Waste Characterization Study for a Northern Canadian Abattoir – Naturally Northern Meats Whitehorse, Yukon, December 2019

Photo Credit: Naturally Northern Meats

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EXECUTIVE SUMMARY

In Yukon, the agriculture industry is growing (Government of Yukon 2017). Specifically, there has been consistent growth in the cattle, pork, and poultry sectors over the last decade. The number of farms raising pork and the total number of pigs has increased substantially, with an eight-fold increase in pig production from 2011 to 2017 (Government of Yukon 2017). The increase in livestock production has created an increased demand for the processing of inspected red meat, resulting in increased production of slaughter waste that requires disposal.

In 2016, Naturally Northern Meats (NNM) became the first and only fixed, licensed, red-meat abattoir in Yukon. Since its inception, the abattoir has been rapidly expanding, and it reached its maximum slaughtering capacity during the 2019 fall season. Currently, all slaughter waste other than specified risk material (SRM) is disposed of by composting. Given that NNM is located off-grid and is outgrowing its current infrastructure, the owners have been rethinking their future waste management approach and are considering implementing anaerobic digestion (AD) technology to dispose of slaughter waste while generating onsite renewable energy and a valuable by-product (digestate).

This report presents the results of a Waste Characterization Study performed at NNM in 2019. The purpose of the study was to characterize the composition and quantity of slaughter waste generated at NNM, and to use that information to estimate the theoretical biochemical methane potential that could be generated from that waste using AD technology.

The study team reviewed Slaughter Record Forms (SRFs) from 2017, 2018, and 2019 (January to October) to characterize the monthly and annual composition and quantity of organic waste generated at NNM. The composition of organic waste generated during the slaughtering process can be characterized into four categories: soft tissue, hard tissue, SRM, and wastewater. The soft tissue was the primary material of interest for this study as it is the material most suitable for biogas generation through the AD process. Soft tissue materials include the organs, intestines, stomach, blood, fat, etc. The monthly weight of soft tissue material generated from each species was multiplied by biochemical methane potential values found in the literature to estimate the theoretical production of cubic metres (m^3) of biogas.

Between January and October of 2019, a total of 303 animals were slaughtered and reported on the SRF. This was almost twice as many animals slaughtered during the same time period in 2018, and 7.5 times as many animals as in 2017. Among the animals slaughtered in 2018 and 2019, pigs were the most abundant, comprising 79% of all animals in 2018 and 62% in 2019. Cows were the second most abundant species slaughtered in both 2018 and 2019, at 13% respectively. Based on the 303 animals slaughtered from January to October 2019, it is estimated that equates to 41.4 tonnes of animals slaughtered, a total rack weight of 28.3 tonnes, 9.8 tonnes of soft tissue, 1.8 tonnes of heads, 0.8 tonnes of hide, and 0.65 tonnes of hooves; this was an 85% increase over slaughters performed in 2018.

Based on the weight of soft tissue generated from slaughters at NNM from January to October in 2018 and 2019, the study team concluded that a total theoretical volume of 1,611 m^3 and 3,153 m^3 of biogas could be generated via the AD process for 2018 and 2019, respectively. This energy potential in terms of megawatt hours (MWh) and diesel fuel equivalents is equal to 9.68 MWh and 18.92 MWh, and 968 and 1,892 litres of diesel in 2018 and 2019.

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ACRONYMS AND ABBREVIATIONS

Acronym / Abbreviation	Definition
AD	anaerobic digestion
BMP	biochemical methane potential
BSE	bovine spongiform encephalopathy
CFIA	Canadian Food Inspection Agency
NNM	Naturally Northern Meats
SRF	Slaughter Record Form
SRM	specified risk material

SYMBOLS AND UNITS OF MEASURE

Acronym / Abbreviation	Definition
%	percent
°C	degrees Celsius
dfe	diesel fuel equivalents
kg	kilogram
kWh	kilowatt hour
MWh	megawatt hour
L	litre
m^3	cubic metre

1.0 INTRODUCTION

Pursuing opportunities for renewable energy projects in the North has become a government priority. A proven and well-understood renewable energy technology that is gaining recognition around the world is anaerobic digestion (AD). AD is a biological process whereby organic material is decomposed by microorganisms in an oxygen-free environment to produce a renewable energy known as biogas. Slaughter waste has been identified to have one of the highest values for biogas potential per unit mass among all types of organic material (Bayr et al. 2012). Hemmera Envirochem Inc. (Hemmera), a wholly owned subsidiary of Ausenco Engineering Canada Inc., has partnered with Balance Biogas and Naturally Northern Meats (NNM) to explore the potential generation of biogas using abattoir waste.

Consisting of approximately 60 percent (%) methane, 40% carbon dioxide, and trace amounts of hydrogen sulphide, ammonia, water vapour, and other gases, biogas has similar properties to propane and can be used for similar applications such as heating, cooking, lighting, and electricity generation. The organic materials most often processed in AD systems are food waste, manure, and human waste, but recent interest has focused on the potential for biogas production from alternative sources of organic material, such as slaughter waste. The benefits of AD include not only the generation of renewable energy, but also the production of a nutrient-rich digestate[1] that is a highly effective fertilizer and soil amendment (Rajendran et al. 2012). It is also an effective tool for managing organic waste and reducing greenhouse gas emissions through methane capture.

1.1 Project Purpose

This report presents the results of a Waste Characterization Study performed at NNM in 2019. The purpose of the study was to characterize the composition and quantity of slaughter waste generated at NNM, and to use that information to estimate the theoretical biochemical methane potential (BMP) that could be generated from that waste using AD technology. Funding for this research has been provided by Ausenco Engineering Canada Inc., Cold Climate Innovation, and the Agricultural Branch of Yukon Government.

1.2 Project Location

NNM is the first and only fixed red-meat abattoir in Yukon. The facility is located approximately 40 kilometres north of Whitehorse along the Klondike Highway (**Figure 1.1**). NNM is located outside municipal boundaries and is not connected to the territorial electricity grid. Power is generated by burning diesel in a 15-kilowatt generator. The coordinates for the facility are 61°01’30.18” N, 135°13’59.57” W.

