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Pursuing Credibility Through Standardization: The Potential for Canadian Product Category Rules to Enhance the Comparability of Greenhouse Gas Emissions Claims of Alberta's Oil Sands

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Pursuing Credibility Through Standardization:

The Potential for Canadian Product Category Rules to Enhance the Comparability of Greenhouse Gas Emissions Claims of Alberta's Oil Sands

by

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Abstract

The accuracy, transparency, and comparability of life cycle estimates are central to the controversy over the use of life cycle assessment to support policy. This thesis examines the potential for a Canadian formal voluntary standard to create product category rules for crude oil products. Such a standard would be developed at the Canadian Standards Association, and may enhance the credibility and improve the comparability of greenhouse gas emissions claims of Alberta's oil sands products. A case study is developed as a narrative of key stakeholders in the proposed standard's development, and interview findings are compared with hypotheses derived from standards literature. Challenges facing consensus in life cycle assessment were found to parallel those facing standards development organizations. Novel findings indicate widespread disagreement with the use of life cycle assessment to support regulation, substantial differences in the desired prescriptiveness of the standard, and a heavy focus placed on its revision post-implementation.

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To dedication.

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Acronyms

AEMP – Alberta Environmental Monitoring Panel

AER – Alberta Energy Regulator

AESRD – Alberta Environment and Sustainable Resource Development

API – American Petroleum Institute

ANSI – American National Standards Institute

CAPP – Canadian Association of Petroleum Producers

CCS – Carbon capture and storage

CEMA – Cumulative Environmental Management Association

CEN – European Committee for Standardization

CEPA – Canadian Energy Pipeline Association

CFERB – Conjoint Faculties Ethics Research Board

COSIA – Canada's Oil Sands Innovation Alliance

CSA – Canadian Standards Association

EC – Environment Canada

EIA – Environmental Impact Assessment

ENGO – Environmental non-governmental organization

EPD – Environmental product declarations

ERCB – Energy Resources Conservation Board

FQD – Fuel Quality Directive

GHG – Greenhouse gas

IAG – Independent Advisory Group

ICT – Information and Communication Technology

ISO – International Organization for Standardization

LARP – Alberta's Lower Athabasca Regional Plan

LCA – Life cycle assessment

LCI – Life cycle inventory analysis

LCIA – Life cycle impact assessment

LCFS – California's Low Carbon Fuel Standard

LPG – Liquefied petroleum gases

NDA – Non-disclosure agreement

NGO – Non-governmental organization

NSC – National Standard of Canada

NSO – National standardization organization

PCR – Product category rules

RCE – Responsible Canadian Energy™

RSC – Royal Society of Canada

SAGD – Steam-assisted gravity drainage

SCC – Standards Council of Canada

SCO – Synthetic crude oil

SDO – Standards development organization

SOR – Steam-to-oil ratio

SSO – Standards Setting Organization

TEOR – Thermally enhanced oil recovery

WRI – World Resources Institute

WTW – Well-to-wheels life cycle assessment (LCA)

WBCSD – World Business Council for Sustainable Development

Definitions

Related to Standards

Canadian Standards Association (CSA) – An SDO in Canada that sets consensus-based, voluntary standards by mediating discussions by representatives on standards setting committees (Salter, 1995a, p. 25). The CSA represents the Standards Council of Canada (SCC) in ISO committees (CSA Group, 2013), and is accredited by the Standards Council of Canada (SCC), who approves its consensus process (CSA Group, 2012b).

Consensus – General agreement, if not unanimity, after a process for resolving objectives to proposed solutions (Cargill & Bolin, 2007, p. 313).

Environmental product declaration (EPD) – Based upon product category rules (PCR), an EPD will establish requirements, select parameter categories, and define third-party involvement and external communication formats (Baumann & Tillman, 2004) for products that are functionally equivalent. EPDs are standardized by ISO 14025 (2006a), and Type III EPD are those which are third-party verified. **Voluntary standard –** A standard set or promulgated from a standard development organization (SDO) or a standard setting organization (SSO).

Formal voluntary standard – A standard developed through a process of consensus and promulgated from a standard development organization (SDO).

Institution – Refers to the market setting in which standards are implemented as well as interactions of industry consortia in which information is shared (Salter, 1995a).

Member body – The “national body most representative of standardization in its country,” also referred to as “full members.” ISO member bodies have full voting rights on ISO committees, and may base their own national standards on ISO standards (ISO, 2009).

National Standard of Canada (NSC) – A standard prepared or reviewed by a Canadian standards development organization (SDO) and approved by the Standards Council of Canada (SCC) (CSA, 2006).

National standardization organization (NSO) – A member body of ISO (de Vries, 1997).

Policy communities – The whole environment in which standards emerge (Salter, 1995a).

Product Category Rules (PCR) – Guidance for conducting each phase of a life cycle assessment (LCA) and reporting results for a particular product category to develop Type III environmental product declarations (EPD) (ISO, 2006a) and to support their comparability (CSA, 2012).

Standards Council of Canada (SCC) – Canada's ISO member body (ISO, 2009) and a federal Crown corporation (SCC, 2012) that approves the consensus process for standards development at the Canadian Standards Association and coordinates Canada's National Standards System (CSA, 2006). It may also be considered a national standardization organization (NSO), as it is the national member of ISO for Canada (de Vries, 1997).

