出國報告（出國類別：進修）

111年度派赴英國參加「ISO 14064-3 溫室氣體聲明之查證與確證附指引之規範」研習課程訓練報告

服務機關：行政院環境保護署環境檢驗所
姓名職稱：許組長元正、李研究員世偉、呂研究員奎宛
派赴國家/地區：英國/倫敦
出國期間：111年10月23日至111年10月30日
報告日期：112年1月16日

摘要

2021 年 4 月 22 日世界地球日蔡總統宣示，2050 淨零轉型是全世界的目標，也是臺灣的目標。為強化國內溫室氣體減量接軌國際最新技術，積極厚植我國研究量能，故本所派員赴歐盟先進國家接受溫室氣體查驗認證課程。

ISO（International Organization for Standardization，國際標準化組織）係為一國家標準機構之全球性聯盟，該組織所制定之 ISO 14060 系列標準，旨在為量化、監督、報告及確證或查證溫室氣體的排放與移除提供明確性與一致性的標準。ISO 文件「ISO 14064-3：溫室氣體聲明之確證與查證附指引之規範」係針對溫室氣體盤查清冊、溫室氣體計畫或方案，提供溫室氣體查證者/確證者一有效指引。本所派員參加本次受訓課程為「ISO 14064-3 溫室氣體聲明之查證與確證附指引之規範」，係為 ISO 14064-3 文件內容講授，以介紹查證及確證執行流程為主。

溫室氣體盤查企業類型甚多，各項專業領域差異頗大，而查驗機構與人員的獨立性和公正性是查驗報告最重要的一環。國際間溫室氣體查驗多依循之 ISO 最新版本，此與國內納管對象的查驗要求不甚相同。國際間查驗報告相互承認是未來碳交易市場的重要機制，目前歐盟雖然尚未明訂查驗報告承認的規定，但隨著碳邊境調整機制（Carbon Border Adjustment Mechanism, CBAM）的推動，仍然是國內必須注意的課題。

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壹、目的

2021 年 4 月 22 日世界地球日蔡總統宣示，2050 淨零轉型是全世界的目標，也是臺灣的目標。我國已於 2022 年 3 月正式公布「臺灣 2050 淨零排放路徑及策略總說明」，因全球氣候變遷現象嚴峻，為加速我國減碳作為並強化氣候變遷調適，以溫室氣體減量及管理法為基礎，環保署提出「溫室氣體減量及管理法」修正草案，並且將法案名稱修改為「氣候變遷因應法」，修正重點包含：2050 淨零排放目標入法、提升層級強化氣候治理、增訂氣候變遷調適專章、強化排放管制及誘因機制促進減量及徵收碳費專款專用，以期促進國家邁向淨零轉型。其中促進減量所採行最佳可行技術並進行增量抵換或自願減量計畫可核予減量額度之誘因機制、國內排放源徵收碳費及碳足跡管理機制等，均涉及溫室氣體查驗及確證應用，因此了解溫室氣體查驗確證制度有其必要性；另為強化國內溫室氣體減量接軌國際最新技術，積極厚植我國研究量能，故本所派員赴歐盟先進國家接受「ISO 14064-3 溫室氣體聲明之查證與確證附指引之規範」課程訓練。

貳、過程

一、訓練行程表

<table>
<tr><th>日期</th><th>行程內容</th></tr>
<tr><td>111 年 10 月 23 日
（星期日）</td><td>搭機啟程</td></tr>
<tr><td>111 年 10 月 24 日
（星期一）</td><td>辦理課程註冊及課程前準備事宜</td></tr>
<tr><td>111 年 10 月 25 日
（星期二）</td><td>課程第一天</td></tr>
<tr><td>111 年 10 月 26 日
（星期三）</td><td>課程第二天</td></tr>
<tr><td>111 年 10 月 27 日
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<tr><td>111 年 10 月 29 日
（星期六）</td><td rowspan="2">搭機回程</td></tr>
<tr><td>111 年 10 月 30 日
（星期日）</td></tr>
</table>

二、講師介紹

（一） 講師姓名：

Fergal Mee

（二） 職稱／任職單位：

Environmental Director／Carbon Action, London

（三） 簡介及經歷：

Fergal 致力於將標準應用於 GHG 管理，並且是 Carbon Action 的創始人之一。Fergal 在製藥、石化、快速消費品和高級工程領域擁有 25 年的工程、科學和管理職位經驗，是非常有經驗的環境顧問和培訓師，參與過環境、能源與溫室氣體排放等項目。曾在諾華製藥公司擔任工廠經理，負責歐洲（瑞士、英國和愛爾蘭）的現場能源和環境運營，同時也參與在歐洲、非洲和亞洲推出有關碳排放量化、減少、驗證和確證的 ISO 14064 系列的課程教學，並且在歐洲、北美、非洲、中東和亞洲從事溫室氣體和碳足跡項目。Fergal 也是 ISO/TC 207/SC 7「溫室氣體管理和相關活動」委員會的成員，參與的項目包含 ISO 標準制定與起草在聯合國氣候變遷大會上發布的 ISO 淨零指南。

三、課程進行方式

（一） 課程表

項次	主題	課程時間
第 1 節	ISO 14064-3 概述	10 月 25 日（星期二）9:00-16:00
第 2 節	ISO 14064-1、ISO 14064-2 與其他相關 ISO 文件簡要介紹	10 月 25 日（星期二）9:00-16:00
第 3 節	查證與確證介紹	10 月 25 日（星期二）9:00-16:00
第 4 節	執行查證與確證之原則	10 月 25 日（星期二）9:00-16:00
第 5 節	適用於查證與確證之要求	10 月 26 日（星期三）9:00-16:00
第 6 節	查證計畫	10 月 26 日（星期三）9:00-16:00
第 7 節	如何執行及完成查驗作業	10 月 26 日（星期三）9:00-16:00
第 8 節	執行確證之程序	10 月 27 日（星期四）9:00-16:00
第 9 節	獨立審查及簽發意見	10 月 27 日（星期四）9:00-16:00

（二） 課程及測驗進行方式

本所派員參加「ISO 14064-3 溫室氣體聲明之查證與確證附指引之規範」課程之訓練，課程內容講授方式主要係由講師將課程內容以簡報方式於螢幕上呈現，並且將簡報內容印製成講義發放給每一位學員，以便參閱課程內容。此外，每一章節課程講授完畢後，講師會讓學員進行習題演練，並且會預留讓學員進行習題演練與討論的時間。案例演練的進行方式主要為學員先閱讀講師提供不同產業的溫室氣體聲明（可能為溫室氣體盤查報告或是溫室氣體計畫）或補充資料，再依據課程各章節中講師介紹之查證／確證之步驟或準則，就案例的資料內容進行討論並回答講師提問（案例演練範例請參考附錄 1）。講師另外會以手寫板輔助，補充名詞解釋或是延伸的概念應用等。

課程後之測試係採線上作答，每位學員以自己的帳號登入系統，系統由題庫中隨機篩選 20 題作為考試內容，每項題目皆為單選題（考題形式請參考附錄範例 2），及格門檻為 70 分，測試時間不限，可參閱課程講義或是 ISO 文件作答。測試及格即可取得課程訓練證明。

四、課程內容概述

（一） 溫室氣體查證/確證之相關國際標準

ISO（International Organization for Standardization，國際標準化組織）係為一國家標準機構之全球性聯盟，該組織所制定之 ISO 14060 系列標準，旨在為量化、監督、報告及確證或查證溫室氣體的排放與移除提供明確性與一致性的標準。除 ISO 14060 系列標準之外，ISO/IEC 17029:2019 符合性評鑑-確證與查證機構之一般原則與要求，為 ISO 最新公告之符合性評鑑標準，屬通用性質，其要求適用於確證與查證兩項活動。ISO 14060 系列與溫室氣體相關的標準如下，圖 1 為溫室氣體標準與 ISO 14060 系列間之關係。

1. ISO 14065:2020 機構提供環境資訊確證與查證之一般性原則要求。

2. ISO 14066：溫室氣體確證與查證小組之適任性要求。

3. ISO 14064-1：組織層級溫室氣體排放與移除之量化及報告附指引之規範。

4. ISO 14064-2：計畫層級溫室氣體排放減量或移除增量之量化、監督及報告附指引之規範。

5. ISO 14064-3：溫室氣體聲明之確證與查證附指引之規範。

6. ISO/TS 14067：產品碳足跡量化及溝通要求及指引標準。

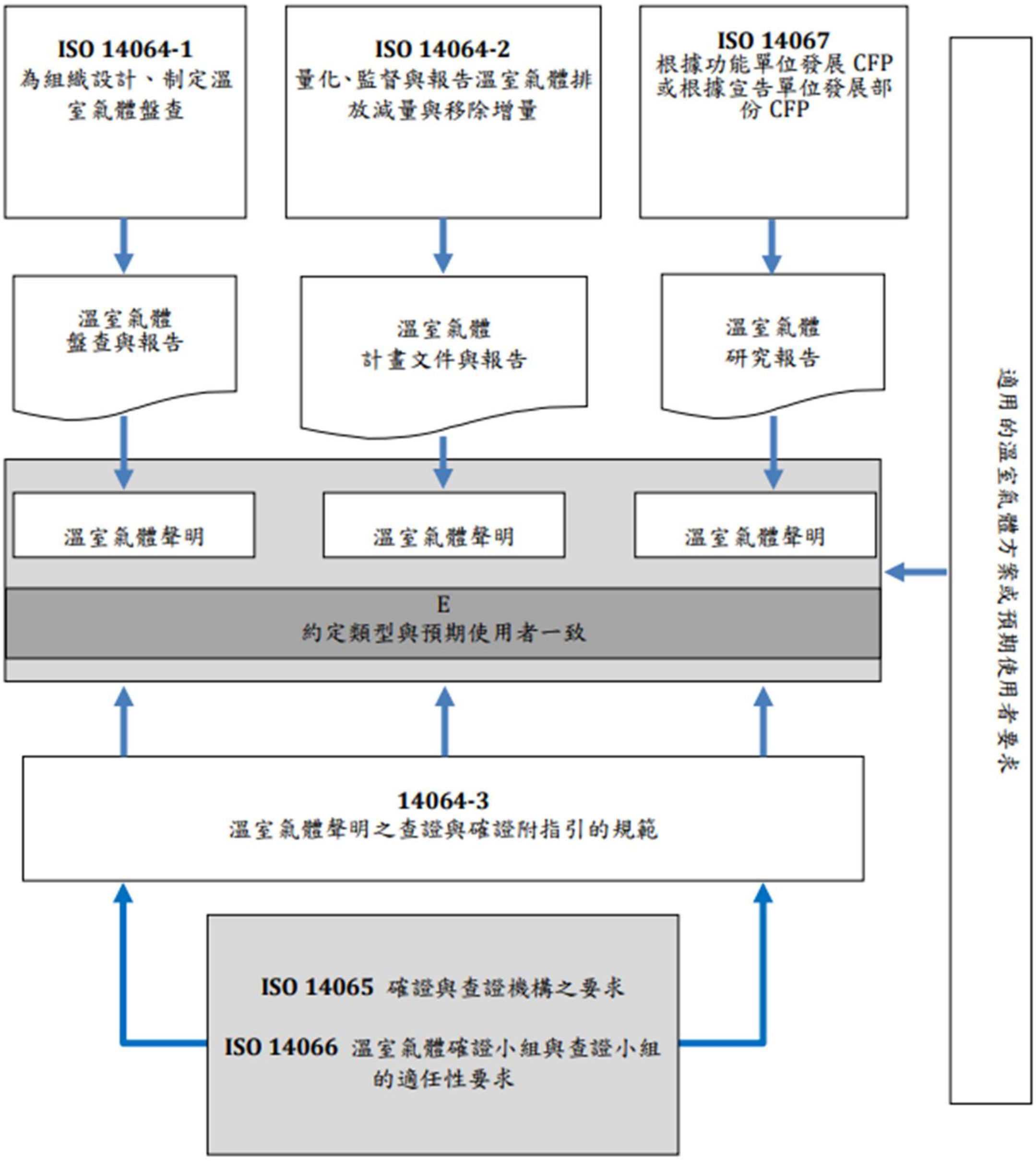


圖 1 溫室氣體標準與 ISO 14060 系列間之關係（引用自參考文獻 1）

（二） 溫室氣體聲明之確證與查證

隨著氣候變遷的議題日漸受到關注以及全球淨零政策的目標宣示，溫室氣體盤查與溫室氣體排放減量或移除增量之查證與確證將變得更加重要。本所派員參加「ISO 14064-3：溫室氣體聲明之確證與查證附指引之規範」課程，該 ISO 文件內容係針對溫室氣體盤查清冊、溫室氣體計畫或方案，提供溫室氣體查證者/確證者一有效指引。

溫室氣體聲明(greenhouse gas statement，GHG statement)係為一事實與客觀之宣告，可以溫室氣體報告或溫室氣體計畫呈現，內容可能包含溫室氣體相關的資訊或是改變溫室氣體基線條件並且能夠造成溫室氣體排放減量或是溫室氣體移除增量的活動。查證或確證是針對溫室氣體聲明之內容進行評估的過程。在 ISO 14060 系列之規範中，查證(Verification)與確證(Validation)定義分述如下：

1. 查證(Verification)：對根據歷史數據與資訊作成之聲明，判定此聲明是否屬實正確並符合準則，進行之評估過程。
2. 確證(Validation)：對支持有關未來活動結果的聲明之各項假設、限制及方法之合理性，進行之評估過程。

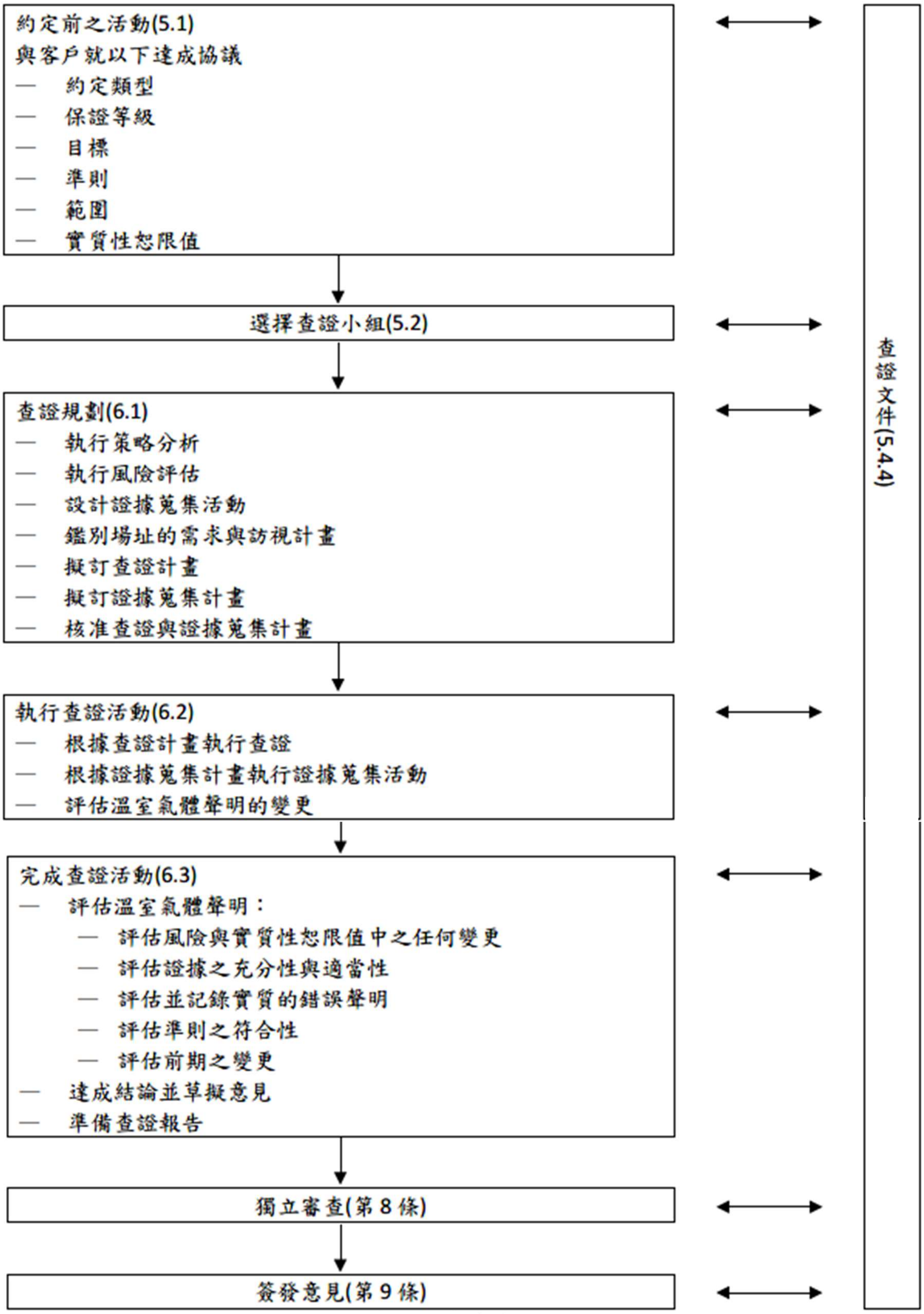
查證與確證之差異在於查證係對過去之資訊進行評估，確證則是針對未來活動的假設結果進行評估。負責查證執行及報告之人員稱為查證者，負責確證執行及報告之人員稱為確證者。