[1] Digestate is the material remaining after the feedstock has undergone the AD process to generate biogas. The digestate contains almost all the macronutrients and micronutrients found in the original feedstocks and has value as a fertilizer and/or soil amendment (Canadian Biogas Association 2019).

1.3 Project Scope

Hemmera's scope of work for this project included reviewing available information, estimating the potential for energy production, and researching applicable regulations. Specifically, Hemmera did the following:

- Reviewed historical monthly Slaughter Record Forms from 2017, 2018, and 2019 to characterize the composition and quantity of slaughter waste generated at NNM
- Performed a literature review to identify biochemical methane potential values for the sources of slaughter waste generated at NNM
- Calculated the monthly and annual potential for production of cubic metres of biogas, kilowatt hours of energy, and diesel fuel equivalents, all based on historical Slaughter Record Form data
- Quantified the total number of animals slaughtered and species composition between January and October of 2018 and 2019
- Researched the regulatory framework for using AD technology as a method of disposal for specified risk material (SRM).

Figure 1.1 Location of Naturally Northern Meats Relative to Surrounding Farms

2.0 BACKGROUND

The market potential of small-scale AD in Canada should be explored because of increasing awareness of the benefits of this technology as a form of renewable energy. Specific market trends driving the growth of AD technology include new environmental policies designed to reduce greenhouse gas emissions, government investment in renewable energy, and stricter waste management policies. The rapidly expanding market for AD is also due in part to the widespread applications of the technology at different scales and in various geographic regions. For example, more than 30 million AD units were installed in China as of 2012, with 80 million expected by 2020 (Rajendran et al. 2012). Many of these are small-scale digesters designed to suit the needs of individual households. In Canada, there are over 100 operational facilities. However, many of these are large plants designed to suit the needs of entire municipalities or large agricultural operations (Canadian Biogas Association 2019).

The use of small-scale digesters in rural and remote areas is gaining attention because they can play a valuable role as a decentralized energy generation system that is cheap to construct and simple to operate (Bosu et al. 2016). Given the remoteness of Yukon, many decentralized energy generation systems already exist in small communities, remote resource camps, and agricultural operations. These energy systems typically consist of diesel and a generator. However, communities, resource camps, and agriculture operations also produce organic material that requires proper management. This organic material could be diverted to an AD to produce renewable energy and a nutrient-rich digestate, as well as offset the consumption of fossil fuels.

In Yukon, the agriculture industry is growing (Government of Yukon 2017). Specifically, the Yukon agriculture sector has seen consistent growth in the cattle, pork, and poultry sectors over the last decade. The number of farms raising pork and the total number of pigs has increased substantially, with an eight-fold increase in pig production from 2011 to 2017 (Government of Yukon 2017). The increase in livestock production has created an increased demand for the processing of inspected red meat, resulting in increased production of slaughter waste that requires disposal.

In 2016, NNM became the first and only fixed, licensed, red-meat abattoir in Yukon. Since its inception, the abattoir has been rapidly expanding, and it reached its maximum slaughtering capacity during the 2019 fall season. Currently, all slaughter waste (excluding specified risk material (SRM)) is disposed of by composting in a composting pit; however, this composting pit has attracted bears and caused nuisance odours. Given that NNM is located off-grid and is outgrowing its current infrastructure, the owners have been rethinking their future waste management approach and are considering the implementation of AD technology to dispose of slaughter waste while generating onsite renewable energy and a valuable digestate.

AD may also play a role in the safe management of SRM. SRM is the term used to classify the tissues of ruminant animals that may contain prions infected by bovine spongiform encephalopathy (BSE), more commonly known as mad cow disease (CFIA 2019). BSE is transmitted when cows consume feed contaminated with BSE prions or animal by-products (BCRC 2018). Humans can develop variant Creutzfeldt-Jakob disease from ingestion of BSE-infected beef (CFIA 2019). For these reasons, SRM must be removed and separated during the slaughter process for safe management (BCRC 2018).

3.0 METHODOLOGICAL APPROACH

This section presents the methodology used to characterize the composition and quantity of organic waste generated at NNM, as well as well as the literature values used to quantify the theoretical BMP from that waste.

3.1 Data Collection

NNM processes livestock for both retail and farm-gate sales[2]. Each animal that is processed for retail sale requires an inspection by a government official (**Figure 3.1**). During the inspection, information about each animal is recorded on a government-issued Slaughter Record Form (SRF), such as the date of slaughter, species, age, sex, rack weight, and farm the animal came from, among other details. The study team reviewed SRFs from 2017, 2018, and 2019 (January to October) to quantify the monthly and annual composition and quantity of organic waste generated at NNM.

Animals processed for farm-gate sales do not require an inspection, so they were not recorded on the SRFs. As a result, the waste generated from farm-gate sale animals was not recorded. To account for this waste, it was assumed that an additional 25% of animals were processed at NNM for farm-gate sales, resulting in a 25% increase of waste material not accounted for on the SRFs (B. Johnson, pers. comm., 2019).

An example SRF is included in **Appendix A**.

Figure 3.1 Government Official Inspecting a Pig

3.2 Waste Composition

The composition of organic waste generated during the slaughtering process can be characterized into four categories: soft tissue, hard tissue, SRM, and wastewater. Soft tissue materials include the organs, intestines, stomach, blood, fat, etc. The soft tissue is suitable feedstock for AD because it contains high concentrations of organic matter that is high in protein and fat. The soft tissue was the primary material of interest for this study as it is the material most suitable for biogas generation through the AD process. Hard tissue materials are the head, hide, and hooves. The hard tissue is not suitable for AD because it contains organic matter that is difficult to decompose and can cause system failures to occur. SRM material includes the skull, brain, eyes, tonsils, spinal cord, specific nerves, and a portion of the small intestine, depending on the animal's age. Cattle aged 30 months and older may contain the prions in the skull, brain, eyes, tonsils, spinal cord, and nerves attached to the brain and spinal cord. Cattle that are under 30 months old may contain the prions only in a portion of their small intestine (CFIA 2019). The final category of waste generated during the slaughtering process is wastewater, which consists of rinse water and blood plus some fat, dirt, hair, etc., with the addition of bleach. At the NNM facility, wastewater is collected in a 5,000-gallon wastewater holding tank located below the slaughterhouse.

