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Date 22/Aug/2002
ABSTRACT

GHG management presents a challenge to the natural gas industry worldwide due to associated processing and transportation emissions and the product which they sell being a potent GHG as well as a fuel commodity. The Canadian natural gas industry is particularly challenged as an expanding primary export market for natural gas in the United States indicates large increases in natural gas production and exports in the short to medium term. Increases in production coupled with new gas supplies that are located geographically more distant from the USA and/or in deeper geological strata will be accompanied by increases in the GHG emissions from the wellhead to burner tip supply chain.

The confluence of pressure to inventory and manage GHG emissions arising from governmental international commitments and higher emissions in an expanding and more distant market creates the need for robust and consistent GHG management systems that are able to clearly monitor and report emissions in a verifiable manner and offer mitigation solutions through identification of techniques to reduce absolute emission levels and to offset emissions through the potential for market based mechanisms.

The thesis objective was to answer the general management question of: “How do natural gas companies in Canada and other annex I and annex b countries manage the liability posed by potential climate change related policy constraints on companies operations and are these systems comparable?” This was accomplished by addressing three underlying research questions. Research question one outlined GHG calculation, monitoring and verification practices. Research question two outlined GHG management practices. The third research question drew a qualitative comparison between Canadian and non-Canadian companies systems.

The thesis outlines present practice and a qualitative comparison that points to the systems as described by respondents being broadly comparable with Canadian companies occupying middle to high position on a ranked response basis. No statistical valid comparison was undertaken due to a poor response from non-Canadian companies surveyed giving a non-representative statistical sample.

The thesis concludes with a call for a broader statistically valid study to confirm the qualitative findings set out in this thesis.
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GLOSSARY

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>AIJ</td>
<td>Activities Implemented Jointly</td>
</tr>
<tr>
<td>C&amp;V</td>
<td>Certification and Verification</td>
</tr>
<tr>
<td>CDM</td>
<td>Clean Development Mechanism</td>
</tr>
<tr>
<td>EIT</td>
<td>Economies in transition</td>
</tr>
<tr>
<td>GHG</td>
<td>Greenhouse Gas</td>
</tr>
<tr>
<td>IGU</td>
<td>International Gas Union</td>
</tr>
<tr>
<td>JI</td>
<td>Joint Implementation</td>
</tr>
<tr>
<td>KP</td>
<td>Kyoto Protocol</td>
</tr>
<tr>
<td>LNG</td>
<td>Liquefied Natural Gas</td>
</tr>
<tr>
<td>MVP</td>
<td>Monitoring and Verification Protocol</td>
</tr>
<tr>
<td>SD</td>
<td>Sustainable Development</td>
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**Accuracy:** Inventory definition: Accuracy is a relative measure of the exactness of an emission or removal estimate. Estimates should be accurate in the sense that they are systematically neither over nor under true emissions or removals, as far as can be judged, and that uncertainties are reduced as far as practicable. Appropriate methodologies conforming to guidance on good practices should be used to promote accuracy in inventories. A statistical definition is: accuracy is a general term which describes the degree to which an estimate of a quantity is unaffected by bias due to systematic error. It should be distinguished from precision (IPCC(a) 2000).

**Activity data:** Inventory definition: Data on the magnitude of human activity resulting in emissions or removals taking place during a given period of time. In the energy sector for example, the total amounts of fuel burned is annual activity data for fuel combustion sources, and the total number of animals being raised, by species, is annual activity data for methane emissions from enteric fermentation.

**Annex B Countries** Annex B countries are the 39 emissions-capped industrialised countries and economies in transition listed in Annex B of the Kyoto Protocol. Legally-binding emission reduction obligations for Annex B countries range from an 8% decrease...
(e.g., various European nations) to a 10% increase (Iceland) in relation to 1990 levels during the first commitment period from 2008 to 2012 (UNFCCC 1992).

**Annex I Countries** Annex I countries include the 36 industrialised countries and economies in transition listed in Annex I of the United Nations Framework Convention on Climate Change (UNFCCC or the Convention). Their responsibilities under the Convention are various, and include a non-binding commitment to reducing their greenhouse gas emissions to 1990 levels by the year 2000. Note that Belarussia and Turkey are listed in Annex I but not Annex B; and that Croatia, Liechtenstein, Monaco and Slovenia are listed in Annex B but not Annex I.

In practice, Annex I of the Convention and Annex B of the Kyoto Protocol are used almost interchangeably. However, strictly speaking, it is the Annex I countries which can invest in Joint Implementation (JI) / Clean Development Mechanism (CDM) projects as well as host JI projects, and non-Annex I countries which can host CDM projects. This is true, despite the fact that it is the Annex B countries that have the emission reduction obligations under the Kyoto Protocol.

**Annex II Countries.** Annex II of the United Nations Framework Convention on Climate Change (UNFCCC or the Convention) includes all original OECD member countries plus the European Union. Under Article 4.2 (g) these countries have a special obligation to help developing countries with financial and technological resources.

**Base year:** The year for which the inventory is to be taken. Currently 1990 (IPCC 1996).

**Climate change:** A change of climate, which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods.

**Climate system:** The totality of the atmosphere, hydrosphere, biosphere and geosphere and their interactions.

**Completeness:** Inventory definition: Completeness means that an inventory covers all sources and sinks as well as all gases included in the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories in addition to other existing relevant source/sink
categories which are specific to individual Parties (and therefore may not be included in the *IPCC Guidelines*). Completeness also means full geographic coverage of sources and sinks of a Party (IPCC 1996).

**Consistency**: Inventory definition: Consistency means that an inventory should be internally consistent in all its elements over a period of years. An inventory is consistent if the same methodologies are used for the base and all subsequent years and if consistent data sets are used to estimate emissions or removals from sources or sinks (IPCC(a) 2000).

**Emissions**: The release of greenhouse gases and/or their precursors into the atmosphere over a specified area and period of time (IPCC 1996).

**Emission factor**: Inventory definition: A coefficient that relates the activity data to the amount of chemical compound, which is the source of later emissions. Emission factors are often based on a sample of measurement data, averaged to develop a representative rate of emission for a given activity level under a given set of operating conditions (IPCC(a) 2000).

**Expert judgment**: Inventory definition: A carefully considered, well-documented qualitative or quantitative judgment made in the absence of unequivocal observational evidence by a person or persons who have a demonstrable expertise in the given field. (IPCC(a) 2000).

**Good practice**: Inventory definition: Good practice is a set of procedures intended to ensure that greenhouse gas inventories are accurate in the sense that they are systematically neither over nor underestimates so far as can be judged, and that uncertainties are reduced so far as possible. Good Practice covers choice of estimation methods appropriate to national circumstances, quality assurance and quality control at the national level, quantification of uncertainties and data archiving and reporting to promote transparency (IPCC(a) 2000).

**Fugitive emissions**: Fugitive emissions are intentional or unintentional releases of gases from anthropogenic activities. In particular, they may arise from the production,
processing, transmission, storage and use of fuels, and include emissions from combustion only where it does not support a productive activity (e.g., flaring of natural gases at oil and gas production facilities) (IPCC 1996).

**Greenhouse gases**: Those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and re-emit infrared radiation (IPCC 1996).

**Natural Gas**: Natural gas comprises gases at normal temperature and pressure occurring in underground deposits. In its marketed state it consists mainly of methane. It includes both “non-associated” gas coming from fields producing hydrocarbons predominantly in gaseous form and “associated” gas produced in association with crude oil. It also includes methane recovered from coal mines (colliery gas). Production is normally measured dry, i.e. after the removal of the natural gas liquids (NGL) and impurities present in the gas at the well head. It therefore excludes gas re-injected into the wells, gas flared and gas used at the production and treatment plants (IPCC 1996).

**Megatonne (Mt)** 1 Million metric tonnes, \((10^6\text{ tonnes})\) \((1000\text{ million kilograms})\)

**Quality assurance (qa)**: Inventory definition: Quality Assurance (QA) activities include a planned system of review procedures conducted by personnel not directly involved in the inventory compilation/development process to verify that data quality objectives were met, ensure that the inventory represents the best possible estimate of emissions and sinks given the current state of scientific knowledge and data available, and support the effectiveness of the quality control (QC) program. (IPCC 1996).

**Quality control (qc)**: Inventory definition: Quality Control (QC) is a system of routine technical activities, to measure and control the quality of the inventory as it is being developed. The QC system is designed to:

(i) Provide routine and consistent checks to ensure data integrity, correctness, and completeness;

(ii) Identify and address errors and omissions;

(iii) Document and archive inventory material and record all QC activities.

QC activities include general methods such as accuracy checks on data acquisition and calculations and the use of approved standardised procedures for emission calculations,
measurements, estimating uncertainties, archiving information and reporting. Higher tier QC activities include technical reviews of source categories, activity and emission factor data, and methods (IPCC 1996).

**Sink:** Any process, activity or mechanism, which removes a greenhouse gas, an aerosol or a precursor of a greenhouse gas from the atmosphere (IPCC 1996).

**Source:** Any process or activity, which releases a greenhouse gas, an aerosol or a precursor of a greenhouse gas into the atmosphere (IPCC 1996).

**UNFCCC:** The UNFCCC was established in June 1992 at the Rio Earth Summit. Its primary objective is the "stabilisation of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic (man-made) interference with the climate system. Such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened, and to enable economic development to proceed in a sustainable manner." The UNFCCC is the governing body for international negotiations (IPCC 1996).

**Venting:** The release of gas to the atmosphere, which cannot be contained or used productively. In some cases, when associated natural gas is released along with oil from production fields remote from energy users, the gas is allowed to escape into the atmosphere. The IPCC Guidelines classify emissions from venting and flaring as fugitive emissions (IPCC 1996).

**Verifiability** Refers to inventories that are capable of being assessed by expert opinion third party auditors as being free of material misstatement, usually to a predetermined benchmark. (IPCC 1996; KPMG 2000; WBCSD 2001).
DEDICATION

To my unborn child and my patient family, friends and colleagues.
OBJECTIVE

The aim of this thesis is to address the following resource management issues:

How do natural gas companies in Canada and other annex I countries manage the liability posed by potential climate change related policy constraints on companies operations and are these systems comparable?

This management issue is approached using a hierarchical system of three research questions. The first two research questions each have a subset of investigative questions and subsequent measurement questions, with the measurement questions forming the basis of the questionnaire on which the results of this thesis are based. The third research question is answered through a weighted comparison of responses from Canadian and non-Canadian companies.

Research question 1. What are the present and future processes and tools available to a company to establish the climate change related liability?

Investigative questions:

- What are the level of and type of GHG emissions monitored?
- What are the legislative requirements to report GHGs?
- What are the GHG calculation methodologies?
- What are the calculation & monitoring methods?
- How are GHGs emissions tracked?
Research question 2. What are the present and future processes and tools available to manage the resultant climate change liability represented by the results of research question 1?

Investigative questions:

- Is there integration of GHG monitoring systems with companies’ environmental management systems?
- What personnel are dedicated to managing GHG issues within a company?
- Does a company have a greenhouse gas emissions reduction target?
- What formal management system for lowering emissions is in place?
- What use is there of flexibility (market) instruments?
- What innovative GHG management methods are there?
- What are the identified major risks of non-compliance with GHG policy?

Research question 3. Given the global nature of climate change related management, are the approaches and results represented by research question 1 & 2 comparable within and between Canadian and non-Canadian companies.

Investigative questions:

What weight should be give to measurement question (questionnaire) responses?
Are the Canadian and non-Canadian, individual company, and average responses comparable?
CHAPTER 1. INTRODUCTION.

For Canadian companies increasing GHG emissions resulting from an expanding market and the pressure to reduce emissions resulting from federal government international commitments creates the need for a robust and defensible GHG management system that is able to clearly monitor and report emissions in a verifiable manner. Any such system must support the use of mitigation solutions through techniques to reduce absolute emission levels and to offset emissions through the potential for market based mechanisms. Due to the international context in which the GHG inventory and management discussion is played out, it would seem advantageous for any inventory and management system to be broadly compatible with other jurisdictions. This would allow valid comparisons to be made and help overcome market barriers impeding any flow of emissions credits as allowed for in the Kyoto protocol market flexibility mechanisms.

There are at present no generally accepted accounting principles (GAAP) for GHG emissions as there are for financial accounting. Attempts to develop international rules and protocols to develop the equivalent for such standards for business unit level emissions are in the early stages. The IPCC and UNFCCC rules and guidelines are primarily designed to facilitate the construction and verification of top down national inventories suitable for the international level discussions (UNFCCC 1990; IPCC 1996) said, they do act as excellent guidelines on the underlying theory and philosophy that all inventories and management procedures will need to refer to. At the business unit level there are two related initiatives that aim to give guidance on how to construct suitable business unit based bottom up GHG inventory and management systems these are: The World Business Council for Sustainable Development (WBCSD) GHG protocol initiative (WBCSD 2001) and the International Organisation for Standardisation (ISO) GHG protocol initiative (Boehmer 2002). The first draft of WBCSD GHG protocol (WBCSD 2001) published in September 2001 was made available too late to influence the design of the questionnaire on which this thesis is based. After careful reviewing of the questionnaire and the WBCSD protocol, this author decided to refer to the WBCSD
protocol in detail, as there are many components within the draft protocol that the questionnaire from this thesis does address. The ISO initiative to develop GHG protocols is less developed and consists of broad outlines of how existing ISO standards, notably the 14000 series may help a company develop a credible inventory and management response to climate change issues (Boehmer 2002) (ISO 2001).

This thesis sets out the author's findings through a literature search of present best recommended practice regarding GHG calculation, monitoring and verification contained in Chapter five and present best recommended and potential GHG management options in Chapter six.

Chapter five starts by describing the three principle greenhouse gases, CO₂, CH₄, N₂O, emitted by the industry and from which lifecycle segment of the industry these emissions can be expected to be derived, these being production, processing, transmission, distribution, storage, and final end use by the customer (final end use is outside of the scope of this thesis but is discussed briefly in quantitative terms to give context). Chapter five then discusses the principles behind a GHG inventory development process. Some sources quote different sets of guiding principles however this thesis has identified six principles that are widely quoted as being necessary for the development of credible GHG inventories: completeness, consistency, accuracy, transparency, verifiability, and relevance. Any future equivalent to generally accepted accounting principles regarding GHG emissions would almost certainly have to be based upon these principles. A full description of the meaning and applications of each of these principles is discussed.

Chapter five also discusses how emissions are estimated on an absolute basis, per production-normalised basis and a life cycle basis, in the Canadian industry. The end of the chapter discusses issues surrounding uncertainty and level of effort regarding gathering GHG emissions and the concept of a de minimus level on information gathering. The chapter ends with a discussion of verification and audit techniques that may be applicable to GHG emissions with particular reference to ISO 14000 series environmental management systems (EMS) and EMS audit guidelines.
Chapter six contains a discussion of GHG management including sections on how GHG management fits with environmental management systems, the role and influence of ISO 14000, what are the management options, what are the natural gas industry greenhouse gas emission reduction opportunities and what is the potential role for market mechanisms.

Chapter 7 details the results of research question 1 "What are the present and future processes and tools available to a company to establish the climate change related liability?" This chapter is set out using the investigative questions detailed in the objective as section headers and uses the measurement questions contained in the questionnaire to answer the investigative question sections.

Chapter 8 details the results of research question 2 "What are the present and future processes and tools available to manage the resultant climate change liability represented by the results of research question 1?" This chapter is also set out using the investigative questions detailed in the objective as section headers and uses the measurement questions contained in the questionnaire to answer the investigative question sections.

Chapter 9 details the results of research question 3 "Given the global nature of climate change related management; are the approaches and results represented by research question 1 & 2 comparable within and between Canadian and non-Canadian companies". This chapter is comprised of a comparative analysis of the weighted and un-weighted responses to the questionnaire. The analysis is divided into three sections looking at: GHG calculation, monitoring and verification questionnaire responses; GHG management questionnaire responses; and the combined questionnaire responses.

Chapter 10 is the discussion and the thesis ends with Chapter 11, containing the conclusions and recommendations.
CHAPTER 2. CONTEXT

International agreements

The Canadian Government signed the United Nations Framework Convention on Climate Change (UNFCCC) in December of 1992. The UNFCCC was established in 1990; over 180 countries have signed the convention. The objective under article 2 of UNFCC reads:

"The ultimate objective of this Convention and any related legal instruments that the Conference of the Parties may adopt is to achieve, in accordance with the relevant provisions of the Convention, stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner."

(UNFCCC 1990)

The Convention's supreme body is the Convention of the Party (COP) meetings. At the COP 3 meeting in Kyoto Japan, the Canadian government committed through the Kyoto protocol to reduce anthropogenic greenhouse gas emissions from Canada to 6% below 1990 levels by the 2008-2012 Kyoto commitment period. The Canadian decision to ratify the Kyoto Protocol, which gives the commitment legal force in Canada, is expected sometime in late 2002 (Canada (a) 2000; Canada (b) 2002).

If the Kyoto protocol is ratified and implemented in Canada, industries that emit significant amounts of greenhouse gasses (GHGs) as part of their operations are likely to see some sort of policy constraint, intended to reduce GHG emissions, placed upon their operations. This constraint may be either fiscal (e.g. the requirement to buy permits), operational (e.g. a targeted legislated cap on emissions or a combination of the both (e.g.
a domestic emissions trading program based upon cap and trade) (Canada (b) 2002). Potential policy options regarding Canadian ratification of Kyoto are contained in a Canadian federal government discussion paper outlining four regulatory options. All of these options are wholly or partially based upon domestic emissions trading (of permits), targeted measures (legislative reductions) and international purchase of GHG permits (use of Kyoto flexibility mechanisms). These policy driven constraints will necessarily be based upon some formula looking in part or in whole at the past present and future emissions profiles and trends of the industries impacted. Based upon the presumption that even in the absence of Kyoto ratification the Canadian natural gas industry is probably facing some sort of carbon constrained future, it would appear to be prudent due diligence for the companies involved to have in place defensible GHG inventory and management systems.