（三） 確證與查證之原則與過程

執行溫室氣體查證或確證應符合五大原則，分別是公正性、以證據為基礎進行評估、公平陳述、文件化以及保守性。在執行查證或確證前，則應先確認下列各事項：

1. 類型。
2. 目標：查證或確證。
3. 範圍：組織邊界、期間。
4. 準則：實質性、保證等級等。

查證的過程包含(1)約定前之活動；(2)選擇查證小組；(3)查證規劃；(4)執行查證



活動；(5)完成查證活動；(6)獨立審查；(7)簽發意見。查證之過程可參考圖 2 所示。

圖 2 查證過程（引用自參考文獻 1）

確證的過程包含(1)約定前之活動；(2)選擇確證小組；(3)確證規劃；(4)執行確證活動；(5)完成確證活動；(6)獨立審查；(7)簽發意見。確證之過程可參考圖 3 所示。

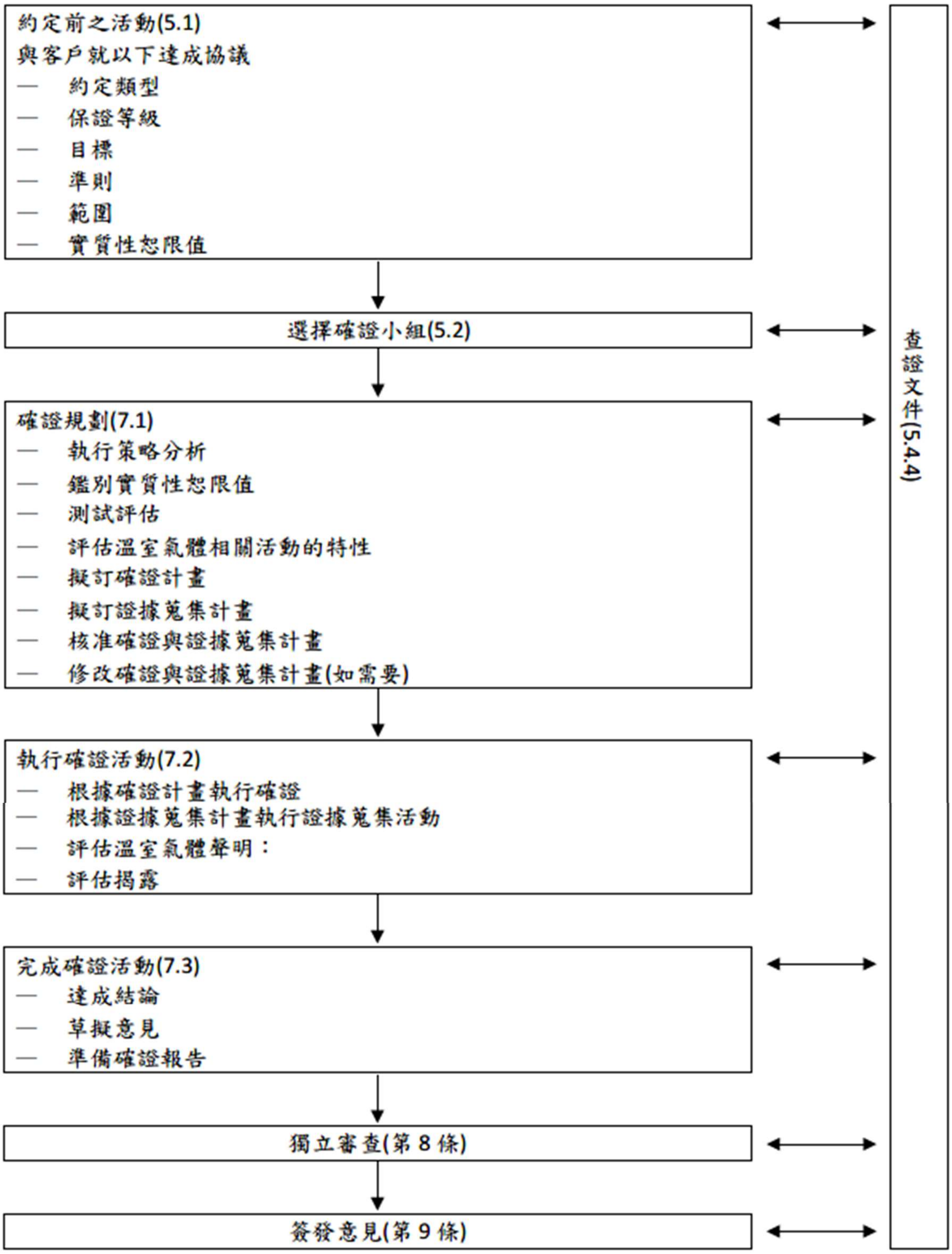


圖 3 確證過程（引用自參考文獻 1）

（四） 獨立審查與簽發意見

完成查證或確證後，查證者或確證者可決定是否簽發或放棄簽發意見，簽發之意見類型可分成下列三種：

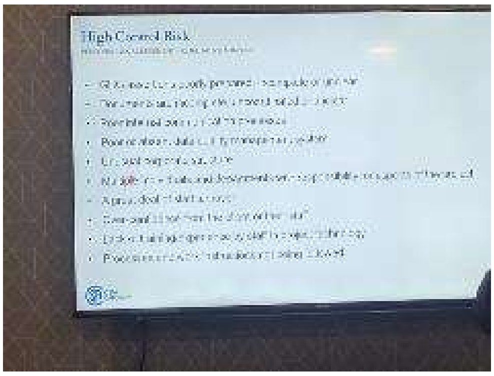
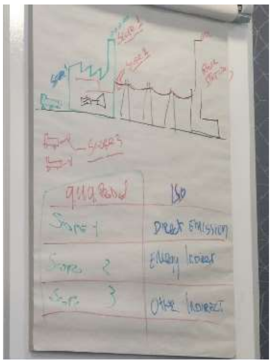
1. 未經修改的意見：若簽發意見屬於此類，意即查證過程有充分且適當的數據支持實質的溫室氣體排放量、移除量或是儲存量；或確證過程中有充分且適當之證據支持未來的估計。
2. 經修改的意見：若簽發意見屬於此類，查證者或確證者須確保溫室氣體聲明沒有實質的錯誤聲明。當有偏離準則要求或是限制範圍時，查證者應決定何種類型之修改意見才適當；當偏離準則要求或擬訂未來估計所用的假設有缺失，確證者應決定何種類型之修改意見才適當。
3. 負面的意見：若簽發意見屬於此類，則代表溫室氣體聲明沒有充分或適當的證據支持未經修改或經修改的意見，或是針對實質的排放量、移除量或儲存未採取適當的準則。

若已確認無法取得充分且適當的證據，並且可判定未發現的實質性錯誤對於溫室氣體聲明造成的影響重大而普遍，此時可放棄簽發意見。

查證或確證過程中，應同時選擇適任之獨立審查者，並執行獨立審查，且審查者不得為執行查證或確證之人員。若獨立審查者在查證或確證期間發現重大議題，須妥善解決後再簽發意見。

簽發之意見內容應包含：(1)鑑別溫室氣體相關活動以及溫室氣體聲明涵蓋的日期與期間；(2)鑑別提出溫室氣體聲明之負責者，另負責者須聲明對該文件負責；(3)用於彙整與評估溫室氣體聲明之準則；(4)宣告溫室氣體聲明之查證或確證係依據 ISO 14064-3 內容執行；(5)查證者及確證者之結論，且查證者之結論須包含保證等級（如該查證適用保證等級時）；(6)簽發意見之日期。

五、受訓照片

參、心得與建議

一、國外考試偏向活用，課程內容相較於國內，偏向實際應用，例如：查驗案例說明、計算技巧、不同計算方式的驗證等等，反觀國內則較多為條文的解釋和經驗分享。

二、溫室氣體盤查企業類型甚多，各項專業領域差異頗大，查驗工作需具備虛心學習的態度，尤其 ISO 14064-3 許多要求的解釋都需配合不同類型的企業特性，若僅依條文規定難以窺得全貌。

三、查驗機構與人員的獨立性和公正性是查驗報告最重要的一環。部分國家甚至明訂企業不得由同一家機構或人員長期執行查驗工作，例如每三年更換一次。

四、國際間溫室氣體查驗多依循之 ISO 最新版本，此與國內納管對象的查驗要求，不甚相同。

五、國際間查驗報告相互承認是未來碳交易市場的重要機制，目前歐盟雖然尚未明訂查驗報告承認的規定，但隨著碳邊境調整機制（Carbon Border Adjustment Mechanism, CBAM）的推動，仍然是國內必須注意的課題。

六、為與國際同步，建議後續國內相關課程可採雙語進行，不僅可同時培養語言能力，亦利於業務與國際接軌。

肆、參考資料

1.CNS 14064-3，溫室氣體-第 3 部：溫室氣體主張之確證與查證附指引之規範，民國 110 年。

2.CNS 14064-1，溫室氣體-第 1 部:組織層級溫室氣體排放與移除量化及報告，附指引之規範，民國 110 年。

3.CNS 14064-2，溫室氣體-第 2 部:專案層級溫室氣難排放減量或移除增量之量化、監督及報告附指引之規範，民國 110 年。

4.ISO 14064-1: 2006 Greenhouse gases - Part1: Specification with guidance at the organization level for quantification and reporting of greenhouse and removals, 2006.

5.ISO 14064-2: 2019, Greenhouse gases - Part 2: Specification with guidance at the project level for quantification, monitoring and reporting of greenhouse gas emission reductions or removal enhancements, 2019.

6.ISO 14064-3: 2019, Greenhouse gases - Part 3: Specification with guidance for the verification and validation of greenhouse gas statements, 2019.

附錄 1　溫室氣體聲明查證與確證案例演練（範例）

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Smith Dairy Case Study

Project Plan: Emission Reductions from Anaerobic Digester at Smith's Dairy

Revised September 2016

Acknowledgement

This draft case study was compiled using the *Draft Quantification Protocol for the Anaerobic Decomposition of Agricultural Materials* (herein referred to as 'Draft Protocol') as a main guide. The development of the Protocol was led by Mr. Keith Driver, M.Sc., P.Eng., MBA, Vice President of Operations for Baseline Emissions Management Inc. with support from Mr. Robert Andrews, Senior Vice President of Baseline Emissions Management Inc., Dr. Xiaomei Li of the Alberta Research Council, Mrs. Karen Haugen-Kozyra of Alberta Agriculture, Food and Rural Development, Mr. Michael Gerbis, P.Eng., President of The Delphi Group and Stephan Wehr, Manager – GHG Services with The Delphi Group. The findings and methods outlined within this draft document are used extensively within this case study since the expertise involved in its creation is seen as best practice guidance for this specific project type. Their proficiency in this subject matter is hereby acknowledged and their guidance is greatly appreciated.

Introduction

The agriculture sector in Canada produces 7.2% of Canada's GHG emissions with a total contribution of 55,000 ktonne CO_2eq (National Inventory Report, 2007). This is the second largest Canadian contributor of GHGs following the energy sector which produces 82% of Canada's emissions. GHG emitting agricultural activities include manure management (methane and nitrous oxide), enteric fermentation from livestock (methane), crop management (carbon dioxide, nitrous oxide) and fertilizer application (nitrous oxide). From these activities several proven techniques have emerged that reduce the amount of emissions produced.

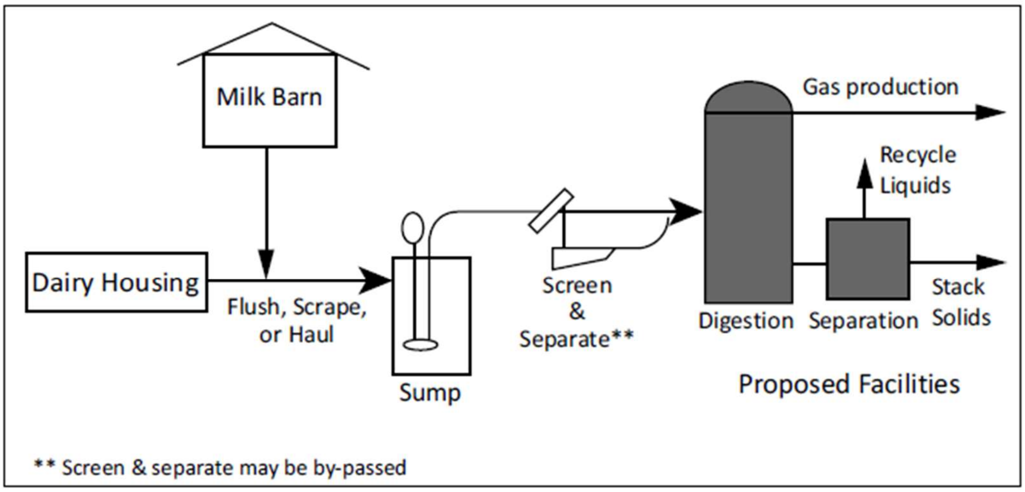
Within this case study an anaerobic digestion system is implemented on a typical dairy farm. Emission reductions are possible as a result of the collection and methanogenic digestion of organic material. The anaerobic digester collects, decomposes and utilizes by-products of the organic material, as opposed to these gases being released into the atmosphere. Waste products, dead stock and various other organic materials are collected in this case study and subsequently moved into the controlled digester area.

Anaerobic digestion is the microbial decomposition of organic matter in the absence of oxygen. Anaerobic is defined as "without air". Within the anaerobic digester, microbes break down organic material producing both natural gas (methane) and carbon dioxide (CO_2). The concentration and volume of natural gas produced by anaerobic digestion is significant enough to be used for heating or electricity production. By utilizing the gas produced from the anaerobic digester, a farming operation may further reduce its dependence on grid sourced electrical supply. In addition to producing useful gas by products, the microbes also significantly reduce the overall volume of organic material, producing a nutrient rich slurry which may be further utilized for crop fertilization.