2 *Farm-gate sales* refers to the direct sale of agricultural produce from the farmer to the consumer, rather than through a retail store.

3.3 Waste Quantity

For the purposes of this study, the weight of soft tissue slaughter waste was of interest, and therefore, was quantified by the study team. The weight of soft tissue was quantified based on data available from the SRF. Since the SRF provides only the rack weight[3] of processed animals, the team used simple calculations and assumptions to estimate the monthly quantity of soft tissue generated at NNM. The rack weight includes the bones but does not include the weight of the head, hide, hooves, and soft tissue material. For pigs and cows, the rack weight is a well-defined percentage of the live weight of the animal. For example, 28% of the live weight of a pig is considered waste material, including both soft and hard tissue; the remaining 72% is considered the rack weight. For a cow, 39% of the live weight of the animal is considered waste (hard and soft), while the remaining 61% is the rack weight (Government of Oklahoma n.d.). Based on the live weight and rack weight of each animal and using estimated weights for the head, hide, and hooves of each species, Hemmera estimated the weight of soft and hard tissue for each animal processed at NNM.

The monthly volume of wastewater generated was estimated based on information provided by the facility owners. Although the weight of SRM was not quantified by the study team, the number of cows slaughtered over and under 30 months of age was quantified.

3.4 Biochemical Methane Potential

To estimate the potential energy generation from soft tissue material, Hemmera's team conducted an extensive literature review, which identified specific BMP values per kilogram of pig and cow soft tissue (**Table 3.1**). The information sources we reviewed included peer-reviewed scientific journal articles, government reports, and technical reports. The BMP values varied depending on the report; therefore, the values found in the literature were pooled, and an average value was used for this study.

Table 3.1 Average Biochemical Methane Potential Values for Pig and Cow Soft Tissue

Average Biochemical Methane Potential	Reference
1 kg of pig soft tissue = 0.2 m^3 biogas	Agtech Centre 2013, Bayr et al. 2012, Rodriguez-Abalde et al. 2011
1 kg of cow soft tissue = 0.5 m^3 biogas	Ware and Power 2016, Agtech Centre 2013, Bayr et al. 2012

The monthly weight of soft tissue material generated from each species was multiplied by the average BMP value to quantify the theoretical production of cubic metres (m^3) of biogas. The energy potential of 1 m^3 of biogas was converted to joules[4] and was subsequently converted to energy potential in terms of kilowatt hours and litres of diesel fuel equivalents (**Table 3.2**). Multiple literature sources were compared to corroborate the data.

Table 3.2 Literature Values Referenced to Convert Theoretical Biogas Volume to Theoretical Kilowatt Hours and Litres of Diesel in Energy Equivalents

Value	Reference
1 m^3 of biogas = 22 megajoules	IRENA 2016, NRCan 2013, Kelleher Environmental 2013
1 m^3 of biogas = 6 kilowatt hours	NRCan 2013
1 m^3 of biogas = 0.6 L diesel fuel	World Nuclear Association 2018

3 The rack weight is the weight of the animal after slaughtering.
4 A joule is a measure of energy.

4.0 RESULTS

The following sections describe the results of the waste characterization, as well as the theoretical energy potential based on the weight of soft tissue waste generated at NNM in 2018 and 2019.

4.1 Waste Characterization

Since NNM began operation in the fall of 2016, there has been consistent growth for the need of their services. This has been demonstrated by nearly a four times increase in the number of animals slaughtered in 2018 compared to 2017, and another doubling in the number of animals slaughtered in 2019 compared to 2018 (**Figure 4.1**). Between January and October of 2019, a total of 303 animals were slaughtered and reported on the government-issued SRF.

One major difference in the number of animals slaughtered between the three years is the occurrence of slaughters in January, February, March, and April. For example, in 2017, there were no animals slaughtered during these four months, whereas 49 animals were slaughtered in 2018, and 87 animals were slaughtered in 2019 during this period. One reason for the increase in late-winter slaughters is the increased demand for locally raised meat at restaurants and grocery stores, meaning the abattoir services are required year-round, rather than just in the fall (B. Johnson, pers. comm., 2019).