**Canadian government response regarding natural gas**

To reduce emissions in the oil and gas sector, the federal Governments *Action Plan 2000* states that its priorities are:

"**Improving energy efficiency by** - expanding the Canadian Industry Program for Energy Conservation to include the oil and gas sector.

**Encouraging carbon dioxide capture and storage by** - working with partners to facilitate the development and deployment of technologies required to capture CO₂ and store it in depleted oil fields or deep saline aquifers. This technology also applies to capturing emissions from coal-fired electricity plants in western Canada.” (Canada (a) 2000).
As part of the ongoing international COP negotiations, the Canadian government has requested the inclusion of clean energy exports to be credited against its commitment period emissions inventory. Clean energy exports are meant to recognise the emissions reduction realised when comparatively lower carbon fuels are exported and burnt helping to mitigate GHGs produced in the country that burns them. Figure 1 shows how emissions associated with the export of oil and gas from Canada in 1999 compare to the
Kyoto gap”\(^1\). Figure 1 shows a total of approximately 45 Mt for emissions associated with the exported fuel in 1999 compared with a “Kyoto gap” of approximately 128 Mt for the same year. This is of concern to Canada as almost all fossil fuel exports from Canada are sent to the USA a country that is no longer within the Kyoto accord framework. Therefore Canada has no mechanism by which to benefit from the lower emissions resulting from the energy exported but is expected to keep the liability from production and processing of the exported fuel. Figure 2 shows the growth in absolute emissions of GHGs associated with exports of natural gas from 13 Mt in 1990 to 28 Mt in 1998; this trend in emissions growth is expected to continue, with emissions resulting from export production being added to the Canadian national inventory (NRCan 1999).

\[\text{GHG Emissions Associated with Exported Gas - Canadian Natural Gas Industry}\]

\[\begin{array}{c}
\text{year} \\
\text{Emissions (Mt CO2eq)} & 10 & 15 & 20 & 25 & 30 & 35 & 40 & 45 \\
\end{array}\]

Figure 2. Natural gas emissions associated with exports 1990 -1998.
Source: (Canada (b) 2000).

\(^1\) The term “Kyoto gap” refers to the difference between where a countries emissions will be (or are estimated to be) during the Kyoto commitment period 2008-2012 and the level at which the country would need to be at in order to be in compliance with the Kyoto commitments.
The Canadian natural gas industry

Environment Canada estimates GHG emissions from the Canadian natural gas sector to be approximately 60 Mt in 1999 out of 699 Mt for Canada as a whole (Canada (c) 2002). A 1997 Canadian Gas Association (CGA) report estimated that in 1995 total emissions from the Canadian Gas Industry were 57,347 kilotonnes of CO₂ equivalent. About 57 percent of this was CO₂, 42 percent was methane and the balance was nitrous oxide. Production and transmission accounted for about 29 percent of total GHG emissions each, while the processing sector accounted for about 36 percent and the balance (6%) was from distribution and storage activities (CGA 1997). Although emissions have grown, the expectation is that these proportions will remain roughly equivalent.

Figure 3, a map of fossil fuel basins in Canada shows how at present gas is primarily produced in the lower and mid sections of the Western Sedimentary Basin with the Eastern Canada Sedimentary Basin (The Sable Island project) recently starting production. Southern Ontario has a small ongoing production capacity. Dashed circles show broad present areas of production and dashed lines show potential areas of future production showing the increase in distance from Canadian and USA markets of potential future production. This figure is adapted from (CAPP 2002)
Figure 3. Map of fossil fuel basins in Canada. (CAPP 2002)
The overall result of increased deliveries of natural gas may be beneficial in terms of GHG emissions if natural gas is used in place of other fossil fuels. Natural gas has significantly lower GHG emissions than other fossil fuels, due to a high Hydrogen (H) to Carbon (C) ratio (high in comparison to other fossil fuels such as oil or coal) (Whittaker et al 2000). The companies involved in the industry do not directly see these benefits in their GHG inventories as the benefit is located at the point of combustion (i.e. the end customer), which may not be located in Canada. Consequently companies must try and manage an increasing GHG inventory in a time when there is pressure to lower GHG emissions in Canada. The same problem complicates the Canadian Government's management of this issue as the (lowered) GHG benefits arising from fuel switching in the United States result in increased emissions in Canada. The present pressure from Canada at the COP negotiations for recognition of clean energy exports to the USA is illustrative of the Canadian governments' recognition of the importance of this (Canada (b) 2002). This particular management issue is beyond the scope of this thesis, which is primarily concerned with the industrial response.

GHG management thus presents a challenge to the Canadian natural gas industry, an expanding demand for natural gas in the United States, the primary export market for the Canadian industry, indicates large increases in natural gas production and exports in the short to medium term. These increases in production will be accompanied by increases in the GHG emissions associated with the production, processing and transportation of natural gas. This increase in emissions is further complicated by the move to explore and produce gas at more remote locations from the US border meaning that Canadian markets will increase the amount of energy needed to transport gas to final markets (see figure 2).
CHAPTER 3. RESEARCH FRAMEWORK

The research framework of this thesis draws heavily on the work of Cooper and Emery (1995). The framework chosen is designed to research and answer business management problems that are of course what GHG emissions represent to the natural gas industry. The approach follows a question hierarchy model (Cooper D R. & Emory C.W. 1995) that starts with defining the management (or academic) question or problem that needs to be solved or answered; preferably this should be a well-defined problem amenable to quantifiable analysis. This management problem is then divided into research questions, which succinctly state the objective of the research. Once the research questions have been established then a sub set of investigative questions is constructed that respond to the requirements for answering the research question. The last level in this research hierarchy is the measurement question, that is, the questions that form the questionnaire sent to respondents. These questions can be framed to give measurable (quantitative) or observational (qualitative) answers (Figure 4). Cooper and Emery (1995) refer to this hierarchy of questions as “four sequential stages moving from the general to specific” and further point that this process should be viewed more “as a continuum rather than a set of four discreet levels.”

Figure 4. The question hierarchy.
(Cooper D R. & Emory C.W. 1995)
This thesis is based upon the following hierarchy of questions that led to the logical development of the questionnaire in Appendix 1. The relevant responses to these questions inform the analysis in the results chapter’s subheadings (these being the investigative questions) and each of the three results chapters answers a research question.

The questions were developed through the literature search contained in chapters five and six and from the authors’ professional experience as a developer and auditor of GHG inventory and management systems in energy industries in Canada, Australia and the UK.

Management question.

The management (academic problem) question is:

How do natural gas companies in Canada and other annex I countries manage the liability posed by potential climate change related policy constraints on companies' operations and are these systems comparable?

This general question is faced by all companies that emit GHGs, although natural gas companies are particularly affected due to the product which they sell being a potent GHG as well as a fuel commodity. The intent of the management question was to synthesis and to encapsulate the issues facing a company from climate change related issues into one generalised question, to find out what systems are in place and whether these are comparable across international boundaries.

From this management question three research questions (or three objectives) and a subset of investigative questions can be formed.
Research question 1.

What are the present and future processes and tools available to a company to establish the climate change related liability?

This research question is meant to gather information on how GHG emissions within a company are identified, calculated, accounted for and also to get a sense of what procedures are in place to enable improvements to be carried out. Collectively these procedures are often referred to as a monitoring and verification process (protocol) or MVP for short; strictly speaking this is too narrow a definition for research question 1, as this section includes identification, calculation and continuous improvement segments. The term monitoring and verification was used as a short hand title in the questionnaire as this is the usual term used in the industry for the suite of activities encompassed here.

Investigative questions:

- What are the level of and type of GHG emissions monitored?
- What are the legislative requirements to report GHGs?
- What are the GHG calculation methodologies?
- What are the calculation & monitoring methods?
- What public reporting occurs?
- What third party verification audit and review occurs, and what are the references to developing international standards?
- How are GHGs emissions tracked?

The investigative questions for research question 1 were framed as a set of stand-alone enquiries that inform the larger research question. The set of measurement questions resulting from these investigative questions are located in Greenhouse Gas Monitoring and Verification section of the questionnaire (Appendix 1).
Research question 2.

What are the present and future processes and tools available to manage the resultant climate change liability represented by the results of research question 1?

This research question is meant to gather information on how GHGs are managed internally including level or resources and management systems employed. Further this research question is meant to gather information on potential GHG management systems being (or that may be) employed by companies.

Investigative questions:

- Is there integration of GHG monitoring systems with companies’ environmental management systems?
- What personnel are dedicated to managing GHG issues within a company?
- Does a company have a greenhouse gas emissions reduction target?
- What formal management systems for lowering emissions are in place?
- What use is there of flexibility (market) instruments?
- What innovative GHG management methods are there?
- What are the identified major risks of non-compliance with GHG policy?

The investigative questions for research question 2 were framed as a set of stand-alone enquiries that inform the larger research question. The set of measurement questions resulting from these investigative questions are located in the GHG management section of the questionnaire (Appendix 1). NB question 12 and 14 “Is the GHG monitoring system integrated into a formal EMS framework within the company?” and “Are personnel dedicated to specifically managing GHG emissions issues within your company? What percentage of time does this person/s spend dealing with GHG related issues?” were originally in the MVP section of the questionnaire. Upon reflection the
Investigative questions that these inform are more properly answered under the GHG management section as per the first two bullets under investigative questions above.

**Research question 3.**

Given the global nature of climate change related management, are the approaches and results represented by research question 1 & 2 comparable within and between Canadian and non-Canadian companies?

This research question is meant to answer whether the responses of Canadian and non-Canadian companies are comparable both within and between the average of each group. Comparisons of national emissions inventories whilst derived from national top down inventory calculation methods do refer to bottom up inventory as a means of benchmarking the accuracy of the national inventories. The fossil fuel sector is one of those used to do this. Of probably more importance is that any putative international GHG emissions trading system will have to be based upon high quality reliable data both at a national and project/entity level.

Investigative questions:

- What weight should be give to measurement question (questionnaire) responses?
- Are the Canadian and non-Canadian, individual company, and average responses comparable?

The investigative questions for research question 3 were framed as a set of stand-alone enquiries that inform the larger research question. The approach to research question three was through tabulating all responses of all companies and grouping them by
Canadian and non-Canadian origin; these responses were then weighted to give a relative sense of the impact of the different measurement questions on any overall comparison.

The tabulated results and weightings for the measurement questions are located in Appendix 2.
CHAPTER 4. METHODOLOGY

Chapter 1 of this thesis introduces the reader to the need for this work and lays out a plan of the document. Chapter 2 gives the contextual background in terms of the international and national discussions and responses to climate change with a focus on the natural gas industry. Chapter 3 lays out the research framework in terms of the question hierarchy theoretical framework as discussed by Cooper and Emory (1995). This chapter (Chapter 4) discusses the methodology used in the thesis. Chapter 5 and chapter 6 are a discussion of current thinking on the GHG calculation monitoring and verification and GHG management respectively. Chapter 7, 8 and 9 address the three research questions posed in the objective in order. Chapter 10 is a discussion on the results and documents the conclusions and recommendations.

Once the measurement questions were formed through the processes discussed in chapter 3, there were still logistical and other methodological issues to be addressed.

Questionnaire logistics

Measurement question information requests in the form of a questionnaire were made through the Canadian Natural Gas Association (CGA) and the International Gas Union (IGU) for participants in the survey. Only companies operating in Annex I and Annex b countries were surveyed as these companies are likely to be facing similar policy pressures regarding GHG inventory and management as companies operating in Canada, the exceptions to this being the USA\(^2\) and Australia\(^3\) (Pew_Centre 2002; Pew_Centre 2002).

\(^2\) The USA effectively has left the Kyoto Protocol negotiating table and adopted a business as usual stance based upon historical gains in efficiency being extrapolated in to future improvement in emissions per unit of GDP. However some companies operating in the USA still track GHG emissions for such purposes as state approvals of projects and permits.

\(^3\) Australia announced in June 2002 that it would not be ratifying the Kyoto protocol, citing economic impacts and the fact that the USA, the world’s largest economy had backed away from the Kyoto process (BBC 2002).
The full questionnaire is located in Appendix 1 and a total of 15 companies responded, five Canadian and 10 non-Canadian companies. The maps in figures 5 and 6 show the countries in which respondents operate.

Confidentiality

The methodological approach and all questions within the questionnaire were screened by the ethical review board of the University of British Columbia and the author was granted permission to proceed with the research. Each respondent was assigned a random number, which is not published in this paper or elsewhere in accordance with the ethical guidelines of the University of British Columbia (UBC 2002). All information contained within the returned questionnaires is published here in aggregate form in such a way as to not identify the respondents. The only analytical tags are the random number (within each group) and whether or not a company operates in Canada or outside of Canada.

Comparative techniques

The comparison was made between Canadian practice and practice as described by the non-Canadian companies polled. One thing that has to be borne in mind regarding polls of this nature is the self-selecting nature of those who respond. Often companies, and individuals in those companies, who are taking a progressive stance and support relatively open information practices will tend to be more responsive.
Figure 5. World map showing country of origin of respondent companies
Research question 1 and research question 2 are answered through a description of the tools and processes used and where applicable charts showing the spread of results. Each sub set of results is described in detail and is used to gain insight into how companies calculate, monitor, verify and manage its GHG emissions.

For research question 3, only questions that have quantifiable answer are used, that is, those that are easily amenable to ranking are used, thus contextually answered questions such as question one and questions twenty six are not included in the ranking. Each question is ranked evenly. A case could be made for weighting different questions although in practice this turned out to be unwieldy and did not markedly affect the results. Questions are assigned a possible max score of 5 and minimum of 1 thus the theoretical maximum a company could score is 56 for the MVP section and 34 for the management section making a total of 90. The ranking of each question is based upon best practice as describe in the referenced international reports and an interview process with Environment Canada senior staff dealing with climate change monitoring verification and management issues at a national and international level (Boileau 2002). All references and assumptions are explicitly stated in the tabulated results and weightings of the measurement questions (Appendix 2). The results of this ranking process are laid out in charts and discussed with the aim of answering research question 3; which is: Given the global nature of climate change related management, are the approaches and results represented by research question 1 & 2 comparable within and between Canadian and non-Canadian companies?

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4 “How does your company monitor the greenhouse gas (GHG) emissions generated by its operation?”

5 “What major risks of not complying with GHG policies has our company identified?”

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**Expert opinion**

“Experts are people who have special skills or knowledge in a particular field” (IPCC(a) 2000), it is important that appropriate experts are selected for eliciting opinions (Hora 1989).

The purpose of finding an “expert opinion” was to ensure that the questions asked did not lead to overt bias in the answers. The ranking review was conducted blind, that is Pierre Boileau could not see the results of the ranking decisions that he made.

The process that was undertaken to elicit expert input into the weightings for the comparative analysis was in two parts. The first part was establishing who to approach and the second was the development and implementation of an appropriate framework for eliciting an expert opinion that was suitable for the research work of this thesis.

**First find your expert**

After enquiring through Environment Canada, the author was directed to Pierre Boileau head of the Environment Canada Greenhouse Gas Verification Centre (Canada (a) 2002). Pierre is charged with developing tools and processes to calculate and verify GHG emissions within the different Canadian economic sectors, sits on Canadian Standards Association working groups to develop GHG audit guidelines and professional standards for GHG auditors and represents Canada on the ISO processes regarding GHG calculation and audit. Pierre Boileau also has input into a number of other Environment Canada initiatives related to the national implementation process. All of this qualifies him as having the “special skills and or knowledge” to give appropriate expert opinion regarding weighting the findings of this thesis.
Expert opinion elicitiation process

Chapter six of the *IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories* (IPCC(a) 2000) contains a protocol for eliciting expert judgement for the purpose for establishing uncertainties within an inventory. This thesis has adapted this protocol for eliciting expert opinion on what the appropriate weightings should be for the comparative analysis. The protocol has five stages.

- Motivating: Establish a rapport with the expert and describe the context of the elicitation.
- Structuring: Clearly define the quantities for which the judgements are to be sought.
- Conditioning: Work with the expert to identify all relevant data models and theory pertaining to the quantity for which judgements are required.
- Encoding: Request the expert’s judgement.
- Verification: Analyse the expert’s response and provide the expert with feedback as to what has been concluded regarding his or her expert judgement. Is this what the expert really meant? Are there inconsistencies in the expert’s judgement?

Motivating, structuring and conditioning were accomplished through sending a draft outline of the thesis together with the tabulated questions contained in Appendix 2. Encoding was accomplished during a telephone interview with Pierre Boileau during which his responses were directly entered into the spreadsheet. Verification was achieved through a series of follow up emails in which the encoded excel sheet was iteratively reviewed by Pierre until he was comfortable that the sheets reflected the encoding conversation that took place during the interview; this verification correspondence regarding the expert judgement is set out in Appendix 4.
Reducing Uncertainty

This chapter discusses current thinking on GHG calculation, monitoring and verification in Canada and internationally. It is laid out to discuss the GHGs of particular concern, where they are emitted within the natural gas industry, the principles for calculating, monitoring and verifying emissions and how are these principles applied. Section headings within the chapter reflect this thread.

One of the two major strategies regarding GHG emissions from the natural gas industry is reducing uncertainty surrounding the emissions levels or emissions intensity through inventory monitoring and verification. This issue is dealt with in this chapter. The second major strategy is to then manage the resultant liability through development of mitigation options, based upon the results of the assessment of emissions levels; chapter 6 speaks to this issue. The sub categories within “reducing uncertainty” can be sub divided into the following, the rest of this chapter will elaborate on these headings.

- What greenhouse gasses are emitted?
- Where do emissions occur?
- Inventory development.
- Emission and activity factors
- Evaluate absolute emissions.
- Evaluate emissions on a normalised by production basis
- Evaluate emissions on a full fuel cycle basis.
- Development of standardised techniques, protocols.
- Verification and Audit development.
What greenhouse gases are emitted?

