1-1-2012

Reducing the Carbon Footprint at an Electric Utility Company

Peter Moore
Ryerson University

REDUCING THE CARBON FOOTPRINT AT AN ELECTRIC UTILITY COMPANY

By

Peter Moore

Bachelor of Arts

English Literature and Geography

University of Ottawa, 2010

A thesis

presented to Ryerson University

in partial fulfilment of

requirements for the degree of

Master of Applied Science

in the Program of

Environmental Applied Science and Management

Toronto, Ontario, Canada 2012

AUTHOR'S DECLARATION FOR ELECTRONIC SUBMISSION OF A THESIS

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I authorize Ryerson University to lend this thesis to other institutions or individuals for the purpose of scholarly research.

I further authorize Ryerson University to reproduce this thesis by photocopying or by other means, in total or in part, at the request of other institutions or individuals for the purpose of scholarly research.

I understand that my thesis may be made electronically available to the public.

Abstract

Reducing the Carbon Footprint at an Electric Utility Company

Peter Moore

Environmental Applied Science and Management

Master of Applied Science, Ryerson University 2012

The purpose of this thesis is the development of options for the reduction of the carbon footprint at an electric utility company. A case study details a systematic approach to reduce corporate greenhouse gas emissions over the next decade. The study focuses on providing three principle outputs: 1) process maps whereby the company may systematically identify its current carbon footprint, 2) scenario analyses to project its future carbon emissions over a ten year period and, 3) recommended actions to reduce GHG emissions over the next decade. A number of recommendations for emission reductions are made. The findings suggest that the degree to which an organization addresses its GHG emissions is substantially influenced by organization-specific social, regulatory, technological and economic forces. The case study reveals that by perceiving corporate carbon management as a periphery objective, organizations limit their ability to reduce GHG emissions and to improve their corporate performance.

Acknowledgement

I would like to thank Dr. Cory Searcy for the outstanding support, constructive criticism, guidance and exceedingly useful advice he provided over the course of the research, without which, this thesis would not have been made possible. I would also like to thank the project liaison, S.S., for championing the study within the case company. Finally, I owe my deepest gratitude to my family and friends for the much needed support they provided during my research, and in all things.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

CDP: Carbon Disclosure Project

EIO-LCA: Economic Input – Output Life Cycle Assessment

EMS: Environmental Management System

EV: Electric Vehicle

FIT: Feed-In Tariff

GCC: Global Climate Coalition

GHG: Greenhouse Gas

HVAC: Heating, Ventilation and Air Conditioning

IPCC: International Panel on Climate Change

LDC: Local Distribution Company

LEED: Leadership in Energy and Environmental Design

NGO: Non-Governmental Organization

OECD: Organisation for Economic Co-operation and Development

OPEC: Organization of the Petroleum Exporting Countries

TFI: Task Force Initiative on National Greenhouse Gas Inventories

TOU: Time of Use

UNFCCC: United Nationals Framework Convention on Climate Change

WBCSD: World Business Council for Sustainable Development

WRI: World Resource Institute

1. Introduction

1.1 Overview

Over the last two decades, climate change has increasingly garnered the attention of the scientific community, policy makers, businesses, and industry. The publication of scientific evidence suggesting severe environmental, economic and social consequences of global warming (International Panel on Climate Change [IPCC], 2007) has prompted some governments and organizations to consider the impact of their policies and operations on the global climate.

However, the issue has been met with a confused degree of accountability. In North America, the political response resembles a regional and jurisdictional patchwork of commitment; provincial and federal governments prescribe to a multitude of greenhouse gas (GHG) emission reduction policies, goals and mechanisms. Both the United States and Canada, the world's first and seventh largest GHG polluters respectively, have repudiated the Kyoto Accord, while Mexico prescribes to its own emission reduction program. Further complicating the matter, efforts to combat climate change within the judicial branch have proven tenuous at best (Hsu, 2008). Despite these complications, and although in most jurisdictions emissions reductions are not yet mandated by regulation, some corporations have begun to address the issue by examining and modifying both their decision making and operational practices.

While corporations often identify the potential for future regulation as a primary motivation, there are other drivers that, in the absence of obligatory reduction requirements, have led an increasing number of North American organizations to voluntarily measure and mitigate their GHG emissions. Some have pursued emissions reduction measures in order to benefit from associated efficiency increases. Facing rising energy prices, the reduction of emissions can provide some organizations with cost savings. Others have sought reduction strategies as a means of increasing shareholder value, or becoming better corporate stewards (Hoffman & Woody, 2008). There are still other motivations and benefits that have been the basis for corporate action and are frequently debated in the literature (refer to section *2.1.4 Motivations, Benefits and Efficacy*).

Regardless of the motivation, as a means of mitigating their contribution to climate change many companies have chosen to evaluate and reduce their corporate carbon footprint (Hoffman & Busch, 2008). While definition within the academic literature is scarce, a carbon footprint is most commonly defined as “a measure of the exclusive total amount of carbon dioxide (CO_2) emissions that are directly and indirectly caused by an activity or are accumulated over the life stages of a product” (Wiedmann & Minx, 2008). This definition is indicative of the state of the discipline within academia, the development of which has focused heavily on activity and product – level applications. As a result, organizations are often challenged with the task of devising unique approaches for management of their GHG emissions.

1.2 Problem Statement

There are some existing methods that organizations have utilized in order to measure emissions. Over the past fifteen years, the development of a GHG accounting discipline has helped many governments, NGOs and businesses to measure, track and report their emissions. Methods prescribed by standards such as the World Resource Institute’s (WRI) *Greenhouse Gas Protocol* also help organizations to measure the progress of their emission reduction initiatives (The World Resource Institute [WRI] & The World Business Council for Sustainable Development [WBCSD], 2001). Despite these developments, organizations continue to experience prohibitive information gaps, and some companies have struggled to develop strategic and scientifically sound models to evaluate and reduce their corporate carbon footprint. As a result of increasing uncertainty regarding the potential for a low carbon economy, and the ambiguity surrounding carbon regulation, companies are faced with the difficult task of planning for their carbon future.

In the face of this uncertainty, there is a need for a holistic approach to assist organizations in the management of their current corporate carbon footprint, but also for future carbon risks and opportunities. There are numerous examples detailing product and activity specific case studies within the applicable academic literature, however, there are a very limited number of published cases exemplifying the application of carbon strategy approaches for organizations.

In response, the purpose of this thesis is to develop options for the reduction of the carbon footprint at a major North American electric utility company. A case study focuses on helping the organization make GHG emission reductions over ‘business as usual’ scenarios for the next decade. The company has taken preliminary steps to assess and plan for reduction of its carbon footprint, including the collection of preliminary GHG data and the implementation of programs to reduce their impact on the environment. This study aims to contribute to these ongoing efforts. Furthermore, the research seeks to contribute to the development and understanding of corporate climate change action. The study provides unique insight into corporate motivation to reduce GHG emissions, as well as developing an approach that can be used by organizations to consider a broad range of emission impacts and opportunities for the present as well as the future.

1.3 Study Objectives

The primary objective of this research is to develop options for reduction of the carbon footprint at the case company. There are three components to this objective:

1. Develop a baseline of GHG emission sources for the partner organization,

2. Project the organization's key emissions over the next ten years, and

3. Develop practical options for the organization to consider reducing its organizational carbon footprint over the next decade.

An ancillary objective is to benchmark the GHG emission measurement and mitigation initiatives within the case company's industry.

This thesis accomplishes these objectives by providing three principle outputs: (a) process maps whereby the case company may systematically identify its current carbon footprint, (b) scenario analyses to help project its future carbon emissions over the next ten years, and (c) a set of recommended actions to reduce the company's GHG emissions over the next decade.

Completing the research has addressed an identified need at the organization and provides a tangible demonstration of the company's commitment to reducing its impact on the environment. Furthermore, the thesis provides a case study demonstrating the application of a unique approach to corporate carbon management. Finally, the case study addresses a number of relevant gaps within the literature.

1.4 Scope

There are a number of significant scoping considerations associated with this study. The approach will include an emphasis on life-cycle assessment type thinking, that is, it will consider the impacts associated with the organization's supply chain, waste, outsourced activities and all other indirect emissions. However, it will not include a full life-cycle assessment as the focus of the thesis is to apply an approach for carbon footprinting to an entire organization, not individual services or products.

While much of the approach may be applicable to all organizations, the study focuses on applying the method within the case company's industry – the electricity transmission and distribution sector.

The study strictly considers the six key GHGs for which the Kyoto Protocol applies: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulphur hexafluoride (SF_6) (referred to as the *Kyoto gases*). These are the GHGs strictly considered by the relevant accounting standards (International Organization for Standardization, 2006a; WRI & WBCSD, 2001).

1.5 Thesis Organization

The thesis is organized into five remaining chapters. A literature review provides background information about climate change policy and the corporate response, carbon accounting and the carbon footprint, scenario analysis for strategic decision making, and the relevant gaps in the literature. A case study section details the partner organization, the approach, and the specific method employed for the fulfillment of each component of the primary objective. The findings of the research are presented in the fifth section. The last two principle sections provide a discussion of the research results, and a conclusion that details contributions to the academic knowledge base, limitations, and suggestions for future research.

2. Literature Review

The literature review provides background information about corporate climate change action, relevant developments, and the principle method employed in the research. The section begins by tracing corporate action on climate change to its roots in the international political arena and provides context for ancillary sections. A summary of the literature regarding corporate action and motivation to mitigate GHG emissions is also provided. Relevant developments regarding GHG accounting and the carbon footprint concept are discussed. The two final sections of the review detail strategic scenario analysis and a summary of gaps within the literature.

2.1 Climate Change Policy and Corporate Response

2.1.1 International Policy and the Development of Carbon Accounting Principles

The root of climate change policy can be traced to the late 1980's, during which time climate change first became an international political concern and branched out from purely scientific forums (Pulver, 2007). Between 1988 and 1989 the United Nations General Assembly first addressed climate change by passing two resolutions, Resolution #43/53, and Resolution #44/207. The first resolution outlined an agreement to protect the global climate for the benefit of current and future generations of mankind; the latter mandated the creation of a Framework Convention on Climate Change (Pulver, 2007). In lieu of Resolution #43/53, the World Meteorological Organization and the United Nations Environment Program established the Intergovernmental Panel on Climate Change (IPCC) in 1988. The objective of the IPCC is to “review and assess the most recent scientific, technical and socio-economic information produced worldwide relevant to the understanding of climate change”(IPCC, 2012a, para. 2).

The IPCC has been instrumental in providing the international community with scientifically sound and credible information about climate change. The organization has published a number of key reports that summarize the findings and research of climate experts from around the globe. The panel’s early work culminated in the release of the *IPCC First Assessment Report* in 1990 (IPCC, 1990) which details the scientific assessment of climate change, an impacts assessment, and response strategies. Three subsequent reports have additionally included consideration for adaptation, mitigation and vulnerabilities related to global climate change. These international publications, and other supporting tools and documents, have for more than two decades provided the global community with a source of scientific information and guidance about climate change.

The publication of scientific evidence suggesting severe environmental, social and economic consequences of anthropogenically-produced global warming prompted a reaction from the international community. At the United Nations Conference on Environment and Development in 1992, 194 nations signed the United Nations Framework Convention on Climate Change (UNFCCC), a treaty aimed at stabilizing anthropogenic GHG emissions in the atmosphere to a level that would prevent adverse impacts to the environment (United Nations Framework Convention on Climate Change [UNFCCC], 2012). A key tenet of the UNFCCC is the requirement of member nations to report GHG emissions and removals on an annual basis. The UNFCCC does not require binding emissions reductions from its signatories, but instead lays the foundation for future protocols that could assign appropriate limits (UNFCCC, 2012). The most prominent of these protocols is the Kyoto Protocol. The Kyoto Protocol set binding emission reduction targets for signatories. However, like other international climate change mitigation efforts, the protocol has been largely criticised for its inability to produce tangible global GHG emission reductions as it was repudiated by a number of the largest GHG emitting nations (Hsu, 2008).

In lieu of the unsuccessful international efforts to reduce emissions, regional programs have emerged. In 2005, the European Union launched an emissions trading scheme, setting mandatory targets with the aim of reducing emissions of largest GHG emitting facilities (Ellerman & Buchner, 2007). Another example can be drawn from British Columbia, Canada, where policymakers introduced a carbon tax in 2008. The tax assigns a price for carbon emissions to encourage individuals, businesses, and industry to measure and reduce the emissions for which they are responsible (British Columbia Ministry of Finance, 2012). Market-based emission reduction schemes have been introduced in other countries and regions (for example, Australia, New Zealand, California, Tokyo, Taiwan, Switzerland, Norway, and Sweden) with mixed degrees of efficacy (Ellerman & Buchner, 2007; Hsu, 2008; Lin & Li, 2011).

Although the UNFCCC treaty has been relatively ineffective at producing emission reductions, the mandated national GHG reporting mechanisms helped to establish the basis for corporate GHG emission accounting. Through the UNFCCC, the IPCC's work has been fundamental in laying the foundation for the development of carbon accounting methodologies. In 1991, the IPCC created the National Greenhouse Gas Inventories Programme (IPCC-NGGIP) and in 1998, formed the Task Force Initiative on National Greenhouse Gas Inventories (TFI) to oversee the programme (International Panel on Climate Change, 2012b). The TFI has two primary objectives:

1) to develop and refine an internationally-agreed methodology and software for the calculation and reporting of national GHG emissions and removals, and
2) to encourage the widespread use of this methodology by countries participating in the IPCC and by signatories of the United Nations Framework Convention on Climate Change (UNFCCC) (International Panel on Climate Change, 2011, para. 6, 7).

The TFI first published the *IPCC Guidelines for National Greenhouse Gas Inventories* in 1995, a document that focuses on providing assistance to federal governments in assembling a national GHG inventory (International Panel on Climate Change, 2012b). The revised 1996 version of the document outlines the official methodology that signatories of the Kyoto Protocol are required to follow in calculation of legally-binding reduction targets. The methods prescribed within the document have not only been used by signatories of the UNFCCC to report national GHG inventories, but have been adopted by the most widely used corporate GHG accounting standard (WRI & WBCSD, 2001). As a result, the IPCC has been crucial to the development of corporate GHG accounting practices.

2.1.2 Corporate Response to Climate Change

Over the past twenty years corporate response to climate change has been one of mixed and continually evolving sentiment. Since the issue first entered the political arena, many corporations have been wary of perceived regulatory risks that threaten to raise energy and production costs, place constraints on productivity, and impact the bottom line (Cavanagh, Gupta, Lashof, & Tatsutani, 1993; Leggett, 2001). Furthermore, the implementation of mandatory abatement programs and investment in low-carbon alternatives can be time, risk and resource intensive. As Jones and Levy (2007) suggest, measures to control GHG emissions may be detrimental to corporations because:

> Investments in research and development are highly risky, as low-emission technologies, such as those for renewable energy, frequently require radically new capabilities that threaten to undermine the position of existing companies and open the industries to new entrants. (p. 430)

As a consequence of these perceived threats, many corporations (and not only those within the fossil-fuel industries) were strongly opposed to any GHG emission mitigation treaty or policy throughout much of the late 1980's and early – mid 1990's (Jones & Levy, 2007; Kolk & Levy, 2001; Leggett, 2001). Those businesses that first entered into the climate change debate had the most at stake; by 2001, the oil industry directly and indirectly accounted for more than half of GHG emissions in industrialized countries (Kolk & Levy, 2001). Many of these multi-national corporations, joined by some businesses from across other sectors, not only opposed mitigation measures, but challenged the climate science behind the earliest IPCC reports (Leggett, 2001). Indicative of their very vocal and prominent involvement in the early debates on climate change science, most of the available academic literature applicable to early corporate response to the issue focuses on oppositional responses by corporations within the oil and automotive industries.

Much of this opposition came from large corporations within the United States (Jones & Levy, 2007). Large oil industry companies, with the support of other businesses, formed organizations like the Global Climate Coalition (GCC) and the Climate Council to organize their opposition and aggressively lobby against climate change policies, treaties and legislation. As Levy and Egan (2003) suggest, these groups played a major role in influencing the United States' early repudiation of the Kyoto Protocol. This attitude prevailed throughout much of the 1990's, a period when the North American energy and automotive sectors invested little in new technologies designed to reduce GHG emissions in the short to medium term (Jones & Levy, 2007).

Although much of the 1990's was characterized by aggressive campaigning and lobbying against climate change science and potential regulation, stanch corporate opposition was not completely ubiquitous. European oil corporations appeared to be more willing to accept adaptation, regulation and implementation of reduction strategies (Kolk & Levy, 2001). While the reason behind this stark contrast is complex and not altogether clear, some researchers point to a difference in cultural, political, and competitive landscapes in which these corporations operate (Kolk & Levy, 2001, Jones & Levy, 2007). However, while European corporations were less aggressively opposed to climate change mitigation, there was still concern about a potential harm to competitiveness (Kolk & Pinkse, 2004).

By the end of the 1990's a shift began to occur that saw many corporations, in North America and Europe, adopt a more cooperative stance toward the climate change issue. Major companies, within and outside of the oil industry, began to affirm the science and to acknowledge the need for some action to curb the GHG emissions of nations and large corporate emitters. Companies within the oil industry that had been staunchly opposed to emissions mitigation were beginning to invest significant capital in emission-reduction technologies and to support emission tracking, trading and reductions (Jones & Levy, 2007).

While Kolk and Levy (2001) and Jones and Levy (2007) agree that there are no clear scientific, technological or regulatory developments that can explain the rather sudden shift, they do point to a number of potential driving forces. Both sources point to three potential components that could have guided this shift: locational, internal organizational, and competitiveness and market position factors. They suggest that early adopters of the softer stance, particularly in Europe, were driven by localized societal concerns and an internal management structure, CEO and corporate culture that were more conscientious of the climate change dilemma, and therefore more willing to act. Later adopters were more influenced by competitive pressures and interdependence that required companies to react to competitors that had already shifted their stance (Jones & Levy 2007).

By 1998, major multinational corporations like Shell and British Petroleum had abandoned the GCC in favour of cooperatives that had adopted a more compromising approach. As Leggett (2001) and Jones and Levy (2007) suggest, a number of new corporations challenged the GCCs self-proclaimed title as the voice of all industry on the climate issue. By 2001, even large multinational oil corporations BP, Shell and Texaco had begun to measure their emissions and invest in renewable technologies (Kolk & Levy, 2001). The Pew Center on Global Climate Change was formed in 1998, an organization whose corporate membership sought to promote a more progressive and supportive role for actions to reduce climate change.

Since 2000, many corporations have begun to embrace an entirely new discourse with regard to climate change mitigation. Rather than positioning mitigation potential as a threat to competitiveness, productivity, and the bottom line, the new philosophy emphasizes potential befits associated with corporate climate change action (Kolk, Levy, & Pinkse, 2008). It is also clear that a greater number of organizations have begun to consider the implications of their operation for global climate change. Indicative of this increase, in 2003 235 major organizations from around the world voluntarily disclosed GHG data and information through the Carbon Disclosure Project. In 2011, 3715 companies chose to disclose (Carbon Disclosure Project, 2012a).

2.1.3 Business Coalitions and Partnerships for Climate Change Action

There is a growing body of information that summarizes and provides analysis for the state and nature of voluntary action – and corporations certainly haven't been working alone. As Jones and Levy (2007) explain, new business coalitions and partnerships with third parties were fundamental for the dissemination of the new business philosophy:

> Perhaps the most significant change in the corporate landscape has been the diffusion and increasing legitimacy of the "win-win" discourse articulating the consonance of the environmental and business interests. Groups such as the Pew Center actively promote this position; indeed, the win-win paradigm is a key discursive foundation for a broad coalition of actors supporting the emerging climate regime. (p. 432)

During a period of relatively little, or no regulatory control (this varies by region), partnerships between non-governmental organizations (NGOs), environmental groups, industry associations, and businesses have played an increasingly important role in corporate climate change action since this "win-win" philosophy first emerged (Hoffman, 2005; Jones & Levy, 2007). Businesses have voluntarily turned to these entities for a number of reasons, including: (a) to seek and share insight into GHG emission measurement and mitigation best practices, (b) to be part of a corporate dialogue, (c) to form representative partnerships that can work with governments on future policy and legislation, and (d) to communicate, or add validity to, carbon inventories, reduction claims or measurement processes (Hoffman, 2005).

The WRI is an NGO that has, since the early 1980's, worked to provide policy research and analysis on major global resource and environmental issues, and facilitated the development of corporate GHG emissions accounting methods. Working with a coalition of businesses, researchers and environmental groups, the organization's climate program has developed the most widely applied GHG emission measurement and accounting standard, *The Greenhouse Gas Protocol* (WRI & WBCSD, 2001).

Originally founded in 1998, the Pew Center on Global Climate Change has transitioned into the Center for Climate and Energy Solutions. Among its other accomplishments, which include the publication of over 100 peer-reviewed reports on climate science, economics, policy and solution, the NGO and environmental think tank established the Business Environmental Leadership Council, consisting of "industry leading, mostly Fortune 500 companies across a range of sectors with combined revenues of $2 trillion and 4 million employees" (Center for Climate and Energy Solutions, 2012a). The cross-industry members of the council have agreed to adopt a proactive stance on climate change and support and provide feedback on business and policy solutions. Members are also required to support the Center's guiding principles, one of which acknowledges the need for mandatory emissions reductions (Center for Climate and Energy Solutions, 2012b).

The Carbon Disclosure Project (CDP) is an NGO that has, since 2000, worked with businesses across the globe to encourage voluntary disclosure of GHG emission inventories, corporate carbon risks, and carbon opportunities (Carbon Disclosure Project, 2012b). Since its inception, the project has garnered the support of 655 institutional investors that represent in excess of US$78 trillion in assets. The CDP seeks to drive positive climate action using stakeholder demand and leverages its investor support to provide incentive for thousands of the world's largest companies to participate (Carbon Disclosure Project, 2012b).

Using the information gathered from these companies, the CDP has compiled the largest database of voluntarily reported corporate GHG information. The organization's key objective is to contribute to the development of standardized reporting procedures and to "provide information relevant to investors relating to the business risks and opportunities from climate change" (Kolk et al., 2008). This database is also extremely useful to the business community, as it allows individual companies to benchmark their GHG measurement initiatives against their competitors (Carbon Disclosure Project, 2012a). In this way, it largely contributes to the development of best practices within individual industries. Through a new program, the CDP has recently begun collecting data and developing reporting standards for emissions associated with corporate supply chains.

Some corporations have also sought more intimate relationships with NGOs in order to tap into expertise and provide validation. For example, Cinergy, a major U.S. energy company, invited Environmental Defense to serve as "an ex-officio member of the GHG Management Committee" that is responsible for implementation of the company's GHG plan (Hoffman, 2010, p. 112). The NGO acted as a third party verifier and reviewed and approved the company's inventory and methods for emission measurement.

2.1.4 Motivations, Benefits and Efficacy

Within the academic literature, many researchers have sought to identify and understand the possible motivations and benefits driving the adoption of this increasingly constructive response (Boiral, 2006; Boiral, Henri, & Talbot, 2011; Grant Thornton, 2007;Hoffman, 2005; Jeswani, Wehrmeyer, & Mulugetta, 2008; Okereke, 2007). As Boiral et al. (2011) suggests, the literature points to a range of influencing factors, both internal and external, including: (a) economic incentives, (b) social and environmental motives, and (c) stakeholder pressure. However, much of the work that has been done to link these motivations to corporate climate change action is speculative, and very little has been done in the way of empirical evaluation (Boiral et al., 2011). This is also true of literature linking economic benefits and the implementation of GHG emission reducing strategies.

Much of the literature that discusses the potential for these economic benefits describes the recent corporate response as a perceived "win-win" relationship between climate change action and corporate competitiveness, a notion that suggests addressing GHG emissions is good business strategy (Boiral, 2006; Boiral et al., 2011; Hoffman, 2005; Hoffman & Woody, 2008; Jones & Levy, 2007; Okereke & Russel, 2010; Schultz & Williamson, 2005). Hoffman (2005) points to number of potential benefits to organizations choosing to be proactive in GHG emission reductions, including:

1. Operational improvements and energy cost savings,

2. Anticipating and influencing future climate change regulations,

3. Assessing new sources of capital,

4. Improving risk management,

5. Elevating corporate reputation,

6. Identifying new market opportunities, and

7. Enhancing human resource management.

Some research has suggested that those businesses that fail to implement climate change strategies are at risk of becoming uncompetitive (Boiral et al., 2011; Hoffman, 2005). The Conference Board, a global independent business association, famously implied that “businesses that ignore the debate over climate change do so at their peril” (Hoffman 2005, p. 6). However, this advantageous relationship, in economic terms at least, has only been corroborated by empirical study on a very limited basis (Boiral et al., 2011).

Despite findings that suggest that companies that implement GHG emission reduction mechanisms financially outperform their competitors, Boiral et al. (2011) found that financial incentives were not motivating factors that influence decision makers. Instead, proactive companies were motivated by “environmental and social concerns (e.g. public demonstration of the company’s commitment, ethical issues, pollution reduction) and by pressure from various stakeholders” (Boiral et al., 2011, Antecedents section, para. 3). These findings contradict suggestions that financial benefits could play a significant role in motivating corporate GHG emission reduction activities. However, although Boiral et al. (2011) suggest the “win-win” relationship is legitimate, as they correlate positive financial performance and GHG reduction activities, their evaluation of the “win-win” relies heavily on subjective instruments. While the results of the study do suggest a positive correlation, they use subjective and potentially biased evaluations of both GHG activity and financial performance. As a result, their economic, -environmental evaluation is problematic. The problems with this type of evaluation could be behind the corporate and government scepticism about the financial implications of GHG emission reduction measures. This could also explain why some corporations have viewed economics as a barrier to GHG emission reduction measures.

It is clear that the degree to which businesses engage in action on climate change is also influenced by governance. From the political perspective, response to climate change has been highly fragmented, both at the international and domestic levels. Countries and individual provinces/states prescribe to different GHG emission reduction policies, partnerships and treaties, or in some cases take no action at all. As a result, corporations are faced with a “patchwork of market-based approaches” (Jones & Levy, 2008, p. 437) that can have a number of implications for competitiveness in an increasingly global economy. Furthermore, as most jurisdictions have yet to implement strict emissions reductions regulations, it remains unclear what future market mechanisms and hard-line emission caps corporations will be subjected to. Hoffman (2005) suggests that policymakers are contributing to market uncertainty by sending weak and ambiguous signals, like the decision made by the United States government not to ratify the Kyoto Protocol:

> While many within the business community dislike the Kyoto Protocol, viewing it as a suboptimal mechanism for bringing about a business solution to this problem, policymakers have created what businesses dislike even more—uncertainty. Companies need a clear picture of future market environments in order to make strategic decisions; and the decision not to ratify the Kyoto Treaty has only made the future market environment cloudier. (p. 23)

Furthermore, depending on a number of factors (size of company, GHG market risks and exposures, nature of the industry, etc.,) it is clear that not all companies would benefit by adopting progressive climate action strategies (Hoffman, 2005; Lash & Wellington, 2007; Porter & Reinhardt, 2007).

Uncertainty is central to questions about the efficacy of corporate climate action. Not all organizations are considering their climate change impact and many that have make limited commitments (Jones & Levy, 2007). Stemming from a lack of clarity regarding future domestic and international climate change policies, many corporations have adopted a "wait and see" approach (Boiral et al., 2011; Sullivan, 2008). This may be particularly true of companies operating within countries that have implemented little regulation and where stakeholder pressure is relatively weak (Boiral et al., 2011). Boiral et al. (2011) point to Canada as an example of a country where a lack of regulatory and stakeholder pressure has resulted in "superficial responses from firms or implementation of measures that do not really improve performance" (Antecedents section, para. 5). However there is evidence to suggest that even in Europe, a region that has been relatively progressive with respect to regulatory action, most companies have adopted a passive stance (Sullivan, 2010).

While most of the literature focuses on discussion about motivations and benefits, a limited number of studies have corroborated the "wait and see" theory by examining how corporations have implemented GHG emission reduction strategies. Sullivan (2010) conducted a benchmark study assessing the GHG management actions of 125 European companies. The findings suggest that most companies have weak climate change policies. That isn't to say that these companies were not implementing GHG management systems, indeed 92% had published climate change policies, 90% had produced GHG emissions inventories, and 86% had perceived at least some of the risks and opportunities associated with climate change. However, only a few of these companies had "made explicit commitments to achieving significant reductions in emissions"(Sullivan, 2008, p. 45). Among a number of other factors contributing to this conclusion, the study found that company reduction targets were relatively weak, and that there was no clear indication as to how targets were to be reached. Reflective of these findings, only 13% of companies had reduced emissions by more than 3% in the 5 years prior to the study.

Jones and Levy (2007) similarly conclude that current market-based approaches and voluntary actions to reduce GHG emissions may be insufficient to combat global climate change. The study characterizes the current GHG emission reduction regime as one that encourages companies to place “more emphasis on management processes, policy influence, and market image than on major investments in risky low-emission technologies” (Jones & Levy, 2007, p. 438). As a result, corporations are implementing the management systems, policies and carbon trading infrastructure to reduce emissions, but are experiencing very little in the way of tangible reductions. The authors attribute this ineffectiveness to a GHG regime that is weak and highly fragmented and lacks the necessary firm regulatory and economic incentives for companies to take substantial action (Jones & Levy, 2007). Furthermore, existing carbon trading schemes carry weak price signals that fail to drive any change.

The findings of such studies cannot be said to be true of all corporations, as the focus is almost strictly limited to performance within a certain region. For instance, the majority of studies have focused on corporate action within very developed nations (Boiral et al., 2011; Hoffman, 2010; Jones & Levy, 2007). Jeswani et al. (2008) conducted a study examining the corporate climate change action of corporations within Pakistan and the United Kingdom, providing the only comparison between developed and developing world initiatives. The findings suggest that due to a number of barriers, including: lack of financial resources, lack of awareness, lack of expertise and absence of policies, corporations in Pakistan were much less active in responding to climate change than those in the UK. However, as these corporations adopt their own management strategies, and continue to develop in emerging economies, they have unique opportunities to learn from the mistakes and unsustainable business principles that have been adopted by some corporations in developed countries (Jeswani et al., 2008).

2.1.5 Corporate Action Summary and Additional Research

Throughout the literature there is consensus that corporate climate change action is a complex issue that has significant economic, social, political and stakeholder implications. Corporations have begun to address the issue and researchers have sought to better understand the motivations, benefits and efficacy of corporate climate change action. While the development of the “win-win” discourse has attempted to make clear the associated benefits, studies have suggested that current implementation of mitigation strategies is highly-fragmented and ineffective at producing substantial emission reductions at a rate needed to prevent irreversible warming of the global climate. Some researchers and NGOs point to the need for greater political leadership to produce policy and regulations that can influence positive corporate GHG emissions performance (Boiral et al., 2011; Carbon Disclosure Project, 2012b; Center for Climate and Energy Solutions, 2012a; Jones & Levy, 2007).

