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Canada

TECHNICAL PROTOCOL PLAN FOR METHANE CAPTURE FROM THE ANAEROBIC TREATMENT OF INDUSTRIAL WASTEWATER

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Version 1

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B.1 Description of the Project Type and How Real Reductions Will be Achieved

Introduction

The anaerobic treatment of wastewater containing high loadings of organic matter has been recognized as a source of greenhouse gas emissions by the Intergovernmental Panel on Climate Change (IPCC) and domestically by Environment Canada (EC) in the 2005 National GHG Inventory. The National Inventory reports GHG emissions from the treatment of municipal and industrial wastewater in Section 8.3 under "Wastewater Handling". In 2005, GHG emissions from wastewater treatment in Canada were 930 kt CO2e (an increase of 19% since 1990), of which 250 kt CO2e were from methane emissions.[1]

In the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (Volume 4), Chapter 6.0 outlines the sources of GHG emissions from wastewater treatment and discharge. IPCC states that "wastewater as well as its sludge components can produce CH_4 if it degrades anaerobically. The extent of CH_4 production depends primarily on the quantity of degradable organic material in the wastewater, the temperature, and the type of treatment system. With increases in temperature, the rate of CH_4 production increases. This is especially important in uncontrolled systems and in warm climates. Below 15°C, significant CH_4 production is unlikely because methanogens are not active and the lagoon will serve principally as a sedimentation tank. However, when the temperature rises above 15°C, CH_4 production is likely to resume. The principal factor in determining the CH_4 generation potential of wastewater is the amount of degradable organic material in the wastewater. Common parameters used to measure the organic component of the wastewater are the biochemical oxygen demand (BOD) and chemical oxygen demand (COD). Under the same conditions, wastewater with higher COD, or BOD, concentrations will generally yield more CH_4 than wastewater with lower COD (or BOD) concentrations"[2].

BOD is defined as the amount of oxygen required by aerobic microorganisms to decompose the organic matter in a sample of water, such as that polluted by sewage. The BOD_5 test is a common analysis performed to determine the degree of water pollution from degradable organic compounds in wastewater. BOD_5 test measures the rate of oxygen uptake by micro-organisms in a sample of water at a temperature of 20°C and over an elapsed period of five days in the dark. In this protocol, the term BOD is used to represent BOD_5 following IPCC 2006 guidance.

[1] National Inventory Report, 1990-2005: Greenhouse Gas Sources and Sinks in Canada (Environment Canada 2005)
[2] IPCC Guidelines for National Greenhouse Gas Inventories: Volume 4, Chapter 6.0 (2006)

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COD is defined as the amount of oxygen required to chemically oxidize organic compounds in water. The COD test is a common water quality test used to indirectly measure the total amount of organic compounds in a water sample using a strong oxidizing agent such as potassium dichromate. A high COD value indicates a high concentration of organic matter in the water sample.

In regard to industrial wastewater, the IPCC states that: "The assessment of CH_4 production potential from industrial wastewater streams is based on the concentration of degradable organic matter in the wastewater, the volume of wastewater, and the propensity of the industrial sector to treat their wastewater in anaerobic systems. Using these criteria, major industrial wastewater sources with high CH_4 gas production potential can be identified as follows:

- Pulp and paper manufacture,
- Meat and poultry processing (slaughterhouses),
- Alcohol, beer, starch production,
- Organic chemicals production,
- Other food and drink processing (dairy products, vegetable oil, fruits and vegetables, canneries, juice making, etc.). [3]"

Of particular interest in Alberta with its large agricultural base are the meat and poultry processing industries that are known to produce large volumes of wastewater that contain high levels of degradable organics. Meat and poultry processing facilities typically employ anaerobic lagoons to treat their wastewater, which are amenable to methane generation.[4] The non-animal food and beverage industries produce considerable amounts of wastewater with significant organic carbon levels and are also known to use anaerobic processes such as lagoons and anaerobic reactors.

This technical protocol plan and the proposed protocol are focused on industrial wastewater treatment systems in the food processing industry and the quantification of associated GHG emissions.

Overview of GHG Reduction Activity

The proposed protocol is applicable to projects that involve the capture and destruction of methane produced from anaerobic wastewater treatment processes such that the venting of biogas to the atmosphere is prevented. The feedstock to the anaerobic digestion system may be untreated industrial wastewater or sludge produced from other wastewater treatment processes at the project site. The most common baseline configuration would be the use of an uncovered deep anaerobic wastewater lagoon where biogas was vented to the atmosphere; however, other facilities may already operate more sophisticated anaerobic digester systems to treat raw wastewater effluents or sludges with high organic loadings but may not utilize the produced biogas.

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[3] Ibid.
[4] Ibid.

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The proposed protocol is also applicable to projects that implement new equipment to utilize the produced biogas, where previously all biogas captured from the anaerobic wastewater treatment systems was flared without energy recovery. The additional GHG reductions arise from the displacement of fossil fuels with biogas produced at the site and from the higher methane destruction efficiency of a controlled combustion device.

The proposed protocol is intended to be applied to anaerobic wastewater treatment systems used in the food processing industry and, as such, may not be suitable for all other types of wastewater treatment systems. In addition, project proponents implementing other types of anaerobic digesters to produce biogas from agricultural residues, source separated organic materials, or energy crops should refer to the Alberta Offset System *Quantification Protocol for the Anaerobic Decomposition of Agricultural Materials*[5]. It should be noted that there is potential for overlap between this quantification protocol and the *Quantification Protocol for the Anaerobic Decomposition of Agricultural Materials,* as some centralized anaerobic digestion projects may treat a variety of organic materials including wastewater or sludges that originate from facilities that would have anaerobically treated the wastewater stream in the baseline such that methane would have been emitted to the atmosphere as defined under the proposed protocol. In such instances the project proponent may refer to this proposed protocol to account for the avoided emissions from wastewater treatment.

Alberta Offset System Eligibility Criteria

In order for a GHG emission reduction activity to create eligible offsets in the Alberta Offset System, a number of eligibility criteria must be met under the Specified Gas Emitters Regulation (SGER), as specified in the February 2008 Offset Credit Project Guidance Document. A summary of how the proposed protocol will address each of the relevant eligibility criteria is given in Table 1, below.

Table 1: Alberta Offset System Eligibility Criteria

Principle	Analysis
Start Date	The proposed protocol is applicable to projects initiated after January 1, 2002 that have implemented systems to capture and destruct methane produced from anaerobic wastewater treatment processes that prevent the venting of biogas to the atmosphere. These systems could be installed as retrofits or modifications to existing wastewater treatment operations or implemented at new greenfield facilities as the best available control technology.
Crediting Period	Projects applying this protocol will have a credit duration period of 8 years, consistent with Alberta Offset System guidelines.
Real	The implementation of a methane capture and destruction system in conjunction with an existing or new anaerobic wastewater treatment system is a specific and tangible action to reduce net GHG emissions associated with the treatment of wastewater streams containing significant amounts of degradable organic materials.

