as high as \$26.05/GJ (400 dairy cow farms). Farms with ≤ 300 dairy cows require funding to be economically feasible. Farms with 100 dairy cows aren't shown because they require $>100\%$ funding.

Figure 34: Farm Scenario #1 – 6: Required RNG Sale Price with RNG Compression & Nutrient Recovery Equipment

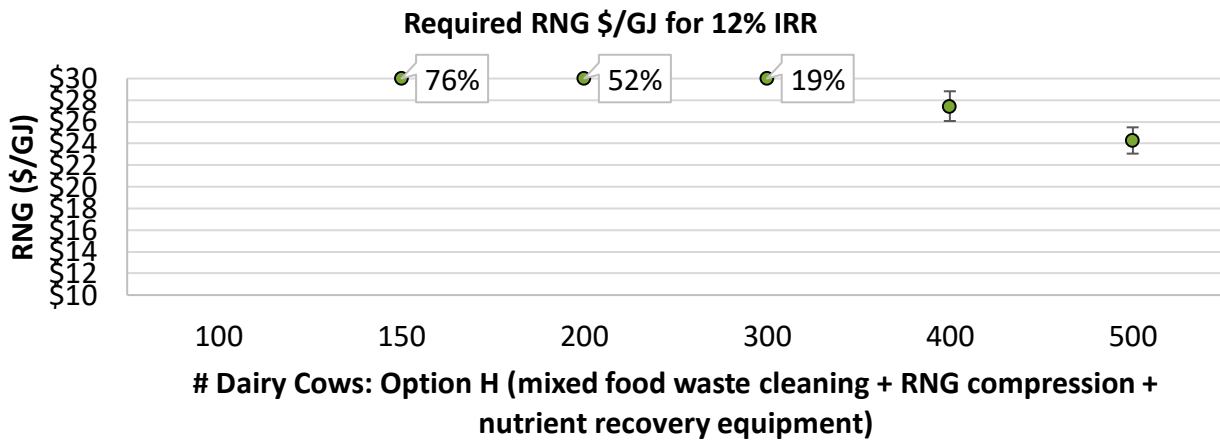


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Summary of Results for Option H: Mixed Food Waste Cleaning, RNG Compression & Nutrient Recovery Equipment

Figure 35 shows that with mixed food waste, RNG compression and nutrient recovery equipment, farms with ≥ 400 dairy cows can be economically feasible in B.C. without funding. The required RNG sale price for these farms is as low as \$23.07/GJ (500 dairy cow farms) to as high as \$28.82/GJ (400 dairy cow farms). Farms with ≤ 300 dairy cows require funding to be economically feasible. Farms with 100 dairy cows aren't shown because they require $>100\%$ funding.

Figure 35: Farm Scenario #1 – 6: Required RNG Sale Price with Mixed Food Waste Cleaning, RNG Compression & Nutrient Recovery Equipment

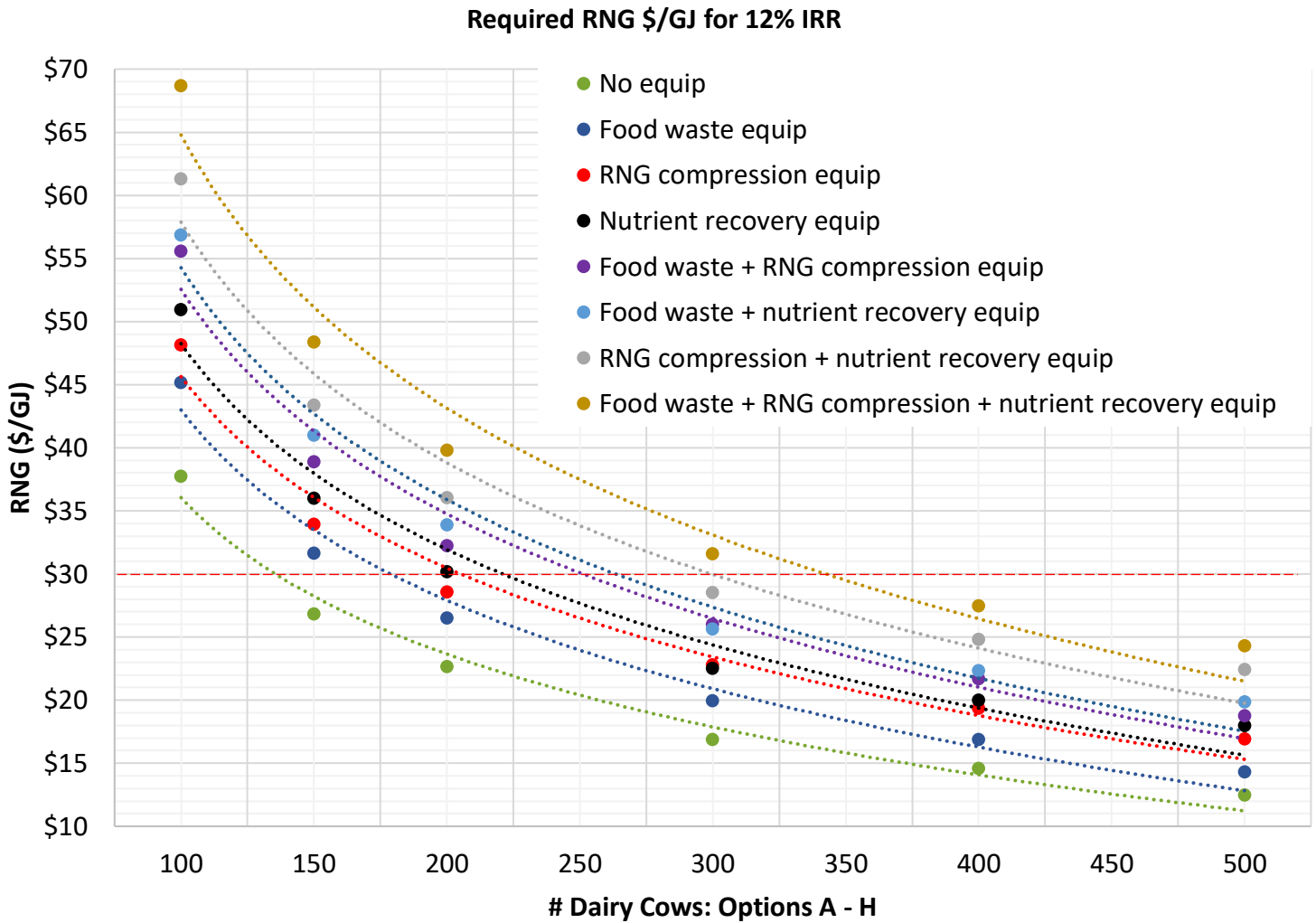


Summary of Results for Farm Scenario #1 – 6 Options A to H

Figure 36 shows the required RNG \$/GJ sale price for Farm Scenario #1 – 6, Option A – H for an unlevered, pre-tax IRR of 12%. Because the required RNG sale price for many Farm Scenarios was $> \$30/\text{GJ}$ (maximum RNG sale price payable in B.C.), Figure 36 was created without an RNG sale price limit for these Farm Scenarios. A logarithmic trend line was used as a line of best-fit.

Figure 36 shows that for all Farm Scenarios #1 – 6, the required RNG sale price decreases as dairy cow numbers increase. This is because biogas plants benefit from economies of scale (typically, the larger the biogas plant, the lower the cost per unit of biogas produced). The required RNG sale price for all Farm Scenarios #1 – 6 also increases as more equipment is required, with mixed food waste cleaning equipment having the smallest and nutrient recovery equipment having the largest impact. Finally, Figure 36 shows which Farm Scenario #1 – 6, Option A – H are currently economically feasible in B.C. Those below the dotted red line are economically feasible, while those above are not and therefore require funding to be economically feasible.

Figure 36: Farm Scenario #1 – 6: Required Base RNG Sale Price†



Note: † Base price increases by 1%/year.

8.2 Farm Scenario #7 & 8: Cattle Manure + Mixed Food Waste

Farm Scenario #7 and 8 assessed the required RNG sale price for different sized cattle feedlots co-digesting cattle manure and mixed food waste, using traditional biogas plant technology. Results for Farm Scenario #7 and 8, Option A – H are first shown separately based on different equipment choices: mixed food waste cleaning, RNG compression and/or nutrient recovery equipment. Where required RNG sale price is >\$30/GJ, the percentage of required funding is shown. Where required RNG sale price is <\$30/GJ, a bar representing +/- 5% is shown to account for price uncertainty.

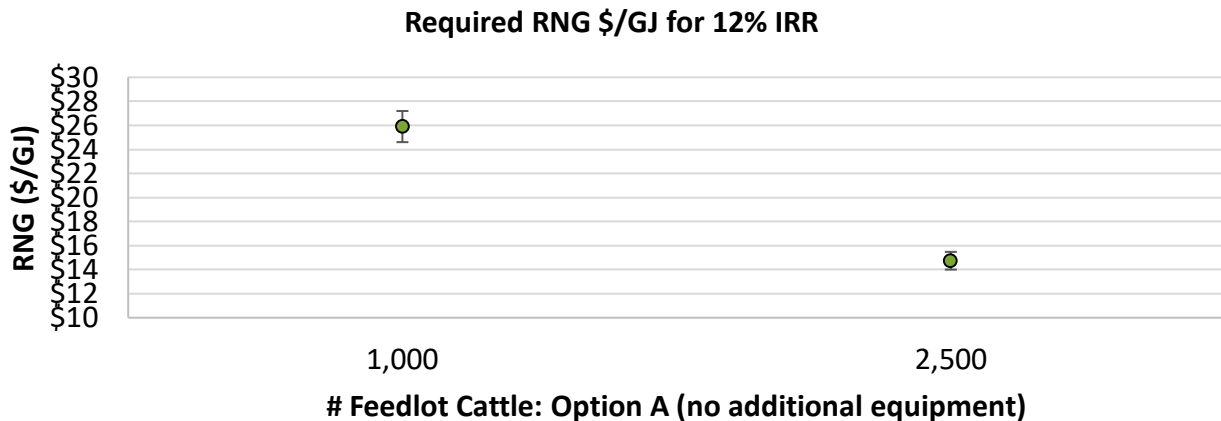
Results for Farm Scenario #7 and 8, Option A – H are then shown collectively. To achieve this, and because many of the Farm Scenarios require an RNG sale price >\$30/GJ, calculations were carried out assuming no RNG sale price limit. While this is not the case in B.C., where maximum RNG sale price is \$30/GJ, this was necessary to show required RNG sale price for every Farm Scenario.

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Summary of Results for Option A: No Additional Equipment

Figure 37 shows that without additional equipment, feedlots with $\geq 1,000$ cattle can be economically feasible in B.C. without funding. The required RNG sale price for these farms is as low as \$14.00/GJ (2,500 cattle feedlots) to as high as \$27.20/GJ (1,000 cattle feedlots).

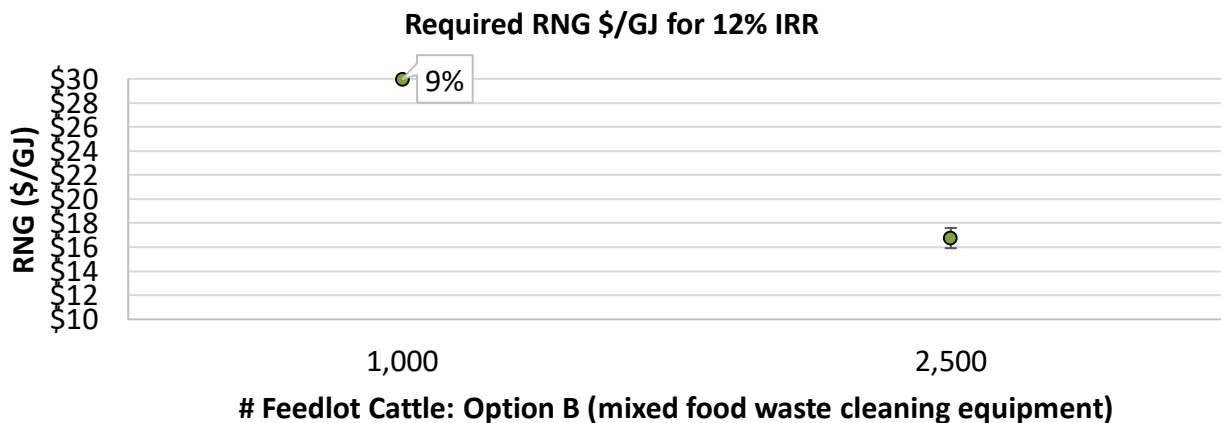
Figure 37: Farm Scenario #7 – 8: Required RNG Sale Price with No Additional Equipment



Summary of Results for Option B: Mixed Food Waste Cleaning Equipment

Figure 38 shows that with mixed food waste cleaning equipment, feedlots with $\geq 2,500$ cattle can be economically feasible in B.C. without funding. The required RNG sale price for these farms is \$15.92 - \$17.60/GJ. Feedlots with 1,000 cattle 9% funding to be economically feasible.

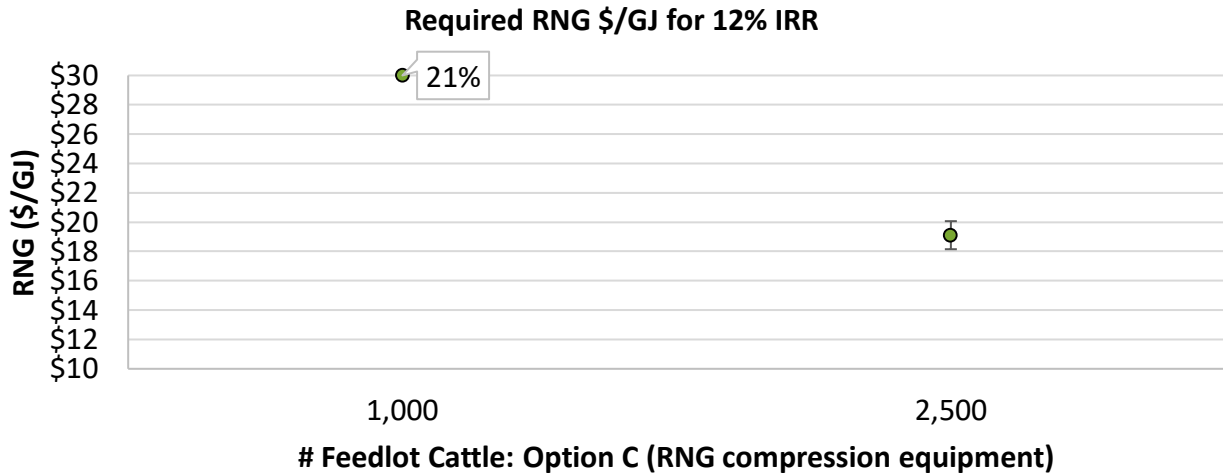
Figure 38: Farm Scenario #7 – 8: Required RNG Sale Price with Mixed Food Waste Cleaning Equipment



Summary of Results for Option C: RNG Compression Equipment

Figure 39 shows that with RNG compression equipment, feedlots with $\geq 2,500$ cattle can be economically feasible in B.C. without funding. The required RNG sale price for these farms is \$18.15 - \$20.07/GJ. Feedlots with 1,000 cattle 21% funding to be economically feasible.

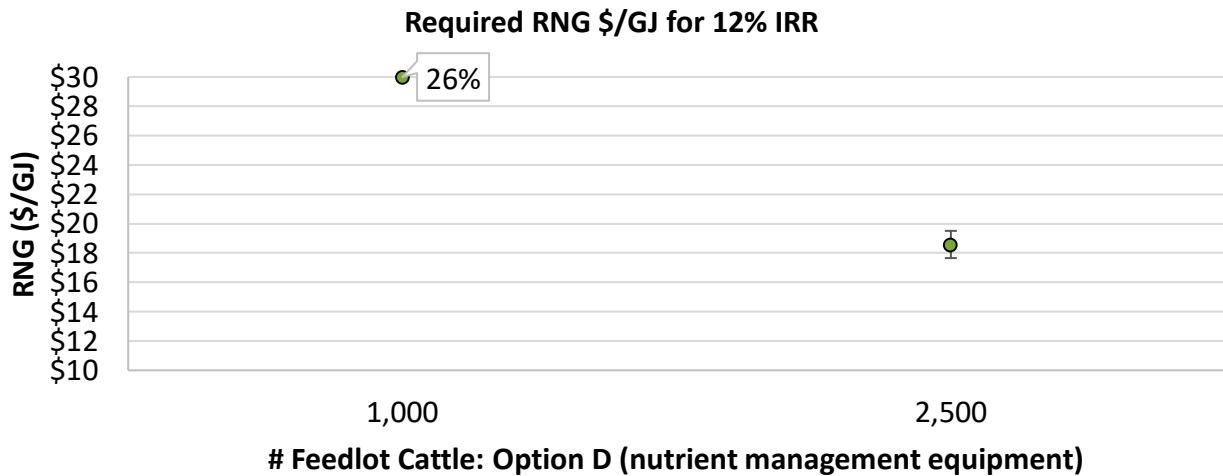
Figure 39: Farm Scenario #7 – 8: Required RNG Sale Price with RNG Compression Equipment



Summary of Results for Option D: Nutrient Recovery Equipment

Figure 40 shows that with nutrient recovery equipment, feedlots with $\geq 2,500$ cattle can be economically feasible in B.C. without funding. The required RNG sale price for these farms is \$17.65 - \$19.51/GJ. Feedlots with 1,000 cattle require 26% funding to be economically feasible.

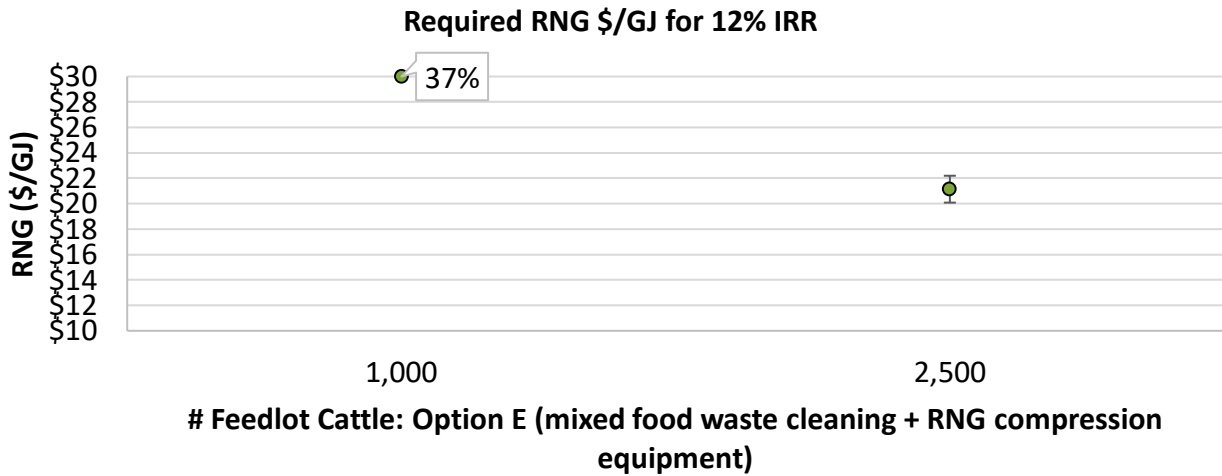
Figure 40: Farm Scenario #7 – 8: Required RNG Sale Price with Nutrient Recovery Equipment



Summary of Results for Option E: Mixed Food Waste Cleaning & RNG Compression Equipment

Figure 41 shows that with mixed food waste cleaning and RNG compression equipment, feedlots with $\geq 2,500$ cattle can be economically feasible in B.C. without funding. The required RNG sale price for these farms is \$20.08 - \$22.22/GJ. Feedlots with 1,000 cattle require 37% funding to be economically feasible.

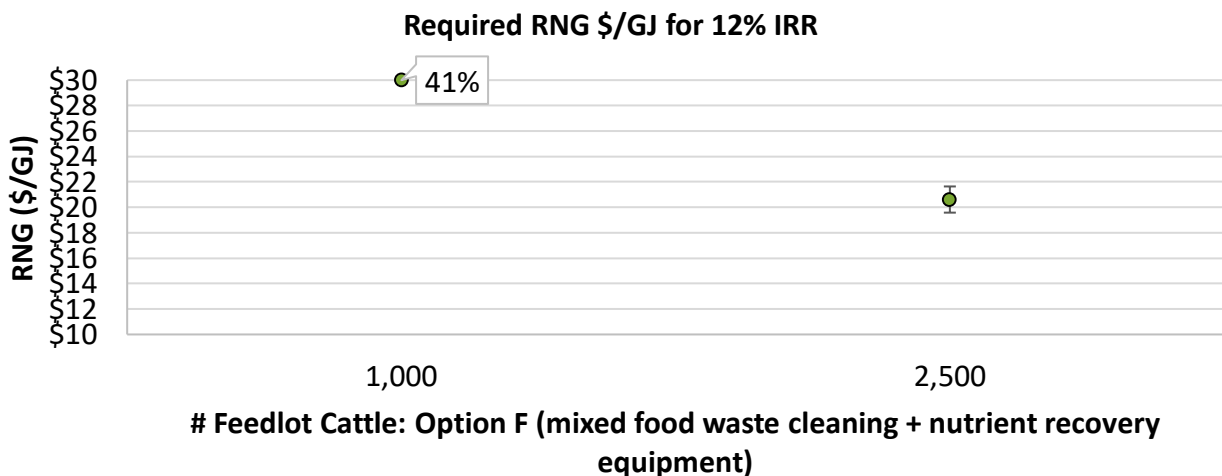
Figure 41: Farm Scenario #7 – 8: Required RNG Sale Price with Mixed Food Waste Cleaning & RNG Compression Equipment



Summary of Results for Option F: Mixed Food Waste Cleaning & Nutrient Recovery Equipment

Figure 42 shows that with mixed food waste cleaning and nutrient recovery equipment, feedlots with $\geq 2,500$ cattle can be economically feasible in B.C. without funding. The required RNG sale price for these farms is \$19.58 - \$21.64/GJ. Feedlots with 1,000 cattle require 41% funding to be economically feasible.