There are a number of gaps in the relevant literature still needing to be addressed. There is a need for additional research into the motivations and factors influencing GHG performance of companies – including the specific position and opinions of senior management (Boiral et al., 2011). There are also a very limited number of case studies focusing on the GHG management process at specific companies. Insight into how companies are adapting GHG standards and accounting to their specific industries is also limited.

2.2 Carbon Accounting, the Carbon Footprint and Corporations

2.2.1 GHG Accounting and Reporting Standards and Principles

The IPCC has provided the fundamental basis not only for national and provincial policy, but for international GHG accounting standards focusing on organizational carbon footprinting (WRI & WBCSD, 2001). Among these are the *Greenhouse Gas Protocol Initiative* standards published by the WRI and the World Business Council for Sustainable Development (WBCSD). The two organizations first conceived of a corporate GHG accounting standard in 1997 (Greenhouse Gas Protocol, 2012). Working closely with environmental NGOs and industry partners they published the first edition of *The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard* (referred to simply as *The GHG Protocol*) in 2001. The corporate standard was developed to assist companies to accurately account for their GHG emissions (WRI & WBCSD, 2001). Since that time, the WRI and WBCSD have continued to refine the standard based on feedback from organizations. The GHG Protocol is the most widely used standard of its kind (Greenhouse Gas Protocol, 2012).

The primary function of the standard is to provide guidance for the development of corporate GHG inventories. The standard defines a GHG inventory as: “A quantified list of an organization’s GHG emissions and sources “ (WRI & WBCSD, 2001, p. 99). It includes consideration for the emission of the six Kyoto Protocol GHGs: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulphur hexafluoride (SF_6). Among its most critical components are the advisory sections on organizational and operational boundaries; they help to define which emission sources a corporation should count towards their inventory.

Setting an organizational boundary, either by equity share or control approach, will determine which emissions sources related to a corporation's operations will be included in their inventory. Put simply, the equity share approach assigns responsibility for emissions based on the percentage share of equity a company has in an operation. The control approach assigns responsibility for emissions based on processes, buildings, or operations over which a corporation has control. This control can be defined in operational or financial terms(WRI & WBCSD, 2001).

Beyond general organizational boundaries, the GHG Protocol standard outlines a framework for scoping GHG emissions by formulating operational boundaries. The standard assigns three different classifications, or scopes of emissions, as a means of providing typology for direct and indirect emissions. Direct emissions are those that result from sources owned or operated by the organization – these are emission sources that would likely be controlled by present or future regulation. Indirect emissions result as a "consequence of the activities of a company but occur at sources owned or controlled by another company" (WRI & WBCSD, 2001, p. 25) – identifying these sources can give an organization the opportunity to go beyond their operational boundary and influence reductions of emissions within their value chain. Making this distinction allows an organization to evaluate a broader range of emission sources associated with not only their operations, but with their supply chain, wastes, and employee's behaviour. By further dividing indirect and direct emissions into separate scopes, the standard seeks to "provide utility for different types of organizations and different types of climate policies and business goals" (WRI & WBCSD, 2001, p. 25).

Scope 1 emissions are direct GHG emissions from fuel sources, physical or chemical processing, and transportation of products, wastes and employees (WRI & WBCSD, 2001). Some examples of Scope 1 emission sources are detailed in the table below:

Table 1 - Examples of Scope 1 Emission Sources	
Company Description	Scope 1 Emission Source
Parcel Delivery Company	Tailpipe emissions from fleet vehicles.

Electricity Generation Corporation	Stack emissions resulting from the generation of electricity at coal-fired power plants.
A Refrigeration Appliance Manufacturer	Hydrofluorocarbon emissions resulting from the manufacturing process.

Scope 2 emissions include electricity-related indirect emissions resulting from the generation of purchased electricity. Scope 3 emissions are other indirect emissions that may relate to company-specific activities or processes (WRI & WBCSD, 2001). These may include emissions resulting from the production of purchased materials, outsourced activities and disposal of waste materials. Some specific examples of Scope 3 classified emissions are detailed in the table below:

Table 2 - Examples of Scope 3 Emission Sources

Company Description	Scope 3 Emission Source
Automobile Manufacturer	Tailpipe emissions associated with the usage of produced vehicles by customers.
Oil Exploration and Extraction Corporation	The emissions associated with employee flights taken for business travel.
Grocer	The emissions associated with the agricultural processes required to grow produce that is sold to customers.

This scoping system has not only been adopted by users of the standards, but embraced throughout the literature as a useful way of framing discussions about emission sources (Carbon Disclosure Project, 2012b; Hoffman, 2005; Lee & Cheong, 2011; United States Environmental Protection Agency, 2012). The scope typology is employed as a framework for developing process maps, and for conceptualizing emission sources throughout the scenario analysis (refer to section *3.5 Method*).

Beyond considerations of boundary and scope, the standard focuses largely on prescribing best practices by which corporations can build, maintain and report a GHG inventory. Guidance is provided for designing an inventory, tracking emissions over time, calculation methodologies, managing inventory quality, accounting for reductions and verification. The standard provides a general framework and set of principles for organizations to adhere to when accounting for their GHG emissions. Standards such as the GHG Protocol not only provide useful methods, but also serve to assure businesses that their GHG inventory and reporting are both credible and comparable (WRI & WBCSD, 2001).

The WRI and WBCSD published the *Corporate Value Chain (Scope 3) Accounting and Reporting Standard* (WRI & WBCSD, 2011) in September 2011 to provide organizations with guidance for Scope 3 emission sources. The standard is accompanied by a quantification guide that prescribes means by which organizations may measure their indirect emissions.

The International Organization for Standardization has also developed a set of standards for accreditation of corporate GHG emissions accounting and reductions. The *ISO 14064-1*: *Specification with guidance at the organization level for quantification and reporting of greenhouse gas emissions and removals* (International Organization for Standardization, 2006a) standard is designed to be GHG program neutral; it is streamlined in order to be used in conjunction with other related international standards, namely, *The GHG Protocol*. The organization has also produced two additional standards in the series – *ISO 14064-2: Specification with guidance at the project level for quantification, monitoring and reporting of greenhouse gas emission reductions or removal enhancements* (International Organization for Standardization, 2006b) and *ISO 14064-3: Specification with guidance for the validation and verification of greenhouse gas assertions* (International Organization for Standardization, 2006c).

Under the ISO 14064 series standards, where other GHG programs are applicable, requirements of that GHG program are additional to the requirements of the ISO standard. Furthermore, "where ISO 14064 prohibits an organization from complying with a requirement of the GHG program, the requirement of the GHG program takes precedence"(International Organization for Standardization, 2006a, p. 11). The standard is relatively flexible in this respect and is meant to be utilized in conjunction with guideline standards like *The GHG Protocol*. The ISO 14064 series standards are meant to accredit the GHG emissions accounting processes of organizations.

Despite the development of GHG accounting standards, a limited number of works have provided general guidelines and principles whereby organizations may consider measuring and reducing their organizational carbon footprint (Hoffman, 2010; Lingl, Carlson, & The David Suzuki Foundation, 2010). Drawing from applicable standards, and the unique carbon management experiences of some organizations, these publications outline principles for setting reduction goals, assessing carbon risks and opportunities, and for engaging the organization in related activities. They generally approach the issue and do not prescribe specific methods or tools that may be utilized by an organization.

There is a gap in the literature with respect to the provision of systematic approaches and tools to assist organizations in the reduction of their corporate carbon footprint. While there are a number of prescriptive sources for GHG emission quantification, there continues to be a need for approaches that can help organizations to evaluate their carbon opportunities and risks and manage accordingly.

2.2.2 The Root of the Footprint Concept

The term ‘footprint’ appears to have been first used to describe anthropogenic impacts on the environment in 1996 by two researchers from the University of British Columbia, William Rees and Mathis Wackernagel . Wackernagel and Rees (1996) suggest that a necessary condition for widespread acceptance of the sustainability concept is the development of a “meaningful unit to measure the natural capital requirements of the [human] economy” (p. 54). Furthermore, this measure should quantify *natural capital* in terms of an area-based estimate of the ecologically productive land (or water) needed to provide the energy and material needs, and absorb all the discharged wastes, of a population (Wackernagel & Rees, 1996). The authors suggested that this measure should be applied to households, businesses or governments. The ecological footprint then, as they defined it, is a measure of the land and water area needed to support a defined human population for an indefinite period of time (Wackernagel & Rees, 1996). This footprint accounts for “the flows of energy and matter to and from any defined economy and converts these into the corresponding land/water area required from nature to support these flows” (Wackernagel & Rees, 1996, p. 49).

2.2.3 The Carbon Footprint: A Problem with Definition

In response to increasing awareness of global warming within the last twenty five years, the ecological footprint concept has been explicitly adapted to the climate change issue, diverging from the more generally applied original developed by Wackernagel and Rees (East, 2008). The term *carbon footprint* has become increasingly popular amongst and widely used by governments, businesses, and the general public in recent years. It is difficult to trace the divergence of the concept to a single source but its adoption throughout the literature and popularity amongst GHG accounting practitioners can be attributed to the increasing attention that climate change has received over the last twenty-five years, much of which stems from the international political arena (Pulver, 2007). However, the *carbon footprint* has become so operationally disassociated from the *ecological footprint* concept that it no longer includes consideration for one of its fundamental principles: the association with a land/water area estimate needed to sustain a specified material/energy flow indefinitely.

As a result, the carbon footprint concept has lost the explicit association with measurable sustainability inherent in the original *footprint* concept. When a carbon footprint is measured and reported, it is done so in units of total CO_2 or CO_2e emitted, and the area of ecologically productive land needed to naturally sequester those emissions is not intrinsically linked. Wackernagel and Rees (1996) suggest that the land-area estimate has utility in its ability to express the extent to which an individual, population, business, etc., have exceeded the local carrying capacity – a measure that would reveal the unsustainable nature of human activity, particularly in the developing world. This measure helps to put flows of energy and matter into broad perspective and it makes clear a tangible association between action and consequence. Having lost these qualities, the carbon footprint concept is a much simpler measure that does not incorporate consideration for natural regenerative capacity. This consideration is only discussed within the literature to a very limited extent (Wiedmann & Minx, 2008). Wiedmann and Minx (2008) suggest that this indicator has been dropped because of the uncertainty associated with relying on a number of different assumptions. For the purpose of standardization and comparability, a very accurate emission-based measure that can allow corporations to benchmark their activities may be necessary. Due to the difficulties in producing precise measurements regarding carbon content in productive land, such a measurement is problematic for the purposes of carbon accounting and trading.

In addition to the loss of this association, the carbon footprint concept has recently experienced a crisis of definition. A review of relevant peer-reviewed literature reveals that the term *carbon footprint* is rarely defined in relevant publications and that the limited available definitions vary, covering a broad set of concepts or processes within the realm of carbon emission measurement and accounting. This finding is corroborated by Wiedmann and Minx (2008) and seeking to rectify the problem, the authors provide the following definition for a carbon footprint: “a measure of the exclusive total amount of CO_2 emissions that are directly and indirectly caused by an activity or are accumulated over the life stages of a product" (p. 3). In the same year of publication, Gell (2008) defines *carbon footprint* with respect to a business:

> A commonplace business metric for CO_2 emissions is the carbon footprint. The carbon footprint of a business is not just the carbon dioxide (and equivalent) emissions associated with utilities, such as electricity, oil and gas. The footprint includes many other contributions, ranging from embodied emissions in materials, equipment and infrastructure, through to travel and the services either used or supplied by the business. (p. 271)

The author applies the carbon footprint concept to the business environment, but stops short of providing a succinct definition that is unique to the corporate context.

Drawing from available definitions, it is clear that a carbon footprint is a measurement of the flow (including both inputs and outputs) of carbon with respect to anthropogenic activities. However, as exemplified by these two sources, there is a range of definitions for the term. As East (2008) explains, the differences in definition often stem from two key elements that are specific to the intended use of the footprint: 1) units of measurement, and 2) scope of measurement. Indicative of the later, while Wiedmann and Minx (2008) are concerned strictly with CO_2 emissions; Gell (2008) includes consideration for CO_2 equivalents. Carbon equivalents, in units of CO_2e, are other Kyoto gases that have been converted to their equivalent atmospheric warming potential using carbon dioxide potential as a reference (IPCC, 2007). Further complicating the matter, many peer-reviewed articles in which *carbon footprint* appears in the title focus on measuring and reducing carbon dioxide (and equivalent) emissions without providing a definition of the term (Emadi, Sohrabi, Jamiolahmady, Ireland, & Robertson, 2011; Friedrich, Pillay, & Buckley, 2009; Virtanen et al., 2011).

Internationally recognized GHG accounting and reporting standards, like the World Resource Institute's (WRI) *Greenhouse Gas Protocol* (referred to as *The GHG Protocol*) and the International Organization for Standardization's ISO-14064 series standards, have adopted an entirely distinct GHG accounting language. Only rarely do they use the terms *greenhouse gas footprint* or *emissions footprint*, and *carbon footprint* is absent entirely. The WRI standard avoids addressing scoping and unit conflicts attributed to the carbon footprint definition by adopting a language more specific to the GHG accounting discipline. For instance, where a business's carbon footprint can include consideration for CO_2e emissions *and* for carbon offsets, a GHG inventory strictly considers emission sources. Furthermore, where the carbon footprint concept may refer more broadly to all indirect and direct GHG emissions and offsets associated with a corporation, a *greenhouse gas inventory* is more specifically "a quantified list of an organization's GHG emissions and sources" for the purpose of accounting (WRI & WBCSD 2001, p. 99).

The literature reveals the problematic nature of defining *carbon footprint* as it applies to the corporate context. As a result of the inconsistently and ambiguity often associated with the use of the term, for the purpose of this study, a carbon footprint will be explicitly defined and adapted to the corporate perspective (see section *3.3 Defining the Corporate Carbon Footprint*).

2.2.4 Use and Application in the Literature

The publication of peer-reviewed literature regarding carbon footprinting has dramatically increased since 2003. Indicative of the rapid increase, a search conducted in April, 2012 for the term *carbon footprint* in the title, abstract or keywords of articles accessed by the Scopus index returned 1,217 results. Of these, four articles were published between 2003 and 2006, 582 between 2007 and 2010, and 631 within the 16 months prior to and including April, 2012 (Scopus, 2012). Similar results were obtained with the Science Direct and Scholars Portal indices.

Articles primarily focus on the measurement and reduction of the carbon footprint associated with specific products, services, processes, regions, industries or countries and very few on corporate or organization carbon footprinting (Bevilacqua, Ciarapica, Giacchetta, & Marchetti, 2011; Carballo-Penela & Doménech, 2010; Das, 2012; Edwards, McKinnon, & Cullinane, 2010; Franchetti & Kilaru, 2012; Gan, Liang, Hamel, Cutforth, & Wang, 2011; Gooding, 2012; Huang, Weber, & Matthews, 2009b; Ilic, Staake, & Fleisch, 2009; Jensen, 2012; Johnson, 2012; Karimi, Qureshi, Bahramloo, & Molden, 2012; Larsen & Hertwich, 2011; Leonardi & Browne, 2010; Stein & Khare, 2009). Limiting the aforementioned Scopus search by using the *corporate*, *company*, and *business* modifiers returned 29, 159 and 112 results respectively. Of these, only very few focus specifically on analysis of GHG emission measurement and reduction for organizations. Although IPCC publications were among the first to address the issue of GHG emissions measurement and management, references within the organization's reports apply to specific quantification methodologies for processes, products, and materials (IPCC, 1996). The importance of the contributions made by the IPCC towards the development of GHG specific metrics and measurement tools, upon which many organizations rely, should not be discounted. However, concerning the development of an organization-focused approach for carbon footprinting, the IPCC material is limited.

The peer-reviewed literature regarding corporate carbon footprint approaches is limited, particularly with respect to specific case studies, a gap that this study may help to address. Although some work has focused on sustainability indicators within the industry (Searcy, Karapetrovic, & McCartney, 2007), an in-depth literature search has failed to find any peer reviewed articles focusing specifically on strategic methods related to GHG emissions measurement and reduction within the electric transmission and distribution utility sector. As *The GHG Protocol* and Hoffman (2010) suggest, standards and carbon accounting activities should be informed by industry-specific information regarding emission measurement and reduction strategies, information that the relevant standards cannot provide due to their generality.

There are a limited number of case studies that are explanatory in nature, providing a summary of actions that particular organizations have or have not taken to reduce their corporate carbon footprint (Hoffman, 2010; Lee & Cheong, 2011; Lingl et al., 2010). One study focuses on a particular component of corporate carbon footprint analysis. Lee and Cheong (2011) provide an investigation of the carbon management practices of the Hyundai Corporation's supply chain. However, their investigation focuses very narrowly on how the corporation has measured the carbon footprint of a single vehicle component. The article does not attempt to provide a holistic approach, but rather serves as a detailed brief on accounting for the carbon emissions associated with a product's life-cycle. As a result, the article may lend itself better to research regarding life-cycle assessment and assigning appropriate boundaries on accounting for carbon in the value chain.

Hoffman (2010) provides case studies detailing the carbon reduction commitments of six large American corporations. The case studies profile each organization, provide an account of the implementation of their climate change program, describe how these programs were integrated within the organization, and detail associated challenges and success stories. Although general principles can be derived from these accounts, they do not include a prescription for a systematic approach to carbon footprinting. Rather, the case studies exemplify how fragmented carbon footprint reduction strategies can be by demonstrating how each organization perused a unique and organization-specific approach.

Articles relating to corporate carbon footprinting suggest that the practice continues to develop with regard to accounting for indirect emission sources (Hoffman & Busch, 2008; Huang, Weber, & Matthews, 2009a, 2009b; Scholz & Wiek, 2005). They focus largely on accounting for corporation's Scope 3 emission sources. Huang et al. (2009a) assert that the existing carbon footprint standards, such as *The GHG Protocol* and *ISO 14064*, focus primarily on scope 1 and scope 2 emissions, and that less focus is directed at a company's upstream and downstream indirect emissions. This gap has been addressed by the recent publication of a Scope 3 standard (WRI & WBCSD, 2011), but the screening and measurement of indirect emissions has received much attention within the literature.

Accounting only for direct emissions is problematic as Huang et al. (2009a) estimate that, on average, 75% of a company's carbon footprint can be attributed to scope 3 sources. Matthews, Hendrickson, and Weber (2008) similarly suggest that by accounting strictly for direct, and energy indirect emissions (Scope 1 and 2 emissions) an organization is accounting for only twenty-six percent of their total carbon footprint. The authors recommend that corporations utilize a screening-level analysis and adopt a broader view of their carbon footprint- including consideration for indirect supply-chain emissions.

Both Huang et al. (2009a) and Lenzen (2001) stress that an important consideration with regard to carbon footprinting is the inherent trade-off between the amount of primary data which must be collected, and the portion of a company's carbon footprint for which the data will account. Where methods of accounting for Scope 3 emissions have been problematic is in accounting for the totality of emissions across the entire supply chain. For instance, if *Company A* has 100 primary suppliers, which in turn each have 100 of their own primary suppliers, *Company A* has a total of 10,000 suppliers accounting strictly for tier 1 and tier 2 suppliers (including primary and secondary suppliers). The number increases for every additional tier that is considered and as a result, any individual attempting to account for the inputs associated with a company's entire supply chain faces a nearly impossible task.

Accounting for any Scope 3 emissions can be a costly and time-consuming process, involving investigation of a vast number of up-stream supply-chain emission sources (Huang et al., 2009a; Lenzen, 2001). In response, Huang et al. (2009a) propose the use of input-output analysis, specifically Economic Input – Output Life Cycle Assessment (EIO-LCA), to determine which upstream emission sources are most significant and likely to contribute largely to a company's carbon footprint. EIO-LCA is a model derived from a procedure known as input-output analysis. Input-output analysis has been proven as a useful tool for estimating the inputs associated with a product or service, or indeed an organization's entire supply-chain, when process life-cycle assessment data is not available (Huang, Lenzen, Weber, Murray, & Matthews, 2009; Murray & Wood, 2010).

Input-output analysis is an accounting procedure that draws from national input-output tables to give practitioners an understanding of the monetary flows to and from discrete sectors of an economy (Murray & Wood, 2010). National input-output tables are published regularly by more than 100 countries and form the basis of the procedure. These tables document the "flow of money to and from the various industry sectors showing just how interdependent they are" (Murray & Wood 2010, p. 7). In broad terms, the tables document both the inputs (what is purchased by an industry to produce goods and services) and the outputs (what is sold by the industry) associated with each industry. Nations build and maintain these tables because they are invaluable for examining inter-industry relationships; for understanding how impacts to one sector could impact another. However, they are also invaluable for understanding the supply-chains of organizations. Each company is able to determine the total size of their industry, and can determine the portion of that industry that their company represents (Murray & Wood, 2010). Based on national input-output tables it is therefore possible to calculate how much of the industry's total inputs the company accounts for.

Perhaps the most profound aspect of input-output analysis is its ability to estimate all of a company's upstream inputs. It accounts for an infinite number of suppliers and captures an organizations entire supply-chain through mathematical processes that "turn an infinite series into a single matrix inverse" (Murray & Wood 2010, p. 19). Where detailed process and life-cycle assessment data is not available, input-output analysis serves as an exceedingly useful estimation tool.

The inventor of input-output analysis, Wassily Leontiff, always intended for it to be used to evaluate more than just monetary flows (Murray & Wood 2010). Within the past twenty years practitioners have increasingly been using the method to account for social and environmental effects of doing business, and not strictly those that are monetary. As Huang et al. (2009a) assert, "when the economic IO model is augmented with environmental information in matrix form, it estimates upstream life cycle environmental impacts of production activities by any sector in the economy" (p. 8510). The EIO-LCA is a variant of an input-output model that applies environmental indicators to the financial information within national input-output tables. The most progressive organizations in terms of carbon management have increasingly turned to EIO-LCA models to scope suppliers to determine the most significant sources of upstream GHG emissions (Murray & Wood, 2010). Once these significant sources have been identified, a company can then go about devoting time and resources to evaluating its carbon life-cycle in greater detail. This will allow an organization to identify those areas for emission reductions, and to track those reductions accordingly.

2.3 Scenario Analysis

2.3.1 Typology and Origins

The term *scenario analysis* is quite broad and encompasses an entire network of distinct types of futures studies – each with a different set of goals, objectives and outcomes. Researchers and practitioners have attempted to provide a number of typologies and there is no single agreed upon set of classification parameters. One useful distinction, adopted by Alcamo (2008), separates scenario analysis into two distinct streams: (a) inquiry-driven scenario analysis, and (b) strategy-driven scenario analysis. Inquiry-driven scenario analysis is primarily used by scientists as a research tool. It often involves the utilization of complex computer modelling in order to produce a product, usually a quantitative scenario. For example, the IPCC uses global climate models in order to run a number of scenarios using different constraints (eg. rainfall, temperature or ice cover) in order to carry out a scenario analysis for potential future climate change. These types of scenarios can be used as inputs for policy-making, but as Alcamo (2008) notes, inquiry-driven scenario builders are often "criticised for not working closely enough with policymakers and other stakeholders" (p. 23); individuals in the policy community receive the final scenarios, but they are not afforded the opportunity to engage with them.

Alcamo (2008) outlines a second scenario type, one that is more focused on interaction between researchers and stakeholders. Strategy-driven scenario analysis is strictly designed for planning. Building these types of scenarios involves analyzing and developing strategies in order to guide decision making and support those decisions that are most preferable for a specific organization or policymaker. Involving managers and directors in the scenario building process is an extremely important part of strategy-driven scenario analysis as it is often these stakeholders that will be affected by, or responsible for the success and acceptance of the final product (Chermack, 2011).

Strategic scenario analysis was first developed by the Shell corporation in the 1970's, and was first detailed in a publication by company strategist, Pierre Wack (Wack, 1985a). Wack and his cohorts were able to use strategic scenario analysis to predict the 1970's oil crisis and help the company mitigate losses. The method developed by Wack and his peers is often referred to as the "Royal Dutch Shell/Global Business Network matrix approach" and is considered the most popular and widely used form of strategic scenario analysis (Chermack, 2011). While inquiry-driven scenarios have proven to be incredibly useful, it is strategy-driven scenarios that can be utilized by managers and planners in order to better align organizations, businesses and industries to make sound decisions for the future (Alcamo, 2008).

2.3.2 Beyond a Forecast

The first developers of strategy-driven scenario analysis at Shell sought to redefine the ways in which the organization planned for the future. As was the case with most organizations at the time, and indeed in some cases today, Wack (1985a) acknowledges that planning for the future is often dominated by forecasting techniques. There are some important differences between forecasting and scenario analysis as outlined throughout the literature. It is important to distinguish between these differences, and here it will help to define and review scenario analysis. Wack (1985a) sees as one of the most significant downfalls of forecasting its projection of what is known of past circumstances onto the future. He acknowledges that forecasts are not always useless, that they are capable of sometimes predicting the future accurately, but only so in extremely stable environments; where moderate to significant changes are not likely to occur. In a world where dramatic change is the norm and not the exception, these forecasts can be rather problematic. Furthermore, more often than not forecasts fail to engage decision-makers to the same degree as scenario analysis, as they rely on simple predictions, often strictly involving quantitative figures (Wack, 1985b).

As van der Heijden (2005) observes, forecasting produces a single, predicted, future outcome and when the balance is disrupted, “this mode of forecasting fails first” (p. 21). By planning and managing around these forecasts, an organization can become extremely inflexible – leaving it vulnerable to sudden shifts and changes to the corporate environment. In terms of competitiveness, any organization relying on forecasting will be sluggish in response to these changes, giving faster responding organizations a clear and distinct advantage. By accommodating for narratives or separate and distinct scenarios ranging from the mild, *business as usual*, to the most extreme *doom monger* archetype, scenario analysis avoids the forecasting pitfall (van Asselt, 2002).

2.3.3 Driving Forces

As outlined by both Wack (1985a) and van der Heijden (2005), another aspect that distinguishes scenario analysis from forecasting is its inherent emphasis on driving forces. Forecasts rely on quantitative summaries and statistical interpolation and the final product is presented to decision makers in numerical format. Scenario analysis seeks to go beyond simple statistical analysis and attempts to determine and present the root causes and factors that will result in a future outcome. If a scenario were a complete puzzle, driving forces would make up the individual pieces. They are those aspects and factors that ultimately make up the storyline of a scenario and “determine the story’s outcome” (Alcamo 2008, p. 607).

The usefulness of driving forces is clear in the planning process – by brainstorming and identifying driving forces, and by avoiding reliance on statistical analysis, planners are more likely to understand root causes, they can structure the storyline, and are better equipped to understand possible outcomes. This is not to discredit statistical analysis, indeed it is extremely useful in many planning applications, but scenario analysis recognizes that it can be rigid and does not contribute to an understanding of why or how events occur.

Scenario analysis involves subjective contribution. For example, the researchers at Shell relied on instinct and intuition when postulating that many oil-producing nations would opt to limit oil production in order to increase the longevity of their reserves, rather than maximizing production and profits over the short-term (Wack 1985b). Driving forces are not only useful during planning, but also in presenting scenarios to decision-makers – as Wack recognized, they offer “the basis on which managers exercise their judgement” (Wack 1985b, p. 79).

Postma and Liebl (2005) offer three useful classifications for driving forces: (a) constant, (b) predetermined, and (c) uncertain. Constant factors are those that are known and relatively unlikely to change. Predetermined factors are those for which patterns are understood, but may not be predictable (for example, demographics and other statistics). Uncertainties are described as factors for which the outcome is known, but the coming about of the outcome is not. (Postma & Liebl, 2005).

One key concern with respect to driving forces is prioritization. Many researchers and practitioners outline the usefulness of the deductive approach, first utilized by Wack (1985a) and further developed by van der Heijden (2005). The search for driving forces can often initiate a snowball effect, whereby a seemingly endless number of aspects surface and the resulting confusion can stifle the planning process. It is necessary for practitioners to limit the number of driving forces and critical uncertainties by focusing on only those that are most significant. In addition to streamlining the planning process, this simplifies results for decision makers, and makes the decision making process much clearer (Chermack, 2011).

2.3.4 Participation and Perception

A key facet of any scenario analysis is participation of a number of stakeholders, employees and managers. As useful as scenario analysis is for strategic planning and evaluation of alternatives, increasingly it is seen as an exemplary tool for organizational learning (Postma & Liebl, 2005). Firstly, participation can be useful in encouraging acceptance of scenarios by managers – by participating in the process, managers not only develop a greater knowledge of the scenarios, but also a sense of ownership. However, the importance of participation in the process goes beyond encouraging acceptance. As Postma and Liebl (2005) explain, "more recently, scenarios aim at making managers aware of environmental uncertainties, stretching manager's mental models, and triggering and accelerating processes of organizational learning" (p. 163). The practitioners acknowledge that on his/her own, an individual can only perceive a limited understanding of the future. Wack knew that in order to create effective scenarios his team would have to branch outwards and incorporate the expertise of specialists from throughout the Shell organization (Wack 1985a). By doing so, the scenarios would become a construct of several points of view. According to Wack (1985a), "scenarios deal with two worlds: the world of facts and the world of perceptions" (p. 146). With a multitude of distinct and specialized contributions, a scenario becomes richer, and it is more likely to change the perception of a manager; to broaden the scope of their perceived possibilities. A primary objective of scenario analysis is to expand the number of imagined outcomes; to alter a singular perspective. This can equip individual decision-makers with the capacity to manage for alternatives that they otherwise would not have conceived (Wack, 1985a).

2.3.5 Criticisms and the Literature

Despite its usefulness, there are some limitations to the scenario analysis process. Firstly, scenario analysis is a resource intensive process (Volkery & Ribeiro, 2009; Wack, 1985a). An organization must be willing to devote the time and resources to ensure that the product of a scenario analysis is robust and useful. As Wack (1985a) exemplifies, scenario analysis is a learning process, whereby reworking of strategies and modifications are common. Wack and his peers made a number of attempts before their employer was satisfied with the results. Furthermore, the process is research intensive, and relies on the expertise of a number of professionals. As a result of the time- and resource-intensive nature of scenario analysis, organizations that operate under conditions that require very expedient planning may not benefit from the use of the method (Chermack, 2011).

One of the criticisms of scenario analysis is that the product is only as strong as the selection of the key driving forces (van der Heijden, 2005). Using a deductive approach, practitioners must be cautious with regard to selection of key uncertainties. Once selected, the analysis is affectively limited to those domains. For such a reason, Alcamo (2008) cautions that "the deductive approach can be seen as stifling creativity" (p. 56). Some practitioners have developed an alternative inductive approach whereby key driving forces are not explicitly set out at the onset of the process (United Nations Environment Program, 2003). Under this approach only general statements are set out that are designed to promote additional analysis and investigation (Alcamo 2008).