There are three principle GHGs emitted by the natural gas industry; other so called “Kyoto gasses” such as SF6 and some HFCs may be emitted but these are typically in extremely small quantities from fire suppression equipment or specialist monitoring, such that even with the large GWP multipliers they do not show up on inventories as a significant source compared to the gasses below. The three principal GHG emitted by the natural gas industry are:

Carbon Dioxide (CO$_2$)

In the natural gas industry, carbon dioxide is emitted from the combustion of natural gas as a fuel to operate compressors, pumps and other equipment and during flaring of gas during routine maintenance procedures and emergency shutdowns of equipment. Carbon dioxide can also be emitted during processing of natural gas when excess carbon dioxide in the raw gas stream is “stripped” and vented to atmosphere, (Whittaker 2000)

Methane (CH$_4$)

Methane emissions occur from routine venting, fugitives, and other discharges of natural gas, which is about 95 percent methane. Methane has a global warming potential (GWP) of 21, that is, over a 100-year time frame methane is 21 times more effective in trapping heat in the atmosphere than carbon dioxide. It is common for companies operating in the natural gas industry for methane to account for 20-30% of total GHG emissions on a CO$_2$e basis ((Alliance 2001) (ATCO 2001) (Irwin 1999) (TransCanada 2001) (Berkakar 2002)). The IPCC lists natural gas operations specifically as one of the three principle
anthropogenic sources of methane releases. (IPCC(a) 2001; IPCC(b) 2001). For these reasons, much research on GHG emissions in the natural gas industry has focused on methane emissions source identification and quantification (USEPA 1996; Kirchgessner 1997).

Nitrous Oxide ($N_2O$)

Nitrous oxide ($N_2O$) is also produced from the combustion of natural gas. Nitrous Oxide has a GWP of 310 over a 100-year time frame, however it is a very small percentage of total emissions from the industry. Nitrous Oxide forms a small percentage of oxide of nitrogen emissions originating from natural gas combustion, typically 1-2% of total oxides of nitrogen (Eby 2002) and represents a small fraction of total emissions < 5% on a CO$_2$e basis.

Where do emissions occur?

Greenhouse gas emissions from the natural gas industry occur during the various sectors of initial production through distribution to consumers. The GHGs typically associated with these sectors are described below. Emissions are categorized into combusted and vented emissions. Figure 7 is a general systems schematic of the industry useful when reading this section.

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Greenhouse gas emissions emanating from the natural gas industry can be classified as originating in one of four ways:

1. **Combustion Emissions**: are exhaust emissions from combustion sources such as compressor engines, burners and flares.

2. **Vented Emissions**: are emissions releases to the atmosphere by design or operational practice (primarily from pneumatic devices, equipment blowdown and dehydrator emissions).

3. **Fugitive Emissions**: are emissions emanating from unintentional leaks emitted from sealed surfaces such as packings and gaskets, or leaks from underground pipelines.

4. **Stripped CO₂**: is the one of the components taken out of raw gas during processing into sales gas. (Irwin 1999; CEPA 2002)

For national inventories, all methane releases are classified as fugitive. Thus, fugitive and vented emissions from above would be considered as one category that is fugitive emissions (IPCC 1996).

Production

The production sector involves all operations associated with the exploration and initial production of natural gas. Most production sites are situated in remote locations, without access to electricity. The natural gas produced is typically the energy source for operating the engines that power all equipment at the sites. Such equipment includes compressors, pumps, and process heaters for gas dehydration and oil treating. The resulting combusted emissions are the largest source of GHG emissions from the production sector. Vented emissions from the production sector occur from the dehydrator regenerators, the pneumatic controls throughout the production site, and from the well in order to purge liquids. These emissions are the production sector's largest source of methane emissions.
Figure 7
General system diagram of the natural gas industry (IGU 2001).
Processing

The processing sector includes operations associated with the transport of natural gas from the well through booster station compressors to the processing plant, and operations at the processing plant itself. At the plant level, natural gas liquids are initially removed from the gas prior to its sweetening process. During the sweetening process, acid gases (hydrogen sulphide and carbon dioxide) are removed and either processed through a sulphur plant or an acid gas flare stack. The sweetened gas is dehydrated and further fractionated to remove any marketable gas liquids prior to being transferred to the gas transmission sector. Most processing plants have electrical power available, however equipment such as compressors and process heaters utilize natural gas as the source of energy; booster stations also utilize natural gas to power compressors. The resulting combusted emissions are the largest source of GHG emissions from the processing sector. Vented emissions are the processing sector’s largest source of methane emissions. These emissions are typically from the glycol dehydrators, storage and transfer of natural gas liquids, and the pneumatic controls throughout the booster stations and processing plant. Carbon dioxide is also emitted through the removal of acid gas and termed as stripped CO₂ emissions.

Transmission

The transmission sector involves all operations associated with the transport of natural gas from the processing plant to the end-use distribution system and storage. The transmission system is comprised of compressor stations that utilize large natural gas-driven centrifugal and reciprocating compressors to move the processed gas through the pipeline. Other equipment such as heaters also utilizes natural gas as the source of energy. The resulting combusted emissions are the largest source of GHG emissions from the transmission sector. Vented emissions are the transmission sector’s largest source of methane emissions. These emissions occur when stopping/starting
compressors, during compressor station and pipeline maintenance, and from pneumatic controls. Fugitive emissions also occur from fittings, valves, and meters associated with the compressor equipment and pipeline.

Distribution

The distribution sector involves taking the natural gas from the transmission pipelines and distributing it to the customer meters at a lower and safer operating pressure. Vented emissions due to leakage are higher in older distribution systems and typically occur from underground piping made from unprotected steel or cast iron. Leakage is significantly lower in newer distribution systems as piping is fabricated from protected steel or plastic.

Storage

The storage sector consists of underground storage of gas in non-potable water aquifers or in depleted gas reservoirs. The gas is stored when its demand is low, typically during the summer months. Minimal GHG emissions occur from storage facilities as the operation typically involves an electric-driven compressor to inject the gas into and remove it from storage.

End Use

GHG emissions associated with natural gas are predominantly located at the point of consumption. In total end use accounts for 80-85% of the total emissions when looking at all emissions from the system including production, processing transmission and processing (UOGWG 1999). Direct emissions are those originating from combustion, venting or fugitive emissions from production, processing, transmission or distribution. Indirect emissions are the upstream emissions from the electric generation of electric
power used in production, processing, transmissions and distribution. End use represents the resultant emissions from combustion of the natural gas by the final (end) user. Figure 8 shows the proportion of emissions from end use versus upstream (production and transportation) emissions.

Figure 8. End use emissions from the natural gas industry Adapted from (UOGWG 1999)
Six key principles of GHG inventory development.

Below are the six key imperatives that this author has derived from Canadian and international literature\(^7\), together with reference to work completed by major audit firms working within this area.

The key imperatives of GHG inventory can be summed as the need for a complete, consistent, accurate, transparent, verifiable and relevant GHG inventory in order to both manage the resultant liability and to assure key stakeholders that the liability is being managed in a proficient manner. Essentially the six principles below are the same requirements as for prudent financial accounting and management and given that GHG emissions are in the early stages of being a monetised commodity and represent both potential assets and (more likely) a possible substantial liability this makes sense.

The following are the six key areas that an inventory should cover:

**Completeness**

Defined by the IPCC the definition of completeness reads: "Completeness means that an inventory covers all sources and sinks as well as all gases included in the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories completeness also means full geographic coverage of sources and sinks of a Party" (IPCC 1996).

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\(^7\) The WBCSD does not include verifiability as an explicit principle but instead treats as a sub unit of transparency, to ease the process of using the two slightly different frameworks; this thesis shall treat verifiability as a distinct category.
Consistency

Defined by the IPCC the definition of consistency reads: “Consistency means that an inventory should be internally consistent in all its elements over a period of years. An inventory is consistent if the same methodologies are used for the base and all subsequent years and if consistent data sets are used to estimate emissions or removals from sources or sinks” (IPCC(a) 2000).

Accuracy

Accurate inventories are obviously a prerequisite to being able to manage GHG emissions, with an accurate accounting of the sources, processes and volumes of emissions management decisions can be taken which efficiently address cost effective opportunities for reduction (IPCC(a) 2000).

“Accuracy is a relative measure of the exactness of an emission or removal estimate. Estimates should be accurate in the sense that they are systematically neither over nor under true emissions or removals, as far as can be judged, and that uncertainties are reduced as far as practicable. Appropriate methodologies conforming to guidance on good practices should be used to promote accuracy in inventories.” (IPCC(a) 2000).

Transparency

Transparency relates to how easily inventories are understood and whether third party reviewers and stakeholders can readily understand them. As such inventories should be clearly laid out and easily reconstructed from the information and assumptions contained in an inventory (ICF 2002), all calculations and underlying data should also have a clear
audit trail (WBCSD 2001). Documents (paper and electronic) must cover all sources of information that forms the inventory.

Verifiability

Verifiability refers to inventories that are capable of being assessed by expert opinion third party auditors as being free of material misstatement, usually to a predetermined benchmark. This acts as a reassurance to regulators and to any future participants in GHG reduction markets that there is some credibility behind figures quoted by a company (KPMG 2000; ICF 2002).8

Relevance

The WBCSD uses slightly different principles to those derived from the IPCC and UNFCCC. The WBCSD adds a relevance criteria, which “defines boundaries that appropriately reflect the GHG emissions of the business and the decision making needs of users” (WBCSD 2001). This principle meant to prevent double counting and under reporting when taking in to account the realities of the often-complex web of ownership, control and influence that define many business-operating units.

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8 For inventory audits at BP and the Canadian natural industry audit the benchmark used was “free of material misstatement within a range of 10%”. KPMG (2000). Development and implementation of a process to audit BP Amoco’s greenhouse gas emissions Audit Overview, http://www.bp.com/downloads/downloads.asp?category=15.

Emission & Activity Factors

Estimating greenhouse gas (GHG) emissions from the natural gas industry is difficult due to the complexity of the facilities and operations included. The Intergovernmental Panel on Climate Change (IPCC) provides the Tier 3 approach “Rigorous Source-Specific Evaluations” for estimating emissions. The natural gas industry has adopted a variation of this approach as its standard method. This approach involves the development of a detailed emissions inventory based on all emission sources from each sector of the natural gas industry. Emissions are grouped into categories specific to the nature of the operation. Typical categories would include combusted emissions, vented emissions, and flared emissions. Actual emissions for each category are then calculated based on activity factors obtained for each emission source and corresponding emission factors. Actual measured emissions data is typically preferred over calculated or estimated emissions.

Emissions can also be adjusted from year-to-year utilizing an activity factor driver. This driver is a percentage showing the increase or decrease of annual throughput in the system or facility. The percentage is applied to the previous year’s activity factor to determine the new annual emissions, assuming the corresponding emission factors remain unchanged.

Total emissions are calculated by multiplying the activity factor by the emission factor. This is done for all emission sources at a given facility, resulting in a detailed emissions inventory. The current global warming potential for each greenhouse gas is then applied to determine the total CO₂ equivalent GHG emissions.
Uncertainty

The emission factor is the estimated amount of emissions generated from a specific source for a specific base unit. For example, the CO₂ emission factor for the combustion of natural gas would typically be 1880 grams CO₂ per cubic metre (m³) (VCR(b) 2002) of gas burned. The base unit of m³ of gas burned is the activity factor required from the actual operation of the emission source, such as a compressor, furnace, or fuel gas consumed from an entire facility. The use of emission factors is not an exact science; they are based on best-available information in the natural gas industry. The accuracy of the factors depends on the amount of actual emission measurements made that mimic typical operating practices in the industry. Measurements taken may not be representative of typical operations depending on the level of maintenance done on the equipment and frequency of operation prior to actual testing. In essence, this is a statistical sampling issue with uncertainty coming from how well the sample used for developing the emission factors truly represents the population sampled. The uncertainty in this is exacerbated by the nature of the industry in that it is heterogeneous in terms of age, design and operational maintenance procedures. All of which can have a major impact of the uncertainty surrounding emission factors. When used on a large and complicated system that also has uncertainty attached to the activity factors this can lead to uncertainty surrounding the final emission estimate to be in the 3 orders of magnitude range (Rotherham 2002).

The uncertainty surrounding the activity and emissions factors can be viewed as an inverse triangle, with uncertainty decreasing as one progresses from broad landscape type GHG estimates towards detailed component counts (activity factors) coupled with component specific emissions measurements (emission factors). The level of resources required goes up as a function of inventory detail. Figure 9 shows graphically, how the pattern (within the Canadian natural gas industry) has been a slow progression from a tier 1 type approach to a higher tiered approach, with higher levels of resources applied to develop and apply more accurate emissions factors and identify activity factors previously not considered.
This is not necessarily a smooth transition and different components within the same company emissions inventory may be at different stages at any one point.

**Resources required**

![Diagram of resource tiers]

Figure 9. Tiered uncertainty attached to emission and activity factors
Adapted from (GRI 2000)

**De minimus**

To put simply the concept of *de minimus* is an engineering rule of thumb that gives guidance at what level further resources should not be applied, as the results obtained would be of minimal use or impact. In effect, what is the minimum cut off point at which one should halt an analytical enquiry. An example of *de minimus* would be the 1000 tonne CO$_2$e (1kt) used in some areas of the Canadian industry (Irwin 1999, Irwin 2002)

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Global Warming Potential

The gases responsible for anthropogenic global warming are thought to cause a net global climate forcing with different gases having differing levels of forcing (Hansen 2000) Global Warming Potentials (GWP) represent the ratio of a gas’s climate change forcing with reference to the forcing of Carbon dioxide (CO₂). There is scientific debate regarding what are the correct values to use for GWP and over what timescale they should be assessed. Different residence times in the atmosphere will give different GWP, the IPCC have recommended the use of GWP factors based upon a 100-year time frame (Kirchgessner 1997). For the first commitment period these are a GWP of 21 for methane (CH₄) and 310 for Nitrous oxide (N₂O). After the first commitment period inventories will have to be normalized using the new 100 year GWP factors laid out in working group 1 third assessment report (IPCC(b) 2001); these are 23 for methane and 296 for nitrous oxide.

**Evaluate absolute emissions,**

An evaluation of absolute emissions is necessary as any GHG mitigation policy will have to be linked to management (reductions) of absolute emissions even if the policy action is couched as being one of emissions per unit of throughput based. Figure 10 shows the absolute emissions from oil and gas production and delivery (excluding road and rail transportation) between 1990 and 1997. The figure shows steady growth in absolute emissions from the Canadian oil and gas industry. Individual gas companies’ emissions are more varied but the general trend is one of growth of absolute emissions from 1990 onwards (Alliance 2001; ATCO 2001; DEGTC 2001; TransCanada 2001).
CO$_2$ emissions from oil and gas production and delivery (excluding road and rail transportation of oil). Including linear regression of trend.

\[ R^2 = 0.9649 \]

Figure 10. Total GHG emissions from the oil and gas production and delivery systems (excluding road and rail transport of oil) for Canada 1980-1997 (Canada 2001)

Evaluate emissions on a normalised by production basis

The oil and gas fields of much of the southern western sedimentary basin are mature, that is, they have reached production plateaus and reserves are increasingly difficult to locate and extract. New wells coming on line tend to be progressively deeper and sourer, this is the case in Canada and throughout the continental USA (USDOE 2002). New production sources from the northern western sedimentary arctic basins increase the distance gas has to be transported to market. Two things related to mature and more distant gas supplies have an impact on the amount of GHG emitted while bringing the
produced natural gas to market; these are that gas needs to be transported further resulting in higher compression emissions and also will have higher process emissions due to deeper gas fields having generally sourer gas reserves (Hyndman 2002). Deeper reserves of natural gas tend to have a higher CO₂ and H₂S content than shallower reserves in this basin. This gas will require higher processing and will produce higher stripped CO₂ emissions, resulting in higher GHG emissions per volume of gas delivered. Figure 11 shows emissions per unit of intensity in MtCO₂e / PJ⁹ associated with exports of natural gas from Canada, emissions per unit of production generally increase due to the effects discussed above. Figure 12 is a specific example and shows the emissions per unit of throughput for Duke Energy Gas Transmission Canada (DEGTC 2002). This chart shows the trends discussed above and DEGTC attributes the U shaped trend in emissions per unit of throughput to higher CO₂ laden gas being processed at its northern BC natural gas processing plants.

Potential new natural gas production from Alaska or Northern Yukon will exacerbate this trend as a pipeline moving gas the approximately km 3,100 km (Yukon 2002) will generate approximately 900,000 tonnes of CO₂e per year¹⁰. If this gas is routed through the newly completed (2000) Alliance Pipeline (Alliance 2001) to central US markets it will have approximately twice the emissions associated with transportation as present gas, originating in northern BC, going through the Alliance pipeline system.

⁹ Petajoule
¹⁰ Based upon Alliance pipeline figures (Alliance 2002) for a roughly equal length (2990 km) and the Alliance pipe being the newest (completed 2001) and therefore the nearest in terms of probable technology used on the Alaska Highway line.
Figure 11. Natural gas emissions associated with exports 1990-1998.
Source: (Canada (b) 2000).

Figure 12. DEGTC GHG emissions per unit of throughput 1990-2001
(DEGTC 2002)
Evaluate emissions on a full fuel cycle basis.

To fully understand the greenhouse gas profile of a fuel, it is important to look at its total lifecycle – all of the emissions associated with the fuel including emissions from initial extraction, processing and delivery as well as those from the final combustion of the fuel. The emissions comparison against oil and coal is important, as this is likely to be one of the major market drivers in the growth of natural gas usage. Other drivers are local air quality issues impacted by the relative emissions of criteria pollutants from gas, oil and coal and the relative price compared to other fuels.