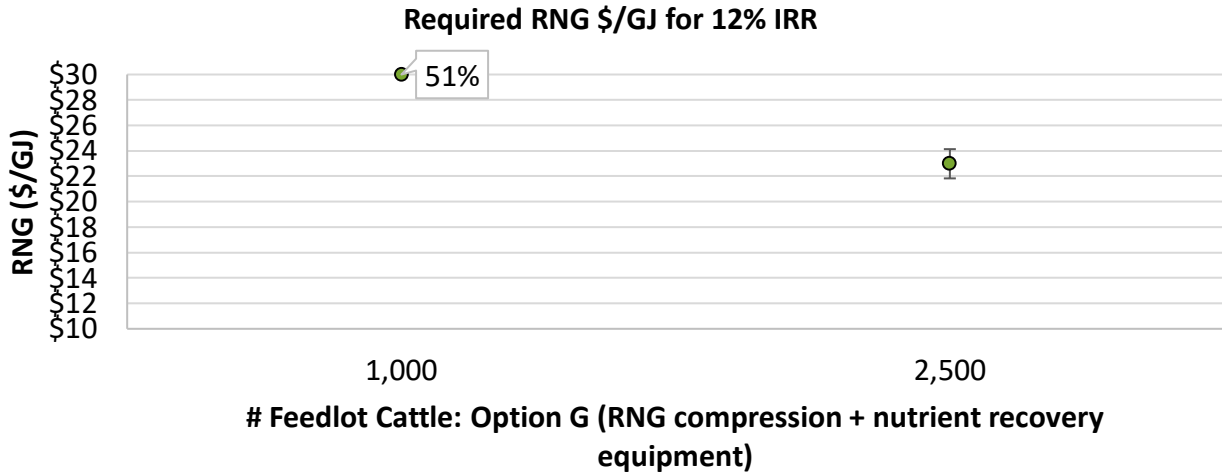
Figure 42: Farm Scenario #7 – 8: Required RNG Sale Price with Mixed Food Waste Cleaning & Nutrient Recovery Equipment



Summary of Results for Option G: RNG Compression & Nutrient Recovery Equipment

Figure 43 shows that with RNG compression and nutrient recovery equipment, feedlots with $\geq 2,500$ cattle can be economically feasible in B.C. without funding. The required RNG sale price for these farms is \$21.83 - \$24.13/GJ. Feedlots with 1,000 cattle require 51% funding to be economically feasible.

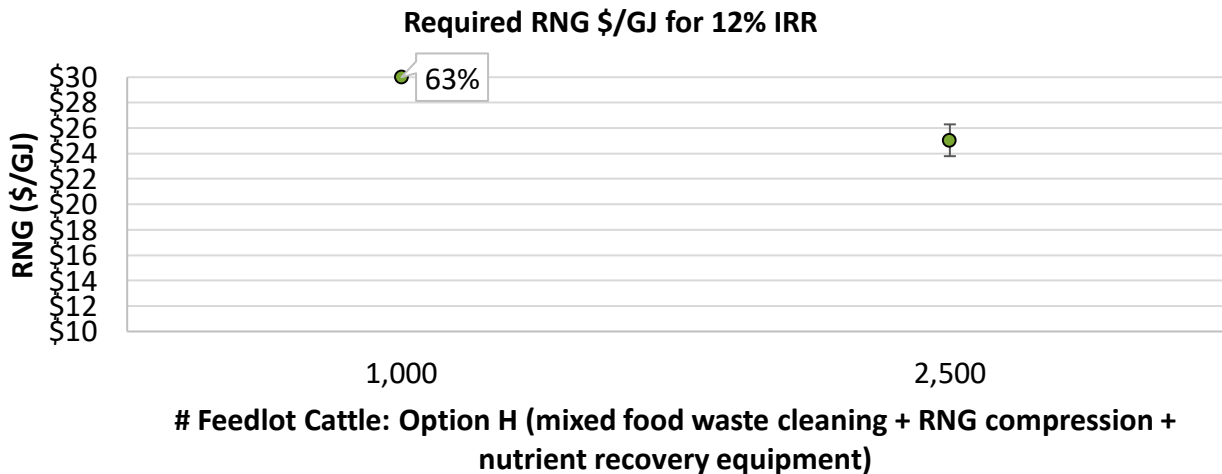
Figure 43: Farm Scenario #7 – 8: Required RNG Sale Price with RNG Compression & Nutrient Recovery Equipment



Summary of Results for Option H: Mixed Food Waste Cleaning, RNG Compression & Nutrient Recovery Equipment

Figure 44 shows that with mixed food waste cleaning, RNG compression and nutrient recovery equipment, feedlots with $\geq 2,500$ cattle can be economically feasible in B.C. without funding. The required RNG sale price for these farms is \$23.79 - \$26.29/GJ. Feedlots with 1,000 cattle require 63% funding to be economically feasible.

Figure 44: Farm Scenario #7 – 8: Required RNG Sale Price with Mixed Food Waste Cleaning, RNG Compression & Nutrient Recovery Equipment



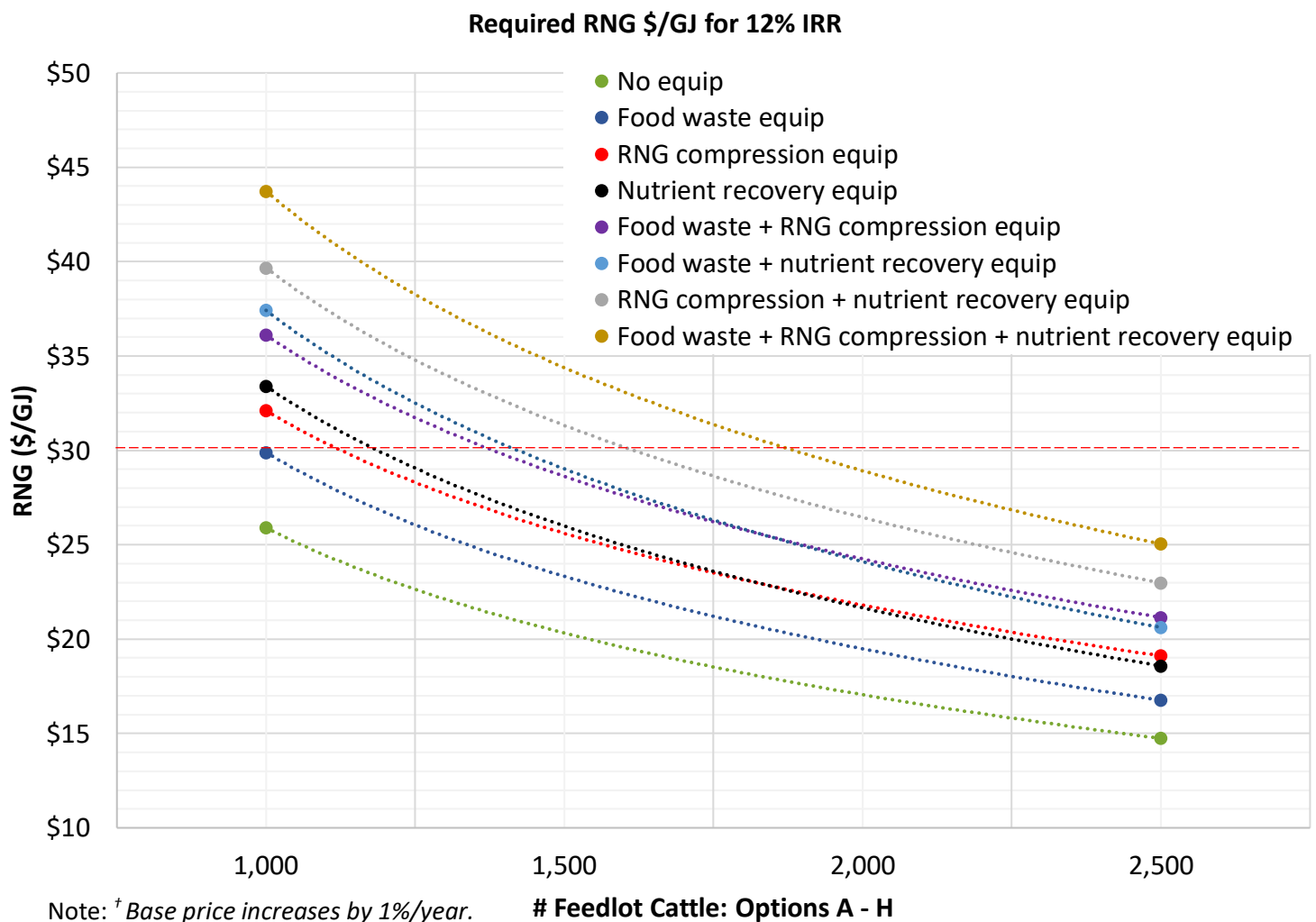
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Summary of Results for Farm Scenario #7 & 8 Options A to H

Figure 45 shows the required RNG \$/GJ sale price for Farm Scenario #7 and 8, Option A – H for an unlevered, pre-tax IRR of 12%. Because the required RNG sale price for many Farm Scenarios was >\$30/GJ (maximum RNG sale price payable in B.C.), Figure 45 was created without an RNG sale price limit for these Farm Scenarios. A logarithmic trend line was used as a line of best-fit.

Figure 45 shows that for Farm Scenarios #8 and 9, the required RNG sale price decreases as feedlot cattle numbers increase. This is because biogas plants benefit from economies of scale (typically, the larger the biogas plant, the lower the cost per unit of biogas produced). The required RNG sale price for Farm Scenarios #8 and 9 also increases as more equipment is required, with mixed food waste cleaning equipment having the smallest and nutrient recovery equipment having the largest impact. Finally, Figure 45 shows which Farm Scenario #8 and 9 Options A – H are currently economically feasible in B.C. Those below the dotted red line are economically feasible, while those above are not and therefore require funding to be economically feasible.

Figure 45: Farm Scenario #7 – 8: Required Base RNG Sale Price†



8.3 Farm Scenario #9 – 13: Dairy Manure + Poultry Manure with Traditional Technology

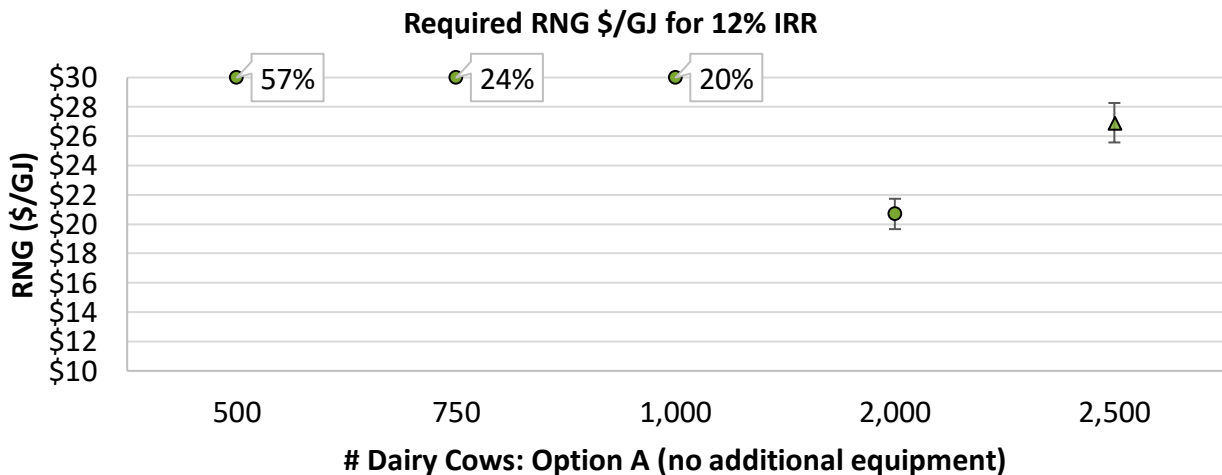
Farm Scenario #9 – 13 assessed the required RNG sale price for different sized dairy farms co-digesting dairy manure and poultry manure, or digesting only dairy manure, using traditional biogas plant technology. Results for Farm Scenario #9 – 13, Option A – D are first shown separately based on different equipment choices; RNG compression and/or nutrient recovery equipment. Where required RNG sale price is >\$30/GJ, the percentage of required funding is shown. Where required RNG sale price is <\$30/GJ, a bar representing +/- 5% is shown to account for price uncertainty.

Results for Farm Scenario #9 – 13, Option A – D are then shown collectively. To achieve this, and because many of the Farm Scenarios require an RNG sale price >\$30/GJ, calculations were carried out assuming no RNG sale price limit. While this is not the case in B.C., where maximum RNG sale price is \$30/GJ, this was necessary to show required RNG sale price for every Farm Scenario.

Summary of Results for Option A: No Additional Equipment

Figure 46 shows that without additional equipment, farms with ≥2,000 dairy cows can be economically feasible in B.C. without funding. The required RNG sale price for these farms is as low as \$19.65/GJ for 2,000 dairy cow farms co-digesting dairy and poultry manure, to as high as \$28.27/GJ for 2,500 dairy cow farms digesting dairy manure only. Farms with ≤ 1,000 dairy cows require funding to be economically feasible.

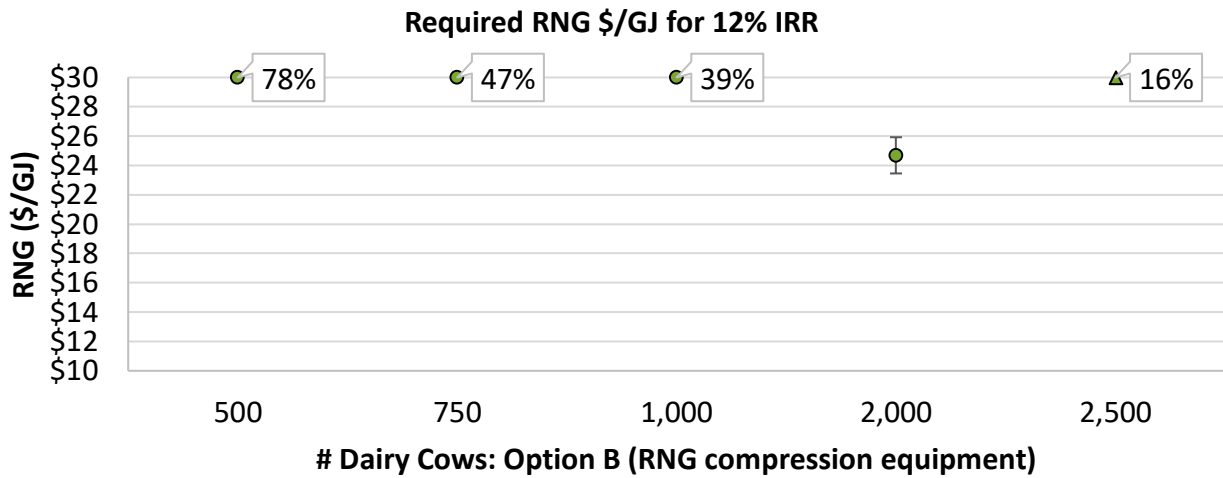
Figure 46: Farm Scenario #9 – 13: Required RNG Sale Price with No Additional Equipment



Summary of Results for Option B: RNG Compression Equipment

Figure 47 shows that with RNG compression equipment, farms with ≥2,000 dairy cows co-digesting dairy and poultry manure can be economically feasible in B.C. without funding. The required RNG sale price for these farms is \$23.46 - \$25.92/GJ. Farms with ≤1,000 dairy cows co-digesting dairy and poultry manure, and farms with ≤2,500 dairy cows digesting dairy manure only, require funding to be economically feasible.

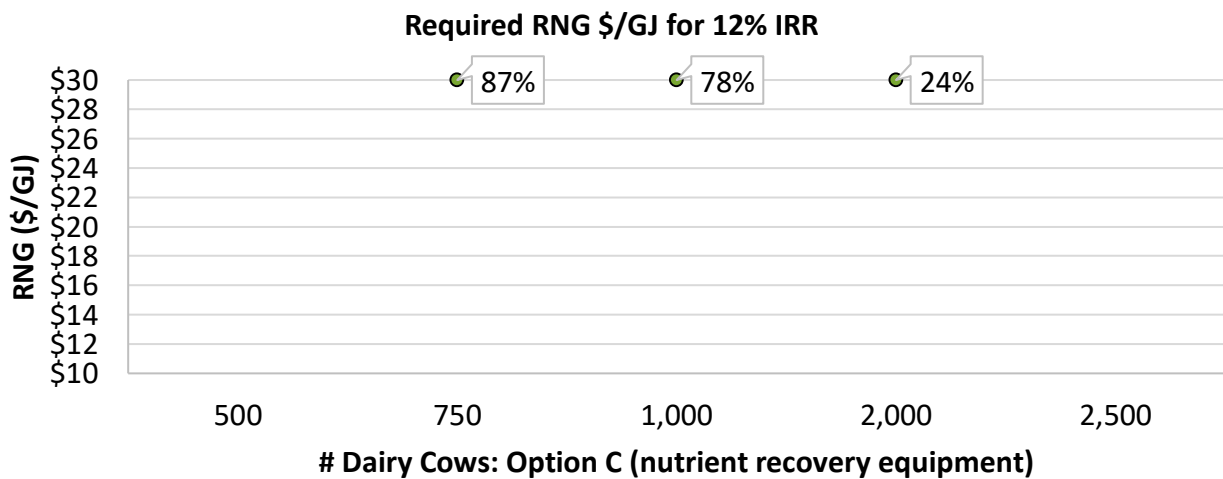
Figure 47: Farm Scenario #9 – 13: Required RNG Sale Price with RNG Compression Equipment



Summary of Results for Option C: Nutrient Recovery Equipment

Figure 48 shows that with nutrient recovery equipment, farms with $\leq 2,000$ dairy cows co-digesting dairy and poultry manure require funding to be economically feasible. Farms with 500 dairy cows co-digesting dairy and poultry manure, and farms with 2,500 dairy cows digesting dairy manure only aren't shown because they require $>100\%$ funding.

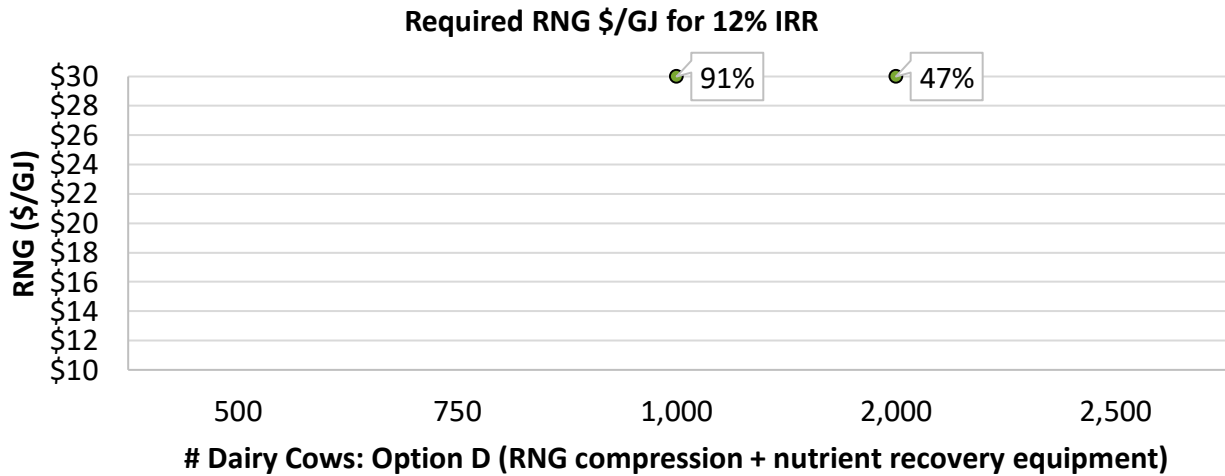
Figure 48: Farm Scenario #9 – 13: Required RNG Sale Price with Nutrient Recovery Equipment



Summary of Results for Option D: RNG Compression & Nutrient Recovery Equipment

Figure 49 shows that with RNG compression and nutrient recovery equipment, farms with $\leq 2,000$ dairy cows co-digesting dairy and poultry manure require funding to be economically feasible. Farms with ≤ 750 dairy cows co-digesting dairy and poultry manure, and farms with 2,500 dairy cows digesting manure only aren't shown because they require $>100\%$ funding.

Figure 49: Farm Scenario #9 – 13: Required RNG Sale Price with RNG Compression & Nutrient Recovery Equipment

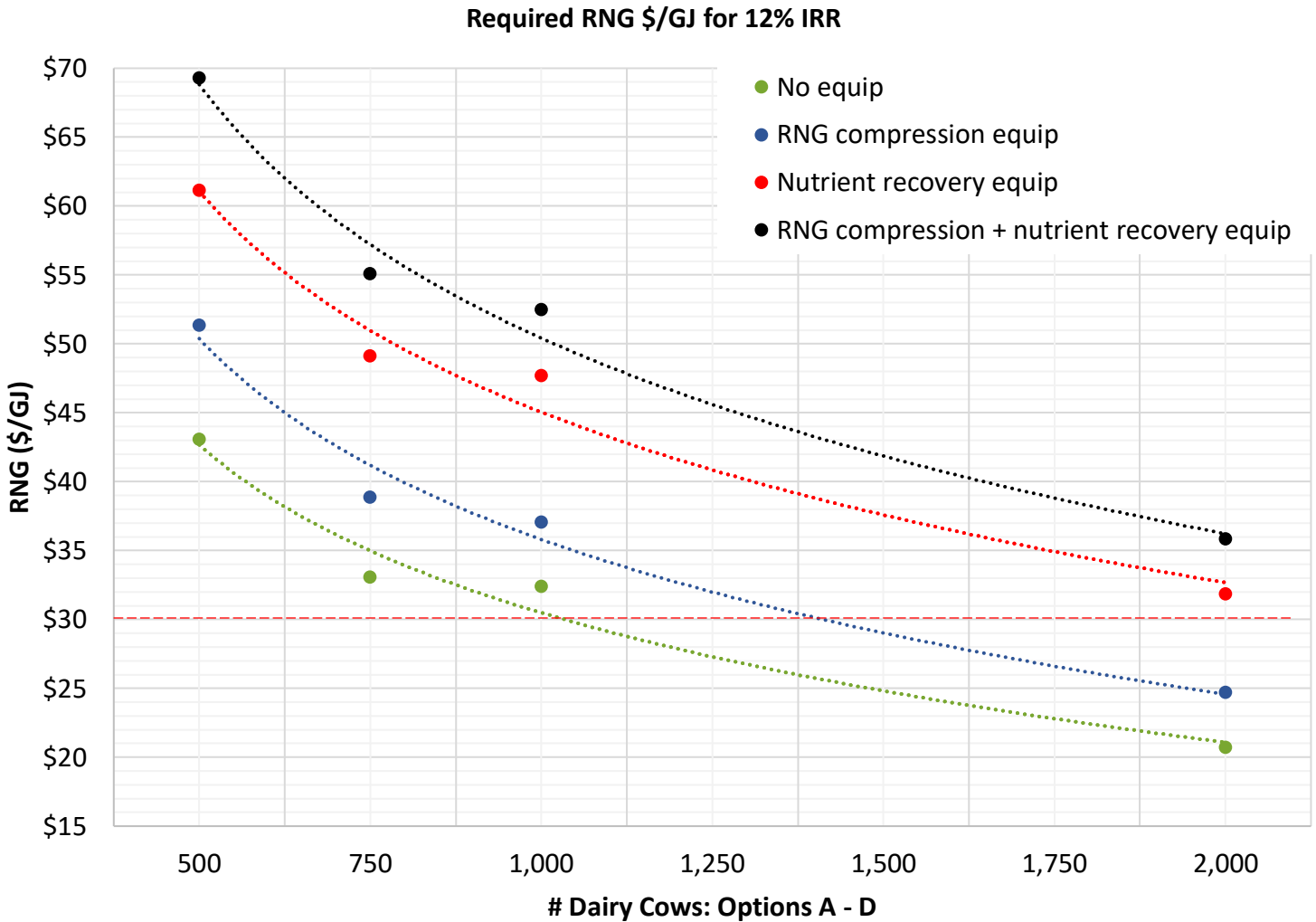


Summary of Results for Farm Scenario #9 – 12 Options A to D

Figure 50 shows the required RNG \$/GJ sale price for Farm Scenario #9 – 12, Option A – D for an unlevered, pre-tax IRR of 12%. Because the required RNG sale price for many Farm Scenarios was >\$30/GJ (maximum RNG sale price payable in B.C.), Figure 50 was created without an RNG sale price limit for these Farm Scenarios. A logarithmic trend line was used as a line of best-fit.