[5] http://www.environment.alberta.ca/documents/Biogas_Protocol_v1_Sept_07.pdf

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	This project activity is not considered to be business as usual, as there are a variety of wastewater treatment processes that have been implemented in Canada that use anaerobic treatment systems such as open anaerobic lagoons that vent methane to the atmosphere.
Demonstrable, Quantifiable	GHG reductions from the capture of methane from anaerobic wastewater treatment systems can be quantified following scientifically acceptable methods based on actual measurement and monitoring. The quantification approaches discussed in this document and the proposed protocol are derived from consensus-based good practice guidance documents developed internationally (refer to section B.2) that give a high degree of certainty with regard to the sources and sinks of GHG emissions associated with anaerobic wastewater treatment. The quantification methodologies outlined in the proposed protocol utilize mass and energy balances that provide a high level of accuracy and reliability through the use of site-specific measurements and internationally recognized models for determining methane emissions from the anaerobic decay of organic matter contained in wastewater. The data management requirements discussed in the proposed protocol are rigorous with regard to tracking the actual mass flow rates of organic matter into and out of the anaerobic treatment unit and the biogas compositions and flow rates into a combustion device to ensure that real GHG reductions are occurring. Collectively, these steps ensure that the GHG reductions are demonstrable and quantifiable.
Not Required by Law	Under current Alberta legislation, there are no requirements to implement methane capture systems in conjunction with anaerobic wastewater treatment units. Therefore, the implementation of a methane capture system in conjunction with an existing or new anaerobic wastewater treatment unit would be surplus to regulation.
Ownership	For consistency with other Alberta Offset System protocols, the proposed protocol does not explicitly assign ownership but instead states the minimum data collection requirements in order to adequately quantify the net GHG benefit from the project activity. It is therefore up to each project proponent to provide proof of ownership of all offsets claimed at the time of third-party verification or upon request by Alberta Environment.
Counted Once	The proposed protocol is not applicable to facilities defined as large final emitters (LFEs) under the Specified Gas Emitters Regulation (SGER). Provided that this criterion is followed, the creation of offsets using the proposed protocol would result in GHG reductions that had not already been counted for compliance purposes.
Verifiable	In general, data quality management must include sufficient data capture such that the mass and energy balances may be easily performed with the need for minimal assumptions and use of

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	contingency procedures. The data should be of sufficient quality to fulfill quantification requirements and be substantiated by company records for the purpose of verification. The primary data would be the mass of COD destructed, the volume of biogas combusted, and the energy output of any combustion devices. Therefore, the proposed approach would be for the project proponent to conduct regular monitoring of each parameter on-site to ensure that the mass and energy balances can be performed with sufficient accuracy.
Occurred in Alberta	Only projects located in Alberta are eligible for offsets. The proposed protocol applies to projects located in Alberta that implement methane capture and destruction systems in conjunction with anaerobic wastewater treatment units.

B.2 Description of Background Information / Best Practice Guidance Used

During the development of the proposed protocol, a significant amount of background information on anaerobic wastewater treatment practices and the flaring and utilization of biogas produced from anaerobic digestion systems was gathered from Canadian and international sources. This information provided the foundation to identify relevant sources and sinks of GHG emissions, to identify potential project and baseline scenarios, to develop the GHG quantification approaches for relevant sources and sinks, and to account for relevant policies. A list of the guidance documents used is provided in Table 2, below.

TABLE 2: Good Practice Guidance Documents

1. Document Title	2. Publishing Body / Date	3. Description
General Protocol Guidance		
ISO 14064-2: 2006: Specification with guidance at the project level for quantification, monitoring and reporting of greenhouse gas emission reductions or removal enhancements	International Standards Organization, 2006	ISO 14064-2:2006 specifies principles and requirements and provides guidance at the project level for quantification, monitoring and reporting of activities intended to cause greenhouse gas (GHG) emission reductions or removal enhancements. It includes requirements for planning a GHG project, identifying and selecting GHG sources, sinks and reservoirs relevant to the project and baseline scenarios, monitoring, quantifying, documenting and reporting GHG project performance, and managing data quality.
National Inventory Report, 1990-2005: Greenhouse Gas Sources and Sinks in Canada	Environment Canada, April 2007	On behalf of the Government of Canada, Environment Canada develops and publishes Canada's GHG inventory annually. The inventory reporting format is based on international reporting methods agreed to by the Parties to the UNFCCC, using the procedures of the Intergovernmental Panel on Climate Change (IPCC).

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1. Document Title	2. Publishing Body / Date	3. Description
Guidelines for National Greenhouse Gas Inventories: Volume 5-Waste. Chapter 6 Wastewater Treatment and Discharge.	Intergovernmental Panel on Climate Change (IPCC), 2006.	This document provides IPCC Tier 1, 2 and 3 methods of quantifying GHG emissions from the municipal and industrial wastewater treatment for the preparation of national GHG inventories.
Alberta Offset System Offset Credit Project Guidance Document	Alberta Environment, February 2008	This Offset Credit Project Guidance Document is one of a series of guidance documents prepared for the Specified Gas Emitters Regulatory Framework. The purpose of this Guide is to outline the process and requirements for undertaking offset projects in Alberta.
A National Inventory of Greenhouse Gas (GHG), Criteria Air Contaminant (CAC) and Hydrogen Sulphide (H2S) Emissions by the Upstream Oil and Gas Industry	Clearstone Engineering Ltd. on behalf of the Canadian Association of Petroleum Producers (CAPP), September 2004	This document was used for emission factors to calculate GHG emissions from fuel combustion as well as the upstream emissions from extraction and production of those fuels.
Quantification Protocols		
CDM Approved Consolidated Baseline and Monitoring Methodology ACM0014 -Avoided Methane Emissions from Wastewater Treatment version 2.1	UNFCCC and CDM Executive Board. May 2008. Version 2.1 was a revision of Version 01, which was released in November 2007.	ACM0014 specifies the quantification methods for determining the baseline and monitoring methodology for wastewater treatment projects that avoid the release of methane emissions. Applicable to projects that capture and flare or utilize biogas normally emitted from anaerobic lagoons or sludge pits. Two quantification approaches are provided for determining GHG emissions from anaerobic wastewater treatment.
Alberta Quantification Protocol for the Anaerobic Decomposition of Agricultural Materials	Alberta Environment. September 2007	GHG quantification protocol for the anaerobic digestion of agricultural materials (e.g. manure). Quantification methods are provided for biogas flaring, venting, utilization for energy recovery (heat, power and upgrading to pipeline quality), and diversion of organic wastes from landfill.
Draft GE AES Methodology for Waste Water Treatment Methane Capture and Destruction Projects Version 1.1	GE AES Greenhouse Gas Services, LLC. August 22, 2007	This document establishes a methodology for the quantification of greenhouse gas (GHG) emissions reductions or credits from organic wastewater treatment in North America. This includes the quantification of GHG emission reductions from the displacement of fossil fuels with methane captured from the wastewater treatment system.
Technical Resources		

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1. Document Title	2. Publishing Body / Date	3. Description
Innovative Biological Treatment Processes for Wastewater in Canada	Catherine N. Mulligan and Bernard F. Gibbs. Water Qual. Res. J. Canada, 2003. Volume 38, No2, 243-265.	This document provides guidance on the types of wastewater treatment technologies (aerobic and anaerobic) used in Canada.
ConAgra Foods: Improving Process Wastewater Operations at a Lamb Weston Plant in Canada.	Global Environment Management Institute. www.gemi.org/waterplanner.	This document outlines the highlights of an anaerobic wastewater treatment project initiated at a potato processing facility in Alberta.
Treatment of Slaughterhouse Wastewater in Anaerobic Sequencing Batch Reactors	Masse, D.I. Agriculture and Agri-Food Canada. June 2000.	This document outlines the properties of slaughterhouse wastewater and appropriate treatment technologies.
Advanced Biological Treatment Processes for Industrial Wastewaters: Principles and Applications.	Cervantes, F.J., Pavlostathis, S.G. and Van Haandel, A.C. IWA Publishing, 2006.	This document provided background information on anaerobic wastewater treatment processes.
Verification of Blue Source Emissions Reductions Credits from Methane Capture and Flare Projects at Tyson Foods Facilities	Michael M. Coté and Ronald C. Collings. Raven Ridge Resources Inc. February 23, 2004.	This document is the verification report for emission reductions claimed from Tyson's five wastewater treatment methane capture projects. This document discusses the data collection and monitoring programs used to create verified emission reductions.
US EPA CFR Part 60.18 New Source Performance Standards	US EPA. July 2006.	This document outlines background information on operational requirements and efficiencies of waste gas flares in the U.S.
Understanding Commercial Opportunities in the Biogas Sector in Canada	Goodfellow Agricola Consultants Inc. Alberta Agriculture Food and Rural Development. March 2006.	This document provided background information on biogas generation and utilization opportunities in Alberta and Canada.