These added benefits resulting from the installation of an anaerobic digestion system will justify the capital investment, and will facilitate easy maintenance of the dairy operation.

Figure 1 illustrates the typical configuration of a dairy operation with capacity for an anaerobic digestion facility. Screening and separation of material may be excluded if silt, sand and bedding material are minimized in the digester feedstock.

Figure 1
Graphic Illustrating Typical Anaerobic Digester Facility (Burke, 2001)



With climate change becoming a global crisis, the search for emission reduction projects and methods for calculating carbon reductions is ever-increasing. Provincial and municipal governments are now turning their attention to realistic and achievable projects that can produce real results. Agriculture, being a significant source of GHG emissions, is seen as an industry with great potential for achieving emission reductions. This increased attention has, in turn, increased the potential revenue for farmers, as added revenue is now available through the sale of reductions of GHGs. Further to the added financial benefits provided by GHG emission offsets, electricity production resulting from the utilization of methane can greatly offset the livestock operations electricity costs.

As this case study deals exclusively with the implementation of an anaerobic digester system, it is important to define terms associated with this type of system. The following definitions were extracted from the Draft Protocol. Within this case study digester definitions are adopted and used from the Protocol findings.

Important Definitions and Terms

Agricultural Material: Agricultural material includes organic residues from the full life cycle of agricultural production, including crop residues, livestock manures, silage, dead stock (special handling applies), food processing by-products, etc. These materials may be produced at primary production agricultural operations or agri-food processing facilities.

Anaerobic Digestion: An active and naturally occurring biological process where organic matter is degraded by methanogenic bacteria to yield methane gas and mineralized organic nutrients.

Land Application: The beneficial use of the agricultural material and/or digestate applied to cropland based upon crop needs and the composition of agricultural material as a source of soil amendment and/or nutrition.

Fugitive Emissions: Intentional and unintentional releases of GHGs from joints, seals, packing, gaskets, etc. within the anaerobic digestion system, including all processing, piping and treatment equipment.

Feedstock: Refers to the substance being collected as organic waste matter from the farming operation (including manure, dead stock, bedding, etc.).

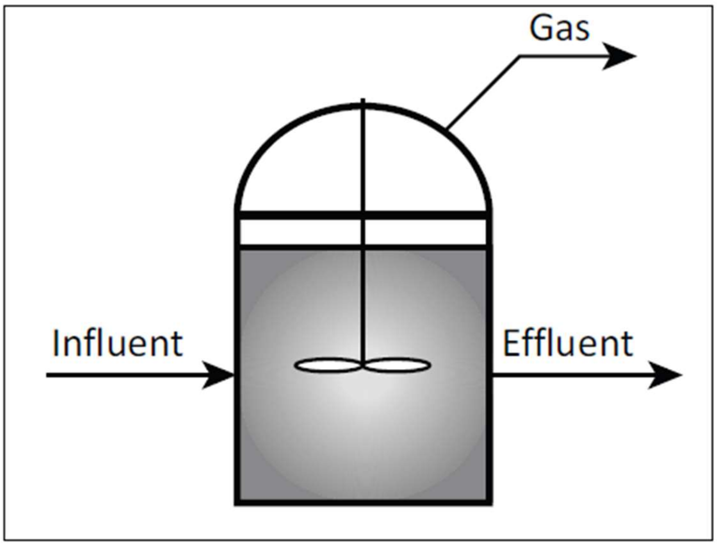
Digester Selection

There are a large number of digester configurations available, each with different positive and negative aspects to their use. Overall, all digesters function to maximize the following objectives (Burke, 2001):

1) Reduce the mass of solids
2) Reduce the odors associated with waste products
3) Produce clean effluent for recycle and irrigation
4) Concentrate the nutrients in a solid product for storage or export
5) Generate energy

Within this case study Smith's Dairy has decided to implement a continuously stirred *('completely mixed reactor')* anaerobic digester. A diagram of a basic Completely Mixed Reactor (CMR) is provided in Figure 2. CMRs function by operating a constant stirring arm and a sludge heating system.

Figure 2:
Continuously Mixed Reactor (Burke, 2001)



By providing adequate temperature and mixing, conditions within the CMR are adjusted to reflect maximum microbial growth while minimizing, if not eliminating, sludge particulate settling. This results in significantly less down time for cleaning and maintenance, which is common in other types of digesters. This digestion system does have slightly higher electricity requirements; however, the increased electricity requirement will facilitate higher gas production, due to proper mixing and heating, and will also further reduce maintenance, as mentioned. Overall a long-term financial plan has indicated that the benefits received from this digester selection will substantiate the increased operating costs. A ten year payback period is expected from this project.

This case study will follow the requirements and guidance outlined in the ISO 14064-2: 2019 GHG Standard for projects.

General Requirements

Relevant GHG Schemes and Protocols

In this case study, the ISO 14064-2:2019 standard, the WRI/WBCSD GHG Protocol for Projects (December 2005) and the Draft Protocol are used as good practice guidance for identifying sources, sinks and reservoirs (SSRs) for the project and baseline scenarios. They also served as good practice guidance for quantifying, monitoring and reporting GHG emissions and emission reductions. In identifying SSRs, a seven step procedure based on a streamlined Life Cycle Assessment (LCA) technique was applied. Additional good practice guidance that was used is outlined below.

A number of other organizations were consulted for guidance when completing this GHG case study. Work completed by Environment Canada was able to provide some guidance, while similar anaerobic digester projects were consulted for design aspects and published gas production rates. As mentioned, the Draft Protocol was the primary reference document which was heavily relied upon to provide expertise for the calculations within the following sections.

Project Description

Project Title, Purpose and Objectives

The project entitled **"Emission Reductions from Anaerobic Digestion at Smith's Dairy"** is being undertaken to reduce emissions of CH_4 and CO_2 gases from the degradation of organic material. Emission reductions will result from the capture and utilization of these gases which are produced within the CMR. Reductions of CO_2 and CH_4 on the dairy farm and the increased benefits of onsite electricity generation and heat production will benefit the overall operation of the dairy farm. The greenhouse gases to be quantified in this project are primarily CO_2 and CH_4.

The objective of this case study is to illustrate how Smith's Dairy quantified and verified the GHG emission reductions achieved through implementing an anaerobic digestion system. It is assumed that these emission reductions could be subsequently sold to a company interested in sourcing emission reductions (i.e., a regulated entity under a GHG program). This provides the added benefit of producing further income for the dairy operator through the sale of offset credits. The emission reductions achieved by Smith's Dairy require verification on an annual basis before the transaction of emission reductions can be completed. The verification process will be done in accordance with ISO 14064-3 by an independent verification body.

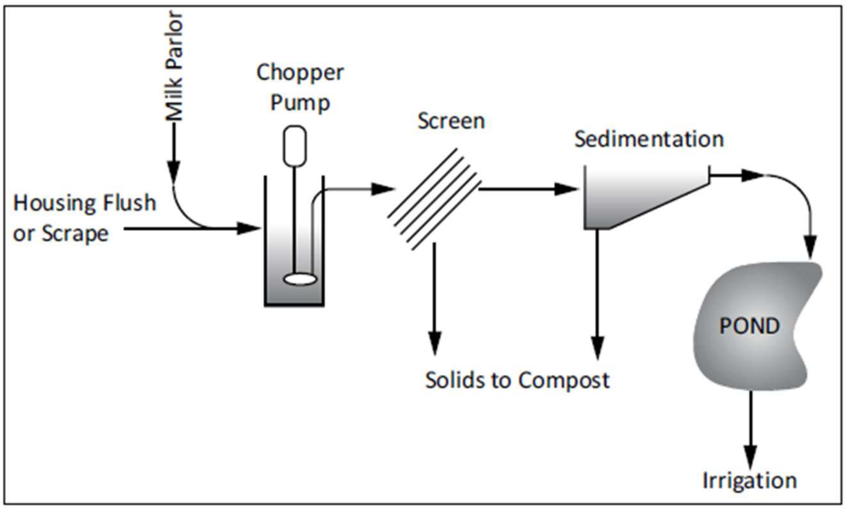
Location of Project

The project is located near Fergus, a community within the Province of Ontario northwest of the city of Guelph. The dairy farm is operated by the Smith family and their 270 tie-stall operation is referred to as the Smith's Dairy. Smith's Dairy is presently managing 700 hectares (ha) of land and 300 mature dairy cows, and has been in operation since 1970.

Conditions Prior to Project Initiation

Smith's Dairy does *not* currently have an anaerobic digester on site. Their manure collection process is comprised of typical screening and gravity separating with lagoon settlement and subsequent land spreading (twice a year). Figure 3 illustrates Smith's Dairy current system.

Figure 3:
Current Manure Management at Smith's Dairy (Burke, 2001)



This will be the first year that Smith's Dairy will be producing electricity from the by-products of anaerobic digestion.

Currently there is no regulation in Ontario stipulating farmers must implement anaerobic digestion for their organic waste management. Smith's Dairy has identified this project as a means to help protect the environment through the production of green energy, but also as a means to reduce operating costs associated with managing their dairy farm.

Project Strategy to Reduce Emissions

It has been shown that there is significant energy potential contained within the organic matter currently disposed of by Smith's Dairy. Significant environmental and financial benefits could be realized if this was managed properly. By collecting and digesting the manure produced on this medium sized dairy farm, Smith's Dairy will successfully offset their electricity needs by producing 100% of their required power. Excess electricity production, above and beyond Smith's Dairy's requirement, is also possible, and selling this excess electricity to the local grid is a viable option under the Ontario Power Authority Standard Offer Program (SOP).

Although the operation of this new natural gas electricity generator will produce GHG emissions, the offsets resulting from the elimination of indirect electricity emissions will far exceed the small direct emissions occurring directly on the farm. Furthermore, emissions from current manure management will be reduced as the operating lagoon will become obsolete.

Smith's Dairy also plans to partner with local farmers to provide them with an alternative means of disposal of deadstock from their operations. Smith's Dairy will utilize their digester for their own deadstock; however, disposal of deadstock is not often necessary, considering their small operation. By allowing local farmers to dispose of deadstock within the anaerobic digester, Smith's Dairy will be removing matter that would have otherwise been land filled. Thus, the equivalent amount of landfill gas savings will further add to Smith's Dairy total of emission reduction potential. Deadstock will be added to the digester after passing through a twister bucket which will effectively reduce the size of the matter to 3 cm diameter pieces. These pieces will be fed into the digester with use of a pump, so as to not open the digester cover and release the contained gases. All deadstock approved for disposal at the Smith's Dairy Digester will follow local laws and criterion set out within the *Dead Animal Disposal Act (DADA)* (OMAFRA, 2007). The transportation and disposal of dead stock will be conducted through a licensed dead stock collector.

In summary, emission reductions will ultimately result from three processes: the closing of the current lagoon, the elimination of indirect emissions associated with off-site electricity generation and the diversion of waste that was previously sent to a landfill. The Draft Protocol outlines the steps required to calculate emission reductions associated with the decreased grid electricity use, manure management and landfill diversion of deadstock.

GHG Emission Reductions from the Project

GHG emission reductions will be first be quantified for the 2003 season (the year in which the project was implemented) and will be quantified on a yearly basis thereafter. Overall, the implementation of an anaerobic digester system will produce emission reductions from two main sources: (1) closing of the manure lagoon and (2) offsetting grid-based electricity. Smith's Dairy will generate emission reductions by reducing methane emissions on-site, producing their own electricity and eliminating reliance on the Provincial electricity. With implementation of manure collection and digestion, Smith's Dairy will eliminate the emissions resulting from their treatment lagoon which will be closed.

The project is expected to generate a total of 279 tonnes of CO_2e emission reductions during the first year, assuming there are no releases of fugitive emissions resulting from unexpected gas releases.

In subsequent years GHG emission reductions will continue to be quantified using this baseline year as a basis for comparison. A period of 10 years was selected as an appropriate period for claiming emission reductions as is it forecasted that by 2015 anaerobic digestion may become standard practice for organic waste management on farms in Ontario.

Risks to the Project's GHG Emission Reductions

The main factors that could potentially reduce the GHG emission reductions estimated for this project include:

- The implementation of new regulations by the Government of Ontario requiring the adoption of digesters on all farming operations
- Anaerobic digestion becoming common practice in Ontario
- Decreasing GHG emission factors for the electricity generation sector. If grid-wide GHG emission factors decrease for the province, there will be fewer indirect emission reductions associated with the Smith Dairy Farm digester
- The mechanical breakdowns of the digester or holes forming in the digester cover (subsequently resulting in aerobic digestion)

- Cleaning of the digester by complete shutdown of the facility, resulting in emission releases as the cover is removed and digestate is disposed of

Project Proponents and Relevant Stakeholders

Smith's Dairy

289 Milk Lane, (519) 123-4568

N1G 1V1

Ontario, Canada

Stakeholder Consultations

This is a private initiative aimed at reducing operating costs and reducing effects on the environment. No open consultations were conducted during this project; however, federal scientists and experts involved in development of the Draft Protocol were consulted on particular elements of the quantification methodology.

The above mentioned consultations with federal officials and leading experts from the Draft Protocol development team were all documented. A list of individuals who were contacted and a description of the data they provided is available upon request. These consultations were conducted as a means of ensuring the methodology described within this case study is appropriate for the Smith Dairy Farm. These consultations confirm that calculations contained within this study are an accurate representation of the GHG emission reduction potential at Smith's Dairy.

Financial Analysis

Financial complications were assessed for both the baseline and project situations. The baseline scenario's "business as usual" case is considered to be sustainable for the foreseeable future. No financial barriers have been identified which would impede the continuation of the current baseline case.

A financial barrier analysis was also completed for the project case comparing the capital investment needed for the development of the anaerobic digester facility to the baseline financing. It was determined that the reduction in future operational costs will outweigh the initial cost of construction of the project case within a 10 year period. This payback period is determined to be substantial but manageable if emission reductions are obtained and used as a financing source. Financial implications associated with the project case, moving from land spreading to anaerobic digestion, will impose financial barriers which will be reduced through obtaining revenue from the sale of emission reductions associated with the project.

With more complex or involved projects a full barrier analysis should be completed and illustrated within the project documentation. The GHG Protocol Barrier Analysis Methodology (found at www.ghgprotocol.org) is good practice guidance for this process.

Methodology Description

Development Approach

Calculations outlined within the Draft Protocol will be followed throughout the emission calculation section. Summary tables will be provided outlining the approach taken for each calculation. Both the project and baseline emissions will be calculated separately, with the resulting emission reduction potential indicated. Methane emissions from the baseline lagoon operation (not quantified within the Draft Protocol) will be quantified and included within this case study.

The calculations will follow the specified method for calculating emissions, as prescribed by the ISO 14064-2: 2019 Standard. The correct method, as outlined within the ISO Standard is as follows:

$$\text{Emission Reduction} = \text{Emissions}_{\text{Baseline}} - \text{Emissions}_{\text{Project}}$$

Within the Draft Protocol, Project and Baseline related emission sources are identified and defined in the following manner. Where:

$$\text{Emissions}_{\text{Baseline}} = \text{Emissions}_{\text{Feedstock Disposal}} + \text{Emissions}_{\text{Incineration}} + \text{Emissions}_{\text{Electricity}} + \text{Emissions}_{\text{Thermal Heat}} + \text{Emissions}_{\text{Fuel Extraction / Processing}} + \text{Emissions}_{\text{Lagoon}}$$

$$\text{Emissions}_{\text{Project}} = \text{Emissions}_{\text{Multiple Sources}} + \text{Emissions}_{\text{Pipeline Distribution and Usage}} + \text{Emissions}_{\text{Flaring}} + \text{Emissions}_{\text{Venting}}$$

As expected, each of the identified sources, within both the project and baseline emission calculation, has corresponding equations and definitions. Please refer to the Project and Baseline descriptions for further development of these equations.