As discussed, scenario analysis requires a broad set of perspectives and a wide knowledge base. The use of specialists may be required in order to provide greater detail into the identification and functioning of driving forces. A wide array of opinions and perspectives is preferable. For this reason, scenario analysis may not be practical for smaller organizations to utilize as they may lack this diverse knowledge-base (Alcamo 2008).

The literature relevant to scenario analysis acknowledges the need for better organization of methods (Alcamo, 2008; Chermack, 2011; van der Heijden, 2005). Many authors have begun to address the issue. Almost all relevant articles included a basic outline of the scenario process, and acknowledged a few key practitioners as the main developers and driving forces of the practice. The two works that receive most credit for the establishment of the process are Pierre Wack's Scenarios: uncharted waters ahead (1985) and Kees van der Heijden's *The Art of Strategic Conversation* (van der Heijden 1996). Wack's article is often credited as the original guideline and document relating to scenario analysis – establishing the body of knowledge. He outlines how Shell made the switch from forecasting techniques to scenario analysis. The method is carefully outlined, and a detailed account of the progression of the process is provided. Perhaps the most profound section of Wack's article relates to influencing the mindsets of managers and decision-makers. Scenario analysis is useless if the product is not appealing to decision-makers and the whole process may be dismissed. Wack recognized this and outlines a process for redefining management's view of reality that emphasizes participation.

This sentiment is supported by van der Heijden (2005). In the book, the author provides a detailed description of the process of scenario analysis, including the history of the method, the basic principles, an outline of the practice as a planning tool, and suggestions for the integration of the process into the institution. However, one main and often cited aspect of the book relates to institutionalized and group learning. The title of the book, *Scenarios: The Art of Strategic Conversation* aptly summarizes the notion of group learning throughout the work. It prescribes a learning process that is not limited to an individual, but rather a network of people working towards an end. Van der Heijden stresses the need for a simple and unified directive in any organization attempting to utilize scenario analysis. However, the author is also cautious of the danger of too much integration. Just as the individual can develop a singular and isolated view of the future, so too can an organization as a whole. Van der Heijden remarks, "scenarios are the best available language for the strategic conversation, as they allow for both differentiation in views, but also bring people together towards a shared understanding of the situation" (van der Heijden 2005). Like Wack's article, van der Heiden's book is seen as one of very few seminal works in the practitioner knowledge, and as such, forms the basis upon which many of the practitioners analyze and utilize the method.

It is apparent in the literature that much more analysis and publication is needed in the discipline. Both Bradfield et al. (2005) and Bishop et al. (2007) argue that while there has been some continued development of the method, that a large portion of this work is "of little use to practitioners" (Bishop et al. 2007). Many articles outline very generally the method itself, review the current literature, or provide an overview of the adaptations and variations of the scenario analysis method. Chermack (2011) provides the most clear and concise detail of a step-by-step process for individuals to follow when conducting a scenario analysis. Where much of the work on scenario analysis broadly discusses the theory, core competencies and benefits of scenario analysis, Chermack (2011) also provides a practical guide that draws from the most seminal works related to the method. As a result, this thesis relies on this practical source for the use of the method.

2.3.6 Scenario Analysis for Environmental Management

The apparent need for development of the researcher and practitioner knowledge applies even more-so to scenario analysis with respect to environmental management and planning. Very few articles focus specifically on the development of strategy-based scenario analysis for the environment management field. Hojer et al. (2008) state:

> Although there is a clear need for futures studies in several tools for environmental systems analysis, it is interesting to note that the literature on methodologies for and case studies of combinations of future studies and environmental systems analysis tools is rather limited. (p.45)

The discipline is clearly in need of further development and publication in this respect, specifically so as strategic scenario analysis' intrinsic make it a potentially useful tool for environmental planning and management. Sustainable ways of thinking and managing are rather recent developments and may not have completely percolated through many organizations and corporations. As a result, they may greatly benefit from the kind of institutional learning and shared knowledge inherent in the scenario analysis approach (as described by both Wack (1985) and van der Heijden (2005). Because sustainability knowledge, science, policy and practice is currently continuing to develop, resulting in new requirements, barriers and opportunities, the approach has great potential for the sharing of this new knowledge – to assist in changing the perspective of decision-makers and managers towards new, greener options.

Höjer et al. (2008) set out to further the discipline with respect to environmental management. The article broadly outlines the traditional method for scenario analysis, however, it also includes strategies for integrating scenario analysis with environmental systems analysis tools. The authors include an analysis of useful means by which scenario analysis may be applied to specific analysis tools, like: strategic environmental assessment, life cycle assessment, cost-benefit analysis, life cycle cost analysis and system for economic and environmental accounting. However, for the purposes of environmental management, the most relevant suggestion is the integration of scenario analysis with environmental management systems (EMS). The authors argue that EMSs like ISO 14001 "are often focused on improvements of already existing activities" (p. 806) and that in this respect that there is a risk that "EMS can have a conserving effect instead of developing environmental strategies in organisations" (Hojer et al. 2008, p. 807). With respect to this argument, scenario analysis could be beneficially integrated into EMS planning and review in order to make the system more nimble and flexible. Hojer et al. (2008) note that specifically, "predictive scenarios can be useful for short-term risk reduction and reduction of costs, e.g. of coming legislation".

In these regards, scenario analysis has the potential to become a useful tool for assisting environmental decision making. Currently, the method is in need of further development in this respect. Case studies detailing the method's application for environmental management are needed. This study helps to address this information gap by providing a specific case study involving the application of the tool for GHG management.

2.4 Summary of Key Gaps in the Literature

The literature review has identified a number of key gaps relevant to corporate climate change actions. They include:

1. A lack of case studies that contribute to the ongoing dialogue about corporate motivation for climate change action, particularly with respect to investigating the mindsets of senior management employees;

2. A lack of systematic approaches to assist organizations in managing and planning for reduction of their corporate carbon footprint,

3. The need for a succinct definition of the corporate carbon footprint, and

4. The need for cases demonstrating the application of the strategic scenario analysis method to environmental management.

This thesis is uniquely equipped to address these gaps as a consequence of the intimate involvement of the case company, and through the application of the particular study methodology.

3. Case Study

The following chapter begins with an introduction to the case study method. In response to a gap in the literature, a succinct definition for the term *corporate carbon footprint* is provided. A brief introduction to the case company sets the context for the study by providing background information about related operations, relevant industry issues, and previous steps taken by the organization to address the corporate carbon footprint. The final section of the chapter provides a detailed explanation of the method employed to investigate the primary objective of the thesis.

3.1 Case Study Research

Yin (2009) defines a case study as “an empirical inquiry that investigates a contemporary phenomenon within its real-life context in which multiple sources of evidence are used ” (p. 18). Yin also suggests that case studies are especially useful when the boundaries between context and phenomenon are not clearly defined. Case studies are most usefully employed in the organizational context when focused on a particular facet, aspect, or unit of a company, as opposed to the organization as a whole (Noor, 2008). Furthermore, as both Yin and Forza (2002) suggest, case studies as a tool are most usefully employed to investigate issues or phenomena that have received relatively little focus in the past.

Characteristic of a case study, practitioners draw on a number sources of evidence to draw conclusion about a specific phenomenon. These sources can be qualitative or quantitative, and drawing from both types can often give a greater understand of the case being studied. Case studies attempt to provide detailed explanations for *how* and *why* something occurs (Yin, 2009). Practitioners suggest the strength of the method lies in its ability to give investigators insight into a complex issue or occurrence when investigating the system as a whole may seem impractical (Gummesson, 1991; Noor, 2008; Yin, 2009). As Flyvbjerg (2006) explains, "the case study produces the type of context dependent knowledge that research on learning shows to be necessary to allow people to develop from rule-based beginners to virtuoso experts" (p. 221).

Critics of the method suggest that case studies provide little in the way of generalization, that researchers are unable to apply what is learned from a specific case to entire system. In response, Yin suggests that case studies excel at generalizing theories and approaches, rather than populations. Furthermore, where scientists must conduct a number of trials or experiments to replicate phenomena under different circumstances (as it is difficult to generalize from a single experiment), the same is true for the case study method (Yin 2009). Case studies have strength in numbers; where one case study may be difficult to generalize from, multiple case studies may lead researchers to a more generalized and complete understanding of a phenomenon (Noor, 2008; Yin 2009).

3.2 The Case Study Adaptation

The study involves a unique marriage of two methods: a case study and a scenario analysis. Case studies focus specifically on contemporary and recent history (Yin 2009). The role of the investigator during a case study should be passive. Facts are gathered through interviews, observations and documentation to reveal the complex issues related to the subject. The researcher seeks to observe the phenomena, and beyond "informal manipulation" (Yin, 2009, p. 11) there is little control over behavioural events.

In contrast, scenario analysis seeks to understand the future; to investigate possible future outcomes by thinking strategically about a set of assumptions or potential future occurrences. By doing so it attempts to prepare decision makers for future uncertainty, but, in order to do so must intimately involve them in the process. As a result, scenario analysis is beneficial for its ability to promote organizational learning; it attempts to rigorously engage an organization in a strategic dialogue about a specific topic. It strongly encourages behavioural change and attempts to alter the mindsets of participants; to introduce them to new ways of thinking about an issue (Wack, 1985a).

Despite the fundamental differences between the methods, the case study has been complementary to the scenario analysis. In this study, early research focused on a literature review and company document review, two components that helped researchers to gain insight into the organization and relevant information about carbon accounting. This stage of the research was more reflective of the case study approach. However, it helped researchers to design the scenario analysis so that it would be particularly relevant to the organization. Researchers were able to gain insight into the unique decision making structure and environment, the previous efforts of the organization to reduce the carbon footprint, the corporate culture, the external forces relevant to the organization and the disposition with respect to carbon management. All of these factors contributed to the design of a scenario analysis that was specific to the organization, its carbon footprint, and the particular individuals that were involved in the process.

Furthermore, interviews lend themselves particularly well to both the case study and scenario analysis methods. While the primary function of the individual interviews conducted by researchers (detailed in section *3.5.4 Strategic Scenario Analysis*) was to gain insight into key driving forces and suggested scenario topics, researchers were able to gain valuable insight into the complex issues surrounding the organization's ongoing efforts to address its carbon footprint; to answer the 'how' and 'why' questions that Yin (2009) suggests the case study method is preferential for addressing. As a result, the interviews acted to reinforce both the scenario analysis and case study components of the research. Refer to section 3.5.4 for a detailed explanation of the strategic scenario building process.

The study is therefore equipped to contribute to academic dialogue about corporate motivations to reduce GHG emissions, to demonstrate how a large corporation has addressed their carbon footprint and to discuss the complexities of corporate carbon management, as well as to test a unique approach for engaging the organization in carbon management initiatives and providing mitigation options.

3.3 Defining the Corporate Carbon Footprint

The findings of the literature review suggest that the definition of the carbon footprint concept, particularly with respect to its application to corporations, remains problematic. There is a need for a succinct definition that is unambiguous about the scope of the measurement regarding direct and indirect emissions, and the inclusion of GHGs other than CO_2. For the purposes of this thesis, a corporate carbon footprint is defined as "a measure of the total amount of CO_2 and other GHG emissions that are directly and indirectly emitted or offset due to the operation of a particular business or corporation".

3.4 Introduction to the Case Company

The case company is a major North American electricity transmission and distribution company. The company has over 5,000 regular employees and approximately 2,000 temporary, contract and part-time employees. The company owns and operates almost all of the transmission capacity and most of the distribution system within the state/province in which it operates. This includes over 100,000 km of high-voltage transmission and low-voltage distribution lines; one of the largest electric grid networks in North America. The company directly provides electricity to over a million customers and to a number of local electricity distribution companies. This study is focused on the parent company - an entity that does not own or operate any electricity generation facilities.

To service its electricity system, the company operates a substantial fleet of over 7,000 vehicles, including: small cars, light trucks, heavy maintenance vehicles, helicopters and other vehicles. The fleet is complimented by service equipment, much of which is used for forestry activities. Furthermore it owns and leases a number of administrative buildings and warehouses. The organization is state/province owned and as a result is strongly influenced by the governing political authority.

3.4.1 Regulatory and Political Environment

The case company operates in a unique political and regulatory environment, particularly as a result of its ownership by the governing authority. The company is not yet regulated with respect to GHG emissions by this provincial/state authority. However, the company is required under federal regulation to report emissions of sulphur hexafluoride.

Despite the lack of formal regulation at the provincial/state level, the government plays an important role in directly and indirectly influencing the climate change action of the organization. The case company is mandated under its corporate policy to return value to its shareholders. As the government is the sole shareholder, the current political policies and platforms of the governing body have a substantial influence on the actions of the organization under this value component of the corporate policy. As the ruling political party has, over the past six years, made the reduction of GHG emissions within the province a significant component of its mandate, the organization has adopted a similar stance on climate change action (see section *4.2 Scenario Analysis*).

Beyond this type of influence, the provincial/state government influences the organization's climate change action in some other key ways. The government has laid the foundation for future regulation of

GHG emissions under a preliminary reporting regulation. Under this regulation, only the largest emitting facilities in the province/state are required to report emissions. As the threshold is well above even the case company's most intensive GHG emitting facilities, a reporting requirement for the organization is not triggered. However, the government has acknowledged that this is a preliminary step in a process to introduce regulation affecting a wider segment of organizations. The government has expressed interest in pursuing market-based reduction mechanisms in the future as a means of curtailing emissions across the largest emitting sectors of the economy.

Operating within a heavily regulated industry, the case company is substantially influenced by the governing authority directly. The organization's carbon footprint, and limitations or the ability to address that footprint are in turn influenced by regulation of the organization more generally. For instance, the price that the case company sets for the electricity is controlled through regulation, and as a result, the company is unable to influence GHG emissions through changes to its primary product pricing. Furthermore, the generation of the electricity the company purchases is also highly regulated. The makeup of the generation mix with respect to carbon intensity (tCO_2e/kWh) is highly dependent on this external factor. In an effort to reduce GHG emissions, the government has introduced a progressive energy policy and regulated the complete phase-out of coal-fired generation in the province/territory by 2014. The government has also introduced a feed-in tariff (FIT) program for renewable energy generation that encourages a shift away from large, centralized generation sources to privately owned, distributed sources. These changes have a number of consequences for the organization's carbon footprint which are discussed further in sections *3.4.2 The Case Company's Current Carbon Inventory*, section *4.2.3 The Scenarios* and *5.1.1 Line Loss and SF6 Emissions – External Forces, Stakeholder Influence and Technical Limitation*.

3.4.2 The Case Company's Current Carbon Inventory

Although not obligated by regulation, the company has, since 2007, taken steps to measure and reduce its corporate carbon footprint. The company has completed a preliminary GHG inventory inclusive of GHG emission sources that are currently measured. These initiatives are detailed briefly in the table below. Also included is the portion of that each emission source comprises of the overall GHG inventory.

Table 3 – The Case Company's Current GHG Initiatives and Inventory			
Emission Source	**Measured**	**Reduction Initiative(s)**	**Portion of the Carbon Inventory in 2010**
Scope 1			

Fleet - tailpipe GHG emissions resulting from fuel combustion.	Yes	Yes	5%
Transmission Switchgear - Sulphur Hexafluoride emissions from equipment leakage	Yes	Yes	7%
Natural Gas Usage in Buildings	Yes	Yes	0.3%
Scope 2			
Building Electricity Consumption	Yes	Yes	0.7%
System/Line Losses (electricity lost/consumed as heat during transport on lines and stations)	Yes	No	87%

A key emissions source of the case company (and any transmission and distribution utility) is the emission of sulphur hexafluoride (SF_6) resulting from the use of transmission switchgear. In an electric power system, switchgear is the combination of electrical disconnect switches, fuses or circuit breakers used to control, protect and isolate electrical equipment (United States Environmental Protection Agency, 2010). Switchgear is insulated with SF_6 gas, a powerful dielectric. It is used globally as the standard for the electric transmission and distribution industry. Under normal circumstances, switchgear equipment inadvertently emits SF_6 into the atmosphere due to leakage. The rate of leakage is proportional to the age of the equipment, becoming more substantial over time. Emission may also occur during the initial filling, maintenance, and recycling of such equipment (United States Environmental Protection Agency, 2010).

SF_6 is an extremely potent GHG with a global warming potential 23,900 times greater than that of CO_2. It has the highest warming potential of any GHG evaluated by the IPCC and is long-lived with an atmospheric lifetime of up to 3,200 years (United States Environmental Protection Agency, 2010).

As indicated by study participants, there are not any feasible alternatives to this equipment, nor is there an alternative gas which can perform the equivalent function. This opinion is corroborated by the United States Environmental Protection Agency's *SF_6 Emission Reduction Partnership for Electric Power Systems* program. Where applicable, this emission source may be referred to as *switchgear emissions* or *SF_6 emissions* throughout this study.

When high-voltage electricity travels across transmission and distribution lines and stations a portion is converted to heat energy. As a result, a transmission and distribution company loses a portion of the electricity it purchases from a generator before it can reach customers (Wu, Nadira, Weber, Thomas, & Maratukulam, 1993). These losses are commonly referred to as *line losses*. As losses can also occur at power stations, they may also be more generally referred to as *system losses*. Line loss or system loss emissions are categorized as indirect Scope 2 emission sources resulting from the consumption of purchased electricity (WRI & WBCSD, 2001).

Many utilities have total losses in the high range of 10% of all electricity traveling on the system (British Columbia Hydro, 2012). In the United States, on an annual basis an average of 7% of all electricity on transmission and distribution systems is lost (The United States Energy Information Agency, 2012).

The reduction of losses is an extremely capital intensive process. Utilities are required to replace major infrastructure such as transmission lines and stations in order to realize efficiency gains. As explained by the company liaison involved in this study, organizations cannot use GHG emission reduction as a justification for replacing major infrastructure because of the capital intensive nature of the activity. Throughout scoping discussions, an indeed as was reinforced by benchmark participants, it is not currently an area on which utilities can afford to focus their GHG emission reduction initiatives.

However, like any other Scope 2 emission source, the intensity of line loss emissions is dependent on the generation source used to supply the consumed electricity. Therefore, changes to the generation source produce intensity changes for the Scope 2 sources for which they are providing electricity. As a result, line loss emissions are particularly affected by external changes to the generation mix. Where a transmission and distribution company purchases most of their power from coal-fired power plants, line loss emissions will be substantial due to the fossil-fuel intensive generation source. Some transmission and distribution utilities that derive electricity from almost entirely renewable energy sources do not measure line loss associated emissions as they are deemed negligible.

If a fossil-fuel intensive generation mix were to shift towards greener, renewable sources then the intensity of an organization's line loss emissions would decrease. This is the case in the region in which the case company operates. The generation sources from which the organization derives the electricity it sells to its customers are becoming significantly less fossil-fuel intensive. As a result, the organization will experience significant reductions to the Scope 2 component of its corporate carbon footprint over the next decade due to external factors (a key consideration of the scenarios detailed in section *4.2.3 The Scenarios*).

3.4.3 Emission Reduction Initiatives

The initiatives to mitigate Scope 1 and Scope 2 emissions (associated with the fleet, buildings and switchgear) have been rigorous over the past five years; the company continues to implement practical emission reduction options for Scope 1 sources. These initiatives include:

1. Fleet emission reductions,

- Integration of fuel efficient and hybrid vehicles where feasible.
- Tire inflation program to ensure fuel efficiency.
- GPS tracking for better route planning.
- Driver training towards more efficient vehicle operation.

2. Building emission reductions, and

- Heating, ventilation and air conditioning (HVAC) retrofits to increase building energy efficiency.
- Lighting retrofit program aimed at installing more efficient lighting in facilities.
- Pursue Leadership in Energy and Environmental Design (LEED) certification standards for new buildings.

3. Switchgear equipment reductions.

- Replace aging equipment with new units that are more efficient and have a lower rate of leakage.
- Recycle SF_6 gas remaining in units taken out of service.

The company sets annual targets for emission reductions for each initiative undertaken. Total reductions are included on the company's internal reports on an annual basis. Emission reduction emissions are proposed and evaluated by the company's 'green team' made up of fifteen individuals representing different business units. A challenge associated with this study is to build on the substantial efforts previously undertaken by the organization. The company has largely taken advantage of the most readily available and identifiable options for emissions reductions.

3.5 Method

The study was designed to apply the approach to the case company using a number of tools and inputs. These tools were chosen specifically for their ability to contribute to the completion of study objectives. A general outline of the applied approach is detailed in Figure 1.

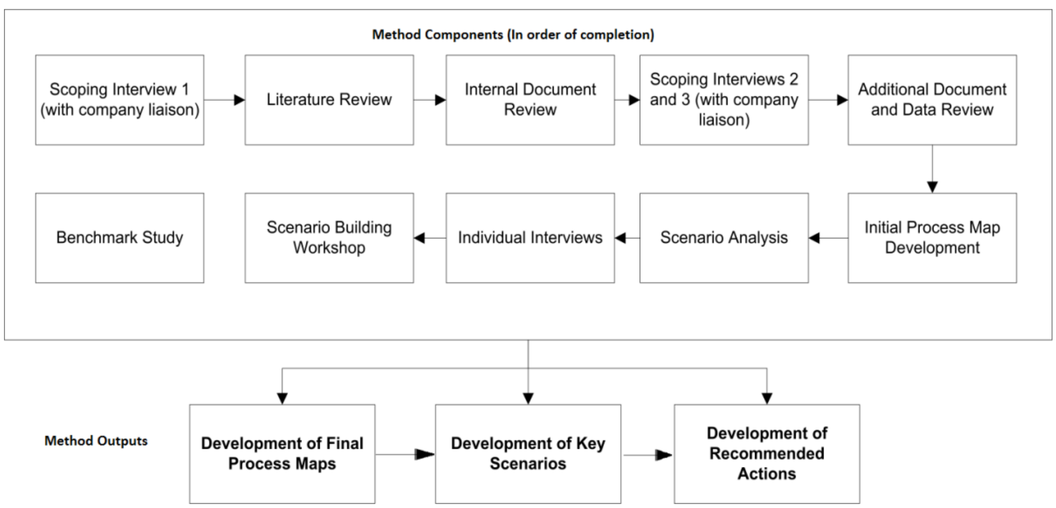

Figure 1 – The Approach Applied with the Case Company.

The study draws from information sources both internal and external to the case company to gain perspective on the organization, and relevant climate change issues. For the purpose of facilitating internal document collection, providing insight into the needs of the organization, and arranging meetings and workshops with members of the case company's senior management team, a company liaison was assigned to the study. The company liaison is a senior management-level employee at the case company who was involved in the project from inception to conclusion. As outsiders to the industry, the research team relied on the liaison for his/her expertise and organization-specific knowledge.

3.5.1 Internal Documentation and Literature Review

At the outset of the study, the company liaison provided relevant internal documentation. Internal company documents were used to gain insight into: the organizations mandate and related policies, steps the organization has already taken to measure and reduce GHG emissions, data related to GHG emissions already measured, information about the organization's 'green team', the nature of the organization's operations, which emission sources are currently measured and mitigated, and GHG emission management initiatives the organization is planning for the future.

The collection and review of the relevant internal documentation set the context for the study. Researchers not only developed an understanding of the measures the organization was already taking to reduce GHG emissions, but were able to determine which emission sources the organization felt were the largest contributors to the entire footprint. Furthermore, the information within the documents gave researchers an understanding of the external forces that were relevant to the organization. For instance, the direct and indirect impacts associated with specific legislation focused on greening generation within the political jurisdiction. Information gathered from internal documents served as an input not only for the process maps, but for the scenario analysis.

In addition to the internal document review, a literature review was conducted of relevant material. This included information pertaining to the relevant standards, methods, carbon footprinting, and corporate climate change action.

Once this foundational information had been reviewed, the study needed to be appropriately scoped with regard to time limitation, needs of the organization, and involvement and time commitment of company personnel.

3.5.2 Study Scoping

Throughout the early stages of the research, the study team worked in close consultation with the company liaison in order to develop the scope of the study. Three separate interviews were held in order to determine how the study could best address the needs of the organization. The interviews also provided a unique opportunity to contribute to the academic knowledge by gaining insight into the mindsets of key decision makers regarding corporate carbon management. Scoping interviews took place in person, and over the telephone at the company liaison's convenience. Additional scoping concerns were addressed as they arose throughout the course of the study. Some specific considerations that were discussed during scoping interviews include:

1. Current study progress,

2. Clarification on some of the provided internal documentation,

3. How the study would complement initiatives already underway at the organization,

4. Necessary modifications to the study plan,

5. Data availability,

6. Time commitments of participating employees, and

7. Progress to be made within the months following the interview.

As the study was completed in partnership with an organization, these interviews were an invaluable opportunity to gather information and opinions from a perspective internal to the company. The meetings insured that the study remained relevant and useful to the case company.

3.5.3 Process Mapping

A process map is an illustrated model of work or relationships (Damelio, 2011). There are three general types of process maps: (a) relationship maps, (b) swim-lane diagrams, and (c) flowcharts.

Relationship maps visually depict the different parts, departments or units within an organization, and the internal or external relationships between those parts. A swim-lane diagram is an illustration of the workflow within an organization. Swim-lane diagrams trace the temporal flow of work from start to finish. A flowchart is an illustration that depicts a sequence of activities that are used to create, produce, or provide a unique output (Damelio, 2011).

Relationship maps were identified as the type of process map that would best be utilized to fulfill the first primary objective of the study: to systematically identify the case company's carbon footprint. Relationship maps allow researchers to provide an illustration of the individual GHG emission sources attributed to each organizational unit within the case company.

For the purposes of this study, the maps were developed using a number of principle inputs:
(a) information within relevant standards about the types of emission sources an organization may account for, (b) internal and external company documents that detail corporate operations and GHG emission sources previously considered, (c) feedback about process map drafts from employees

participating in the study, and (d) the benchmark component of the study. In addition, the maps included consideration for upstream and downstream emission sources. Finally, the process maps include indicators for current GHG emission data quality.

The maps not only help the case company to identify emission sources not previously considered, but assisted in the scenario analysis component of the study. The visual representation of the company's emission sources helped participants, who were a multi-disciplinary sample, to conceptualize the full range of activities that contribute to the corporate carbon footprint.

3.5.4 Strategic Scenario Analysis

Strategic scenario analysis is a planning tool that attempts to account for uncertainty in the strategy building process. The analysis is premised upon the consideration of possible future outcomes that have the potential to dramatically impact a region, government, or organization. By considering key driving forces that are both uncertain, and have the potential to impact an organization, the process prepares decision makers for uncertain future outcomes. The purpose of the analysis is not to produce one scenario that "gets it right", but to have "a set of scenarios that illuminates the major forces driving the system, their interrelationships, and the critical uncertainties" (Wack 1985a, p. 141). As a result of pre-emptive consideration, decision makers are better equipped to adapt to sudden changes in the corporate environment due to these forces.

Scenario analysis emphasizes collaborative thinking and learning. By facilitating a strategic conversation between a diverse group of stakeholders, the tool has the potential to promote organizational learning (van der Heijden, 2005). Scenarios are enriched by the inclusion of a multidisciplinary group; practitioners are encouraged to include individuals from different departments and backgrounds to form the scenario building team. By contrast, a strategy developed by a single individual may be narrowly focused, reflective of a single set of assumptions and opinions. Furthermore, it is preferential to include the intended end users of the final product (Chermack, 2011). Therefore, where possible, practitioners are encouraged to include employees with decision making clout, as scenarios are aimed at informing the decision making process. The scenario analysis method was chosen not only for its ability to accommodate for future uncertainty, but additionally for its ability to engage the organization in carbon management activities. As Hoffman (2010) and Lingl and Carlson (2010) suggest, this is a key principle of any carbon management activity. Participating organizations in a study detailed within Hoffman (2010) suggest, "senior-level support and engagement are the most critical components of any successful climate strategy” (p. 39). The company liaison cited organizational learning as a key outcome he/she expected of the process.

i. The Scenario Building Team

For the purpose of the study, the scenario building team was chosen in consultation with the company liaison. Researchers approached the liaison with three main criteria against which participants were to be considered:

1. Participants should represent a diverse cross-section of the organization. Different lines of business and departments should be represented,

2. Participants should come from upper-management or have significant decision making responsibilities. They should have a reasonable understanding of how the organization works at a macro level and the major internal and external factors that impact the organization; and

3. They should be involved in the organization’s internal GHG measurement and mitigation team. Alternatively, they should be able to contribute to a discussion relevant to the completion of the second study objective.

Based on these criteria, the company liaison selected a total of eleven individuals to participate in the scenario building process. The liaison also participated in the process, which brings the total number of participants within the scenario building team to twelve. These individuals came from a diverse cross-section of the organization, as indicated in Table 4. The scenario analysis involved employee participation in both individual interviews and a group workshop, and an individual’s participation in either an interview or a workshop is indicated in the table.

Table 4 - The Scenario Building Team

Title	Department	Interview	Workshop
Director	Asset Management	x	x
Director	Strategy and Conservation	x	x
Director	Logistics	x	x
Director	Corporate Communications	x	
Director	Equipment Services	x	
Manager	Environmental Services and Approvals	x	

Director	Facility Management	x	
Manager	Asset Management		x
Manager	Fleet Services		x
Director	Outsourcing Services		x
Field Manager	Grid Operations		x
Manager	Conservation and Environment		x

ii. Purpose and Scope

Before a scenario building process begins, the purpose or question that the analysis is to investigate needs to be clearly defined. Additional consideration needs to be given to the scope and time frame of the analysis (Chermack, 2011). The purpose and scope were determined in consultation with the company liaison. A ten year period was determined to be particularly important with respect to the corporation's carbon footprint. Therefore, the objective of the scenario analysis was to explore the question stated below.

1. How could the case company's carbon footprint change over the next 10 years?

The purpose was to produce scenarios that could better prepare the organization to manage its carbon footprint over the next decade, in light of future uncertainty regarding the regional electricity market and the organization. However, beyond provision of carbon scenarios, researchers and the company liaison identified an additional objective associated with the scenario analysis: to facilitate organizational learning and engage decision-makers in the carbon management of the corporation.

iii. Engaging the Organization: The 'Domains' of Scenario Analysis

The analysis was a means of encouraging decision-makers within the case company to think critically about the company's current and future carbon footprint. Indeed, throughout the literature, the literature suggests that scenario planning is an exceptional tool for promoting organizational learning, altering perceptions, and engaging senior leadership within an organization (Chermack, 2011; Duncan & Wack, 1994; Postma & Liebl, 2005; Wack, 1985a, 1985b; van Asselt, 2002; van der Heijden, 2005). These types of benefits are amongst the "Six Domains of Scenario Planning Theory" that Chermack (2011) suggests serve as the fundamental foundation of scenario planning (see Figure 2).