B.3 Regulatory, Legal Requirements and/or Government Incentive/Grant Programs

<u>Relevant Climate Change Regulations</u>

In Alberta, the Specified Gas Emitters Regulation applies to facilities with GHG emissions of greater than 100,000 tonnes CO_2e per year, which are referred to as large final emitters (LFEs). All facilities exceeding this threshold are required to reduce GHG emissions by 12% on an intensity basis beginning July 1, 2007. Because of these requirements, any facility classified as an LFEs is not eligible for offset generation, as any GHG emission reduction activity that occurs within the boundary of an LFE site will be subject to the SGER. In Alberta, there were no food processing facilities or wastewater treatment plants subject to the SGER in 2007.

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In April 2007, the federal government of Canada released the Regulatory Framework for Air Emissions, which outlined the broad design for regulations of industrial emissions of air pollutants and greenhouse gases. In March 2008, the federal government then provided further details on the proposed regulation of GHGs through the "Turning the Corner" document titled "Regulatory Framework for Industrial Greenhouse Gas Emissions." This framework provided more detailed sector specific regulations for large emitting facilities and included mention of the planned use of a sector-wide approach that would require an 18% reduction based on 2006 intensity levels for many industries. There were no targets set for the food processing industry or for wastewater treatment operators.

No other relevant climate change regulations were identified.

Other potentially relevant regulations / requirements

At this time no specific legal requirements were identified in Alberta that would require food processing facility operators to invest in systems to capture and combust methane emitted from their anaerobic wastewater treatment systems.

In Alberta, industrial facilities, including those in food processing industries that operate wastewater treatment facilities, require an environmental approval (EA) under the Environmental Protection and Enhancement Act in order to operate. Within an environmental approval, air emissions and wastewater discharges are both subject to a variety of terms and conditions, which vary depending on the specific activities undertaken at the facility. Each EA includes air emissions monitoring and reporting requirements for point sources (such as stacks) and some sources of fugitive emissions to ensure that provincial air quality objectives (such as air emission limits) are being met and that nearby residents are not negatively affected by operations at the site (through odour, for example). Most environmental approvals do not specifically refer to greenhouse gas emission reduction requirements and emissions of methane (for example, from anaerobic wastewater lagoons) are not normally subject to specific thresholds as compared to other air contaminants such as volatile organic compounds and odorous compounds that may be emitted from wastewater treatment operations.

In Alberta, environmental approvals also specify industrial wastewater management practices, wastewater monitoring/testing requirements, acceptable means of discharging wastewater to off-site facilities or surface water bodies, and end-of-pipe wastewater effluent limits that must be met by the operator. Most EAs, however, do not specify the method or technology that the operator must use in order to treat the industrial wastewater effluent to within the specified limits.

In the EA for Cargill's High River beef processing facility an "industrial wastewater control system" is defined to mean the parts of the plant that collect, store, or treat industrial wastewater; however, there are no specific references as to how the industrial wastewater control system should be operated or how it should control methane releases to the atmosphere.

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The most relevant wastewater discharge limits specified in the EA for Cargill's High River facility are the five day BOD limits (BOD_5), which are specified at a maximum daily average of 70kg BOD_5/day and a maximum daily release of 160 kg BOD_5/day[6]. The monitoring of BOD_5 is specified in the EA to be conducted at a minimum frequency of once per month at the influent to the industrial wastewater control system and three times per week at the effluent discharge to the nearby surface water body.[7]

The land application of sludge or digestate from anaerobic wastewater treatment units or digesters may be required to meet the allowable nutrient loading levels recommended by the Agricultural Operations Practices Act and Regulations. Any limitations on the land application of sludge are not expected to impact the eligibility of anaerobic wastewater treatment projects, as land application would normally occur with any type of wastewater treatment process (aerobic or anaerobic) and anaerobic treatment units have been shown to significantly reduce sludge generation compared to aerobic systems.[8]

Based on the review of a relevant environmental approval for Cargill's High River facility, there do not appear to be any specific requirements related to the capture and combustion of methane emitted from the anaerobic wastewater treatment unit that would affect the eligibility of that facility to generate offsets. Therefore, it appears unlikely that specific requirements would exist under the Alberta EA process that would require the capture and combustion of methane produced from anaerobic wastewater treatment processes at other facilities. However, each individual project proponent would have to assess their facility's EA to ensure that no requirements exist that would render their methane capture project ineligible to generate offsets under the Alberta Offset System.

Potentially relevant climate change incentives

There were no incentives identified for anaerobic wastewater treatment or biogas projects that were explicitly termed climate change incentives; however, several programs were identified that do provide incentives to biogas projects that generate energy.

In 2006, Alberta released a Nine-Point Bio-Energy Plan, which included a total of $239 million to be invested over five years to bio-energy projects through producer credit programs, capital investments, and feasibility and market development studies. The program states that "methane from anaerobic digestion processes" is eligible under the producer credit program: subsidies are 2 cents per kilowatt hour (kWh) for production from capacity of 3 megawatts (MW) or more, and 6 cents per kWh for production from capacity of less than 3MW.[9] The Bio-Energy Infrastructure Development Program (BIDP) also identifies cogeneration units and biogas upgrading facilities as eligible infrastructure for grants.

[6] Alberta Environmental Approval 683-02-00. Cargill Limited.
[7] Ibid.
[8] Innovative Biological Treatment Processes for Wastewater in Canada. Water Quality Res. Journal Canada. 2003. Mulligan C & Gibbs B.
[9] Bio-fuel and Bio-gas Producer Credit Program Guidelines. Alberta Energy Nine-Point Bio-Energy Plan.

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The Federal ecoENERGY program for Renewable Power also provides an incentive of one cent per kilowatt-hour for up to 10 years to eligible low-impact, renewable electricity projects constructed over between April 1, 2007 to March 31, 2011. Projects that use biogas to produce electricity are eligible to participate provided that they meet the requirements of Environment Canada's Environmental Choice™ program Criteria Document CCD-003.[10]

The Federation of Canadian Municipalities (FCM) has a Green Municipal Fund (GMF) program, which provides a variety of loans or grants for sustainable projects, including projects that involve upgrades to wastewater treatment plants and implementation of energy generation systems using biogas. GMF has provided funding to several municipal wastewater treatment facilities to replace existing biogas flare systems with energy recovery units, including those in Red Deer and Fort Saskatchewan.[11] The greatest level of funding attainable is loans, loans with grants of up to 80% of capital costs associated with a project or grants for up to 50% of costs of a project (up to a maximum of $350,000).

Elsewhere in Canada, the Ontario Biogas Systems Financial Assistance Program is a $11.2-million investment program designed to help farmers and agri-food businesses develop biogas generation and utilization systems. The program will cover up to 70% of eligible costs for feasibility studies and up to 40% of eligible costs associated with construction and implementation.[12]

There are programs that have provided subsidies to biogas projects in Manitoba and Quebec; however, most of these projects utilize animal wastes as feedstocks rather than wastewater from food processing facilities.

B.4 Barriers to Implementation

There are a variety of barriers that may affect the development of an anaerobic wastewater treatment system with methane capture and combustion infrastructure. The most significant barrier is likely the capital cost of implementing a methane capture and destruction system in conjunction with an existing or new anaerobic treatment unit. The capital costs for a particular project would vary greatly depending on the infrastructure already in place at the site.