Chronological Plan

The ISO 14064-2: 2019 standard requires that a chronological plan be presented for the project activities. Table 1 outlines and describes the project activities and their timing.

Table 1:
Project Activity Timeline

TASK	DATE	RESPONSIBILITY	DESCRIPTION
PRODUCER APPLICATION	January	Producer	Intention to Install Anaerobic Digester. Includes all necessary design documents and building plans and permits.
INSTALLATION	April	Project Proponent, Construction Team	Project proponent selects site, design and methods. Implementing the design and on site construction is started.
IMPLEMENTATION OF THE MANURE COLLECTION SYSTEM	June to October	Producer	Beginning of new manure management and startup of anaerobic digester with organic matter.
MONITORING AND VERIFICATION OF THE GAS PRODUCTION	July to October	Project Proponent, Verifier	Selection of location for field assessment of anaerobic digester, including monitoring and verification of anaerobic digester.
PRODUCER FIELD RECORD SHEETS	November	Producer	For each month, complete gas volume production records are submitted with detailed record sheets.
MONITORING AND VERIFICATION OF GAS AND ELECTRICITY GENERATION	Ongoing	Project Proponent, Verifier	Specific records of gas production and electricity generation need to be maintained.
CALCULATION OF GHG EMISSION REDUCTIONS	January	Project Proponent	Confirmation that electricity demand was offset, using detailed record sheet data and applying appropriate coefficients and calculation of GHG emission reductions for anaerobic digestion.
FINAL VERIFICATION	February	Verifier	Verification of emission reductions and the GHG removal and emission reduction calculations.

Identifying GHG Sources, Sinks and Reservoirs Relevant for the Project

Selection and Establishment of Criteria and Procedures

A review of applicable good practice guidance for criteria and procedures to identify Sources, Sinks and Reservoirs (SSRs) relevant to the project included:

- WRI/WBCSD GHG Protocol for Projects, December 2005
- ISO 14064-2: 2019
- Draft Anaerobic Digestion Protocol
- Alternate data sources for Anaerobic Digestion Projects
- Agriculture and Agri-Food Canada

The procedure is a systematic approach meant to address the principles of accuracy, consistency, completeness, transparency and relevance and therefore fulfills the requirements of the ISO standard.

Other good practice guidance documents and procedures identified in this area were not selected as reference material because of the lack of transparency and completeness associated with their procedures. The seven steps in a streamlined lifecycle approach mentioned earlier allow the identification of all relevant SSRs (e.g., transportation, installation, operation, maintenance).

The following seven step procedure was utilized, along with the Draft Protocol, to ensure all relevant sources, sinks and reservoirs associated with the project are identified:

1) Identify (potential) SSRs for the system that are controlled or owned by the project proponent. Focus on the primary project activities (i.e., the direct SSRs that aim to provide the main effect(s) on GHGs)
2) Identify (potential) SSRs that are physically related to the direct project, trace products, materials and energy inputs/outputs upstream and downstream to origins in natural resources along the life cycle
3) Identify (potential) SSRs that are economically affected by the project. Consider the economic and social consequences of the project (compared to the baseline), look for activities, market effects and social changes that result from or are associated with the project activity
4) For each identified SSR determine parameters required to estimate or measure GHGs. This includes materials and energy inputs/outputs and information on activities, products and services for the SSR
5) Select SSR scale by aggregating or disaggregating identified potential SSRs. The number of SSRs defined and the degree of detail required is a function of the analysis at hand. This is guided by availability of data, management of data collection and assurance of accurate

GHG quantification. As a rule of thumb, more detailed (disaggregated) SSRs are appropriate where it is known that:

- The project system differs from the baseline system
- Ore specific quantification is necessary
- Data is readily available
- Aggregated SSRs are sufficient where the project and baseline systems are identical

6) Determine the function(s) (products, goods and services) provided by the system of SSRs. The whole system of SSRs may perform one or more functions, plus individual SSRs may have specific functions. Ensure functional equivalence between the project and baseline

7) Confirm that:
   - All SSRs are identified
   - Each SSR is classified appropriately as owned, related or affected
   - All GHG inputs and outputs for each SSR are identified
   - The sequence of SSRs for the system is correct
   - Repeat previous steps as necessary

Application of Procedure

By following the above steps and referencing good practice guidance, all the appropriate SSRs associated with anaerobic digestion were identified. The SSRs that are controlled or directly owned by the project are those elements whose operations are under the direct influence of the project proponent, and they are often found on the project site. The related SSRs are the GHG sources, sinks and reservoirs that have material or energy flows into, out of, or within the project. These SSRs are generally found upstream or downstream from the project and also include activities involved with the design, construction and decommissioning of the project. No *affected* SSRs were identified for the project or baseline cases.

Upstream SSRs

Upstream SSRs involve material and energy flows associated with the production and distribution of equipment and dairy inputs that are purchased from an off-farm source and are required for manure management. These SSRs are considered *related* because they are not directly controlled by the dairy producer or project proponent in dairy production.

Downstream SSRs

Downstream SSRs are associated with the end products of dairy production, specifically the transportation and processing of dairy products and utilization of livestock feedstock, or human food products. These downstream SSRs are considered *related* since they are not controlled by the dairy producer or project proponent directly. For this case study these downstream SSRs are not considered *affected* since they are not impacted by the project activity of anaerobic digestion.

A summary of the identified Project-based SSRs is presented in Table 2, and flowcharts of these SSRs are presented in and Figure 5. Note that within, the SSRs contained within the dashed box are those directly controlled by Smith's Dairy.

Figure 4:
Simplified Project Flow Diagram (Draft Protocol, 2007)

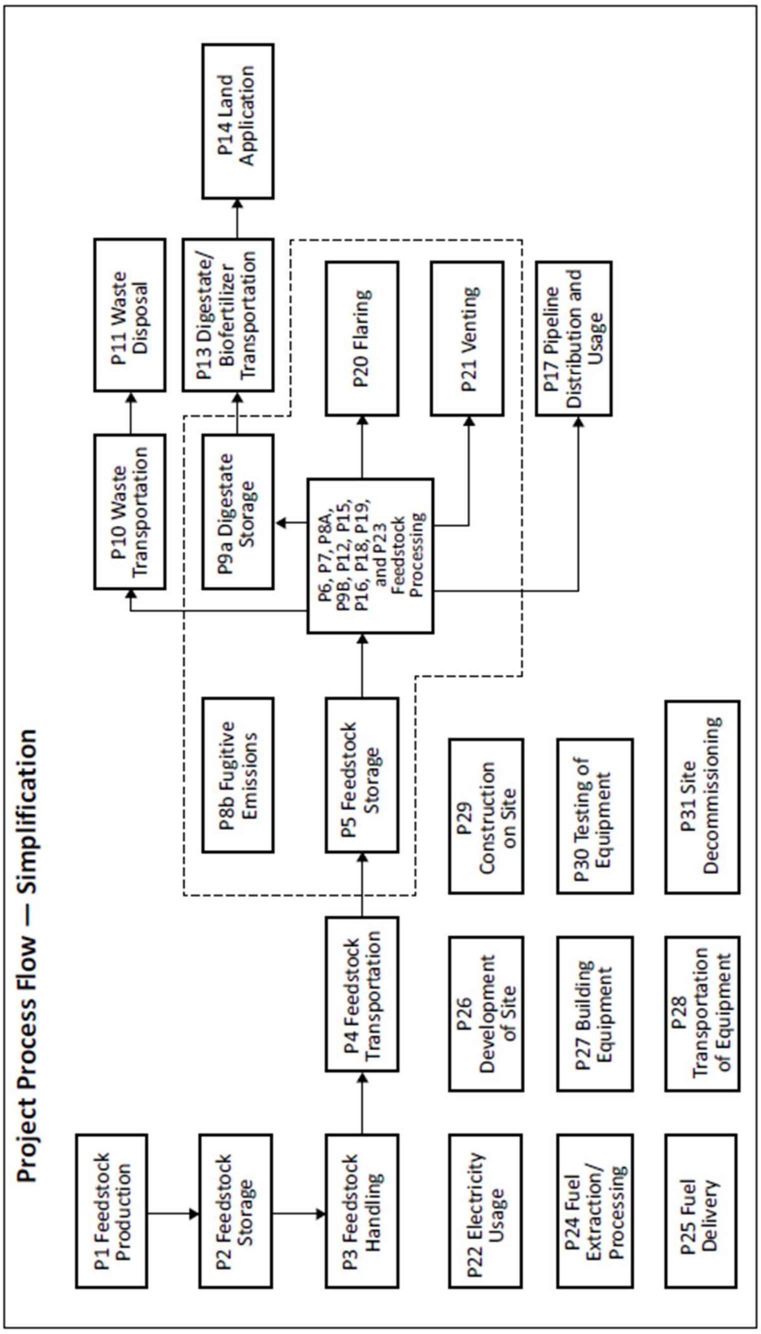


Figure 5:
Project Related SSRs (Draft Protocol, 2007)

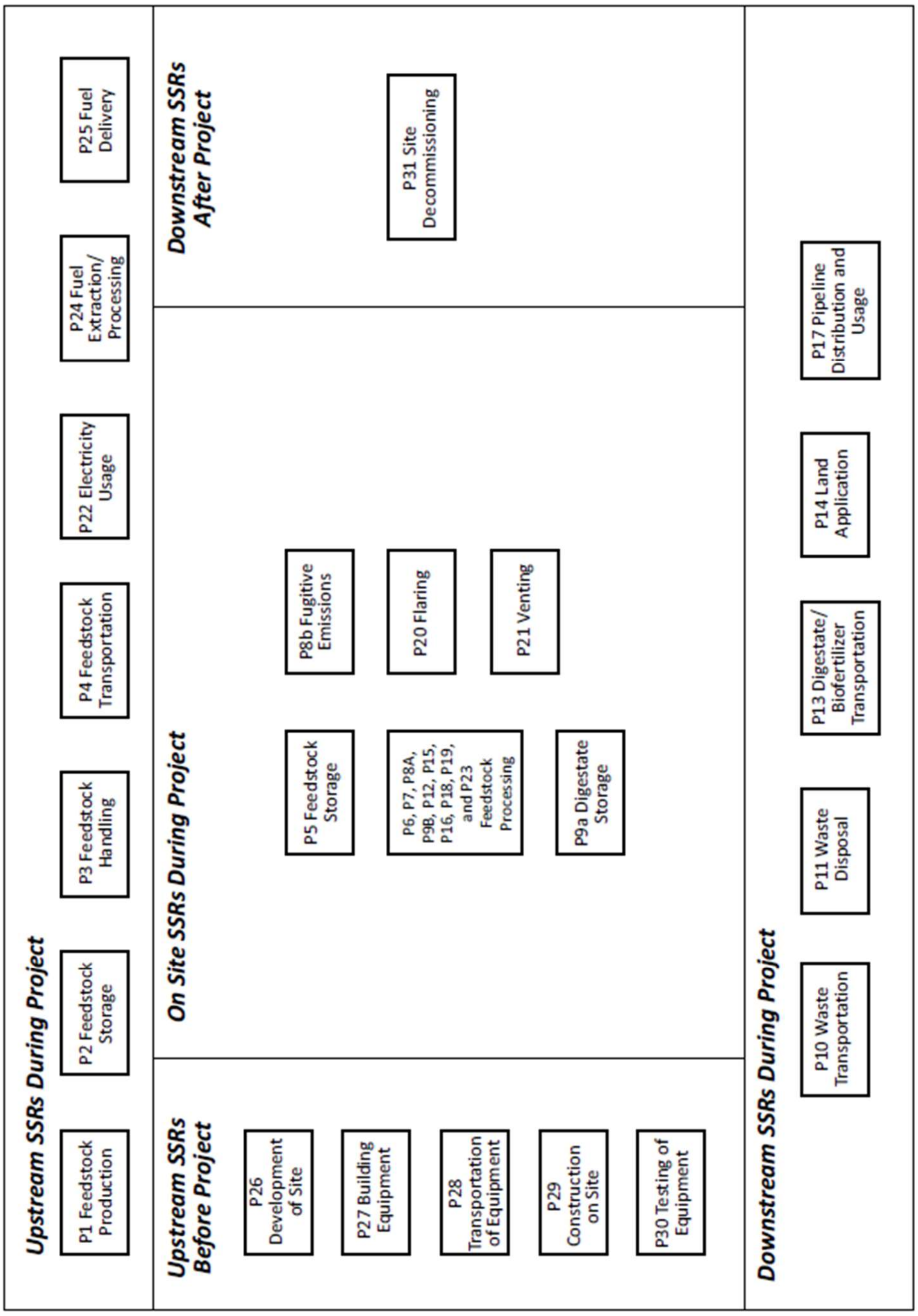


Table 2:
Identified project SSRs (Draft Protocol, 2007)
Upstream SSRs During Project Operation

SSR	DESCRIPTION	CONTROLLED, RELATED OR AFFECTED
P1 Feedstock Production	Feedstock may be produced either by the animals based on the rations they are fed or as other organic matter such as material agriculture products.	Related
P2 Feedstock Storage	Feedstock may be stored before handling and transportation.	Related
P3 Feedstock Handling	Feedstock may be handled using a number of means.	Related
P4 Feedstock Transportation	Feedstock may be transported to the site for storage.	Related
P22 Electricity Usage	Electricity may be produced to meet the electricity demand associated with the project.	Related
P24 Fossil Fuel Extraction / Processing	Fossil fuel used requires initial extraction and processing.	Related
P25 Fossil Fuel Delivery	Fossil fuel used on the farm has to be transported to the site.	Related

Table 3:
Identified project SSRs (Draft Protocol, 2007)
Onsite SSRs During Project Operation

SSR	DESCRIPTION	CONTROLLED, RELATED OR AFFECTED
P5 Feedstock Storage	Feedstock may be stored at the facility pending input to the digester.	Controlled
P6, P7, P8a, P9b, P12, P15, P16, P18, P19 and P23 Feedstock Processing	Feedstock may be processed and transported to the digester.	Controlled
	Components of the feedstock may need to be processed to address Specific Risk Material (SRM) requirements.	Controlled
	The digester requires energy for its operation.	Controlled
	The digestate may have the liquids and solids separated as a means of preventing continued	Controlled

(Continued)

Table 3: (Concluded)

SSR	DESCRIPTION	CONTROLLED, RELATED OR AFFECTED
	biological activity associated with secondary storage.	
	Digestate/biofertilizer will be produced.	Controlled
	Liquid from the digestate/biofertilizer production may be treated or recycled.	Controlled
	Biogas may be processed and compressed to meet pipeline specification.	Controlled
	Co-generation systems may convert the methane gas into power. This system may be supplemented by other fossil fuels.	Controlled
	Systems may be required to distribute the thermal energy to neighbouring sites.	Controlled
	Thermal energy may be distributed to other facilities or within the site.	Controlled
P8b Fugitive Emissions	The digester may have fugitive emissions from its operation.	Controlled
P9a Digestate Storage	The digestate may need to be stored after being removed from the digester.	Controlled
P20 Flaring	Biogas may be flared during operation.	Controlled
P21 Venting	Biogas may be vented during operation.	Controlled

Table 4:
Identified project SSRs (Draft Protocol, 2007)
Downstream SSRs During Project Operation

SSR	DESCRIPTION	CONTROLLED, RELATED OR AFFECTED
P10 Waste Transportation	Waste digestate and biofertilizer materials may be transported to a disposal location.	Related
P11 Waste Disposal	Waste digestate solids and biofertilizer materials may be disposed of.	Related
P13 Digestate / Biofertilizer Transportation	Digestate/biofertilizer may be transported from the site.	Related

(Continued)

Table 4: (Concluded)

SSR	DESCRIPTION	CONTROLLED, RELATED OR AFFECTED
P14 Land Application	Digestate/biofertilizer may be applied to the land.	Related
P17 Pipeline Distribution and Usage	Biogas may be shipped by pipeline and then utilized at another site.	Related

Table 5:
Identified project SSRs (Draft Protocol, 2007)
Other

SSR	DESCRIPTION	CONTROLLED, RELATED OR AFFECTED
P26 Development of Site	Site development may be required, which could include grading, construction of buildings, etc.	Related
P27 Building Equipment	Equipment may need to be fabricated.	Related
P28 Transportation of Equipment	Equipment and supplies may need to be transported to the site.	Related
P29 Construction on Site	Equipment may need to be assembled on site.	Related
P30 Testing of Equipment	Site testing may cause emissions.	Related
P31 Site Decommissioning	Decommissioning of the site.	Related

Determining the Baseline Scenario

The baseline scenario is the hypothetical reference case that best represents the conditions most likely to occur in the absence of a proposed greenhouse gas project. The baseline scenario identified for this project covers the manure processing used prior to the implementation of the anaerobic digester. Looking at historic data, it was quickly observed that land spreading and lagoon disposal were the two methods utilized prior to implementation of this project.