Figure 50 shows that for all Farm Scenarios #9 – 12, the required RNG sale price decreases as dairy cow numbers increase. This is because biogas plants benefit from economies of scale (typically, the larger the biogas plant, the lower the cost per unit of biogas produced). The required RNG sale price for all Farm Scenarios #9 – 12 also increases as more equipment is required, with RNG compression equipment having the smallest and nutrient recovery equipment having the largest impacts. Finally, Figure 50 shows which Farm Scenario #9 – 12, Option A – D are currently economically feasible in B.C. Those below the dotted red line are economically feasible, while those above are not and therefore require funding to be economically feasible.

Figure 50: Farm Scenario #9 – 12: Required Base RNG Sale Price†



Note: † Base price increases by 1%/year.

8.4 Farm Scenario #14 – 18: Dairy Manure + Poultry Manure with Modular Technology

Farm Scenario #14 – 18 assessed the required RNG sale price for different sized dairy farms co-digesting dairy manure and poultry manure using modular biogas plant technology. Results for Farm Scenario #14 – 18, Option A and B are first shown separately based on different equipment choices: with and without nutrient recovery equipment. Where required RNG sale price is >\$30/GJ, the percentage of required funding is shown. Where required RNG sale price is <\$30/GJ, a bar representing +/- 5% is shown to account for price uncertainty.

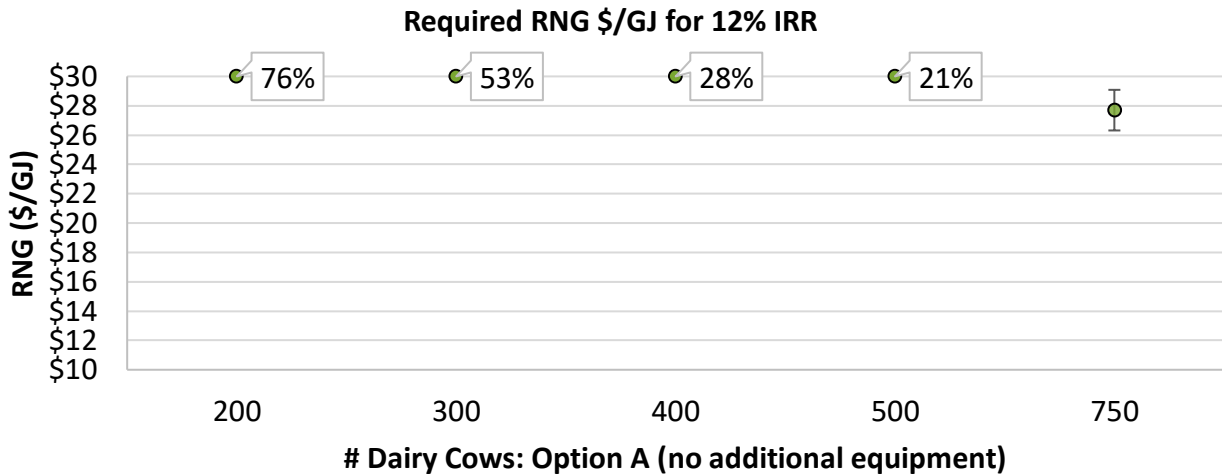
Results for Farm Scenario #14 – 18, Option A and B are then shown collectively. To achieve this, and because many Farm Scenarios require an RNG sale price >\$30/GJ, calculations were carried out assuming no RNG sale price limit. While this is not the case in B.C., where maximum RNG sale price is \$30/GJ, this was necessary to show the required RNG sale price for every Farm Scenario.

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Summary of Results for Option A: No Additional Equipment

Figure 51 shows that without additional equipment, farms with ≥ 750 dairy cows co-digesting dairy and poultry manure using modular technology can be economically feasible in B.C. without funding. The required RNG sale price for these farms is \$26.32 - \$29.09/GJ. Farms with ≤ 500 dairy cows co-digesting dairy and poultry manure using modular technology require funding to be economically feasible.

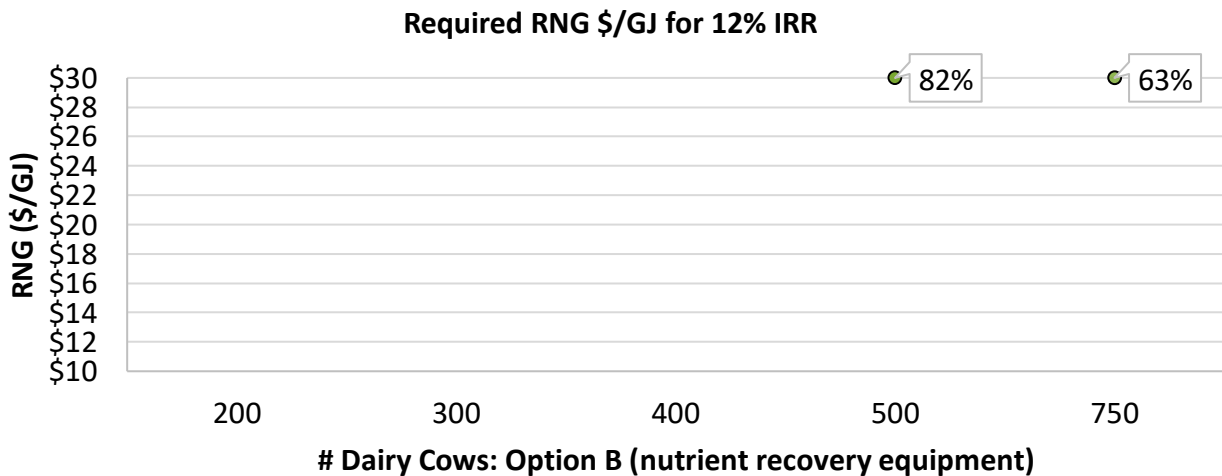
Figure 51: Farm Scenario #14 – 18: Required RNG Sale Price with No Additional Equipment



Summary of Results for Option B: Nutrient Recovery Equipment

Figure 52 shows that with nutrient recovery equipment, farms with ≤ 750 dairy cows co-digesting dairy and poultry manure using modular technology require funding to be economically feasible. Farms with ≤ 400 dairy cows aren't shown because they require $>100\%$ funding.

Figure 52: Farm Scenario #14 – 18: Required RNG Sale Price with Nutrient Recovery Equipment



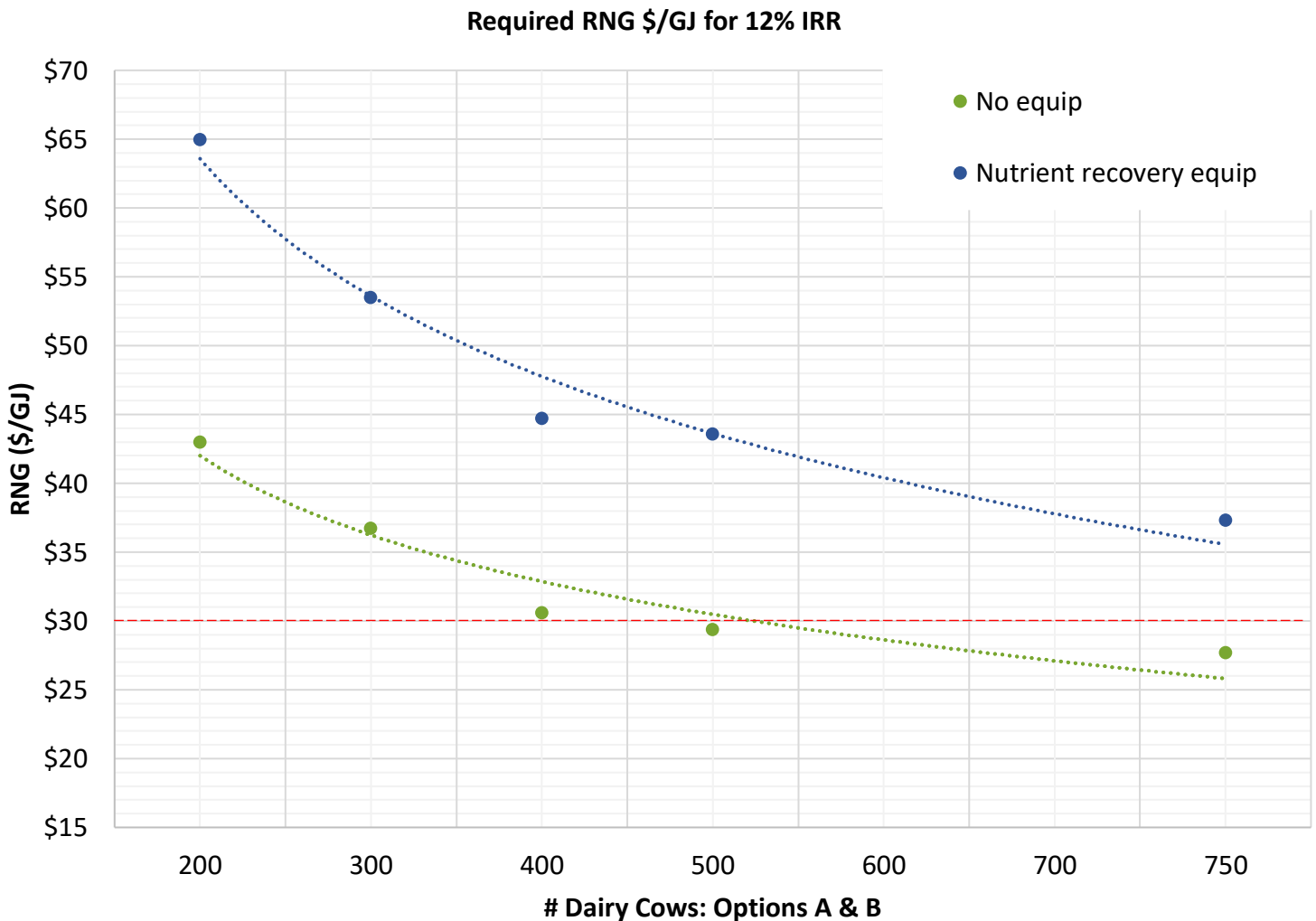
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Summary of Results for Farm Scenario #14 – 18 Options A & B

Figure 53 shows required RNG \$/GJ sale price for Farm Scenario #14 – 18, Option A and B for an unlevered, pre-tax IRR of 12%. Because the required RNG sale price for many Farm Scenarios was >\$30/GJ (maximum RNG sale price payable in B.C.), Figure 53 was created without an RNG sale price limit for these Farm Scenarios. A logarithmic trend line was used as a line of best-fit.

Figure 53 shows that for all Farm Scenarios #14 – 18, the required RNG sale price decreases as dairy cow numbers increase. This is because biogas plants benefit from economies of scale (typically, the larger the biogas plant, the lower the cost per unit of biogas produced). The required RNG sale price for all Farm Scenarios #14 – 18 also increases when nutrient recovery equipment is required. Finally, Figure 53 shows which Farm Scenario #14 – 18, Option A and B are currently economically feasible in B.C. Those below the dotted red line are economically feasible, while those above are not and therefore require funding to be economically feasible.

Figure 53: Farm Scenario #14 – 18: Required Base RNG Sale Price†



Note: † Base price increases by 1%/year.

9

**Greenhouse
Gas Reductions**

9. Greenhouse Gas Reductions

On-farm biogas plants capture methane from manure and mixed food waste that would otherwise go into the atmosphere. This methane, once upgraded to Renewable Natural Gas (RNG), displaces natural gas. Therefore, on-farm biogas plants reduce greenhouse gas emissions. Some methane escapes during biogas upgrading to RNG, natural gas is used to heat tanks, and digestate storage releases methane. Therefore, on-farm biogas plants produce greenhouse gas emissions.

To estimate greenhouse gas emission reductions from on-farm biogas plants in B.C., the B.C. Biogas & Composting Plant Greenhouse Gas Calculation Tool was used. To use this Tool a location for the biogas plant is required. Information on where mixed food waste used to go before being co-digested in the biogas plant is also required. Finally, whether digestate fibre will be composted, and the number of years the biogas plant will operate are also required.

9.1 Farm Scenario #1 – 8: Greenhouse Gas Emission Reductions

For Farm Scenario #1 – 8, it was assumed that the biogas plants are located in the Fraser Valley. It was also assumed that 100% of mixed food waste co-digested used to be landfilled in the Vancouver landfill, and that this landfill captures 75% of the landfill gas it produces. Finally, it was assumed that no digestate fibre is composted, and that the biogas plants will operate for 20 years.³

Figure 54 shows average cost per tonne of carbon dioxide equivalent (CO₂e) reductions based on estimated CAPEX for the lowest (i.e., no additional equipment) and highest cost (i.e., mixed food waste cleaning, RNG compression and nutrient recovery equipment) Farm Scenario #1 – 8 biogas plants. Not surprisingly, the larger the biogas plant for Farm Scenario #1 – 6 and #7 – 8 (i.e., the larger the volume of feedstock), the greater the greenhouse gas emission reductions and lower the cost per tonne.

Figure 54: Farm Scenario #1 – 8: Greenhouse Gas Emission Reductions

Farm Scenario	CAPEX (low)	CAPEX (high)	GJ/Year	Greenhouse Reductions (T/Year)	\$/Tonne CO₂e (low)	\$/Tonne CO₂e (high)
#1	\$4,431,272	\$7,045,467	24,980	2,784	\$79.58	\$126.53
#2	\$4,814,048	\$7,459,786	37,470	4,177	\$57.63	\$89.30
#3	\$5,726,801	\$8,404,082	49,959	5,569	\$51.42	\$75.45
#4	\$6,645,002	\$9,859,640	74,939	8,353	\$39.78	\$59.02
#5	\$7,971,006	\$11,593,654	99,919	11,137	\$35.79	\$52.05
#6	\$8,705,093	\$12,821,983	124,898	13,922	\$31.26	\$46.05
#7	\$5,857,596	\$8,524,466	45,837	3,859	\$75.90	\$110.45
#8	\$8,989,517	\$12,304,300	114,593	9,647	\$46.59	\$63.77

³ Choosing a different location for the biogas plant or landfill has minimal impact on estimated greenhouse gas emission reductions. If mixed food waste isn't going to a landfill, or if the landfill's gas capture system doesn't capture 75% of the landfill gas produced, estimated greenhouse gas emission reductions can be significantly different.

9.2 Farm Scenario #9 – 13 Greenhouse Gas Emission Reductions

For Farm Scenario #9 – 13, it was assumed that the biogas plants are located in the Fraser Valley. It was also assumed that no digestate fibre is composted, and that the biogas plants will operate for 20 years.⁴

Figure 55 shows average cost per tonne of carbon dioxide equivalent (CO₂e) reductions based on estimated CAPEX for the lowest (i.e., no additional equipment) and highest cost (i.e., RNG compression and nutrient recovery equipment) Farm Scenario #9 – 13 biogas plants. Not surprisingly, for most Farm Scenarios #9 – 12, the larger the biogas plant (i.e., the larger the volume of feedstock), the greater the greenhouse gas emission reductions and lower the cost per tonne.

However, while greenhouse gas emission reductions are greater for Farm Scenario #11 (1,000 dairy cows) than Farm Scenario #10 (750 dairy cows), the cost per tonne of greenhouse gas emission reductions is slightly lower for Farm Scenario #10. This is because some biogas equipment is only built at certain sizes/for certain volumes. Therefore, when a piece of equipment is too small, the next size/volume up must be used, even if it is much larger (and therefore more expensive) than required. As such, while larger biogas plants will have greater greenhouse gas emission reductions, they aren’t always guaranteed to provide the lowest cost greenhouse gas emission reductions.

Figure 55: Farm Scenario #9 – 13: Greenhouse Gas Emission Reductions

Farm Scenario	CAPEX (low)	CAPEX (high)	GJ/Year	Greenhouse Reductions (T/Year)	\$/Tonne CO ₂ e (low)	\$/Tonne CO ₂ e (high)
#9	\$5,279,016	\$7,033,175	26,848	2,198	\$120.09	\$159.99
#10	\$6,142,706	\$8,103,231	40,273	3,297	\$93.16	\$122.89
#11	\$8,497,355	\$10,951,681	53,697	4,397	\$96.63	\$124.54
#12	\$10,519,185	\$13,281,583	107,394	8,793	\$59.82	\$75.52
#13	\$7,655,380	\$10,076,046	40,368	7,956	\$48.11	\$63.32

9.3 Farm Scenario #14 – 18 Greenhouse Gas Emission Reductions

For Farm Scenario #14 – 18, it was assumed that the biogas plants are located in the Fraser Valley. It was also assumed that no digestate fibre is composted, and that the biogas plants will operate for 20 years.⁵

Figure 56 shows average cost per tonne of carbon dioxide equivalent (CO₂e) reductions based on estimated CAPEX for the lowest (i.e., no additional equipment) and highest cost (i.e., nutrient recovery equipment) Farm Scenario #14 – 18 biogas plants. Not surprisingly, for most Farm Scenarios, the larger the biogas plant (i.e., the larger the volume of feedstock), the greater the greenhouse gas emission reductions and lower the cost per tonne.

⁴ *Ibid.*

⁵ *Ibid.*

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However, while greenhouse gas emission reductions are greater for Farm Scenario #17 (500 dairy cows) than Farm Scenario #16 (400 dairy cows), the cost per tonne of greenhouse gas emission reductions is slightly lower for Farm Scenario #16. This is because some biogas equipment is only built at certain sizes/for certain volumes. Therefore, when a piece of equipment is too small, the next size/volume up must be used, even if it is much larger (and therefore more expensive) than required. As such, while larger biogas plants will have greater greenhouse gas emission reductions, they aren't always guaranteed to provide the lowest cost greenhouse gas emission reductions.

Figure 56: Farm Scenario #14 – 18: Greenhouse Gas Emission Reductions

Farm Scenario	CAPEX (low)	CAPEX (high)	GJ/Year	Greenhouse Reductions (T/Year)	\$/Tonne CO ₂ e (low)	\$/Tonne CO ₂ e (high)
#14	\$1,837,204	\$2,436,916	10,739	879	\$104.51	\$138.62
#15	\$2,566,148	\$3,165,861	16,109	1,319	\$97.28	\$120.01
#16	\$2,878,968	\$3,478,681	21,479	1,759	\$81.84	\$98.88
#17	\$3,617,415	\$4,429,228	26,848	2,198	\$82.29	\$100.76
#18	\$4,662,536	\$5,686,449	40,273	3,297	\$70.71	\$86.24

9.4 Farm Scenario #19 & 20 Greenhouse Gas Emission Reductions

For Farm Scenario #19 and 20, it was assumed that the biogas plants are located in the Fraser Valley. It was also assumed that no digestate fibre is composted, and that the biogas plants will operate for 20 years.⁶

Figure 57 shows the cost per tonne of carbon dioxide equivalent (CO₂e) reductions based on estimated CAPEX for Farm Scenario 19 and 20 biogas plants. Not surprisingly, the larger the biogas plant (i.e., the larger the volume of feedstock), the greater the greenhouse gas emission reductions and lower the cost per tonne.

Figure 57: Farm Scenario #19 – 20: Greenhouse Gas Emission Reductions

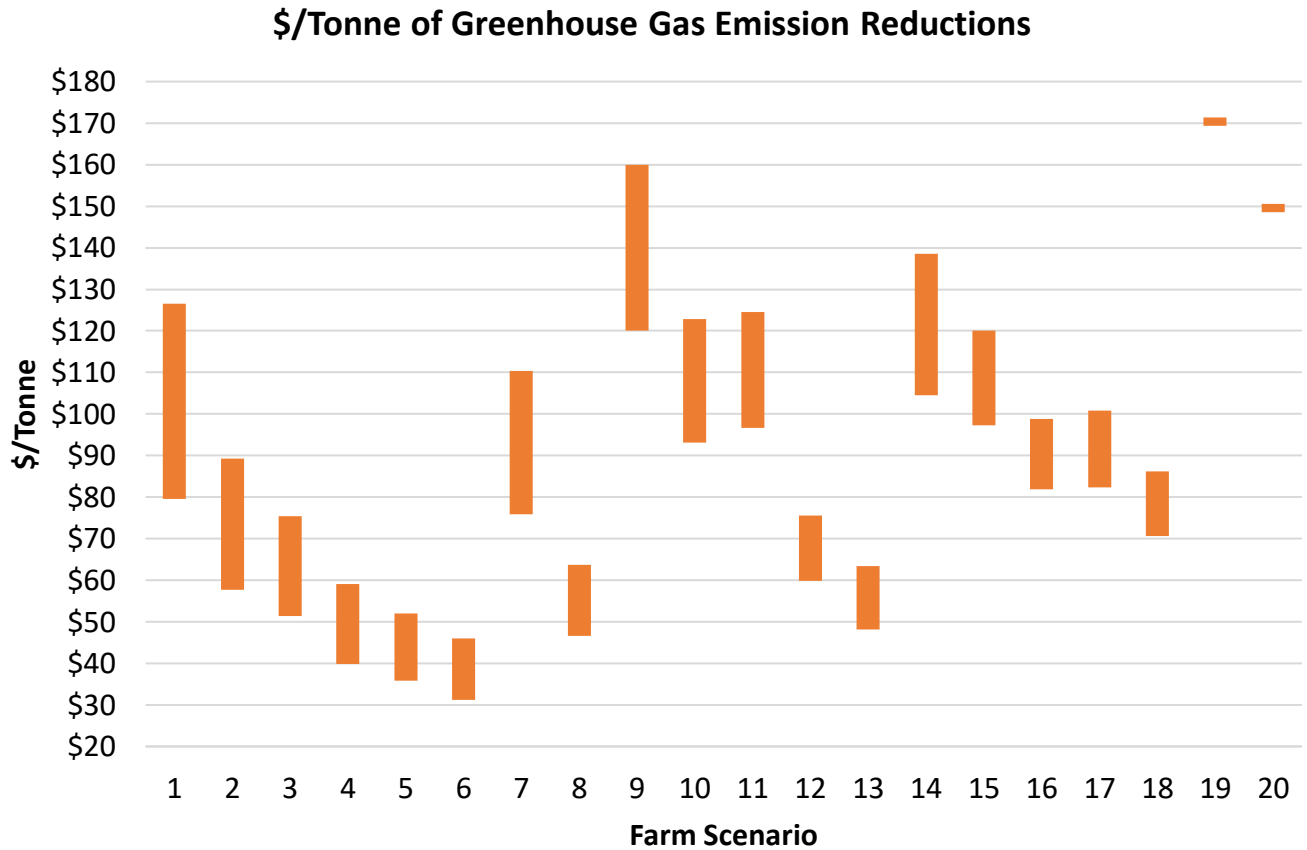
Farm Scenario	CAPEX	GJ/Year	Greenhouse Reductions (T/Year)	\$/Tonne CO ₂ e
#19	\$9,893,352	90,324	2,920	\$169.41
#20	\$17,351,333	180,648	5,840	\$148.56

⁶ *Ibid.*

9.5 Greenhouse Gas Emission Reduction Summary

Figure 58 shows the cost per tonne of carbon dioxide equivalent (CO₂e) reductions based on estimated CAPEX for all Farm Scenarios #1 - 20. Typically, the larger the biogas plant (i.e., the larger the volume of feedstock), the greater the greenhouse gas emission reductions and lower the cost per tonne.