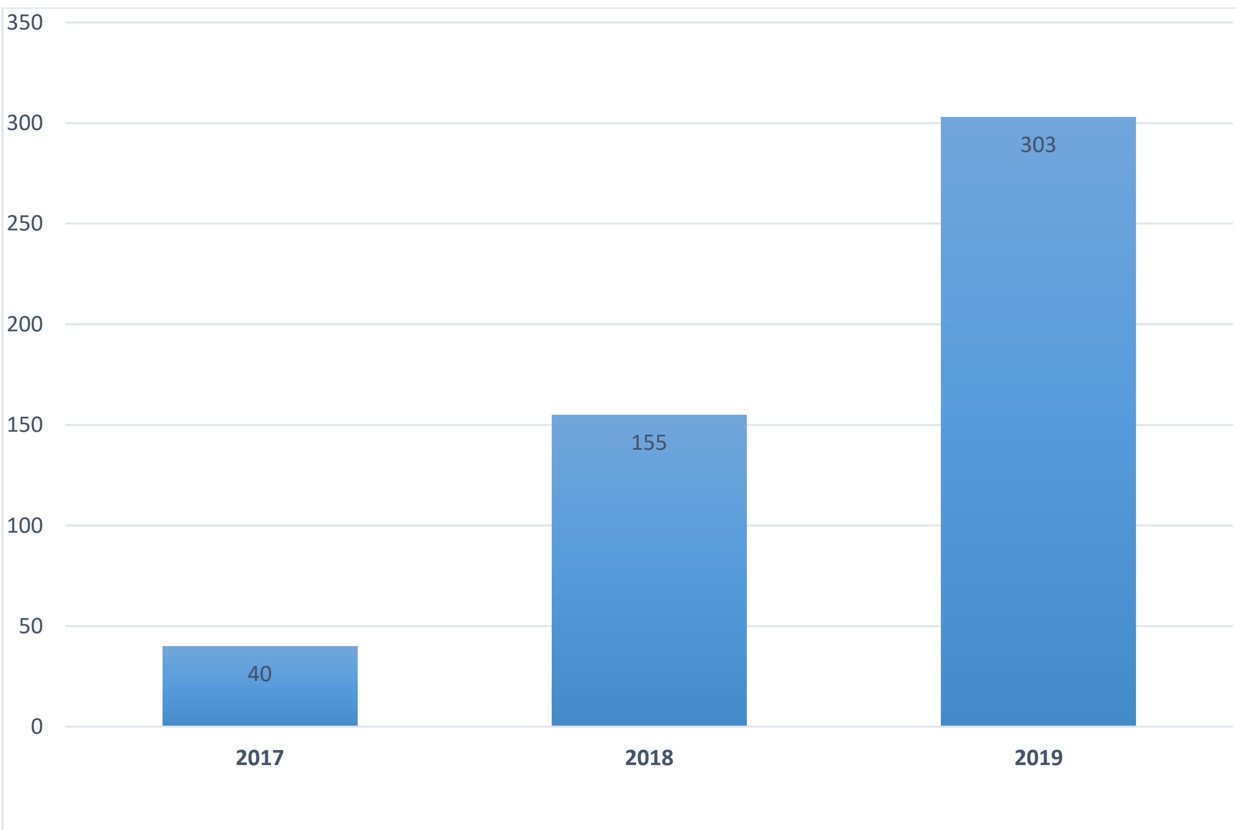

Figure 4.1 Number of Slaughtered Animals Reported on the Slaughter Record Form at Naturally Northern Meats from January to October in 2017, 2018, and 2019

4.1.1 Species Composition

Among the government-inspected animals slaughtered in 2018 and 2019 for retail sales, pigs were the most abundant, comprising 79% of all animals in 2018 and 62% in 2019 (**Figure 4.2**). Cows were the second most abundant species slaughtered in both 2018 and 2019, at 13% respectively. Although the overall number of slaughtered pigs increased in 2019, the percentage of pigs decreased due to an increase in species diversity. In 2019, 34 sheep, 17 goat, and 1 elk were slaughtered, compared to zero of each of these species in 2018.

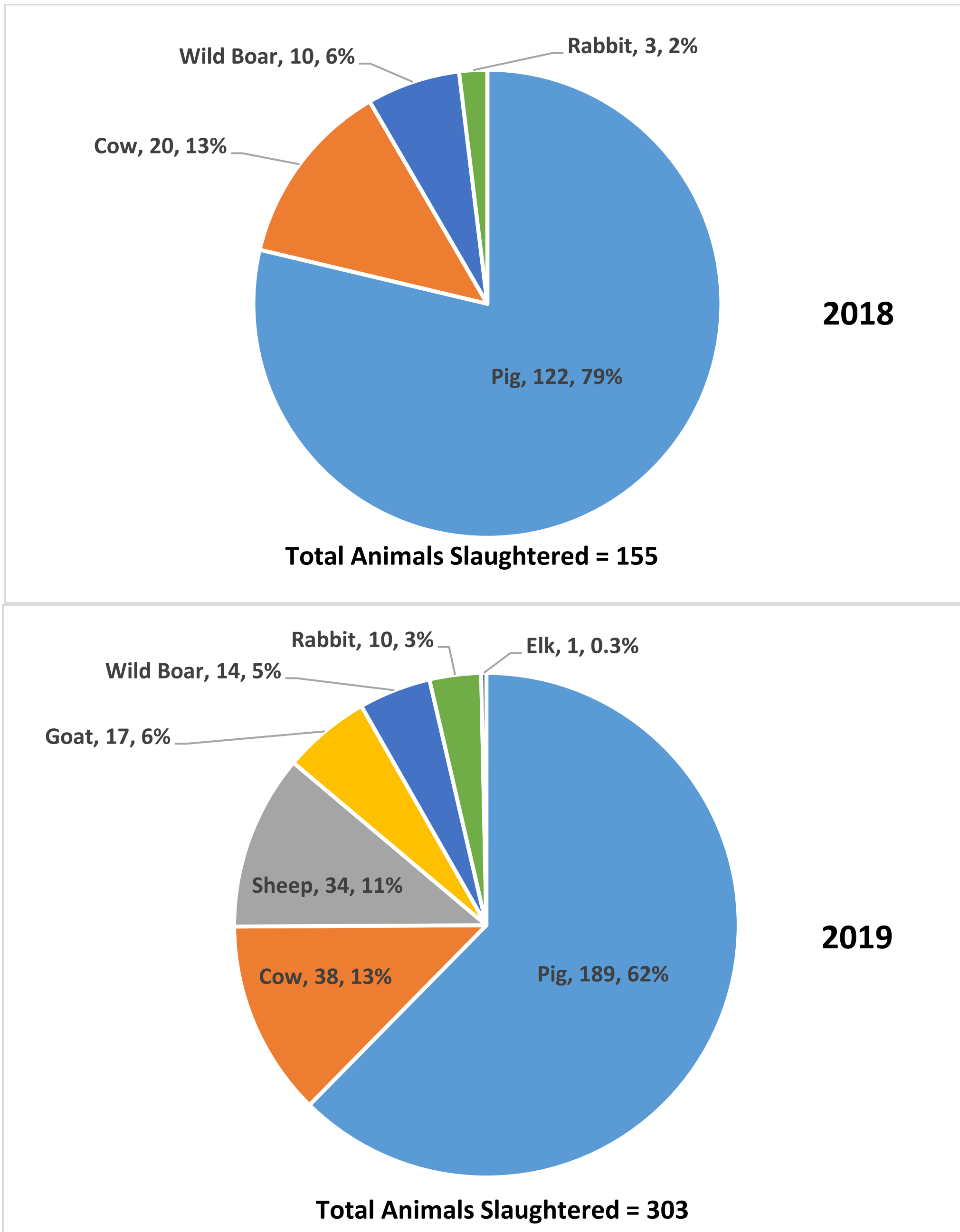

Figure 4.2 Species Composition of Animals Slaughtered from January to October in 2018 and 2019