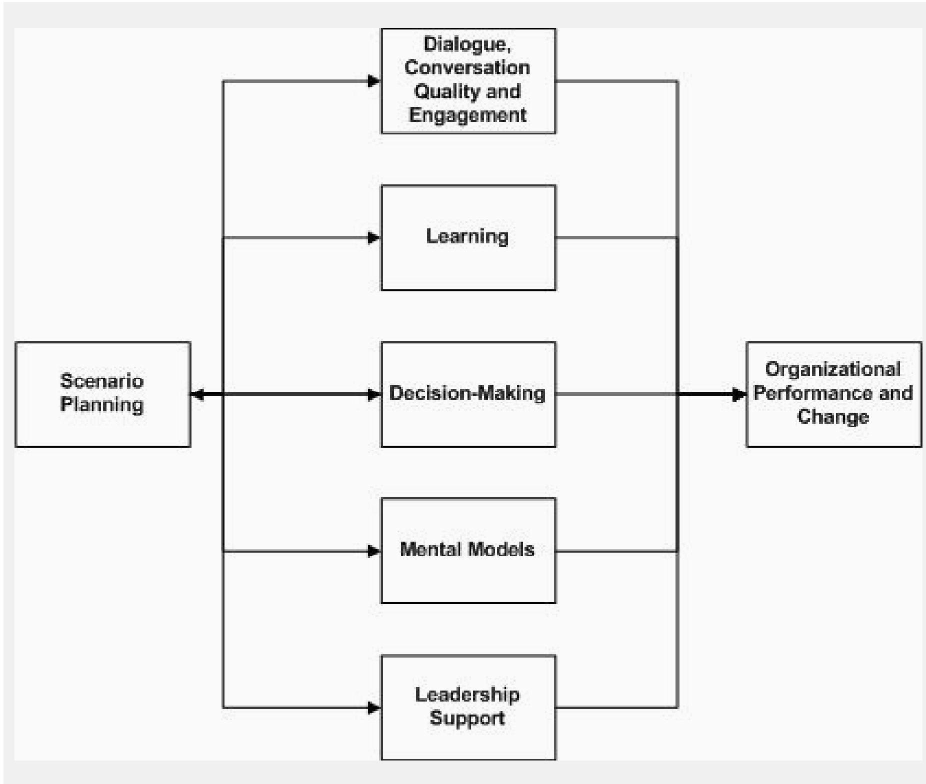

Figure 2 - The Six Theoretical Domains of Scenario Analysis (Adapted from Chermack, 2011).

These theories have received considerable attention throughout the relevant literature (Schwartz, 1991; Wack, 1985b; van der Heijden, 2005). The six domains attempt to explain how scenario analysis delivers a useful final product, but also provides an organization with process associated benefits. Furthermore each domain should be assessed and provide input to be used to improve the method itself. The domains are:

1. Dialogue, Conversation Quality and Engagement. As Chermack (2011) explains, dialogue, conversation and engagement are the "fundamental means for sharing mental models and developing a shared understanding of the organization and its external environment". Collaboration through conversation in the scenario building process allows for the engagement of multiple stakeholders, points of view, and belief systems. Scenario analysis attempts to avoid strategies built on a narrowly focused set of individual opinions; it aims to shift perceptions and to encourage individuals to consider possible alternative outcomes. van der Heijden (2005) stresses that multi-stakeholder communication and ongoing dialogue is the basis for sound strategy and refers to this type of collaboration as 'strategic conversation'.

2. Organizational Learning. Throughout the literature, practitioners suggest that any planning activity should be perceived as a learning opportunity (Chermack, 2011; Schwartz, 1991; van der Heijden, 2005). As Wack (1985b) suggests, a key outcome of any planning activity should be that participants view their organization in a different light. Participants should have gained insight or perspectives into the "internal and external environments [relevant to the organization] and how they interact" (Chermack, 2011, p. 33). The outcome is that participants are better equipped to work within the organization towards management of the particular issue of focus.

3. Decision Making. The final product of any scenario planning process aims to inform the decision making process toward better organizational performance. As Chermack (2011) suggests, scenario planning has utility in addressing the problem of bounded rationality in decision making – "that human beings cannot effectively cope with all the available information and alternatives in making decisions" (p. 43).Scenarios overcome this issue by providing a collaborative story that includes consideration for an array of external and internal factors through a medium that is "easily remembered" (Chermack, 2011, p. 43).

4. Mental Models. A mental model is an individual's perception of the world. They "incorporate our experiences, learning, biases, values, and beliefs about how the world works" (Chermack, 2011, p. 48). Mental models are deeply entrenched and can be very inflexible; they can make it difficult for decision makers to perceive of the significance of alternative solutions. As Wack (1985b) and Chermack (2011) suggest, by incorporating participants with a diverse set of backgrounds and involving them in strategic conversations, scenario analysis exposes them to other ways of seeing the world (Wack 1985b). It forces participants to "re-examine their assumptions and alter their mental models" (Chermack 2011, p. 48). By doing so, participants are exposed to relevant information that may have otherwise gone unnoticed (Wack 1985b).

5. Leadership Support. Scenario planning practitioners consider leadership a key component of the analysis. Without the involvement and support of an organization's leadership, and project is "likely to fail" (Chermack 2011, p. 50). Scenario planning must involve upper-management (the users of such scenarios) if it is to accomplish the task of preparing the organization for future uncertainty; it is after all, these individuals who will be responsible to reacting to future environmental changes. Scenario planning is more intimate than traditional planning methods. It is as much about the process, about changing the perceptions of its participants, as it is about the final product (Wack 1985b).For this reason, practitioners are encouraged to involve senior management and key decision makers in the scenario building process.

6. Organization Performance and Change. Chermack suggests that this domain results from the collective influence of the other five. Performance and change as a result of the scenario building process comes at three levels. Organization performance increases as the organization becomes more nimble and able to adapt quickly to future risks and opportunities. This type of result has been corroborated in the literature (Phelps, Chan, & Kapsalis, 2001). Process level changes are also emphasized as a key outcome of the analysis. Scenario analysis outcomes often lead to development of alternative processes within an organization. van der Heijden (2005) suggests that these process changes are a necessary precursor to organizational change. Practitioners suggest the most profound change occurs at the job/performer level (Chermack, 2011; Schwartz, 1991; Wack, 1985b; van der Heijden, 2005). Due to the modification of mental models and the intensive learning experience involved in participation, individuals are better equipped to manage efficiently for their organization.

iv. The Scenario Building Process

Drawing extensively from the relevant literature, Chermack (2011) provides a clear step-by-step guide by which academic and business users can conduct a strategic scenario analysis. The guide provided the basis for the analysis, but was adapted to adhere to the strict time and participant availability constraints unique to the study (discussed in section *6.3 Limitations*). Specifically, where Chermack (2011) and van der Heijden (2005) strongly prescribe workshops in order to develop a list of initial driving forces and uncertainties, to work around unique availability constraints imposed by the organization this research relied more heavily on individual interviews. The adapted step-by-step process, as well as the specific approach for each step, is detailed below.

1. *Brainstorm the major forces: semi-structured interviews.* The purpose of this step is to determine the major forces that participants feel the organization is facing with respect to the objective question. To that end, researchers (in consultation with the company liaison) invited nine employees to participate in individual interviews. Of the nine invitees, seven individuals chose to participate (see table 4, p. 42 for details about participants). The interviews were 30-45 minutes in length, semi-structured, and were conducted in person at the employee's workplace. Although the principle goal of the interviews was to determine major forces and scenario topics upon which to focus, researchers gathered additional information to gain a better understanding of the organization's:

- Motivation to mitigate GHG emissions,
- GHG emission data quality and gaps,
- Willingness to fund GHG emission measurement and mitigation efforts,
- Perceived future mitigation opportunities,
- Internal driving forces and company dynamics,
- Foreseeable challenges associated with GHG measurement and reduction initiatives, and
- Relevant future developments (for example, the construction of new facilities or lines).

Gathering this information helped researchers to define the plots of the scenarios. Furthermore, it helped identify possible future developments that may impact the organization's carbon footprint. Additionally, the responses could be used to contribute to the ongoing discussion throughout the literature pertaining to corporate motivation to reduce GHG emissions. The interviews were also used as an opportunity to solicit feedback on process maps.

These types of interviews are prescribed by Chermack (2011) for their ability to give practitioners insight into manager's mental models. As relative outsiders to the organization, they provided researchers with much needed perspective into the internal dynamics related to the corporation's initiatives to measure and reduce their GHG emissions.

2. Rank the forces by relative uncertainty and potential impact to the organization. Feedback from interview participants included suggestions for seven potential scenarios on which to focus the analysis. Participants believed these topics to have underlying major forces that had the potential to impact the company's carbon footprint over the next ten years, and for which there was a relatively high level of associated uncertainty. Based on the availability of the scenario team, it was determined that the analysis could be reasonably expected to produce two scenarios. As a result, researchers, in consultation with the company liaison, were required to conduct a ranking exercise to determine which of the suggested topics had the potential to have the greatest impact to the organization's carbon footprint, and for which there was the most uncertainty. In the context of the analysis, issues that are considered to have a high level of uncertainty are those that the outcome of which are unknown.

Practitioners refer to these forces or topics as the 'critical uncertainties'. One useful means of assessing all the potential forces is to use a quadrant-based ranking space (Figure 3) (Chermack 2011). Using such a system allows the scenario team to assign major forces to one of four quadrants: (a) the upper-left quadrant: high impact and low uncertainty, (b) the lower-left quadrant: low impact and low uncertainty, (c) the lower-right quadrant: low impact and high uncertainty, and (d) the upper-right quadrant: high impact and high uncertainty.

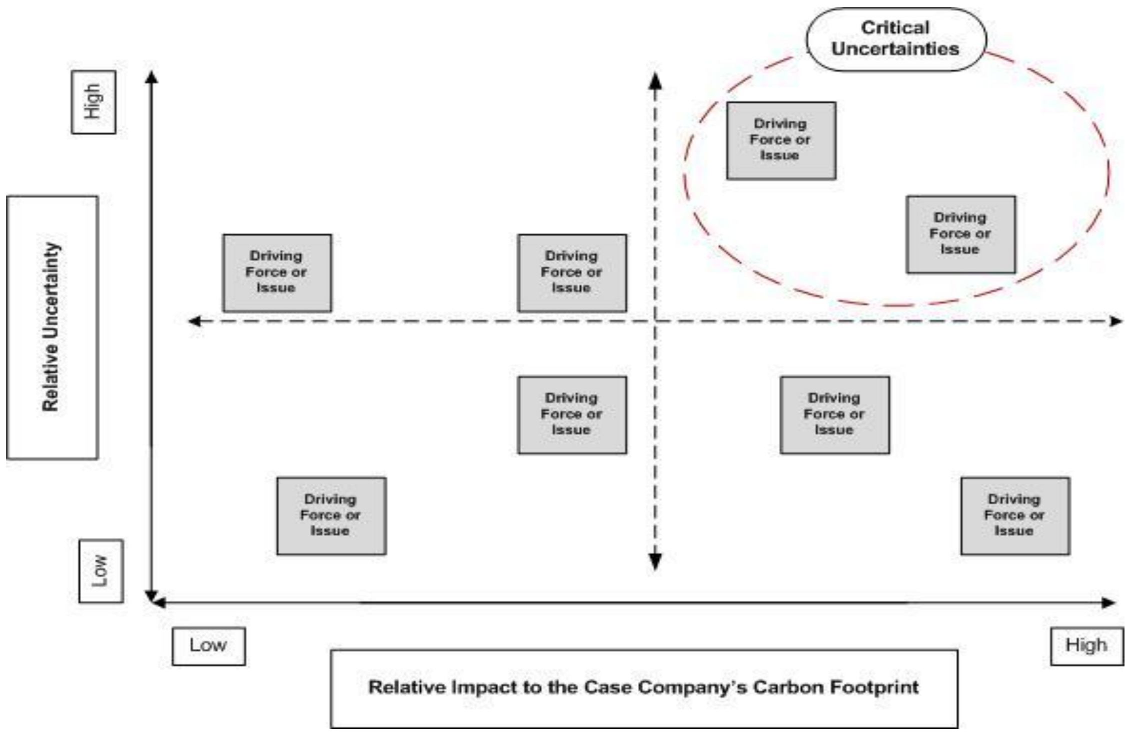

Figure 3 - The Ranking of Key Driving Forces or Issues (Adapted from Chermack, 2011).

The ranking process is usually conducted during a workshop involving the entire scenario team, as it offers an opportunity for participants to debate and develop a dialogue about the key issues facing the organization. This step has a role to play in shifting perceptions, and helping the group work towards a "shared mental model" (Chermack, 2011). However, due to availability constraints unique to the study, the ranking process was conducted by the company liaison in consultation with researchers (a limitation discussed in section *6.3 Limitations*).

3. Develop the scenario logics or plots. The scenario logics serve as the general framework, or plots, for the scenarios. This stage begins with a debate and discussion about which of the issues or key driving forces represent the critical uncertainties on which to focus the scenarios (Chermack, 2011). The scenario team must choose from those issues lying in the upper-right quadrant (there can be several), and limit the selection depending on the number of desired scenarios to be produced. Once determined, the specific critical uncertainties form the basis for the creation of the scenarios, and associated plots.

There is a range of opinions in the literature about the optimal number of scenarios an analysis should focus on developing (Chermack 2011). Chermack (2011) suggests the analysis should logically produce four distinct scenarios, drawing from two selected critical uncertainties. The critical uncertainties can be mapped on a 2x2 matrix, creating four additional quadrants by adding a high value and low value to each. Other literature suggests the analysis should produce two principle scenarios (Wack, 1985a).

However, as Chermack (2011) explains, regardless of the number of output scenarios, the “key is to make sure the scenarios are distinctive and memorable” (p. 144). For the purpose of the study, the researchers, in consultation with the company liaison, chose two critical uncertainties upon which to build two principle scenarios. As previously discussed, this decision was primarily motivated by limited participant availability.

The scenario logics, or plots, were developed by members of the scenario building team during a two-hour workshop. In addition to the eight participants involved in the individual interviews, the company liaison invited six other employees to participate in the workshop. These participants were selected by the project liaison based on their involvement in previous GHG reduction measurement and reduction initiatives within the organization. The reason for the additional invites was to ensure there would be a sufficient number of participants representing different expertise and departments within the organization.

Where individual interviews could be scheduled at the participant’s convenience, the workshop required a firmer time commitment. Additional individuals were invited as it was anticipated that a number of employees would be unable to participate due to scheduling conflicts. The invitees represented a diverse cross-section of the organization and were deemed capable of making valuable contributions to the dialogue. If invitees could not attend they were encouraged to send a representative in their place. In total, seven invitees agreed to participate in the workshop or to send a representative. The company liaison also provided input, bringing the total number of participants to eight.

The workshop was semi-structured and focused on generating conversation and dialogue about the critical uncertainties. The discussion was guided by an agenda that had participants focus their discussion on relevant issues, including:

- Internal and external forces related to the critical uncertainties,
- Specific events or steps that could lead to the event/scenario,

- Impacts within the organization’s industry and resulting implications for the organization,
- The relevant stakeholders that could be involved and the extent of their involvement,
- The predetermined elements that could influence the scenario (events already in motion and beyond the control of the company), and
- How the organization could/would react to the circumstances.

The workshop was two hours in length and the resulting strategic conversation served as the foundation for drafting of two key scenarios. Digital recordings of the discussion generated by participant were frequently reviewed to ensure accuracy.

4. Write the scenario stories. Drawing from the key factors, trends and critical uncertainties discussed by participants, the narrative of the scenarios were written upon completion of the scenario building workshop. The narratives relied on some assumptions that were made by the scenario building team. Furthermore, they required research into some key elements that participants felt needed further investigation.

The scenarios were initially written by researchers. Once drafts had been completed, feedback, criticisms and suggestions were solicited from the scenario team through email correspondence. Involving decision-makers in the writing process is key to the success of the scenarios as it contributes to a sense of ownership. As Chermack (2011) suggests, if involved in the scenario writing process, decision-makers are more likely to carefully consider the final product.

5. Communicate the scenarios. Once the final versions of the scenarios had been written, they were included in a final report to the organization. The scenarios were also linked to the process maps, in order to provide a visual indication of the implications of the scenarios for the company’s GHG emission sources.

3.5.5 Benchmark Study

During the early stages of the scenario building process, participants identified as a key gap a lack of industry-specific information regarding GHG measurement and mitigation initiatives. Furthermore, a number of sources suggest that any carbon management activity should be augmented by industry specific knowledge (Hoffman, 2010; Lingl et al., 2010; WRI & WBCSD, 2010). In response, a benchmark component was included in the study. The benchmark focused on gathering information about the actions major organizations within the transmission and distribution sector were taking to measure and reduce GHG emissions. The goal was to develop a list of best practices and provide companies with an indication of progress within the industry.

The CDP has, since the early 2000's, sought to collect similar data at the international level. However, the project has received only very limited information about industry initiatives within the case company's country. Furthermore, where utility companies from other countries have participated in the project, they have mostly disclosed information pertinent to electricity generation-sourced emissions. The benchmark component of this study addressed these gaps. Furthermore, it offered an opportunity for researchers to investigate options for the reduction of the case company's carbon footprint based on initiatives occurring elsewhere in the industry.

In consultation with the company liaison, researchers developed inclusion/exclusion criteria for participation. The criteria were designed to include companies that were within the case company's industry, the electric transmission and distribution industry. The criteria are:

1. Organizations should operate within the case company's country. It was preferable to include organizations operating in relatively similar markets and under the same federal regulatory regime. Time limitations also made inclusion of foreign companies impractical. Furthermore, due to geography, organizations operating within the case company's country were more similar with respect to the scale and nature of their operations. These criteria ensured that information gathered was transferable and applicable to participants.

2. Organizations should have substantial transmission and distribution assets (more than 1000 kilometres of transmission lines). Since the study excluded consideration for generation-based emissions and as the case company was strictly a transmission and distribution utility, the benchmark was limited to those emission sources attributed to transmission, distribution, and other lines of business. Integrated utility companies were considered for participation.

Adhering to these criteria, researchers compiled a list of eleven utility companies to be invited to participate. These were the only eleven companies that suited the aforementioned criteria. Due to the nature of the informed consent agreements, the names of participants and organizations have been withheld. Invitations were facilitated by an industry association. Through this association researchers were able to directly contact those individuals from each organization that were responsible for GHG management. After three rounds of invitations, five organizations had responded positively to the invitation and elected to participate in the study.

Information was solicited during 20-30 minute interviews; held over the telephone at the participant's convenience. Interviews were conducted with one individual from each of the five of the participating organizations. Each participant was selected to participate by the industry association. Names and contact information were provided from their environment and sustainability steering committee. As part of every invitation, where necessary, invitees were asked to refer researchers to employees that would have the most detailed knowledge related to the provided questions. As a result, participants had detailed knowledge of the organization's efforts to measure and reduce GHG emissions. Interview questions related to:

- Sources being measured and tracked by the organization,
- How emissions are being measured,
- How or if the organization reports GHG emissions,
- Initiatives designed to reduce GHG emissions,
- Challenges organizations have encountered in efforts to measure and reduce emissions, and
- GHG emissions measurement and mitigation initiatives planned for the future.

Upon completion of the interviews, the findings of the benchmark were summarized in a final report. Each participating organization received the report in an email communication. The distribution of the results was a key incentive for participation, and may help some participating organizations to draw from industry best practices.

3.5.6 Developing the Recommended Actions

The final step in the approach involves the development of a set of recommended actions that the organization may consider. The recommendations are focused on providing a number of options for the reduction of the organization's carbon footprint over the next decade. A key requirement of these options is that they are both reasonable and practical. Working closely with the organization and gathering feedback during interviews and the workshop helped researchers to gain an understanding of the organization's threshold for carbon management activities. For instance, senior management participants suggested that replacing major infrastructure could not be justified as GHG emission savings – an activity that is too capital intensive. The recommended actions are made with consideration for information drawn from the following sources:

- The literature review,

- The scoping interviews,
- The benchmark component,
- Applicable standards,
- The scenario analysis, and
- The internal document review.

4. Findings

The following chapter provides a summary of the research findings. The section begins with an explanation and presentation of the key process maps. The results of the scenario analysis follow, and each of the primary scenarios is presented. The chapter concludes with a summary of the benchmark findings, and the presentation of recommended actions.

4.1 Mapping the Organization’s GHG Emission Sources

Based on the review of relevant documentation, researchers developed a series of process maps that identified the case company’s GHG emission sources. As the company had, at the outset of the project, strictly considered direct and energy indirect emission sources, a key objective of the process maps was to identify Scope 3 emission sources associated with the organization’s carbon footprint. The aim was to help the organization to identify its emission sources, including those not previously considered for measurement and mitigation. For guidance on inclusion of Scope 3 sources, the GHG Protocol Standard was consulted. Furthermore, consultation of company documents and feedback from interview participants helped to identify additional emission sources unique to the organization. This stage of the approach resulted in the development of two principle relationship maps:

1. The Stream-flow map (Figure 4). Consideration of both direct and indirect emission sources was considered. The map is informed by life-cycle analysis insofar as it depicts the organization’s emission sources along a cradle-to-grave timeline, to capture emission sources both upstream and downstream of the company’s operations. The map includes a clearly delineated operational boundary based on equity share. Scope 3 sources occurring concurrently with operations (neither upstream nor downstream) are considered.

Emission sources are organized from left- to-right according to their position in the life-cycle system of the company’s supplies, products, services, operations and waste. Sources appearing on the furthest left are those occurring within the company's supply chain. Those sources occurring downstream of operations, such as the disposal of wastes, appear on the far right of the map.

The stream-flow map also includes a data assessment for emission sources currently measured and tracked by the organization. The data assessment categories draw from the IPCC guidelines for emission inventories prescribed by the *GHG Protocol,* which suggest a hierarchy of calculation approaches (WRI & WBCSD, 2001).

2. The Scope Scenario Maps (Figures 5 and 6). These two maps apply the scoping emission source categorization system prescribed by the GHG Protocol standard. The map can provide the organization with a useful typology by which to conceptualize different types of direct and indirect emissions sources. Furthermore, the case company has stated that in order to ensure that emissions measurement and activities are credible and comparable it would be necessarily to adhere to GHG accounting standards for its present and future GHG management activities. A key component of these maps is the integration of scenario results. Each map details the emission source changes associated with one of the scenarios.

In addition to identifying the organization's emission sources, the stream-flow map provides an analysis of the case company's existing GHG data. The data quality assessment is informed by the quality principles outlined within *The GHG Protocol* standard.

Details about the process maps were discussed extensively with the company liaison during the scoping interviews. This helped to ensure that the maps were general enough that they would be accessible to a wide range of employees, and that they are a valuable source of information for the organization. This consideration was tested during the scenario building process as the maps served as a starting point for discussions about the corporation's carbon footprint. Providing each interview and workshop participant with a copy of the process maps served a dual purpose. Indeed it provided researchers with the opportunity to gather feedback regarding the maps. However, the maps served a didactic function during the scenario analysis; leading participants to consider a broad range of emission sources associated with the organization's carbon footprint and prompted relevant discussion.

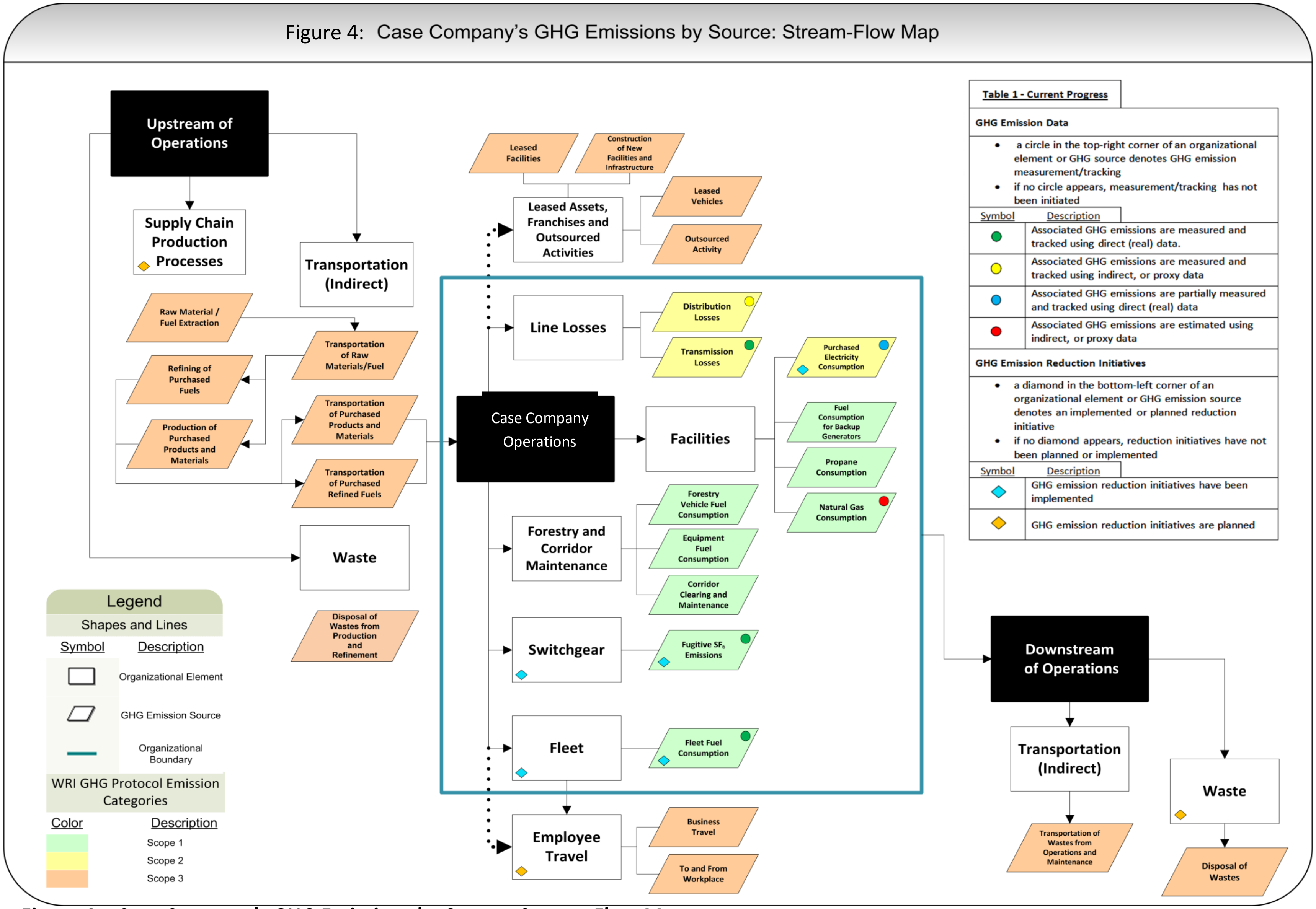

Figure 4 – Case Company's GHG Emissions by Source: Stream-Flow Map

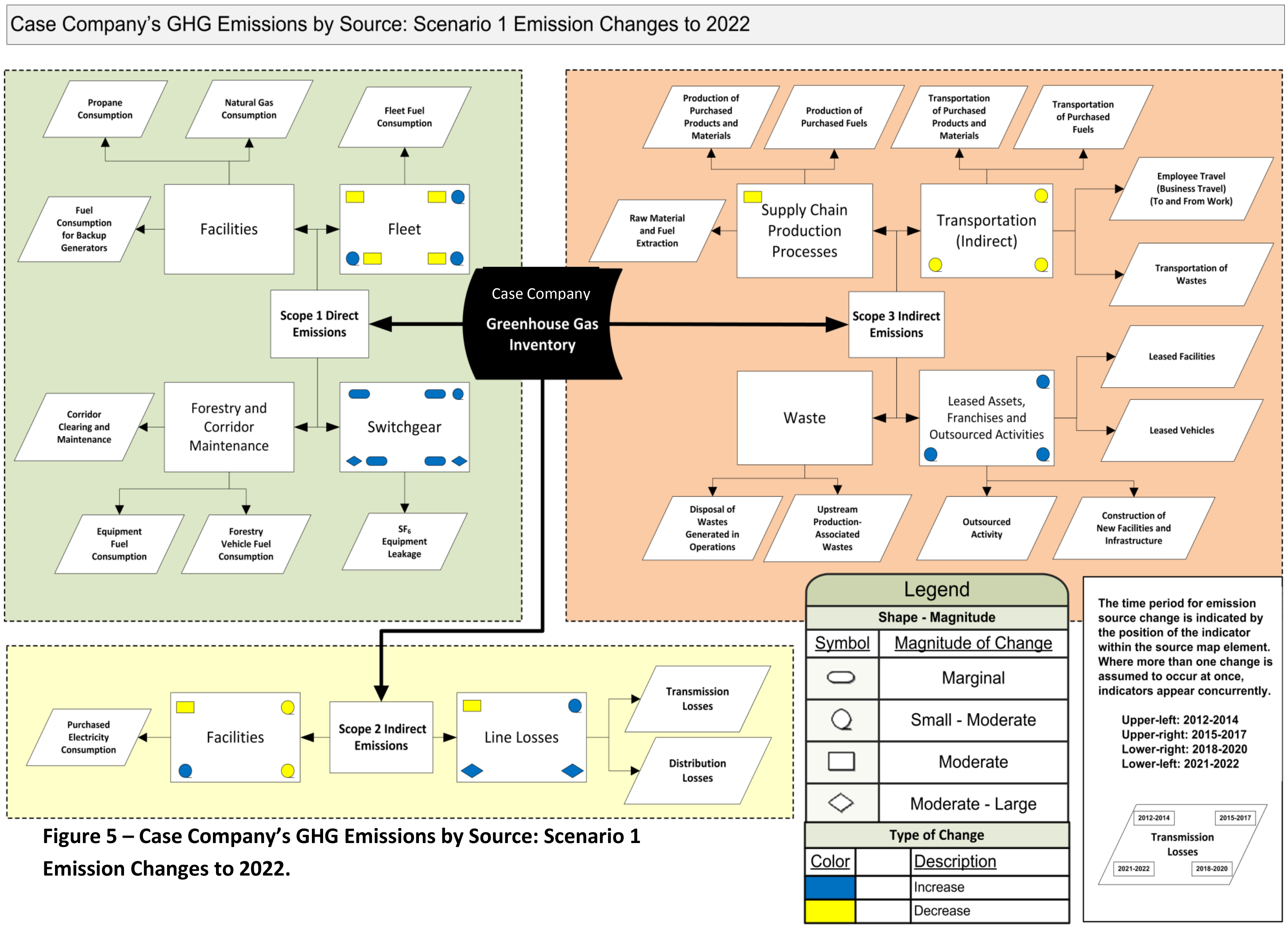

Figure 5 – Case Company's GHG Emissions by Source: Scenario 1 Emission Changes to 2022.