Relevant good practice guidance procedures and criteria used to identify and assess potential baseline scenarios include:

- WRI/WBCSD GHG Protocol for Projects, December 2005
- ISO 14064-2 2019
- Draft Anaerobic Digester Protocol
- Environment Canada, OMAFRA documents
- CDM Tool
- CDM Approved Methodologies

Procedure to Determine Baseline Scenario

The selected procedure and criteria is the project specific approach from the WBCSD/WRI GHG Protocol for Projects.

The project specific approach from the GHG protocol outlines the following six steps in identifying baseline candidates:

1) Define the product or service provided by the project activity
2) Identify possible types of baseline candidates
3) Define and justify the geographic area and the temporal range used to identify baseline candidates
4) Define and justify any other criteria used to identify baseline candidates
5) Identify a final list of baseline candidates
6) Identify baseline candidates that are representative of common practice. In identifying the baseline candidates that are of common practice, those baseline scenarios whose GHG emissions are higher than those of common practice can be eliminated from the list of potential baseline candidates

In order to appropriately select baseline candidates, the project activity must be clearly defined so as to select baseline scenarios/candidates that provide the same level of product, activity, or service. In this case, we are concerned with managing the entire amount of organic material produced by the dairy operation as well as the previous treatment approaches for deadstock from other farms. Table 3 lists potential baseline scenarios considering the project description, SSRs, alternative project types, activities and technologies, data availability, reliability, limitations and any other relevant information concerning present or future conditions.

Table 6:
List of Baseline Candidates

PROJECT ACTIVITY	BASELINE CANDIDATES
Anaerobic Digestion of organic material (manure, deadstock, etc.)	• Historical benchmark (site-specific lagoon and land spreading treatment for manure as well as landfilling for deadstock) • Performance Standard / Normalized Baseline (sector-wide treatment approaches for manure and deadstock) • Comparison (maintaining site-specific manure and deadstock treatment for a portion of the organic material in order to use as a control for the project) • Projection-based (expected future manure and deadstock treatment conditions, based on market trends, economic and regulatory factors) • Already registered (emissions profile from a baseline that has already been approved by a GHG program or regulatory authority)

Justification of Baseline Scenario

To arrive at a final baseline candidate, each of the above proposed baselines were examined in detail to determine their feasibility. The procedure for selecting the baseline scenario addresses the principles of transparency, relevance, completeness, consistency and conservativeness, as defined within the ISO 14064-2: 2019 Standard.

Based on the comparative assessment of decision making criteria, shown within Table 4 below, the *performance standard approach*, was identified as the most appropriate baseline scenario based on all the consulted good practice guidance.

Table 7:
Comparative Assessment (Draft Protocol, 2007)

1. Baseline Options	2. Description	3. Static/ Dynamic Baseline	4. Accept or Reject and Justify
Historic Benchmark	Under this scenario historic disposal at the farm would be used to calculate the emissions under the baseline condition.	Static	Reject. The volumes of materials handled each year are subject to changes because of market forces, weather, etc. Past emission trends would not be representative of future emission trends. Maintaining a baseline based on a historic data is not reasonable.
Performance Standard	Under this scenario calculations would be estimated based on the average industry emissions profile for the disposal of organic material.	Dynamic	**Accept**. Operational parameters such as material composition, climatology, etc., impact the performance standard. These have been evaluated and incorporated into authoritative emission rates from Environment Canada.
Comparison	Under this scenario a control volume of organic material would undergo the baseline disposal practice as a means of calculating the emissions under the baseline condition.	Dynamic	Reject. Maintaining a control quantity of manure and deadstock that are treated in the previous manner would be resource and data-intensive and costly. There are suitable models that could provide equivalent certainty for this type of data.
Projection Based	Under this scenario the emissions from the disposal of an equivalent quantity of agricultural material would be calculated using existing models covering the activities under the baseline condition.	Dynamic	Reject. This method will account for the market forces, weather and energy demand and operational parameters without adding multiple streams of material management. However, models suitable to determine these emissions will rely on the same Environment Canada data as the Performance Standard.
Already Registered	Under this scenario the emissions would be estimated based on other baseline methodologies registered with the GHG Program.	Unknown	Not available at this time.
Other 1	N/A	N/A	N/A

As indicated, the Draft Protocol suggests using a *performance standard* as the selected baseline as it can account for all of the diverse factors incorporated within the baseline scenario. By developing the baseline case using performance standards, the complex factors associated with the pre-digester manure operation are accounted for through good practice guidance and established authoritative scientific research.

Noting that the standards for quantification were created by industry and governmental leaders, credibility can be incorporated into the data by using these factors and this baseline approach. The performance standard will still require historic data on animal populations, climatic factors, etc., similar to the business as usual case, to properly determine the correct performance factors to utilize.

Currently, Smith's Dairy uses a combination of lagoons and land spreading to manage their organic matter as their standard operating procedure. Deadstock is landfilled using appropriate procedures consistent with the *Dead Animal Disposal Act*. As the performance standard is based on business as usual data and noting that infrastructure is already in place within this baseline scenario, no further requirements are foreseen as barriers to the baseline. It should be noted that lagoon emissions are identified as significant at Smith's Dairy and will be incorporated into this baseline scenario.

Details of Accepted Baseline

By using the *Performance Standard*, Smith's Dairy can easily determine their current GHG footprint and corresponding reduction potentials using approved and standardized coefficients. The details of this selected baseline methodology are adopted below by incorporating the Smith's Dairy business as usual information with performance-based emission factors.

Time Period for Baseline Calculations

Records of dairy operation should be obtained from the years leading up to the project activity, selecting the most recent data available. In essence, the baseline year should be as accurate a representation of a business as usual case as possible. Three years of dairy activity prior to the project year (2001 - 2003) were ultimately selected to represent the baseline activity, due to availability of reliable records and similarity of the farming activities to the project year. The data for these specific years will be averaged and evaluated using the performance standard approach. (300 head of dairy cattle is assumed to remain constant throughout the preceding years).

Identifying GHG Sources, Sinks and Reservoirs for the Baseline Scenario

The feasibility analysis performed above justifies the selection of a *performance standard* as the baseline scenario from which emission reductions will be quantified.

The same 7-step procedure employed above for the project was used for identification of SSRs for the baseline scenario. Due to the project and the baseline having similar processes, the identified SSRs found for the project case apply to those of the baseline scenario. It should be noted that, although the baseline and project SSRs are alike, changes in emission rates for key parameters such as manure management do exist.

Figure 7 differentiates the SSRs by specific categories. Table 5 lists the SSRs for the Baseline case, as identified by using the systematic approach meant to address the principles of completeness, transparency and relevance and therefore fulfills the requirements of the ISO standard.

Figure 6:
Simplified Baseline Flow Diagram (Draft Protocol, 2007)

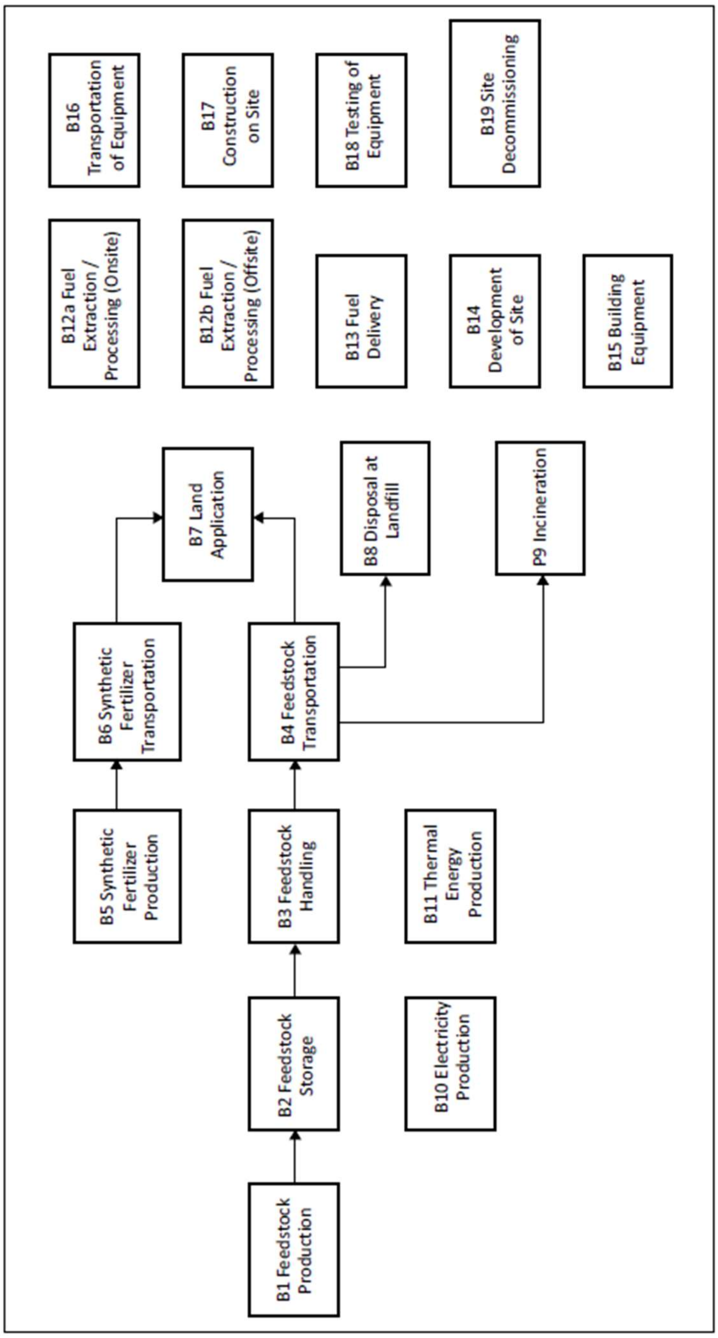


Figure 7:
Identified Baseline SSRs (Draft Protocol, 2007)

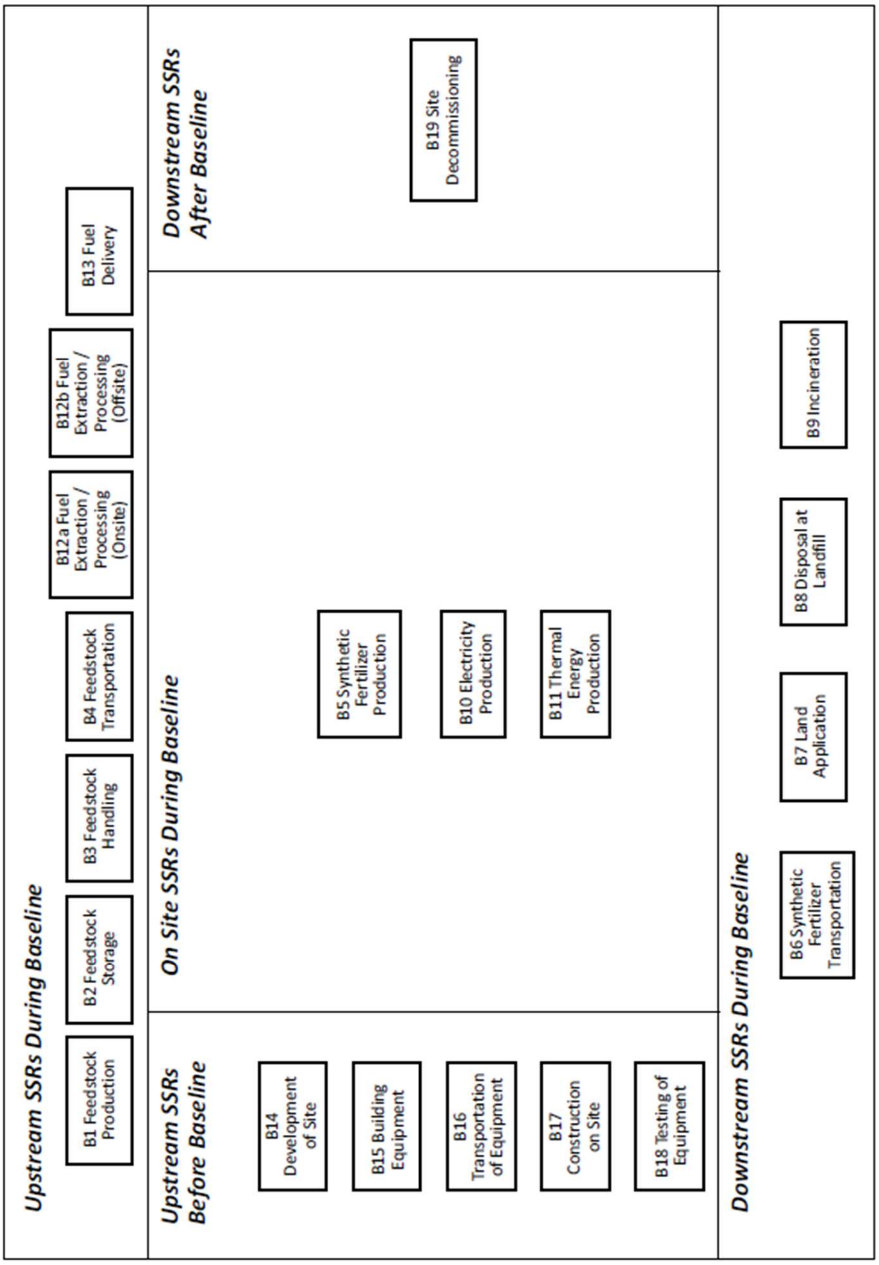


**Table 8:
Baseline SSRs (Draft Protocol, 2007)**
Upstream SSRs during Baseline Operation

SSR	DESCRIPTION	CONTROLLED, RELATED OR AFFECTED
B1 Feedstock Production	Feedstock may have been produced by the animals based on the rations they are fed or as organic matter such as agriculture products.	Related
B2 Feedstock Storage	Feedstock may have been stored prior to handling and transportation.	Related
B3 Feedstock Handling	Feedstock may have been collected and handled using a number of means to facilitate transportation.	Related
B4 Feedstock Transportation	Feedstock may have been transported from the source to where it was land applied.	Related
B12a Fossil Fuel Extraction / Processing (Onsite)	Fossil fuel used may need to be extracted and processed.	Related
B12b Fossil fuel Extraction / Processing / Combustion (Offsite)	Biogas input to the pipeline offsets natural gas extraction, processing and combustion.	Related
B13 Fossil Fuel Delivery	Fossil fuel used may need to be transported to site.	Related