Figure 58: Greenhouse Gas Emission Reductions Summary



Appendix A: Farm Scenario #1 - 100 Dairy Cows + Mixed Food Waste

Capital Costs

		Option A	Option B	Option C	Option D	Option E	Option F	Option G	Option H
Digester									
Off-Farm Feedstock Storage		\$180,000	\$180,000	\$180,000	\$180,000	\$180,000	\$180,000	\$180,000	\$180,000
Feedstock Pre-Treatment		\$0	\$500,000	\$0	\$0	\$500,000	\$500,000	\$0	\$500,000
Digester Tank		\$710,000	\$710,000	\$710,000	\$710,000	\$710,000	\$710,000	\$710,000	\$710,000
Pasteurization System		\$272,000	\$272,000	\$272,000	\$272,000	\$272,000	\$272,000	\$272,000	\$272,000
Heating and Hot Water Pipes		\$140,000	\$140,000	\$140,000	\$140,000	\$140,000	\$140,000	\$140,000	\$140,000
Control System		\$80,000	\$80,000	\$80,000	\$80,000	\$80,000	\$80,000	\$80,000	\$80,000
Buildings		\$137,500	\$330,000	\$137,500	\$357,500	\$330,000	\$550,000	\$357,500	\$550,000
Weigh Station		\$60,000	\$60,000	\$60,000	\$60,000	\$60,000	\$60,000	\$60,000	\$60,000
Misc.	5%	\$78,975	\$113,600	\$78,975	\$89,975	\$113,600	\$124,600	\$89,975	\$124,600
<i>Subtotal</i>		<i>\$1,658,475</i>	<i>\$2,385,600</i>	<i>\$1,658,475</i>	<i>\$1,889,475</i>	<i>\$2,385,600</i>	<i>\$2,616,600</i>	<i>\$1,889,475</i>	<i>\$2,616,600</i>
Biogas Upgrading									
Biogas Upgrader		\$1,460,000	\$1,460,000	\$1,460,000	\$1,460,000	\$1,460,000	\$1,460,000	\$1,460,000	\$1,460,000
Spare Parts (% of cost)	3%	\$43,800	\$43,800	\$43,800	\$43,800	\$43,800	\$43,800	\$43,800	\$43,800
Installation Costs		\$400,000	\$400,000	\$400,000	\$400,000	\$400,000	\$400,000	\$400,000	\$400,000
Flare		\$105,000	\$105,000	\$105,000	\$105,000	\$105,000	\$105,000	\$105,000	\$105,000
Compression & Transport		\$0	\$0	\$640,583	\$0	\$640,583	\$0	\$640,583	\$640,583
<i>Subtotal</i>		<i>\$2,008,800</i>	<i>\$2,008,800</i>	<i>\$2,649,383</i>	<i>\$2,008,800</i>	<i>\$2,649,383</i>	<i>\$2,008,800</i>	<i>\$2,649,383</i>	<i>\$2,649,383</i>
Digestate Management									
Nutrient Recovery Equip		\$0	\$0	\$0	\$675,000	\$0	\$675,000	\$675,000	\$675,000
Additional Storage		\$186,842	\$186,842	\$186,842	\$186,842	\$186,842	\$186,842	\$186,842	\$186,842
<i>Subtotal</i>		<i>\$186,842</i>	<i>\$186,842</i>	<i>\$186,842</i>	<i>\$861,842</i>	<i>\$186,842</i>	<i>\$861,842</i>	<i>\$861,842</i>	<i>\$861,842</i>
Other Costs									
Hydro Service Upgrades	1%	\$38,541	\$45,812	\$44,947	\$47,601	\$52,218	\$54,872	\$54,007	\$61,278
Site Prep + Civil Works	1.5%	\$57,812	\$68,719	\$67,421	\$71,402	\$78,327	\$82,309	\$81,011	\$91,917
Project Development	2%	\$77,082	\$91,625	\$89,894	\$95,202	\$104,437	\$109,745	\$108,014	\$122,557
Engineering & Project Mgt	5%	\$192,706	\$229,062	\$224,735	\$238,006	\$261,091	\$274,362	\$270,035	\$306,391
Risk Management	5%	\$211,013	\$250,823	\$246,085	\$260,616	\$285,895	\$300,427	\$295,688	\$335,498
<i>Subtotal</i>		<i>\$577,154</i>	<i>\$686,041</i>	<i>\$673,081</i>	<i>\$712,828</i>	<i>\$781,968</i>	<i>\$821,715</i>	<i>\$808,755</i>	<i>\$917,642</i>
Total Capital Costs		\$4,431,272	\$5,267,283	\$5,167,782	\$5,472,945	\$6,003,794	\$6,308,957	\$6,209,455	\$7,045,467

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Operating Costs

		Option A	Option B	Option C	Option D	Option E	Option F	Option G	Option H
Digester									
Electrical Cost		\$34,697	\$34,697	\$34,697	\$34,697	\$34,697	\$34,697	\$34,697	\$34,697
Natural Gas Cost		\$26,229	\$26,229	\$26,229	\$26,229	\$26,229	\$26,229	\$26,229	\$26,229
Labour Cost		\$35,100	\$46,800	\$35,100	\$35,100	\$46,800	\$46,800	\$35,100	\$46,800
Service & Maintenance		\$40,000	\$75,000	\$40,000	\$40,000	\$75,000	\$75,000	\$40,000	\$75,000
Insurance + Legal + Acc		\$45,000	\$45,000	\$45,000	\$45,000	\$45,000	\$45,000	\$45,000	\$45,000
Reinvestments (% of CAPEX)	2%	\$33,170	\$47,712	\$33,170	\$37,790	\$47,712	\$52,332	\$37,790	\$52,332
Contingency	10%	\$21,419	\$27,544	\$21,419	\$21,881	\$27,544	\$28,006	\$21,881	\$28,006
<i>Subtotal</i>		<i>\$235,614</i>	<i>\$302,981</i>	<i>\$235,614</i>	<i>\$240,696</i>	<i>\$302,981</i>	<i>\$308,063</i>	<i>\$240,696</i>	<i>\$308,063</i>
Biogas Upgrading									
Electrical Cost		\$32,028	\$32,028	\$32,028	\$32,028	\$32,028	\$32,028	\$32,028	\$32,028
Media Cost (\$/kg)		\$5,338	\$5,338	\$5,338	\$5,338	\$5,338	\$5,338	\$5,338	\$5,338
Consumables (e.g., oil)		\$10,676	\$10,676	\$10,676	\$10,676	\$10,676	\$10,676	\$10,675.93	\$10,676
Reinvestment (% of CAPEX)	2%	\$29,200	\$29,200	\$42,012	\$29,200	\$42,012	\$29,200	\$42,012	\$42,012
Labour Cost		\$23,400	\$23,400	\$23,400	\$23,400	\$23,400	\$23,400	\$23,400	\$23,400
Service & Maintenance		\$90,000	\$90,000	\$90,000	\$90,000	\$90,000	\$90,000	\$90,000	\$90,000
Compression & Transport		\$0	\$0	\$117,815	\$0	\$117,815	\$0	\$117,815	\$117,815
Contingency	10%	\$19,064	\$19,064	\$32,127	\$19,064	\$32,127	\$19,064	\$32,127	\$32,127
<i>Subtotal</i>		<i>\$209,706</i>	<i>\$209,706</i>	<i>\$353,395</i>	<i>\$209,706</i>	<i>\$353,395</i>	<i>\$209,706</i>	<i>\$353,395</i>	<i>\$353,395</i>
Digestate Management									
Electrical Cost		\$0	\$0	\$0	\$17,520	\$0	\$17,520	\$17,520	\$17,520
Service & Maint (% of CAPEX)	5%	\$0	\$0	\$0	\$33,750	\$0	\$33,750	\$33,750	\$33,750
Labour Cost		\$0	\$0	\$0	\$46,800	\$0	\$46,800	\$46,800	\$46,800
Transportation (\$/tonne)		\$0	\$0	\$0	\$38,534	\$0	\$38,534	\$38,534	\$38,534
Reinvestment (% of CAPEX)	2%	\$0	\$0	\$0	\$13,500	\$0	\$13,500	\$13,500	\$13,500
Contingency	10%	\$0	\$0	\$0	\$15,010	\$0	\$15,010	\$15,010	\$15,010
<i>Subtotal</i>		<i>\$0</i>	<i>\$0</i>	<i>\$0</i>	<i>\$165,114</i>	<i>\$0</i>	<i>\$165,114</i>	<i>\$165,114</i>	<i>\$165,114</i>
Total Operating Costs		\$445,320	\$512,687	\$589,010	\$615,516	\$656,376	\$682,883	\$759,206	\$826,573

Appendix B: Farm Scenario #2 - 150 Dairy Cows + Mixed Food Waste

Capital Costs

		Option A	Option B	Option C	Option D	Option E	Option F	Option G	Option H
Digester									
Off-Farm Feedstock Storage		\$210,000	\$210,000	\$210,000	\$210,000	\$210,000	\$210,000	\$210,000	\$210,000
Feedstock Pre-Treatment		\$0	\$500,000	\$0	\$0	\$500,000	\$500,000	\$0	\$500,000
Digester Tank		\$810,000	\$810,000	\$810,000	\$810,000	\$810,000	\$810,000	\$810,000	\$810,000
Pasteurization System		\$272,000	\$272,000	\$272,000	\$272,000	\$272,000	\$272,000	\$272,000	\$272,000
Heating and Hot Water Pipes		\$140,000	\$140,000	\$140,000	\$140,000	\$140,000	\$140,000	\$140,000	\$140,000
Control System		\$80,000	\$80,000	\$80,000	\$80,000	\$80,000	\$80,000	\$80,000	\$80,000
Buildings		\$137,500	\$330,000	\$137,500	\$357,500	\$330,000	\$550,000	\$357,500	\$550,000
Weigh Station		\$60,000	\$60,000	\$60,000	\$60,000	\$60,000	\$60,000	\$60,000	\$60,000
Misc.	5%	\$85,475	\$120,100	\$85,475	\$96,475	\$120,100	\$131,100	\$96,475	\$131,100
<i>Subtotal</i>		<i>\$1,794,975</i>	<i>\$2,522,100</i>	<i>\$1,794,975</i>	<i>\$2,025,975</i>	<i>\$2,522,100</i>	<i>\$2,753,100</i>	<i>\$2,025,975</i>	<i>\$2,753,100</i>
Biogas Upgrading									
Biogas Upgrader		\$1,560,000	\$1,560,000	\$1,560,000	\$1,560,000	\$1,560,000	\$1,560,000	\$1,560,000	\$1,560,000
Spare Parts (% of cost)	3%	\$46,800	\$46,800	\$46,800	\$46,800	\$46,800	\$46,800	\$46,800	\$46,800
Installation Costs		\$400,000	\$400,000	\$400,000	\$400,000	\$400,000	\$400,000	\$400,000	\$400,000
Flare		\$105,000	\$105,000	\$105,000	\$105,000	\$105,000	\$105,000	\$105,000	\$105,000
Compression & Transport		\$0	\$0	\$668,017	\$0	\$668,017	\$0	\$668,017	\$668,017
<i>Subtotal</i>		<i>\$2,111,800</i>	<i>\$2,111,800</i>	<i>\$2,779,817</i>	<i>\$2,111,800</i>	<i>\$2,779,817</i>	<i>\$2,111,800</i>	<i>\$2,779,817</i>	<i>\$2,779,817</i>
Digestate Management									
Nutrient Recovery Equip		\$0	\$0	\$0	\$675,000	\$0	\$675,000	\$675,000	\$675,000
Additional Storage		\$280,264	\$280,264	\$280,264	\$280,264	\$280,264	\$280,264	\$280,264	\$280,264
<i>Subtotal</i>		<i>\$280,264</i>	<i>\$280,264</i>	<i>\$280,264</i>	<i>\$955,264</i>	<i>\$280,264</i>	<i>\$955,264</i>	<i>\$955,264</i>	<i>\$955,264</i>
Other Costs									
Hydro Service Upgrades	1%	\$41,870	\$49,142	\$48,551	\$50,930	\$55,822	\$58,202	\$57,611	\$64,882
Site Prep + Civil Works	1.5%	\$62,806	\$73,712	\$72,826	\$76,396	\$83,733	\$87,302	\$86,416	\$97,323
Project Development	2%	\$83,741	\$98,283	\$97,101	\$101,861	\$111,644	\$116,403	\$115,221	\$129,764
Engineering & Project Mgt	5%	\$209,352	\$245,708	\$242,753	\$254,652	\$279,109	\$291,008	\$288,053	\$324,409
Risk Management	5%	\$229,240	\$269,050	\$265,814	\$278,844	\$305,624	\$318,654	\$315,418	\$355,228
<i>Subtotal</i>		<i>\$627,009</i>	<i>\$735,896</i>	<i>\$727,045</i>	<i>\$762,683</i>	<i>\$835,932</i>	<i>\$871,570</i>	<i>\$862,718</i>	<i>\$971,605</i>
Total Capital Costs		\$4,814,048	\$5,650,060	\$5,582,101	\$5,855,721	\$6,418,113	\$6,691,733	\$6,623,774	\$7,459,786

B.C. On-Farm Biogas Benchmark Study, Version 2

Operating Costs

		Option A	Option B	Option C	Option D	Option E	Option F	Option G	Option H
Digester									
Electrical Cost		\$52,045	\$52,045	\$52,045	\$52,045	\$52,045	\$52,045	\$52,045	\$52,045
Natural Gas Cost		\$39,343	\$39,343	\$39,343	\$39,343	\$39,343	\$39,343	\$39,343	\$39,343
Labour Cost		\$35,100	\$46,800	\$35,100	\$35,100	\$46,800	\$46,800	\$35,100	\$46,800
Service & Maintenance		\$40,000	\$75,000	\$40,000	\$40,000	\$75,000	\$75,000	\$40,000	\$75,000
Insurance + Legal + Acc		\$45,000	\$45,000	\$45,000	\$45,000	\$45,000	\$45,000	\$45,000	\$45,000
Reinvestments (% of CAPEX)	2%	\$35,900	\$50,442	\$35,900	\$40,520	\$50,442	\$55,062	\$40,520	\$55,062
Contingency	10%	\$24,739	\$30,863	\$24,739	\$25,201	\$30,863	\$31,325	\$25,201	\$31,325
<i>Subtotal</i>		<i>\$272,126</i>	<i>\$339,493</i>	<i>\$272,126</i>	<i>\$277,208</i>	<i>\$339,493</i>	<i>\$344,575</i>	<i>\$277,208</i>	<i>\$344,575</i>
Biogas Upgrading									
Electrical Cost		\$48,042	\$48,042	\$48,042	\$48,042	\$48,042	\$48,042	\$48,042	\$48,042
Media Cost (\$/kg)		\$8,007	\$8,007	\$8,007	\$8,007	\$8,007	\$8,007	\$8,007	\$8,007
Consumables (e.g., oil)		\$16,014	\$16,014	\$16,014	\$16,014	\$16,014	\$16,014	\$16,013.90	\$16,014
Reinvestment (% of CAPEX)	2%	\$31,200	\$31,200	\$44,560	\$31,200	\$44,560	\$31,200	\$44,560	\$44,560
Labour Cost		\$23,400	\$23,400	\$23,400	\$23,400	\$23,400	\$23,400	\$23,400	\$23,400
Service & Maintenance		\$90,000	\$90,000	\$90,000	\$90,000	\$90,000	\$90,000	\$90,000	\$90,000
Compression & Transport		\$0	\$0	\$127,861	\$0	\$127,861	\$0	\$127,861	\$127,861
Contingency	10%	\$21,666	\$21,666	\$35,788	\$21,666	\$35,788	\$21,666	\$35,788	\$35,788
<i>Subtotal</i>		<i>\$238,329</i>	<i>\$238,329</i>	<i>\$393,672</i>	<i>\$238,329</i>	<i>\$393,672</i>	<i>\$238,329</i>	<i>\$393,672</i>	<i>\$393,672</i>
Digestate Management									
Electrical Cost		\$0	\$0	\$0	\$17,520	\$0	\$17,520	\$17,520	\$17,520
Service & Maint (% of CAPEX)	5%	\$0	\$0	\$0	\$33,750	\$0	\$33,750	\$33,750	\$33,750
Labour Cost		\$0	\$0	\$0	\$46,800	\$0	\$46,800	\$46,800	\$46,800
Transportation (\$/tonne)		\$0	\$0	\$0	\$57,801	\$0	\$57,801	\$57,801	\$57,801
Reinvestment (% of CAPEX)	2%	\$0	\$0	\$0	\$13,500	\$0	\$13,500	\$13,500	\$13,500
Contingency	10%	\$0	\$0	\$0	\$16,937	\$0	\$16,937	\$16,937	\$16,937
<i>Subtotal</i>		<i>\$0</i>	<i>\$0</i>	<i>\$0</i>	<i>\$186,308</i>	<i>\$0</i>	<i>\$186,308</i>	<i>\$186,308</i>	<i>\$186,308</i>
Total Operating Costs		\$510,455	\$577,822	\$665,799	\$701,845	\$733,165	\$769,212	\$857,188	\$924,555

Appendix C: Farm Scenario #3 - 200 Dairy Cows + Mixed Food Waste

Capital Costs

		Option A	Option B	Option C	Option D	Option E	Option F	Option G	Option H
Digester									
Off-Farm Feedstock Storage		\$225,000	\$225,000	\$225,000	\$225,000	\$225,000	\$225,000	\$225,000	\$225,000
Feedstock Pre-Treatment		\$0	\$500,000	\$0	\$0	\$500,000	\$500,000	\$0	\$500,000
Digester Tank		\$1,020,000	\$1,020,000	\$1,020,000	\$1,020,000	\$1,020,000	\$1,020,000	\$1,020,000	\$1,020,000
Pasteurization System		\$330,000	\$330,000	\$330,000	\$330,000	\$330,000	\$330,000	\$330,000	\$330,000
Heating and Hot Water Pipes		\$210,000	\$210,000	\$210,000	\$210,000	\$210,000	\$210,000	\$210,000	\$210,000
Control System		\$120,000	\$120,000	\$120,000	\$120,000	\$120,000	\$120,000	\$120,000	\$120,000
Buildings		\$137,500	\$330,000	\$137,500	\$357,500	\$330,000	\$550,000	\$357,500	\$550,000
Weigh Station		\$60,000	\$60,000	\$60,000	\$60,000	\$60,000	\$60,000	\$60,000	\$60,000
Misc.	5%	\$105,125	\$139,750	\$105,125	\$116,125	\$139,750	\$150,750	\$116,125	\$150,750
<i>Subtotal</i>		<i>\$2,207,625</i>	<i>\$2,934,750</i>	<i>\$2,207,625</i>	<i>\$2,438,625</i>	<i>\$2,934,750</i>	<i>\$3,165,750</i>	<i>\$2,438,625</i>	<i>\$3,165,750</i>
Biogas Upgrading									
Biogas Upgrader		\$1,820,000	\$1,820,000	\$1,820,000	\$1,820,000	\$1,820,000	\$1,820,000	\$1,820,000	\$1,820,000
Spare Parts (% of cost)	3%	\$54,600	\$54,600	\$54,600	\$54,600	\$54,600	\$54,600	\$54,600	\$54,600
Installation Costs		\$400,000	\$400,000	\$400,000	\$400,000	\$400,000	\$400,000	\$400,000	\$400,000
Flare		\$125,000	\$125,000	\$125,000	\$125,000	\$125,000	\$125,000	\$125,000	\$125,000
Compression & Transport		\$0	\$0	\$695,452	\$0	\$695,452	\$0	\$695,452	\$695,452
<i>Subtotal</i>		<i>\$2,399,600</i>	<i>\$2,399,600</i>	<i>\$3,095,052</i>	<i>\$2,399,600</i>	<i>\$3,095,052</i>	<i>\$2,399,600</i>	<i>\$3,095,052</i>	<i>\$3,095,052</i>
Digestate Management									
Nutrient Recovery Equip		\$0	\$0	\$0	\$675,000	\$0	\$675,000	\$675,000	\$675,000
Additional Storage		\$373,685	\$373,685	\$373,685	\$373,685	\$373,685	\$373,685	\$373,685	\$373,685
<i>Subtotal</i>		<i>\$373,685</i>	<i>\$373,685</i>	<i>\$373,685</i>	<i>\$1,048,685</i>	<i>\$373,685</i>	<i>\$1,048,685</i>	<i>\$1,048,685</i>	<i>\$1,048,685</i>
Other Costs									
Hydro Service Upgrades	1%	\$49,809	\$57,080	\$56,764	\$58,869	\$64,035	\$66,140	\$65,824	\$73,095
Site Prep + Civil Works	1.5%	\$74,714	\$85,621	\$85,145	\$88,304	\$96,052	\$99,211	\$98,735	\$109,642
Project Development	2%	\$99,618	\$114,161	\$113,527	\$117,738	\$128,070	\$132,281	\$131,647	\$146,190
Engineering & Project Mgt	5%	\$249,045	\$285,402	\$283,818	\$294,345	\$320,174	\$330,702	\$329,118	\$365,474
Risk Management	5%	\$272,705	\$312,515	\$310,781	\$322,308	\$350,591	\$362,118	\$360,384	\$400,194
<i>Subtotal</i>		<i>\$745,891</i>	<i>\$854,778</i>	<i>\$850,035</i>	<i>\$881,565</i>	<i>\$958,922</i>	<i>\$990,452</i>	<i>\$985,709</i>	<i>\$1,094,596</i>
Total Capital Costs		\$5,726,801	\$6,562,813	\$6,526,397	\$6,768,475	\$7,362,409	\$7,604,487	\$7,568,070	\$8,404,082