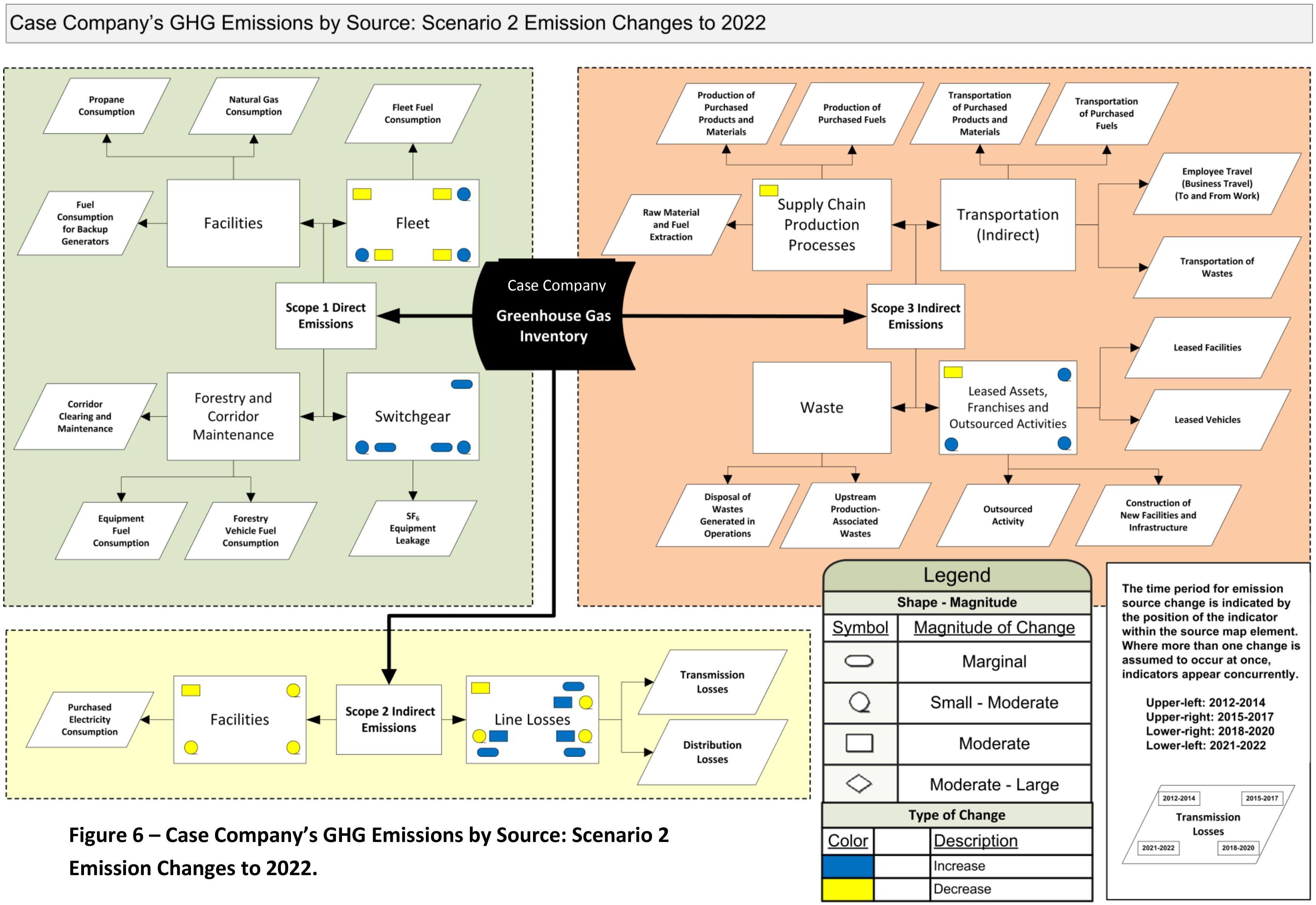

Figure 6 – Case Company's GHG Emissions by Source: Scenario 2 Emission Changes to 2022.

4.2 Scenario Analysis

The scenario building process was carried out over an eight month period and involved close consultation with the case company. The findings or results of each step of the scenario building process, as it pertained to this research, are detailed below. To reiterate, the objective question the scenario analysis sought to explore was:

1. How could the case company's carbon footprint change over the next decade?

4.2.1 Brainstorm the Major Forces: Semi-Structured Interviews

The seven individual interviews provided valuable insight into the case company's relevant internal driving forces. It was favourable to involve managers and key decision-makers as they were able to provide an indication of the company-specific dynamics related to ongoing efforts to measure and reduce the corporate carbon footprint. The summary of interview responses are detailed below and organized according to the key consideration that each question was designed to address. These considerations are:

- Key driving forces or potentially useful scenario topics,
- Motivations to mitigate GHGs,
- Willingness to mitigate GHGs,
- Funding emission measurement and mitigation efforts,
- Data assessment and gaps,
- New mitigation opportunities,
- Foreseeable challenges associated with GHG measurement and reduction initiatives, and
- Relevant future developments within the organization.

The findings of the interviews, detailed below, are support by a number of key quotes taken directly from interview participants. Some key quotes have been integrated into the responses. A complete list of key quotes is included in Appendix A.

i. Key driving forces or potentially useful scenario topics

Participants identified seven scenarios or key driving forces that they believed to be particularly relevant to the organization's future carbon footprint. The interview participants were asked to provide options that they were somewhat uncertain about and warranted further demonstration. As a result, the following list of potential scenario topics represent what Postma and Liebl (2005) would classify as *uncertain driving forces*. Chermack (2011) refers to these as the *critical uncertainties*. The interview(s) from which content was derived is indicated in parenthesis.

1. The electrification of the general population's vehicles and public transportation (Interviews 1, 4 and 7). Although it was believed that electrification of service fleet vehicles would certainly decrease the company's GHG emissions, some participants identified the adoption of electric vehicles by the general public as having the potential to dramatically impact the company's carbon footprint. Participants identified this external driving force as one that should be explored further into the scenario building process (Interviews 1, 4 and 7).

Key Quote: "Amount of power used is another element that has the potential to have an influence. The question I've got on my mind is, what is the impact of the electrification of either rail or cars? I'm just not sure what that means at the end of the day" (Interview 1).

2. A substantial increase in carbon sinks and offset initiatives (through forestry, bullfrog power, carbon trading, etc.). Recognizing that there will be a limit to the amount of operational emissions that can be feasibly reduced within the organization's inventory, interview participants expressed interest in exploring carbon offset opportunities both internal and external to the organization (Interviews 1, 5 and 7).

Key Quote: "We haven't done very much in terms of carbon offsets. That's an area that I would be curious to explore further" (Interview 1).

3. Increased awareness and education within the employee culture. Three participants expressed interest in exploring the relationship between employee's behaviours and the company's carbon footprint (Interviews 2, 6 and 7). Participants expressed interest in an investigation of links between increased awareness, education, training and incentive programs, to enhance the employee culture and resulting emission decreases. Participants cited changes to supply and material use, personal electricity use, behaviours in employee's personal lives, and driving habits of fleet vehicle operators as means of mitigating individual carbon impacts.

Key Quote: "The introduction of a theoretical model for carbon savings in which individuals can apply inputs based on the carbon theory they are trying to reduce. The output would provide an illustration of what the savings are from a carbon emissions perspective. It would help employees understand how their everyday actions affect the company's overall GHG footprint" (Interview 2).

4. Early retirement of aging assets, facilities and lines. One participant suggested the scenario that would present the most significant consequences for the company's carbon footprint would be a change to economic equation with respect to line losses (Interview 3). If the equation were modified to put a higher value on line losses, this could drive the early retirement of some of the company's aging assets. Justified by lower operating costs associated with newer, more efficient technology, this would require a fundamental shift from replacement at fail, or end of life philosophy. This may offer significant emission savings if line losses were reduced, but the potential scenario is very dependent on other developments both internal and external to the organization. The participant suggested this change would not be justified by GHG emissions reductions (but by financial drivers), but reductions would result as a consequence.

Key Quote: "A shift with respect to how the company values line losses. This is so pervasive throughout the organization that it can enable a lot of change. One can say 'Well you can keep that line up there for another ten years'. But in reality if we can get to that point where the line loss differential is large enough to drive the early retirement of some older assets and lines, I really have believed for quite a while that that really is the lynchpin to making investment decisions. If we can get to the point where that is very clearly in the economic view of things and people really understand that, then you shift the discussion away from end of life to reduction of total costs of operating the system. If you can change that equation and really champion that notion, I think that would drive a lot of change" (Interview 5).

5. The continued change of the energy generation mix in the political jurisdiction and the implementation of the green energy legislation. Participants identified both the changing energy mix in the political jurisdiction, and the implementation of green energy legislation as having the potential to influence the company's future carbon footprint (Interviews 1, 3, 4, 5 and 7). Although supplying greener power sources to the region's electricity grid, some participants suggested that the company's footprint may increase as a result of the implementation of new green energy legislation (Interviews 1 and 5). This was identified as an issue that should be explored further (Interviews 1 and 4).

6. Adoption of truly decentralized or distributed generation (electricity consumption near point of generation). One participant suggested that a scenario focus on the influence of an increase in distributed generation in the political jurisdiction on the case company's carbon footprint (Interview 7). The participant emphasized that this type of system would necessarily involve electricity consumption near the point of generation, or the creation of micro-grids to service regions around distributed

generation sources. This may decrease line losses as the electricity produced from these sources would not necessarily need to be fed into the main grid, an issue that warranted further investigation.

7. A change to the capital investment philosophy within the organization (increase or decrease). One interview participant expressed interest in investigating a scenario involving a change to the company's strong capital investment philosophy (Interview 6). The purchase of new fleet vehicles and facility upgrades are quite capital intensive activities, this type of change could influence the company's carbon footprint.

Key Quote: "If you were to build a model or scenario, then what you would want to look at is original capital value and ask yourself: 'If you increase capital investment, how does that change the opportunities, flexibility and speed of your GHG emission reductions?" (Interview 6).

ii. Motivations to Mitigate

The motivations most frequently identified as driving the case company's GHG mitigation measures are shareholder value and good corporate citizenship. Participants felt that the organization's environmental and climate change policies draw heavily from the values and agenda of the provincial/state government, the organization's sole shareholder (Interviews 1, 3, and 5). As the provincial/state government has, in recent years, made reducing GHG emissions a key agenda item, participants believe it is important for the case company to incorporate similar commitments into the corporate policy. By doing so, participant's suggested the organization is returning value to its shareholder. One participant suggested that if the provincial/state government were to drop GHG emission reduction as a key policy point, that the organization's future emission reduction initiatives may be considerably less robust (Interview 1). Three participants also referenced the organization's component of the corporate vision document related to environmental stewardship as a motivation for reducing GHG emissions (Interviews 1, 2, and 6).

Four participants also stated that as the company encourages its customers to conserve electricity and reduce associated GHG emissions, it is important for the corporation to lead by example and do the same; that reducing emissions is part of being a good corporate citizen (Interviews 2, 5, 6 and 7). One participant emphasized that it is important not to mistake the organization's efforts as "green-washing"; that the company's mitigation efforts are tangible and internally-driven, not merely a branding façade (Interview 6).

Key Quote: "Our mitigation efforts are less about branding and more about being a good corporate steward" (Interview 6).

Enhancing the corporation's reputation among its stakeholders and improving the employee culture were also cited as significant motivations that drive mitigation initiatives (Interviews 2, 5, and 7). One participant cited operating cost reductions as a key motivation for reducing corporate GHG emissions (Interview 6).

iii. Willingness to Mitigate

Participants generally agreed that there is a willingness to reduce GHG emissions at all levels of the organization. However, the majority believe that this willingness is frequently limited by a need to satisfy a number of other strategic objectives under the organization's corporate vision (Interviews 1, 3, 4, and 7). Each of these strategic objectives is assigned priority and economic, health and safety and system reliability priorities may often outweigh GHG emission reductions. Considering the company's commitment to these other strategic objectives, participants generally believe GHG measurement and reduction initiatives have received the appropriate level of priority (Interviews 1, 4, 5, 7).

Key Quote: "Considering our commitment to other strategic objectives, there is an appropriate level of willingness" (Interview 4).

Some participants also suggested that GHG emission reductions will often occur as a secondary objective, or indirect outcome; resulting from initiatives that are primarily justified by energy conservation and efficiency gains (Interview 2, 5 and 7).

iv. Funding GHG Emission Measurement and Mitigation Efforts

Six of seven participants agreed that GHG measurement and mitigation efforts are sufficiently funded so as to ensure they are meaningful (Interviews 1-6). The majority again cited the prioritization of strategic objectives; suggesting that funding of the company's GHG mitigation initiatives is appropriately balanced with respect to the company's commitment to other strategic objectives (Interviews 1, 2, 3 and 5).

One of the participants suggested that these efforts are substantially underfunded, and as a result, are not meaningful citing the low priority of GHG emission reduction initiatives relative to other strategic objectives (Interview 7). Another participant suggested it is difficult to justify GHG mitigation initiatives because of the difficulty in identifying and calculating tangible paybacks (Interview 2).

One participant stated that it is clear that these efforts will be, for the most part, integrated into the existing resource plans (Interview 6). That is, the corporation would not devote new resources specifically to the reduction of GHG emissions.

v. Data Assessment and Gaps

All but one of the participants believed the company's current measurement metrics and methods to be sufficient (Interviews 1-6). Some participants explicitly emphasized the importance of measurement as a prerequisite to mitigation. Measurement allows the company to track the progress of reduction initiatives related to specific equipment or processes and if a source cannot be tracked it isn't likely to be addressed (Interviews 1 and 4).

Key Quote: "If it can't be tangibly tracked and measured, it isn't likely to be mitigated" (Interview 4).

Two of the seven participants expressed concern over the measurement of SF_6 switchgear leakage-based emissions, suggesting that the measurement process needs to be further refined (Interviews 1 and 4). The concern relates to tracking SF_6 emissions that occur during maintenance and top-up procedures. As current SF_6 emission measurements are based on a metric which uses top-up quantities to estimate switchgear leakage emissions (based on stored bottle volumes), it is assumed that the balance of the bottles is attributed to equipment leakage. However, the metric does not account for SF_6 that may have been emitted during maintenance or top-up procedures. Participants believe it is difficult to mitigate SF_6 emissions if it is unclear whether they are occurring during the top-up procedure or as a result of the regular operation of the equipment (Interviews 1 and 4).

Participants identified another gap relating to the measurement of emissions resulting from employee behaviours (Interviews 2 and 6). Participants suggested that there is not enough available information about the magnitude and potential contribution of employee's behaviours to the company's carbon footprint. Some behavioural examples offered by participants include: waste disposal, personal electricity consumption, resource and material use, and the driving habits of fleet vehicle operators (Interviews 2 and 6).

vi. New Mitigation Opportunities

Participants were asked to identify new mitigation opportunities that may allow the company to realize emissions reductions above and beyond business as usual. Some of the identified options have not yet been considered by the organization's 'green team,' others are in the preliminary planning stage or have already been implemented to some extent.

1. New Buildings, Upgrades and Refurbishments

Incorporate conversationalist-type thinking into new building designs and construction procedures. The participant also suggested efficiency improving facility upgrades and refurbishments should be a priority (Interview 6). However, the participant explained that these considerations are already adequately addressed in the company's energy efficiency program (Interview 6). Furthermore, the organization currently tracks emission reductions resulting from the lighting and HVAC upgrades associated with a comprehensive retrofit program.

2. Purchase and integrate additional fuel efficient/hybrid/electric vehicles into the company fleet.

Two participants suggested that the organization integrate additional fuel efficient/hybrid and electric vehicles into the company fleet (Interviews 2 and 3). The organization has taken steps to integrate these types of the vehicles into the fleet where feasible. Additional implications of this option are discussed in detail in *6.1.2 Technical Limitations – Sulphur Hexafluoride and Fleet Emissions.*

3. Modify supply-chain management

One participant suggested the company could better organize and schedule shipments of products and materials with an emphasis on fewer overall shipments carrying larger or bulk loads (Interview 5). The organization often receives materials and parts on half-empty trucks. The participant suggested that with better logistics planning, the organization could reduce emissions associated with shipping by requiring fewer deliveries.

With respect to procurement - investigate alternative products or materials that may offer GHG emission savings. Alternatives cannot be substantially more expensive than their counterparts (Interview 5).

4. Alter the economic equation and value of line losses

Shift the discussion from replacement at end of life or fail to reduction of total costs of operating the system (Interview 5). If the line loss differential is large enough to drive the early retirement of some older assets and lines then this could increase efficiency, significantly decrease operating and maintenance costs and reduce GHG emissions. The primary justification would not be reduction of GHG gas emissions, and this change would be driven by cost savings due to greater efficiency on the system. Emission reductions would occur as a consequence (Interview 5).

5. Enhance the employee culture towards greater participation in GHG emission reduction efforts

Identify new ways of drawing attention to, and changing behaviours relating to, and educating about employee's individual contributions to the case company's carbon footprint (Interviews 2 and 6). Participants suggested a number of different initiatives stemming from this recommendation:

a) Introduce a theoretical model for carbon savings in which individuals can apply inputs based on the carbon theory relating to an emission source they are trying to reduce. The output would provide an illustration of the savings from a carbon emissions perspective. The aim would be to help employees understand how their everyday actions influence the company's overall carbon footprint (Interview 2).

b) Create meaningful incentives and rewards to encourage participation and competition (Interview 2).

c) Measure GHG reductions within the fleet through driver development. Determine a means of rating driving habits with respect to the associated GHG emissions (Interview 6).

d) Less anecdotal measurement and more information gathered around how driver's habits influence fuel consumption and GHG emissions. There are tools that measure consumption of fuel based on how a vehicle is driven (Interview 6).

6. Reduce the need for employee travel

One participant suggested that the organization could make better use of available communications technology towards realizing greater GHG emission savings (Interview 3). The organization does currently have a program in place to encourage employees to use available video conferencing technology where business travel can be avoided.

7. Increase the number of carbon sinks and offset initiatives (Interviews 1 and 7)

Develop a measure for the carbon storage potential of biodiversity and habitat building initiatives within the company. The organization has habitat building programs in place for current and future developments. One participant suggested the organization should measure the GHG removal potential of these initiatives to be tracked as part of the GHG inventory (Interview 6).

Additionally, it was suggested that the organization should explore alternative or external carbon offset initiatives that the company may influence or support (Interview 1).

vii. Foreseeable Challenges

Participants identified cost as a barrier to the implementation of future GHG measurement and mitigation initiatives (Interviews 4, 5, 6 and 7). Participants suggested that while GHG emission reduction is a priority, there are other strategic objectives that must be weighed against this effort. With limited financial resources, the company is required to balance investments among these objectives. For example, one participant suggested that the reliability of the system to provide electricity to customers must necessarily be a higher priority than GHG emission reductions (Interview 2).

Key Quote: "The need to ensure the grid is maintained in a reliable fashion versus the need to reduce carbon emissions; it is a function of priorities and reliability, at the moment, comes first" (Interview 2).

Participants also identified political willingness to address climate change as a potential barrier to implementation of related initiatives (Interviews 1 and 5). They suggested a strong linkage between the company's climate change policy and that of the provincial/state government, considered a major driving force behind the company's mitigation philosophy. There may be additional indirect consequences for corporate GHG inventories stemming from the implementation of policies at the provincial/state level (Interview 4). Political commitment to these initiatives is a necessary requirement for the continued commitment by the case company (Interview 1).

Technology is also perceived as a challenge with respect to GHG measurement and mitigation initiatives (Interviews 3 and 6). Although it is anticipated that new technologies will benefit mitigation efforts in the future, it is clear that there is some apprehension with regard to the reliability and longevity of some of the more recent technological breakthroughs, strictly with respect to vehicles (Interviews 3 and 6). '

Key Quote: "With respect to fleet reductions, technology is just not in a position to assist the company in these initiatives yet. Technology needs to catch-up in order to be a better fit for the company" (Interview 6).

Participants would consider integrating additional new hybrid and electric vehicles after the products and materials have been proven to be technically sound in the specific climate in which the company would require them to operate. Furthermore, many of the organization's vehicles are designed specifically for the industry and cleaner alternatives for these product lines have simply not been developed. It is clear that while some technologies do offer the potential to assist the company in reducing GHG emissions, they may require further development before being suitable for integration with the fleet (Interview 6).

There is additional concern over the limited number of available metrics and lack of communication within the industry. Two participants suggested there is a lack of detail regarding metrics and measurement techniques within company's corporate scorecards and annual reports (Interviews 1 and 4). It is unclear how other companies in the industry are tracking their GHG emissions. This concern has been addressed by the benchmark component of this research, detailed in section *3.5.5 Benchmark*.

One participant identified a change of direction within the electricity sector as a potential challenge and barrier to GHG emission reduction initiatives. Where new developments are concerned, the participant suggested that contracts are open to greater participation by companies from around the world in the bidding process. Projects are awarded to those companies proposing the lowest associated financial cost and very little consideration is given to environmental costs, including those associated with GHG emissions (Interview 5).

Key Quote: "There are issues with respect to how the energy sector is changing. There's a confused degree of accountabilities in terms of regulating new electricity developments. There is very little focus on the environment by the involved stakeholders and authorities, who tend to place more emphasis on reliability and cost. There seems to be a shift towards promoting more competition over new construction and development contracts, with countries and large corporations biding on transmission and distribution projects. The winning bid is often the one with the lowest associated financial cost, with very little consideration for environmental cost. This type of decision making does not appear to be changing. As a result, cost has become the controlling factor, not environmental protection or GHG emissions" (Interview 5).

viii. Relevant future developments

Participants identified three key future developments they believe will have a significant impact on the company's carbon footprint. The first is the electrification vehicles. Participants have suggested that the prospect of integrating more electric and fuel efficient vehicles into the company's fleet offers the opportunity for additional emission reductions (Interviews 1, 2, 6 and 7). The adoption of electric vehicles by the general public is believed to have the effect of off-loading vehicle emissions onto both the case company and the local generation authorities (Interviews 3 and 5). However, participants are unsure of the magnitude of this impact to company's carbon footprint.

The second development is the continued shift towards a greener power generation mix in the province/state in which the company operates. Participants were similarly unsure of the impact this would have on the company's carbon footprint.

The implementation of relevant 'green transmission enabling' legislation was also identified as a significant development having the potential to impact the company's carbon footprint (Interviews 1, 3, 4 and 5). This legislation will require the organization to develop significant new infrastructure and to ensure new green energy sources are connected to the power grid. Participants generally disagreed about the future consequences of this legislation for the organization's carbon footprint.

4.2.2 Ranking Key Driving Forces and Potential Scenario Topics

Interview participants identified seven potential key driving forces as scenario topics on which to focus the analysis. Scenario practitioners have suggested throughout the literature that the optimal number of scenarios any strategic analysis should focus on producing lies between two and four (Phelps et al., 2001). Due to the limited availability of the scenario building team, researchers and the company liaison determined that the analysis would focus on producing two scenarios. Furthermore, it was determined that the scenario building team would not be available to participate in a driving force ranking workshop (a limitation that is discussed in section 6.3 Limitations).

As a substitute, the ranking procedure was completed by the company liaison. The liaison is the individual within the organization most familiar with the corporate carbon footprint, the current GHG initiatives, and those planned for the future, and he/she was well suited for the task. The ranking process was completed during a telephone interview with the liaison. He/she was asked to rank each potential scenario topic according to relative uncertainty (the degree to which the end result and the steps in getting there are relatively unknown) and perceived impact to the organization. Each scenario topic was ranked twice, once according to relative level of perceived uncertainty, and again according to perceived impact to the carbon footprint.

As the ranking process occurred over the telephone, and as the ranking process participation was limited, a ranking grid was deemed unnecessary. Instead, the liaison was asked to assign a number value for each ranking on a scale of ten, where zero represented no uncertainty and no perceived impact and ten represented the most uncertainty and largest impact. The scenario options with the highest cumulative value (over 7.5) were deemed the critical uncertainties. Those scenarios perceived as presenting the largest potential impact to the organization and for which there was relatively high uncertainty, called the *critical uncertainties,* were:

1. Adoption of truly decentralized or distributed generation (electricity consumption near point of generation),

2. The continued change of the energy generation mix in the state/province and the implementation of green energy-enabling legislation, and

3. The electrification of the general population's vehicles and public transportation.

Upon further consultation with the liaison it was determined that the scenario topic regarding the changing generation mix and green energy-enabling legislation was subordinate to the other two. However, it was desirable to include consideration of these elements in light of the other scenario options. It was determined that consideration for those elements would be included within the discussion and plot development of the other two identified options, serving as the two principle scenarios.

4.2.3 The Scenarios

The scenario building workshop focused on generating strategic conversation about the scenario topics amongst a sample of employees representing a cross-section of the organization. The discussion served as the primary source for the development of two principle scenarios. However, information gathered from company documents, from the interviews, and from external sources also provided valuable inputs for the development of the scenarios. The two principle scenarios are detailed below. Some key supporting quotes are integrated into the scenarios. A complete list of quotes for significant elements of each scenario is included in Appendix A.

i. Scenario 1: The electrification of the general population's vehicles and public transportation.

Over the next decade, a number of factors push residents of the province/state towards adoption of electric vehicles (EVs). Oil prices surge as global demand increases, particularly in developing countries, and foreign supply to Canada and the U.S. continues to decrease (The United States Energy Information Agency, 2011). Additionally, a larger share of the oil supply is derived from unconventional sources requiring more costly extraction processes (Becker, Sidhu, & Tenderich, 2009). Canadian oil supply and production are strained as U.S. and domestic demand continues to increase. The average price of gasoline increases substantially through to 2022.

EV battery technology becomes less costly and carmakers divert more expertise and resources to design and production. The resulting purchase price decrease is supplemented even further by rigorous rebate programs and other financial incentives. Advances in battery technology increase single-charge range capability helping to alleviate some consumer range anxiety. As EVs become more feasible and affordable their market penetration becomes substantial, and by 2022 they comprise a 12 - 16% share of light vehicles on provincial/state roadways.

Despite increased EV penetration, internal combustion-powered vehicles continue to be more practical in rural areas and for long distance trips. As a result, EV penetration occurs primarily in and around urban centres over the ten year period. Charging infrastructure varies by location and price over this period as private and public interests experiment with charging systems (Level 2 and Level 3) and battery swap ventures. By 2020, businesses with offices and headquarters in major urban areas begin to offer metered charging outlets for commuting employees.

Key Quote: "I think that it is generally accepted that the introduction of electric vehicles is going happen in urban areas first because of things like range anxiety" (Speaker 1).

Between 2012 and 2014 EV penetration is minimal and there are few corresponding impacts to transmission and generation utilities. However, approaching 2016, local distribution companies (LDCs) begin to experience problems in areas that have a relatively large number of EVs. Additionally, these impacts may be more substantial in densely populated urban areas due to electrification of public service vehicles. Local neighbourhood transformers may not be able to accommodate many customers charging at once (Electric Transportation Engineering Corporation 2009). Rather than overhauling existing infrastructure, cash-strapped LDCs turn to electricity price regulating authorities to negotiate more aggressive time-of-use (TOU) pricing.

Key Quotes:

1. “The impacts will be very location sensitive, you’ll have pockets or areas with significant uptake and the equipment in those areas will see the impact” (Speaker 2).

2. “It’s those densely populated places [that will be most affected], and those are the places that are already in crisis today” (Speaker 5).

By 2016, TOU rate changes have helped to ensure that a greater proportion of charging occurs during off-peak hours. Throughout 2016 and 2017, the case company begins to experience marginal increases to line losses, corresponding to greater loading on the system. Adapting to the shift to EVs, price regulators begin to include consideration for necessary infrastructure improvements and upgrades when setting electricity prices – adopting higher rates per kWh and more exorbitant peak pricing.

Key Quotes:

1. “The time of use rates we have in place right now [2012]; the cost differential is not significant enough to drive a change in behaviour. So right now the additional amount you’re going to have to pay to charge your vehicle during peak hours is not exorbitant enough” (Speaker 2).

2. “What I’m thinking might happen is that the government sees the penetration of electric vehicles, sees that people are indiscriminately recharging whenever they want – the peak is going up and that’s driving more assets having to be put in place – and they mandate that there has to be some cost control on the time of charging” (Speaker 1).

By the end of 2019 EVs make up at least 10% of all light vehicles in the state/province, surpassing the 6% share that researchers suggest the grid could accommodate without further investment in transmission and power-generation (Hajimiragha, Caizares, Fowler, & Elkamel, 2010). Level 2 charging equipment is installed in homes and public spaces, providing the convenience of shorter charge times. The electricity requirement for each EV charge is comparable to the addition of a home to the grid. In response to the resulting load increase, major investment is required within urban distribution networks as aging infrastructure is put under pressure as a consequence of increased loading. The adoption of EVs begins to shift energy and requirements attributed to the transportation sector onto electric utilities. The two industries are increasingly required to collaborate with respect to their strategic planning. However, the responsibility to mitigate associated emissions increasingly lies with utility companies.

By 2022 the province/state has made a substantial commitment to clean generation sources, but the province still relies on natural gas to provide ~25-30% of the generation supply mix. This figure is based on two assumptions: 1) that the government is not on track to meet its goal of reducing demand 14% by 2030, and 2) that there is an increasing reliance on natural gas as backup generation.

The case company's Scope 2 emissions attributed to line losses and consumption in administrative buildings decrease during the first two years of the timeline, as the provincial/state government succeeds in phasing-out coal generation. Scope 3 emissions also decrease as suppliers and outsourced activities are similarly affected by the phase-out. However, as a consequence of increasing EV penetration, LDCs experience greater loading on their systems, which in turn, increases the loading on the case company's system between 2015 and 2022. The corresponding increase to line losses increases the company's total Scope 2 GHG emissions. TOU for EV charging has a significant impact on the magnitude of this increase.

Key Quotes:

1. "With higher loading you get higher loss" (Speaker 2).

2. "They're [LDC] the front end, but our stations are feeding them, so I think there's going to be a cascading impact on [the case company]" (Speaker 2).

By 2016, modifications to TOU pricing ensure 75% of EV customers charge during off-peak hours and the remaining 25% charge during peak hours. As a result, the peak load is larger and there is a relatively flat, higher loading occurring throughout the day and night. In order to accommodate these changes, the company must: (a) improve or build new infrastructure to accommodate heavier loading, and (b) make significant investments in new assets to ensure requirements for facility-based redundancies. Without the introduction of alternative insulating technology, the addition of new stations within the system during the last four years of the scenario timeline increases the company's SF_6 emissions.

Key Quote: "If you have charging during peak hours you're going to have to build more facilities, [and you will have] more SF_6" (Speaker 2).

Additionally, as installed switchgear equipment ages the rate of leakage increases, also contributing to slightly higher SF_6 emissions. The company's line loss-associated emissions increase as new infrastructure comes into service. Scope 1 fleet-associated emissions also increase during this period as the fleet is required to service more infrastructure, more frequently.