On a full fuel cycle basis natural gas has the potential to help reduce overall systemic GHG emissions through fuel switching away from other fossil fuels. This is due to natural gas having higher hydrogen to carbon ratio than either oil or coal. When burnt, natural gas produces lower greenhouse gasses (GHG) usually expressed in tonnes carbon dioxide equivalent (CO$_2$e) per unit of useful energy (either Gigajoules (GJ) for non electrical uses or Megawatt Hours (MW.h) for electric generation) with the emission resultant units being tonnes CO$_2$e / GJ or tonnes CO$_2$e / MW.h.

Carbon dioxide and nitrous oxide emission rates are known to a relatively high degree of certainty as they are combustion releases or releases from processing plants all of which can be calculated from meter readings. Methane emissions, especially fugitive emissions, are known with less certainty. The most comprehensive survey of methane release from the natural gas industry to date (Kirchgessner 1997) gives a Methane release figure of 1.42 ± 0.47 % of total gross national production this equates to 8.9 ± 3 billion cubic metres per year.

The United States Environmental Protection Agency (US EPA) & Gas Research Institute (GRI) Research and Development multi-volume set of reports (Kirchgessner 1997) does not explicitly deal with comparative GHG emissions of gas versus oil and or coal, but concerns itself with reporting an overall emission total for the industry, with detailed methodology and sectoral splitting of emissions. Referring to Volume 2 of the multi volumes (Harrison 1996) there is a detailed analysis of the study results and how, based
on this, natural gas compares to oil and coal in terms of GHG emissions when looked at on a full fuel cycle basis.\footnote{Full fuel cycle refers to the emissions that result from the combustion of a fuel and the emissions upstream of combustion. Upstream emissions include all combustion of fuel for transportation and in the case of natural gas any methane emissions resulting from leaks or planned release due to operation and / maintenance of the gas pipeline infrastructure.}

For example, taking a range of global warming potentials under the most conservative conditions of analysis (a 50-year timeframe), oil contributes 20% more CO$_2$ equivalent emissions than natural gas, and coal contributes 50% more (Kirchgessner 1997).

On a per unit of weight basis, different greenhouse gases such as methane (CH$_4$) and nitrous oxide (N$_2$O) have a different impact on climate change relative to the effect of a similar weight of carbon dioxide (CO$_2$) over the same time period. To allow comparisons between various greenhouse gases, the emissions are expressed according to their individual Global Warming Potential. For example, the GWP of methane is 6.5 over 500 years and 34 over 50 years. A GWP of 21 for a time period of 100 years is generally used by the industry as recommended by the Intergovernmental Panel on Climate Change (IPCC 2001; IPCC(a) 2001; IPCC(b) 2001).

Figure 13 shows a range of global warming potentials (GWP) for natural gas from GWP of 6.5 over 500 years to GWP of 34 over 50 years. The Kirchgessner Report examines how natural gas compares to oil and coal. Under the most conservative conditions of this analysis (i.e., CH$_4$ GWP for 50-year atmospheric lifetime), oil contributes 20% more CO$_2$ equivalent emissions than natural gas, and coal contributes 50% more.

This Kirchgessner US -EPA comprehensive study of the US Natural gas industry is in general agreement with findings of a lifecycle study completed by the Canadian Natural Gas Association, Figure 14 details the findings contained in the summary paper by Whittaker et al. (2000) of this study. This was an industry-financed study and to date has not been peer reviewed or assessed by a third party. This said it does generally agree
with the Kirchgessner USEPA report cited above and with figures derived from Environment Canada (Canada (c) 2002).

The column of % differences, which shows the relative contribution of equivalent CO2 from gas compared to oil and coal.

<table>
<thead>
<tr>
<th>Fuel Source</th>
<th>kg CO2/M^3</th>
<th>Equivalent CO2 Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CH4 GWP=6.5</td>
<td>CH4 GWP=34</td>
</tr>
<tr>
<td>Gas</td>
<td>1.67</td>
<td>1.92</td>
</tr>
<tr>
<td>Oil</td>
<td>2.33</td>
<td>2.35</td>
</tr>
<tr>
<td>Coal</td>
<td>2.68</td>
<td>2.88</td>
</tr>
</tbody>
</table>

Figure 13. Comparison of carbon equivalent emissions from natural gas relative to other fossil fuels
Adapted from (Kirchgessner 1997).

<table>
<thead>
<tr>
<th>Upstream</th>
<th>Transmission</th>
<th>Storage</th>
<th>Distribution</th>
<th>End-Use</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO2</td>
<td>25,500</td>
<td>5,295</td>
<td>62</td>
<td>81</td>
<td>119,515</td>
</tr>
<tr>
<td>CH4</td>
<td>735</td>
<td>280</td>
<td>6</td>
<td>58</td>
<td>3</td>
</tr>
<tr>
<td>NOx</td>
<td>203.6</td>
<td>30.5</td>
<td>1.4</td>
<td>0.1</td>
<td>145.0</td>
</tr>
</tbody>
</table>

Figure 14. Natural gas emissions per unit of through put.
Adapted from (Whittaker 2000).

Figure 14 represents lifecycle analysis modelling results based upon a 1995 Life-Cycle Inventory of Canadian natural gas industry-Wide Emissions (kilotonnes). The model uses a 1995 annual emissions profile, with a constraint of 148,203 x 10^6 m^3 of natural gas which is placed on the amount of gas produced in the upstream segment (the actual amount reported in 1995).

All of the lifecycle emissions analysis discussed above applies to present sources and markets within the Canadian natural gas industry. As sources of gas become deeper and increasingly distant to markets then the lifecycle emissions and comparative GHG
advantage of natural gas is likely to erode. To what extent this may happen is beyond the scope of this thesis, but it does underline the need for developing knowledge and management of GHG emissions within the industry.

Verification and audit development

The still emerging standards being developed at a national and international level (ISO 2001; WBCSD 2001; Canada (a) 2002) that present auditing of GHG inventory and management systems is accomplished by referring the ISO 14010, 14011 and 14012 (ISO(a) 1996; ISO(b) 1996; ISO(c) 1996; ISO(d) 1996; ISO(e) 1996) and financial accounting audit principles to design a verification and audit methodology for GHG systems. The influence of ISO 14001 in management systems is discussed more fully in the next chapter. Figure 15 shows a schematic of an ISO 14000 series type approach to the methodological process with the steps expanded on further in the text. The steps one through three should be viewed as iterative, hence the top dashed loop arrow.

Internal and External Knowledge

The objective is to establish what Internal and External Knowledge exists and will be accomplished through a review and reporting of current leading practice in GHG inventory methodology, and will include but not be limited by: company specific internal practices (where easily documented and available); industry Association recommended practices (e.g., CGA, GRIC, CAPP, VCR); regulatory Agencies recommended practice (e.g., Statistics Canada, Baseline Protection Initiative, NEB); and international agencies recommended best practices.
Figure 15. Conceptual outline of GHG inventory validation and audit sequence (Irwin 1999)

GHG INVENTORY VALIDATION and AUDIT SEQUENCE

Objective

INTERNAL & EXTERNAL KNOWLEDGE

PROCESS INTEGRITY

DATA INTEGRITY

REPORT SUBSTANTIATION

Method

Review Leading Practice
- Internal Practices
- Industry Associations
- Regulatory Agencies
- International Agencies

Validate Process
- Identification Methods
- Measurement & Estimation Methods
- Calculation Methods
- Information Systems

Verify Data Integrity
- Document Review
- Interviews
- Data Sampling

Inventory Attestation
- Statement Review
- Text Footnoting
- Attest Statement
Process Integrity

The objective here is to establish process integrity of the GHG inventories through a validation of process, and should include but not be limited to reviewing and validating:

- GHG identification methods; these are meant to establish types of GHGs emitted and sources of the emissions and to identify the processes for reviewing and updating as and when new information is available.

- GHG measurement and estimation methods; These relate to what are the actual measurement and estimation methods used by field and analytical staff to calculate and estimate GHG emissions and what are the processes for reviewing and updating as and when new information is available.

- GHG calculation methods; these relate to what are calculation methods used by field and analytical staff to calculate and estimate GHG emissions. How are the calculations set up? What are the procedures to avoid double and under counting of emissions? Are correct activity factor definitions and quantities being used? Are correct emission factors being applied? What are the procedures for changing these factors as and when they require updating?

- GHG reporting and information systems. Are they suitable for the purpose? For example a small natural gas distribution company probably does not need to set up an elaborate database to calculate its emissions basic spreadsheet would be more than adequate, whereas for a large fully integrated company with many complex operations this may be the appropriate approach as spreadsheets become unwieldy and prone to human error for very large systems.

Are these processes structured to allow for continuous improvement of the documents and / or other records? Are ongoing reviews of best practice in place that integrate
developments in internal and external knowledge into the relevant data identification and manipulation streams? Is there a formal review and communication system in place to identify and disseminate new information?

Data Integrity

The objective is to establish data integrity of the GHG inventory through a verification process and should include but is not limited by:

- GHG inventory related document review; That all sources (activity factors) and emission factors are current and documented to a standard that allows easy reconstruction of the inventory process

- Interviews with relevant personnel; including questions on documentation, inventory structure, data gathering procedures and methods of review and improvement.

- Data sampling of the GHG inventory, testing of representative data samples to ensure that correct data inputs, calculation procedures and record keeping is in place.

Report Substantiation

The objective of an appropriate audit process related to GHG emissions inventories within the natural gas industry is to establish whether a company or industry’s stated emissions inventory is a realistic and credible account of the GHG emissions from processes and operations carried out by that company or industry.
Various audit techniques and procedures can be used to accomplish this goal, as an example set out below are the sub components of an audit due to be completed for the Canadian Natural Gas Industry (downstream of the processing plant) in 2002.

The audit aims to test and establish an opinion on:

- The thoroughness in identifying all sources;
- The data and documentation and supporting determination of activity factors;
- The degree to which activity factors are defined and classified by technology or practice;
- The choices of emissions factors relative to published factors from several well recognized sources;
- How boundaries between business units are defined and shared between neighbouring business units; and
- How “ownership” of emissions is divided in jointly owned businesses.

(KPMG 2000; ICF 2002)

The audit generally is finalised with a:

- A statement review; describing the main findings of the audit
- Text footnoting, where applicable;
- A formal attest statement. Attesting that company X reported GHG emissions are within boundary Y (e.g. 95% of actual) and that the inventory is free of material misstatement
CHAPTER 6. GREENHOUSE GAS MANAGEMENT

How does GHG management fit with environmental management systems

There is an emerging consensus that GHG emissions management fit within some aspects of a general environmental management scheme such as detailed by ISO14001. The WBCSD and ISO, both influential in developing corporate environmental management systems, point to GHG management being unique in its global impacts and in the potential for mitigation response. GHGs are the subject of complex international negotiations that have the potential to impact economic and social development destinies throughout the world, no other environmental issue has such wide ranging societal effects. Emissions trading systems offer the potential for GHG mitigation systems to have no contact either physically or materially to the point of emissions origins. This has led to WBCSD and ISO initiating the design of protocols to deal with GHG inventorying and verification systems with a view to supporting both national inventory processes and the potential requirement of an emissions trading system (WBCSD 2001; ISO 2001).

The role and influence of ISO 14000

ISO 14001 is the only ISO standard against which a corporate entity can be certified. The standard specifies the requirements for an environmental managements system, while other ISO standards (ISO, 14004, 14010, 14011 and 14012) specify general guideline for implementation as well as principles and procedures and qualifications for auditors of ISO 14001 systems (ISO(a) 1996; ISO(b) 1996; ISO(c) 1996; ISO(d) 1996; ISO(e) 1996).

12. The nearest comparison would be the Montreal protocol which essentially boiled down to a switch from one set of evaporative CFC chemicals to another set with a lower ozone depleting potential, this said the Montreal protocol does point to international treaties working when the political will is apparent.
The standard is designed to be applicable to any entity (organisation) that wishes to:

- Implement, maintain and improve an environmental management system
- Assure itself of its conformance with its own stated environmental policy
  (those policy commitments of course must be made)
- Demonstrate conformance
- Ensure compliance with environmental laws and regulations
- Seek certification of its environmental management system by an external
  third party organization
- Make a self-determination of conformance

Extract taken from ISO 14001 (ISO(a) 1996).

The fact that ISO 14001 is widely implemented and the core aspects of it are now well known within, and outside of, companies that have been certified means that implementation and auditing principles taken from ISO will be easily accepted when used for GHG management. These principles of course are only a guide and many other factors both economic and social (not least of which is politically driven regulation) must feed into a system that manages GHGs. Indeed ISO 14001 has been criticized for failing to embrace environmental performance disclosure, (Krut R. & Gleckman 1998) which is one of the central elements of GHG management at a national and corporate level (IPCC(a) 2000; WBCSD 2001; IPCC 2002; VCR(a) 2002; VCR(b) 2002).

Where ISO has proved a useful template to follow has been in the use of the concept of continual improvement, a conceptual framework for an evolving work in progress system such as that developing for GHG inventory development and management. It allows for the design and construction of a system that is meant to loop through continuous iterations of policy, planning, implementation and operation, checking and corrective action and management review (ISO(a) 1996; ISO(b) 1996; ISO(c) 1996; ISO(d) 1996; ISO(e) 1996).
Management options

The Canadian response to climate change, irrespective of whether the Kyoto Accord is ratified by Canada, is very likely to involve some system based upon an allocated amount of GHG emissions per sector, or company plus some measure of targeted command and control regulations (Canada (b) 2002) aimed at managing GHGs in specific “targeted” areas. The discussion on how allocations may be made and the specific targeted measures likely to be used is beyond the scope of this thesis and is part of the ongoing decision making process leading up to a decision on ratification. Regardless of the eventual regulatory system, it is beneficial to the natural gas industry to thoroughly document its greenhouse gas (GHG) emissions and all corresponding reductions in emissions. Quantitative analysis of emissions reductions may lead to opportunities for the industry to be a low-cost supplier of emissions reductions, or to ease the regulatory burden imposed. Development of emission reduction cost curves is a first in being able to develop a response to targeted measures and decide at what point along the curve a company decides to use economic responses such as emissions trading to manage its emissions liability. The United States natural gas industry is in a similar situation, as illustrated by the US EPA in figure 16. This chart shows a forecasted estimate of methane abatement at different monetary values of carbon. A chart for the Canadian gas industry should be similar.

Internal management decisions within companies will be framed by the development of cost curves similar to the US industry curve shown below (Figure 16). Emissions reduction opportunities that are below on or just above the curve, for a given current value of carbon (and also for a forecast future value of carbon) are most likely to be implemented within a company. Those emissions that are above the curve for a given value of carbon are likely not to implement if the company can indeed buy fully fungible carbon credits that equal the price of carbon at which the decision is made.
Two factors complicate this picture: The first being, all projects within a company must compete internally for capital and this internal rate of return may make realising projects that are at or even below the cost of carbon difficult to do. This may even be the case if the natural gas saved, for example through a leak detection and repair program, is equal or greater that the cost of the project implementation. This project is not likely to move ahead if it does not meet the company’s’ internal rate of return hurdle.

The second factor complicating the simplified cost curve decision-making process is cost recovery. So for a project such as the one used as an example above, it would be extremely difficult to move ahead if there is no cost recovery method for the business unit.
concerned. Cost recovery in the present Canadian utility model for natural gas companies only happens when the company owns the gas that it is transporting. This in effect means that traditionally natural gas distribution utilities have been more active in leak detection and repair programs than have transmission companies where cost recovery is generally not achievable.

**Develop mitigation options- Natural gas industry greenhouse gas emission reduction opportunities**

Having said all of the above, GHG reduction projects do make it through the internal hurdles and there are many examples of such projects (USEPA(b) 2002).

The basic list of project types that may impact the GHG emissions of a company include:

- Accelerated leak detection and repair (LDAR) programs. These are methane fugitive and vented reduction projects and are aimed at lowering leakage rates and reducing process related emissions. The USEPA natural gas star program details many such fugitive and vented emission reduction opportunities (USEPA 1999; USEPA(b) 2002).

- Improved Technology and efficiency opportunities. These are aimed at lowering the energy per unit of work thus lowering resultant emissions for any given volume of gas delivered. Many examples of energy efficiency initiatives can be found such as changing from older reciprocating engines to new turbine driven engines (USEPA 1999; Pembina 2002; USEPA(b) 2002).

- Geological sequestration. This is concerned with geologically sequestering GHG emissions from the natural gas industry. At present this technology is used for sequestering of acid gas stripped from raw gas during processing to sales gas. An
example of this is the Jedney II acid gas sequestration project in northern BC (DEGTC 2002).

The potential role for market mechanisms

A full discussion on the desirability and merits of using market mechanisms to manage GHG emissions is beyond the scope of this thesis. This discussion will be limited to the present known circumstances.

Three international market mechanisms are allowed under the Kyoto Protocol (UNFCCC 1992). These are the only allowed emissions trading schemes accepted under international rules:

- Emissions trading (ET) enables a country having surplus allowances to trade them to countries that need to meet their Kyoto commitment. This trading system is bi-directional meaning a country can export or import emissions allowances from any other signatory country.
- Kyoto Protocol Article 6. Joint Implementation (JI) which enables a country to trade project-based emissions reductions from signatory countries to the protocol to meet its Kyoto commitments. This trading scheme is bi-directional.
- Kyoto Protocol Article 12. Clean development mechanism (CDM), which enables a country to trade project-based emissions from (import) non-signatory countries to the protocol. This trading scheme is uni-directional that is credits can only flow from non-signatory countries to signatory countries.

The UNFCCC rules inter-country emissions trading schemes above are complemented by a developing suite of intra-country emissions trading schemes designed to lower the cost of GHG abatement as per the above discussion. These are meant to form a policy lever
that helps companies within a signatory country to make any necessary reductions to
meet regulatory goals in as cost effective manner as possible. Examples of this approach
are the UK emissions trading scheme (UK 2002) and the Canadian approach outlined in
the recent discussion paper from the federal government regarding climate change
management options for Canada (Canada (b) 2002). Some of these domestic emissions
trading schemes (DET) are more advanced in terms of rules setting than others. There
are at present no clearly understood or universally accepted mechanisms for linking DET
schemes with those allowed under UNFCCC rules. The one common thread that joins all
of the trading schemes is that all will require that there be credible and verifiable data
upon which trades (and liabilities) under the schemes are based.