B.C. On-Farm Biogas Benchmark Study, Version 2

Operating Costs

		Option A	Option B	Option C	Option D	Option E	Option F	Option G	Option H
Digester									
Electrical Cost		\$69,394	\$69,394	\$69,394	\$69,394	\$69,394	\$69,394	\$69,394	\$69,394
Natural Gas Cost		\$52,457	\$52,457	\$52,457	\$52,457	\$52,457	\$52,457	\$52,457	\$52,457
Labour Cost		\$35,100	\$46,800	\$35,100	\$35,100	\$46,800	\$46,800	\$35,100	\$46,800
Service & Maintenance		\$40,000	\$75,000	\$40,000	\$40,000	\$75,000	\$75,000	\$40,000	\$75,000
Insurance + Legal + Acc		\$45,000	\$45,000	\$45,000	\$45,000	\$45,000	\$45,000	\$45,000	\$45,000
Reinvestments (% of CAPEX)	2%	\$44,153	\$58,695	\$44,153	\$48,773	\$58,695	\$63,315	\$48,773	\$63,315
Contingency	10%	\$28,610	\$34,735	\$28,610	\$29,072	\$34,735	\$35,197	\$29,072	\$35,197
<i>Subtotal</i>		<i>\$314,714</i>	<i>\$382,080</i>	<i>\$314,714</i>	<i>\$319,796</i>	<i>\$382,080</i>	<i>\$387,162</i>	<i>\$319,796</i>	<i>\$387,162</i>
Biogas Upgrading									
Electrical Cost		\$64,056	\$64,056	\$64,056	\$64,056	\$64,056	\$64,056	\$64,056	\$64,056
Media Cost (\$/kg)		\$10,676	\$10,676	\$10,676	\$10,676	\$10,676	\$10,676	\$10,676	\$10,676
Consumables (e.g., oil)		\$21,352	\$21,352	\$21,352	\$21,352	\$21,352	\$21,352	\$21,351.86	\$21,352
Reinvestment (% of CAPEX)	2%	\$36,400	\$36,400	\$50,309	\$36,400	\$50,309	\$36,400	\$50,309	\$50,309
Labour Cost		\$23,400	\$23,400	\$23,400	\$23,400	\$23,400	\$23,400	\$23,400	\$23,400
Service & Maintenance		\$90,000	\$90,000	\$90,000	\$90,000	\$90,000	\$90,000	\$90,000	\$90,000
Compression & Transport		\$0	\$0	\$137,907	\$0	\$137,907	\$0	\$137,907	\$137,907
Contingency	10%	\$24,588	\$24,588	\$39,770	\$24,588	\$39,770	\$24,588	\$39,770	\$39,770
<i>Subtotal</i>		<i>\$270,472</i>	<i>\$270,472</i>	<i>\$437,469</i>	<i>\$270,472</i>	<i>\$437,469</i>	<i>\$270,472</i>	<i>\$437,469</i>	<i>\$437,469</i>
Digestate Management									
Electrical Cost		\$0	\$0	\$0	\$17,520	\$0	\$17,520	\$17,520	\$17,520
Service & Maint (% of CAPEX)	5%	\$0	\$0	\$0	\$33,750	\$0	\$33,750	\$33,750	\$33,750
Labour Cost		\$0	\$0	\$0	\$46,800	\$0	\$46,800	\$46,800	\$46,800
Transportation (\$/tonne)		\$0	\$0	\$0	\$77,067	\$0	\$77,067	\$77,067	\$77,067
Reinvestment (% of CAPEX)	2%	\$0	\$0	\$0	\$13,500	\$0	\$13,500	\$13,500	\$13,500
Contingency	10%	\$0	\$0	\$0	\$18,864	\$0	\$18,864	\$18,864	\$18,864
<i>Subtotal</i>		<i>\$0</i>	<i>\$0</i>	<i>\$0</i>	<i>\$207,501</i>	<i>\$0</i>	<i>\$207,501</i>	<i>\$207,501</i>	<i>\$207,501</i>
Total Operating Costs		\$585,185	\$652,552	\$752,183	\$797,769	\$819,550	\$865,135	\$964,766	\$1,032,133

Appendix D: Farm Scenario #4 - 300 Dairy Cows + Mixed Food Waste

Capital Costs

		Option A	Option B	Option C	Option D	Option E	Option F	Option G	Option H
Digester									
Off-Farm Feedstock Storage		\$250,000	\$250,000	\$250,000	\$250,000	\$250,000	\$250,000	\$250,000	\$250,000
Feedstock Pre-Treatment		\$0	\$750,000	\$0	\$0	\$750,000	\$750,000	\$0	\$750,000
Digester Tank		\$1,360,000	\$1,360,000	\$1,360,000	\$1,360,000	\$1,360,000	\$1,360,000	\$1,360,000	\$1,360,000
Pasteurization System		\$330,000	\$330,000	\$330,000	\$330,000	\$330,000	\$330,000	\$330,000	\$330,000
Heating and Hot Water Pipes		\$210,000	\$210,000	\$210,000	\$210,000	\$210,000	\$210,000	\$210,000	\$210,000
Control System		\$120,000	\$120,000	\$120,000	\$120,000	\$120,000	\$120,000	\$120,000	\$120,000
Buildings		\$137,500	\$330,000	\$137,500	\$357,500	\$330,000	\$550,000	\$357,500	\$550,000
Weigh Station		\$60,000	\$60,000	\$60,000	\$60,000	\$60,000	\$60,000	\$60,000	\$60,000
Misc.	5%	\$123,375	\$170,500	\$123,375	\$134,375	\$170,500	\$181,500	\$134,375	\$181,500
<i>Subtotal</i>		<i>\$2,590,875</i>	<i>\$3,580,500</i>	<i>\$2,590,875</i>	<i>\$2,821,875</i>	<i>\$3,580,500</i>	<i>\$3,811,500</i>	<i>\$2,821,875</i>	<i>\$3,811,500</i>
Biogas Upgrading									
Biogas Upgrader		\$2,050,000	\$2,050,000	\$2,050,000	\$2,050,000	\$2,050,000	\$2,050,000	\$2,050,000	\$2,050,000
Spare Parts (% of cost)	3%	\$61,500	\$61,500	\$61,500	\$61,500	\$61,500	\$61,500	\$61,500	\$61,500
Installation Costs		\$400,000	\$400,000	\$400,000	\$400,000	\$400,000	\$400,000	\$400,000	\$400,000
Flare		\$170,000	\$170,000	\$170,000	\$170,000	\$170,000	\$170,000	\$170,000	\$170,000
Compression & Transport		\$0	\$0	\$900,320	\$0	\$900,320	\$0	\$900,320	\$900,320
<i>Subtotal</i>		<i>\$2,681,500</i>	<i>\$2,681,500</i>	<i>\$3,581,820</i>	<i>\$2,681,500</i>	<i>\$3,581,820</i>	<i>\$2,681,500</i>	<i>\$3,581,820</i>	<i>\$3,581,820</i>
Digestate Management									
Nutrient Recovery Equip		\$0	\$0	\$0	\$675,000	\$0	\$675,000	\$675,000	\$675,000
Additional Storage		\$507,144	\$507,144	\$507,144	\$507,144	\$507,144	\$507,144	\$507,144	\$507,144
<i>Subtotal</i>		<i>\$507,144</i>	<i>\$507,144</i>	<i>\$507,144</i>	<i>\$1,182,144</i>	<i>\$507,144</i>	<i>\$1,182,144</i>	<i>\$1,182,144</i>	<i>\$1,182,144</i>
Other Costs									
Hydro Service Upgrades	1%	\$57,795	\$67,691	\$66,798	\$66,855	\$76,695	\$76,751	\$75,858	\$85,755
Site Prep + Civil Works	1.5%	\$86,693	\$101,537	\$100,198	\$100,283	\$115,042	\$115,127	\$113,788	\$128,632
Project Development	2%	\$115,590	\$135,383	\$133,597	\$133,710	\$153,389	\$153,503	\$151,717	\$171,509
Engineering & Project Mgt	5%	\$288,976	\$338,457	\$333,992	\$334,276	\$383,473	\$383,757	\$379,292	\$428,773
Risk Management	5%	\$316,429	\$370,611	\$365,721	\$366,032	\$419,903	\$420,214	\$415,325	\$469,507
<i>Subtotal</i>		<i>\$865,483</i>	<i>\$1,013,679</i>	<i>\$1,000,306</i>	<i>\$1,001,156</i>	<i>\$1,148,502</i>	<i>\$1,149,353</i>	<i>\$1,135,979</i>	<i>\$1,284,176</i>
Total Capital Costs		\$6,645,002	\$7,782,823	\$7,680,145	\$7,686,675	\$8,817,966	\$8,824,497	\$8,721,818	\$9,859,640

B.C. On-Farm Biogas Benchmark Study, Version 2

Operating Costs

		Option A	Option B	Option C	Option D	Option E	Option F	Option G	Option H
Digester									
Electrical Cost		\$104,090	\$104,090	\$104,090	\$104,090	\$104,090	\$104,090	\$104,090	\$104,090
Natural Gas Cost		\$78,686	\$78,686	\$78,686	\$78,686	\$78,686	\$78,686	\$78,686	\$78,686
Labour Cost		\$35,100	\$46,800	\$35,100	\$35,100	\$46,800	\$46,800	\$35,100	\$46,800
Service & Maintenance		\$40,000	\$75,000	\$40,000	\$40,000	\$75,000	\$75,000	\$40,000	\$75,000
Insurance + Legal + Acc		\$45,000	\$45,000	\$45,000	\$45,000	\$45,000	\$45,000	\$45,000	\$45,000
Reinvestments (% of CAPEX)	2%	\$51,818	\$71,610	\$51,818	\$56,438	\$71,610	\$76,230	\$56,438	\$76,230
Contingency	10%	\$35,469	\$42,119	\$35,469	\$35,931	\$42,119	\$42,581	\$35,931	\$42,581
<i>Subtotal</i>		<i>\$390,163</i>	<i>\$463,305</i>	<i>\$390,163</i>	<i>\$395,245</i>	<i>\$463,305</i>	<i>\$468,387</i>	<i>\$395,245</i>	<i>\$468,387</i>
Biogas Upgrading									
Electrical Cost		\$96,083	\$96,083	\$96,083	\$96,083	\$96,083	\$96,083	\$96,083	\$96,083
Media Cost (\$/kg)		\$16,014	\$16,014	\$16,014	\$16,014	\$16,014	\$16,014	\$16,014	\$16,014
Consumables (e.g., oil)		\$32,028	\$32,028	\$32,028	\$32,028	\$32,028	\$32,028	\$32,027.79	\$32,028
Reinvestment (% of CAPEX)	2%	\$41,000	\$41,000	\$59,006	\$41,000	\$59,006	\$41,000	\$59,006	\$59,006
Labour Cost		\$23,400	\$23,400	\$23,400	\$23,400	\$23,400	\$23,400	\$23,400	\$23,400
Service & Maintenance		\$90,000	\$90,000	\$90,000	\$90,000	\$90,000	\$90,000	\$90,000	\$90,000
Compression & Transport		\$0	\$0	\$233,936	\$0	\$233,936	\$0	\$233,936	\$233,936
Contingency	10%	\$29,853	\$29,853	\$55,047	\$29,853	\$55,047	\$29,853	\$55,047	\$55,047
<i>Subtotal</i>		<i>\$328,378</i>	<i>\$328,378</i>	<i>\$605,514</i>	<i>\$328,378</i>	<i>\$605,514</i>	<i>\$328,378</i>	<i>\$605,514</i>	<i>\$605,514</i>
Digestate Management									
Electrical Cost		\$0	\$0	\$0	\$17,520	\$0	\$17,520	\$17,520	\$17,520
Service & Maint (% of CAPEX)	5%	\$0	\$0	\$0	\$33,750	\$0	\$33,750	\$33,750	\$33,750
Labour Cost		\$0	\$0	\$0	\$46,800	\$0	\$46,800	\$46,800	\$46,800
Transportation (\$/tonne)		\$0	\$0	\$0	\$115,601	\$0	\$115,601	\$115,601	\$115,601
Reinvestment (% of CAPEX)	2%	\$0	\$0	\$0	\$13,500	\$0	\$13,500	\$13,500	\$13,500
Contingency	10%	\$0	\$0	\$0	\$22,717	\$0	\$22,717	\$22,717	\$22,717
<i>Subtotal</i>		<i>\$0</i>	<i>\$0</i>	<i>\$0</i>	<i>\$249,888</i>	<i>\$0</i>	<i>\$249,888</i>	<i>\$249,888</i>	<i>\$249,888</i>
Total Operating Costs		\$718,541	\$791,683	\$995,678	\$973,511	\$1,068,819	\$1,046,653	\$1,250,648	\$1,323,790

Appendix E: Farm Scenario #5 - 400 Dairy Cows + Mixed Food Waste

Capital Costs

		Option A	Option B	Option C	Option D	Option E	Option F	Option G	Option H
Digester									
Off-Farm Feedstock Storage		\$300,000	\$300,000	\$300,000	\$300,000	\$300,000	\$300,000	\$300,000	\$300,000
Feedstock Pre-Treatment		\$0	\$750,000	\$0	\$0	\$750,000	\$750,000	\$0	\$750,000
Digester Tank		\$1,700,000	\$1,700,000	\$1,700,000	\$1,700,000	\$1,700,000	\$1,700,000	\$1,700,000	\$1,700,000
Pasteurization System		\$375,000	\$375,000	\$375,000	\$375,000	\$375,000	\$375,000	\$375,000	\$375,000
Heating and Hot Water Pipes		\$280,000	\$280,000	\$280,000	\$280,000	\$280,000	\$280,000	\$280,000	\$280,000
Control System		\$160,000	\$160,000	\$160,000	\$160,000	\$160,000	\$160,000	\$160,000	\$160,000
Buildings		\$137,500	\$330,000	\$137,500	\$357,500	\$330,000	\$550,000	\$357,500	\$550,000
Weigh Station		\$60,000	\$60,000	\$60,000	\$60,000	\$60,000	\$60,000	\$60,000	\$60,000
Misc.	5%	\$150,625	\$197,750	\$150,625	\$161,625	\$197,750	\$208,750	\$161,625	\$208,750
<i>Subtotal</i>		<i>\$3,163,125</i>	<i>\$4,152,750</i>	<i>\$3,163,125</i>	<i>\$3,394,125</i>	<i>\$4,152,750</i>	<i>\$4,383,750</i>	<i>\$3,394,125</i>	<i>\$4,383,750</i>
Biogas Upgrading									
Biogas Upgrader		\$2,450,000	\$2,450,000	\$2,450,000	\$2,450,000	\$2,450,000	\$2,450,000	\$2,450,000	\$2,450,000
Spare Parts (% of cost)	3%	\$73,500	\$73,500	\$73,500	\$73,500	\$73,500	\$73,500	\$73,500	\$73,500
Installation Costs		\$400,000	\$400,000	\$400,000	\$400,000	\$400,000	\$400,000	\$400,000	\$400,000
Flare		\$170,000	\$170,000	\$170,000	\$170,000	\$170,000	\$170,000	\$170,000	\$170,000
Compression & Transport		\$0	\$0	\$955,189	\$0	\$955,189	\$0	\$955,189	\$955,189
<i>Subtotal</i>		<i>\$3,093,500</i>	<i>\$3,093,500</i>	<i>\$4,048,689</i>	<i>\$3,093,500</i>	<i>\$4,048,689</i>	<i>\$3,093,500</i>	<i>\$4,048,689</i>	<i>\$4,048,689</i>
Digestate Management									
Nutrient Recovery Equip		\$0	\$0	\$0	\$975,000	\$0	\$975,000	\$975,000	\$975,000
Additional Storage		\$676,192	\$676,192	\$676,192	\$676,192	\$676,192	\$676,192	\$676,192	\$676,192
<i>Subtotal</i>		<i>\$676,192</i>	<i>\$676,192</i>	<i>\$676,192</i>	<i>\$1,651,192</i>	<i>\$676,192</i>	<i>\$1,651,192</i>	<i>\$1,651,192</i>	<i>\$1,651,192</i>
Other Costs									
Hydro Service Upgrades	1%	\$69,328	\$79,224	\$78,880	\$81,388	\$88,776	\$91,284	\$90,940	\$100,836
Site Prep + Civil Works	1.5%	\$103,992	\$118,837	\$118,320	\$122,082	\$133,164	\$136,927	\$136,410	\$151,254
Project Development	2%	\$138,656	\$158,449	\$157,760	\$162,776	\$177,553	\$182,569	\$181,880	\$201,673
Engineering & Project Mgt	5%	\$346,641	\$396,122	\$394,400	\$406,941	\$443,882	\$456,422	\$454,700	\$504,182
Risk Management	5%	\$379,572	\$433,754	\$431,868	\$445,600	\$486,050	\$499,782	\$497,897	\$552,079
<i>Subtotal</i>		<i>\$1,038,189</i>	<i>\$1,186,386</i>	<i>\$1,181,229</i>	<i>\$1,218,788</i>	<i>\$1,329,425</i>	<i>\$1,366,984</i>	<i>\$1,361,827</i>	<i>\$1,510,024</i>
Total Capital Costs		\$7,971,006	\$9,108,827	\$9,069,234	\$9,357,604	\$10,207,056	\$10,495,426	\$10,455,833	\$11,593,654

B.C. On-Farm Biogas Benchmark Study, Version 2

Operating Costs

		Option A	Option B	Option C	Option D	Option E	Option F	Option G	Option H
Digester									
Electrical Cost		\$138,787	\$138,787	\$138,787	\$138,787	\$138,787	\$138,787	\$138,787	\$138,787
Natural Gas Cost		\$104,915	\$104,915	\$104,915	\$104,915	\$104,915	\$104,915	\$104,915	\$104,915
Labour Cost		\$35,100	\$46,800	\$35,100	\$35,100	\$46,800	\$46,800	\$35,100	\$46,800
Service & Maintenance		\$40,000	\$75,000	\$40,000	\$40,000	\$75,000	\$75,000	\$40,000	\$75,000
Insurance + Legal + Acc		\$45,000	\$45,000	\$45,000	\$45,000	\$45,000	\$45,000	\$45,000	\$45,000
Reinvestments (% of CAPEX)	2%	\$63,263	\$83,055	\$63,263	\$67,883	\$83,055	\$87,675	\$67,883	\$87,675
Contingency	10%	\$42,706	\$49,356	\$42,706	\$43,168	\$49,356	\$49,818	\$43,168	\$49,818
<i>Subtotal</i>		<i>\$469,771</i>	<i>\$542,912</i>	<i>\$469,771</i>	<i>\$474,853</i>	<i>\$542,912</i>	<i>\$547,994</i>	<i>\$474,853</i>	<i>\$547,994</i>
Biogas Upgrading									
Electrical Cost		\$128,111	\$128,111	\$128,111	\$128,111	\$128,111	\$128,111	\$128,111	\$128,111
Media Cost (\$/kg)		\$21,352	\$21,352	\$21,352	\$21,352	\$21,352	\$21,352	\$21,352	\$21,352
Consumables (e.g., oil)		\$42,704	\$42,704	\$42,704	\$42,704	\$42,704	\$42,704	\$42,703.72	\$42,704
Reinvestment (% of CAPEX)	2%	\$49,000	\$49,000	\$68,104	\$49,000	\$68,104	\$49,000	\$68,104	\$68,104
Labour Cost		\$23,400	\$23,400	\$23,400	\$23,400	\$23,400	\$23,400	\$23,400	\$23,400
Service & Maintenance		\$90,000	\$90,000	\$90,000	\$90,000	\$90,000	\$90,000	\$90,000	\$90,000
Compression & Transport		\$0	\$0	\$254,028	\$0	\$254,028	\$0	\$254,028	\$254,028
Contingency	10%	\$35,457	\$35,457	\$62,770	\$35,457	\$62,770	\$35,457	\$62,770	\$62,770
<i>Subtotal</i>		<i>\$390,023</i>	<i>\$390,023</i>	<i>\$690,468</i>	<i>\$390,023</i>	<i>\$690,468</i>	<i>\$390,023</i>	<i>\$690,468</i>	<i>\$690,468</i>
Digestate Management									
Electrical Cost		\$0	\$0	\$0	\$17,520	\$0	\$17,520	\$17,520	\$17,520
Service & Maint (% of CAPEX)	5%	\$0	\$0	\$0	\$48,750	\$0	\$48,750	\$48,750	\$48,750
Labour Cost		\$0	\$0	\$0	\$46,800	\$0	\$46,800	\$46,800	\$46,800
Transportation (\$/tonne)		\$0	\$0	\$0	\$154,135	\$0	\$154,135	\$154,135	\$154,135
Reinvestment (% of CAPEX)	2%	\$0	\$0	\$0	\$19,500	\$0	\$19,500	\$19,500	\$19,500
Contingency	10%	\$0	\$0	\$0	\$28,670	\$0	\$28,670	\$28,670	\$28,670
<i>Subtotal</i>		<i>\$0</i>	<i>\$0</i>	<i>\$0</i>	<i>\$315,375</i>	<i>\$0</i>	<i>\$315,375</i>	<i>\$315,375</i>	<i>\$315,375</i>
Total Operating Costs		\$859,794	\$932,936	\$1,160,239	\$1,180,252	\$1,233,381	\$1,253,393	\$1,480,697	\$1,553,838