The main costs of retrofitting an existing open anaerobic lagoon would be the synthetic lagoon covers that are used to capture the produced biogas. The installation of a brand new enclosed anaerobic treatment unit, such as an Upflow Anaerobic Sludge Blanket (UASB), would require a larger investment in the anaerobic treatment unit itself and

[10] ecoENERGY Program for Renewable Power. Government of Canada.
[11] Green Municipal Fund Approved Projects Database. Federation of Canadian Municipalities. Accessed 11-17-2008. http://www.sustainablecommunities.ca/Search/Search/Search.aspx?lang=e
[12] Ontario Biogas Systems Financial Assistance Program. OMAFRA. Accessed 11-17-2008, http://www.omafra.gov.on.ca/english/engineer/biogas/

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limited equipment to capture the biogas. At the Lamb Weston site in Taber, Alberta, the implementation of a new anaerobic treatment unit cost $5.3 million.[13]

Both covered lagoon systems and enclosed reactors would still require additional infrastructure to condition the biogas and remove water vapour, hydrogen sulphide, and other contaminants prior to combustion in an energy recovery unit such as a boiler or engine. The project may also have to install a new flare as the primary or secondary method to ensure methane destruction. For projects that recover energy from biogas, the level of capital investment would again depend on whether existing boilers were available at the site to utilize the biogas or if new engines and generators were purchased to generate electricity for the grid.

Projects upgrading biogas to pipeline quality would also have substantial upfront costs for biogas purification, CO2 removal, and compression. In each case, the return on investment would have to be evaluated to justify spending a large amount of capital to move forward with project development. Many project developers may simply not have access to sufficient capital to develop the project either. The opportunity to obtain an additional revenue stream from the sale of verified GHG emission reductions could help make many projects more economically viable.

Other impediments to project development could include the lack of a nearby user to utilize the produced biogas (raw or upgraded), heat or power generated at the project site. The ability to interconnect to the electricity grid or to tie into the natural gas pipeline may also be difficult in some jurisdictions.

Other barriers could include training operators on the operation of the anaerobic wastewater treatment system, if such a system was not previously in place, and training operators how to operate and maintain new biogas conditioning and energy generation equipment. The operation of this equipment would likely fall outside day-to-day operations at the processing facility and plant workers would need to be trained in operations, maintenance, and trouble-shooting the equipment.

B.5 Review of Technology / Scientific Knowledge

Anaerobic digestion is a biological process in which the decomposition of organic matter occurs under oxygen-free conditions, resulting in the generation of biogas, consisting of 60 to 80% methane, 20 to 40% carbon dioxide, and various trace compounds such as hydrogen sulphide and ammonia.[14] The anaerobic digestion process begins with a hydrolysis step in which the feedstock materials are broken down by bacteria into organic polymers such as carbohydrates that are made available for other bacteria. Acidogenic (acid forming) bacteria then convert the sugars and amino acids into carbon dioxide,

[13] ConAgra Foods: Improving Process Wastewater Operations at a Lamb Weston Plant in Canada.

[14] Anaerobic Digestion. Alberta Agriculture and Rural Development. http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/eng4468

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hydrogen, ammonia, and organic acids. Acetogenic bacteria then convert these resulting organic acids into acetic acid, along with additional ammonia, hydrogen, and carbon dioxide.[15] Methanogenic (methane forming) bacteria finally convert these products to methane and carbon dioxide, which are collectively referred to as biogas.

In order to optimize the production of methane, it is necessary to maintain a controlled process, specifically with respect to temperature. The optimum temperatures for anaerobic digestion are in the mesophilic (35-40°C) and thermophilic ranges (55-60°C). Digesters operating within the thermophilic range are characterized by a shorter retention time but have a higher susceptibility to upsets than digesters operating in the mesophilic range.

There are a wide variety of off-the-shelf anaerobic wastewater treatment systems that can be applied to treat wastewater with high COD loadings. Some of the common types of digesters are described below.

Types of Anaerobic Digesters

The most common types of anaerobic digesters used by the food processing industry are anaerobic lagoons, upflow anaerobic sludge blanket (UASB) reactors and expanded granular sludge bed (EGSB) reactors. There are a wide range of digesters used to process manure and other organic materials, such as complete mix digesters, plug flow digesters, and covered lagoons, but these digesters may or may not be suited to wastewater treatment applications. For this reason, only the most common types of digesters used in wastewater treatment applications are discussed below.

Anaerobic lagoons are the simplest type of digester commonly used to treat high strength concentrated industrial wastewater streams. These lagoons are generally 2 to 6 metres deep and are designed primarily based on the wastewater effluent flow rate from the processing facility and the retention time required to ensure a high level of COD destruction. Systems that handle warm wastewater effluent will operate more effectively and produce more biogas than comparable systems exposed to ambient temperatures, especially in cold climates. It is common for scum to form on the top of most anaerobic lagoons, specifically at meat processing facilities where a grease cap is commonly observed. This scum or grease cap stops air from mixing with the wastewater and reduces oxygen contact with the anaerobic bacteria, which in turn helps the anaerobic bacteria thrive at all depths of the lagoon. Anaerobic lagoons are frequently used to handle and treat animal manure from confined animal feeding operations. The lagoon serves to partially stabilize the organic matter in the wastewater stream before periodic land application. Anaerobic lagoons are often followed by further aerobic treatment to meet effluent discharge limits.

The UASB reactor uses a blanket of granular sludge that is suspended in the tank to enable contact between the inlet wastewater stream and the anaerobic bacteria contained

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[15] Anaerobic Digestion. http://www.waste.nl/content/download/472/3779/file/WB89-InfoSheet(Anaerobic%20Digestion).pdf

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in the sludge bed. Wastewater flows upwards through the blanket and is digested (degraded) by the anaerobic microorganisms. The sludge blanket is kept in place based on the settling properties of the granules of bacteria that have aggregated together that are subject to the downward force of gravity and the upward flow of the inlet wastewater.[16] The ability of the bacteria to aggregate enables them to be retained within the digester without being washed out. The solid particles are generally retained within the digester for one to three months while the liquid passes through the digester within hours or days. This keeps the reactor small in size, but concentrated in terms of biological activity in the sludge.

UASB reactors are ideally suited to dilute wastewater streams with low solid levels and can be used to treat wastewater with only a few hundred mg/L of COD. The distinguishing feature between UASB and EGSB is that a faster rate of upward-flow velocity is designed for the wastewater passing through the EGSB sludge bed.[17] The EGSB reactor is a variation on the UASB, which uses a high wastewater flow rate to achieve improved contact between the wastewater and the sludge bed. A 2001 study of 1,215 wastewater treatment facilities in 65 countries showed that the most common technologies used were either UASB or EGSB reactors.[18]

<u>End uses for biogas</u>

There are multiple end uses for biogas and the proposed protocol is intended to be flexible in regard to these options. Greenhouse gases may be reduced by simply installing a flare to destruct the methane, but more productive uses of biogas would include the generation of heat and/or electricity. The heat and/or electricity could be used on or off-site depending on the specific energy demands of the facility. The most common scenarios would be the use of biogas in a facility boiler to reduce natural gas consumption or the use of the biogas in an engine to generate electricity to be sold to the grid. Biogas can also be conditioned by implementing equipment to remove CO_2, H_2S, and water vapour to meet pipeline quality natural gas specifications.

B.6 Review of Existing Projects

There are a variety of industries that use anaerobic wastewater treatment processes such as, potato processors, French fry producers, sugar beet processors, breweries, soft drink bottlers, ethanol plants, distilleries, slaughterhouses, by-product processors, meat processors, vegetable processors, and other facilities. Each facility has unique COD loading rates and process demands, but the overall goal is always to remove organic matter (COD) from the wastewater stream to meet effluent discharge limits. Most often anaerobic systems will be followed by aerobic processes or other polishing steps to remove the last remaining COD from the wastewater.