In allocating additional funding for EV related investments, the Government requests that some green energy enabling transmission and distribution projects (ETDPs) planned for the next ten years be put on hold. The Feed-in Tariff (FIT) program is modified to reduce the number of renewable generation start-ups to be connected to the grid. Preference is given to enabling a few select generation projects with the largest potential output. Furthermore, many of the ETDPs are pushed beyond 2020. Consequently, the implementation of the ETDPs has a lesser impact on the case company's carbon footprint than would be expected. There are some increases to line loss and SF_6 associated emissions as some ETDPs come online between 2015 and 2017. As renewable generation sources provide lower than expected capacity, the share of the province's/state's electricity derived from natural gas increases through to 2022.

Despite emissions increases, the case company continues to implement mitigation measures over the course of the scenario timeline. By 2020, the company begins to offer metered charging stations to encourage employees to make greener commuting choices. Employees increasingly adopt hybrid or electric vehicles for their daily commute and work-related travel, mitigating Scope 3 emissions. Furthermore, supply chain associated emissions see a similar decline as other organizations mitigate the impact of their operations. Greater efficiencies with respect to the company's fleet contribute to additional emission reductions over the next ten years.

Key Quote: "Just by a change in human behaviours I think you'll see a reduction maybe not in miles driven, but in consumption. Just by human behaviour changes you'll probably see about a 20-25% decrease in fuel consumption. This is based on more efficient systems that continually come online as we replace our fleet, and changing the behaviour of individual operators" (Speaker 3).

Key changes to the case company's carbon footprint as a result of Scenario 1 are detailed in Figure 7.

<table>
<tr><th></th><th></th><th colspan="4">Timeline</th></tr>
<tr><th>Scope</th><th>Emissions Source</th><th>2012-2014</th><th>2015-2017</th><th>2018-2020</th><th>2021-2022</th></tr>
<tr><td rowspan="4">Scope 1</td><td rowspan="2">SF6 Switchgear</td><td></td><td>Small-Moderate Increase
Assumption: Some enabling projects come into service.</td><td colspan="2">Moderate-Large Increase
Assumption: New infrastructure for heavier EV-related loading, new assets to ensure redundancies.</td></tr>
<tr><td colspan="4">Marginal Increase
Assumption: The rate of SF6 leakage increases as equipment ages.</td></tr>
<tr><td rowspan="2">Fleet</td><td></td><td colspan="3">Small-Moderate Increase
Assumption: Fleet is required to service a larger system, and more frequently as a result of heavier loading on equipment.</td></tr>
<tr><td colspan="4">Moderate Decrease (20%)
Assumption: Increased efficiencies, change in driver behaviours and trip planning, integration of more hybrids and EVs.</td></tr>
<tr><td rowspan="2">Scope 2</td><td>Line Losses</td><td>Moderate Decrease
Assumption: province/state fully phases-out coal generation.</td><td>Small-Moderate Increase
Assumption: Slight loading increases due to early adopters of EVs. Some enabling infrastructure and facilities come online.</td><td colspan="2">Moderate-Large Increase
Assumption: Heavier EV-related loading, public service EV vehicle loading, new assets to reinforce the system.</td></tr>
<tr><td>Admin. Building Electricity Consumption</td><td>Moderate Decrease
Assumption: province/state fully phases-out coal generation.</td><td colspan="2">Small - Moderate Decrease
Assumption: Remain a significant source of emissions due to continued reliance on natural gas generation. However, reductions are achieved through further efficiencies, change in user behaviours, and retrofits.</td><td>Small-Moderate Increase
Assumption: Case company begins to offer metered charging at admin. buildings for commuting employees.</td></tr>
<tr><td>Scope 3</td><td>Supply Chain, Outsourced Activities, Leased Equipment and Facilities, Employee Travel</td><td>Moderate Decrease
Assumption: The coal phase-out reduces the carbon footprint associated with supplier's operations, leased equipment and facilities.</td><td colspan="3">Small Increase
Assumption: Construction of new infrastructure, reinforcement of the system. Outsourced work increased.

Small-Moderate Decrease
Assumption: employees increasingly adopt EVs for work-related travel. *Shifting associated emissions to Scope 2 inventory.</td></tr>
</table>

Figure 7 - Scenario 1 Greenhouse Gas Emission Source Changes Summary Chart: 2012-2022.

ii. Scenario 2: Load displacement, the implementation of green energy-enabling legislation, and the changing generation mix in the province/state.

The province/state continues to embrace renewable generation over the next ten years. Remaining coal-fired generation is phased out by the end of 2014, meeting a key objective of the government's long-term energy plan. The phase-out decreases the case company's Scope 2 emissions (from purchased electricity and line losses) between 2012 and 2015. The company's share of Scope 3 emissions are reduced as leased facilities and the company's supply chain are similarly affected by the phase-out. However, the province/state falls short of the projected renewable capacity and conservation targets for the ten year period, and the difference in demand is made up by natural gas generation. As a result, province/state continues to rely on fossil–fuel source generation for ~20% of capacity through to 2022. Consequently, the company's share of emissions from Scope 2 and 3 sources are reduced but remain substantial.

While electric vehicles experience some market penetration over the ten year period, the rate is much lower than predicted. Due to higher oil production by Organization of the Petroleum Exporting Countries (OPEC) member countries and lower than expected economic growth in non-OECD countries the price of oil remains low (U.S. Energy Information Administration, 2011). Although prices at the pump remain volatile, with periods of rapid fluctuation, they remain relatively low through to 2022. Without a strong financial incentive drivers are hesitant to adopt EVs. By 2022 only 5% of all vehicles operated by the general public are electric, below the 6% share that researchers suggest the grid could accommodate without further investment in transmission and power-generation (Hajimiragha et al., 2010). As a result of low market penetration, and without necessitating the requirement for system upgrades, EVs have only a slight impact on the company's Scope 2 line loss-associated emissions.

As a consequence of legislation aimed at providing enabling transmission capacity for green energy sources, the company is directed to plan and bring into service a number of priority transmission projects.

Key Quote: "The way the [renewable energy enabling legislation] was structured was, if you build it we have to take it" (Speaker 6).

The government remains committed to investing $2 billion for these and other projects over the next seven years in order to ensure the connection of renewable generation to the system. The projects are detailed in a general 'Green Plan' and fall under three categories: 1) core transmission, 2) enabling transmission and 3) regional transmission. Of the five total projects, two are infrastructure upgrades to be in service by the end of 2014. Two more are new lines to come into service by the end of 2017, and the remaining project is a new line that has not yet been assigned a completion date. Additionally, a number of other station and circuit upgrades are to be completed during the same period.

The implementation of this plan has a number of consequences for the company's carbon footprint. The construction of infrastructure and stations will bring new switchgear into service. As there is a direct relationship between total SF_6 leakage and installed base, the company's Scope 1 SF_6 emissions will increase over the course of the scenario timeline. Over the course of the entire scenario timeline, SF_6 emissions also increase as equipment ages and rate of leakage increases.

Key Quote: "The older the equipment gets, the more it leaks – that is the reality of it" (Speaker 7).

The rate of increase may peak shortly after 2017, a year when two major new lines are expected to come into service. To service the new infrastructure, requirements of the company's fleet may also contribute to an additional increase to Scope 1 emissions. Furthermore, the expansion of the system will increase the company's total line losses.

Key Quote: "Unfortunately these wind farms are located in areas where there is hardly any load, so what is happening is our losses are going through the roof on those circuits" (Speaker 2).

Because the grid will continue to rely on natural gas generation, the emission factor used to calculate the associated CO_2e impact will include consideration for some fossil fuel-based generation. Finally, these new infrastructure projects will contribute to an increase in the company's Scope 3 emissions attributed to construction.

Between 2015 and 2022 the increase in number of renewable start-ups surpasses the rate at which new infrastructure can enable their integration with the transmission system. Furthermore, FIT prices are dramatically reduced between 2014 and 2016 as the province/state continues to operate with a surplus of electricity on the grid, which it exports at a loss.

Key Quote: "We're certainly dealing with a surplus base-load generation problem now, and right now that is the biggest problem we are dealing with" (Speaker 6).

This leaves many potential start-ups without the means to feasibly connect to the grid. As a result of rural connection difficulties, and as FIT subsidises continue to decrease, a greater share of start-ups are micro-FIT or capacity allocation-exempt projects – small projects connected to local distribution systems. These projects have fewer up-front costs and are located at the point of demand or near existing distribution infrastructure. They are installed by homeowners, businesses, and industry looking to produce some or all of their required electricity, and to sell the surplus to distributors.

The majority of these start-ups are solar installations, as public opposition to localized wind generation remains prominent through to 2022. Due to high start-up costs, the adoption of these localized generation sources is insignificant over the first half of the scenario timeline. However, as the price of photovoltaic technology decreases, and as efficiencies improve, rates of adoption increase from 2016 to 2022. Due to reduced transmission loading, the company experiences a decrease in Scope 2 GHG line loss emissions during this six year period.

Key Quote: “It [load displacement] could reduce losses quite a bit, provided it is confined to the area where the load is, for example, if it doesn’t have to travel 200 kilometres to [major municipality]” (Speaker 2).

Some Scope 1, 2 and 3 emissions are mitigated by strategies that the company implements over the course of the scenario timeline. Further efficiencies allow the company to reduce emissions resulting from its vehicle fleet and facilities. Furthermore, as load displacement becomes more economically feasible, the company begins to install solar capacity at administrative buildings – offering a clean alternative for generating a portion of required electricity.

Key changes to the case company’s carbon footprint as a result of Scenario 2 are detailed in Figure 8.

<table>
<tr><th colspan="2"></th><th colspan="4">Timeline</th></tr>
<tr><th>Scope</th><th>Emissions Source</th><th>2012-2014</th><th>2015-2017</th><th>2018-2020</th><th>2021-2022</th></tr>
<tr><td rowspan="4">Scope 1</td><td rowspan="2">SF6 Switchgear</td><td></td><td>Marginal Increase
Assumption: Over a third of enabling transmission projects expected to come into service</td><td colspan="2">Small-Moderate Increase
Assumption: A number of additional enabling projects to come into service.</td></tr>
<tr><td colspan="4">Marginal Increase
Assumption: The rate of SF6 leakage increases as equipment ages.</td></tr>
<tr><td rowspan="2">Fleet</td><td></td><td colspan="3">Small-Moderate Increase
Assumption: Fleet is required to service a larger system.</td></tr>
<tr><td colspan="4">Moderate Decrease (20%)
Assumption: Increased efficiencies, change in driver behaviours and trip planning, integration of more hybrids and EVs.</td></tr>
<tr><td>Scope 2</td><td>Line Losses</td><td>Moderate Decrease
Assumption: province/state fully phases-out coal generation.</td><td colspan="3">Small - Moderate Decrease
Assumption: Decreasing transmission loading as load displacement becomes more significant factor.</td></tr>
<tr><td rowspan="2">Scope 2</td><td>Line Losses</td><td></td><td colspan="3">Moderate Increase
Assumption: Expansion of the system (enabling projects) will increase case company's absolute total line losses.

Marginal Increase
Assumption: Slightly heavier EV-related loading, public service EV vehicle loading.</td></tr>
<tr><td>Admin. Building Electricity Consumption</td><td>Moderate Decrease
Assumption: province/state fully phases-out coal generation.</td><td colspan="2">Small - Moderate Decrease
Assumption: Remain a significant source of emissions due to continued reliance on natural gas generation. However, reductions are achieved through further efficiencies, change in user behaviours, and retrofits.</td><td>Small-Moderate Decrease
Assumption: case company begins to install solar capacity at administrative buildings – offering a clean alternative for generating a portion of required electricity.</td></tr>
<tr><td>Scope 3</td><td>Supply Chain, Outsourced Activities, Leased Equipment and Facilities, Employee Travel</td><td>Moderate Decrease
Assumption: Coal phase-out reduces the carbon footprint associated with supplier's operations, leased equipment and facilities.</td><td colspan="3">Small-Moderate Increase
Assumption: Construction of new infrastructure.</td></tr>
</table>

Figure 8 - Scenario 2 Greenhouse Gas Emission Source Changes Summary Chart: 2012-2022.

4.3 Benchmark

A summary of the findings of the benchmark component of the study is detailed below. As indicated within the literature, industry-specific knowledge is vital to the construction of any carbon management strategy (WRI & WBCSD, 2011). The study does not include consideration for generation assets, but rather other lines of business. Each header represents a category investigated by researchers.

4.3.1 GHG Emission Source Tracking and Measurement

Participants were asked to list the GHG emission sources currently measured and tracked by their respective organizations. The results are categorized according to the scoping system prescribed by the World Resource Institute's *GHG Protocol Standard*. The table below details findings for Scope 1 and Scope 2 emission sources. An ancillary paragraph discusses Scope 3 and other emission sources reported by participants.

Emission Category	Emission Source	Number of Organizations Measuring/Tracking Source
Scope 1 (direct)		
	Sulphur Hexafluoride/ Tetrafluoromethane from Equipment Leakage	5
	Fleet Fuel Consumption*	5
	Natural Gas Fuel Consumption	4
	Propane (consumption in lift-trucks)	1
	Diesel Generators, Maintenance Generators or Emergency Generators	3
	Use of Aerosols	1
Scope 2 (indirect)		
	System/Line Losses	3
	Building/Facility Electricity Consumption	4
*Inclusion of vehicle categories in accounting for fleet emissions may vary. A cumulative list of types cited by participants: maintenance vehicles, light and heavy vehicles, utility vehicles (snowmobiles, 4x4s, tractors, snow-blowers) and aircraft.		

Table 5 - GHG Emission Sources Measured and Tracked by Participating Organizations.

With respect to Scope 2 emission sources, not all organizations actively measure and track emissions associated with system losses and electricity consumption within buildings. Participants indicated two principle reasons for exclusion of these sources: 1) the organization is an integrated utility and these emission sources are accounted for under the Scope 1 category, or 2) the generation mix feeding the system does not include significant fossil fuel generation sources.

A limited number of organizations reported having measured and tracked Scope 3 emission sources (Benchmark Interviews 1, 2 and 5). One organization actively tracks emissions associated with business-related travel and employee travel to-and-from work (Benchmark Interview 1). Business-related travel is tracked whether mode of transportation is aircraft or train. The emissions associated with leased or outsourced vehicles and equipment are also tracked by the organization. Three organizations reported having measured and tracked emission offsets or costs associated with electricity imports and exports from/to neighbouring grids (Benchmark Interviews 1, 2 and 5).

4.3.2 Emission Reporting

Of the five participating organizations only two have mandatory Scope 1 emission reporting requirements (Benchmark Interviews 1 and 4). These organizations and one other (Interview 3) also report additional emissions related data voluntarily. Participants pointed to three mechanisms for voluntary reporting: (a) As part of industry organization initiatives (eg. the Canadian Energy Association), (b) within corporate sustainability reports, and (c) to a climate change or GHG registry. Two organizations indicated that GHG emissions are reported for internal use only (Interviews 2 and 5). None of the participating organizations reported having participated in the Carbon Disclosure Project. Those organizations measuring/tracking Scope 3 emission sources indicated that these savings/costs are reported internally.

4.3.3 Methods for Measuring and Tracking Emission Sources

Organizations reported a number of methods for measuring/tracking emission sources. The reported methods are detailed for each emission source in the table below.

Emission Source	Measurement Method	Inputs
Scope 1 and 2		
Fleet	Calculated by applying associated emission factors to fuel consumption.	• Fuel invoices • Some organizations by vehicle/equipment type

SF6/CF4 Emissions	With consideration for gas top-ups. Weighing cylinders before and after top-ups to determine top-up quantity and applying relevant emission factors.	• Refill cylinder weight differential
Natural Gas	Based on fuel invoice and applying relevant emission factors to quantity of fuel consumed.	• Fuel invoice
	Based on tracked metered readings for building consumption.	• Where relevant metered readings
	Estimated based on consumption averages or proxy data.	• Average consumption per square foot estimates
Building Electricity Consumption	Apply relevant emission factor to meter consumption readings for buildings.	• Relevant emission factor for generation mix • Metered electricity consumption data for facilities
Propane	Apply relevant emission factor to consumption data gathered from invoices.	• Fuel invoices
Diesel Generators, Maintenance Generators, Emergency Generators	Emission factors applied to fuel consumption values gathered from invoices.	• Fuel invoices
	For some units calculations based on number of operating hours.	• Fuel consumption per hour and type of fuel
Aerosols	Method unknown	
System Losses	Apply applicable emission factors to the sum of total transmission and distribution losses.	• Total transmission and distribution losses, relevant emission factor for generation mix
Scope 3		
Business Travel	Apply relevant industry (airline, railway, automobile) standards for fuel consumption to distance travelled.	• Travel invoice to estimate distance travelled • Relevant industry emission estimates
Electricity Exports and Imports	Apply applicable emission factors to total actual or estimated value for amount of electricity exported or imported.	• Differential between emission factors for relevant point of origin and point of consumption generation mixes • Total value for imported or exported electricity

Table 6 - GHG Emission Reduction Initiatives Identified by Participating Organizations

4.3.3 Challenges Associated with GHG Emission Measurement and Reduction Initiatives

Participants were asked to describe any challenges their organization had experienced in their ongoing efforts to measure and reduce GHG emissions. The responses are detailed below:

Smaller Emission Sources - Data for some smaller sources such as those associated with forestry and maintenance activities is difficult to gather and maintain. At least one participant suggested that because these emission sources are much less significant than fleet, SF6 and facility sources, they may not be worth prioritizing (Benchmark Interviews 2 and 3).

Supply Chain Emissions. Supply chain emissions are difficult to manage due to complexity of gathering and working with supplier data (Benchmark Interview 1). Participants also suggested that the management of these sources would be equally difficult (Benchmark Interview 1, 3 and 5). None of the organizations that participated in the benchmark currently measure/track supply chain emission sources.

Activity/Component Specific Information. Information about an emission source is general and does not convey the intensity of emissions per component part or specific activity within a process. It is difficult to address an emission source if these particulars are unknown. For instance, what share of SF6 emissions occur during the top-up process as opposed to leakage? What share of fleet emissions increases are due to a change in driving habits, to idling? In some cases fuel usage is the basis for emissions calculations, but the metrics do not account for the different particular uses for the fuel. It is difficult to measure where to most effectively focus reduction efforts (Benchmark Interview 2).

Employee Culture. One participant reported difficulties with respect to the large size of the organization. Changes to employee culture occur slowly and it takes a great deal of time for information to disseminate throughout the organization. Furthermore, the participant noted overcoming the generational gap within many organizations as a barrier to implementing GHG reduction initiatives (Benchmark Interview 2).

SF_6/CF_4 Measurement. One participant cited difficulties regarding the measurement of SF_6 emissions. The participant suggested that measuring the mass balance of the gas correctly is a difficult process, and as a result, it is difficult to validate measurement and calibrate scales (Benchmark Interview 3).

Cost Component and Government Involvement. One participant noted the difficulties in addressing GHG emission mitigation without sufficient price signals for carbon (Benchmark Interview 2). Another participant suggested that it is difficult to plan for future emission reduction initiatives when the future of the government's involvement and leadership in emissions reductions is unclear (Benchmark Interview 3).

4.3.4 Initiatives

Every organization indicated having implemented some type of initiative aimed at either GHG emission reductions or efficiency and conservation increases that have otherwise resulted in emission reductions. Emission reduction initiatives reported by participants are detailed under general categories below.

Fleet Emission Reduction Initiatives

a) Integrate new fuel efficient/hybrid/electric light vehicles with the company's fleet,
b) Retire older, less fuel efficient vehicles sooner;
c) Cap the speeds of heavy trucks at 90 km/h,
d) Install heaters within truck cabs that can be operated when the engine is shut off,
e) Implement an anti-idling policy,
f) Implement a trip planning policy requiring drivers to receive approval prior to travelling,
g) Ensure that bucket-truck operators can operate truck ignition from the bucket, and
h) Use biodiesel where feasible.

Facilities Emission Reduction Initiatives

a) HVAC and lighting retrofits to improve energy efficiency within facilities and buildings,
b) Pursue LEED certification for the design of new buildings, and upgrade of existing buildings;
c) Install occupancy sensors where practical to ensure lights are only on when needed, and
d) Regularly schedule energy audits to investigate potential saving opportunities.

SF_6 and CF_4 Reduction Initiatives

a) Replace older, less efficient units that tend to have greater rate of leakage,
b) Capture gas where possible for reuse, and
c) Ensure that gas within units that are taken out of service is appropriately disposed of or recycled.

Scope 3 Reduction Initiatives

a) Encourage customers to conserve electricity,
b) Make readily available and encourage the use of video conferencing technology to reduce the need for business related travel, and
c) Actively participate in research and development partnerships aimed at reducing emissions of the customer base. One organization has partnered with two other organizations to develop a

pilot project aimed at providing the public with electric vehicle charging stations. The organization has also worked with public transit authorities to study the electrification of the local transit system.

Three of five participants cited cost as a limiting factor to emission reduction initiatives (Benchmark Interviews 2, 4 and 5). Furthermore, some participants described the aforementioned initiatives as being primarily justified by their potential for cost savings, while GHG emission reductions served as a secondary objective (Benchmark Interviews 1, 2 and 4).

4.3.5 Mitigation Initiatives Planned for the Future

In addition to those initiatives already implemented by their organization, participants were asked to discuss mitigation options that are planned for the future. In response, participants suggested a number of considerations:

a) Reducing the requirements of small diesel generators by building renewable capacity in remote communities,
b) Tracking displacement of emissions due to exported electricity within the organization's GHG inventory,
c) Integrating additional fuel efficient, hybrid and electric vehicles with the fleet,
d) Better managing trips and fleet efficiencies attributed to operators, and
e) Begin to investigate Scope 3 emission reduction potential, particularly those associated with employee travel and business travel.

Two participants suggested that their organizations had already achieved reductions to an extent that is reasonable under the voluntary system (Benchmark Interviews 2 and 4). As a result, one participant suggested that the organization had largely adopted a 'wait and see' philosophy (Benchmark Interview 2). The same participant suggested that substantial emission reductions need to be motivated by a more meaningful price signal for carbon emissions.

4.3.6 Other Key Opportunities

Each participant was asked to discuss any GHG emission measurement or reduction opportunities that they personally felt their organization was not currently addressing. The responses are detailed below.

Better tracking – To develop a better internal tracking system for emissions across all the scope boundaries. Two participants suggested that their organizations needs to develop a more complete GHG inventory (Benchmark Interviews 2 and 5), and one indicated a need for a better system for continually updating that inventory (Benchmark Interview 2).

Greenhouse gas emission reduction initiatives are too decentralized – One participant suggested that individual departments and teams within the organization are tackling separate components of the GHG emission measurement and reduction initiatives; that there is a need for a centralized authority organizing initiatives and maintaining the inventory (Benchmark Interview 2).

Better management of Scope 3 emission sources –One participant suggested that addressing indirect emission sources is the next logical step for carbon footprint reductions. However, before these emission sources can be reduced, there needs to be a more accurate and accessible way to measure them (Benchmark Interview 5).

4.4 Recommended Actions

The third primary objective of the study was to provide a set of recommended actions whereby the organization can reduce their carbon footprint over the next decade. The set of actions was compiled based on consideration of a number of inputs including: company documents, the results of the benchmark study, the results of the scenario analysis, the literature review, and relevant standards. Each of the recommendations aims at directly reduce emissions, or taking a preliminary and necessary step towards reduction. In some cases this may involve a recommendation to measure a source not previously considered. As participants of the individual interviews suggest, and as is suggested by other sources in the literature (Carbon Disclosure Project, 2012b; Huang, Weber, & Matthews, 2009a; WRI & WBCSD, 2001) measurement is a necessary precursor to the reduction of a GHG emission source. Without the ability to measure an emission source, there is not a way to track the progress of reduction initiatives.

A key consideration for the recommended actions is that they are both feasible and practical options. Working closely with the organization and engaging senior management has helped to gauge the level commitment and action that can reasonably be pursued by the organization. The recommendations are for a ten year period between 2012 and 2022.

4.4.1 Consideration for Previous Initiatives and Relevant Issues

An in-depth review of the organization's current measurement and reduction initiatives was a key consideration of the study. The review revealed that the organization has been proactive in measuring and reducing the emissions of some of their most significant emissions sources. As detailed in section *3.4 Introduction to the Case Company*, measurement initiatives have focused on four key components of the organization's carbon footprint: the organization's fleet emissions, building associated emissions, line loss associated emissions, and SF_6 emissions. These sources represent the majority of the organization's Scope 1 and Scope 2 emissions.

The organization has completed a preliminary GHG inventory that quantifies these sources by applying methodologies prescribed by the GHG Protocol and the IPCC, and emissions metrics that are frequently updated by the federal government.

With respect to reduction initiatives, the organization has, since 2007, taken significant steps to reduce the intensity of most of its measured sources. These initiatives are detailed in *section 3.4 Introduction to the Case Company*. The only source that is measured for which there is not a reduction initiative is the line loss component of the organization's carbon footprint. Scoping discussions with the company liaison revealed that any initiatives to reduce these emissions would necessarily involve very substantial capital investments, and were therefore not feasible GHG emission reduction options.

The study focused on identifying areas in which the organization may realize emission reductions beyond those already pursued. A challenge was to determine how the organization may build on current efforts. The benchmark component of the study indicated that for many sources the organization has gone beyond the industry average.

4.4.2 Recommendations for GHG Emission Reductions

1. Screen Scope 3 Supply Chain Emission Sources.

An aspect of the carbon footprint for which the case company has devoted little focus is Scope 3 emission sources. As researchers have suggested, on average 75% of a company's carbon footprint can be attributed to scope 3 sources (Huang et al., 2009). This presents the organization with a significant opportunity to reduce some of their largest indirect emission sources. By accounting for their Scope 3 emission sources, the organization may identify those areas within the corporate value chain that may be most effectively addressed and of which the carbon impact can be significantly mitigated. Beyond identifying mitigation opportunities, WRI and WBCSD's *Corporate Value Chain (Scope 3) Accounting and Reporting Standard* identifies some other benefits organizations may realize by accounting for Scope 3 emission sources:

i) Identify and understand risks and opportunities associated with value chain emissions,

ii) Engage value chain partners in GHG management, and

iii) Enhance stakeholder information and corporate reputation through public reporting.

However, one of the difficulties in Scope 3 accounting is data prioritizing and boundaries. With a large number of total suppliers (across all tiers) it can be difficult for an organization to determine which data should be gathered and where the most intensive GHG emissions are embodied in the supply chain. Gathering life-cycle and supplier data is a very time and resource intensive process. What is needed is a screening process to determine where data collection efforts may be most usefully focused (WRI & WBCSD, 2011)

As indicated in section *2.2.4 Use and Application within the Literature*, the input-output analysis procedure provides a useful means of evaluating an environmental impact associated with an organization's entire supply chain or individual product lifecycle. Murray and Wood (2009) note the widespread use of the adapted model, EIO-LCA, by corporations to scope which suppliers are the most significant with respect to their carbon footprint, listing a number of large multinational corporations who have utilized it in the past. Additionally, the WRI and WBSCD have prescribed the model for Scope 3 corporate footprint screening. The publication of the standard is recent but it is clear that the method is gaining momentum as a useful means for organizations to estimate Scope 3 emissions sources.

The results of the EIO-LCA can be used to provide the basis for more rigorous data collection. Once an organization identifies a component of the supply chain footprint to be addressed, product-level or supplier data can be collected in order to perform a more rigorous measurement. Calculation methods are outlined in detail and with guidance within *The GHG Protocol* standard.

2. Measure and Manage Employee Travel and Business Travel

As Huang et al. (2009) assert, while EIO-LCA models are well suited for estimating the emissions associated with supply chains, they are not ideal for estimating emissions associated with business and employee travel. They do not distinguish between passenger and freight transportation, and as a result it is unclear what portion of transportation emissions are due to employee and business travel. Luckily these emissions sources are easily accounted for using activity and emission factor data, as outlined within the WRI/WBSCD Scope 3 standard.

The case company does not currently measure emissions associated with employee travel to and from work or business travel. As the organization employs over 5,000 individuals both sources have the potential to make up a significant portion of the corporate carbon footprint.

The benchmark component of the study revealed that at least one other North American utility company is actively measuring the carbon emissions associated with both business related travel and employee travel. The organization measures business travel using invoices for train and airplane trips, applying an industry specific emission factor to the total distance travelled. An annual survey is used to collect information about the distance employee are travelling to and from work, as well as the mode of transportation. Appropriate emissions factors can then be applied to determine the emission associated with employee travel. These methods of calculation are additionally prescribed by the WRI/WBSCD standard. Measuring these emission sources can provide the basis for tracking reduction initiatives.

The benchmark component of the study also revealed that at least one organization is actively encouraging its employees to make better use of video conferencing technology as a means of avoiding business travel and offsetting associated GHG emissions. This type of initiative may also be usefully employed at the case company. The United States Environmental Protection Agency has made similar commitments under its plan to reduce Scope 3 GHG emissions (United States Environmental Protection Agency, 2012). Emissions associates with employee travel to and from work can be mitigated by implementing ride-share programs and by promoting alternative modes of transportation that are not single-occupancy.

3. Solicit Employee Suggestions from throughout the Organization.

Hoffman (2005) provides one of a limited number of literary works that outline specific case studies featuring the GHG reduction initiatives of corporations. One example from these case studies exemplifies how some major corporations have approached employees throughout all levels of their organization to solicit new ideas for emission reduction initiatives.

Hoffman (2005) points to Cinergy, a large integrated power utility company, as an organization that has successfully implemented a program to involve all employees. The organization began soliciting the opinions regarding emissions reduction options of all of its 7,842 employees in 2004. Suggestions are limited to five pages and are required to include descriptions of how the proposed project would reduce emissions, an evaluation of the project's permanence, how reductions would be quantified and an estimate for associated costs. In 2004, the company received over 150 emission reduction project proposals. All proposals are assessed by the organization's core GHG emission reduction committee, which decides which may be effectively implemented.

DuPont (an agriculture, nutrition and bio-based materials corporation in the United States) has implemented a similar program to communicate the importance of climate change throughout the organization (Hoffman, 2010). The company annual selects employees to receive its Sustainable Growth Excellence Awards for individuals and business units that submit environmental projects for review. Over 400 projects are proposed each year, many of which related to reducing GHG emissions. Twelve finalists are chosen each year and awarded $5000 and a dinner with the chief executive officer.

This type of inclusive approach is ideal for brainstorming realistic opportunities for emission reductions. The case company current relies on its 'green team' to formulate ideas for emission reductions. This team represents employees (mostly managers) from across all lines of business. However, engaging the entire organization offers the opportunity to tap into the collective creativity of over 5,000 individuals. Furthermore, involving those employees who are 'on the ground' or closest to the organization's physical systems and labour offers a unique opportunity to garner the opinions of individuals who have the most intimate knowledge of the organization's systems. Cinergy received the most proposals for small system and power plant efficiency projects (Hoffman, 2005). These can have a significant cumulative impact to an organization's carbon footprint.