4.1.2 Waste Composition and Quantity

Based on the 303 government-inspected animals slaughtered from January to October 2019, it is estimated that equates to 41.4 tonnes of animals slaughtered, a total rack weight of 28.3 tonnes, 9.8 tonnes of soft tissue generated, 1.8 tonnes of heads, 0.8 tonnes of hide, and 0.65 tonnes of hooves (**Table 4.1).** (Note: 1 tonne = 1,000 kilograms (kg)). This was an 85% increase compared to slaughters performed in 2018. Among the total weight of organic waste generated in 2018 and 2019, 75% was soft tissue and 25% was hard tissue. Among the 9.8 tonnes of soft tissue generated in 2019, 57% was generated from pigs; 39% was generated from cows; and 4% was generated from all other animals. Assuming that farm-gate sale slaughters, not inspected by a government official, contributed 25% more animals to be slaughtered, the 2019 slaughter values presented above would increase by 25%. This assumption was based on first-hand knowledge provided by the facility owners.

Table 4.1 Total Weight of Organic Material Processed from Government-inspected and Farm-gate Sale Slaughters from January to October in 2018 and 2019

Year	Weight (kg)					
	Live Weight	Rack Weight	Soft Tissue	Head	Hide	Hooves
Government-inspected Slaughters						
2018	22,436	15,421	5,246	1,091	364	377
2019	41,465	28,359	9,835	1,818	795	658
Government-inspected + Estimated Farm-gate Sale Slaughters						
2018	28,045	19,276	6,557	1,364	455	471
2019	51,831	35,449	12,294	2,272	994	822

In addition to the solid organic waste detailed in **Table 4.1**, large quantities of wastewater requiring disposal are generated during the slaughtering process each month. An onsite 5,000-gallon wastewater holding tank is emptied approximately once per month, depending on the season, via a hired vacuum truck. Wastewater is transferred offsite for disposal because it contains blood and fat. Although the wastewater does have BMP, the wastewater was not quantified for this study.

In addition to livestock slaughtering, NNM also processes wild game. Since these animals are field dressed, the organic waste material that is generated is discarded in the environment where the animals were shot; therefore, these animals contribute small amounts of waste to NNM (i.e., hair, fat, and excess meat trimmings removed during the butchering process). Thus, these weights of organic material were not quantified and not included in this study.

4.1.3 Seasonal Trends

As expected, late summer and fall is the busiest time of year for slaughtering at NNM and is when most slaughter waste is produced. These trends were observed in both 2018 and 2019 (**Figure 4.3**). Among the 9.8 tonnes of soft tissue produced in 2019, 60% was generated during July, August, September, and October. This is compared to 52% generated during these four months in 2018. The largest amount of soft tissue waste in 2019 was generated in September (1.9 tonnes), while the largest amount of soft tissue waste in 2018 was generated in November (1.8 tonnes). On average, an additional 400 kg of soft tissue were produced on a monthly basis in 2019 compared to 2018.

April, May, and June generated the least waste material in 2019, with only 15% produced during these three months, while April, May, and June generated 34% of the waste in 2018. Interestingly, the month of May is when the third-most soft tissue material was generated in 2018; however, the least amount of soft tissue material was generated in May in 2019. The same amount of soft tissue material was generated in October 2018 and October 2019. No data was available for November and December 2019.

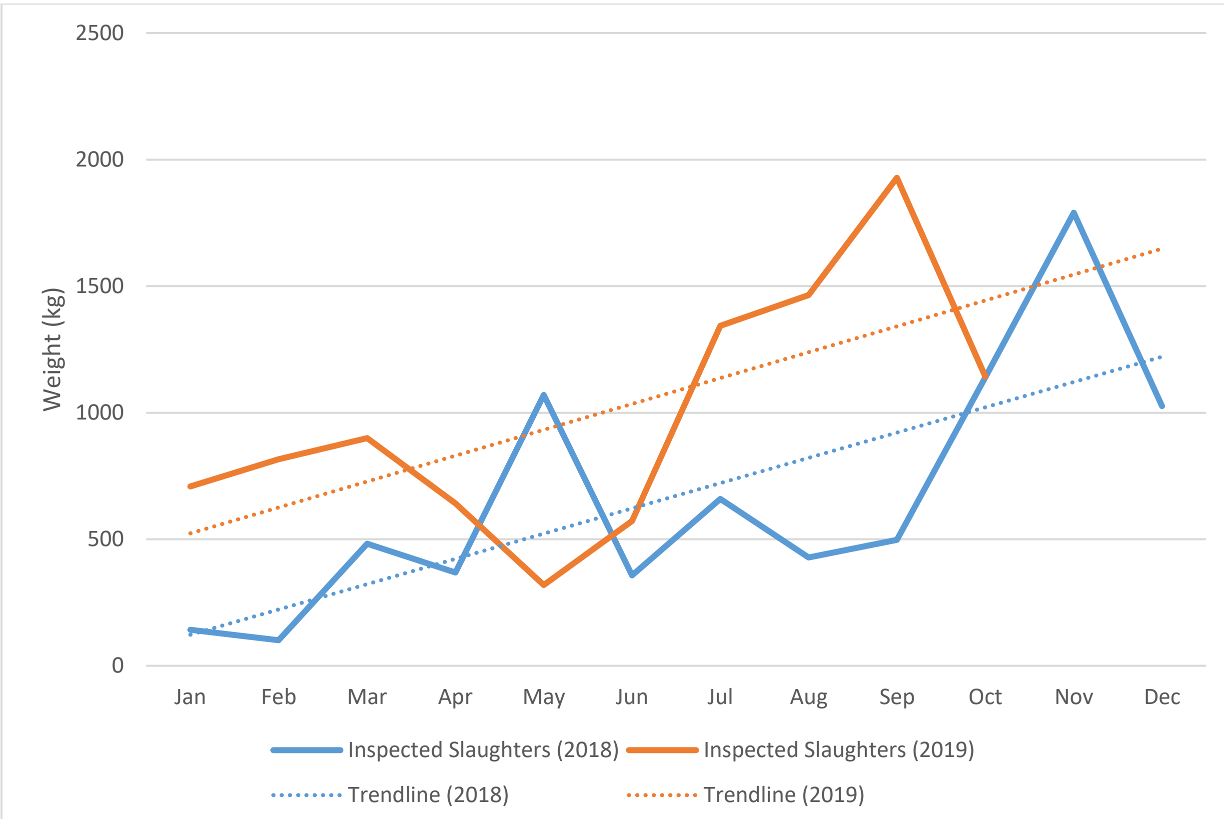

Figure 4.3 Monthly Weight of Soft Tissue Generated from Government-inspected Slaughters at Naturally Northern Meats in 2018 and 2019