Despite the uncertainty regarding how emissions trading schemes may work and what the
final rules may be many companies are engaging in pilot and grey market trades to both
establish experience in how to trade and to influence the development of the final suite of
rules and regulations that will govern trading schemes.

Some energy companies have a sophisticated system of integrating of market
mechanisms within their GHG management systems. Some companies in Canada are
very active in the purchase of emissions reductions. Nearly all of these companies are
large electrical generating utilities which face a many mega tonne liability from GHG
emissions. The natural gas sector in terms of GHG emissions is a “second” order source
but the body of knowledge developed by many of these emission-trading leaders is being
actively followed by many in the natural gas industry.

The main issues that come to the fore seem to be based around limiting the potential
down side risk of emissions trading (Lesiuk 2002). Below is a proposed hierarchical
system of approaching this issue.

Companies have to consider:
1. Whether market mechanism will form part of their active GHG management strategy.
   - If so does the company participate:
     - As a creator and seller of emissions reductions
     - As a buyer of emissions reductions
     - Both of the above

2. Which market mechanism may the company be willing to participate in:
   - Inter company emissions trading such as the proposed DET system from the Canadian Federal Government (Canada (b) 2002).
   - Joint implementation type projects
   - Clean development type projects, CDM and JI project are actively encouraged by the Canadian Government and the Department of Foreign Affairs and International Trade has a CDM and JI office dedicated to facilitating projects of this nature (DFAIT 2002).

3. What are the sectors that a company would consider using for the basis of emissions trading, this may be a wide net or often is limited to the area in which a company has expertise readily at hand to evaluate the project.
   - Industrial efficiency projects
   - Domestic efficiency projects
   - Renewable energy projects
   - Transportation projects
   - Biological sink projects
   - Geological sink projects
   - No preference, wide as possible

4. Is there a particular preference regarding geographical area or origin of projects?
   For many reasons a company may wish to avoid certain geographic areas, reasons
may be for social, political, economic instability in the region or as simple as the fact that the company has no experience in dealing in a particular region.

- Within the country that the company operates (Domestic emissions trading)
- Projects within Annex I countries (Joint Implementation)
- Projects within Non Annex I countries (Clean Development Mechanism)
- No preference,

If not covered by the above a company may wish to identify further constraints on areas and types of emissions projects that it may potentially engage in.
CHAPTER 7. RESULTS FOR RESEARCH QUESTION 1: GHG INVENTORY MONITORING AND VERIFICATION

What are the level of and type of GHG emissions monitored?

Measurement question 1. “How does your company monitor the greenhouse gas (GHG) emissions generated by its operations?”

Measurement question 2. “Which greenhouse gas emissions does your company monitor, CO₂, CH₄, N₂O, and/or SF₆?”

Of the five Canadian companies that responded, all calculate their GHG emissions based upon physical measurements where possible and industry accepted activity factor multiplied by emission factors (AF x EF) where not possible. Physical measurements were all for fuel gas related to combustion emissions and activity factors (multiplied by emission factors) where all related to fugitive emissions. All of these companies reported the three greenhouse gasses (CO₂, CH₄ and N₂O) that the natural gas industry typically emits. This is very much in line with the standard reporting procedures developed by the Canadian industry through cross company cooperation and liaison with Environment Canada (full set of GRI references).

The ten non-Canadian companies were more heterogeneous in the approaches taken, and the gasses accounted for. Of the ten companies that responded, two reported for all three gasses (CO₂ N₂O and CH₄), six reported for CO₂ and CH₄ only. The remaining two companies reported for CH₄ releases only and CO₂ releases only respectively. The gases reported are summarized in figure 17.

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Here fugitive is used in the UNFCCC sense, in that it incorporates leaks (usually termed fugitive within the industry) and vented (deliberate release of gas for operational or maintenance reasons) emissions.
Measurement question 2: Which greenhouse gas emissions does your company monitor?

Figure 17. GHG gasses reported by 5 Canadian & 10 non-Canadian natural gas companies

What are the legislative requirements to report GHGs?

Measurement question 3. "What is the legislative requirement [to report]?

Measurement Question 4 “Is your company in compliance with the legislative requirements?”

- Unknown
- Below compliance,
- In compliance,
- Above compliance
- Or well above Compliance?
Qualitative clarification to measurement question 4. “Please state the report or findings that support the above answer”

No Canadian or non-Canadian companies reported having to report or manage GHG emissions as a regulatory requirement and thus all companies reported that they exceeded or met legislative compliance requirements. This self evaluation points to the inventory and emission identification work carried out as being of a voluntary nature at present.

**What are the GHG calculation methodologies?**

**Measurement question 5.** “What is the specific methodological process your company uses to identify, calculate track and report emissions?”

**Measurement question 6.** Is this methodological process derived from:

- National / Sub-National government recommended practice (such as Government documents / templates/ software)
- Non Governmental Organisation recommended practice (such as NGO documents / templates/ software)
- Industry specific recommended practice (such as industry association documents / templates/ software)
- Other, please specify

Canadian companies stated that they follow Canadian natural gas industry best practice methodology to prepare their GHG inventory, that is they reported using industry specific recommended practice. The companies reported:

- Applying emission factors to natural gas system components
- That emission factors are derived from the most current source documents used throughout the Canadian natural gas industry. These documents include industry sponsored research (e.g. GTC Handbook for Estimating Methane Emissions from 64
Canadian Natural Gas Systems, 1998; GRI-GHG Calc, etc.; Government documents (e.g. US EPA Document AP-42) and Government/Private Sector Partnership Documents (Registration Guide, Canada's Climate Change, Voluntary Challenge & Registry Inc.) (GTC 1998; GRI 2000; USEPA(b) 2002; VCR(a) 2002; VCR(b) 2002)

- Discussing the interpretation and application of the industry guidance documents mentioned above within the industry in an attempt to maintain consistency of inventory development.
- A designated staff person who "owns" the emission calculation and reporting process.
- Company specific and industry wide third party audits of GHG calculation methods and reported results.

The methodological processes were reported as being derived from industry developed best practice sponsored by the CGA through GTC (GTC 1998), with reference to USA government, US EPA Document AP-42 sources and Canadian government sponsored sources (Voluntary Challenge and Registry Inc.) (USEPA(a) 2002; VCR(b) 2002). Two companies reported having some input in developing the calculation methodology with further input from non-governmental organisations.

The non-Canadian companies had a more diverse methodological approach. This was expected due to the range of differing GHGs reported (see figure 17). Figure 18 shows methodological approaches ranged from using national government recommended emission factors for all processes and GHG types with ongoing re-evaluation of methodology and results to a basic simulation model based upon pipe lengths and pressure that only generated an estimate for fugitive emissions. Four companies reported that the methodological approach was taken directly from government agencies; five reported using industry or company specific developed procedures and one company reported using methodologies taken from non-governmental organisations. Non-
Canadian companies offered no detailed elaboration on methods or procedures, such as the Canadian companies response.
Question 6. Is this methodological process derived from, please choose

Figure 18. The methodological processes used for calculating GHG emissions
What are the calculation & monitoring methods?

Measurement question 7. “How does your company monitor and report of GHG emissions?”

- Paper based.
- Spreadsheet monitoring and reporting (such as Excel)
- Data base monitoring and reporting (such as Access)
- Fully integrated with company purchase and financial management software (such as SAP).
- Other, please specify

Measurement question 8. “Is the monitoring and verification system web based; totally, partially or not at all?”

Canadian companies reported using spreadsheets as the primary calculation tool (4 respondents) with one respondent reporting using a database as the calculation tool. The information collection systems are paper or email based (with spreadsheet attachments) with one company reporting having a partially web based integrated reporting system.

A similar spread can be seen in Figure 19 for the non-Canadian companies with six reporting using spreadsheets alone, one paper based calculations only, one using a web based system fully integrated in to the companies financial and accounting software and two reported using a mix of spreadsheet, database and paper methods. Two companies reported having a fully integrated web based reporting system (one using spreadsheets and the other using the companies financial and accounting software), one company reported having the system partially web based and the remainder of non-Canadian companies reported having no web based reporting.
Measurement question 7. How does your company monitor and report of GHG emissions?

Figure 19. How companies monitor and report GHG emissions.
What public reporting occurs?

Measurement Question 9. “In what form are the GHG emissions reported in a publicly accessible manner?”

- Not reported Publicly
- Company Web site
- Government Web site
- NGO website
- Printed document
- Other please specify

Although not a prerequisite for the development of a comprehensive, accurate, transparent and verifiable inventory, public reporting is seen as a method by which companies are held somewhat to public account in their approaches to GHG calculation and management. Canada, the USA and Australia all have some form of voluntary reporting scheme that is either a general scheme such as the Voluntary Challenge and Registry (VCR(a) 2002; VCR(b) 2002) and the Australian Greenhouse Challenge (Australia 2002) which target large and small GHG emitters or a more targeted one such as the US EPA natural gas star Program (USEPA(b) 2002) which targets GHG emissions (specifically methane emissions) from the natural gas industry. All Canadian companies that answered the survey either report publicly on the VCR website (VCR(a) 2002) and / or in the company’s own web site.

Figure 20 shows that for non-Canadian firms seven companies stated that the company GHG inventories where publicly available either from government web sites (3 responses) company websites (6 responses) or as a paper base document (7 responses)\(^4\).

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\(^4\)These numbers reflect the fact that most companies that reported done so in variety of mediums.
Two non-Canadian companies explicitly stated that the company inventory was not available publicly in any medium.
Measurement question 9. In what form are the GHG emissions reported in a publicly accessible manner?

Figure 20. In what form are GHG emissions reported in a publicly accessible manner?
What third party verification audit and review occurs, and what are the references to developing international standards?

Measurement question 10. “Is the GHG monitoring and reporting subject to third party verification audit or review?”

- No Third Party verification
- Informally by company staff
- Formally by consulting company
- Formally by NGO
- Formally by Government Agency
- Other please specify

Measurement question 11. “Does this third party review refer to an established Environmental Management System audit framework such as ISO 14001? Please state the EMS audit framework used?”

In order for inventories to be deemed credible and, as a beginning point in the continual improvement process of good environmental management practice, independent third party audits are required. The extent to which companies, and industries, subject themselves to audit can be seen as a measure of willingness to be seen as both credible and open to the challenges of continual improvement.

All of the Canadian companies surveyed are participating in an audit by ICF (ICF 2002) of inventories across the Canadian Natural gas industry. This audit does reference the ISO 14001 Environment Health and Safety Management System standard as well as the ISO audit standards 14010, 14011 and 14012 (ISO(a) 1996; ISO(b) 1996; ISO(c) 1996; ISO(d) 1996; ISO(e) 1996).
Of the non-Canadian companies surveyed only one did not have some form of third party audit / review of company GHG inventories. Of the 9 that did have third party reviews consulting companies undertook two, one was conducted by a non-governmental organisation and six by either a government agency or a combination of government agency and consulting company. Two of the inventories reviewed by government agencies referenced ISO standards and one of the consultant reviews referenced ISO standards. These findings are summarised in figure 21.

All but one of the companies surveyed went through some form of external review although ISO standards were, overall, less influential in the non-Canadian group of companies surveyed.
How are GHGs emissions tracked?

Measurement question 13. “Does your company monitor and track specific actions and/or projects that reduce GHG emissions as part of the monitoring and reporting system?”

☐ Yes, our company monitors and tracks all specific actions that reduce GHG emissions. [Highest level of detail].
☐ Yes, our company monitors and tracks medium level actions that reduce GHG emissions (such as a compressor retrofit). [Medium high level of detail].
☐ Yes, our company monitors and tracks all specific very major actions that reduce GHG emissions (such as a major new facility). [Medium level of detail].
☐ No, our company does not monitor and track actions that reduce GHG emissions (i.e. reductions only show on system wide level). [Lowest level of detail].

The purpose of this section of the questionnaire was to gather information on the level of detail a company kept regarding changes in its operations that may effect GHG emissions. The responses were ranked to give a qualitative answer to the level of detail that a company went into regarding GHG inventory changes. With four possible answers, that went through from a major facility change, to a minor facility change (such as a compressor station retro fit), through to tracking all specific action, and no tracking of emissions reductions at all.

Figure 22 shows how all Canadian respondents, to differing extents, tracked actions that reduced GHG emissions. All five stated they tracked emission reductions from major facility changes, three stated that they tracked emissions reductions to a minor facility change level and one stated that they tracked all specific actions that reduced GHG emissions.

Two non-Canadian respondents reported that they do not track actions that reduce GHG emissions, one stated that only changes from major facilities are tracked, two stated that
they track changes to a minor facility level and five stated that they track all specific actions that result in GHG reductions.
Measurement question 13. Does your company monitor and track specific actions and/or projects that reduce GHG emissions as part of the monitoring and reporting system?

![Bar chart showing the response to the measurement question.](image)

- **Yes, our company monitors and tracks all specific actions that reduce GHG emissions**: 5 companies (Canadian: 3, non-Canadian: 2)
- **Yes, our company monitors and tracks all specific very major actions that reduce GHG emissions (such as a major new facility)**: 1 company (Canadian: 1, non-Canadian: 0)
- **Yes, our company monitors and tracks medium level actions that reduce GHG emissions (such as a compressor retrofit)**: 4 companies (Canadian: 3, non-Canadian: 1)
- **No, our company does not monitor and track actions that reduce GHG emissions**: 2 companies (Canadian: 1, non-Canadian: 1)

**Response**

Figure 22. Chart of level of detail a company tracks GHG emissions reductions.
Summary of chapter 7 results

The general pattern that emerges in this chapter is one of voluntary action accompanied by generally open reporting. Calculation monitoring and verification systems are seen to be at differing levels of methodological progression. There is evidence that the industry in general is listening to outside agencies and third party sources of information both for design of systems and for third party reviews of results. The influence of the ISO based international standards is reported by half of all respondents, although only one reported actually being certified regarding GHG systems. There is evidence that the majority of the industry is tracking GHG emissions reduction activities at least to a large project impact level, a necessary prerequisite for any emissions trading scheme.

The largest source of concern, in this author’s opinion, is the minority of companies (2) that report only calculating and reporting one of the two major GHGs emitted by the natural gas industry these being CO₂ and CH₄. Any natural gas company that does not account for its releases of CO₂ or CH₄ is significantly misrepresenting the true GHG impact of the company.
CHAPTER 8. RESULTS FOR RESEARCH QUESTION 2: GREENHOUSE GAS MANAGEMENT.

Is there integration of GHG monitoring systems with companies environmental management system?

Measurement question 12. “Is the GHG monitoring system integrated into a formal EMS framework within the company?”

- Yes, fully integrated into the company Environmental Management System
- Somewhat integrated into the company Environmental Management System
- No, it operates independently from the company Environmental Management System

This question assumes that all companies have in place an environmental management system (EMS). This assumption is valid for the both Canadian companies surveyed (personal communication EMS & GHG managers of Canadian companies\(^\text{15}\)) and the group of international companies surveyed (personal communication EMS & GHG managers & surveys of company websites\(^\text{16}\)).

Full integration into a company EMS leads to better co-ordination of GHG management throughout the company as EMS systems have links to all levels of operations including higher management input. Full integration also permits management of GHGs as part of a multi-pollutant approach rather than a stand-alone component of environmental management. Air emissions such as Nitrogen oxides are particularly suited to being linked with GHGs as part of a multi-pollutant approach.

\(^\text{15}\) Unfortunately this statement has to be accepted at face value, as giving the personal communication or website references would compromise the confidentiality of the questionnaire respondents.

\(^\text{16}\) Same as footnote 14.
Figure 23 shows that of the Canadian respondents four reported GHG monitoring as being somewhat integrated into the companies EMS with three companies pointing to this being part of a deepening integration process with a view to full integration in the near term. One company reported having GHG inventory and management issues as being separate from the company EMS.

Of non-Canadian respondents five reported that the GHG monitoring was fully integrated into the company EMS system, one company reported it being somewhat integrated (with no statement regarding whether this is a transition as per Canadian companies above), one company reported that there was no integration and one left this answer blank.
Measurement question 12. Is the GHG monitoring system integrated into a formal EMS framework within the company?

Figure 23. Extent of GHG monitoring system integration into respondent’s formal EHS framework.
What personnel are dedicated to managing GHG issues within a company?

Measurement question 14. “Are personnel dedicated to specifically managing GHG emissions issues within your company? What percentage of time does this person/s spend dealing with GHG related issues?”

(percentage range)
- 5%
- 6-25%
- 26-50%
- 51-75%
- 76-100%

(staff position /title)
- Corporate Executive
- Senior Corporate Manager
- Corporate Professional Analyst (or similar)
- Subsidiary Company Executive
- Subsidiary Company Manager
- Subsidiary Company Professional Analyst (or similar)
- None of the above - please describe position

Measurement question 15. “If not described above how is the monitoring and reporting system of GHG emissions managed within your company?”

- Outside consultants
- Spread of load across the company, (many staff doing a small amount)
- Mix of the two
- Other please specify

This section was designed to gain a measure of the time spent and seniority of staff used in dealing with GHG inventory & management issues. As can be seen from figure 24 there is a fairly wide spread of responses although there is a common response that higher
level of management on the whole are engaged in dealing with issue at least a portion of the time. This observation holds true for the non-Canadian companies where the pattern seen was one of high management / senior professionals at the corporate level dealing with the issue OR higher management / senior professionals within the subsidiary dealing with the issue. This would seem to point to GHG inventory and management issues as being a significant concern for the companies who responded (excepting perhaps the three respondents that left this section blank). Three Canadian companies responded that they used a mix of internal resources and outside consultants. Two left this question field blank as it was an optional field if the field regarding percentage of management time did not adequately describe how the company’s approach. Three non-Canadian companies reported the same, four reported using a spread of load internally across companies to deal with GHG inventory and management and one reported using outside consultants alone.
<table>
<thead>
<tr>
<th>Designation</th>
<th>&lt;5%</th>
<th>6-25%</th>
<th>26-50%</th>
<th>51-75%</th>
<th>76-100%</th>
<th>total</th>
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<td>3</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>Senior Corporate Manager</td>
<td>1</td>
<td>3</td>
<td></td>
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<td></td>
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<td>Corporate Professional Analyst or similar</td>
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<td>1</td>
<td>2</td>
<td></td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>Subsidiary Company Executive</td>
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<td>Senior Corporate Manager</td>
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<td>Corporate Professional Analyst or similar</td>
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<td></td>
<td>5</td>
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<tr>
<td>Subsidiary Company Professional Analyst or similar</td>
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<td>5</td>
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<tr>
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Figure 24. Comparison of responses of designated staff time resources to GHG inventory and management issues.
Does a company have a greenhouse gas emissions reduction target?