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[16] Anaerobic Granular Sludge Bed Reactor Technology. Field, Jim. September 15, 2002. http://www.uasb.org/discover/agsb.htm#egsb
[17] Ibid.
[18] Innovative Biological Treatment Processes for Wastewater in Canada. Mulligan, C. and Gibbs, B.

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In Alberta, there have been several food processing facilities that have implemented methane capture systems to capture and combusted biogas generated from anaerobic wastewater treatment processes. They are as follows:

Cargill Meat Solutions

- In 2004, the Cargill High River facility installed geo-membrane covers on two anaerobic lagoons to capture biogas produced from the decomposition of organic matter contained in the effluent from the beef processing plant. The biogas is used on site in facility boilers and displaces approximately 25% of the natural gas required by the processing plant. Had the facility not installed the methane capture system, all of the methane would have been vented to atmosphere.

Lamb Weston

- The Lamb Weston Potato Plant in Taber, Alberta constructed an anaerobic wastewater treatment unit in October 2004. The facility uses a wet fermentation digestion process in a tarp-covered lagoon. The feedstock is potato by-product from the facility's french-fried potato processing plant. This water-effluent had previously been screened for solids and then spread on agricultural lands as a fertilizer.

  The $5.3M biogas system was introduced primarily to control water consumption, landfill wastes and energy costs. The gas is used as a natural gas replacement to fire internal boilers and Lamb Weston estimates that the facility saves $510,000 due to lower electrical requirements and $310,000 in natural gas costs. Better water management and conservation allowed for a plant expansion and an increase of 22 million pounds of additional finished product capacity.

Roger's Sugar

- Roger's Sugar in Taber, Alberta installed a full-scale UASB system to treat wastewater effluent from the sugar beet mill in 1999.[19] Initially, biogas produced from the anaerobic reactor was collected and flared, but in the future Rogers Sugar may consider utilizing the excess biogas as a supplemental fuel for the facility boilers.

Tyson Foods

- In 2001, Tyson foods began covering anaerobic lagoons at five of their wastewater treatment facilities throughout the US Midwest. The raw wastewater from the animal processing facilities is pumped through underground pipes into open anaerobic lagoons. The lagoons are earthen pits approximately 20 feet deep. At each of the five wastewater treatment facilities, the existing anaerobic lagoons were covered with a gas-tight high density polyethylene (HDPE) material. Each site is equipped with a waste gas flare to destruct all of the produced methane. As a result of Tyson's capture and flaring of biogas at their wastewater treatment facilities, significant reductions in direct emissions have been achieved. Their

[19] Innovative Biological Treatment Processes for Wastewater in Canada. Mulligan et Al.2003.

sites verified a total of 550,290 metric tonnes of GHG emission reductions between January 2002 and November 2003.

B.7 Summary of Quantification Approaches

Identification of Sources and Sinks of GHG Emissions

In order to develop quantification approaches around the capture and combustion of biogas containing methane generated from anaerobic wastewater treatment processes, it was necessary to examine a typical wastewater treatment processes flow diagram to identify all potential sources of GHG emissions from wastewater production through to discharge. The identification of sources and sinks was completed using the best practice guidance documents listed in Table B.1 and by examining typical project configurations in Alberta. This life cycle analysis was done following the ISO-14064-2 standard where the different sources and sinks (SSs) of GHG emissions were classified as upstream, on-site, downstream, controlled, related and affected.

The results of this analysis were then compared to the sources and sinks of GHG emissions quantified under the Clean Development Mechanism (CDM) Methodology ACM0014: Mitigation of Greenhouse Gas Emissions from the Treatment of Industrial Wastewater and the Alberta Offset System Quantification Protocol for the Anaerobic Decomposition of Agricultural Materials. A brief summary of this analysis is presented in this section for context along with a typical process flow diagram incorporating the identified sources and sinks of GHG emissions.

The lifecycle analysis of a typical food processing facility identified various sources and sinks of GHG emissions that would be upstream of the anaerobic wastewater treatment units, including elements related to the production and transportation of fuels and chemicals used at the site, facility operations consuming fossil fuels and electricity, and the processes generating the wastewater streams that require treatment.

On-site SSs would likely include: energy generation systems that provide heat to the plant; wastewater pre-treatment processes; anaerobic wastewater treatment units; any aerobic wastewater treatment units used to remove residual COD; wastewater polishing processes; sludge handling processes; infrastructure to capture, condition and combust biogas produced from the anaerobic treatment system; and energy generation and distribution infrastructure.

Downstream SSs would likely include sludge transport, disposal/treatment, wastewater discharge, and off-site use of biogas or energy output from the facility. The day-to-day operations of a food processing facility and associated wastewater treatment equipment would also require a variety of infrastructure. The development (and later decommissioning) of this infrastructure would have some associated GHG emissions that are not directly tied to the upstream, downstream or on-site elements.

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A process flow diagram was developed for the proposed protocol based on the life cycle analysis of the project activities and the review of the various best practice guidance documents and quantification approaches referred to in section B.2. Figure 1, below, summarizes the different SSs identified for a typical food processing facility operating an anaerobic wastewater treatment unit and associated equipment to capture and combust biogas. The most material SSs recommended for quantification, as discussed in the following section are shaded in grey in Figure 1. The dashed line in Figure 1 represents the main processes within the food processing facility operations at which information may need to be collected by the project proponent.

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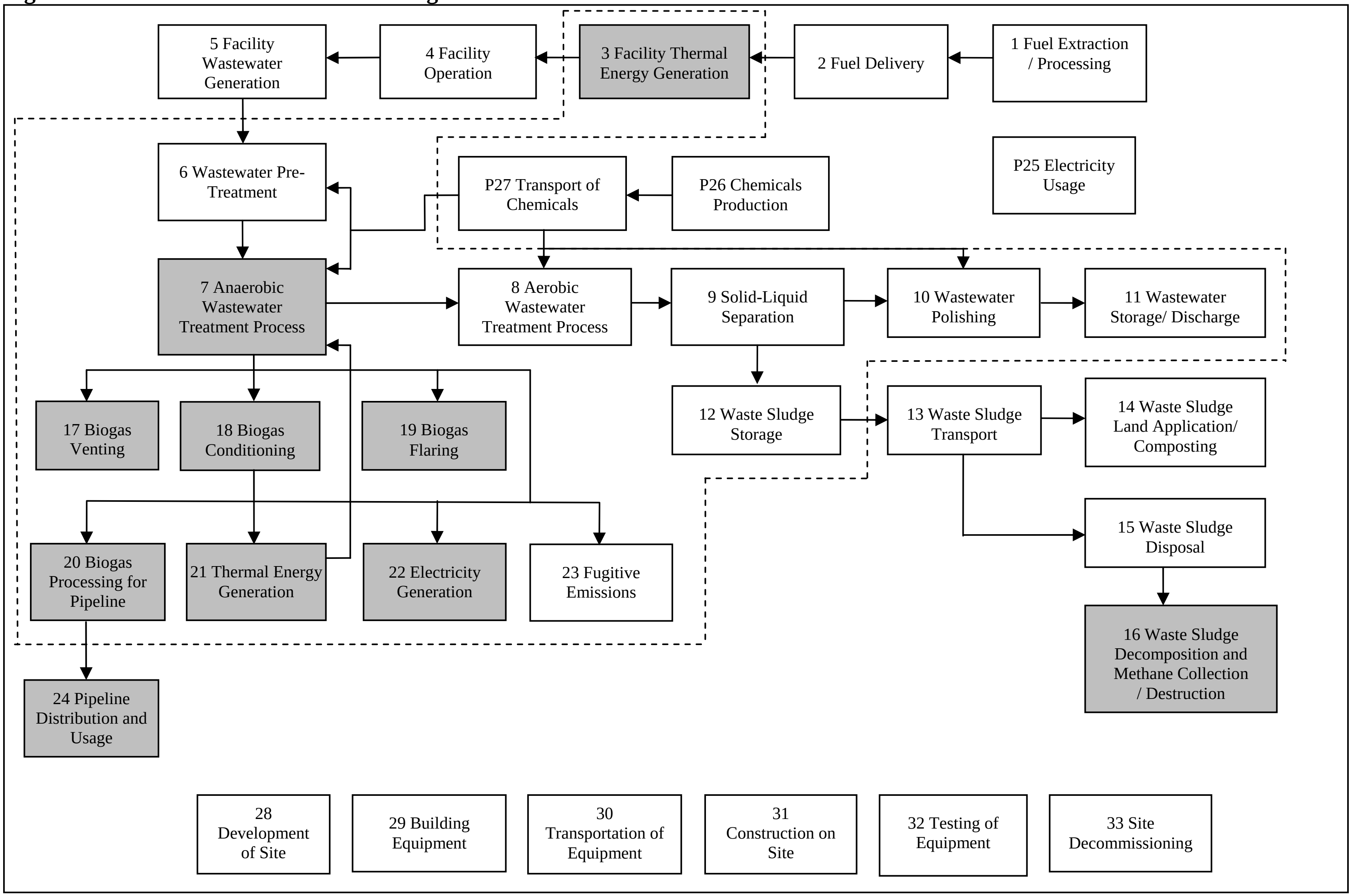
Figure 1: Recommended Process Flow Diagram