As Hoffman (2005) suggests, in addition to providing valuable emission reduction options, involvement of the entire organization garners internal support for climate change initiatives. Such programs help to foster a corporate culture of stewardship (Hoffman, 2005).

4. Leased Assets and Outsourced Activities

Key Scope 3 emission sources outlined by the WRI/WBCSD Scope 3 accounting standard are those associated with leased assets and outsourced activities. As indicated by the company liaison in scoping discussions, the case company has substantial leased assets (including the company's headquarters) and outsources some of its labour and activities. The case company does not currently track or reduce emissions associated with these sources.

In many cases these sources can be easily measured using data from the supplier or company supplying the service. In most cases the case company can rely on site-specific or supplier-specific data for energy consumption to calculate associated emissions. Once these sources have been measured, the organization can work with the supplier to reduce the source. In many cases the company may already have similar initiatives in place for reducing sources of their Scope 1 emissions. The company can then work with a supplier to implement those same initiatives at the site, or with respect to the activity. For example, with respect to a leased office building, the organization can work with the property owner to make the same lighting and HVAC retrofits that have been made at its own facilities.

5. Purchase Carbon Offsets

A carbon offset is a unit of GHG reductions that is created by one party and purchased and used to reduce the carbon footprint of another party (Lingl & Carlson, 2010). They represent a market-based solution to climate change that, as Lingl and Carlson (2010) explain, are based on two principles:

> 1) The location where the GHG reductions occur is not important with respect to the climate impact, because the GHGs are quickly diffused around the globe once they enter the atmosphere; and
>
> 2) The costs involved in reducing GHG emission vary across economic sectors and activities around the world. At present, every business will encounter a threshold beyond which it is too expensive or difficult to make further reductions in its own emissions. By purchasing carbon offsets a business can create more reductions than would otherwise be possible, through a more cost-effective offset project somewhere else (Longl and Carlson, 2010).

Regarding the second principle, Whirlpool experienced such a threshold in the late 1990’s. After making significant commitments to increasing efficiency and reducing GHG emissions, the organization hired a third party to analyze their manufacturing process and evaluate further opportunities. None were found and Whirlpool acknowledged that there was a “reduction saturation point”, approaching which offered fewer realistic opportunities for further efficiencies (Hoffman, 2010).

This threshold has the potential to impact any business, including case company. Carbon offsets offer the organization a means of accommodating for their emissions by supporting initiatives beyond their operational boundary and value chain.

However, as Longl and Carlson (2010) note, an organization must be wary of the quality of carbon offsets when evaluating options. Businesses who support low quality offsets may risk their corporate reputation.

6. Account for Electricity Exports to Fossil-Fuel Intensive Systems

The case company operates in a region with a rapidly greening generation mix. As a result, the organization's line loss associated emissions have the potential to significantly decrease over the next decade. However, the case company may also contribute to greening the energy supply in neighbouring jurisdictions.

This recommendation is industry-specific and resulted from the in-depth case study involving the case company, and the benchmark component focused specific on the utility industry. The case company's electricity grid system is connected to grids within neighbouring jurisdictions for the purpose of electricity importation and exportation. During the scenario building workshop, participants suggested that the organization is increasingly facing a surplus of electricity on the grid system at points throughout the day and night. As a result, the organization is required to export significant portions of electricity to neighbouring jurisdictions.

As indicated in the results of the benchmark component of the study, three utility companies within the organization's country have already begun to track emissions offsets and costs associated with the import or export of electricity to/from neighbouring jurisdictions. The following principles can be followed to account for these emissions:

a) Where electricity is exported to a jurisdiction with a more fossil-fuel intensive generation mix (with a higher ratio of CO_2e emitted per kilowatt hour of electricity produced) an organization accounts for the offset emissions within Scope 3 of the corporate carbon inventory.

b) Where electricity is exported to a jurisdiction that has a cleaner generation mix (with a lower ratio of CO_2e emitted per kilowatt hour of electricity produced) an organization accounts for the GHG emission cost within Scope 3 of the corporate carbon inventory.

c) Where electricity is imported from a neighbouring jurisdiction that has a more fossil-fuel intensive generation mix an organization accounts for the associated GHG emission cost derived from providing their customers with the electricity under Scope 3 of the corporate carbon inventory.

d) Where electricity is imported from a neighbouring jurisdiction that has a cleaner generation mix an organization accounts for the GHG emission offset derived from providing their customers with cleaner electricity under Scope 3 of the corporate carbon inventory.

The principles were developed by the author drawing on a variety of observations from the findings of the benchmark study.

As the case company exports a significantly larger share of electricity than is imported (Scenario Building Group Workshop, March 2, 2012), and as the generation mix continues to shift towards renewable sources, the organization stands to gain significant carbon reductions by accounting for these Scope 3 emission sources.

7. On-Site Renewable Energy Sources to Offset Grid Demand

This recommendation is applicable to Scenario 2: Load displacement, the implementation of the green energy-enabling legislation, and the changing generation mix in the province/state**.** It is based on the assumption made within the scenario that the capital costs associated with solar and wind renewable technologies for on-site electricity generation will decrease significantly over the next decade.

It is not currently feasible for individuals or organizations to produce on-site electricity for homes, offices or warehouses due to lengthy pay-back periods (Scenario Building Group Workshop, March 2, 2012). In regions supplied by fossil-fuel intensive generation sources, current up-front capital costs for solar and wind on-site energy provision make the generation sources an impractical solution to carbon footprint reduction. Payback periods for on-site renewable systems vary greatly and are determined by a range of factors that are unique to each climate, electricity regime and economy. A study that included consideration for different regions of the United States found that payback times for solar on-site generation can be typically over 25 years (Sedghisigarchi, 2009).

Although the generation mix in the case company's region will continue to shift towards renewables over the next decade, the province/state will continue to rely on fossil-fuels to produce a substantial portion of required electricity. This consideration was included by participants in each of the scenarios. Furthermore, participants agreed that the up-front capital costs of renewable for on-site generation will likely decrease significantly over the next decade. When the capital costs of such technology are reduced, payback periods are significantly reduced and installations become more feasible

(Sedghisigarchin, 2009). As a result, wind, solar or hybrid systems may become an effective means for the organization to:

1. Produce electricity at a discount over the long-term,
2. Reduce GHG emissions associated with the organization's carbon footprint, and
3. Negate line/system losses associated with a portion of electricity powering buildings and facilities.

For these reasons, the United States Environmental Protection Agency has installed a number of renewable on-site generation sources at select facilities (United States Environmental Protection Agency, 2012).

8. EV charging for Employees

The adoption of electric vehicles by the general public, coupled with a shift towards more renewable generation sources offers the potential for significant transportation associated GHG emission reductions within any province/state. As previously discussed, the generation mix that feeds the case company's electricity grid is transitioning away from fossil-fuel generation sources.

Both scenarios developed by participants suggest at least a portion of the population to adopt electric vehicles over the next decade. While the adoption of electric vehicles does threaten to dramatically increase the case company's Scope 2 emission sources associated with line losses and SF_6 emissions (as indicated within Scenario 1, section *4.2.3 The Scenarios*), it also presents an opportunity for the organization to reduce the GHG emissions associated with employee commuting (Scope 3). By offering electric vehicle charging stations at workplaces, organizations can encourage adoption by employees. While the organization may choose to offer the electricity free of charge at first – adoption may be limited at first – the service can be made cost neutral by metering the stations and providing the charge at cost.

5. Discussion

5.1 The Complexity of Carbon Management

The case study provides one of a limited number of comprehensive investigations into the issue of carbon management within organizations. The scenario analysis has afforded the study the rare opportunity to evaluate corporate carbon management activities based on extensive and intimate involvement of a range of senior-level decision makers. As a result, the study is in the unique position to contribute to the ongoing dialogue regarding corporate motivation and climate change action within the literature.

Researchers have pointed to social, stakeholder, environmental, regulatory and economic factors that positively influence corporate GHG reductions (Boiral et al., 2011; Hoffman, 2005, 2010; Okereke, 2007). Some of the factors are prominent in the findings of this research and corroborate such arguments. Of the seven senior management employees that participated in the study, four referenced social responsibility as a key motivation behind the company's commitment to reduce GHG emissions. Participants suggested that it was important for the organization to be a good corporate steward. In addition, the findings show that stakeholder pressure has a significant impact on the company's determination to reduce GHG emissions. Participants also suggested that the attitude of the company shareholder regarding climate change strongly influences the corporation. Finally, participants cited the corporation's commitment to protecting the environment under the environmental stewardship component of its corporate policy as a major driving force behind its climate change action.

Indeed the findings of the research suggest that the degree to which the case company addresses its GHG emissions is substantially influenced by particular social, regulatory, technological, stakeholder and economic factors that are unique to the organization. These factors are both internal and external to the case company. However, where the literature points to these factors as positively influencing action, the case study suggests that they may also limit an organization's ability to mitigate GHG emissions. In particular external, technological and stakeholder factors may limit a corporation's ability to address climate change. Furthermore, the academic literature has largely ignored the relationship of corporate climate change action to an organization's core corporate strategy, an aspect for which this thesis is equipped to contribute. The research points to the need for an integrated carbon management strategy that is intrinsically linked to all of an organization's key corporate objectives. Both of these points are discussed in the following subsections.

5.1.1 Line Loss and SF6 Emissions – External Forces, Stakeholder Influence and Technical Limitation

As outlined within *4.2 Introduction to the Case Company,* line loss Scope 2 emissions are the case company's most substantial GHG emission source. As a means of mitigating Scope 2 emission sources, standards and sources within the literature suggest that individuals and organizations may reduce their consumption of electricity. There are generally two reduction options for Scope 2 emissions: (a) reducing total electricity consumed by limiting an activity or process (eg. turning off the lights), and (b) making processes more efficient so that they can perform the same task or amount of work using less electricity. However, with regard to the case company the issue of reducing Scope 2 line loss associated emissions is significantly more complex.

The company has taken no action to reduce Scope 2 emissions associated with line losses. The liaison and other members of the scenario building team deemed reduction of GHG emissions resulting from line losses infeasible. Understanding this sentiment requires an investigation of the particular business environment in which the case company operates.

With regard to reduction option (a), Scope 2 line losses emissions are difficult to manage due to external influence. As a transmission and distribution company, the case company serves as an intermediary between the electricity generator and the consumer, the general public. The case company has as its primary objective the safe and reliable provision of electricity to the general public within the political jurisdiction in which it operates. In this capacity, the organization is vulnerable to external changes to customer electricity demand. The company has, since before it managed GHG emissions, made extensive efforts to encourage its customers to conserve electricity. However, where existing load demand increases, or new load is needed (due to new land or region development) the organization must act accordingly. When loading increases or new transmission and distribution lines are required, the case company's line or system losses and resulting Scope 2 emissions increase.

Additionally, the organization serves at the pleasure of its sole shareholder and operates in a highly regulated industry. The shareholder (and regulating authority) plays a dominant role in the operations of the organization. As a result, the case company is required to respond to directives submitted by the shareholder requesting the construction of new infrastructure. In the instance of the case company, this has been particularly relevant in response to the enacting of green generation-enabling legislation aimed at connecting distributed generation sources to the electricity grid. Reflective of this consideration, Scenario 2 includes consideration for moderate increases to line loss-associated emissions due to the construction of new infrastructure (refer to section *4.2.3 The Scenarios*). As a result of these external and regulatory influences, the company has little influence over reduction option (a). Limiting the amount of electricity supplied to the general public would directly conflict with the organization's mandated core function. Furthermore, the company faces the social pressures associated with providing what many North Americans might consider to be an essential service. The potential for line loss emission mitigation due to reduction option (b) is discussed in section 5.1.2.

Some sources within the literature suggest that corporate response is often dependent on the development of new technology (Boiral, 2006; Jones & Levy, 2007; Kolk & Pinkse, 2004).The case study provides an example of an instance when a particular technology has limited the organization's ability to reduce GHG emissions. The case company and the industry have adopted sulphur hexafluoride insulated switchgear equipment (as detailed in *4.2 Introduction to the Case Company*) as the industry standard. As a result of normal operation this equipment emits one of the most potent known GHGs. The industry has become dependent on this technology to perform a vital function within an electrical grid (United States Environmental Protection Agency, 2010). Although there has been extensive study devoted to finding an alternative that may perform a similar function, a feasible replacement has not been found (United States Environmental Protection Agency, 2010). This sentiment was corroborated by a workshop participant (Scenario Building Workshop, March 2, 2012). The participant suggested that while there are limited means of reducing associated emissions, there is no feasible way to completely eliminate emissions associated with the equipment.

Participants of the interviews (Interview 2 and 6) also suggested currently technical limitations as a barrier to realizing further fleet associated emission reductions. The case company's fleet is required to perform industry-specific tasks under the climate changes particular to the region in which the vehicles operate. As a result, the majority of the case company's fleet is made up of specialty vehicles. Although technological innovation has contributed to the greening of vehicles generally, the same cannot be said for these specialty vehicles. As indicated by the participant of Interview 6, such technology is not yet in a position to assist the company in reducing associated GHG emissions. The participant suggested that adopting such technology at this stage of development may compromise the fleet's ability to carry out maintenance of core components of the system.

The study reveals that organizations could be challenged to reduce GHG emissions when operating in an environment that presents constraints that are largely unavoidable. In some cases, these constraints are imposed upon the organization externally and by stakeholders. In other instances, these constraints may be due to legacy decisions, industry standard equipment, or technologies that are difficult to remediate.

5.1.2 Corporate Climate Change Action on the Periphery and the Win-Win Reasoning

The academic literature has largely ignored the relationship of corporate climate change action to an organization's core corporate strategy. An analysis of the nature of climate change action integration within the case organizations reveals that the degree to which the organization addresses its carbon footprint is largely motivated by its commitment to its other strategic objectives.

The case study reveals that corporate climate change action remains on the periphery; it is an isolated component of the organization's corporate policy rather than a holistic and integrated component within its core strategic objectives. As revealed by interview participants, GHG emissions reductions are often limited by the organization's commitment to other strategic objectives. The presence of corporate climate change action as a subsidiary objective provides the basis for this balancing against the organization's other strategic objectives. In other words, it is not intrinsically linked to them. This affords senior management, indeed the entire organization, the opportunity to ignore the decision for GHG emission reductions in the day-to-day operations of the company. It is clear that this opportunity often leads to limitation of GHG reduction opportunities. Participants suggested that core strategic objectives, such as health and safety, economics, and system reliability, often outweigh those for climate change action (Interviews 1, 3, 4 and 7) .

Regarding the challenges surrounding the case company's efforts to reduce GHG emissions, the participant of Interview 2 suggested, "the need to ensure the grid is maintained in a reliable fashion versus the need to reduce carbon emissions; it is a function of priorities and reliability, at the moment, comes first." Indeed it is unreasonable for an organization to compromise its core function to reduce GHG emissions, an act that would certainly harm its competitiveness. This is particularly true of the case company; the organization plays a vital role in the operation of the entire state/province in which it operates as it provides a necessary service. Jeopardizing the reliability of the electrical system has major consequences for society. However, by distinguishing climate change as an ancillary objective, decision makers have, to a degree, precluded the possibility of achieving both objectives simultaneously. Rather than integrating GHG emission reduction decisions into key strategic objectives, decision makers perceive of climate change action as an objective on the periphery, subject to its own distinct funding, initiatives and consideration.

By opting not to integrate GHG emission reduction thinking into core strategic objectives, the organization is not only limiting its ability to achieve substantial GHG reductions, but it may be prevented from realizing a competitive advantage. Within the literature, researchers have pointed to a "win-win' philosophy that suggests that climate change actions is competitively advantageous to organizations (Boiral, 2006; Hoffman, 2005; Jones & Levy, 2007; Okereke & Russel, 2010; Schultz & Williamson, 2005). However, a key finding of Boiral et al. (2011) suggests that while it is economically beneficial for organizations to adopt climate change actions, the "win-win" reasoning is rarely the justification for doing so; that organizations largely pursue climate change action due to social, environmental and stakeholder related influences.

This thesis strongly corroborates the findings of Boiral et al. (2011). Pushing GHG mitigation to the periphery of the organization's strategic objectives, participants frame the organization's efforts as being largely responsive to external social, environmental and stakeholder pressures that are cited as the key motivations for action (Interviews 1, 2, 3, 5, 6 and 7). Only one participant suggested that the organization pursues GHG emissions reductions for their ability to reduce costs and positively impact corporate performance (Interview 6). This illuminates perhaps one of the largest challenges associated with corporate GHG management, assigning an economic valuation of related initiatives. Although some GHG reduction initiatives can be quantified in terms of energy cost savings, many remain problematic in this respect. However, even when the financial implications are relatively understood, and the action would result in cost savings, it is clear that GHG emission mitigation remains on the periphery.

An ideal example of this sentiment is demonstrated by the way in which the organization approaches mitigation of its largest emission source. As discussed in section 5.1.1, corporations can achieve reduction of Scope 2 emission sources by making processes more efficient so that they may perform the same task or amount of work using less electricity (option [b]). As suggested by the company liaison, and a number of other participants, reducing line losses through improving efficiency requires significantly large capital investments. It would require the replacement of current infrastructure with state-of the art technology and materials (Interview 3). As the participant of Interview 3 suggested, any such investment would not be justified by GHG emission reductions, but by other drivers. Investing that amount of capital strictly in GHG emission reduction initiatives may also compromise the organization's ability to satisfy its core economic objective, an objective that, as the participant of Interview 5 suggested, values the replacement of assets when they fail and not because they are high loss. However, as the participant suggested, replacing assets that are high loss not only produces significant line loss and GHG reductions, but would be financially beneficial to the company, and improve the reliability of the system (Interview 5). The findings therefore support the logic of the "win-win" reasoning, but suggest that because of the peripheral nature of corporate climate change action managers are not considering it during the decision making process.

As indicated by the discussion, corporate carbon management is a complex issue that involves a number of social, economic, technological, environmental and stakeholder factors that must be considered. It is clear that companies can be limited in their ability to influence their carbon footprint because of a number of external, stakeholder and technological implications. However, the ability of the organization to reduce GHG emissions is also affected by the nature of the relationship between climate change action and the organization's core strategic objectives.

As a result of the peripheral nature of corporate climate change action, the organization has largely ruled out the possibility of reducing their largest measured emission source. While the organization has taken steps to reduce its carbon footprint, these initiatives focus strictly on emission sources that are relatively small by comparison (see section 3.4 *Introduction to the Case Company*). Also indicative of this sentiment, prior to this thesis the organization had only considered a limited number of their total emission sources. As a result, the organization can be said to have adopted the "wait and see" approach to carbon management (Boiral et al., 2011; Sullivan, 2010). This thesis makes a strong case for more holistic integration of corporate climate change action with the corporation's core objectives. By doing so, the organization has the potential not only to further reduce their impact to the environment, but to positively influence performance.

What is ideally needed is integration of carbon management ideals with the company's key corporate objectives. The consideration for carbon reductions needs to be incorporated into the day-to-day decisions made by managers, directors and other employees across the entire organization. In this sense, reducing GHG emissions becomes an integral and unavoidable part of the everyday operation of the company. However, greater leadership from government (in the form of mandatory emission reduction regulations) may be needed to force organizations to address GHG management within core strategic plans. It is also clear that any such action needs to be informed by the specific external, stakeholder and technological implications that influence a corporate carbon footprint.

5.2 The Benchmark Results: The Importance of Industry-Specific Knowledge, A Gap in the GHG Protocol, and the "Wait and See" Approach to Carbon Management

Some sources within the literature point to the importance of industry specific knowledge to GHG mitigation efforts (Hoffman, 2010; Lingl et al., 2010; WRI & WBCSD, 2001). In early scoping interviews, the liaison explained that despite the usefulness of GHG accounting standards for guidance on emissions measurement, there were industry-specific implications that general guidelines could not help to address. While the GHG protocol does provide this type of information for some industries (Greenhouse Gas Protocol, 2012), the list is certainly not all inclusive. Considering the magnitude of the global warming impact associated with SF_6 emissions, and its ubiquitous usage within the electric utility sector, the GHG protocol should consider integrating guidance for this sector.

In response to the lack of industry-specific knowledge, the benchmark serves as a valuable tool. The results provide participants with relevant knowledge that is unique to the industry but may not be included in the *GHG Protocol*. Through communication of ideas, challenges and methods the industry as a whole is better equipped to address GHG emissions.

The benchmark did contribute to the development of a better understanding of the case company's carbon footprint. For instance, the case company had not previously considered accounting for indirect emission offsets or costs associated with imported and exported electricity. Furthermore, it has suggested some alternative methodologies which the organization may consider implementing to better capture their corporate carbon footprint within the GHG inventory.

However, the benchmark also further contributes to reinforcing the "wait and see" philosophy detailed in the literature (Boiral et al., 2011; Sullivan, 2010). The most obvious indicator is the suggestion by two participants that their organizations had achieved emissions reductions to an extent that was reasonable (Benchmark Interviews 2 and 4), suggesting further reduction was unwarranted. One participant explicitly stated that the organization was hesitant to substantially reduce emissions until a meaningful price signal for carbon emissions had been established (Benchmark Interview 2). Furthermore, with one exception, the participating companies largely focus on reduction of a few Scope 1 and Scope 2 emission sources. Despite the identification of a vast number of relevant emissions sources indicated within the process maps (see section 4.1 *Mapping the Organization's GHG emission sources*), participating organizations have cumulatively developed reduction initiatives addressing just five emission sources.

The findings also suggest that organizations within the industry continue to view corporate climate change action as a periphery objective. As three of the five participants suggested, cost is a limiting factor to GHG emission reductions. It is clear that the "win-win" reasoning does not play a role in motivating reduction initiatives within these organizations, but rather the initiatives are seen as alternatives to the core strategy.

5.3 The use of Scenario Analysis for Carbon Management

It is clear that management of the case company's carbon footprint is a complex issue that is impacted by external, social, economic, stakeholder and technological factors. The case study indicates that these factors take on organization-specific implications that may influence an organization's ability to address the corporate carbon footprint. Scenario analysis offers a means of making sense of this complexity by integrating knowledge and opinions from throughout the organization, and investigating and surfacing key assumptions. Indeed, the analysis detailed within this thesis has helped the organization to develop a significantly better understanding about the vulnerability of the corporate carbon footprint to external influences. In this sense, it has been demonstrated as a useful tool for corporate carbon footprinting, and provides a much needed demonstration of the application of strategic analysis to the environmental management field (Höjer et al., 2008). However, the most profound contribution this thesis has made to the field is its ability to demonstrate how scenario analysis can take a strategic objective from the periphery of an organization, and integrate it with considerations for core issues.

As identified by numerous sources within the literature (Bishop, Hines, & Collins, 2007; Chermack, 2011; Peterson, Cumming, & Carpenter, 2003; Phelps et al., 2001; Wack, 1985a, 1985b; van der Heijden, 2005), a primary objective of scenario analysis is to change and improve the quality of individual's perceptions. By doing so, scenario analysis seeks to better prepare them to make decisions that are beneficial to an organization in the future. To that end, typical analyses focus on core issues facing an organization. For instance, for Wack (1984a) and his scenario building team at Shell the core issue was the supply of oil from the Middle East, a major contributing factor to the organizations ability to accomplish its primary objective. However, where the analysis within this thesis differs is its focus on an issue that lies on the periphery of the organization's group of objectives. The consequences associated with the management of the corporate carbon footprint may be severe in the long term (to the environment and the organization), but are perceived to be much less relevant to organization's ability to survive in the future than other strategic objectives. This is made very clear by the responses of participants detailed in section 4.2.1.

However, despite having a focus on a purpose question (see page 44) related to an objective on the periphery, the analysis was steered by participants toward those issues that had the potential to dramatically impact the way the organization operates entirely. For example, Scenario 1 details the dramatic implications the electrification of vehicles would have across the entire organization; implications that were extensively discussed by participants. For instance, it would involve dramatic restructuring of the infrastructure and significant new capital investment. However, keeping to the purpose of the analysis, participants discussed these core issues in the context of the corporate carbon footprint. It is not surprising then that the scenarios projected significant changes to the carbon footprint over the next ten years; participants were investigating issues that threatened to upset the status quo of the organization's core function. It is this consideration that reveals the utility of scenario analysis for carbon management. It incorporates consideration into discussions regarding core strategy.

Furthermore, rather than considering GHG emission management as a responsive measure, implemented to reduce the impact of existing processes within the organization, it places the issue in the context of key proactive strategy. The ultimate aim of scenario analysis is to help the organization to quickly and proactively act to change in the environment. Where traditional initiatives to mitigate climate change have been reactive in nature, this type of consideration encourages proactive thinking.

As with any scenario analysis, it is difficult to measure the degree to which the process has expanded the mental models of participants. However, by requiring participants to strategically discuss the key issues facing an organization while integrating consideration for carbon management, the process has contributed to bringing the issue of corporate carbon management closer to the core. Certainly with regard to the process, the development of the scenarios has contributed to enhancing how key decision makers within the organization perceive of the corporate carbon footprint.

6. Conclusions

6.1 Summary

As major emitters of GHGs, organizations have an important role to play in addressing the threat of climate change. An in depth literature review has revealed that while there has been extensive debate throughout the literature about corporate willingness and motivation to address the issue, there are only very few examples of case studies detailing the particular actions taken by companies. Furthermore, there are a very limited number of examples involving the implementation of a systematic approach for assisting organizations in their ongoing efforts to reduce their GHG emissions.

There remains a degree of uncertainty regarding the future of corporate climate change mitigation. Standards are constantly evolving and new products and green technologies are continually coming to market that have the potential to detriment or aid mitigation efforts. Furthermore, the international community and federal and provincial/state governments have increasingly adopted a patchwork of response mechanisms. Finally, as indicated by the development of the case study and key scenarios, the footprint of organizations can be particularly vulnerable to external influence and economic and social factors. The resulting effect is that corporations are increasingly faced with uncertainty about the future of their carbon management activities. Organizations are charged with the task of developing and implementing environmental strategies while compensating for this uncertainty. Current approaches focus on planning for the present, with very little regard for how an organization's carbon footprint may change in the future.

Another key consideration regarding carbon footprinting is the reliance on industry-specific knowledge and communication. As suggested by Hoffman (2010) and the WBCSD/WRI *GHG Protocol*, industry-specific knowledge regarding carbon management activities is crucial to the development of carbon strategies. Standards such as the WBCSD/WRI GHG Protocol contain valuable information for organizations about emission sources and measurement, but do not provide extensive detail about sources and measurement within specific sectors.

This thesis addresses these gaps by providing a case study exemplifying the application of a unique carbon footprint approach at an electric utility company. The approach includes three principle objectives: 1) to develop a baseline of GHG emission sources for the partner organization, 2) to project its key emissions over the next ten years and, 3) develop practical options for the organization to consider reducing its organizational carbon footprint over the next decade. These objectives were addressed through the development of three principle outputs: 1) process maps whereby the case company may systematically identify its current carbon footprint, 2) scenario analyses to help project its future carbon emissions over the next ten years, and 3) a set of recommended actions to reduce the company's GHG emissions over the next decade. An ancillary objective identifying relevant industry related initiatives through a benchmarking exercise.

A review of key internal documents, the consultation of relevant standards, consultations with company employees, and a benchmark of the industry formed the basis for the construction of the process maps. The corporation had previously considered five emission sources within its carbon inventory and GHG emission reduction plan. The process maps identify twenty other emission sources that the organization may consider for the management of the corporate carbon footprint. Where the organization had strictly considered Scope 1 and Scope 2 emission sources, the maps include an emphasis on Scope 3 emission sources as well. Furthermore, the maps provide a data assessment based on quality indicators prescribed by applicable standards. Finally, the maps include consideration for carbon footprint changes as outlined within each of the distinct scenarios. The process maps also facilitated discussion among participants for other components of the study.

The scenario analysis led to the construction of two distinct scenarios. Each scenario provides a narrative based on a set of assumptions, driving forces and occurrences resulting from strategic conversation among participants. Scenario 1 is highlighted by a dramatic shift of carbon emissions from the general public and the transportation sector onto the utility sector. As a result, the organization may face increases to its Scope 1 and Scope 2 GHG emissions over the next decade. However, there is a resulting opportunity for the decrease of Scope 3 emissions. Scenario 2 is highlighted by a shift towards load displacement resulting in a decrease to Scope 2 emission sources. However, this decrease is discounted in the first half of the scenario due to significant investment in new infrastructure. As a result of the scenario analysis process, the corporation is better equipped to respond to rapid changes to the structure and magnitude of their carbon footprint.

Based on a detailed literature review, an internal document review, the scenario building process and the industry benchmark, a series of recommended actions were developed aimed at reducing the organization’s carbon footprint over the next decade. The recommendations, made for present and future consideration, include: screening Scope 3 supply chain emissions with EIO-LCA, managing employee travel and business travel emissions, soliciting employee project proposals, reducing emissions associated with leased assets and outsourced activities, purchasing carbon offsets, accounting for electricity import and export associated emissions, developing on-site renewable generation, offering charging stations to employees to encourage electric vehicle adoption. These actions focus largely on steps the case company can take to measure or reduce its Scope 3 emission sources. Although the company has taken significant steps to reduce direct emissions, indirect sources have received little focus. By addressing them, the organization can take advantage of a significant opportunity to reduce their impact to the environment, and to better compete in future carbon constrained markets (Boiral et al., 2011).

6.2 Contributions

As highlighted in the literature review, there are relatively few case studies detailing the application of a systematic approach for corporate carbon footprinting. This study has helped to develop such a systematic approach that may be employed by corporations both within and outside of the electric utility sector. It provides a baseline upon which much needed advancement in the practice can be made. Furthermore, the approach integrates strategic scenario analysis, a tool that can be used to accommodate for the complexity inherent in carbon management and the relevant future uncertainty. The research exemplifies the usefulness of the scenario analysis process for bringing corporate carbon management from the periphery and integrating it with discussions about the core issues facing an organization. As a result, the approach has demonstrated how the application of scenario analysis is well suited for the task of developing and integrating carbon management strategies within organizations.

The benchmark component of the research has provided a valuable indication of the industry-specific methods and initiatives relating to GHG emission management. Industry-specific knowledge is vital to the success of any carbon management strategy. Standards and guidelines are too general to account for methods and mitigation options associated with each specific industry. The results of this component of the research will be useful to any corporation within the industry for the purpose carbon management and have been particularly useful in identifying options for the reduction of the case company's carbon footprint. The findings may also be useful to the case company to help them to improve measurement and tracking methods.

Finally, the study has contributed to the academic literature regarding corporate carbon footprinting generally. The case study demonstrated that organizations' ability to address their GHG emissions may be significantly impacted by external, regulatory, economic, social and technological factors. The factors may be relevant in ways unique to each organization and may be internal or external. The study has also demonstrated that the ability of an organization to reduce GHG emissions is also affected by the nature of the relationship between climate change action and the organization's core strategic objectives.