Measurement question 16. “What is your company elective GHG emissions reductions target?”

☐ The target is, please specify dates and amount and type of elective reduction (e.g. $X$ absolute tonnes below, or $Y$ % below a given date baseline).

☐ We are actively developing a target with expectation of an announcement in (please state date).

☐ We do not have a company elective GHG reduction target.

Measurement question 17. “What baseline year does your company as reference point for targets?”

This section was designed to gain insight into whether or not companies are actively setting (and presumably) pursuing emissions reductions targets as part of their GHG management strategy. This can be seen as a measure of how proactive companies are in dealing with this issue prior to there being a legislative requirement to act.

Three Canadian respondents reported having company emissions reduction targets and two reported being actively considering targets. All Canadian companies reported using 1990 as the baseline for targets. Figure 25 shows the three reported reduction targets for Canadian companies.

<table>
<thead>
<tr>
<th>Target Metric</th>
<th>Baseline yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absolute emissions to be 3% below 1990 levels by 2005</td>
<td>1990</td>
</tr>
<tr>
<td>Absolute emissions and emissions intensity to be 75% of 1990 levels (no target date given)</td>
<td>1990</td>
</tr>
<tr>
<td>Bringing absolute emissions down to 1990 levels (no target date given)</td>
<td>1990</td>
</tr>
</tbody>
</table>

Figure 25. Canadian companies target metric against baseline year
Six non-Canadian companies reported having set GHG emissions reduction targets and four stated that they had no set emissions reduction targets. Figure 26 shows the six reported reduction targets for non-Canadian companies.

<table>
<thead>
<tr>
<th>Target metric</th>
<th>Baseline year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emissions intensity reductions (emissions per unit of throughput) of 25%</td>
<td>1998</td>
</tr>
<tr>
<td>between 1998 and 2010 (expressed as a reduction from 25g CO₂e. m⁻³ to 19g</td>
<td></td>
</tr>
<tr>
<td>CO₂e. m⁻³)</td>
<td></td>
</tr>
<tr>
<td>Reductions of 1.5 million tonnes CO₂e below business as usual in 2010</td>
<td>2010 BAU²⁷</td>
</tr>
<tr>
<td>(estimated as a 15% reduction in absolute emissions)</td>
<td>as reference case</td>
</tr>
<tr>
<td>Reductions in absolute emissions to 6% below 1990 levels by 2010</td>
<td>1990</td>
</tr>
<tr>
<td>A reduction in emissions per unit of throughput (no metrics or target year</td>
<td>1990</td>
</tr>
<tr>
<td>given)</td>
<td></td>
</tr>
<tr>
<td>Methane emissions target for 2002 to be 0.008% of transmission volume</td>
<td>1996-2000 five year rolling average²⁸</td>
</tr>
<tr>
<td>(emissions intensity target), (no metric’s of percentage reduction given)</td>
<td></td>
</tr>
<tr>
<td>Reductions in emissions intensity (emissions per unit of throughput) of 1%</td>
<td>1990²⁹</td>
</tr>
<tr>
<td>per year between 2001- 2006. This respondent also reported a demand side</td>
<td></td>
</tr>
<tr>
<td>management target of 5Mt CO₂e for 2005 and 7 Mt CO₂e in 2010.</td>
<td></td>
</tr>
</tbody>
</table>
terms of percentage absolute emissions reductions compared to absolute emissions reductions in 1990 (UNFCCC 1992) with differing percentage reductions for each country. Therefore, only companies whose targets are based upon an absolute target will be able to fit easily within countries frameworks designed to reduce emissions on an absolute basis. Emissions per unit of throughput targets are a useful indicator of increasing industrial efficiency but are much less easy to incorporate within a national reduction plan as increases in delivered volumes can easily overwhelm the absolute impact of intensity reductions.

What formal management system for lowering emissions is in place?

Measurement question 18. “What formal GHG management system does your company have in place for lowering emissions? Please describe”

This section aimed at gathering information on particular formal management strategies that a company has in place for lowering GHG emissions. Only one Canadian company answered this section with reference to management systems aimed at enabling emissions reductions, one pointed to a formal bi-weekly meeting of senior professionals aimed at identifying and planning for internally generated and offset based GHG reduction opportunities. All other companies referred to the links with the company EMS system but pointed to no additional management process targeted at enabling reductions.

Three non-Canadian companies stated that they had no formal management system aimed at lowering emissions. Two answered in way that did not really address the question and are best viewed as having no formal management system in place. Three companies replied that they had an ISO 14001 based management system in place, with two of these stating that this had been certified as such. Two companies reported having a continuous improvement process in place to monitor reductions and feed back results into operations. 

confusion regarding the question or the target may be a staged response with the emissions
What use is there of flexibility (market) instruments?

Measurement question 19. “How does this management system include active consideration of market mechanisms\(^{20}\) to manage GHG levels? Please describe

Measurement question 20. "Which flexibility mechanisms is your company considering?\(^{21}\)"

- Inter company emissions trading
- Joint implementation type projects
- Clean development type projects

Measurement question 21. “Will your company likely participate in flexibility mechanisms as a:”

- As a creator and seller of emissions reductions
- As a buyer of emissions reductions
- Both of the above

Measurement question 22. “Does your company have a publicly stated preference towards particular project classifications?” (e.g., geological sinks, energy efficiency projects, biological sinks)

- Industrial efficiency projects
- Domestic efficiency projects
- Renewable energy projects

---

\(^{20}\) Greenhouse gases affect the atmosphere on a global level - the location of their source is not relevant. International climate policy makers, however, face the dilemma that only OECD and Eastern European countries have committed to quantitative emission targets in the Kyoto Protocol, whereas developing countries, with prevailing high emission intensities and low abatement costs, have not accepted these targets. Therefore, the Protocol established two project-based mechanisms to promote the implementation of reduction opportunities in developing countries: the Clean Development Mechanism (CDM) and Joint Implementation (JI). Together with international emissions trading, these represent the three Kyoto “flexibility mechanisms”. Clean Development Mechanism applies to emission reduction projects undertaken between Annex I and non-Annex I countries. Joint Implementation applies to emission reduction projects undertaken between Annex I countries (Oberthür & Ott 1999) (Jepma & Munasinge 1998)
Transportation projects
• Biological sink projects
• Geological sink projects
• No preference

Measurement question 23. “Does your company have a particular preference regarding geographical area?”

• Within the country that the company operates (Domestic emissions trading)
• Projects within Annex I countries (Joint Implementation)
• Projects within Non Annex I countries (Clean Development Mechanism)
• No preference
• Other please specify

Measurement question 24. “Does your company have any other constraints regarding provenance of emission reductions? If so please describe briefly below.”

The use of flexibility instruments allows Annex I countries and entities operating within them to take advantage of lower GHG emissions reduction opportunities outside of the Annex I country boundaries (Oberthür S. & Ott H.E. 1999).

No Canadian and one non-Canadian company respondent reported having a formal management system in place that stated Kyoto market mechanisms were actively considered as part of this management process. This points to the answers to this section as being mainly an ad hoc response to the use of Kyoto market mechanisms and of these mechanisms, not being fully incorporated in to the planning and management processes of all but one company that responded.

Intra company emissions trading was not included as an option, this was an oversight by the author.
The responses stated in this section do indicate that there has been some active consideration of how market mechanisms will play a part in a company's management response, even though overall they are not formally integrated into management plans. The lack of formal integration is not surprising given the high uncertainties surrounding the final rules of engagement for emissions trading schemes.

![Image]

**Figure 27. Response to use of flexibility (market) instruments.**

Figure 27 shows the response to the use (as a buyer, seller, or both) of market type instruments in order to manage GHG emissions within a company. Four out of five Canadian and six out of ten non-Canadian companies answered this question. Of interest is that only two Canadian companies self-assessed themselves as buyers only in an emissions trading system, all other respondents assessed their participation as likely being buyers and sellers in an emissions trading system. These companies either view their systems as being able to move through credit and deficit styles in emissions levels or they view the use of an emissions trading regime as a means to buy (or create) low, hold and
sell high in the traditional market manner, most likely given the sophisticated gas spot market trading capabilities of many natural gas companies it is the latter.

Figure 28 shows preferences regarding which type of project a company considered the most useful. Two non-Canadian companies left this field blank; all others answered. The responses were normalised to give each response a total weight of 1 across the entire chart. Meaning that if a company answered to two categories the answers were 0.5 each and if three 0.33 each. This gives cumulative totals for the entire chart of 5 responses for Canadian and 8 responses for non-Canadian companies. The chart shows a spread of detailed preferences from Canadian companies with non-Canadian companies having, with two exceptions no preference.
Does your company have a publicly stated preference towards particular project classifications?

- Canadian
- Non Canadian

![Bar chart showing preferences for different project classifications.]

Figure 28. Response to preferences within projects underpinning market mechanisms
Does your company have a particular preference regarding geographical area?

Figure 29. Response to preference of geographical area of origin for projects that underpin market mechanisms.
Figure 29 shows the emissions reduction projects geographic provenance of origin preferences for respondents. Here there is a marked difference in response with the majority of Canadian respondents wanting projects located within the country in which a company may operate and the majority of non-Canadian companies having no preference as to the location of origin.

One Canadian and one non-Canadian company responded that they had additional constraints regarding provenance of origin of emissions reduction projects. The Canadian company responding pointed to a preference for projects to be reviewed through current Canadian GHG validation processes such as GERT (GERT 2002) or PERT (now clean air Canada) (CAC 2002). The non-Canadian company pointed to a requirement for projects to be sustainable in all other aspects. This reflects the requirement under article 12 of the Kyoto Protocol for all CDM projects to contribute to the host countries sustainable development goals (UNFCCC 1992).

What innovative GHG management methods are there?

Measurement question 25. “Does your company have any innovative or creative ways of coping with GHG which has not been dealt with so far in this survey?”

The list of measures here was mentioned by Canadian and non-Canadian companies.

- Geological sequestration of CO2 from processing emissions, here the reported emissions reductions ranged from 2,000 tonnes to over 1 million tonnes per year.

- Accelerated Leak detection and repair programs (LDAR), using ultrasonic, high-flow, and other measurement devices to accurately measure methane leaks at facilities enabling a full cost benefit analysis to be carried out. This enables the company to effectively target the largest leaking components at the lowest cost.

22 The respondents emphasis as laid out in the questionnaire returns.
• Vent gas collection system for compressor dry gas seals, referencing IGU (2002)

• Innovative procedures for reducing losses from low pressure lines

• Investments in collection and utilisation of landfill gas.

What are the identified major risks of non-compliance with GHG policy?

Measurement question 26. "What major risks of not complying with GHG policies has your company identified?"

Three Canadian companies and 7 non-Canadian companies identified the regulation of GHG emissions as the primary risk. Three companies (1 Canadian 2 non Canadian) pointed to public perceptions as being a risk factor

Participant Comments.

Measurement question 27 Participant comments. If you have comments not covered by the questions above please note them below.

Two respondents answered this section, however comments were framed in manner that would identify the companies concerned and so the comments are not published here.
Summary of chapter 8 results

Differences in approach regarding integration of GHG monitoring systems can be seen, with Canadian companies seeming to have less of an integrated approach than non-Canadian. Resources allocated to the management of GHG would seem broadly similar pointing to equal levels of effort regardless of the management systems in place. Wide variation can be seen in baseline approaches, nor surprisingly given the lack of policy direction on this issue.

Only one company had a formal system for integrating market mechanisms in place for using market mechanisms to manage GHGs, although the responses regarding details of GHG trading point to the implications behind market mechanisms being given active consideration by the majority of respondents. Canadian companies answered in more detail on the market mechanism questions with non-Canadian companies more often favouring the no preference options.

Companies listed many known active internal management methods of reducing GHG emissions.

Perhaps unsurprisingly the main risk factor identified was of regulation of GHG within the industry.
CHAPTER 9. RESULTS FOR RESEARCH QUESTION 3: A COMPARATIVE ANALYSIS

**GHG calculation, monitoring and verification.**

Looking at Figure 30 and 31 the following can be seen regarding GHG inventory development, monitoring and verification. Figure 31 shows the non-weighted responses for GHG monitoring and verification. With no weightings attached this figure is essentially a census of which questions a company answered on the questionnaire and not of how the response acts as an indicator regarding GHG monitoring, verification or management. Figure 32 represents the answers with the weightings derived from interviews with Environment Canada senior staff dealing with climate change monitoring verification and management issues at a national and international level (Boileau 2002).

With a maximum possible weighted score of 56 all but three (both non Canadian companies) ranked higher than 60% of the highest possible mark, (Figure 32). The spread of results was wider in the non-Canadian group; this is probably not surprising given the different regulatory regimes that they operate under. The most interesting point to note between the two groups is that the average scores were very close, 37 for Canadian and 35 for non Canadian, and if the two outliers represented by companies 6 and 12 are discounted then there is good alignment between the GHG inventory development, monitoring and verification procedures of the two groups.

Figure 33 shows that when ranked in terms of overall score Canadian companies occupy a space that can be termed the upper middle segment of the continuum of scores with the highest three scoring companies were non-Canadian as were the lowest four. This implies that for this data set the two groups are probably comparable in terms of basic inventory calculation, monitoring, and verification.
Non-weighted GHG inventory, monitoring & verification scores by respondent

Figure 30. Chart of non-weighted GHG inventory, monitoring & verification scores by respondent
Weighted GHG inventory, Monitoring & Verification scores by respondent

Figure 31. Chart of weighted GHG inventory, monitoring & verification scores by respondent.
<table>
<thead>
<tr>
<th></th>
<th>Canadian</th>
<th>Non Canadian Companies</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Company 1</td>
<td>Company 2</td>
</tr>
<tr>
<td>GHG inventory, monitoring &amp; verification percentage score</td>
<td>68%</td>
<td>63%</td>
</tr>
<tr>
<td>GHG management percentage score</td>
<td>66%</td>
<td>63%</td>
</tr>
<tr>
<td>Total percentage score</td>
<td>67%</td>
<td>63%</td>
</tr>
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</table>

Figure 32. Table of percentage weighted score of possible maximum
Figure 33. Ranking of GHG calculation monitoring and verification scores for all respondents. Solid shading represents Canadian companies, maximum score possible = 56.
GHG Management

As per the above section on inventory calculation, monitoring and verification this section compares the un-weighted against weighted respondent scores. Figure 34 shows the non-weighted responses for GHG management, with no weightings attached this figure is essentially a census of which questions a company answered on the questionnaire and not of how the response acts as an indicator regarding GHG monitoring, verification or management. Figure 35 represents the answers with the weightings derived from interviews with Environment Canada senior staff dealing with climate change monitoring verification and management issues at a national and international level (Boileau 2002).

Figure 34 shows the unranked scores with an average score of six for all companies, although the spread of scores was higher for non-Canadian companies.

Looking at figure 35, on the ranked score, with a maximum possible weighted score of 34 Canadian companies averaged 23 and non-Canadian companies averaged 18. Non-Canadian companies had a wider spread of response scores ranging from 2 up to 29 (the highest overall score)
Figure 34. Chart of non weighted management score
Solid shading represents Canadian companies, maximum score possible = 8
Weighted GHG Management scores by respondent

Figure 35. Chart of weighted management score
Solid shading represents Canadian companies, maximum score possible = 56.
Figure 36. Ranking of weighted GHG management scores for all companies. Solid shading represents Canadian companies, maximum score possible = 34
Figure 36 shows that when ranked in terms of overall score Canadian companies occupy the middle segment of the continuum of scores with the two highest scoring companies being non-Canadian as were the lowest five.

This seems to imply that for this data set the two groups are comparable in terms of management practices.

**Comparison of total scores**

Figures 37, and 38 below show the un-weighted and weighted scores of the respondents.

Figure 37 shows that non-weighted total scores were 21 for Canadian companies and 19 for non-Canadian companies.

Figure 38 shows the weighted scores, which show an average of 60 for Canadian companies and 54 for non-Canadian companies. With non Canadian companies exhibiting a wider spread of scores around the average value.
Figure 37. Chart of unweighted total score
Solid shading represents Canadian companies, maximum score possible = 30
Figure 38. Weighted total score
Solid shading represents Canadian companies, maximum score possible = 56.
Figure 39 shows all weighted scores ranked. This chart clearly shows that apart from two low scoring and one high scoring outliers, all companies occupy a range between 54 and 65 out of a possible score of 90, with Canadian companies again occupying mid to high levels in the scoring. This narrow range of overall scores (outliers apart) points to the strong likelihood that the various GHG calculation, monitoring, verification and management systems polled here are in all major aspects comparable.
Figure 39: Ranking of total weighted scores for all companies. Solid shading represents Canadian companies, maximum score possible = 90.
Summary of chapter 9 results

For the data set contained in this thesis Canadian companies are broadly comparable to the non-Canadian firms in GHG calculation, monitoring verification and management terms, averages are broadly comparable for all weightings and when ranked Canadian companies occupy central to high (although not top) positions on the continuum of scores.