4.1.4 Specified Risk Material

Most cattle processed at NNM are less than 30 months old, meaning a small amount of SRM has been produced historically (B. Johnson, personal communication, July 26, 2019). Among the 38 cows slaughtered in 2019, four were more than 30 months old and 34 were younger. Compared to 2018, among the 34 cows slaughtered, nine were more than 30 months old and 25 were younger. As NNM continues to grow and more people raise cattle in Yukon, the number of cattle being slaughtered has increased, which has resulted in a greater amount of SRM being produced each year (B. Johnson, pers. comm., July 26, 2019).

At NNM, the SRM is currently isolated from the rest of the slaughter waste for separate disposal. Since operations began in the fall of 2016, a total of seven barrels of SRM has accumulated. Currently, the SRM is temporarily stored onsite in barrels. Once an adequate amount has accumulated, NNM representatives will personally transport the SRM to the Bessborough Landfill in British Columbia. Transportation of the SRM to Bessborough requires a Canadian Food Inspection Agency (CFIA) transport permit (B. Johnson, personal communication, July 26, 2019). To date, no SRM has been transported off the NNM property.

4.2 Biochemical Methane Potential

Based on the monthly weight of soft tissue generated from government-inspected slaughters at NNM from January to October in 2018 and 2019, the study team concluded that a total volume of 1,611 m^3 and 3,153 m^3 of biogas for 2018 and 2019, respectively, could theoretically be generated via the AD process (**Table 4.2**). This represents a 96% increase in potential biogas generation in 2019 compared to 2018. If soft tissue from all farm-gate sales were included, these values could be 25% higher. There is large variation in the potential for energy generation on a month-to-month basis. Since the potential for energy generation is directly correlated to the weight of waste generated, the peak season for energy generation is late summer and early fall.

Based on the theoretical volume of biogas generation, energy potential in terms of kilowatt hours and diesel fuel equivalents was also calculated (**Table 4.2**). A total of 968 and 1,892 litres of diesel fuel equivalents could be produced from January to October in 2018 and 2019, respectively. Moreover, a total of 9.68 megawatt hours (MWh) and 18.92 MWh of electricity equivalents could be produced from January to October in 2018 and 2019, respectively.

Table 4.2 Theoretical Monthly Energy Production (Biogas, Diesel Fuel Equivalents, Megawatt Hours) Based on Weight of Soft Tissue Disposed in 2018 and 2019.

	Unit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
2018	m^3	28	20	96	74	368	71	211	85	180	478	1,611
	dfe (L)	17	12	58	44	221	43	127	51	108	287	968
	MWh	0.17	0.12	0.60	0.44	2.21	0.43	1.27	0.51	1.08	2.87	9.68
2019	m^3	236	243	274	203	80	178	366	566	617	390	3,153
	dfe (L)	142	146	164	122	48	107	219	340	370	234	1,892
	MWh	1.42	1.46	1.64	1.22	0.48	1.07	2.19	3.40	3.70	2.34	18.92

Notes:

m^3: cubic metres.

dfe (L): diesel fuel equivalent measured in litres.

MWh estimates are based on an assumption of 100% efficiency.

5.0 DISCUSSION

5.1 Trends in Composition and Quantity

The Yukon agriculture industry has experienced consistent growth over the last decade. Specifically, the cattle, pork, and poultry sectors have grown, and the number of farms raising pork as well as the total number of pigs have increased substantially, with an eight-fold increase in pig production from 2011 to 2017 (Government of Yukon 2017). Factors responsible for the increase in livestock production include government investment in growing the Yukon agriculture industry, increased awareness of food security, and increased demand for locally raised meat products in Whitehorse restaurants and grocery stores (B. Johnson, pers. comm., 2019). The increase in livestock production has in turn resulted in an increased demand for year-round processing of inspected red meat, as well as an increase in slaughter waste requiring disposal. Based on historical trends, it is anticipated that the quantity of waste available for digestion at NNM will continue to increase.

These trends were supported by the data in this study. For example, the total number of animals slaughtered in 2019 was almost twice as many as 2018, and 7.5 times as many as 2017, over the same time period. Furthermore, the data show that on average, there was 400 kg more soft tissue waste produced on a monthly basis in 2019 than in 2018. In 2019, a total of 9.8 tonnes of soft tissue waste was generated from government-inspected slaughters in January to October, compared to 5.2 tonnes in 2018. The diversity of species slaughtered in 2019 also increased compared to 2018. For example, 34 sheep, 17 goat, and 1 elk were slaughtered in 2019, compared to zero of each of these species in 2018. Data from 2018 and 2019 confirmed there is an increase in slaughter waste requiring disposal during the late summer and fall.

5.2 Specified Risk Material

One challenge with managing the increased volume of slaughter waste is managing the increased volumes of SRM. Several SRM disposal methods are available, many of which require continuous management because they do not destroy the potentially BSE-infected prions. Canadian abattoirs may landfill or compost small amounts of SRM on site, and composted SRM may be spread on land that is not being grazed for a minimum of five years (FTGURC 2009; CAAP 2012). Other options include perpetual containment, disposal at a landfill that accepts SRM, or transfer of SRM to a rendering plant that makes bone meal and eventually landfills the reduced SRM (FTGURC 2009). In Yukon, options for SRM disposal are limited. None of Yukon's landfills will accept SRM, and there are no territorial treatment facilities that can denature SRM (CAAP 2012). Some farmers choose to bury or compost small amounts of SRM on their farm, but they must perpetually manage these areas to ensure no other livestock encounter the site.