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Determination of Material Sources and Sinks of GHG Emissions

Following the lifecycle analysis that facilitated the identification of relevant sources and sinks of GHG emissions, a preliminary analysis of these SSs was performed to identify the most material sources of GHG emissions in the project and baseline conditions. These material SSs were then the focal point for the development of quantification approaches. The evaluation of these SSs was completed based on a review of the best practice guidance documents discussed in Table 2, below. These technical seed documents (TSDs) formed the basis of the scientific consensus behind the quantification of GHG emissions from anaerobic wastewater treatment and biogas capture and combustion.

Table 3, below, summarizes the relevant TSDs that were used in the development of GHG quantification approaches

Table 3: Quantification Approaches

Technical Seed Documents	Scope of Methodology	Emission Sources Identified and Quantified
CDM Consolidated methodology for mitigation of greenhouse gas emissions from treatment of industrial wastewater (ACM0014 v2.1.)	Applicable to projects that capture and flare or utilize biogas normally emitted from anaerobic lagoons or sludge pits. Two quantification approaches are provided for determining GHG emissions from anaerobic wastewater treatment.	• CH_4 emissions from anaerobic wastewater treatment • CH_4 emissions from flaring, venting, leakage, sludge land application, residual COD in wastewater effluent • Electricity consumption/ generation • Generation of heat • Consumption of fossil fuels to operate treatment units
Alberta Quantification Protocol for the Anaerobic Decomposition of Agricultural Materials (September 2007)	Limited to the anaerobic digestion of agricultural materials and therefore does not contain quantification methods for anaerobic wastewater treatment. Quantification methods are provided for biogas flaring, venting, utilization for energy recovery (heat, power and upgrading to pipeline quality) and diversion of organic wastes from landfill.	• Biogas flaring, venting and combustion • Displacement of fossil fuels and electricity with energy from biogas combustion • Baseline emissions from waste decay in landfill • Consumption of fossil fuels to operate the digester and associated equipment

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Based on the technical seed documents in Table 3, it was evident that parts of both methodologies would need to be adapted into the Alberta Offset System format in order to develop a quantification protocol around the capture of methane from the anaerobic treatment of industrial wastewater. The CDM methodology provided relevant quantification approaches for baseline GHG emissions from open anaerobic lagoons or sludge pits, while the Alberta protocol provided relevant quantification approaches for the full range of possible uses of biogas produced from the anaerobic treatment unit. The development of quantification approaches for the proposed protocol was facilitated through the adaption of the existing best practice TSDs as discussed below.

The two CDM approaches for determining the baseline methane emissions from anaerobic lagoons or sludge pits (without methane capture) were evaluated for their relevance to Alberta project configurations. Both approaches utilize a mass balance on the anaerobic treatment unit to determine the amount of organic material, expressed in terms of chemical oxygen demand that would have been removed from the treatment unit under anaerobic conditions in order to estimate baseline methane emissions. The basis of this approach is that each unit of COD removed from the system under anaerobic conditions can produce a certain theoretical maximum amount of methane (that is, each unit of COD has a certain methane generation potential). The actual methane generation rate is dependent on the temperature of the system, the depth of the system and COD exposure to oxygen, chemical oxidizing agents and sedimentation.

<u>CDM Methane Conversion Factor (MCF) Method</u>

The methane conversion factor (MCF) method is based on the COD of the wastewater that would have entered the anaerobic lagoon in the absence of the project activity, the maximum methane generation potential per unit of COD, and a methane conversion factor.[20] The main difference between this method and the organic removal ratio, below, is the use of a methane conversion factor. The MCF represents the extent to which ideal anaerobic conditions are present in the wastewater treatment unit, which is primarily dependent on the depth of the anaerobic treatment unit (such as a lagoon) and the temperature of the system. Methanogenic bacteria require oxygen free (anaerobic) conditions in order to survive and their rate of consumption of COD is dependent on temperature. Optimum temperatures for anaerobic digestion are generally from 35-40 °C or 55-60 °C for mesophilic and thermophilic systems, respectively. In most baseline scenarios the pre-existing anaerobic treatment unit would not operate at these temperatures and it is therefore necessary to correct for decreased methane generation due to lower temperatures.

The CDM methodology includes a “temperature factor” to express the influence of temperature on methane generation rates, consistent with the approach used by the

[20] Mitigation of greenhouse gas emissions from treatment of industrial wastewater. CDM ACM0014.

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California Climate Action Registry (CCAR) Livestock Reporting Protocol[21]. A "depth factor" is also used to express the influence of the depth of the lagoon or sludge pit on methane generation based on the surface oxidation of COD that occurs due to oxygen contact with the organic matter in the lagoon.

CDM Organic Removal Ratio (ORR) Method

The organic removal ratio (ORR) method measures the reduction of the COD in a wastewater or sludge stream between its entry into and exit from the treatment system (the open lagoon or the sludge pit). The organic removal ratio is a project-specific factor expressing the fraction of COD that is degraded in the open lagoon or sludge pit (that is, between the entry and exit points).[22]

Losses of COD in a sludge pit or lagoon system can occur through three main routes:

- Anaerobic decomposition (and consequently methane emissions);
- Oxidative decomposition, either aerobic at the pond surface, or through chemical oxidation where there is a presence of an oxidizing agent such as sulphate
- Sedimentation of certain suspended materials that can be lost through other routes, and settle to the lagoon bottom, remaining on a more or less permanent basis.[23]

The ORR method uses the same mass balance method as the methane conversion factor method, but attributes the loss of COD to either sedimentation or oxidative decomposition rather than the impact of temperature. The assumption is that oxidative decomposition can be estimated using known factors (COD removed per hectare of surface area), while sedimentation would have to be determined through measurements of the lagoon depth. Therefore, the primary differences with the ORR method are that temperature is not accounted for and the depth of the anaerobic treatment unit must be measured periodically to determine sedimentation rates. Both the MCF and ORR methods account for oxidative decomposition of COD.