Appendix F: Farm Scenario #6 - 500 Dairy Cows + Mixed Food Waste

Capital Costs

		Option A	Option B	Option C	Option D	Option E	Option F	Option G	Option H
Digester									
Off-Farm Feedstock Storage		\$300,000	\$300,000	\$300,000	\$300,000	\$300,000	\$300,000	\$300,000	\$300,000
Feedstock Pre-Treatment		\$0	\$750,000	\$0	\$0	\$750,000	\$750,000	\$0	\$750,000
Digester Tank		\$1,700,000	\$1,700,000	\$1,700,000	\$1,700,000	\$1,700,000	\$1,700,000	\$1,700,000	\$1,700,000
Pasteurization System		\$375,000	\$375,000	\$375,000	\$375,000	\$375,000	\$375,000	\$375,000	\$375,000
Heating and Hot Water Pipes		\$350,000	\$350,000	\$350,000	\$350,000	\$350,000	\$350,000	\$350,000	\$350,000
Control System		\$200,000	\$200,000	\$200,000	\$200,000	\$200,000	\$200,000	\$200,000	\$200,000
Buildings		\$137,500	\$330,000	\$137,500	\$357,500	\$330,000	\$550,000	\$357,500	\$550,000
Weigh Station		\$60,000	\$60,000	\$60,000	\$60,000	\$60,000	\$60,000	\$60,000	\$60,000
Misc.	5%	\$156,125	\$203,250	\$156,125	\$167,125	\$203,250	\$214,250	\$167,125	\$214,250
<i>Subtotal</i>		<i>\$3,278,625</i>	<i>\$4,268,250</i>	<i>\$3,278,625</i>	<i>\$3,509,625</i>	<i>\$4,268,250</i>	<i>\$4,499,250</i>	<i>\$3,509,625</i>	<i>\$4,499,250</i>
Biogas Upgrading									
Biogas Upgrader		\$2,880,000	\$2,880,000	\$2,880,000	\$2,880,000	\$2,880,000	\$2,880,000	\$2,880,000	\$2,880,000
Spare Parts (% of cost)	3%	\$86,400	\$86,400	\$86,400	\$86,400	\$86,400	\$86,400	\$86,400	\$86,400
Installation Costs		\$400,000	\$400,000	\$400,000	\$400,000	\$400,000	\$400,000	\$400,000	\$400,000
Flare		\$170,000	\$170,000	\$170,000	\$170,000	\$170,000	\$170,000	\$170,000	\$170,000
Compression & Transport		\$0	\$0	\$1,160,058	\$0	\$1,160,058	\$0	\$1,160,058	\$1,160,058
<i>Subtotal</i>		<i>\$3,536,400</i>	<i>\$3,536,400</i>	<i>\$4,696,458</i>	<i>\$3,536,400</i>	<i>\$4,696,458</i>	<i>\$3,536,400</i>	<i>\$4,696,458</i>	<i>\$4,696,458</i>
Digestate Management									
Nutrient Recovery Equip		\$0	\$0	\$0	\$1,200,000	\$0	\$1,200,000	\$1,200,000	\$1,200,000
Additional Storage		\$756,267	\$756,267	\$756,267	\$756,267	\$756,267	\$756,267	\$756,267	\$756,267
<i>Subtotal</i>		<i>\$756,267</i>	<i>\$756,267</i>	<i>\$756,267</i>	<i>\$1,956,267</i>	<i>\$756,267</i>	<i>\$1,956,267</i>	<i>\$1,956,267</i>	<i>\$1,956,267</i>
Other Costs									
Hydro Service Upgrades	1%	\$75,713	\$85,609	\$87,313	\$90,023	\$97,210	\$99,919	\$101,623	\$111,520
Site Prep + Civil Works	1.5%	\$113,569	\$128,414	\$130,970	\$135,034	\$145,815	\$149,879	\$152,435	\$167,280
Project Development	2%	\$151,426	\$171,218	\$174,627	\$180,046	\$194,419	\$199,838	\$203,247	\$223,039
Engineering & Project Mgt	5%	\$378,565	\$428,046	\$436,567	\$450,115	\$486,049	\$499,596	\$508,117	\$557,599
Risk Management	5%	\$414,528	\$468,710	\$478,041	\$492,875	\$532,223	\$547,057	\$556,389	\$610,571
<i>Subtotal</i>		<i>\$1,133,801</i>	<i>\$1,281,997</i>	<i>\$1,307,520</i>	<i>\$1,348,093</i>	<i>\$1,455,716</i>	<i>\$1,496,290</i>	<i>\$1,521,812</i>	<i>\$1,670,008</i>
Total Capital Costs		\$8,705,093	\$9,842,914	\$10,038,869	\$10,350,385	\$11,176,691	\$11,488,207	\$11,684,161	\$12,821,983

B.C. On-Farm Biogas Benchmark Study, Version 2

Operating Costs

		Option A	Option B	Option C	Option D	Option E	Option F	Option G	Option H
Digester									
Electrical Cost		\$173,484	\$173,484	\$173,484	\$173,484	\$173,484	\$173,484	\$173,484	\$173,484
Natural Gas Cost		\$131,143	\$131,143	\$131,143	\$131,143	\$131,143	\$131,143	\$131,143	\$131,143
Labour Cost		\$35,100	\$46,800	\$35,100	\$35,100	\$46,800	\$46,800	\$35,100	\$46,800
Service & Maintenance		\$40,000	\$75,000	\$40,000	\$40,000	\$75,000	\$75,000	\$40,000	\$75,000
Insurance + Legal + Acc		\$45,000	\$45,000	\$45,000	\$45,000	\$45,000	\$45,000	\$45,000	\$45,000
Reinvestments (% of CAPEX)	2%	\$65,573	\$85,365	\$65,573	\$70,193	\$85,365	\$89,985	\$70,193	\$89,985
Contingency	10%	\$49,030	\$55,679	\$49,030	\$49,492	\$55,679	\$56,141	\$49,492	\$56,141
<i>Subtotal</i>		<i>\$539,330</i>	<i>\$612,471</i>	<i>\$539,330</i>	<i>\$544,412</i>	<i>\$612,471</i>	<i>\$617,553</i>	<i>\$544,412</i>	<i>\$617,553</i>
Biogas Upgrading									
Electrical Cost		\$160,139	\$160,139	\$160,139	\$160,139	\$160,139	\$160,139	\$160,139	\$160,139
Media Cost (\$/kg)		\$26,690	\$26,690	\$26,690	\$26,690	\$26,690	\$26,690	\$26,690	\$26,690
Consumables (e.g., oil)		\$53,380	\$53,380	\$53,380	\$53,380	\$53,380	\$53,380	\$53,379.65	\$53,380
Reinvestment (% of CAPEX)	2%	\$57,600	\$57,600	\$80,801	\$57,600	\$80,801	\$57,600	\$80,801	\$80,801
Labour Cost		\$23,400	\$23,400	\$23,400	\$23,400	\$23,400	\$23,400	\$23,400	\$23,400
Service & Maintenance		\$90,000	\$90,000	\$90,000	\$90,000	\$90,000	\$90,000	\$90,000	\$90,000
Compression & Transport		\$0	\$0	\$281,620	\$0	\$281,620	\$0	\$281,620	\$281,620
Contingency	10%	\$41,121	\$41,121	\$71,603	\$41,121	\$71,603	\$41,121	\$71,603	\$71,603
<i>Subtotal</i>		<i>\$452,329</i>	<i>\$452,329</i>	<i>\$787,632</i>	<i>\$452,329</i>	<i>\$787,632</i>	<i>\$452,329</i>	<i>\$787,632</i>	<i>\$787,632</i>
Digestate Management									
Electrical Cost		\$0	\$0	\$0	\$30,660	\$0	\$30,660	\$30,660	\$30,660
Service & Maint (% of CAPEX)	5%	\$0	\$0	\$0	\$60,000	\$0	\$60,000	\$60,000	\$60,000
Labour Cost		\$0	\$0	\$0	\$70,200	\$0	\$70,200	\$70,200	\$70,200
Transportation (\$/tonne)		\$0	\$0	\$0	\$192,669	\$0	\$192,669	\$192,669	\$192,669
Reinvestment (% of CAPEX)	2%	\$0	\$0	\$0	\$24,000	\$0	\$24,000	\$24,000	\$24,000
Contingency	10%	\$0	\$0	\$0	\$37,753	\$0	\$37,753	\$37,753	\$37,753
<i>Subtotal</i>		<i>\$0</i>	<i>\$0</i>	<i>\$0</i>	<i>\$415,282</i>	<i>\$0</i>	<i>\$415,282</i>	<i>\$415,282</i>	<i>\$415,282</i>
Total Operating Costs		\$991,659	\$1,064,801	\$1,326,962	\$1,412,023	\$1,400,104	\$1,485,164	\$1,747,326	\$1,820,467

Appendix G: Farm Scenario #7 – 1,000 Feedlot Cattle + Mixed Food Waste

Capital Costs

		Option A	Option B	Option C	Option D	Option E	Option F	Option G	Option H
Digester									
Off-Farm Feedstock Storage		\$180,000	\$180,000	\$180,000	\$180,000	\$180,000	\$180,000	\$180,000	\$180,000
Feedstock Pre-Treatment		\$0	\$500,000	\$0	\$0	\$500,000	\$500,000	\$0	\$500,000
Dry Feeder		\$370,000	\$370,000	\$370,000	\$370,000	\$370,000	\$370,000	\$370,000	\$370,000
Digester Tank		\$810,000	\$810,000	\$810,000	\$810,000	\$810,000	\$810,000	\$810,000	\$810,000
Pasteurization System		\$272,000	\$272,000	\$272,000	\$272,000	\$272,000	\$272,000	\$272,000	\$272,000
Heating and Hot Water Pipes		\$140,000	\$140,000	\$140,000	\$140,000	\$140,000	\$140,000	\$140,000	\$140,000
Control System		\$80,000	\$80,000	\$80,000	\$80,000	\$80,000	\$80,000	\$80,000	\$80,000
Buildings		\$137,500	\$330,000	\$137,500	\$357,500	\$330,000	\$550,000	\$357,500	\$550,000
Weigh Station		\$60,000	\$60,000	\$60,000	\$60,000	\$60,000	\$60,000	\$60,000	\$60,000
Misc.	5%	\$102,475	\$137,100	\$102,475	\$113,475	\$137,100	\$148,100	\$113,475	\$148,100
<i>Subtotal</i>		<i>\$2,151,975</i>	<i>\$2,879,100</i>	<i>\$2,151,975</i>	<i>\$2,382,975</i>	<i>\$2,879,100</i>	<i>\$3,110,100</i>	<i>\$2,382,975</i>	<i>\$3,110,100</i>
Biogas Upgrading									
Biogas Upgrader		\$1,820,000	\$1,820,000	\$1,820,000	\$1,820,000	\$1,820,000	\$1,820,000	\$1,820,000	\$1,820,000
Spare Parts (% of cost)	3%	\$54,600	\$54,600	\$54,600	\$54,600	\$54,600	\$54,600	\$54,600	\$54,600
Installation Costs		\$400,000	\$400,000	\$400,000	\$400,000	\$400,000	\$400,000	\$400,000	\$400,000
Flare		\$125,000	\$125,000	\$125,000	\$125,000	\$125,000	\$125,000	\$125,000	\$125,000
Compression & Transport		\$0	\$0	\$686,397	\$0	\$686,397	\$0	\$686,397	\$686,397
<i>Subtotal</i>		<i>\$2,399,600</i>	<i>\$2,399,600</i>	<i>\$3,085,997</i>	<i>\$2,399,600</i>	<i>\$3,085,997</i>	<i>\$2,399,600</i>	<i>\$3,085,997</i>	<i>\$3,085,997</i>
Digestate Management									
Nutrient Recovery Equip		\$0	\$0	\$0	\$675,000	\$0	\$675,000	\$675,000	\$675,000
Additional Storage		\$543,094	\$543,094	\$543,094	\$543,094	\$543,094	\$543,094	\$543,094	\$543,094
<i>Subtotal</i>		<i>\$543,094</i>	<i>\$543,094</i>	<i>\$543,094</i>	<i>\$1,218,094</i>	<i>\$543,094</i>	<i>\$1,218,094</i>	<i>\$1,218,094</i>	<i>\$1,218,094</i>
Other Costs									
Hydro Service Upgrades	1%	\$50,947	\$58,218	\$57,811	\$60,007	\$65,082	\$67,278	\$66,871	\$74,142
Site Prep + Civil Works	1.5%	\$76,420	\$87,327	\$86,716	\$90,010	\$97,623	\$100,917	\$100,306	\$111,213
Project Development	2%	\$101,893	\$116,436	\$115,621	\$120,013	\$130,164	\$134,556	\$133,741	\$148,284
Engineering & Project Mgt	5%	\$254,733	\$291,090	\$289,053	\$300,033	\$325,410	\$336,390	\$334,353	\$370,710
Risk Management	5%	\$278,933	\$318,743	\$316,513	\$328,537	\$356,323	\$368,347	\$366,117	\$405,927
<i>Subtotal</i>		<i>\$762,927</i>	<i>\$871,814</i>	<i>\$865,715</i>	<i>\$898,600</i>	<i>\$974,602</i>	<i>\$1,007,487</i>	<i>\$1,001,388</i>	<i>\$1,110,275</i>
Total Capital Costs		\$5,857,596	\$6,693,608	\$6,646,781	\$6,899,269	\$7,482,793	\$7,735,281	\$7,688,454	\$8,524,466

B.C. On-Farm Biogas Benchmark Study, Version 2

Operating Costs

		Option A	Option B	Option C	Option D	Option E	Option F	Option G	Option H
Digester									
Electrical Cost		\$63,668	\$63,668	\$63,668	\$63,668	\$63,668	\$63,668	\$63,668	\$63,668
Natural Gas Cost		\$48,129	\$48,129	\$48,129	\$48,129	\$48,129	\$48,129	\$48,129	\$48,129
Labour Cost		\$35,100	\$46,800	\$35,100	\$35,100	\$46,800	\$46,800	\$35,100	\$46,800
Service & Maintenance		\$40,000	\$75,000	\$40,000	\$40,000	\$75,000	\$75,000	\$40,000	\$75,000
Insurance + Legal + Acc		\$45,000	\$45,000	\$45,000	\$45,000	\$45,000	\$45,000	\$45,000	\$45,000
Reinvestments (% of CAPEX)	2%	\$43,040	\$57,582	\$43,040	\$47,660	\$57,582	\$62,202	\$47,660	\$62,202
Contingency	10%	\$27,494	\$33,618	\$27,494	\$27,956	\$33,618	\$34,080	\$27,956	\$34,080
<i>Subtotal</i>		<i>\$302,430</i>	<i>\$369,797</i>	<i>\$302,430</i>	<i>\$307,512</i>	<i>\$369,797</i>	<i>\$374,879</i>	<i>\$307,512</i>	<i>\$374,879</i>
Biogas Upgrading									
Electrical Cost		\$58,770	\$58,770	\$58,770	\$58,770	\$58,770	\$58,770	\$58,770	\$58,770
Media Cost (\$/kg)		\$9,795	\$9,795	\$9,795	\$9,795	\$9,795	\$9,795	\$9,795	\$9,795
Consumables (e.g., oil)		\$19,590	\$19,590	\$19,590	\$19,590	\$19,590	\$19,590	\$19,590.09	\$19,590
Reinvestment (% of CAPEX)	2%	\$36,400	\$36,400	\$50,128	\$36,400	\$50,128	\$36,400	\$50,128	\$50,128
Labour Cost		\$23,400	\$23,400	\$23,400	\$23,400	\$23,400	\$23,400	\$23,400	\$23,400
Service & Maintenance		\$90,000	\$90,000	\$90,000	\$90,000	\$90,000	\$90,000	\$90,000	\$90,000
Compression & Transport		\$0	\$0	\$134,591	\$0	\$134,591	\$0	\$134,591	\$134,591
Contingency	10%	\$23,796	\$23,796	\$38,627	\$23,796	\$38,627	\$23,796	\$38,627	\$38,627
<i>Subtotal</i>		<i>\$261,751</i>	<i>\$261,751</i>	<i>\$424,902</i>	<i>\$261,751</i>	<i>\$424,902</i>	<i>\$261,751</i>	<i>\$424,902</i>	<i>\$424,902</i>
Digestate Management									
Electrical Cost		\$0	\$0	\$0	\$17,520	\$0	\$17,520	\$17,520	\$17,520
Service & Maint (% of CAPEX)	5%	\$0	\$0	\$0	\$33,750	\$0	\$33,750	\$33,750	\$33,750
Labour Cost		\$0	\$0	\$0	\$46,800	\$0	\$46,800	\$46,800	\$46,800
Transportation (\$/tonne)		\$0	\$0	\$0	\$51,451	\$0	\$51,451	\$51,451	\$51,451
Reinvestment (% of CAPEX)	2%	\$0	\$0	\$0	\$13,500	\$0	\$13,500	\$13,500	\$13,500
Contingency	10%	\$0	\$0	\$0	\$16,302	\$0	\$16,302	\$16,302	\$16,302
<i>Subtotal</i>		<i>\$0</i>	<i>\$0</i>	<i>\$0</i>	<i>\$179,323</i>	<i>\$0</i>	<i>\$179,323</i>	<i>\$179,323</i>	<i>\$179,323</i>
Total Operating Costs		\$564,181	\$631,548	\$727,332	\$748,586	\$794,699	\$815,953	\$911,737	\$979,104

Appendix H: Farm Scenario #8 – 2,500 Feedlot Cattle + Mixed Food Waste

Capital Costs

		Option A	Option B	Option C	Option D	Option E	Option F	Option G	Option H
Digester									
Off-Farm Feedstock Storage		\$270,000	\$270,000	\$270,000	\$270,000	\$270,000	\$270,000	\$270,000	\$270,000
Feedstock Pre-Treatment		\$0	\$750,000	\$0	\$0	\$750,000	\$750,000	\$0	\$750,000
Dry Feeder		\$460,000	\$460,000	\$460,000	\$460,000	\$460,000	\$460,000	\$460,000	\$460,000
Digester Tank		\$1,360,000	\$1,360,000	\$1,360,000	\$1,360,000	\$1,360,000	\$1,360,000	\$1,360,000	\$1,360,000
Pasteurization System		\$330,000	\$330,000	\$330,000	\$330,000	\$330,000	\$330,000	\$330,000	\$330,000
Heating and Hot Water Pipes		\$280,000	\$280,000	\$280,000	\$280,000	\$280,000	\$280,000	\$280,000	\$280,000
Control System		\$160,000	\$160,000	\$160,000	\$160,000	\$160,000	\$160,000	\$160,000	\$160,000
Buildings		\$137,500	\$330,000	\$137,500	\$357,500	\$330,000	\$550,000	\$357,500	\$550,000
Weigh Station		\$60,000	\$60,000	\$60,000	\$60,000	\$60,000	\$60,000	\$60,000	\$60,000
Misc.	5%	\$152,875	\$200,000	\$152,875	\$163,875	\$200,000	\$211,000	\$163,875	\$211,000
<i>Subtotal</i>		<i>\$3,210,375</i>	<i>\$4,200,000</i>	<i>\$3,210,375</i>	<i>\$3,441,375</i>	<i>\$4,200,000</i>	<i>\$4,431,000</i>	<i>\$3,441,375</i>	<i>\$4,431,000</i>
Biogas Upgrading									
Biogas Upgrader		\$2,880,000	\$2,880,000	\$2,880,000	\$2,880,000	\$2,880,000	\$2,880,000	\$2,880,000	\$2,880,000
Spare Parts (% of cost)	3%	\$86,400	\$86,400	\$86,400	\$86,400	\$86,400	\$86,400	\$86,400	\$86,400
Installation Costs		\$400,000	\$400,000	\$400,000	\$400,000	\$400,000	\$400,000	\$400,000	\$400,000
Flare		\$170,000	\$170,000	\$170,000	\$170,000	\$170,000	\$170,000	\$170,000	\$170,000
Compression & Transport		\$0	\$0	\$987,421	\$0	\$987,421	\$0	\$987,421	\$987,421
<i>Subtotal</i>		<i>\$3,536,400</i>	<i>\$3,536,400</i>	<i>\$4,523,821</i>	<i>\$3,536,400</i>	<i>\$4,523,821</i>	<i>\$3,536,400</i>	<i>\$4,523,821</i>	<i>\$4,523,821</i>
Digestate Management									
Nutrient Recovery Equip		\$0	\$0	\$0	\$675,000	\$0	\$675,000	\$675,000	\$675,000
Additional Storage		\$1,071,896	\$1,071,896	\$1,071,896	\$1,071,896	\$1,071,896	\$1,071,896	\$1,071,896	\$1,071,896
<i>Subtotal</i>		<i>\$1,071,896</i>	<i>\$1,071,896</i>	<i>\$1,071,896</i>	<i>\$1,746,896</i>	<i>\$1,071,896</i>	<i>\$1,746,896</i>	<i>\$1,746,896</i>	<i>\$1,746,896</i>
Other Costs									
Hydro Service Upgrades	1%	\$78,187	\$88,083	\$88,061	\$87,247	\$97,957	\$97,143	\$97,121	\$107,017
Site Prep + Civil Works	1.5%	\$117,280	\$132,124	\$132,091	\$130,870	\$146,936	\$145,714	\$145,681	\$160,526
Project Development	2%	\$156,373	\$176,166	\$176,122	\$174,493	\$195,914	\$194,286	\$194,242	\$214,034
Engineering & Project Mgt	5%	\$390,934	\$440,415	\$440,305	\$436,234	\$489,786	\$485,715	\$485,605	\$535,086
Risk Management	5%	\$428,072	\$482,254	\$482,134	\$477,676	\$536,316	\$531,858	\$531,737	\$585,919
<i>Subtotal</i>		<i>\$1,170,846</i>	<i>\$1,319,042</i>	<i>\$1,318,712</i>	<i>\$1,306,520</i>	<i>\$1,466,909</i>	<i>\$1,454,716</i>	<i>\$1,454,386</i>	<i>\$1,602,582</i>
Total Capital Costs		\$8,989,517	\$10,127,339	\$10,124,805	\$10,031,191	\$11,262,626	\$11,169,012	\$11,166,478	\$12,304,300