The wider spread of scores for non-Canadian companies is not surprising given the different regulatory systems and cultural setting in which the different companies operate.
CHAPTER 10. DISCUSSION AND CONCLUSION

The Canadian respondents represent over half of all Canadian natural gas companies and approximately 40-50% of natural gas deliveries in Canada. The response from non-Canadian companies was much lower. Of the 60 plus companies approached for responses ten sent completed questionnaires back. In particular, there was a very poor response rate from companies operating in the USA, with only one completed response. The Canadian responses could be considered a representative sample of how the issue is managed in Canada; however, this cannot be said of the non-Canadian companies. Due to this no statistically valid conclusions can be drawn. Despite this drawback, a qualitative sense of how the issue of GHG inventory and management of the resultant business risk has been gained.

Referring to the Cooper and Emory (1995) research processes diagram in Appendix 3 this thesis could perhaps be usefully looked on as a detailed pilot study that establishes whether or not a wider and deeper piece of research is practical and would result in useful results. Although not statistically valid, it would appear that there is a case for a wider more statistically valid study to investigate the questions posed and analysed here.

Research question 1 and 2 do shed interesting light on the spectrum of approaches regarding GHG management and what some of the key similarities and differences are. Research question 3 was aimed at establishing whether the various systems in place could indeed be compared and the initial results are encouraging that the various systems are comparable and may be able in time to become useful baseline and accounting frameworks. These frameworks are then tied into the inventory discussions surrounding the international UNFCCC discussions and the nascent international market for GHG credits and or emission offsets. The results point to Canadian companies being mid to high in the total rankings, and achieve a higher average through being fairly consistent and high scoring. Of note is the fact that in the calculation, monitoring and verification section the three highest scores were achieved by non-Canadian companies (Figure 32).
The average for this section was lower due to two very scoring outliers. This is an interesting finding and will be of interest to Canadian natural gas companies and Canadian industry associations representing natural gas companies who have been championing Canadian natural gas companies as “world leaders’ in the field. These results point to Canadian companies being among the top tier in the world although perhaps not actually leading the field. All of the above of course is framed with the caveat that due to the small non-Canadian company sample size these are not statistically valid comparisons. However, as a qualitative “pilot” finding it is interesting.

Canadian companies do seem to rank higher than non Canadian companies when it comes to GHG management issues, most of this difference comes from stated responses and attitudes towards international market mechanisms for dealing with GHG emissions. Although when two extremely low ranking outliers are removed this is not the case. When viewed as part of the continuum of rankings Canadian companies are very much in the middle ground of the spectrum.

If one was to recommend a general strategy for a newly formed natural gas company regarding recommendations on how to calculate, monitor, verify and manage GHG emissions emanating from its operations then the following would be the key points.

1. Construct an inventory: follow the six key principles of inventory development outlined in this thesis. These being; Completeness, Consistency, Accuracy, Transparency, Verifiability and Relevance.

2. Recognise that inventories are “works in progress”. Set a system in place that reviews and revises them, as new information is made available. ISO 14000 continuous improvement type procedures are an example of this.

3. Develop a system for identifying and costing GHG reduction opportunities within the company. Knowing the cost curves behind a system will enable a clear
understanding of when to manage GHGs internally and when to enter the nascent GHG credit market and purchase reductions.

The overarching risk facing companies regarding climate change would seem to be one of regulatory policies designed to lower annex B and I countries’ GHG emissions and how these will potentially impact the companies’ operations.

The comparative analysis does show in a qualitative manner that for this data set the GHG calculation monitoring, verification and management systems of the companies polled in this thesis are comparable. This would seem encouraging for international efforts such as the WBCSD protocol initiative (WBCSD 2001) and ISO (ISO(a) 1996; ISO(b) 1996; ISO(c) 1996; ISO(d) 1996; ISO(e) 1996) process that aim to more fully standardise inventory and management related processes across countries and economic sectors.

**Conclusion**

No statistically valid conclusions can be drawn from this thesis due to the small non-representative sample (related to poor survey response) size of the non-Canadian companies. Certain qualitative statements can be made regarding the results and if viewed as a pilot study then these could form the basis of a more comprehensive statistically valid research study.

Based upon the results of this thesis the following qualitative statements can be made: Canadian companies seem on average slightly better in terms of calculation monitoring and verification than non-Canadian companies, although when looked at as a continuum (Figure 33) this is less apparent. There is much common ground between the GHG
calculations, monitoring, verification and management systems analysed in this thesis. Some significant differences do exist between and within Canadian and non-Canadian systems. However overall the systems can be considered comparable in a broad sense. A larger study with a statistically valid sample will be necessary for this conclusion to be verified.

The overall comparison points to Canadian companies appearing to sit comfortably in the continuum of score rankings and thus would seem to be using comparable systems. This is a useful finding and bodes well for international efforts to standardise approaches across countries and industrial sectors.

Recommendations

A process for developing the larger study above and for developing a common framework for GHG emissions calculation, monitoring, verification and management should be considered as a useful approach to addressing the inconsistencies documented in this thesis. This process would benefit greatly from having a prior agreement or covenant of co-operation in place that would ensure the statistical comparability of the survey results.

This would appear to be a role suited to an Industry association such as International Gas Union in conjunction with the developing standards processes at the World Business Council on Sustainable Development and / or the International Organisation for Standardisation.


BIBLIOGRAPHY


CAPP (2002). Canadian Oil and Gas Production Basin Map, Canadian Association of Petroleum Producers, Calgary, Canada.


UOGWG (1999). "Upstream Oil and Gas Industry Options Paper Report of The Upstream Oil and Gas Working Group of The Industry Issues Table to The National Climate Change Secretariat." Upstream Oil and Gas Working


APPENDIX 1. THE QUESTIONNAIRE


Rationale

GHG management presents a challenge to the natural gas industry. International agreements on Climate change such as the Kyoto Protocol are likely to mean increased political pressure for natural gas companies to both develop defensible GHG inventories and to manage (i.e. reduce) the emissions identified. Actions to reduce GHGs globally and within individual countries also represent a significant opportunity for natural gas companies, as natural gas is the least GHG intensive fuel on a per unit of energy basis. Fuel switching from other higher carbon fuels can be seen as part of a balanced approach to GHG reductions. Any increases in production will be accompanied by increases in the GHG emissions associated with the production, processing and transportation of natural gas. The evidence indicates that the overall result may be beneficial in terms of GHG emissions and the release of criteria air contaminants (CAC) if natural gas is used in place of other fossil fuels. Natural gas has significantly lower GHG emissions than other fossil fuels, due to a high Hydrogen (H) to Carbon (C) ratio (high in comparison to fossil fuels such as oil or coal). Nitrogen oxides (NOx), the only CAC of concern, can be significantly lowered through low NOx combustion technologies.

The companies involved in the industry, however, do not usually directly see these benefits in their GHG inventories as the benefit is located at the point of combustion (i.e. the end customer). Consequently companies must try and manage an increasing GHG inventory in a time when there is pressure to lower GHG emissions.

The confluence of higher emissions in an expanding market and the pressure to reduce emissions, creates the need for a robust GHG management system that is able to clearly monitor and report emissions in a verifiable manner and offer mitigation solutions through techniques to reduce absolute emission levels and to offset emissions through the potential for market based mechanisms.

To develop a “snapshot” of the management of GHG in the natural gas industry worldwide a comparative analysis based upon the questionnaire below is proposed.

Westcoast Energy Inc. of Vancouver B.C., Canada has agreed to act a sponsor for this study. Westcoast is the second largest natural gas company in Canada and has subsidiaries in all parts of the industry, and this study will therefore have access to representative samples of all aspects of the industry’s constituent parts nationally. The Canadian Natural Gas Association (CGA) and the International Gas Union (IGU) also have agreed to support this work through direct polling of their members.
In keeping with the University of British Columbia strict ethical guidelines in studies of this type, all results will kept confidential by the author and only aggregated findings will published in the final paper.

Please fill in the attached questionnaire and email or fax directly to:

Tony Irwin  
Masters Degree Candidate,  
Resource Management and Environmental Science,  
University of British Columbia,  
C/O 3536 10th Avenue W.,  
Vancouver BC,  
V6R 2G1

Tel: (604) 738 1289  
Fax: (604) 738 2956  
Email: tony@irmc.net
Benchmarking Questionnaire

Greenhouse Gas Monitoring and Verification

1. How does your company monitor the greenhouse gas (GHG) emissions generated by its operations?

2. Which greenhouse gas emissions does your company monitor?

<table>
<thead>
<tr>
<th>Please tick</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon Dioxide (CO₂)</td>
</tr>
<tr>
<td>Methane (CH₄)</td>
</tr>
<tr>
<td>Nitrous Oxide (N₂O)</td>
</tr>
<tr>
<td>Sulphur Hexafluoride (SF₆)</td>
</tr>
<tr>
<td>Other please specify</td>
</tr>
</tbody>
</table>

3. What is the legislative requirement?

4. Is your company in compliance with the legislative requirements?

<table>
<thead>
<tr>
<th>Please tick</th>
<th>Below compliance</th>
<th>In compliance</th>
<th>Above compliance</th>
<th>Well above Compliance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unknown</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Please state the report or findings that support the above answer

5. What is the specific methodological process your company uses to identify, calculate track and report emissions?
6. Is this methodological process derived from

<table>
<thead>
<tr>
<th>Please tick</th>
</tr>
</thead>
<tbody>
<tr>
<td>National / Sub- National government recommended practice (such as Government documents / templates/ software)</td>
</tr>
<tr>
<td>Non Governmental Organisation recommended practice (such NGO documents / templates/ software)</td>
</tr>
<tr>
<td>Industry specific recommended practice (such as industry association documents / templates/ software)</td>
</tr>
<tr>
<td>Other, please specify</td>
</tr>
</tbody>
</table>

7. How does your company monitor and report of GHG emissions?

<table>
<thead>
<tr>
<th>Please tick</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paper based</td>
</tr>
<tr>
<td>Spreadsheet monitoring and reporting (such as Excel)</td>
</tr>
<tr>
<td>Data base monitoring and reporting (such as Access)</td>
</tr>
<tr>
<td>Fully integrated with company purchase and financial management software (such as SAP)</td>
</tr>
<tr>
<td>Other, please specify</td>
</tr>
</tbody>
</table>

8. Is the monitoring and verification system web based?

<table>
<thead>
<tr>
<th>Please tick</th>
</tr>
</thead>
<tbody>
<tr>
<td>Totally</td>
</tr>
<tr>
<td>Partially</td>
</tr>
<tr>
<td>Not at all</td>
</tr>
</tbody>
</table>
9. In what form are the GHG emissions reported in a publicly accessible manner?

<table>
<thead>
<tr>
<th>Please tick</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not reported Publicly</td>
</tr>
<tr>
<td>Company Web site</td>
</tr>
<tr>
<td>Government Web site</td>
</tr>
<tr>
<td>NGO website</td>
</tr>
<tr>
<td>Printed document</td>
</tr>
<tr>
<td>Other please specify</td>
</tr>
</tbody>
</table>

10. Is the GHG monitoring and reporting subject to third party verification audit or review?

<table>
<thead>
<tr>
<th>Please tick</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Third Party verification</td>
</tr>
<tr>
<td>Informally by company staff</td>
</tr>
<tr>
<td>Formally by consulting company</td>
</tr>
<tr>
<td>Formally by NGO</td>
</tr>
<tr>
<td>Formally by Government Agency</td>
</tr>
<tr>
<td>Other please specify</td>
</tr>
</tbody>
</table>

11. Does this third party review refer to an established Environmental Management System audit framework such as ISO 14001? Please state the EMS audit framework used.

12. Is the GHG monitoring system integrated into a formal EMS framework within the company?

<p>| |</p>
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes, fully integrated into our Environmental Management System</td>
</tr>
<tr>
<td>Somewhat integrated in to Environmental Management System</td>
</tr>
<tr>
<td>No, it operates independently from the company Environmental Management System</td>
</tr>
</tbody>
</table>
13. Does your company monitor and track specific actions and /or projects that reduce GHG emissions as part of the monitoring and reporting system?

| Yes, our company monitors and tracks all specific actions that reduce GHG emissions |
| Yes, our company monitors and tracks all specific very major actions that reduce GHG emissions (such as a major new facility) |
| Yes, our company monitors and tracks medium level actions that reduce GHG emissions (such as a compressor retrofit) |
| No, our company does not monitor and track actions that reduce GHG emissions |

14. Are personnel dedicated to specifically managing GHG emissions issues within your company? What percentage of time does this person/s spend dealing with GHG related issues?

- P5%
- 6-25%
- 26-50%
- 51-75%
- 76-100%

<table>
<thead>
<tr>
<th>Percentage of Time Spent on GHG management</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Corporate Executive</td>
</tr>
<tr>
<td></td>
<td>Senior Corporate Manager</td>
</tr>
<tr>
<td></td>
<td>Corporate Professional Analyst (or similar)</td>
</tr>
<tr>
<td></td>
<td>Subsidiary Company Executive</td>
</tr>
<tr>
<td></td>
<td>Subsidiary Company Manager</td>
</tr>
<tr>
<td></td>
<td>Subsidiary Company Professional Analyst (or similar)</td>
</tr>
<tr>
<td></td>
<td>None of the above – please describe position</td>
</tr>
</tbody>
</table>

15. If not described above how is the monitoring and reporting system of GHG emissions managed within your company?

| Outside consultants |
| Spread of load across the company, (many staff doing a small amount) |
| Mix of the two |
| Other please specify |
GHG Management

16. What is your company elective GHG emissions reductions target?

<table>
<thead>
<tr>
<th>The target is, please specify dates and amount and type of elective reduction (e.g. X absolute tonnes below, or Y % below a given date baseline)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>We are actively developing a target with expectation of an announcement in (please state date)</td>
<td></td>
</tr>
<tr>
<td>We do not have a company elective GHG reduction target</td>
<td></td>
</tr>
</tbody>
</table>

17. What baseline year does your company as reference point for targets?

18. What formal GHG management system does your company have in place for lowering emissions? Please describe

19. How does this management system include active consideration of market mechanisms to manage GHG levels? Please describe
Greenhouse gases affect the atmosphere on a global level - the location of their source is not relevant. International climate policy makers, however, face the dilemma that only OECD and Eastern European countries have committed to quantitative emission targets in the Kyoto Protocol, whereas developing countries, with prevailing high emission intensities and low abatement costs, have not accepted these targets. Therefore, the Protocol established two project-based mechanisms to promote the implementation of reduction opportunities in developing countries: the Clean Development Mechanism\(^{23}\) (CDM) and Joint Implementation\(^{24}\) (JI). Together with international emissions trading, these represent the three Kyoto "flexibility mechanisms".

20. Which flexibility mechanisms is your company considering?

<table>
<thead>
<tr>
<th>Mechanism</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inter company emissions trading</td>
</tr>
<tr>
<td>Joint implementation type projects</td>
</tr>
<tr>
<td>Clean development type projects</td>
</tr>
</tbody>
</table>

21. Will your company likely participate in flexibility mechanisms as a:

<table>
<thead>
<tr>
<th>Participation</th>
</tr>
</thead>
<tbody>
<tr>
<td>As a creator and seller of emissions reductions</td>
</tr>
<tr>
<td>As a buyer of emissions reductions</td>
</tr>
<tr>
<td>Both of the above</td>
</tr>
</tbody>
</table>

22. Does your company have a publicly stated preference towards particular project classifications? (e.g., geological sinks, energy efficiency projects, biological sinks)

<table>
<thead>
<tr>
<th>Project Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industrial efficiency projects</td>
</tr>
<tr>
<td>Domestic efficiency projects</td>
</tr>
<tr>
<td>Renewable energy projects</td>
</tr>
<tr>
<td>Transportation projects</td>
</tr>
<tr>
<td>Biological sink projects</td>
</tr>
<tr>
<td>Geological sink projects</td>
</tr>
<tr>
<td>No preference</td>
</tr>
</tbody>
</table>

\(^{23}\) Clean Development Mechanism applies to emission reduction projects undertaken between Annex I and non-Annex I countries.

\(^{24}\) Joint Implementation applies to emission reduction projects undertaken between Annex I countries.
23. Does your company have a particular preference regarding geographical area

<table>
<thead>
<tr>
<th>Preference</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Within the country that the company operates (Domestic emissions trading)</td>
<td></td>
</tr>
<tr>
<td>Projects within Annex I countries (Joint Implementation)</td>
<td></td>
</tr>
<tr>
<td>Projects within Non Annex I countries (Clean Development Mechanism)</td>
<td></td>
</tr>
<tr>
<td>No preference</td>
<td></td>
</tr>
<tr>
<td>Other please specify</td>
<td></td>
</tr>
</tbody>
</table>

24. Does your company have any other constraints regarding provenance of emission reductions? If so please describe briefly below.

25. Does your company have any innovative or creative ways of coping with GHG which has not been dealt with so far in this survey?
26. What major risks of not complying with GHG policies has your company identified?

If you have comments not covered by the questions above please note them below.

Name and contact details of sender

Name

Title

Company

Address

Country

Telephone

Fax

Email
Thank you for participating in this survey all results will kept confidential by the author and only aggregated findings will published in the final paper.