Selection of a Quantification Approach

The CDM methane conversion factor (MCF) approach was selected for the proposed protocol in order to provide the most flexibility to different project configurations in Alberta. The primary reason that this method was chosen for the proposed protocol was to account for the impact of temperature on the anaerobic digestion process. In open lagoons or other systems subject to ambient temperatures, the monthly average temperature would significantly affect the methane generation rate in the baseline condition, especially in cold Canadian climates. The organic removal ratio method, which does not account for the affect of temperature on the rate of anaerobic decomposition,

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[21] Livestock Reporting Protocol. CCAR. http://www.climateregistry.org/resources/docs/protocols/project/livestock/CCAR_Livestock_Project_Reporting_Protocol_June_2007.pdf

[22] Ibid.

[23] Ibid.

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would not adequately characterize the actual methane generation for all project configurations (specifically those sites using open anaerobic lagoons). Additionally, the monitoring methodology proposed to determine sedimentation (loss of COD) under the ORR method was also not practical for most anaerobic treatment units (that is, the measurements would require the removal of a lagoon cover and use of a row boat in order to measure depth, which would result in the venting of significant amounts of methane and would expose workers to potentially fatal contaminants such as hydrogen sulphide and unsafe hazards due to the explosive gas atmosphere).

The proposed protocol utilizes best practice guidance from the 2006 IPCC Guidelines for National Greenhouse Gas Inventories and the Clean Development Mechanism Methodology ACM0014 to determine the baseline methane emissions from the anaerobic decomposition of organic matter contained in wastewater streams. Since it is not normally practical to measure methane generation from open anaerobic systems prior to the installation of a methane capture system, the best available quantification approach at this time is the use of the methane conversion factor method that incorporates the impacts of temperature and depth of the anaerobic system on the methane production per unit of organic matter destructed in the system.

The proposed quantification approach adopted from CDM uses a mass balance on the anaerobic treatment unit to establish the amount of COD actually removed from the wastewater under anaerobic conditions and relates that quantity of COD to annual methane emissions using a methane conversion factor. This method uses site specific measurements of the wastewater flow rates and COD concentrations at the inlet and outlet of the anaerobic treatment unit to determine COD removal and uses average temperatures and system depths to determine the methane conversion factor. The conservativeness factors used in the CDM methodology are also used in this quantification approach to ensure that the overall estimation of baseline emissions is sufficiently conservative.

<u>GHG emissions from Other Sources and Sinks</u>

The quantification approaches for GHG emissions from biogas venting, conditioning, flaring, upgrading to pipeline quality, thermal energy generation, electricity generation and waste disposal in landfill are largely adopted from the Alberta Quantification Protocol for the Anaerobic Decomposition of Agricultural Materials. This quantification approach provides the greatest flexibility for projects to quantify GHG emission reductions through the use of biogas on-site or off-site for energy generation.

Additionally, the proposed protocol allows for the quantification of GHG emissions from projects where the baseline scenario was the flaring of biogas generated from the anaerobic treatment of wastewater. This quantification approach uses best practice guidance on the operation and destruction efficiency of flares from the US EPA CFR 40.18 and the GE AES Methodology for Waste Water Treatment Methane Capture and Destruction Projects.

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B.8 Other Impacts (optional)

The implementation of a methane gas capture system in conjunction with an anaerobic wastewater treatment system has other benefits aside from reducing greenhouse gas emissions, such as the ability to decrease VOC emissions released from the facility. The capture and combustion systems may also reduce the amount of unwanted odour emitted from the project site. Some of the other benefits from these systems are that there is the potential to create non-emitting electricity from the biogas captured – using it either to offset facility electricity demand or selling to the grid as renewable energy. Additionally, for sites that implement new or enhanced anaerobic treatment units (for instance, in place of aerobic systems), the quantity of sludge generated can decrease significantly, which decreases the amount of potentially odorous material applied to land or disposed of in landfill. The costs and environmental impacts of either land applying or landfilling the material are significant.

B.9 Assessment of Baseline Scenarios

An assessment of potential baseline scenarios was conducted based on the recommended methodology from best practice guidance in the Alberta Offset Credit Project Guidance Document and using CDM Methodology ACM0014. Potential baseline options were assessed based on their capacity to quantify the baseline methane emissions from anaerobic wastewater treatment in a practical manner using available data. Each baseline scenario also contemplated the selection of a static or dynamic approach. Table 4, below, provides a summary of the different baselines considered.

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TABLE 4: Assessment of Possible Baseline Scenarios

1. Baseline Options	2. Description	3. Static/ Dynamic	4. Accept or Reject and Justify
1.Historic Benchmark	Assessment of the baseline emissions from anaerobic wastewater treatment based on site-specific measurements of methane emissions over several years from the anaerobic treatment unit prior to the installation of a methane capture system.	Static	Reject. The measurement of methane emissions prior to the installation of a methane capture system is not generally practiced and therefore this data is not generally available.
2.Performance Standard	Assessment of the typical GHG emissions from anaerobic wastewater treatment facilities as a proxy to estimate the avoided GHG emissions from a specific site that implemented a methane capture project. This approach would likely require an industry-wide characterization of GHG emissions per unit of COD treated or per volume of wastewater treated.	Dynamic or Static	Reject. Typical industry GHG emissions data per unit of COD are not available in Canada. Each facility will also have different wastewater generation rates, inlet and outlet COD concentrations and technologies in place to meet end-of-pipe effluent limits. There is also a lack of projects to justify an accurate industry performance standard or benchmark. For example, in Alberta there are only two beef processing plants. Since the measurement of methane emissions from anaerobic wastewater treatment systems is not normally undertaken unless a capture system is already in place, it would not be feasible to establish normal industry GHG emissions.
3.Comparison-based	Assessment of the baseline GHG emissions from anaerobic wastewater treatment based on the performance of the project site as compared to a control group.	Dynamic	Reject. Individual facilities will vary greatly in terms of processing facility operations, wastewater generation rates, inlet and effluent COD concentrations, temperatures and wastewater treatment technologies employed. This approach would also create unnecessary monitoring and measurement burdens for the project developer.

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1. Baseline Options	2. Description	3. Static/ Dynamic	4. Accept or Reject and Justify
4. Projection-Based	Assessment of the baseline GHG emissions from anaerobic wastewater treatment using a model to predict the baseline emissions per unit of chemical oxygen demand removed from the wastewater under anaerobic conditions based on site specific temperatures and anaerobic treatment system depths.	Dynamic	Accept. This approach uses site specific measurements of COD removed in the anaerobic treatment unit (based on wastewater flow rates and COD concentrations) and average monthly temperatures to evaluate the baseline methane emissions according to a widely used model from CDM and IPCC best practice guidance. This method of predicting baseline methane emissions represents a conservative approach that accounts for site to site variations in temperature and depth, which may impact methane generation in the baseline.
5.Adjusted Baseline	Assessment of the baseline GHG emissions using site specific data and adjusting for existing methane capture activity levels or common industry practices. This approach could be used in conjunction with a performance standard if methane capture were the normal industry practice (e.g. due to regulations).	Static or Dynamic.	Reject. The variability in food processing operations is too high to generalize the industry wastewater treatment practices. A variety of wastewater treatment technologies are used in Canada, including both anaerobic and aerobic processes. The choice of system will depend on the type of wastewater, size of the facility, regional regulations, proximity to residential areas etc. Simple facilities may use open lagoons with long retention times operating at close to ambient temperatures, while others may use advanced high rate anaerobic reactors operating at elevated temperatures ideal for methane generation.

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B.10 Selection of Baseline Scenario

The baseline scenario represents the GHG emissions that would have occurred from the anaerobic treatment of wastewater and venting of produced biogas had the project not installed a methane capture system and the GHG emissions from fossil fuels that would have been consumed had the project activity not installed a biogas utilization system.