**Table 9:
Baseline SSRs (Draft Protocol, 2007)**
Onsite SSRs during Project Operation

SSR	DESCRIPTION	CONTROLLED, RELATED OR AFFECTED
B5 Synthetic Fertilizer Production	Synthetic fertilizer may have been produced.	Related
B10 Electricity Production	Electricity may be produced net of parasitic energy requirements.	Related
B11 Thermal Energy Production	Thermal energy may be produced to meet the project demand.	Related

Table 10:
Baseline SSRs (Draft Protocol, 2007)
Downstream SSRs during Baseline Operation

SSR	DESCRIPTION	CONTROLLED, RELATED OR AFFECTED
B6 Synthetic Fertilizer Transportation	Synthetic fertilizer may be transported from a manufacturing or retail facility for land application.	Related
B7 Land Application	Synthetic fertilizer and/or feedstock may have been applied to the land.	Related
B8 Disposal in Landfill	Feedstock may have been disposed of at landfill.	Related
B9 Incineration	Feedstock may have been incinerated.	Related

Table 11:
Baseline SSRs (Draft Protocol, 2007)
Others

SSR	DESCRIPTION	CONTROLLED, RELATED OR AFFECTED
B14 Development of Site	The site may need to be developed, which could include grading, buildings, etc.	Related
B15 Building Equipment	Equipment may need to be fabricated off site.	Related
B16 Transportation of Equipment	Equipment and supplies for the facility may need to be transported to the site.	Related
B17 Construction on Site	Equipment may need to be assembled on site.	Related
B18 Testing of Equipment	Fossil fuel use and other operations at the site during testing may cause emissions.	Related
B19 Site Decommissioning	Decommissioning of the site.	Related

Detailed Description of Baseline SSRs

Please refer to Annex A for complete and detailed descriptions of all SSRs.

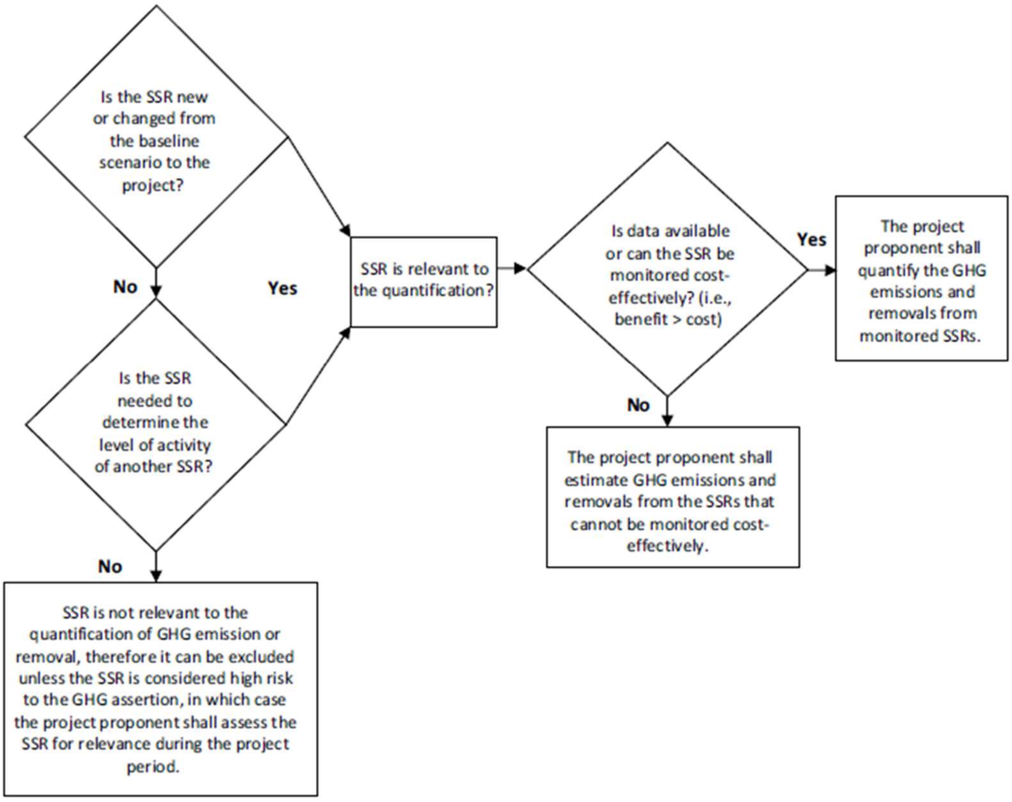
Selecting Relevant GHG Sources, Sinks and Reservoirs for Monitoring or Estimation of GHG Emissions and Removals

Criteria and Procedures for Relevance of SSRs

There is limited good practice guidance available for the selection of relevant GHG SSRs that can be used for the purposes of determining whether a particular SSR should be monitored or estimated. Therefore, the following procedure was developed and is justified based on the GHG quantification principles specified in ISO 14064-2 (relevance, conservativeness).

The procedure, illustrated in Figure 8, was applied to assess, in sequence, each identified SSR determined to be relevant for the project and the selected baseline scenario to determine whether the GHG SSRs would be monitored or estimated. In cases where a SSR is selected for estimation rather than monitoring the rational for that decision is justified, allowing the quantification to be faster and cheaper without compromising the credibility of the quantification of GHG emission reductions.

Figure 8:
Procedure for selection of SSRs relevant for GHG quantification



This Case Study includes descriptions of SSRs which are not quantified due to the lack of applicability to the Smith's Dairy operation (e.g., SSR related to Incineration; B9). However, other farming operations may utilize technologies different than that of Smith's Dairy, and all SSRs should be re-considered on a case by case basis if this quantification method is used by those farms.

Application of Criteria and Procedures

Provides a comparison of Project and Baseline SSRs and illustrates the findings from the relevance test presented in Figure 8. In addition to the SSRs in the following table, certain SSRs were eliminated from the quantification as no significant change in emissions is expected between the baseline and the project activity.

Table 12
Selection of Baseline and Project SSRs for Quantification (Draft Protocol, 2007)
Upstream SSRs

1. IDENTIFIED SSRS	2. BASELINE (C, R, A)	3. PROJECT (C, R, A)	4. INCLUDE OR EXCLUDE FROM QUANTIFICATION	5. JUSTIFICATION FOR EXCLUSION
P1 Feedstock Production	N/A	Related	Exclude	Changes in rations may yield differing energy values for manure. However, rations are typically tied to yield from the animal, availability, cost, etc. Further, the impacts of changes in feed regimes on enteric emissions from livestock are not sufficiently understood as to provide accuracy in measurement or estimation, in an economically efficient monitoring regime. Further, Canada's national inventory does not capture differences in enteric fermentation based on changes of feed regime. Production of other feed stocks is considered not to change between the project and the baseline.
B1 Feedstock Production	Related	N/A	Exclude	
P2 Feedstock Storage	N/A	Related	Exclude	Project Storage emissions may be excluded as lagoons will be eliminated. Furthermore, Project Storage emissions are quantified within the anaerobic digester SSRs, thus they may be excluded here in order to avoid double counting.
B2 Feedstock Storage	Related	N/A	**Include**	Baseline feedstock storage should be quantified and included as significant GHG emissions result from the baseline storage of manure in lagoons and on-site stockpiles.
P3 Feedstock Handling	N/A	Related	Exclude	Excluded as under the majority of configurations, the emissions from the project condition are equivalent to those of the baseline scenario.
B3 Feedstock Handling	Related	N/A	Exclude	

(Continued)

Table 12 (Concluded)

1. IDENTIFIED SSRS	2. BASELINE (C, R, A)	3. PROJECT (C, R, A)	4. INCLUDE OR EXCLUDE FROM QUANTIFICATION	5. JUSTIFICATION FOR EXCLUSION
P4 Feedstock Transportation	N/A	Related	Exclude	Excluded as under the majority of configurations, the emissions from the project condition are equivalent to those of the baseline scenario.
B4 Feedstock Transportation	Related	N/A	Exclude	
P22 Electricity Usage	N/A	Related	Exclude	Excluded as these SSRs are not relevant to the project as the emissions from these practices are covered under proposed greenhouse gas regulations. In addition, under the majority of configurations, the emissions from the project condition will not be significantly different than to those of the baseline scenario.
P24 Fossil Fuel Extraction / Processing	N/A	Related	Exclude	Excluded as these SSRs are not relevant to the project as the emissions from these practices are covered under proposed greenhouse gas regulations. In addition, under the majority of configurations, the emissions from the project condition will not be significantly different than to those of the baseline scenario.
B12a Fossil Fuel Extraction / Processing (Onsite)	Related	N/A	Exclude	
B12b Fossil Fuel Extraction / Processing / Combustion (Offsite)	Related	N/A	Exclude	Excluded because biogas is not input into the pipeline for future extraction/processing/combustion.
P25 Fossil Fuel Delivery	N/A	Related	Exclude	Excluded as these SSRs are not relevant to the project as the emissions from these practices are covered under proposed greenhouse gas regulations. In addition, under the majority of configurations, the emissions from the project condition will be equivalent to those of the baseline scenario.
B13 Fossil Fuel Delivery	Related	N/A	Exclude	

Table 13:
Selection of Baseline and Project SSRs for Quantification (Draft Protocol, 2007)
Onsite SSRs

1. IDENTIFIED SSRS	2. BASELINE (C, R, A)	3. PROJECT (C, R, A)	4. INCLUDE OR EXCLUDE FROM QUANTIFICATION	5. JUSTIFICATION FOR EXCLUSION
P5 Feedstock Storage	N/A	Controlled	Exclude	Excluded as, under the majority of project conditions, feedstock residency time is less than 30 days, ensuring that the total feedstock storage time under the project condition is less than the total feedstock storage time under the baseline condition.
P6, P7, P8a, P9b, P12, P15, P16, P18, P19 and P23 Feedstock Processing	N/A	Controlled	**Include**	N/A
P8b Fugitive Emissions	N/A	Controlled	Exclude	Excluded because it is expected that the CMR will not require significant maintenance once in continuous operation, therefore fugitive emissions will minimized. Contingency measures exist to estimate these emissions if significant downtime does occur for maintenance of the digester.
P9a Digestate Storage	N/A	Controlled	Exclude	Separation of the solid and liquid phases of the digestate serves to stabilize the digestate, minimizing the continuation of the anaerobic digestion processes and the emissions associated with it. Also, the CMR is not expected to generate significant amounts of digestate because of the enhanced digester performance.
P20 Flaring	N/A	Controlled	**Include**	N/A
P21 Venting	N/A	Controlled	**Include**	N/A
B5 Synthetic Fertilizer Production	N/A	Related	Exclude	Excluded as these SSRs are not relevant to the project as the emissions from these practices are covered

(Continued)

Table 13: (Concluded)

1. IDENTIFIED SSRS	2. BASELINE (C, R, A)	3. PROJECT (C, R, A)	4. INCLUDE OR EXCLUDE FROM QUANTIFICATION	5. JUSTIFICATION FOR EXCLUSION
				under proposed greenhouse gas regulations. In addition, under the majority of configurations, the emissions from the project condition will be equivalent to those of the baseline scenario.
B10 Electricity Production	Related	N/A	**Include**	Smith's Dairy relies solely on grid-produced electricity during the baseline case, therefore emissions resulting from grid-based electricity generation must be quantified. These emissions are expected to be displaced through the production of electricity from the digester. In addition, surplus electricity will be sold to the grid, therefore the quantity of electricity generated by the digester displaces an equivalent quantity of electricity from the grid.
B11 Thermal Energy Production	Related	N/A	Exclude	Smith's Dairy does not currently produce thermal energy from its organic matter.

Table 14:
Selection of Baseline and Project SSRs for Quantification (Draft Protocol, 2007)
Downstream SSRs

1. IDENTIFIED SSRS	2. BASELINE (C, R, A)	3. PROJECT (C, R, A)	4. INCLUDE OR EXCLUDE FROM QUANTIFICATION	5. JUSTIFICATION FOR EXCLUSION
P10 Waste Transportation	N/A	Related	Exclude	Excluded as quantity of waste and related emissions from its on-site transport are expected to be equivalent between the project and the baseline.
P11 Waste Disposal	N/A	Related	Exclude	Excluded as the waste is essentially inert, and its disposal would not contribute to methane production and would have no impact on methane collection and destruction systems.
P13 Digestate / Biofertilizer Transportation	N/A	Related	Exclude	Excluded as under the majority of configurations, the emissions from the project condition are equivalent to those of the baseline scenario.
B6 Synthetic Fertilizer Transportation	Related	N/A	Exclude	Excluded as under the majority of configurations, the emissions from the project condition are equivalent to those of the baseline scenario.
P14 Land Application	N/A	Related	Exclude	The nitrogen stabilization in the project condition (P14 Land Application) is such that the amount of nitrous oxide released will be less, and the amount of carbon that is biologically sequestered in the soil will be greater than in the baseline condition (B7 Land Application). As this involves complex data capture, management and calculation, involving considerable uncertainty, it is reasonable to exclude the emission reductions from this SSRs. This approach is also consistent with the conservativeness principle.
B7 Land Application	Related	N/A	Exclude	The nitrogen stabilization in the project condition (P14 Land Application) is such that the amount of nitrous oxide released will be less, and the amount of carbon that is biologically sequestered in the soil will be

(Continued)

Table 14: (Concluded)

1. IDENTIFIED SSRS	2. BASELINE (C, R, A)	3. PROJECT (C, R, A)	4. INCLUDE OR EXCLUDE FROM QUANTIFICATION	5. JUSTIFICATION FOR EXCLUSION
				greater than in the baseline condition (B7 Land Application). As this involves complex data capture, management and calculation, involving considerable uncertainty, it is reasonable to exclude the emission reductions from this SSRs. This approach is also consistent with the conservativeness principle.
P17 Pipeline Distribution and Usage	N/A	Related	Exclude	Smith's Dairy will not have a connection to a pipeline distribution system after implementation of the anaerobic Digester. Thus, this SSR is excluded.
B8 Disposal in Landfill	Related	N/A	**Include**	N/A
B9 Incineration	Related	N/A	Exclude	Smith's Dairy did not incinerate their organic waste prior to the implementation of the anaerobic Digester. Thus, this SSR is equal to zero and will be omitted. *Other sites may need to quantify this SSR.