Yours truly,

Tony Irwin

Tony Irwin
Masters Degree Candidate,
Resource Management and Environmental Science
University of British Columbia
C/O 3536 10th Avenue W.
Vancouver BC
V6R 2G1

Tel: (604) 738 1289
Cell: (604) 716 7791
Fax: (604) 738 2956
Email: tony@irmc.net
APPENDIX 2. TABULATED RESULTS AND WEIGHTINGS OF MEASUREMENT QUESTIONS
<table>
<thead>
<tr>
<th>Question</th>
<th>Canadian</th>
<th>Non Canadian</th>
<th>All respondents Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>GHG Inventory, Monitoring &amp; Verification</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Question 1. How does your company monitor the greenhouse gas (GHG) emissions generated by its processes?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Question 2. Which greenhouse gas emissions does your company monitor?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carbon Dioxide (CO(_2))</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Methane (CH(_4))</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Nitrous Oxide (N(_2)O)</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Sulphur Hexafluoride (SF(_6))</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Question 3. What is the legislative requirement?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Described</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>No legislative requirement</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Question 4. Is your company in compliance with the legislative requirements?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unknown</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Below compliance</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>In compliance</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Above compliance</td>
<td>4</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Well above Compliance</td>
<td>5</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>Question 5. What is the specific methodological process your company uses to identify, calculate and report emissions?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>National / Sub-National government recommended practice (such as Government documents / Non Governmental Organisation recommended practice (such as NGO documents / templates/software)</td>
<td>2</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Industry specific recommended practice (such as industry association documents / templates/software)</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Other, please specify</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Typically 80 or more of emissions from an integrated gas system are CO\(_2\) from combustion and processing of gas fugitive methane is approximately 12-16 % and the balance is N\(_2\)O. A small role for SF\(_6\), which has a very high GWP but very low emissions rate typically measured in kilograms.
<table>
<thead>
<tr>
<th>Company</th>
<th>Weighting and maximum possible score</th>
<th>Canadian</th>
<th>Non Canadian</th>
<th>All respondents Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Question 7. How does your company monitor and report of GHG emissions?</td>
<td>Paper based</td>
<td>1</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td>Spreadsheet monitoring and reporting (such as Excel)</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Data base monitoring and reporting (such as Access)</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Fully integrated with company purchase and financial management software (such as SAP)</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Other, please specify</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Question 8. Is the monitoring and verification Totally</td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Partially</td>
<td>2</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Not at all</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Question 9. In what form are the GHG emissions reported in a publicly accessible manner?</td>
<td>Not reported Publicly</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Company Web site</td>
<td>5</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Government Web site</td>
<td>3</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>NGO website</td>
<td>3</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Printed document</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Question 10. Is the GHG monitoring and reporting subject to third party verification audit or review?</td>
<td>No Third Party verification</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Informally by company staff</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Formally by consulting company</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Formally by NGO</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Formally by Government Agency</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Question 11. Does this third party review refer to an established Environmental Management System audit framework such as ISO 14001? Please state the EMS audit framework used.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Question 12. Is the GHG monitoring system integrated into a formal EMS framework within the company?</td>
<td>Yes, fully integrated into our Environmental Management System</td>
<td>5</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Somewhat integrated into Environmental Management System</td>
<td>3</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>No, it operates independently from the company Environmental Management System</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Question</td>
<td>Weighting</td>
<td>maximum possible score</td>
<td>Canadian</td>
<td>Non Canadian</td>
</tr>
<tr>
<td>----------</td>
<td>-----------</td>
<td>------------------------</td>
<td>----------</td>
<td>-------------</td>
</tr>
<tr>
<td>Question 13. Does your company monitor and track specific actions and/or projects that reduce GHG emissions as part of the monitoring and reporting system?</td>
<td>g 1-5</td>
<td></td>
<td>Com 1</td>
<td>Com 2</td>
</tr>
<tr>
<td>Yes, our company monitors and tracks all specific actions that reduce GHG emissions</td>
<td>5</td>
<td>5</td>
<td>0 5 0 0 0 5</td>
<td>0 5 0 0 5 0 5 5 0</td>
</tr>
<tr>
<td>Yes, our company monitors and tracks all specific very major actions that reduce GHG emissions</td>
<td>3</td>
<td>0 0 3 0 0 3</td>
<td>0 0 0 0 0 0 0 0 3</td>
<td>6</td>
</tr>
<tr>
<td>Yes, our company monitors and tracks medium level actions that reduce GHG emissions (such as)</td>
<td>4</td>
<td>4 0 0 4 4 12</td>
<td>0 0 0 4 4 0 0 0 8</td>
<td>20</td>
</tr>
<tr>
<td>No, our company does not monitor and track actions that reduce GHG emissions</td>
<td>1</td>
<td>0 0 0 0 0 0</td>
<td>1 0 0 0 0 2</td>
<td>2</td>
</tr>
<tr>
<td>Question 14. Are personnel dedicated to specifically managing GHG emissions issues within your company? What percentage of time does this person's spend dealing with GHG related issues?</td>
<td></td>
<td></td>
<td>Corporate Executive</td>
<td>0.05 0.25 0.75 0 0.25 0.325</td>
</tr>
<tr>
<td>Senior Corporate Manager</td>
<td>4</td>
<td>1 0.4 0.8 0.6 0 0.2 0.4</td>
<td>0 0.48 0 0.48 0 0 0 1.48 0.48 0.8</td>
<td>0.744 0.6356</td>
</tr>
<tr>
<td>Corporate Professional Analyst (or similar)</td>
<td>1</td>
<td>1 0.2 0.05 0.37 0 0.5 0.28</td>
<td>0 0 0 0.12 0.12 0 0 0.37 0.88 0.4</td>
<td>0.378 0.3344</td>
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<tr>
<td>Subsidiary Company Executive</td>
<td>3</td>
<td>3 0 0 0.45 0 0 0.45</td>
<td>0 0.36 0 0.36 0 0 0 0.36 0</td>
<td>0.36 0.3862</td>
</tr>
<tr>
<td>Subsidiary Company Manager</td>
<td>2</td>
<td>2 0 0 0 0 0 0.3</td>
<td>0.24 0.24 0 0 0 0 0 0 0.24 0.2</td>
<td>0.222 0.2433</td>
</tr>
<tr>
<td>Subsidiary Company Professional Analyst (or similar)</td>
<td>1</td>
<td>1 0 0 0.15 0 0 0.15</td>
<td>0.12 0 0 0.12 0.2 0 0 0.12 0.1 0.11</td>
<td>0.1157</td>
</tr>
<tr>
<td>Question 15. If not described above how is the monitoring and reporting system of GHG emissions?</td>
<td></td>
<td></td>
<td>Outside consultants</td>
<td>1 0 0 0 0 0 0</td>
</tr>
<tr>
<td>Spread of load across the company, (many staff doing a small amount)</td>
<td>3</td>
<td>3 0 0 0 0 0 0</td>
<td>0 0 0 3 0 3 0 0 0 0 0</td>
<td>6</td>
</tr>
<tr>
<td>Mix of the two</td>
<td>2</td>
<td>0 0 2 0 2 4</td>
<td>0 0 0 0 0 0 2 0 0 2</td>
<td>6</td>
</tr>
<tr>
<td>GHG Inventory, Monitoring &amp; Verification Totals</td>
<td>56</td>
<td>38 35 43 38 39 38</td>
<td>28 35 44 44 38 36 20 45 42 31 35</td>
<td>542</td>
</tr>
<tr>
<td>Percentage score</td>
<td>0.68 0.63 0.77 0.68 0.69 0.68</td>
<td>0.51 0.62 0.78 0.79 0.68 0.65 0.36 0.81 0.74 0.54 0.63</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Question</td>
<td>Company</td>
<td>Canadian</td>
<td>Non Canadian</td>
<td>All respond Total</td>
</tr>
<tr>
<td>------------------------------------------------------------------------</td>
<td>---------</td>
<td>----------</td>
<td>--------------</td>
<td>------------------</td>
</tr>
<tr>
<td></td>
<td>Weight</td>
<td>maximum possible score</td>
<td>1 2 3 4 5</td>
<td>6 7 8 9 10 11 12 13 14 15</td>
</tr>
<tr>
<td>Question 16. What is your company elective GHG emissions reductions target?</td>
<td>5 5</td>
<td>0 5 0 5 5</td>
<td>15</td>
<td>0 5 5 5 5 0 0 5 5</td>
</tr>
<tr>
<td>The target is, please specify dates and amount and type of elective reduction (e.g. X absolute tonnes below, or Y % below a given date baseline)</td>
<td>3 3</td>
<td>3 0 3 0 0</td>
<td>6</td>
<td>0 0 0 0 0 0 0 0 0</td>
</tr>
<tr>
<td>We are actively developing a target with expectation of an announcement in (please state date)</td>
<td>1</td>
<td>0.0 0.0 0.0 0.0 0.0</td>
<td>1.0 0.0 0.0 0.0 1.0 1.0 0.0 0.0</td>
<td>4.0</td>
</tr>
<tr>
<td>We do not have a company elective GHG reduction target</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Question 17. What baseline year does your company as reference point for targets?</td>
<td>3 3</td>
<td>3 3 3 3</td>
<td>15</td>
<td>0 0 0 3 0 0 3 3</td>
</tr>
<tr>
<td>1990</td>
<td>0 0 0 0 0 0 0 0 0</td>
<td>9.0</td>
<td>9.0</td>
<td></td>
</tr>
<tr>
<td>non 1990</td>
<td>0 0 0 0 0 0 0 0 0</td>
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<td>9.0</td>
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<td>no baseline</td>
<td>1</td>
<td>0 0 0 0 0 0</td>
<td>1 0 0 0 1 1 0 0 0</td>
<td>3.0</td>
</tr>
<tr>
<td>Question 18. What formal GHG management system does your company have in place for lowering emissions?</td>
<td>1</td>
<td>0 0 0 0 0</td>
<td>0 0 0 0 0 0</td>
<td>0</td>
</tr>
<tr>
<td>Question 19. How does this management system include active consideration of market mechanisms to manage GHG levels?</td>
<td>1</td>
<td>0 0 0 0 0</td>
<td>0 0 0 0 0 0</td>
<td>0</td>
</tr>
<tr>
<td>Question 20 Which flexibility mechanisms is your company considering?</td>
<td>5 5</td>
<td>5 5 5 0 5</td>
<td>20</td>
<td>0 0 5 0 5 5 0 0 5</td>
</tr>
<tr>
<td>Inter company emissions trading</td>
<td>3 3</td>
<td>0 0 0 0 0</td>
<td>0</td>
<td>0 3 0 0 0 0 0 0 3 3</td>
</tr>
<tr>
<td>Joint implementation type projects</td>
<td>1 1</td>
<td>0 0 1 0 0</td>
<td>1</td>
<td>0 1 0 0 1 0 1 1 1 0 0</td>
</tr>
<tr>
<td>Question 21. Will your company likely participate in a flexibility mechanisms as a Creator and seller of emissions reductions</td>
<td>5 5</td>
<td>0 0 0 0 0</td>
<td>0</td>
<td>0 0 0 0 0 0 0 0 0 0</td>
</tr>
<tr>
<td>Buyer of emissions reductions</td>
<td>3</td>
<td>0 0 3 3 6.0</td>
<td>0 0 0 0 0 0 0 0 0 0 0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Both of the above</td>
<td>3</td>
<td>0 3 3 6.0</td>
<td>0 3 3 3 3 0 0 3 3 18.0</td>
<td>24.0</td>
</tr>
<tr>
<td>Question 22. Does your company have a publically stated preference towards particular project classifications?</td>
<td>5 5</td>
<td>1.65 1.65 1.25 0.0 1.65</td>
<td>6.2</td>
<td>0 0 0 0 0 0 0 1 0 0 1.3</td>
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<tr>
<td>Industrial efficiency projects</td>
<td>4</td>
<td>1.32 1.32 1.00 0.0 1.32</td>
<td>5.0</td>
<td>0 0 0 0 0 0 0 1 0 0 1.0</td>
</tr>
<tr>
<td>Domestic efficiency projects (demand side management)</td>
<td>4</td>
<td>1.3 1.3 1.00 0.0 0.0</td>
<td>3.6</td>
<td>0 0 0 0 0 0 0 1 0 0 1.0</td>
</tr>
<tr>
<td>Renewable energy projects</td>
<td>4</td>
<td>0.0 0.0 0.0 0.0 0.0</td>
<td>0.0</td>
<td>0 0 0 0 0 0 0 1 0 0 1.0</td>
</tr>
<tr>
<td>Transportation projects</td>
<td>3</td>
<td>0.0 0.0 0.0 0.0 0.99</td>
<td>1.0</td>
<td>0 3 0 0 0 0 0 0 0 0 3.0</td>
</tr>
<tr>
<td>Biologic sink projects</td>
<td>2</td>
<td>0.0 0.0 0.5 0.0 0.0</td>
<td>0.5</td>
<td>0 0 0 0 0 0 0 0 0 0 0.0</td>
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<tr>
<td>Geological sink projects</td>
<td>2</td>
<td>0.0 0.0 0.0 0.0 0.0</td>
<td>0.0</td>
<td>0 3 3 3 3 3 3 0 3 3 18.0</td>
</tr>
<tr>
<td>Question</td>
<td>Company</td>
<td>Canadian</td>
<td>Non Canadian</td>
<td>All Respondent Total</td>
</tr>
<tr>
<td>----------</td>
<td>---------</td>
<td>----------</td>
<td>--------------</td>
<td>---------------------</td>
</tr>
<tr>
<td></td>
<td>Weighting</td>
<td>maximum possible score</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Question 23. Does your company have a particular preference regarding geographical area?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Within the country that the company operates (DET)</td>
<td>4</td>
<td>0 4 0 0 16.0</td>
<td>0 0 4 0 0 0 2 0 0 6.0 22.0</td>
<td></td>
</tr>
<tr>
<td>Projects within Annex I countries (JI)</td>
<td>3</td>
<td>0 0 0 0 0 0.0</td>
<td>0 0 0 0 0 0 0 0 0 0 0 0.0 0.0</td>
<td></td>
</tr>
<tr>
<td>Projects within Non Annex I countries (CDM)</td>
<td>2</td>
<td>0 0 0 0 0 0.0</td>
<td>0 0 0 0 0 0 0 1 0 0 1 0 1.0</td>
<td></td>
</tr>
<tr>
<td>No preference (all of the above) we do not discriminate</td>
<td>2</td>
<td>0 0 2 0 0 2.0</td>
<td>0 2 0 2 2 2 0 2 2 2 2 12.0 14.0</td>
<td></td>
</tr>
<tr>
<td>Other please specify</td>
<td>1</td>
<td>0 0 0 0 0</td>
<td>0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0</td>
<td></td>
</tr>
<tr>
<td>Question 24. Does your company have any other constraints regarding provenance of emission reductions?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>yes</td>
<td>1</td>
<td>0 0 0 0 0 1 1.0</td>
<td>0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0.0 1.0</td>
<td></td>
</tr>
<tr>
<td>no</td>
<td>1</td>
<td>1 1 1 1 0 4.0</td>
<td>1 1 1 1 1 1 1 1 1 1 1 10.0 14.0</td>
<td></td>
</tr>
<tr>
<td>Question 25. Does your company have any innovative or creative ways of coping with GHG policies which has not been dealt with so far in this survey?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>yes</td>
<td>1</td>
<td>1 0 1 0 0 2.0</td>
<td>0 0 0 0 0 1 0 0 0 0 1.0 3.0</td>
<td></td>
</tr>
<tr>
<td>no</td>
<td>1</td>
<td>0 1 0 1 1 3.0</td>
<td>1 1 1 1 1 0 1 1 1 1 9.0 12.0</td>
<td></td>
</tr>
</tbody>
</table>

**GHG Management Totals**

| Percentage Score | 22 21 21 18 24 23 | 2 22 29 15 23 18 4 14 22 27 18 295 |

|  | 0.7 | 0.6 | 0.6 | 0.5 | 0.7 | 0.584059 | 0.06 | 0.65 | 0.85 | 0.44 | 0.68 | 0.53 | 0.12 | 0.42 | 0.65 | 0.79 | 0.524265 |

See notes for applicable ranking system.
<table>
<thead>
<tr>
<th>Question</th>
<th>Canadian</th>
<th>Non Canadian</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Weighting maximum possible score</td>
<td>Average</td>
</tr>
<tr>
<td></td>
<td>Canadian</td>
<td>Non Canadian</td>
</tr>
<tr>
<td></td>
<td>Company</td>
<td>Company</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>60</td>
<td>56</td>
</tr>
<tr>
<td></td>
<td>0.67</td>
<td>0.63</td>
</tr>
</tbody>
</table>

Yellow shaded areas not included in totals as they are qualitative statements. Answers in italics are not added to totals.

Green shaded areas are quantitative and are included in totals

Blue shaded areas are rankings
APPENDIX 3. THE RESEARCH PROCESS- A FLOW DIAGRAM

The research process
Adapted from
Cooper and Emory (1995)

Management Question*

Research question

Exploration

Design

Sampling Plan

Budget and Value

Assessment

Pilot testing

Data Collection

Analysis and Interpretation

Report results

Revision of research and investigative questions

Revision of research and investigative questions

*or academic research question
APPENDIX 4. EXPERT OPINION ELICITATION VERIFICATION

Verification of the results

Email correspondence with Pierre Boileau following the interview to verify the expert opinions he stated, style content and format is exactly as copied from the email.

END OF CORRESPONDENCE

Yes Tony,

This latest version does reflect our discussions well. I think this is a valuable learning tool and very helpful from my own perspective. Good luck with it.

Cheers

Pierre.

--- Original Message ---
From: Tony Irwin [mailto:Tony@irmc.net]
Sent: Thursday, July 04, 2002 5:52 AM
To: Boileau, Pierre [NCR]
Subject: RE: Questionnaire weightings

Pierre,

re 1. No new questions or answers can be added at this stage, I will be mentioning intra company trading in the thesis text as an oversight in the original questionnaire.

re 2. q 24 and 25 are place markers and do not add to the totals; attached is a much tidier version with this as an explicit comment.

I think that this reflects the conversation we had fairly well.

Once again thanks for the time and effort regards
Hi Tony,

Looks great. Only a couple of comments:

1. I thought that under question 20 you were going to include intra-company emissions trading.
2. Under questions 24 and 25 you still have a score, although these aren't supposed to be included in the totals.

Hope that's helpful,

Pierre.
Thank you very much for participating in this work, your contribution has been very valuable, and I am sure your insight will strengthen the resultant work considerably.

Attached is the weighted questionnaire summary sheet, that was the subject of the interview this morning. I have added the weightings on a 1-5 scale as per our discussions. Please can you review and confirm that they capture the substance of the conversation. Please feel free to make any adjustments or give further comment.

Regards

Tony

START OF CORRESPONDENCE