Operating Costs

		Option A	Option B	Option C	Option D	Option E	Option F	Option G	Option H
Digester									
Electrical Cost		\$159,170	\$159,170	\$159,170	\$159,170	\$159,170	\$159,170	\$159,170	\$159,170
Natural Gas Cost		\$120,323	\$120,323	\$120,323	\$120,323	\$120,323	\$120,323	\$120,323	\$120,323
Labour Cost		\$35,100	\$46,800	\$35,100	\$35,100	\$46,800	\$46,800	\$35,100	\$46,800
Service & Maintenance		\$40,000	\$75,000	\$40,000	\$40,000	\$75,000	\$75,000	\$40,000	\$75,000
Insurance + Legal + Acc		\$45,000	\$45,000	\$45,000	\$45,000	\$45,000	\$45,000	\$45,000	\$45,000
Reinvestments (% of CAPEX)	2%	\$64,208	\$84,000	\$64,208	\$68,828	\$84,000	\$88,620	\$68,828	\$88,620
Contingency	10%	\$46,380	\$53,029	\$46,380	\$46,842	\$53,029	\$53,491	\$46,842	\$53,491
<i>Subtotal</i>		<i>\$510,179</i>	<i>\$583,321</i>	<i>\$510,179</i>	<i>\$515,261</i>	<i>\$583,321</i>	<i>\$588,403</i>	<i>\$515,261</i>	<i>\$588,403</i>
Biogas Upgrading									
Electrical Cost		\$146,926	\$146,926	\$146,926	\$146,926	\$146,926	\$146,926	\$146,926	\$146,926
Media Cost (\$/kg)		\$24,488	\$24,488	\$24,488	\$24,488	\$24,488	\$24,488	\$24,488	\$24,488
Consumables (e.g., oil)		\$48,975	\$48,975	\$48,975	\$48,975	\$48,975	\$48,975	\$48,975.23	\$48,975
Reinvestment (% of CAPEX)	2%	\$57,600	\$57,600	\$77,348	\$57,600	\$77,348	\$57,600	\$77,348	\$77,348
Labour Cost		\$23,400	\$23,400	\$23,400	\$23,400	\$23,400	\$23,400	\$23,400	\$23,400
Service & Maintenance		\$90,000	\$90,000	\$90,000	\$90,000	\$90,000	\$90,000	\$90,000	\$90,000
Compression & Transport		\$0	\$0	\$265,831	\$0	\$265,831	\$0	\$265,831	\$265,831
Contingency	10%	\$39,139	\$39,139	\$67,697	\$39,139	\$67,697	\$39,139	\$67,697	\$67,697
<i>Subtotal</i>		<i>\$430,527</i>	<i>\$430,527</i>	<i>\$744,665</i>	<i>\$430,527</i>	<i>\$744,665</i>	<i>\$430,527</i>	<i>\$744,665</i>	<i>\$744,665</i>
Digestate Management									
Electrical Cost		\$0	\$0	\$0	\$17,520	\$0	\$17,520	\$17,520	\$17,520
Service & Maint (% of CAPEX)	5%	\$0	\$0	\$0	\$33,750	\$0	\$33,750	\$33,750	\$33,750
Labour Cost		\$0	\$0	\$0	\$46,800	\$0	\$46,800	\$46,800	\$46,800
Transportation (\$/tonne)		\$0	\$0	\$0	\$128,628	\$0	\$128,628	\$128,628	\$128,628
Reinvestment (% of CAPEX)	2%	\$0	\$0	\$0	\$13,500	\$0	\$13,500	\$13,500	\$13,500
Contingency	10%	\$0	\$0	\$0	\$24,020	\$0	\$24,020	\$24,020	\$24,020
<i>Subtotal</i>		<i>\$0</i>	<i>\$0</i>	<i>\$0</i>	<i>\$264,217</i>	<i>\$0</i>	<i>\$264,217</i>	<i>\$264,217</i>	<i>\$264,217</i>
Total Operating Costs		\$940,707	\$1,013,849	\$1,254,844	\$1,210,006	\$1,327,986	\$1,283,148	\$1,524,143	\$1,597,285

B.C. On-Farm Biogas Benchmark Study, Version 2

Appendix I: Farm Scenario #9 – 500 Dairy Cows + Poultry Manure

Capital Costs

		Option A	Option B	Option C	Option D
Digester					
Dry Feeder		\$415,000	\$415,000	\$415,000	\$415,000
Digester Tank		\$1,360,000	\$1,360,000	\$1,360,000	\$1,360,000
Heating and Hot Water Pipes		\$280,000	\$280,000	\$280,000	\$280,000
Control System		\$160,000	\$160,000	\$160,000	\$160,000
Buildings		\$0	\$0	\$220,000	\$220,000
Misc.	5%	\$110,750	\$110,750	\$121,750	\$121,750
<i>Subtotal</i>		<i>\$2,325,750</i>	<i>\$2,325,750</i>	<i>\$2,556,750</i>	<i>\$2,556,750</i>
Biogas Upgrading					
Biogas Upgrader		\$1,460,000	\$1,460,000	\$1,460,000	\$1,460,000
Spare Parts (% of cost)	3%	\$43,800	\$43,800	\$43,800	\$43,800
Installation Costs		\$400,000	\$400,000	\$400,000	\$400,000
Flare		\$105,000	\$105,000	\$105,000	\$105,000
Compression & Transportation		\$0	\$644,688	\$0	\$644,688
<i>Subtotal</i>		<i>\$2,008,800</i>	<i>\$2,653,488</i>	<i>\$2,008,800</i>	<i>\$2,653,488</i>
Digestate Management					
Nutrient Recovery Equipment		\$0	\$0	\$650,000	\$650,000
Additional Covered Storage		\$256,897	\$256,897	\$256,897	\$256,897
<i>Subtotal</i>		<i>\$256,897</i>	<i>\$256,897</i>	<i>\$906,897</i>	<i>\$906,897</i>
Other Costs					
Hydro Service Upgrades	1%	\$45,914	\$52,361	\$54,724	\$61,171
Site Preparation + Civil Works	1.5%	\$68,872	\$78,542	\$82,087	\$91,757
Project Development	2%	\$91,829	\$104,723	\$109,449	\$122,343
Engineering & Project Mgt	5%	\$229,572	\$261,807	\$273,622	\$305,857
Risk Management	5%	\$251,382	\$286,678	\$299,616	\$334,913
<i>Subtotal</i>		<i>\$687,569</i>	<i>\$784,111</i>	<i>\$819,499</i>	<i>\$916,041</i>
Total Capital Costs		\$5,279,016	\$6,020,246	\$6,291,946	\$7,033,175

B.C. On-Farm Biogas Benchmark Study, Version 2

Operating Costs

		Option A	Option B	Option C	Option D
Digester					
Poultry Manure (\$/tonne)		\$62,358	\$62,358	\$62,358	\$62,358
Electrical Cost		\$37,292	\$37,292	\$37,292	\$37,292
Natural Gas Cost		\$18,794	\$18,794	\$18,794	\$18,794
Labour Cost		\$23,400	\$23,400	\$23,400	\$23,400
Service & Maintenance		\$40,000	\$40,000	\$75,000	\$75,000
Insurance + Legal + Accounting		\$45,000	\$45,000	\$45,000	\$45,000
Reinvestments (% of CAPEX)	2%	\$46,515	\$46,515	\$51,135	\$51,135
Contingency	10%	\$21,100	\$21,100	\$25,062	\$25,062
<i>Subtotal</i>		<i>\$294,459</i>	<i>\$294,459</i>	<i>\$338,041</i>	<i>\$338,041</i>
Biogas Upgrading					
Electrical Cost		\$34,424	\$34,424	\$34,424	\$34,424
Media Cost (\$/kg)		\$5,737	\$5,737	\$5,737	\$5,737
Consumables (oil, filters, etc.)		\$11,475	\$11,475	\$11,475	\$11,475
Reinvestment (% of CAPEX)	2%	\$29,200	\$42,094	\$29,200	\$42,094
Labour Cost		\$23,400	\$23,400	\$23,400	\$23,400
Service & Maintenance		\$90,000	\$90,000	\$90,000	\$90,000
Compression & Transportation		\$0	\$87,084	\$0	\$87,084
Contingency	10%	\$19,424	\$29,421	\$19,424	\$29,421
<i>Subtotal</i>		<i>\$213,659</i>	<i>\$323,634</i>	<i>\$213,659</i>	<i>\$323,634</i>
Digestate Management					
Electrical Cost		\$0	\$0	\$17,520	\$17,520
Service & Maint (% of CAPEX)	5%	\$0	\$0	\$32,500	\$32,500
Labour Cost		\$0	\$0	\$46,800	\$46,800
Transportation (\$/tonne)		\$0	\$0	\$134,613	\$134,613
Reinvestment (% of CAPEX)	2%	\$0	\$0	\$13,000	\$13,000
Contingency	10%	\$0	\$0	\$24,443	\$24,443
<i>Subtotal</i>		<i>\$0</i>	<i>\$0</i>	<i>\$268,876</i>	<i>\$268,876</i>
Total Operating Costs		\$508,119	\$618,094	\$820,577	\$930,552

B.C. On-Farm Biogas Benchmark Study, Version 2

Appendix J: Farm Scenario #10 – 750 Dairy Cows + Poultry Manure

Capital Costs

		Option A	Option B	Option C	Option D
Digester					
Dry Feeder		\$460,000	\$460,000	\$460,000	\$460,000
Digester Tank		\$1,700,000	\$1,700,000	\$1,700,000	\$1,700,000
Heating and Hot Water Pipes		\$350,000	\$350,000	\$350,000	\$350,000
Control System		\$200,000	\$200,000	\$200,000	\$200,000
Buildings		\$0	\$0	\$220,000	\$220,000
Misc.	5%	\$135,500	\$135,500	\$146,500	\$146,500
<i>Subtotal</i>		<i>\$2,845,500</i>	<i>\$2,845,500</i>	<i>\$3,076,500</i>	<i>\$3,076,500</i>
Biogas Upgrading					
Biogas Upgrader		\$1,560,000	\$1,560,000	\$1,560,000	\$1,560,000
Spare Parts (% of cost)	3%	\$46,800	\$46,800	\$46,800	\$46,800
Installation Costs		\$400,000	\$400,000	\$400,000	\$400,000
Flare		\$105,000	\$105,000	\$105,000	\$105,000
Compression & Transportation		\$0	\$674,174	\$0	\$674,174
<i>Subtotal</i>		<i>\$2,111,800</i>	<i>\$2,785,974</i>	<i>\$2,111,800</i>	<i>\$2,785,974</i>
Digestate Management					
Nutrient Recovery Equipment		\$0	\$0	\$800,000	\$800,000
Additional Covered Storage		\$385,345	\$385,345	\$385,345	\$385,345
<i>Subtotal</i>		<i>\$385,345</i>	<i>\$385,345</i>	<i>\$1,185,345</i>	<i>\$1,185,345</i>
Other Costs					
Hydro Service Upgrades	1%	\$53,426	\$60,168	\$63,736	\$70,478
Site Preparation + Civil Works	1.5%	\$80,140	\$90,252	\$95,605	\$105,717
Project Development	2%	\$106,853	\$120,336	\$127,473	\$140,956
Engineering & Project Mgt	5%	\$267,132	\$300,841	\$318,682	\$352,391
Risk Management	5%	\$292,510	\$329,421	\$348,957	\$385,868
<i>Subtotal</i>		<i>\$800,061</i>	<i>\$901,019</i>	<i>\$954,453</i>	<i>\$1,055,411</i>
Total Capital Costs		\$6,142,706	\$6,917,838	\$7,328,099	\$8,103,231

B.C. On-Farm Biogas Benchmark Study, Version 2

Operating Costs

		Option A	Option B	Option C	Option D
Digester					
Poultry Manure (\$/tonne)		\$93,537	\$93,537	\$93,537	\$93,537
Electrical Cost		\$55,939	\$55,939	\$55,939	\$55,939
Natural Gas Cost		\$28,191	\$28,191	\$28,191	\$28,191
Labour Cost		\$23,400	\$23,400	\$23,400	\$23,400
Service & Maintenance		\$40,000	\$40,000	\$75,000	\$75,000
Insurance + Legal + Accounting		\$45,000	\$45,000	\$45,000	\$45,000
Reinvestments (% of CAPEX)	2%	\$56,910	\$56,910	\$61,530	\$61,530
Contingency	10%	\$24,944	\$24,944	\$28,906	\$28,906
<i>Subtotal</i>		<i>\$367,920</i>	<i>\$367,920</i>	<i>\$411,502</i>	<i>\$411,502</i>
Biogas Upgrading					
Electrical Cost		\$51,636	\$51,636	\$51,636	\$51,636
Media Cost (\$/kg)		\$8,606	\$8,606	\$8,606	\$8,606
Consumables (oil, filters, etc.)		\$17,212	\$17,212	\$17,212	\$17,212
Reinvestment (% of CAPEX)	2%	\$31,200	\$44,683	\$31,200	\$44,683
Labour Cost		\$23,400	\$23,400	\$23,400	\$23,400
Service & Maintenance		\$90,000	\$90,000	\$90,000	\$90,000
Compression & Transportation		\$0	\$96,407	\$0	\$96,407
Contingency	10%	\$22,205	\$33,194	\$22,205	\$33,194
<i>Subtotal</i>		<i>\$244,259</i>	<i>\$365,138</i>	<i>\$244,259</i>	<i>\$365,138</i>
Digestate Management					
Electrical Cost		\$0	\$0	\$30,660	\$30,660
Service & Maint (% of CAPEX)	5%	\$0	\$0	\$40,000	\$40,000
Labour Cost		\$0	\$0	\$70,200	\$70,200
Transportation (\$/tonne)		\$0	\$0	\$201,920	\$201,920
Reinvestment (% of CAPEX)	2%	\$0	\$0	\$16,000	\$16,000
Contingency	10%	\$0	\$0	\$35,878	\$35,878
<i>Subtotal</i>		<i>\$0</i>	<i>\$0</i>	<i>\$394,658</i>	<i>\$394,658</i>
Total Operating Costs		\$612,179	\$733,059	\$1,050,419	\$1,171,298

B.C. On-Farm Biogas Benchmark Study, Version 2

Appendix K: Farm Scenario #11 – 1,000 Dairy Cows + Poultry Manure

Capital Costs

		Option A	Option B	Option C	Option D
Digester					
Dry Feeder		\$525,000	\$525,000	\$525,000	\$525,000
Digester Tank		\$2,900,000	\$2,900,000	\$2,900,000	\$2,900,000
Heating and Hot Water Pipes		\$420,000	\$420,000	\$420,000	\$420,000
Control System		\$240,000	\$240,000	\$240,000	\$240,000
Buildings		\$0	\$0	\$220,000	\$220,000
Misc.	5%	\$204,250	\$204,250	\$215,250	\$215,250
<i>Subtotal</i>		<i>\$4,289,250</i>	<i>\$4,289,250</i>	<i>\$4,520,250</i>	<i>\$4,520,250</i>
Biogas Upgrading					
Biogas Upgrader		\$2,050,000	\$2,050,000	\$2,050,000	\$2,050,000
Spare Parts (% of cost)	3%	\$61,500	\$61,500	\$61,500	\$61,500
Installation Costs		\$400,000	\$400,000	\$400,000	\$400,000
Flare		\$125,000	\$125,000	\$125,000	\$125,000
Compression & Transportation		\$0	\$703,661	\$0	\$703,661
<i>Subtotal</i>		<i>\$2,636,500</i>	<i>\$3,340,161</i>	<i>\$2,636,500</i>	<i>\$3,340,161</i>
Digestate Management					
Nutrient Recovery Equipment		\$0	\$0	\$1,200,000	\$1,200,000
Additional Covered Storage		\$464,861	\$464,861	\$464,861	\$464,861
<i>Subtotal</i>		<i>\$464,861</i>	<i>\$464,861</i>	<i>\$1,664,861</i>	<i>\$1,664,861</i>
Other Costs					
Hydro Service Upgrades	1%	\$73,906	\$80,943	\$88,216	\$95,253
Site Preparation + Civil Works	1.5%	\$110,859	\$121,414	\$132,324	\$142,879
Project Development	2%	\$147,812	\$161,885	\$176,432	\$190,505
Engineering & Project Mgt	5%	\$369,531	\$404,714	\$441,081	\$476,264
Risk Management	5%	\$404,636	\$443,161	\$482,983	\$521,509
<i>Subtotal</i>		<i>\$1,106,744</i>	<i>\$1,212,117</i>	<i>\$1,321,036</i>	<i>\$1,426,409</i>
Total Capital Costs		\$8,497,355	\$9,306,389	\$10,142,647	\$10,951,681

B.C. On-Farm Biogas Benchmark Study, Version 2

Operating Costs

		Option A	Option B	Option C	Option D
Digester					
Poultry Manure (\$/tonne)		\$124,716	\$124,716	\$124,716	\$124,716
Electrical Cost		\$74,585	\$74,585	\$74,585	\$74,585
Natural Gas Cost		\$37,588	\$37,588	\$37,588	\$37,588
Labour Cost		\$23,400	\$23,400	\$23,400	\$23,400
Service & Maintenance		\$40,000	\$40,000	\$75,000	\$75,000
Insurance + Legal + Accounting		\$45,000	\$45,000	\$45,000	\$45,000
Reinvestments (% of CAPEX)	2%	\$85,785	\$85,785	\$90,405	\$90,405
Contingency	10%	\$30,636	\$30,636	\$34,598	\$34,598
<i>Subtotal</i>		<i>\$461,709</i>	<i>\$461,709</i>	<i>\$505,291</i>	<i>\$505,291</i>
Biogas Upgrading					
Electrical Cost		\$68,848	\$68,848	\$68,848	\$68,848
Media Cost (\$/kg)		\$11,475	\$11,475	\$11,475	\$11,475
Consumables (oil, filters, etc.)		\$22,949	\$22,949	\$22,949	\$22,949
Reinvestment (% of CAPEX)	2%	\$41,000	\$55,073	\$41,000	\$55,073
Labour Cost		\$23,400	\$23,400	\$23,400	\$23,400
Service & Maintenance		\$90,000	\$90,000	\$90,000	\$90,000
Compression & Transportation		\$0	\$105,730	\$0	\$105,730
Contingency	10%	\$25,767	\$37,747	\$25,767	\$37,747
<i>Subtotal</i>		<i>\$283,438</i>	<i>\$415,222</i>	<i>\$283,438</i>	<i>\$415,222</i>
Digestate Management					
Electrical Cost		\$0	\$0	\$30,660	\$30,660
Service & Maint (% of CAPEX)	5%	\$0	\$0	\$60,000	\$60,000
Labour Cost		\$0	\$0	\$70,200	\$70,200
Transportation (\$/tonne)		\$0	\$0	\$269,226	\$269,226
Reinvestment (% of CAPEX)	2%	\$0	\$0	\$24,000	\$24,000
Contingency	10%	\$0	\$0	\$45,409	\$45,409
<i>Subtotal</i>		<i>\$0</i>	<i>\$0</i>	<i>\$499,495</i>	<i>\$499,495</i>
Total Operating Costs		\$745,148	\$876,931	\$1,288,225	\$1,420,008

B.C. On-Farm Biogas Benchmark Study, Version 2

Appendix L: Farm Scenario #12 – 2,000 Dairy Cows + Poultry Manure

Capital Costs

		Option A	Option B	Option C	Option D
Digester					
Dry Feeder		\$645,000	\$645,000	\$645,000	\$645,000
Digester Tank		\$3,450,000	\$3,450,000	\$3,450,000	\$3,450,000
Heating and Hot Water Pipes		\$570,000	\$570,000	\$570,000	\$570,000
Control System		\$310,000	\$310,000	\$310,000	\$310,000
Buildings		\$0	\$0	\$220,000	\$220,000
Misc.	5%	\$248,750	\$248,750	\$259,750	\$259,750
<i>Subtotal</i>		<i>\$5,223,750</i>	<i>\$5,223,750</i>	<i>\$5,454,750</i>	<i>\$5,454,750</i>
Biogas Upgrading					
Biogas Upgrader		\$2,450,000	\$2,450,000	\$2,450,000	\$2,450,000
Spare Parts (% of cost)	3%	\$73,500	\$73,500	\$73,500	\$73,500
Installation Costs		\$400,000	\$400,000	\$400,000	\$400,000
Flare		\$170,000	\$170,000	\$170,000	\$170,000
Compression & Transportation		\$0	\$972,072	\$0	\$972,072
<i>Subtotal</i>		<i>\$3,093,500</i>	<i>\$4,065,572</i>	<i>\$3,093,500</i>	<i>\$4,065,572</i>
Digestate Management					
Nutrient Recovery Equipment		\$0	\$0	\$1,200,000	\$1,200,000
Additional Covered Storage		\$831,856	\$831,856	\$831,856	\$831,856
<i>Subtotal</i>		<i>\$831,856</i>	<i>\$831,856</i>	<i>\$2,031,856</i>	<i>\$2,031,856</i>
Other Costs					
Hydro Service Upgrades	1%	\$91,491	\$101,207	\$105,801	\$115,517
Site Preparation + Civil Works	1.5%	\$137,237	\$151,811	\$158,702	\$173,276
Project Development	2%	\$182,982	\$202,414	\$211,602	\$231,034
Engineering & Project Mgt	5%	\$457,455	\$506,036	\$529,005	\$577,586
Risk Management	5%	\$500,914	\$554,109	\$579,261	\$632,456
<i>Subtotal</i>		<i>\$1,370,079</i>	<i>\$1,515,577</i>	<i>\$1,584,371</i>	<i>\$1,729,869</i>
Total Capital Costs		\$10,519,185	\$11,636,291	\$12,164,477	\$13,281,583

B.C. On-Farm Biogas Benchmark Study, Version 2

Operating Costs

		Option A	Option B	Option C	Option D
Digester					
Poultry Manure (\$/tonne)		\$249,432	\$249,432	\$249,432	\$249,432
Electrical Cost		\$149,170	\$149,170	\$149,170	\$149,170
Natural Gas Cost		\$75,175	\$75,175	\$75,175	\$75,175
Labour Cost		\$23,400	\$23,400	\$23,400	\$23,400
Service & Maintenance		\$40,000	\$40,000	\$75,000	\$75,000
Insurance + Legal + Accounting		\$45,000	\$45,000	\$45,000	\$45,000
Reinvestments (% of CAPEX)	2%	\$104,475	\$104,475	\$109,095	\$109,095
Contingency	10%	\$43,722	\$43,722	\$47,684	\$47,684
<i>Subtotal</i>		<i>\$730,374</i>	<i>\$730,374</i>	<i>\$773,956</i>	<i>\$773,956</i>
Biogas Upgrading					
Electrical Cost		\$137,695	\$137,695	\$137,695	\$137,695
Media Cost (\$/kg)		\$22,949	\$22,949	\$22,949	\$22,949
Consumables (oil, filters, etc.)		\$45,898	\$45,898	\$45,898	\$45,898
Reinvestment (% of CAPEX)	2%	\$49,000	\$68,432	\$49,000	\$68,432
Labour Cost		\$23,400	\$23,400	\$23,400	\$23,400
Service & Maintenance		\$90,000	\$90,000	\$90,000	\$90,000
Compression & Transportation		\$0	\$211,460	\$0	\$211,460
Contingency	10%	\$36,894	\$59,983	\$36,894	\$59,983
<i>Subtotal</i>		<i>\$405,837</i>	<i>\$659,818</i>	<i>\$405,837</i>	<i>\$659,818</i>
Digestate Management					
Electrical Cost		\$0	\$0	\$39,420	\$39,420
Service & Maint (% of CAPEX)	5%	\$0	\$0	\$60,000	\$60,000
Labour Cost		\$0	\$0	\$93,600	\$93,600
Transportation (\$/tonne)		\$0	\$0	\$538,452	\$538,452
Reinvestment (% of CAPEX)	2%	\$0	\$0	\$24,000	\$24,000
Contingency	10%	\$0	\$0	\$75,547	\$75,547
<i>Subtotal</i>		<i>\$0</i>	<i>\$0</i>	<i>\$831,020</i>	<i>\$831,020</i>
Total Operating Costs		\$1,136,211	\$1,390,192	\$2,010,813	\$2,264,794