BSE prions are extremely difficult to denature, so there are limited methods acceptable by the CFIA as adequate for destruction. Acceptable methods are incineration, which requires a temperature of at least 850^{o}C for a minimum of 15 minutes; gasification, which requires SRM to be under the moisture content threshold of 30%; alkaline hydrolysis, which produces a sterile aqueous liquid that can be turned into usable products such as soil additive, fertilizer, or bio-diesel fuel; and thermal hydrolysis, which is a pollution-free process that converts various wastes into value-added products. There are limited SRM disposal facilities currently operating in Canada, and each destruction process is very expensive to establish. Moreover, most facilities require high volumes of material to be processed to be economically feasible (FWC 2008, FTGURC 2009).

The CFIA is the regulatory body in charge of SRM management and requires Canadian abattoirs to follow strict protocols for managing and disposing SRM waste. The CFIA does not consider AD a suitable method of SRM disposal because the process does not reach a high enough temperature to denature the prions to a point satisfactory to the CFIA (FWC 2008). If untreated SRM is placed directly into an anaerobic digester with the other organic waste, the rest of the digestate is then be considered SRM (FWC 2008; A. Lewis, personal communication, August 1, 2019). To avoid substantially increasing the amount of SRM requiring management, the SRM would need to be treated by another process initially (e.g., incineration, gasification, hydrolysis). The SRM could then be safely placed in the digester with the other waste material (FWC 2008). However, the CFIA approved pre-treatment options are not economically feasible for a small and remote abattoir (FTGURC 2009). Presently, the best options for SRM management at NNM are to continue stockpiling SRM and eventually take it to the Bessborough Landfill or apply for a permit to compost and/or landfill the SRM onsite (A. Lewis, personal communication, August 1, 2019).

5.3 Biochemical Methane Potential

From an energy perspective, slaughter waste is ideal for biogas production because it contains high concentrations of energy-rich material such as blood, fat, and proteins (Bayr et al. 2012, Castellucci et al. 2013). However, too much of this energy-rich material can inhibit the production of biogas (Palatsi et al. 2011, Ek et al. 2011, Rajendran et al. 2012). For example, a successful anaerobic digester must have a feedstock with a carbon-to-nitrogen ratio of approximately 25:1. Since soft tissue is high in nitrogen, this tissue must be mixed with organic material that is high in carbon to obtain the optimum carbon-to-nitrogen ratio. To minimize buildup of inhibitory compounds and to optimize the output of biogas, literature has shown that a well-balanced combination of different feedstock material, known as co-digestion, is the most effective method (McDonald et al. 2008, Rajendran et al. 2012).

Co-digestion can improve nutrient balance, maintain pH, and result in positive synergisms between microorganisms, ultimately leading to increased economic viability of the digester system (Rajendran et al. 2012). In several studies, co-digestion resulted in a higher methane yield than did mono-digestion (Bayr et al. 2012, Castellucci et al. 2013). At a minimum, an equal amount of co-digestion material is expected to be mixed with the soft tissue for digestion purposes. Possible materials for co-digestion with slaughter waste include manure (cow, pig, horse, chicken, etc.), cardboard, straw, sawdust, food waste, spent brewery grains, or other agricultural or municipal organic waste.

Based on the monthly weight of soft tissue generated from government-inspected slaughters at NNM from January to October in 2018 and 2019, Hemmera's study team concluded that total theoretical biogas volumes of 1,611 m^3 and 3,153 m^3 for 2018 and 2019, respectively, could be generated via the AD process. These biogas volumes could be substantially increased if the slaughter waste were co-digested with at least an equal weight of the organic material listed above. In fact, without co-digestion with a carbon-rich organic material, exclusive digestion of slaughter waste is likely to face challenges and possible system failure.

In summary, our team is confident in the methodological approach used to perform the characterization and calculations, and is therefore, confident in the results

6.0 RECOMMENDATIONS

This study has identified a growing demand for the services provided by Naturally Northern Meats. With this demand, comes an increase in slaughter waste that must be properly handled, stored, and disposed. Not only can AD provide a waste management solution for NNM, it can also generate value-added commodities such as renewable energy and a nutrient-rich digestate. Therefore, further research to understand the costs and benefits of installing a digester at NNM is worth considering. Based on the results of this study, Hemmera offers two recommendations to advance the development of AD technology at NNM: (1) undertake a pilot-study, and (2) conduct a feasibility study.

6.1 Pilot Study

Balance BioGas, in partnership with Hemmera, has received financial support to design, construct, and undertake a pilot-study during the first half of 2020. The purpose of the pilot-study is to (1) validate the theoretical BMP values used in this study, (2) quantify the energy required to operate the pilot-study, and (3) characterize the chemical and biological parameters of the feedstock used and digestate produced. One outcome of the pilot-study will be the development of a feedstock recipe to optimize the co-digestion of three different feedstocks: soft tissue slaughter waste, food waste, and pig manure.

6.2 Feasibility Study

Following the results of the pilot-study, a feasibility study will be required to evaluate the costs and benefits of constructing and operating a digester at NNM. The feasibility study will include the following items:

1. Permitting Overview

   The regulatory constraints of installing an AD system in Yukon will need to be understood early in the development process. A permitting memo is recommended that will outline and discuss the regulatory/permitting requirements necessary for implementation of an AD system in Yukon.

2. Waste Audit

   An updated and expanded Waste Characterization Study will be required to accurately quantify all currently available and potential additional sources of organic material available for digestion at NNM.

3. Digester Design

   A full-scale design will be required to predict the costs incurred from the construction, operation, maintenance, and permitting of an AD system at NNM.

4. Expenses

   An analysis of the estimated costs incurred for the construction, operation, maintenance, and permitting of an AD system at NNM will be completed.

5. Cost Savings

   Based on the actual BMP values determined during the pilot-study, estimated values for energy offset from using biogas will be presented.

6. Revenue Potential

   The revenue potential from tipping fees and the sale of digestate will be evaluated and discussed.