By perceiving corporate carbon management as a periphery objective, an organization may be failing to capitalize on significant opportunities for emission reductions. It is clear that organizations continue to dissociate GHG management with economic benefits. Furthermore, as indicated by the findings of the case study, when the issue remains on the periphery, organizations tend to adopt a “wait and see” approach to carbon management. Without stronger leadership from government, the issue may remain on the periphery.

6.3 Limitations

A limitation of the study regards the availability of the scenario building team. The scenario building process should involve extensive involvement of the organization over the course of a number of workshops. The company liaison determined that employees would only be available to participate in a single workshop. However, researchers adapted the method to include heavier reliance on interviews. As participants were able to schedule interviews at their convenience, it was a more preferable method. However, this did limit the strategic conversation amongst participants to just the one workshop session.

Ideally, the ranking process should involve all members of the scenario building team. It is important to prompt a debate and strategic conversation about the key driving forces that culminates in the selection of a few key options. This limitation was mitigated as the process was completed by that employee with the most detailed knowledge of the organization’s carbon footprint and the relevant issues. In order to further mitigate the limited availability of participants, correspondence for the purpose of the scenario building process also occurred between researchers and participants electronically.

6.4 Recommendation for Future Research

There are some relevant topics upon which future research should focus. Although some publications discuss the application of input-output analysis to corporate carbon footprinting, there is a need for case studies that demonstrate the specific process by which an organization applies the tool and adapts their carbon strategy accordingly. Furthermore, research in this area could focus on the development of a carbon procurement plan that draws from the results of the analysis to guide the purchasing decisions made by the organization towards reductions. The plan should be aimed at helping organizations to reduce the emissions associated with their supply chain emissions, which as the literature suggests, make up a significant portion of an organization’s carbon footprint. It is clear from the research that organizations have considered Scope 3 emission reductions to a limited extent. The development of methods and strategies for the reduction of these emissions is generally needed.

The literature would also benefit from further investigation of the integration of corporate climate change action with organization's core strategic objectives. Although this may be a difficult process to implement, as it necessarily involves modifying the way in which an organization approaches everyday business, it certainly warrants further research. Finally, as indicated throughout this study, industry-specific information is a necessity of any carbon management process. Additional research into the issues and opportunities within other sectors should be pursued.

APPENDICES

Appendix A: Key Supporting Quotes

The following is a list of key supporting quotes transcribed directly from audio recordings of both the individual interviews and the group workshops. The quotes are provided to support findings summaries included in the body text.

The following table provides key quotes from the individual interviews:

Key Consideration	Speaker	Key Quote
Major Forces/ Potential Scenarios	Interview 1	The one scenario that stands out to me is the electrification of the general population's vehicles. I'd like to know what potential there is out of that.
	Interview 3	Amount of power used is another element that has the potential to have an influence. The question I've got on my mind is: what is the impact of the electrification of either rail or cars? I'm just not sure what that means at the end of the day.
	Interview 1	We haven't done very much in terms of carbon offsets. That's an area that I would be curious to explore further.
	Interview 2	The introduction of a theoretical model for carbon savings in which individuals can apply inputs based on the carbon theory they are trying to reduce. The output would provide an illustration of what the savings are from a carbon emissions perspective. It would help employees understand how their everyday actions affect the company's overall GHG footprint.

	Interview 5	A shift with respect to how the company values line losses. This is so pervasive throughout the organization that it can enable a lot of change. One can say 'Well you can keep that line up there for another ten years'. But in reality if we can get to that point where the line loss differential is large enough to drive the early retirement of some older assets and lines, I really have believed for quite a while that that really is the lynchpin to making investment decisions. If we can get to the point where that is very clearly in the economic view of things and people really understand that, then you shift the discussion away from end of life to reduction of total costs of operating the system. If you can change that equation and really champion that notion, I think that would drive a lot of change.
	Interview 6	If you were to build a model or scenario, then what you would want to look at is original capital value and ask yourself: 'If you increase capital investment, how does that change the opportunities, flexibility and speed of your GHG emission reductions?
Motivations to Mitigate	Interview 6	Our mitigation efforts are less about branding and more about being a good corporate steward.
Willingness to Mitigate	Interview 4	Considering the company's commitment to other strategic objectives, there is an appropriate level of willingness.
Funding GHG Emission Measurement and Mitigation Efforts	Interview 6	From the top-down, it is clear that the GHG mitigation efforts are to be integrated into the current resource plans. We wouldn't go out and hire for an additional position focused on GHG mitigation.
Data Assessment and Gaps	Interview 4	If it can't be tangibly tracked and measured, it isn't likely to be mitigated.

	Interview 2	One source that is often overlooked, and can influence any other source is people. People drive GHG emissions.
New Mitigation Opportunities	Interview 3	Right now we don't value the replacement of assets because they are high loss, but because they fail or come to the end of their useful life and pose a risk.
Foreseeable Challenges	Interview 2	The need to ensure the grid is maintained in a reliable fashion versus the need to reduce carbon emissions; it is a function of priorities and reliability, at the moment, comes first.
	Interview 1	Our provincial government has decided that reducing greenhouse gases is an important policy item, evident in the introduction of the Green Energy Act and other related legislation. Because we are driven by the corporate strategy and that strategy includes a strong component of shareholder value, then this political commitment is required to maintain our drive to improve as far as greenhouse gas emissions are concerned.
	Interview 6	With respect to fleet reductions, technology is just not in a position to assist the company in these initiatives yet. Technology needs to catch-up in order to be a better fit for the company.

	Interview 5	There are issues with respect to how the energy sector is changing. There's a confused degree of accountabilities in terms of regulating new electricity developments. There is very little focus on the environment by the involved stakeholders and authorities, who tend to place more emphasis on reliability and cost. There seems to be a shift towards promoting more competition over new construction and development contracts, with countries and large corporations biding on transmission and distribution projects. The winning bid is often the one with the lowest associated financial cost, with very little consideration for environmental cost. This type of decision making does not appear to be changing. As a result, cost has become the controlling factor, not environmental protection or GHG emissions.
Relevant Future Developments	Interview 1	Although it will integrate green, cleaner sources of electricity with the grid, it [the Green Energy Plan] will increase the company's line losses and may contribute to more substantial GHG emissions.

Key quotes transcribed from the scenario building workshop for scenario 1:

Speaker	Supporting Quote
Speaker 1	I think that it is generally accepted that the introduction of electric vehicles is going to happen in urban areas first because of things like range anxiety.
Speaker 2	The impacts will be very location sensitive, you'll have pockets or areas with significant uptake and the equipment in those areas will see the impact.

Speaker 2	The other thing that's going to have a big impact on the system would be, for example, if the (…)* Police Force decided to convert their fleet to EVs, (…)* School Board, the [municipal government], etcetera.
Speaker 5	It's those densely populated places [that will be most affected], and those are the places that are already in crisis today.
Speaker 2	The Time of use rates we have in place right now [2012]; the cost differential is not significant enough to drive a change in behaviour. So right now the additional amount you're going to have to pay to charge your vehicle during peak hours is not exorbitant enough.
Speaker 1	What I'm thinking might happen is that the government sees the penetration of electric vehicles, sees that people are indiscriminately recharging whenever they want – the peak is going up and that's driving more assets having to be put in place – and they mandate that there has to be some cost control on the time of charging.
Speaker 2	With higher loading you get higher loss.
Speaker 5	All you've done is you've outsourced your vehicle emissions.
Speaker 1	If you have an electric car and you use level 2 charging, you're almost adding [the equivalent demand of] a house.
Speaker 5	The question then is then are they [the utilities] more effective at mitigating emissions than individuals.
Speaker 5	For every 10 MW of wind power you need 10 MW of natural gas backup.
Speaker 1	If you electrify a significant amount of the vehicles in [state/province]*, that's going to increase demand on transmission usage because the supply to urban centres is going to need to increase.
Speaker 2	They're [LDC] the front end, but our stations are feeding them, so I think there's going to be a cascading impact on [the case company]*.

Speaker 2	As you add more load to the system, which you will with electric vehicles, your losses will go up significantly.
Speaker 5	I think the fallout is that we have a flat load that is as high as it is today, in which case you have to build a lot more facilities for redundancies so you can actually take elements out of service, so that you can maintain the system. Then, since you don't have any relief on your system in the evenings, you have to build more robust capacity. So we're talking about a lot of asset investment, even beyond the fact that most of our infrastructure is already old.
Speaker 7	The older the equipment gets, the more it leaks – that is the reality of it.
Speakers 5 and 6	If you are installing new stations, do you have more SF6?…Certainly
Speaker 2	If you have charging during peak hours you're going to have to build more facilities, [and you will have] more SF6.
Speaker 7	That's all we have is SF6, any new equipment we get uses SF6. There is no alternative.
Speaker 3	Just by a change in human behaviours I think you'll see a reduction maybe not in miles driven, but in consumption. Just by human behaviour changes you'll probably see about a 20-25% decrease in fuel consumption. This is based on more efficient systems that continually come online as we replace our fleet, and changing the behaviour of individual operators
	* indicates information removed for confidentiality

Key quotes transcribed from the scenario building workshop for 2cenario 2:

Speaker	Supporting Quote
Speaker 6	The way the Green Energy Act was structured was, if you build it we have to take it.
Speaker 7	There is a direct correlation between the amount of SF6 installed gear you have and the amount of net leakage.

Speaker 7	You are going to require more maintenance and that means more travel to these stations.
Speaker 7	The older the equipment gets, the more it leaks – that is the reality of it.
Speaker 2	Unfortunately these wind farms are located in areas where there is hardly any load, so what is happening is our losses are going through the roof on those circuits.
Speaker 6	They have to get environmental approval, so they [renewable generators] found land which is cheaper and as far away as possible from anyone that will complain.
Speaker 6	We're certainly dealing with a surplus base-load generation problem now, and right now that is the biggest problem we are dealing with.
Speaker 2	It [load displacement] could reduce losses quite a bit, provided it is confined to the area where the load is, for example, if it doesn't have to travel 200 kilometres to [major municipality]*.
Speaker 5	The NIMBY-ism is going to be there so it has got to be something that is almost invisible, which then leads you to solar rather than other generation options.
Speaker 5	In order for that [load displacement] to happen, your technology has to be significantly better, and your cost has got to be really a lot cheaper.

* information removed for confidentiality

7. References

Alcamo, J. (2008). *Environmental Futures: The practice of environmental scenario analysis*. Amsterdam: Elsevier.

Becker, T. J., Sidhu, I., & Tenderich, B. (2009). *Electric vehicles in the United States: A new model with forecasts to 2030*. Retrieved from http://cet.berkeley.edu/dl/CET_TechnicalBrief_Economic Model2030_f.pdf

Bevilacqua, M., Ciarapica, F. E., Giacchetta, G., & Marchetti, B. (2011). A carbon footprint analysis in the textile supply chain. *International Journal of Sustainable Engineering*, *4*(1), 24-36. doi:10.1080/19397038.2010.502582

Bishop, P., Hines, A., & Collins, T. (2007). The current state of scenario development: An overview of techniques. *Foresight*, *9*(1), 5-25.

Boiral, O. (2006). Global warming: Should companies adopt a proactive strategy? *Long Range Planning*, *39*(3), 315-330. doi:10.1016/j.lrp.2006.07.002

Boiral, O., Henri, J.-F., & Talbot, D. (2011). Modeling the Impacts of Corporate Commitment on Climate Change. *Business Strategy and the Environment*. Published online in Wiley Online Library. doi:10.1002/bse.723

British Columbia Hydro. (2012). Power is lost in BC Hydro's grid, but smart meters will help. Retrieved April 12, 2012, from http://www.bchydro.com/news/conservation/unplug_this_blog/2011/ smart_meters_efficiencies.html

British Columbia Ministry of Finance. (2012). Carbon tax review, and carbon tax overview. Retrieved June 3, 2012, from http://www.fin.gov.bc.ca/tbs/tp/climate/carbon_tax.htm

Carballo-Penela, A., & Doménech, J. L. (2010). Managing the carbon footprint of products: the contribution of the method composed of financial statements (MC3). *The International Journal of Life Cycle Assessment*, *15*(9), 962-969. doi:10.1007/s11367-010-0230-1

Carbon Disclosure Project. (2012a). Our program reports. Retrieved May 14, 2012, from https://www.cd project.net/en-US/Results/Pages/reports.aspx

Carbon Disclosure Project. (2012b). What we do. Retrieved May 16, 2012, from https://www.cd project.net/en-US/WhatWeDo/Pages/investors.aspx

Cavanagh, R., Gupta, A., Lashof, D., & Tatsutani, M. (1993). Utilities and CO2 emissions: Who bears the risks of future regulation? *The Electricity Journal*, *6*(2), 64-75. doi:10.1016/1040-6190(93)90041-I

Center for Climate and Energy Solutions. (2012a). Business environmnetal leadership council. Retrieved May 12, 2012, from http://www.c2es.org/business/belc

Center for Climate and Energy Solutions. (2012b). About us. Retrieved May 12, 2012, from http://www.c2es.org/about

Chermack, T. J. (2011). *Scenario Planning in Organizations: How to create, use, and assess scenarios*. San Francisco, CA: Berrett-Koehler Publishers.

Damelio, R. (2011). *Basics of process mapping* (2nd ed.). London, UK: Productivity Press.

Das, S. (2012). Achieving carbon neutrality in the global aluminum industry. *JOM*, *64*(2), 285-290. doi:10.1007/s11837-012-0237-0

Duncan, N. E., & Wack, P. (1994). Scenarios designed to improve decision making. *Strategy & Leadership*, *22*(4), 18-46.

East, A. J. (2008). *Vegetable industry carbon footprint scoping study: What is a carbon footprint? An overview of definitions and methodologies*. Sydney, Australia. Retrieved from http://www.vegie carbontool.com.au/uploads/Discussion Paper 1_What is a carbon footprint.pdf

Edwards, J. B., McKinnon, A. C., & Cullinane, S. L. (2010). Comparative analysis of the carbon footprints of conventional and online retailing: A "last mile" perspective. *International Journal of Physical Distribution & Logistics Management*, *40*(1/2), 103-123. doi:10.1108/09600031011018055

Ellerman, a. D., & Buchner, B. K. (2007). The european union emissions trading scheme: Origins, allocation, and early results. *Review of Environmental Economics and Policy*, *1*(1), 66-87. doi:10.1093/reep/rem003

Emadi, A., Sohrabi, M., Jamiolahmady, M., Ireland, S., & Robertson, G. (2011). Reducing heavy oil carbon footprint and enhancing production through CO2 injection. *Chemical Engineering Research and Design*, *89*(9), 1783-1793. doi:10.1016/j.cherd.2010.08.008

Flyvbjerg, B. (2006). Five misunderstandings about case-study research. *Qualitative Inquiry*, *12*(2), 219-245. doi:10.1177/1077800405284363

Forza, C. (2002). Survey research in operations management: A process-based perspective. *International Journal of Operations & Production Management*, *22*(2), 152-194. doi:10.1108/01443570210414310

Franchetti, M., & Kilaru, P. (2012). Modeling the impact of municipal solid waste recycling on greenhouse gas emissions in Ohio, USA. *Resources, Conservation and Recycling*, *58* (1), 107-113. doi:10.1016/j.resconrec.2011.11.004

Friedrich, E., Pillay, S., & Buckley, C. (2009). Carbon footprint analysis for increasing water supply and sanitation in South Africa: A case study. *Journal of Cleaner Production*, *17*(1), 1-12.

Gan, Y., Liang, C., Hamel, C., Cutforth, H., & Wang, H. (2011). Strategies for reducing the carbon footprint of field crops for semiarid areas. A review. *Agronomy for Sustainable Development*, *31*(4), 643-656. doi:10.1007/s13593-011-0011-7

Gooding, C. H. (2012). Data for the carbon footprinting of rendering operations. *Journal of Industrial Ecology*, *16*(2), 223-230. doi:10.1111/j.1530-9290.2011.00430.x

Grant Thornton. (2007). *International business report 2007: Global overview*. Retrieved from http://www.internationalbusinessreport.com/files/ international_business_report_2007_ global_overview.pdf

Greenhouse Gas Protocol. (2012). About us. Retrieved from http://www.ghgprotocol.org/about-ghgp

Gummesson, E. (1991). *Qualitative Methods in Management Research*. Los Angeles, CA: Sage Publications.

Hajimiragha, A., Caizares, C. A., Fowler, M. W., & Elkamel, A. (2010). Optimal transition to plug-in hybrid electric vehicles in Ontario, Canada, considering the electricity-grid limitations. *IEEE Transactions on Industrial Electronics*, *57*(2), 690-701. doi:10.1109/TIE.2009.2025711

Hoffman, A. J. (2005). Climate change strategy: The business logic behind voluntary greenhouse gas reductions. *California Management Review*, *47*(3), 21-46.

Hoffman, A. J. (2010). *Strategies: How leading companies are reducing their climate change footprint*. Michigan: University of Michigan Press.

Hoffman, A. J., & Woody, J. (2008). *Climate change: What's your business strategy?* Boston, MA: HBS Press Books.

Hoffman, V., & Busch, T. (2008). Corporate carbon performance indicators: Carbon intensity, dependency, exposure and risk. *Journal of Industrial Ecology*, *12*(4), 505-520.

Hsu, S. (2008). A Realistic Evaluation of Climate Change Litigation through the Lens of a Hypothetical Lawsuit. *University of Colorado Law Review*, *79* (1). Retrieved from http://works.bepress.com /shi_ling_hsu/6/

Huang, Y. A., Lenzen, M., Weber, C. L., Murray, J., & Matthews, H. S. (2009). The role of input–output analysis for the screening of corporate carbon footprints. *Economic Systems Research*, *21*(3), 217-242. doi:10.1080/09535310903541348

Huang, Y. A., Weber, C., & Matthews, H. (2009a). Categorization of scope 3 emissions for streamlined enterprise carbon footprinting. *Environmental Science and Technology*, *43*(22), 8509-8515.

Huang, Y. A., Weber, C. L., & Matthews, H. S. (2009b). Carbon footprinting upstream supply chain for electronics manufacturing and computer services. *2009 IEEE International Symposium on Sustainable Systems and Technology*, 1-6. IEEE. doi:10.1109/ISSST.2009.5156679

Höjer, M., Ahlroth, S., Dreborg, K. H., Ekvall, T., Finnveden, G., Hjelm, O., Hochschorner, E. (2008). Scenarios in selected tools for environmental systems analysis. *Journal of Cleaner Production*, *16*(18), 1958-1970. doi:10.1016/j.jclepro.2008.01.008

IPCC. (1996). *Revised 1996 IPCC guidelines for national greenhouse gas inventories*. Retrieved from http://www.ipcc-nggip.iges.or.jp/public/gl/invs6a.html

Ilic, A., Staake, T., & Fleisch, E. (2009). Using sensor information to reduce the carbon footprint of perishable goods. *IEEE Pervasive Computing*, *8*(1), 22-29. doi:10.1109/MPRV.2009.20

International Organization for Standardization. (2006a). *ISO 14064-1:Greenhouse gases - Part 1: Specification with guidance at the organization level for quantification and reporting of greenhouse gas emissions and removals*. Geneva.

International Organization for Standardization. (2006b). *ISO 14064-2: Specification with guidance at the project level for quantification, monitoring and reporting of greenhouse gas emission reductions or removal enhancements*. Geneva.

International Organization for Standardization. (2006c). *ISO 14064-3: Specification with guidance for the validation and verification of greenhouse gas assertions*. Geneva.

International Panel on Climate Change. (1990). *IPCC first assessment report 1990*. Retrieved from http://www.ipcc.ch/publications_and_data/publications_and_data_reports.shtml#.UAIIyrVfHYH

International Panel on Climate Change. (2011). IPCC TFI home. *About IPCC TFI*. Retrieved September 17, 2011, from http://www.ipcc-nggip.iges.or.jp/org/aboutnggip.html

International Panel on Climate Change. (2012a). Organization. *About Us*. Retrieved June 30, 2012, from http://www.ipcc.ch/organization/organization.shtml

International Panel on Climate Change. (2012b). Publications. *Task Force on National Greenhouse Gas Inventories*. Retrieved January 15, 2012, from http://www.ipcc-nggip.iges.or.jp/public/gl/invs1.html

Jensen, J. K. (2012). Product carbon footprint developments and gaps. *International Journal of Physical Distribution & Logistics Management*, *42*(4), 338-354. doi:10.1108/09600031211231326

Jeswani, H. K., Wehrmeyer, W., & Mulugetta, Y. (2008). How warm is the corporate response to climate change ? evidence from Pakistan and the UK. *Business Strategy and the Environment*, *17*(1), 46-60. doi:10.1002/bse

Johnson, E. P. (2012). Carbon footprints of heating oil and LPG heating systems. *Environmental Impact Assessment Review*, *35*(4), 11-22. doi:10.1016/j.eiar.2012.01.004

Jones, C. a., & Levy, D. L. (2007). North American Business Strategies Towards Climate Change. *European Management Journal*, *25*(6), 428-440. doi:10.1016/j.emj.2007.07.001

Karimi, P., Qureshi, A. S., Bahramloo, R., & Molden, D. (2012). Reducing carbon emissions through improved irrigation and groundwater management: A case study from Iran. *Agricultural Water Management*, *108* (5), 52-60. doi:10.1016/j.agwat.2011.09.001

Kolk, A., & Levy, D. (2001). Winds of change: Corporate strategy, climate change and oil multinationals. *European Management Journal*, *19*(5), 501-509.

Kolk, A., Levy, D., & Pinkse, J. (2008). Corporate responses in an emerging climate regime: The institutionalization and commensuration of carbon disclosure. *European Accounting Review*, *17*(4), 719-745.

Kolk, A., & Pinkse, J. (2004). Market strategies for climate change. *European Management Journal*, *22*(3), 304-314. doi:10.1016/j.emj.2004.04.011

Larsen, H. N., & Hertwich, E. G. (2011). Analyzing the carbon footprint from public services provided by counties. *Journal of Cleaner Production*, *19*(17-18), 1975-1981. doi:10.1016/j.jclepro.2011.06.014

Lash, J., & Wellington, F. (2007). Competitive advantage on a warming planet. *Harvard Business Review*, *85*(3), 95-102.

Lee, K.-H., & Cheong, I.-M. (2011). Measuring a carbon footprint and environmental practice: the case of Hyundai Motors Co. (HMC). *Industrial Management & Data Systems*, *111*(6), 961-978. doi:10.1108/02635571111144991

Leggett, J. (2001). *The carbon war: Global warming and the end of the oil era*. New York, NY: Routledge.

Lenzen. (2001). Errors in conventional and input-output-based life-cycle inventories. *Journal of Industrial Ecology*, *4*(4), 127-148.

Leonardi, J., & Browne, M. (2010). A method for assessing the carbon footprint of maritime freight transport: European case study and results. *International Journal of Logistics Research and Applications*, *13*(5), 349-358. doi:10.1080/13675567.2010.511607

Levy, D. L., & Egan, D. (2003). A neo-gramscian approach to corporate political strategy: conflict and accommodation in the climate change negotiations. *Journal of Management Studies*, *40*(4), 803-829. doi:10.1111/1467-6486.00361

Lin, B., & Li, X. (2011). The effect of carbon tax on per capita CO2 emissions. *Energy Policy*, *39*(9), 5137-5146. doi:10.1016/j.enpol.2011.05.050

Lingl, P., Carlson, D., & The David Suzuki Foundation. (2010). *Doing business in a new climate: A guide to measuring, reducing and offsetting greenhouse gas emissions*. London, UK: Earthscan.

Matthews, H. S., Hendrickson, C. T., & Weber, C. L. (2008). The importance of carbon footprint estimation boundaries. *Environmental Science & Technology*, *42*(16), 5839-5842. doi:10.1021/es703112w

Murray, J., & Wood, R. (2010). *The sustainability practitioner's guide to input-output analysis*. Champaign, IL: Common Ground Publishing.

Noor, K. B. M. (2008). Case study: A strategic research methodology. *American Journal of Applied Sciences*, *5*(11), 1602-1604.

Okereke, C. (2007). An exploration of motivations, drivers and barriers to carbon management. *European Management Journal*, *25*(6), 475-486. doi:10.1016/j.emj.2007.08.002

Okereke, C., & Russel, D. (2010). Regulatory pressure and competitive dynamics: carbon management strategies of UK energy-intensive companies. *California Management Review*, *52*(4), 100-124. doi:10.1525/cmr.2010.52.4.100

Peterson, G., Cumming, G., & Carpenter, S. (2003). Scenario planning: A tool for conservation in an uncertain world. *Conservation Biology*, *17*(2), 358-366.

Phelps, R., Chan, C., & Kapsalis, S. C. (2001). Does scenario planning affect performance? Two exploratory studies. *Journal of Business Research*, *51*(12), 223-232.

Porter, M., & Reinhardt, F. (2007). Grist: A strategic approach to climate. *Harvard Business Review*, *85*(10), 22-26.

Postma, T. J. B., & Liebl, F. (2005). How to improve scenario analysis as a strategic management tool? *Technological Forecasting and Social Change*, *72*(2), 161-173.

Pulver, S. (2007). Making sense of corporate environmentalism. *Organization & Environment*, *20*(1), 44-83.

Scholz, R. W., & Wiek, A. (2005). Operational eco-efficienty: Comparing firms' environmental investments in different domains of operation. *Journal of Industrial Ecology*, *9*(4), 155-170.

Schultz, K., & Williamson, P. (2005). Gaining competitive advantage in a carbon-constrained world: Strategies for European business. *European Management Journal*, *23*(4), 383-391. doi:10.1016/j.emj.2005.06.010

Schwartz, P. (1991). *The art of the long view*. New York: Doubleday.

Schäfer, F., & Blanke, M. (2012). Farming and marketing system affects carbon and water footprint – a case study using Hokaido pumpkin. *Journal of Cleaner Production*, *28*, 113-119. Elsevier Ltd. doi:10.1016/j.jclepro.2011.08.019

Scopus. (2012). Analyze results: TITLE-ABS-KEY("carbon footprint") AND DOCTYPE(ar). Retrieved April 12, 2012, from http://www.scopus.com/term/analyzer.url?sid=PjstGHT9KWpEzs1Y009_El2:50 &origin=resultslist&src=s&s=TITLE-ABS-KEY("carbon+footprint")+AND+DOCTYPE(ar)&sort=plf-f&sdt=b&sot=b&sl=49&count=1252&analyzeResults=Analyze+results&txGid=PjstGHT9KWpEzs1Y009_El2:7

Searcy, C., Karapetrovic, S., & McCartney, D. (2007). Integrating sustainable development indicators with existing business infrastructure. *International Journal of Innovation and Sustainable Development*, *1*(4), 389-411.

Sedghisigarchi, K. (2009). Residential solar systems: Technology, net-metering, and financial payback. *Proceedings from the 2009 IEEE Electrical Power & Energy Conference (EPEC)*, 1-6. IEEE. doi:10.1109/EPEC.2009.5420778

Stein, M., & Khare, A. (2009). Calculating the carbon footprint of a chemical plant: A case study of Akzonobel. *Journal of Environmental Assessment Policy and Management*, *11*(3), 291. doi:10.1142/S1464333209003373

Sullivan, R. (2008). *Corporate response to climate change*. Sheffield, UK: Greenleaf Publishing.

Sullivan, R. (2010). An assessment of the climate change policies and performance of large European companies. *Climate Policy*, *10*(1), 38-50. doi:10.3763/cpol.2008.0591

The United States Energy Information Agency. (2011). *Annual energy outlook, 2011: With projections to 2035.* Retrieved from http://www.eia.gov/forecasts/aeo/pdf/ 0383(2011).pdf

The United States Energy Information Agency. (2012). Frequently asked questions: How much electricity is lost in transmission and distribution in the United States? Retrieved from http://205.254.135.7/ tools/faqs/faq.cfm?id=105&t=3

United Nations Environment Program. (2003). *Four scenarios for Europe*. Retrieved from http://www.unep.org/ geo/GEO3/pdfs/four_scenarios_europe.pdf

United Nations Framework Convention on Climate Change. (2012). Background on the UNFCCC: The international response to climate change. Retrieved May 12, 2012, from http://unfccc.int/ essential_background/items/6031.php

United States Environmental Protection Agency. (2010). *Sulfur Hexafluoride emission reduction partnership for electric power systems*. Retrieved from http://www.epa.gov/electricpower-sf6/ documents/sf6_2010_ann_report.pdf

United States Environmental Protection Agency. (2012). EPA's greenhouse gas goals and reduction strategy. Retrieved May 18, 2012, from http://www.epa.gov/oaintrnt/ghg/strategies.htm

Virtanen, Y., Kurppa, S., Saarinen, M., Katajajuuri, J., Usva, K., & Mäenpää, I. (2011). Carbon footprint of food- approaches from national input-output statistics and a LCA of a food portion. *Journal of Cleaner Production*, *19*(16), 1849-1856.

Volkery, A., & Ribeiro, T. (2009). Scenario planning in public policy: Understanding use, impacts and the role of institutional context factors. *Technological Forecasting and Social Change*, *76*(9), 1198-1207. doi:10.1016/j.techfore.2009.07.009

WRI, & WBCSD. (2001). *The greenhouse gas protocol: A corporate accounting and reporting standard*. Retrieved from http://www.ghgprotocol.org/files/ghgp/public/ghg-protocol-revised.pdf

WRI, & WBCSD. (2011). *Corporate value chain (Scope 3) accounting and reporting Standard*. Retrieved from http://www.ghgprotocol.org/files/ghgp/public/Corporate Value Chain %28Scope 3%29/ Accounting and Reporting Standard.pdf

Wack, P. (1985a). Scenarios : Shooting the rapids. *Harvard Business Review*, *85*(November-December), 139-151.

Wack, P. (1985b). Scenarios: Uncharted waters ahead. *Harvard Business Review*, *85*(September-October), 73-89.

Wackernagel, M., & Rees, W. (1996). *Our ecological footprint: reducing human impact on the earth*. Gabriola Island, BC: New Society Publishers.

Wiedmann, T., & Minx, J. (2008). A definition of "carbon footprint." In C. Pertsova (Ed.), *Ecological Economics Research Trends* (pp. 1-11). Hauppauge NY: Nova Science Publishers.

Wu, F. F., Nadira, R., Weber, E. P., Thomas, C. L., & Maratukulam, D. J. (1993). Bulk transmission system loss analysis. *IEEE Transactions on Power System*, *8*(2), 405-416.

Yin, R. K. (2009). *Case study research: Design and methods* (4th ed.). Thousand Oaks, CA: Sage Publications.

van Asselt, M. B. A. (2002). Uncertainty in integrated assessment modelling. *Climatic Change*, *54*(1), 75-105.

van der Heijden, K. (2005). *Scenarios: The art of strategic conversation* (2nd ed.). New York, NY: Wiley.