Table 15:
Selection of Baseline and Project SSRs for Quantification (Draft Protocol, 2007)
Other

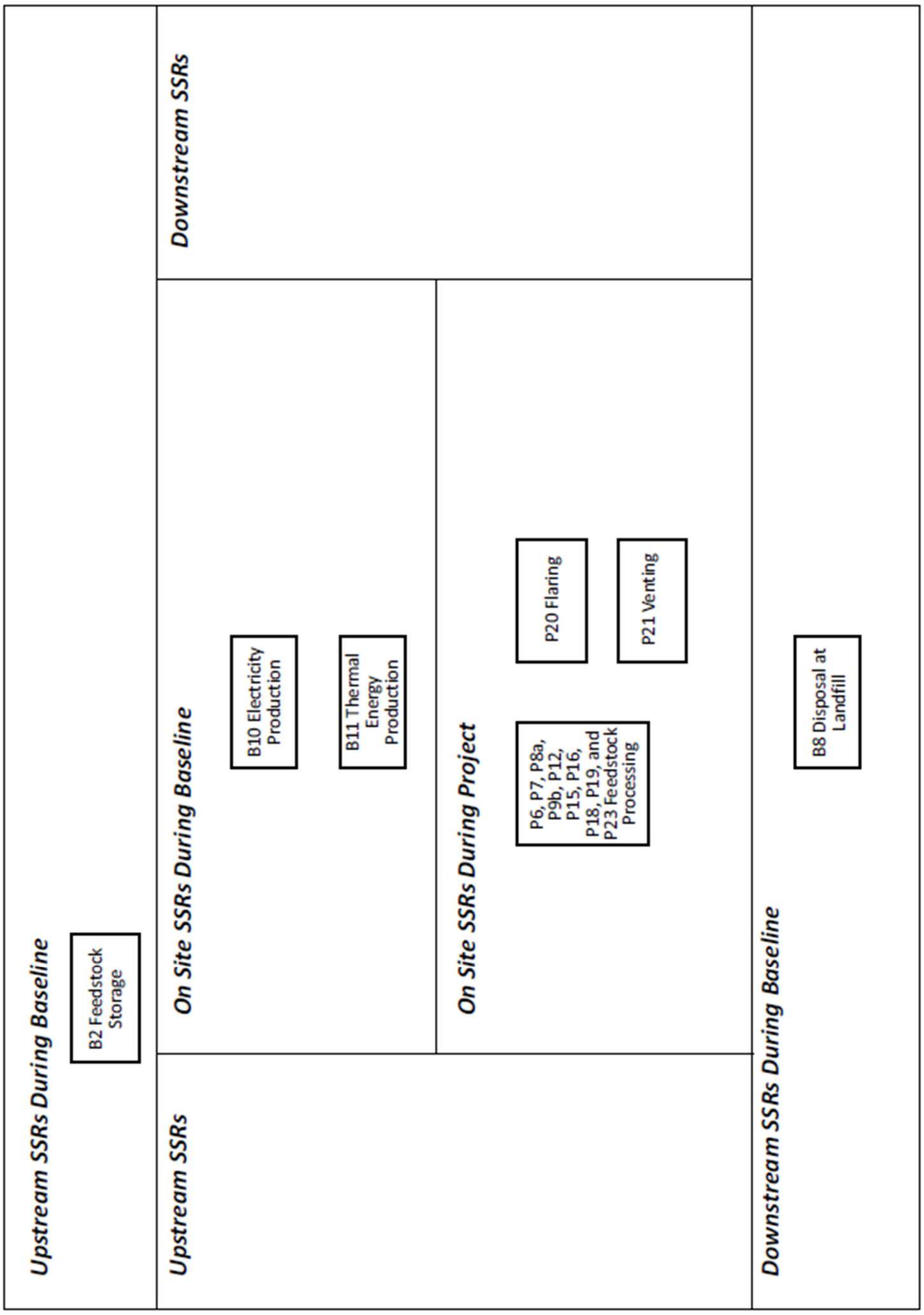
1. IDENTIFIED SSRS	2. BASELINE (C, R, A)	3. PROJECT (C, R, A)	4. INCLUDE OR EXCLUDE FROM QUANTIFICATION	5. JUSTIFICATION FOR EXCLUSION
P26 Development of Site	N/A	Related	Exclude	Emissions from site development are not considered significant given the long project life and the minimal site development typically required.
B12 Development of Site	Related	N/A	Exclude	These emissions should be zero in comparison with the site development emissions for the project.
P27 Building Equipment	N/A	Related	Exclude	Emissions from constructing the equipment are not considered significant given the long project life and the minimal building equipment typically required.
B13 Building Equipment	Related	N/A	Exclude	These emissions should be zero in comparison with the project emissions from constructing the equipment.
P28 Transportation of Equipment	N/A	Related	Exclude	Emissions from transportation of equipment are not considered significant given the long project life and the minimal transportation of equipment typically required.
B14 Transportation of Equipment	Related	N/A	Exclude	These emissions should be zero in comparison with the project activity, since no new equipment is likely to need to be transported.
P29 Construction on Site	N/A	Related	Exclude	Emissions from construction on site are not considered significant given the long project life and the minimal construction on site typically required.
B15 Construction on Site	Related	N/A	Exclude	These emissions should be zero in comparison with the project activity, since no new construction should be required on the farm site.

(Continued)

Table 15: (Concluded)

1. IDENTIFIED SSRS	2. BASELINE (C, R, A)	3. PROJECT (C, R, A)	4. INCLUDE OR EXCLUDE FROM QUANTIFICATION	5. JUSTIFICATION FOR EXCLUSION
P30 Testing of Equipment	N/A	Related	Exclude	Emissions from testing of equipment are not considered significant given the long project life and the minimal testing of equipment typically required.
B16 Testing of Equipment	Related	N/A	Exclude	These emissions should be zero in the baseline case since no new equipment needs to be installed or tested.
P31 Site Decommissioning	N/A	Related	Exclude	Emissions from decommissioning are not considered significant given the long project life and the minimal decommissioning typically required.
B17 Site Decommissioning	Related	N/A	Exclude	These emissions should be zero in the baseline case since no new equipment needs to be installed.

Figure 9:
SSRs for Quantification (Draft Protocol, 2007)



Quantifying GHG Emissions

GHG Quantification Procedure

In using the good practice guidance documents outlined above and following the Draft Protocol's suggested SSRs, *six* primary emission sources were identified as relevant for this project and thus constituted the main differences between the Project and Baseline scenarios at Smith's Dairy. Incorporated into these SSRs is the quantification of emissions resulting from grid-based electricity generation and baseline lagoon emission rates as well as landfill emissions from the deadstock.

The following calculation sections contain the necessary calculation routines to estimate emission reductions associated with the project activity. In most cases, these rely upon emission factors developed by industry leaders and governmental research since for many of the identified SSRs direct measurement is too costly and complex.

Emission Quantification Equations

The Draft Protocol provides extensive information and good practice guidance when determining the emissions from the anaerobic digester operation. As stated earlier, their expertise is acknowledged in this subject matter, and the methods proposed by this protocol are followed through the calculation section of this case study.

Relevant SSRs required for Smith's Dairy have been previously identified, and the following calculation equations formulize their emission quantification.

Please refer to Annex B for full and complete descriptions of the following equations.

Project Equations

P6, P7, P8a, P9b, P12, P15, P16, P18, P19 and P23 Feedstock Processing

Emissions $_{Multiple\ Sources}$ = (Vol. Biogas $_{Combusted}$ * % CH_4 * EF Biogas CH_4) ; (Vol. Biogas Combusted * % CH_4 * EF Biogas N_2O) ;
∑ (Vol. Fuel $_i$ * EF Fuel $_{i\ CO2}$) ; ∑ (Vol. Fuel $_i$ * EF Fuel $_{i\ CH4}$) ; ∑ (Vol. Fuel $_i$ * EF Fuel $_{i\ N2O}$)

where:

Vol. Biogas $_{Combusted}$	=	Volume of Biogas Combusted (metered in the project)
% CH_4	=	Methane Composition in Biogas (measured in the project)
EF Biogas CH_4	=	CH_4 Emissions Factor for Biogas
EF Biogas N_2O	=	N_20 Emissions Factor for Biogas
Vol Fuel i	=	Volume of Each Type of Fuel used to supplement the IC engine (metered in the project)
EF Fuel $_{iCO2}$	=	CO_2 Emissions Factor for Each Type of Fuel
EF Fuel $_{i\ CH4}$	=	CH_4 Emissions Factor for Each Type of Fuel
EF Fuel $_{i\ N2O}$	=	N_20 Emissions Factor for Each Type of Fuel

P20 Flaring

Emissions $_{Flaring}$ = (Vol. Biogas Flared * % CH_4 * EF Biogas $_{CH4}$) ; (Vol. Biogas Flared * % CH_4 * EF Biogas $_{N2O}$) ;
∑ (Vol. Fuel $_i$ * EF Fuel $_{i\ CO2}$) ; ∑ (Vol. Fuel $_i$ * EF Fuel $_{i\ CH4}$) ; ∑ (Vol. Fuel $_i$ * EF Fuel $_{i\ N2O}$)

where:

Vol. Biogas Flared	=	Volume of Biogas Flared (metered in the project)
% CH_4	=	Methane Composition in Biogas (measured in the project)
EF Biogas $_{CH4}$	=	CH_4 Emissions Factor for Biogas
EF Biogas $_{N2O}$	=	N_20 Emissions Factor for Biogas
Vol Fuel i	=	Volume of Each Type of Fuel used to Supplement Flare (metered in the project)
EF Fuel $_{i\ CO2}$	=	CO_2 Emissions Factor for Each Type of Fuel
EF Fuel $_{i\ CH4}$	=	CH_4 Emissions Factor for Each Type of Fuel
EF Fuel $_{i\ N2O}$	=	N_20 Emissions Factor for Each Type of Fuel

P21 Venting

$$\text{Emissions}_{\text{Venting}} = (\text{Max. Storage Vol.}_{\text{Vessel}} + \text{Flow Biogas}_{\text{Vessel}} * \text{Time}_{\text{Venting}}) * \%\ CH_4$$

where:

Max. Storage Vol. $_{\text{Vessel}}$	=	Maximum volume of biogas stored in Vessel at Steady State
Flow Biogas $_{\text{Vessel}}$	=	Flow Rate of Biogas at Steady State
Time $_{\text{Venting}}$	=	Time that vessel is venting
% CH_4	=	Methane Composition in Biogas

Baseline Equations

B8 Disposal at Landfill

$$\text{Emissions}_{\text{Feedstock Disposal}} = (\text{Mass}_{\text{Feedstock Landfill}} * MCF * DOC * DOC_F * F * 16/12 - R) * (1- OX)$$

where:

Mass $_{\text{Feedstock Landfill}}$	=	Mass of Feedstock to Landfill (monitored in project)
MCF	=	Methane Correction Factor
DOC	=	Degradable Organic Carbon
DOC_F	=	Fraction of Degradable Organic Carbon Dissimilated
F	=	Fraction of CH_4 in Off gas from Disposal Site
R	=	Recovered CH_4 at Disposal Site
OX	=	Oxidation Factor

B10 Electricity Production

$$\text{Emissions}_{\text{Electricity}} = \text{Electricity} * EF_{\text{Elec}}$$

where:

Electricity	=	Electricity Produced net of Parasitic energy requirements (monitored in project)
EF_{Elec}	=	Region-Specific Emissions Factor for Electricity

B11 Thermal Energy Produced

$$Emissions_{Thermal\ Heat} = \sum (Vol.\ Fuel_i * EF\ Fuel_{i\ CO2})\ ;\ \sum (Vol.\ Fuel_i * EF\ Fuel_{i\ CH4})\ ;\ \sum (Vol.\ Fuel_i * EF\ Fuel_{i\ N2O})$$

where:

Vol Fuel i	=	Volume of Each Type of Fuel used for production of thermal energy
$EF\ Fuel_{i\ CO2}$	=	CO_2 Emissions Factor for Each Type of Fuel
$EF\ Fuel_{i\ CH4}$	=	CH_4 Emissions Factor for Each Type of Fuel
$EF\ Fuel_{i\ N2O}$	=	N_20 Emissions Factor for Each Type of Fuel

Calculations

Taking the preceding quantification information as good practice guidance, the resulting calculations and Project-related SSRs as well as the Baseline SSRs have been tabulated (refer to tables 16-23). A summary table of all Project and Baseline emissions is provided as Table 24.

The dairy data comes from the previously mentioned 270 tie-stall dairy operation with 300 head of dairy cattle producing organic matter.

Table 16:
Quantification of P6-P8a, P9b, P12, P15, P16, P18, P19 and P23 Feedstock Processing

VOLUME OF FUEL	BIOGAS (M^3)	DIESEL (LITERS)	NATURAL GAS (M^3)	GASO-LINE (LITRES)	OTHER TYPE
January	26,150	1,674	-	-	-
February	23,625	1,511	-	-	-
March	26,150	1,674	-	-	-
April	25,300	1,620	-	-	-
May	26,150	1,674	-	-	-
June	25,300	1,620	-	-	-
July	26,150	1,674	-	-	-
August	26,150	1,674	-	-	-
September	25,300	1,620	-	-	-
October	26,150	1,674	-	-	-
November	25,300	1,620	-	-	-
December	26,150	1,674	-	-	-
Total	**307,875**	**19,712**	**-**	**-**	**-**

Table 17:
Quantification of P20 Flaring

VOLUME OF FUEL	BIOGAS FLARED (M^3)	NATURAL GAS USED IN FLARE (M^3)
January	20	-
February	20	-
March	20	-

(Continued)

Table 17: (Concluded)

VOLUME OF FUEL	BIOGAS FLARED (M^3)	NATURAL GAS USED IN FLARE (M^3)
April	20	-
May	20	-
June	20	-
July	20	-
August	20	-
September	20	-
October	20	-
November	20	-
December	20	-
Total	**240**	**-**
Emissions Factor (CO_2)	- kg CO_2 per m^3	1.891 kg CO_2 per m^3
Emissions Factor (CH_4)	0.00049	0.00049 kg CH_4 per m^3
Emissions Factor (N_2O)	0.000049	0.000049
Emissions (CO_2)	-	-
Emissions (CH_4)	0.1176	-
Emissions (N_2O)	0.01176	-
Global Warming Potential (CH_4)	21	21
Global Warming Potential (N_2O)	310	310
Greenhouse Gas Emissions	6.12	-

Total Greenhouse Gas Emissions 6.12 kg CO_2e

Table 18:
Quantification of P21 Venting

EVENT DATES	MAXIMUM STORAGE VOLUME OF BIOGAS IN VESSEL AT STEADY STATE	FLOW RATE OF BIOGAS AT STEADY STATE	TIME OF VENTING	METHANE CONTENT OF BIOGAS	VOLUME OF METHANE VENTED
1	10 m^3	10 m^3 / hr	2 Hours	55%	11 m^3
2	10 m^3	10 m^3 / hr	2 Hours	55%	11 m^3
3	10 m^3	10 m^3 / hr	2 Hours	55%	11 m^3
4	10 m^3	10 m^3 / hr	2 Hours	55%	11 m^3
5	10 m^3	10 m^3 / hr	2 Hours	55%	11 m^3
6	10 m^3	10 m^3 / hr	2 Hours	55%	11 m^3

Table 19:
Quantification of P21 Venting

TOTAL VOLUME OF METHANE VENTED	66 M^3
Methane Density	0.668 kg CH_4 per m^3
Mass of Methane Vented	44 kg CH_4
Global Warming Potential (CH_4)	21 kg CO_2e per m^3 of CH_4
Total Greenhouse Gas Emissions	924 kg CO_2e

Table 20:
Quantification of B2 – Feedstock Storage (Manure management in Baseline)

TOTAL VOLUME OF BIOGAS DIVERTED	KG CH_4 PRODUCED
January	740 Kg
February	740 Kg
March	740 Kg
April	740 Kg
May	740 Kg
June	740 Kg

(Continued)

Table 20: (Concluded)

TOTAL VOLUME OF BIOGAS DIVERTED	KG CH_4 PRODUCED
July	740 Kg
August	740 Kg
September	740 Kg
October	740 Kg
November	740 Kg
December	740 Kg
Total	**8,880** Kg
Methane Correction Factor	1.00
Emissions (CH_4)	8,880 kg CH_4
Global Warming Potential of CH_4	21
Greenhouse Gas Emissions	186,480 kg CH_4

It should be noted that this calculation is a result of multiplying the number of managed cows by the emission factor for manure management; as provided by the Canadian National (GHG) Inventory, 2006, p.200. This value is seen to take into account annual weather patterns and provides the resulting number of emissions from current manure management operations, including lagoon emissions.