B.C. On-Farm Biogas Benchmark Study, Version 2

Appendix M: Farm Scenario #13 – 2,500 Dairy Cows

Capital Costs

		Option A	Option B	Option C	Option D
Digester					
Digester Tank		\$3,450,000	\$3,450,000	\$3,450,000	\$3,450,000
Heating and Hot Water Pipes		\$570,000	\$570,000	\$570,000	\$570,000
Control System		\$310,000	\$310,000	\$310,000	\$310,000
Buildings		\$0	\$0	\$220,000	\$220,000
Misc.	5%	\$216,500	\$216,500	\$227,500	\$227,500
<i>Subtotal</i>		<i>\$4,546,500</i>	<i>\$4,546,500</i>	<i>\$4,777,500</i>	<i>\$4,777,500</i>
Biogas Upgrading					
Biogas Upgrader		\$1,560,000	\$1,560,000	\$1,560,000	\$1,560,000
Spare Parts (% of cost)	3%	\$46,800	\$46,800	\$46,800	\$46,800
Installation Costs		\$400,000	\$400,000	\$400,000	\$400,000
Flare		\$105,000	\$105,000	\$105,000	\$105,000
Compression & Transportation		\$0	\$674,384	\$0	\$674,384
<i>Subtotal</i>		<i>\$2,111,800</i>	<i>\$2,786,184</i>	<i>\$2,111,800</i>	<i>\$2,786,184</i>
Digestate Management					
Nutrient Recovery Equipment		\$0	\$0	\$1,200,000	\$1,200,000
<i>Subtotal</i>		<i>\$0</i>	<i>\$0</i>	<i>\$1,200,000</i>	<i>\$1,200,000</i>
Other Costs					
Hydro Service Upgrades	1%	\$66,583	\$73,327	\$80,893	\$87,637
Site Preparation + Civil Works	1.5%	\$99,875	\$109,990	\$121,340	\$131,455
Project Development	2%	\$133,166	\$146,654	\$161,786	\$175,274
Engineering & Project Mgt	5%	\$332,915	\$366,634	\$404,465	\$438,184
Risk Management	5%	\$364,542	\$401,464	\$442,889	\$479,812
<i>Subtotal</i>		<i>\$997,080</i>	<i>\$1,098,069</i>	<i>\$1,211,373</i>	<i>\$1,312,362</i>
Total Capital Costs		\$7,655,380	\$8,430,754	\$9,300,673	\$10,076,046

B.C. On-Farm Biogas Benchmark Study, Version 2

Operating Costs

		Option A	Option B	Option C	Option D
Digester					
Electrical Cost		\$56,072	\$56,072	\$56,072	\$56,072
Natural Gas Cost		\$28,258	\$28,258	\$28,258	\$28,258
Labour Cost		\$23,400	\$23,400	\$23,400	\$23,400
Service & Maintenance		\$40,000	\$40,000	\$75,000	\$75,000
Insurance + Legal + Accounting		\$45,000	\$45,000	\$45,000	\$45,000
Reinvestments (% of CAPEX)	2%	\$90,930	\$90,930	\$95,550	\$95,550
Contingency	10%	\$28,365.93	\$28,366	\$32,328	\$32,328
<i>Subtotal</i>		<i>\$312,025</i>	<i>\$312,025</i>	<i>\$355,607</i>	<i>\$355,607</i>
Biogas Upgrading					
Electrical Cost		\$51,758	\$51,758	\$51,758	\$51,758
Media Cost (\$/kg)		\$8,626	\$8,626	\$8,626	\$8,626
Consumables (oil, filters, etc.)		\$17,253	\$17,253	\$17,253	\$17,253
Reinvestment (% of CAPEX)	2%	\$31,200	\$44,688	\$31,200	\$44,688
Labour Cost		\$23,400	\$23,400	\$23,400	\$23,400
Service & Maintenance		\$90,000	\$90,000	\$90,000	\$90,000
Compression & Transportation		\$0	\$96,473	\$0	\$96,473
Contingency	10%	\$22,224	\$33,220	\$22,224	\$33,220
<i>Subtotal</i>		<i>\$244,461</i>	<i>\$365,418</i>	<i>\$244,461</i>	<i>\$365,418</i>
Digestate Management					
Electrical Cost		\$0	\$0	\$39,420	\$39,420
Service & Maint (% of CAPEX)	5%	\$0	\$0	\$60,000	\$60,000
Labour Cost		\$0	\$0	\$93,600	\$93,600
Transportation (\$/tonne)		\$0	\$0	\$553,883	\$553,883
Reinvestment (% of CAPEX)	2%	\$0	\$0	\$24,000	\$24,000
Contingency	10%	\$0	\$0	\$77,090	\$77,090
<i>Subtotal</i>		<i>\$0</i>	<i>\$0</i>	<i>\$847,994</i>	<i>\$847,994</i>
Total Operating Costs		\$556,486	\$677,443	\$1,448,062	\$1,569,019

Appendix N: Farm Scenario #14 – 200 Dairy Cows + Poultry Manure

Capital Costs

		Option A	Option B
Digester			
Modular Digester		\$519,500	\$519,500
Building		\$0	\$110,000
Misc.	5%	\$25,975	\$31,475
<i>Subtotal</i>		<i>\$545,475</i>	<i>\$660,975</i>
Biogas Upgrading			
Biogas Upgrader		\$572,000	\$572,000
Spare Parts (% of cost)	3%	\$17,160	\$17,160
Installation Costs		\$400,000	\$400,000
Flare		\$95,000	\$95,000
<i>Subtotal</i>		<i>\$1,084,160</i>	<i>\$1,084,160</i>
Digestate Management			
Nutrient Recovery Equipment		\$0	\$450,000
Additional Covered Storage		\$102,759	\$102,759
<i>Subtotal</i>		<i>\$102,759</i>	<i>\$552,759</i>
Other Costs			
Hydro Service Upgrades	1%	\$17,324	\$22,979
Risk Management	5%	\$87,486	\$116,044
<i>Subtotal</i>		<i>\$104,810</i>	<i>\$139,023</i>
Total Capital Costs		\$1,837,204	\$2,436,916

B.C. On-Farm Biogas Benchmark Study, Version 2

Operating Costs

		Option A	Option B
Digester			
Poultry Manure (\$/tonne)		\$24,943	\$24,943
Electrical Cost		\$14,917	\$14,917
Natural Gas Cost		\$7,518	\$7,518
Labour Cost		\$11,700	\$11,700
Service & Maintenance		\$20,000	\$20,000
Insurance + Legal + Accounting		\$20,000	\$20,000
Reinvestments (% of CAPEX)	2%	\$10,910	\$13,220
Contingency	10%	\$8,504	\$8,735
<i>Subtotal</i>		<i>\$118,492</i>	<i>\$121,033</i>
Biogas Upgrading			
Electrical Cost		\$13,770	\$13,770
Media Cost (\$/kg)		\$2,295	\$2,295
Consumables (oil, filters, etc.)		\$4,590	\$4,590
Reinvestment (% of CAPEX)	2%	\$11,440	\$11,440
Labour Cost		\$23,400	\$23,400
Service & Maintenance		\$50,000	\$50,000
Contingency	10%	\$10,549	\$10,549
<i>Subtotal</i>		<i>\$116,044</i>	<i>\$116,044</i>
Digestate Management			
Electrical Cost		\$0	\$17,520
Service & Maint (% of CAPEX)	5%	\$0	\$22,500
Labour Cost		\$0	\$23,400
Transportation (\$/tonne)		\$0	\$53,845
Reinvestment (% of CAPEX)	2%	\$0	\$9,000
Contingency	10%	\$0	\$12,627
<i>Subtotal</i>		<i>\$0</i>	<i>\$138,892</i>
Total Operating Costs		\$234,535	\$375,968

Appendix O: Farm Scenario #15 – 300 Dairy Cows + Poultry Manure

Capital Costs

		Option A	Option B
Digester			
Modular Digester		\$970,000	\$970,000
Building		\$0	\$110,000
Misc.	5%	\$48,500	\$54,000
<i>Subtotal</i>		<i>\$1,018,500</i>	<i>\$1,134,000</i>
Biogas Upgrading			
Biogas Upgrader		\$720,500	\$720,500
Spare Parts (% of cost)	3%	\$21,615	\$21,615
Installation Costs		\$400,000	\$400,000
Flare		\$105,000	\$105,000
<i>Subtotal</i>		<i>\$1,247,115</i>	<i>\$1,247,115</i>
Digestate Management			
Nutrient Recovery Equipment		\$0	\$450,000
Additional Covered Storage		\$154,138	\$154,138
<i>Subtotal</i>		<i>\$154,138</i>	<i>\$604,138</i>
Other Costs			
Hydro Service Upgrades	1%	\$24,198	\$29,853
Risk Management	5%	\$122,198	\$150,755
<i>Subtotal</i>		<i>\$146,395</i>	<i>\$180,608</i>
Total Capital Costs		\$2,566,148	\$3,165,861

B.C. On-Farm Biogas Benchmark Study, Version 2

Operating Costs

		Option A	Option B
Digester			
Poultry Manure (\$/tonne)		\$37,415	\$37,415
Electrical Cost		\$22,375	\$22,375
Natural Gas Cost		\$11,276	\$11,276
Labour Cost		\$11,700	\$11,700
Service & Maintenance		\$20,000	\$20,000
Insurance + Legal + Accounting		\$20,000	\$20,000
Reinvestments (% of CAPEX)	2%	\$20,370	\$22,680
Contingency	10%	\$10,572	\$10,803
<i>Subtotal</i>		<i>\$153,709</i>	<i>\$156,250</i>
Biogas Upgrading			
Electrical Cost		\$20,654	\$20,654
Media Cost (\$/kg)		\$3,442	\$3,442
Consumables (oil, filters, etc.)		\$6,885	\$6,885
Reinvestment (% of CAPEX)	2%	\$14,410	\$14,410
Labour Cost		\$23,400	\$23,400
Service & Maintenance		\$50,000	\$50,000
Contingency	10%	\$11,879	\$11,879
<i>Subtotal</i>		<i>\$130,671</i>	<i>\$130,671</i>
Digestate Management			
Electrical Cost		\$0	\$17,520
Service & Maint (% of CAPEX)	5%	\$0	\$22,500
Labour Cost		\$0	\$23,400
Transportation (\$/tonne)		\$0	\$80,768
Reinvestment (% of CAPEX)	2%	\$0	\$9,000
Contingency	10%	\$0	\$15,319
<i>Subtotal</i>		<i>\$0</i>	<i>\$168,507</i>
Total Operating Costs		\$284,379	\$455,427

Appendix P: Farm Scenario #16 – 400 Dairy Cows + Poultry Manure

Capital Costs

		Option A	Option B
Digester			
Modular Digester		\$970,000	\$970,000
Building		\$0	\$110,000
Misc.	5%	\$48,500	\$54,000
<i>Subtotal</i>		<i>\$1,018,500</i>	<i>\$1,134,000</i>
Biogas Upgrading			
Biogas Upgrader		\$957,000	\$957,000
Spare Parts (% of cost)	3%	\$28,710	\$28,710
Installation Costs		\$400,000	\$400,000
Flare		\$105,000	\$105,000
<i>Subtotal</i>		<i>\$1,490,710</i>	<i>\$1,490,710</i>
Digestate Management			
Nutrient Recovery Equipment		\$0	\$450,000
Additional Covered Storage		\$205,517	\$205,517
<i>Subtotal</i>		<i>\$205,517</i>	<i>\$655,517</i>
Other Costs			
Hydro Service Upgrades	1%	\$27,147	\$32,802
Risk Management	5%	\$137,094	\$165,651
<i>Subtotal</i>		<i>\$164,241</i>	<i>\$198,454</i>
Total Capital Costs		\$2,878,968	\$3,478,681

B.C. On-Farm Biogas Benchmark Study, Version 2

Operating Costs

		Option A	Option B
Digester			
Poultry Manure (\$/tonne)		\$49,886	\$49,886
Electrical Cost		\$29,834	\$29,834
Natural Gas Cost		\$15,035	\$15,035
Labour Cost		\$11,700	\$11,700
Service & Maintenance		\$20,000	\$20,000
Insurance + Legal + Accounting		\$20,000	\$20,000
Reinvestments (% of CAPEX)	2%	\$20,370	\$22,680
Contingency	10%	\$11,694	\$11,925
<i>Subtotal</i>		<i>\$178,519</i>	<i>\$181,060</i>
Biogas Upgrading			
Electrical Cost		\$27,539	\$27,539
Media Cost (\$/kg)		\$4,590	\$4,590
Consumables (oil, filters, etc.)		\$9,180	\$9,180
Reinvestment (% of CAPEX)	2%	\$19,140	\$19,140
Labour Cost		\$23,400	\$23,400
Service & Maintenance		\$50,000	\$50,000
Contingency	10%	\$13,385	\$13,385
<i>Subtotal</i>		<i>\$147,233</i>	<i>\$147,233</i>
Digestate Management			
Electrical Cost		\$0	\$17,520
Service & Maint (% of CAPEX)	5%	\$0	\$22,500
Labour Cost		\$0	\$23,400
Transportation (\$/tonne)		\$0	\$107,690
Reinvestment (% of CAPEX)	2%	\$0	\$9,000
Contingency	10%	\$0	\$18,011
<i>Subtotal</i>		<i>\$0</i>	<i>\$198,122</i>
Total Operating Costs		\$325,753	\$526,415

Appendix Q: Farm Scenario #17 – 500 Dairy Cows + Poultry Manure

Capital Costs

		Option A	Option B
Digester			
Modular Digester		\$1,390,000	\$1,390,000
Building		\$0	\$110,000
Misc.	5%	\$69,500	\$75,000
<i>Subtotal</i>		<i>\$1,459,500</i>	<i>\$1,575,000</i>
Biogas Upgrading			
Biogas Upgrader		\$1,155,000	\$1,155,000
Spare Parts (% of cost)	3%	\$34,650	\$34,650
Installation Costs		\$400,000	\$400,000
Flare		\$105,000	\$105,000
<i>Subtotal</i>		<i>\$1,694,650</i>	<i>\$1,694,650</i>
Digestate Management			
Nutrient Recovery Equipment		\$0	\$650,000
Additional Covered Storage		\$256,897	\$256,897
<i>Subtotal</i>		<i>\$256,897</i>	<i>\$906,897</i>
Other Costs			
Hydro Service Upgrades	1%	\$34,110	\$41,765
Risk Management	5%	\$172,258	\$210,916
<i>Subtotal</i>		<i>\$206,368</i>	<i>\$252,681</i>
Total Capital Costs		\$3,617,415	\$4,429,228

B.C. On-Farm Biogas Benchmark Study, Version 2

Operating Costs

		Option A	Option B
Digester			
Poultry Manure (\$/tonne)		\$62,358	\$62,358
Electrical Cost		\$37,292	\$37,292
Natural Gas Cost		\$18,794	\$18,794
Labour Cost		\$11,700	\$11,700
Service & Maintenance		\$20,000	\$20,000
Insurance + Legal + Accounting		\$20,000	\$20,000
Reinvestments (% of CAPEX)	2%	\$29,190	\$31,500
Contingency	10%	\$13,698	\$13,929
<i>Subtotal</i>		<i>\$213,032</i>	<i>\$215,573</i>
Biogas Upgrading			
Electrical Cost		\$34,424	\$34,424
Media Cost (\$/kg)		\$5,737	\$5,737
Consumables (oil, filters, etc.)		\$11,475	\$11,475
Reinvestment (% of CAPEX)	2%	\$23,100	\$23,100
Labour Cost		\$23,400	\$23,400
Service & Maintenance		\$50,000	\$50,000
Contingency	10%	\$14,814	\$14,814
<i>Subtotal</i>		<i>\$162,949</i>	<i>\$162,949</i>
Digestate Management			
Electrical Cost		\$0	\$17,520
Service & Maint (% of CAPEX)	5%	\$0	\$32,500
Labour Cost		\$0	\$23,400
Transportation (\$/tonne)		\$0	\$134,613
Reinvestment (% of CAPEX)	2%	\$0	\$13,000
Contingency	10%	\$0	\$22,103
<i>Subtotal</i>		<i>\$0</i>	<i>\$243,136</i>
Total Operating Costs		\$375,981	\$621,659

Appendix R: Farm Scenario #18 – 750 Dairy Cows + Poultry Manure

Capital Costs

		Option A	Option B
Digester			
Modular Digester		\$1,909,500	\$1,909,500
Building		\$0	\$110,000
Misc.	5%	\$95,475	\$100,975
<i>Subtotal</i>		<i>\$2,004,975</i>	<i>\$2,120,475</i>
Biogas Upgrading			
Biogas Upgrader		\$1,457,500	\$1,457,500
Spare Parts (% of cost)	3%	\$43,725	\$43,725
Installation Costs		\$400,000	\$400,000
Flare		\$105,000	\$105,000
<i>Subtotal</i>		<i>\$2,006,225</i>	<i>\$2,006,225</i>
Digestate Management			
Nutrient Recovery Equipment		\$0	\$850,000
Additional Covered Storage		\$385,345	\$385,345
<i>Subtotal</i>		<i>\$385,345</i>	<i>\$1,235,345</i>
Other Costs			
Hydro Service Upgrades	1%	\$43,965	\$53,620
Risk Management	5%	\$222,026	\$270,783
<i>Subtotal</i>		<i>\$265,991</i>	<i>\$324,404</i>
Total Capital Costs		\$4,662,536	\$5,686,449

B.C. On-Farm Biogas Benchmark Study, Version 2

Operating Costs

		Option A	Option B
Digester			
Poultry Manure (\$/tonne)		\$93,537	\$93,537
Electrical Cost		\$55,939	\$55,939
Natural Gas Cost		\$28,191	\$28,191
Labour Cost		\$11,700	\$11,700
Service & Maintenance		\$20,000	\$20,000
Insurance + Legal + Accounting		\$20,000	\$20,000
Reinvestments (% of CAPEX)	2%	\$40,100	\$42,410
Contingency	10%	\$17,593	\$17,824
<i>Subtotal</i>		<i>\$287,059</i>	<i>\$289,600</i>
Biogas Upgrading			
Electrical Cost		\$51,636	\$51,636
Media Cost (\$/kg)		\$8,606	\$8,606
Consumables (oil, filters, etc.)		\$17,212	\$17,212
Reinvestment (% of CAPEX)	2%	\$29,150	\$29,150
Labour Cost		\$23,400	\$23,400
Service & Maintenance		\$50,000	\$50,000
Contingency	10%	\$18,000	\$18,000
<i>Subtotal</i>		<i>\$198,004</i>	<i>\$198,004</i>
Digestate Management			
Electrical Cost		\$0	\$17,520
Service & Maint (% of CAPEX)	5%	\$0	\$42,500
Labour Cost		\$0	\$23,400
Transportation (\$/tonne)		\$0	\$201,920
Reinvestment (% of CAPEX)	2%	\$0	\$17,000
Contingency	10%	\$0	\$30,234
<i>Subtotal</i>		<i>\$0</i>	<i>\$332,574</i>
Total Operating Costs		\$485,063	\$820,177

B.C. On-Farm Biogas Benchmark Study, Version 2

Appendix S: Farm Scenario #19 (2.5 Million Chickens) and #20 (5 Million Chickens)

Capital Costs

		#19	#20
Digester			
Dry Feeder		\$730,000	\$1,350,000
Digester Tanks		\$3,450,000	\$4,600,000
Heating and Hot Water Pipes		\$280,000	\$350,000
Control System		\$160,000	\$200,000
Misc.	5%	\$231,000	\$325,000
<i>Subtotal</i>		<i>\$4,851,000</i>	<i>\$6,825,000</i>
Biogas Upgrading			
Biogas Upgrader		\$2,045,000	\$3,400,000
Spare Parts (% of cost)	3%	\$61,350	\$102,000
Installation Costs		\$400,000	\$400,000
Flare		\$170,000	\$320,000
<i>Subtotal</i>		<i>\$2,676,350</i>	<i>\$4,222,000</i>
Digestate Management			
Nutrient Recovery Equipment		\$1,238,781	\$4,836,055
<i>Subtotal</i>		<i>\$1,239,446</i>	<i>\$4,836,055</i>
Other Costs			
Hydro Service Upgrades	1%	\$75,274	\$110,470
Site Preparation + Civil Works	1.5%	\$112,910	\$165,705
Project Development	2%	\$150,547	\$220,940
Engineering & Project Mgt	5%	\$376,368	\$552,350
Risk Management	5%	\$412,122	\$604,823
<i>Subtotal</i>		<i>\$1,127,221</i>	<i>\$1,654,288</i>
Total Capital Costs		\$9,893,352	\$17,537,343

B.C. On-Farm Biogas Benchmark Study, Version 2

Operating Costs

		Option A	Option B
Digester			
Electrical Cost		\$125,460	\$250,920
Natural Gas Cost		\$63,227	\$126,454
Labour Cost		\$23,400	\$23,400
Service & Maintenance		\$40,000	\$40,000
Insurance + Legal + Accounting		\$45,000	\$45,000
Reinvestments (% of CAPEX)	2%	\$97,020	\$136,500
Contingency	10%	\$39,411	\$62,227
<i>Subtotal</i>		<i>\$433,517</i>	<i>\$684,501</i>
Biogas Upgrading			
Electrical Cost	\$0.10	\$115,809	\$231,618
Media Cost (\$/kg)	\$5.00	\$19,302	\$38,603
Consumables (oil, filters, etc.)		\$38,603	\$77,206
Reinvestment (% of CAPEX)	2%	\$40,900	\$68,000
Labour Cost	\$45	\$23,400	\$23,400
Service & Maintenance		\$90,000	\$90,000
Contingency	10%	\$32,801	\$52,883
<i>Subtotal</i>		<i>\$360,815</i>	<i>\$581,710</i>
Digestate Management			
Nutrient Recovery		\$309,695	\$1,209,014
<i>Subtotal</i>		<i>\$309,861</i>	<i>\$1,209,014</i>
Total Operating Costs			
		\$1,104,194	\$2,475,225