7. Greenhouse Gas Offset Analysis

   One of the many benefits of AD is the reduction in greenhouse gas emissions through methane capture. The Government of Canada, through Environment and Climate Change Canada, is developing a new regulation to reduce greenhouse gas emissions through the increased use of lower carbon fuels and alternative technologies. The Clean Fuel Standard aims to reduce greenhouse gas emissions by 30 million tonnes annually by 2030 by implementing a carbon pricing strategy. The goal of pricing carbon is to incentivize investment into cleaner fuels and more efficient operations. By quantifying the amount of greenhouse gases that can be offset by implementing AD technology, an economic value can be assigned to those emission reductions.

8. Market Analysis

   A market analysis will be performed to evaluate the market potential for small-scale AD in Yukon and Canada. Factors influencing the market potential include: increased awareness of the benefits of the technology, technical reliability of the technology, increased government programs designed to cost share in the development of these systems; and the emergence of new government policies designed to expand growth in reliable renewable energy markets.

7.0 CLOSURE

In closing, we sincerely appreciate the opportunity to have conducted this Waste Characterization Study for Naturally Northern Meats on behalf of Balance Biogas.

If you have any questions, please do not hesitate to contact Devon Yacura by phone at 867.456.4865 ext. 718 or by email at dyacura@hemmera.com.

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8.0 REFERENCES

AgTech Centre. 2013. Energy Opportunities Anaerobic Digestion: Meat Processing. Prepared for the Government of Alberta.

Bayr, S., M. Rantanen, P. Kaparaju, and J. Rintala. 2012. Mesophilic and thermophilic anaerobic co-digestion of rendering plant and slaughterhouse wastes. Bioresource Technology 104:28–36.

Beef Cattle Research Council (BCRC). 2018. Specified Risk Material (SRM) Disposal. Available at www.beefresearch.ca/research-topic.cfm/specified-risk-material-srm-disposal-52

Bosu, R., S.K. Talukdar, and M.A. Zahed. Biogas utilization from biomass and kitchen waste and its impact on energy cost on a university campus. American Journal of Engineering Research 5:150–157.

Canadian Agricultural Adaptation Program (CAAP). 2012. Analysis of Waste Management Strategies for On-Farm Meat Processing. Available at http://www.yukonag.ca/cms-assets/documents/93494-974040.on-farmwastemanagement.pdf.

Canadian Biogas Association. 2019. Canadian Anaerobic Digestion Guideline – Draft. Available at https://biogasassociation.ca/resources/

Canadian Food Inspection Agency (CFIA). 2019. Guidance on Specified risk material (SRM). Available at https://www.inspection.gc.ca/food/food-specific-requirements-and-guidance/meat-products-and-food-animals/srm/eng/1369768468665/1369768518427

Castellucci, S., S. Cocchi, E. Allegrini, and L. Vecchione. 2013. Anaerobic digestion and co-digestion of slaughterhouse wastes. Journal of Agricultural Engineering, XLIV (s2):e104.

Ek, A.E.W., S. Hallin, L. Vallin, A. Schnürer, and M. Karlsson. 2011. Slaughterhouse waste co-digestion – Experiences from 15 years of full-scale operation. World Renewable Energy Congress. May 8–13, 2011, Linköping, Sweden.

Ference Weicker & Company Ltd. (FWC). 2008. Specified Risk Material Containment and Destruction Options and Evaluations for the Fraser Valley. British Columbia Ministry of Agriculture and Lands. Available at https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/agriculture-and-seafood/agricultural-land-and-environment/waste-management/specified-risk-material/srm_containment_and_destruction_options_fraser_valley.pdf

From the Ground Up Resource Consultants Inc. (FTGURC). 2009. Slaughterhouse Waste and Specified Risk Material (SRM) Management Study. Available at https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/agriculture-and-seafood/agricultural-land-and-environment/waste-management/specified-risk-material/slaughterhouse_waste_and_srm_mgmt_study_vancouver_island.pdf

Government of Oklahoma. n.d. How much meat? Oklahoma Department of Agriculture, Food & Forestry. Food Safety Division, Meat Inspection Services.

Government of Yukon. 2017. Yukon Agriculture State of the Industry Report: 2013 to 2017. Prepared by Department of Energy, Mines and Resources, Agriculture Branch.

International Renewable Energy Agency (IRENA). 2016. Measuring Small-scale Biogas Capacity and Production. Abu Dhabi, United Arab Emirates.

Kelleher Environmental. 2013. Canadian Biogas Study: Benefits to the Economy, Environment and Energy. Technical Document. Prepared for the Canadian Biogas Association.

McDonald, T., G. Achari, and A. Abiola. 2008. Feasibility of increased biogas production from the co-digestion of agricultural, municipal, and agro-industrial wastes in rural communities. Journal of Environmental Engineering and Science 7:263–273.

Natural Resources Canada (NRCan). 2013. ARCHIVED – Step 1: Calculate your energy costs and consumption. Available at https://www.nrcan.gc.ca/maps-tools-publications/publications/energy-publications/energy-efficiency-publications/energy-efficiency-buildings/step-1-calculate-your-energy-costs-and-consumption/6561

Palatsi, J., M. Viñas, M. Guivernau, B. Fernández, and X. Flotats. 2011. Anaerobic digestion of slaughterhouse waste: Main process limitations and microbial community interactions. Bioresource Technology 102:2219–2227.

Rajendran, K., S. Aslanzadeh, and M.J. Taherzadeh. 2012. Household biogas digesters – A review. Energies 5:2911–2942.

Rodríguez-Abalde, A., B. Fernández, G. Silvestre, and X. Flotats. 2011. Effects of thermal pre-treatments on solid slaughterhouse waste methane potential. Waste Management 31:1488–1493.

Ware, A., and N. Power. 2016. Biogas from cattle slaughterhouse waste: Energy recovery towards an energy self-sufficient industry in Ireland. Renewable Energy 97:541–549.

World Nuclear Association. 2018. Heat values of various fuels. Available at https://www.world-nuclear.org/information-library/facts-and-figures/heat-values-of-various-fuels.aspx

8.1 Personal Communication

Johnson, Brynn. Owner of Naturally Northern Meats. Numerous face-to-face conversations in 2019.

Lewis, Alicia. Canadian Food Inspection Agency Representative in Dawson Creek. Phone call on August 1, 2019.

APPENDIX A
Slaughter Record Form