The baseline condition is considered as projection based. Under this scenario, the emissions from the anaerobic decomposition of an equivalent quantity of organic matter (expressed as chemical oxygen demand) contained in an industrial wastewater effluent stream that is treated under clearly anaerobic conditions would be calculated using existing models covering the activities under the baseline condition. This is accomplished by applying a mass balance on the COD into and out of the baseline anaerobic treatment system and accounting for the effects of temperature and oxygen exposure on the biological process consistent with the methane conversion factor method outlined in CDM Methodology ACM0014 for Anaerobic Wastewater Treatment Projects. The GHG emissions from fossil fuels consumed in the baseline and replaced with renewable energy output from the biogas utilization system would be accounted for using direct measurement of the biogas energy output in the project activity and displacement of the most likely or most conservative fossil fuel type.

The baseline scenario for projects that previously flared biogas without energy recovery in an open flare assumes a conservative methane destruction efficiency. The displacement of fossil fuel derived energy sources with energy produced from biogas in the project condition would be accounted for using metered biogas production volumes and/or combustion system energy output data.

This dynamic approach accounts for the market forces, wastewater generation rates, weather and energy demand and operational parameters without adding multiple streams of material management.

B.11 Definition of the Project Condition

The proposed protocol is applicable to projects that involve the capture and destruction of methane produced from anaerobic wastewater treatment processes and prevent the venting of biogas to the atmosphere. These systems could be installed as retrofits or modifications to existing wastewater treatment operations or implemented at new Greenfield facilities as the best available control technology.

The most common baseline configuration would be the use of an uncovered deep anaerobic wastewater lagoon where biogas was vented to the atmosphere; however, other facilities may already operate more sophisticated anaerobic digester systems to treat raw wastewater effluent or sludges with high organic loadings but may not utilize the produced biogas. This protocol is also applicable to projects that implement new equipment to utilize the produced biogas, where previously all biogas captured from the anaerobic wastewater treatment systems was flared without energy recovery. The

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baseline scenario in this case assumes the use of an open flare with 95% methane destruction efficiency.[24] The feedstock to the anaerobic digestion system may be untreated industrial wastewater or sludge produced from other wastewater treatment processes at the project site.

This protocol is intended to be applied to anaerobic wastewater treatment systems used in the food processing industry and, as such, may not be suitable for all other types of wastewater treatment systems. In addition, project proponents implementing other types of anaerobic digesters to produce biogas from agricultural residues, source-separated organic materials, or energy crops, should refer to the Alberta Offset System *Quantification Protocol for the Anaerobic Decomposition of agricultural Materials*.

The decomposition of organic matter, contained in wastewater effluents as suspended or dissolved solids and or in more concentrated sludges, under clearly anaerobic conditions produces biogas consisting primarily of methane and carbon dioxide. Biogas composition will vary depending on the composition of wastewater treated, but typically consists of 50-80% methane and 20-50% carbon dioxide, with trace amounts of hydrogen sulphide and other volatile organic compounds. The degradable organic matter contained in wastewater effluents is usually measured in terms of COD or BOD. For consistency with the Intercontinental Panel on Climate Change (IPCC) and Clean Development Mechanism Methodology ACM0014 approaches, this protocol uses COD.

Typically, the implementation of methane capture projects at anaerobic wastewater treatment facilities includes the establishment of several supporting units including biogas conditioning units, piping, blowers, flares and thermal/ electrical energy generation systems. This equipment would be installed in addition to other wastewater treatment equipment used to remove other contaminants present in the effluent and to ensure all wastewater discharged to a sanitary sewer system or surface water body meets applicable regional limits.

Wastewater is collected from different operations within the source facility and directed to a pre-treatment area for screening, grit removal, dissolved air flotation, or other physical or chemical adjustments before it is treated in the anaerobic digester where anaerobic microbes consume the majority of organic matter and produce combustible biogas in the process. The wastewater then undergoes one or more aerobic treatment processes (bioreactors, clarifiers, etc.) to remove the remaining organic solids to within acceptable limits. After the aerobic process, the wastewater stream undergoes coagulation and flocculation to precipitate out inorganic compounds (such as phosphorous) and to settle out particles so that they can be physically separated using a filter or belt press. The filtered solids may be stored temporarily and then sent for disposal, composting or land application, while the effluent continues to a polishing step for any final chemical adjustments (e.g. pH) before continuing on to a storage lagoon or directly discharged

[24] **This assumption is consistent with the GE AES Methodology for Waste Water Treatment Methane Capture and Destruction Projects Version 1.0 – August 22, 2007**

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from the site. The biogas produced in the anaerobic treatment unit is flared or conditioned to remove water vapour and other contaminants and then combusted to produce energy.

B.12 Functional Equivalence

The project and the baseline should provide the same function and quality of products or services. This type of comparison requires a common metric or unit of measurement for comparison between the project and baseline activities.

In the proposed protocol functional equivalence is established based on the mass of COD removed in the anaerobic wastewater treatment unit and the energy output from the biogas combustion unit. The proposed approach uses a mass balance on the anaerobic treatment unit to establish the mass of COD that would have decayed under anaerobic conditions in the baseline without a methane capture system in place. In the project condition the actual COD removal is tracked based on wastewater flow rates and COD concentrations into and out of the anaerobic treatment unit. Each unit of COD can be converted into an associated methane generation potential based on the characteristics of the anaerobic treatment system (such as depth) and the temperature of the wastewater to relate the baseline to the project condition.

For projects that implement biogas energy generation systems the unit of functional equivalence would be the quantity of energy output from the system that results in the displacement of fossil fuels. By using the energy output from the energy generation system (such as kWh or GJ) any differences in higher heating value between biogas and conventional fossil fuels is eliminated.

B.13 Flexibility Mechanisms

Flexibility in applying the proposed quantification protocol is provided to project developers in five ways:

1. In cases where the project proponent measures BOD in the wastewater stream (and not the COD), the conversion factor of 2.4 kg of COD per 1 kg of BOD may be applied to convert from kg of BOD to kg of COD as per the 2006 IPCC Guidelines for National Greenhouse Gas Inventories;
2. Projects that do not enhance the anaerobic digestion process (for example, an enhancement could be through the addition of a heat source or insulation to the digester, the addition of other organic substrates, a change in hydraulic retention time or solids retention time, a change in COD loading rate, or other design change that increases biogas output materially) may use site-specific chemical oxygen demand and biogas production data in the project condition to develop monthly site-specific methane generation rates (SSMGR) per unit of COD removed for the baseline provided that two years of consistent operation of the anaerobic treatment unit has been attained without any significant modifications to enhance the generation of biogas. Methane generation rates should be calculated on a monthly basis to account for temperature impacts on the baseline system;

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3. For projects for which the baseline condition was the flaring of biogas that has been replaced with a controlled combustion device (for example, due to the installation of equipment for energy recovery), the default flare destruction efficiency may be substituted with a site-specific value based on manufacturer's specifications, flare combustion efficiency testing, and flare operating records. Flare destruction efficiency may depend on the type of flare, the use of fuel gas, steam or air to assist in combustion, the net heating value of the waste gas, flare gas exit velocity, and cross-wind speed. Due to the uncertainty around assessing the destruction efficiencies of flares, if the project proponent wishes to substitute the default baseline flare efficiencies used in the protocol with a lower efficiency, he/she must ensure that an independent third-party validation of the flare destruction efficiency has been completed by a professional engineer in order to apply this flexibility mechanism.
4. Site-specific emission factors may be substituted for the generic emission factors indicated in the proposed protocol document. The methodology for generation of these emission factors must ensure accuracy and be robust enough to provide uncertainty ranges in the factors;
5. Measurement and data management procedures may be modified by the project developer to account for the available equipment as long as the specified minimum standards for data quantity, frequency and quality are met. Where these standards cannot be met, the project developer must justify why the method used represents a reasonable deviation to the quantification methodology provided.

The project proponent will have to justify their approach in detail to apply any of these flexibility mechanisms.

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