Thus:

29.6 (kg CH_4/ head per year) * 300 head = 8,880 kg CH_4

8,880 kg CH_4 per year / 12 months/year = 740 kg CH_4 per month

Assuming equal distribution over the year:

Table 21:
Quantification of B10 Electricity Production

	ELECTRICITY PRODUCED
January	43,594 kWh
February	39,375 kWh
March	43,594 kWh
April	42,188 kWh
May	43,594 kWh
June	42,188 kWh

(Continued)

Table 21: (Concluded)

	ELECTRICITY PRODUCED
July	43,594 kWh
August	43,594 kWh
September	42,188 kWh
October	43,594 kWh
November	42,188 kWh
December	43,594 kWh
Total	**513,285** kWh
Emissions Factor for Electricity[1]	0.222 kg of CO_2e per kWh
Greenhouse Gas Emissions	113,948 kg CO_2e

[1] Emission Factor for Ontario taken from the National Inventory Report, 2006, p.364.

Table 22:
Quantification of diverted deadstock (B8 Disposal at Landfill)

TOTAL VOLUME OF BIOMASS DIVERTED	AGRICULTURAL MATERIAL DIVERTED
January	634 kg
February	634 kg
March	634 kg
April	634 kg
May	634 kg
June	634 kg
July	634 kg
August	634 kg
September	634 kg
October	634 kg
November	634 kg
December	634 kg
Total	**7,608** kg
Methane Correction Factor	1.00

(Continued)

Table 22: (Concluded)

TOTAL VOLUME OF BIOMASS DIVERTED	AGRICULTURAL MATERIAL DIVERTED
Degradable Organic Carbon	0.30
Fraction of Degradable Organic Carbon Dissimilated	0.77
Fraction of CH_4 in Landfill Gas	0.50
Recovered CH_4 at Landfill [2]	-
Oxidation Factor	0
Conversion Factor	16 / 12
Emissions (CH_4)	1,172 kg CH_4
Global Warming Potential of CH_4	21
Greenhouse Gas Emissions	24,621 kg CO_2e

Table 23:
Quantification of B11 Thermal Energy Produced

VOLUME OF FUEL	BIOGAS	DIESEL	NATURAL GAS	GASO-LINE	OTHER TYPE
January	- m^3	- Litres	844 m^3	- Litres	-
February	- m^3	- Litres	844 m^3	- Litres	-
March	- m^3	- Litres	844 m^3	- Litres	-
April	- m^3	- Litres	844 m^3	- Litres	-
May	- m^3	- Litres	844 m^3	- Litres	-
June	- m^3	- Litres	844 m^3	- Litres	-
July	- m^3	- Litres	844 m^3	- Litres	-
August	- m^3	- Litres	844 m^3	- Litres	-
September	- m^3	- Litres	844 m^3	- Litres	-
October	- m^3	- Litres	844 m^3	- Litres	-
November	- m^3	- Litres	844 m^3	- Litres	-
December	- m^3	- Litres	844 m^3	- Litres	-
Total	- m^3	- Litres	10,128 m^3	- Litres	-

Table 24:
Summary of Emissions Data

	Biogas		Diesel		Natural Gas		Gasoline		Other	
									Type	
Emissions Factor (CO_2)	-	kg CO_2 per m^3	2.73	kg CO_2 per Litre	1.891	kg CO_2 per m^3	2.83	kg CO_2 per Litre		kg CO_2 per
Emissions Factor (CH_4)	0.00049	kg CH_4 per m^3	0.00018	kg CH_4 per Litre	0.00049	kg CH_4 per m^3	0.00018	kg CH_4 per Litre		kg CH_4 per
Emissions Factor (N_2O)	0.000049	kg N_2O per m^3	0.0004	kg N_2O per Litre	0.000049	kg N_2O per m^3	0.000031	kg N_2O per Litre		kg N_2O per
Emissions (CO_2)	-	kg CO_2	53,805.6	kg CO_2	-	kg CO_2	-	kg CO_2	-	
Emissions (CH_4)	150.9	kg CH_4	3.6	kg CH_4	-	kg CH_4	-	kg CH_4	-	
Emissions (N_2O)	15.1	kg N_2O	7.9	kg N_2O	-	kg N_2O	-	kg N_2O	-	
Global Warming Potential (CH_4)	21	kg CO_2e per kg of CH_4	21	kg CO_2e per kg of CH_4	21	kg CO_2e per kg of CH_4	21	kg CO_2e per kg of CH_4	21	kg CO_2e per kg of CH_4
Global Warming Potential (N_2O)	310	kg CO_2e per kg of N_2O	310	kg CO_2e per kg of N_2O	310	kg CO_2e per kg of N_2O	310	kg CO_2e per kg of N_2O	310	kg CO_2e per kg of N_2O
Greenhouse Gas Emissions	7,844.7	kg CO_2e	56,323.2	kg CO_2e	-	kg CO_2e	-	kg CO_2e	-	kg CO_2e
Total Greenhouse Gas Emissions									64,168	kg CO_2e

Summary of Emission Reduction Calculations

As stated earlier, the emission reductions possible will be a summation of the individual calculation components found with the following equation.

Emission Reduction = Emissions $_{Baseline}$ – Emissions $_{Project}$

Table 25:
Summation of Emission Reduction Offset Credits

GHG	PROJECT EMISSIONS (KG)	BASELINE EMISSIONS (KG)	GHG EMISSION REDUC-TION ACHIEVED (KG)	GLOBAL WARMING POTEN-TIAL	CO_2e (KG)
Carbon Dioxide (CO_2)	53,805	19,146	-34,659	1	-34,659
Methane (CH_4)	198.62	10,057	9,858.38	21	207,026
Nitrous Oxide (N_2O)	23.011	0.49612	-22.52	310	-6,979.8
Hydrofluorocar-bons (HFCs)	-	-	-	various	-
Perfluorocarbons (PFCs)	-	-	-	various	-
Sulphur Hexafluoride (SF_6)	-	-	-	23,900	-
Carbon Dioxide Equivalent(CO_2e)	0	113,948	113,948	-	113,948
Total					**279,335**

Table 26:
Summation of Estimated Emission Reductions
Baseline Emissions

ELEMENT DESCRIPTION	GAS	GWP	KG	KG CO_2e
B2 Feedstock Storage	CH_4	21	8,880.00	186,480
B8 Disposal in Landfill	CH_4	21	1,172.00	24,612

(Continued)

Table 26: (Concluded)

ELEMENT DESCRIPTION	GAS	GWP	KG	KG CO_2e
B10 Electricity Production	CO_2	1	113,948.00	113,948
B11 Thermal Energy Production	CO_2	1	19,146.00	19,146
	CH_4	21	4.96	104
	N_2O	310	0.50	154
Total			344,444	

Table 27:
Summation of Estimated Emission Reductions
Project Emissions

ELEMENT DESCRIP-TION	GAS	GWP	KG	KG CO_2e	GHG EMISSION REDUC-TION
P6, P7, P8a, P9b, P12, P15, P16, P18, P19 and P23 Feedstock Processing	CO_2	1	53,805.60	53,806	
	CH_4	21	154.50	3,245	
	N_2O	310	23.00	7,130	
P20 Flaring	CH_4	21	0.11760	2.470	
	N_2O	310	0.01176	3.646	
P21 Venting	CH_4	21	44.00	924	
Totals				65,110	279

Monitoring the GHG project

Continuous monitoring (metering and measurement) of the anaerobic digestion unit is mandatory, as the gas production values will naturally fluctuate, and accurate records must be complied. This entails that complete and accurate records must be maintained for each month the unit is operation. Accurate accounts of deadstock additions (kg) and daily manure collection volumes should also be recorded. The more complete and robust the monitoring is on the digester, regarding inflow of organic material and outflow of gases, the easier validation and verification procedures will be.

Electricity generation values will also need to be metered and recorded and maintained for offsetting the farm's electrical needs. Accurate accounts of these quantities of electricity generated will affect the overall quantity of possible emission reductions.

Table 16 illustrates the specific monitoring procedures needed for this case study. Frequencies of measurements are identified as well as the specific components of each SSR which require quantification. By following this table, based on good practice guidance, the project proponent will successfully monitor the required components for this project.

Further to these specific monitoring requirements, project proponents are advised to keep accurate and up-to-date records of digestate management. Digestate volumes in both liquid and solid form should be recorded, and the specific uses of the digestate should also be monitored and recorded (such as land spreading). Depending on the application and management of digestate material, project proponents may need to consider quantifying emissions resulting from this digester by-product. In most cases the emissions from general manure management will exceed emissions resulting from the management of digestate material; however, in some cases digester by-products may result in increased emissions in comparison to the baseline case. Please refer to the technical descriptions provided within Annex C for applicability, as provided by the Draft Protocol.

Table 28:
Data Collection Procedures (Draft Protocol, 2007)
Project SSRs
P6, P7, P8a, P9b, P12, P15, P16, P18, P19 and P23 Feedstock Processing

PARAMETER / VARIABLE	UNIT	MEAS-URED / ESTIMAT-ED	CONTINGENCY METHOD	FREQUEN-CY	JUSTIFY MEASUREMENT OR ESTIMATION AND FREQUENCY
Volume of Biogas Combusted / Vol. Biogas Combusted	m^3	Metered	Reconciliation of heat and power produced against volume of biogas required to produce that power.	Continuously	Most accurate method.
Methane Composition	-	Measured	Use previous year data, data	Daily	Provides reasonable estimate of the

(Continued)

Table 28: (Concluded)

PARAMETER / VARIABLE	UNIT	MEAS-URED / ESTIMAT-ED	CONTINGENCY METHOD	FREQUEN-CY	JUSTIFY MEASUREMENT OR ESTIMATION AND FREQUENCY
in Biogas / % CH_4			that most accurately reflects current feedstock, or current year data retrospectively.		parameter when continuous monitoring cannot be used.
Volume of Each Type of Fuel / Vol $Fuel_i$	m^3	Metered	Reconciliation of volume of fuel purchased within given time period.	Continuously	Most accurate method.
Electricity Usage / Electricity	kWh	Metered	Reconciliation of power requirements for facility as per equipment output ratings.	Continuously	Most accurate method.

Table 29:
Data Collection Procedures (Draft Protocol, 2007)
Project SSRs
P20 Flaring

PARAMETER / VARIABLE	UNIT	MEAS-URED / ESTIMAT-ED	CONTINGENCY METHOD	FREQUEN-CY	JUSTIFY MEASUREMENT OR ESTIMATION AND FREQUENCY
Volume of Biogas Flared / Vol. Biogas Flared	m^3	Metered	Use volumetric calculation as per venting calculation: (Flow Biogas Vessel * Vol. Manure Vessel / Flow Manure Vessel + Flow Biogas Vessel * Time Flaring)	As per venting data require-ments.	Most accurate method.
Methane Composition in Biogas / % CH_4	-	Measured	Use previous year data, data that most accurately reflects current feedstock, or current year data retrospectively.	During incident	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
Volume of Each Type of Fuel used to Supplement Flare /Vol $Fuel_i$	m^3	Metered	Reconciliation of volume of fuel purchased within given time period.	Continuously	Most accurate method.

Table 30:
Data Collection Procedures (Draft Protocol, 2007)
Project SSRs
P21 Venting

PARAMETER / VARIABLE	UNIT	MEAS-URED / ESTIMAT-ED	CONTINGENCY METHOD	FREQUEN-CY	JUSTIFY MEASUREMENT OR ESTIMATION AND FREQUENCY
Flow Rate of Biogas at Steady State / Flow Biogas Vessel	m^3 / hr	Metered	Average flow rate of biogas from the digester at steady state for the preceding period.	When incident occurs	Reference value will remain consistent unless system is re-engineered (i.e., change in system configuration).
Time that vessel is venting / t	hr	Monitored	Reconciliation of records with power supply to the grid.	When incident occurs	Most accurate method.
Methane Composition in Biogas / % CH_4	-	Metered	Direct Measurement	Annual or upon change in feedstock	Biogas composition should remain relatively stable during steady state operation. Material changes in feedstock would warrant additional measurement.

Table 31:
Data Collection Procedures (Draft Protocol, 2007)
Baseline SSRs

PROJECT / BASE-LINE SSR	PARAME-TER / VARIABLE	UNIT	MEAS-URED / ESTI-MATED	CONTINGEN-CY METHOD	FRE-QUENCY	JUSTIFY MEASURE-MENT OR ESTIMATION AND FREQUENCY
B8 Disposal at Landfill	Mass of Deadstock to Landfill / Mass	kg	Moni-tored	N/A	At receipt	Monthly estimates of deadstock added to the digester should be recorded. This provides accurate information regarding mass diverted from landfill.
B10 Electricity Production	Electricity Produced net of Parasitic energy require-ments / Electricity	kWh	Calcu-lated	Reconciliation of power delivered to the electricity grid.	From gross – net electricity produced	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
B11 Thermal Heat Produced	Volume of Each Type of Fuel / Vol $Fuel_i$	m^3	Record-ed	Calculated relative to metered quantity of Thermal Heat billed to the customer.	From previous monthly invoices	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.

Data Management Plan

The above monitoring plan provides a list of the data which will be collected during the life of the project. It is important that all of the information is logged and retained for use during the validation process, future verification processes and for general future reference. The following plan will be implemented:

1) All data will be recorded on paper at the point of collection. These daily, weekly, monthly, annual, or as required recording sheets will be filed in an appropriate filing cabinet, with secure access
2) These records will be transferred to a prepared spreadsheet as collected. The spreadsheet will have limited access and secure fields
3) The network on which the electronic files are saved will be backed up on a regular basis
4) As the number of records increases, an appropriate cataloguing system will be implemented to ensure that each record is uniquely identified and can be easily found upon request
5) All data will be checked for quality control measures on a regular basis. This will assess the likelihood that the numbers are correct, based on proposed trends. Any possible discrepancies will result in duplicate measurements
6) All calculations will be checked by a second person to ensure accuracy
7) All correspondence, meeting minutes and decisions made will be recorded, retained and justified for future use
8) All documents will be correctly labelled, stating the author and reason for the document
9) The data management plan will be reviewed on a regular basis and any potential improvements will be addressed

附錄 2　課程考題

（每位學員考卷不同，以下為考題範例)

1. If the the validation of a project prior to a verification is materially flawed, then:

Select one:

a.

It is corrected on-site by the verifier

b.

The GHG statement is modified by the verifier

c.

The project cannot be verified

d.

It is noted in the verification opinion

Feedback

The correct answer is: The project cannot be verified

2. What is an indicator of high inherent risk for the verification of a GHG project?

Select one:

a.

Use of customized protocol and emission factors

b.

Processes and work instructions not being followed

c.

Poor data quality management system

d.

Documents are incomplete, uncoordinated or unclear

Feedback

The correct answer is: Use of customized protocol and emission factors