Standards setting organization (SSO) – An organization which promulgates standards and instils legitimacy in specifications (Cargill & Bolin, 2007, p. 299). SDOs differ in terms of openness of the standardization process and decision-making rules (de Vries, 1997).

Standards development organization (SDO) – A standards setting organization (SSO) that leads standards development through a process of formal consensus. The Canadian Standards Association (CSA) is a Canadian SDO, and may produce a National Standard of Canada (NSC) approved by the Standards Council of Canada (SCC) and which is responsible for a standard's technical content (CSA, 2006). SDOs are also referred to as "standards develop*ing* organizations" in standards literature (de Vries, 1997).

Definitions

Related to Life Cycle Assessment

All of the following have been taken directly from ISO (2006b).

Data quality – Characteristic of data that relate to their ability to satisfy stated requirements.

Life cycle – Consecutive and interlinked stages of a product system, from raw material acquisition or generation from natural resources to final disposal

Life cycle assessment (LCA) – Compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle

Life cycle inventory analysis (LCI) – Phase of life cycle assessment involving the compilation and quantification of inputs and outputs for a product throughout its life cycle

Life cycle impact assessment (LCIA) – Phase of life cycle assessment aimed at understanding and evaluating the magnitude and significance of the potential environmental impacts for a product system throughout the life cycle of the product

Comparative assertion – Environmental claim regarding the superiority or equivalence of one product versus a competing product that performs the same function

Transparency – Open, comprehensive and understandable presentation of information

Co-product – Any of two or more products coming from the same unit process or product system

Process – Set of interrelated or interacting activities that transforms inputs into outputs

Energy flow – Input to or output from a unit process or product system, quantified in energy units

Functional unit – Quantified performance of a product system for use as a reference unit, such as work done over distance as measured in MJ.

Impact category – Class representing the environmental issue of concern

Impact category indicator - Quantifiable representation of an impact category. The shorter expression "category indicator" is often used. For climate change, this can refer to infrared radiative forcing (W/m^2).

Impact/Indicator parameter – Can include emissions, energy and material resources, and wastes. For example, greenhouse gas (GHG) emissions, measured in gCO_{2e}.

Input – Product, material or energy flow that enters a unit process

Output – Product, material or energy flow that leaves a unit process

Sensitivity analysis - Systematic procedures for estimating the effects of the choices made regarding methods and data on the outcome of a study

System boundary - Set of criteria specifying which unit processes are part of a product system

Uncertainty analysis - Systematic procedure to quantify the uncertainty introduced in the results of a life cycle inventory analysis due to the cumulative effects of model imprecision, input uncertainty and data variability. Either ranges or probability distributions are used to determine uncertainty in the results.

Unit process – Smallest element considered in the life cycle inventory analysis for which input and output data are quantified

Chapter 1: Introduction

Product comparisons uphold consumer choice, and are made between functionally equivalent products based on the determination and communication of product attributes. With increasing global scrutiny of climate change, the greenhouse gas (GHG) footprint of crude oil has been the focus of recent attention, both in Canada and internationally. Alberta's heavy crude oil, and the oil sands particularly, face market competition from lighter crudes and biofuels, and are subject to what some in industry perceive as unfair discrimination through policies which govern importing jurisdictions based on the comparison of life cycle emissions between products. The creation of product category rules (PCRs) by standardizing life cycle assessment (LCA) of these products may result in more credible GHG calculations by enhancing the accuracy and transparency of emissions estimates. This may allow for a more unbiased comparison between Alberta's heavy crudes and their market competitors.

The aims of this thesis are to (1) to investigate the potential for a Canadian PCR for crude oil to address issues facing the standardization of LCA for Alberta's oil sands, and (2) to elucidate potential process issues and ways to mitigate them in the development of such a standard at the Canadian Standards Association (CSA), a Canadian standards development organization (SDO). The following questions guide the research:

1. What are the current issues facing the oil sands industry in Alberta with respect to standardization of data, governance, and communication?
2. To what extent might a CSA PCR for crude oil help to mitigate these issues, given alternatives of regulations or industry standards?
3. Given anticipated issues in the development of such a standard, how would this standard be most effectively developed?

To answer these questions, a literature review is conducted to identify the state of the literature on requirements and considerations in the formation of formal voluntary standards at SDOs, and to identify major issues facing the standardization of LCA of Alberta's oil sands products. Hypotheses are generated based on the information gathered. Next, a case study is developed on the potential for a CSA PCR for crude oil to address select issues facing Alberta's oil sands and to predict potential challenges in its development process. Finally, interview findings are compared with what is predicted by hypotheses, and conclusions are made as to the potential for a CSA PCR for crude oil to be successful in addressing the issues identified. This is followed by recommendations for an effective and efficient development process for the PCR.

This thesis is an examination of a potential standard at the initial proposal stage, which is a critical moment in its final outcome as its form begins to take shape and stakeholders begin to consider their potential strategic involvement. It provides an overview of the environment in which a CSA PCR for crude oil would be developed before negotiations begin. This thesis contributes an empirical study by gathering evidence to estimate the potential viability of a national standard developed by an SDO to increase the credibility of life cycle estimates by enhancing their transparency and accuracy. Contributions are made in (1) validating or challenging standards literature with evidence, and by (2) offering ways to mitigate process issues, as recommendations for improvements. The qualitative interpretation of findings was deemed most appropriate given the nascent state of discussions on this subject, and with the recognition that the voluntary standards setting process is not akin to the "idealized world of the rational policy planner" (Breyer, 1982, p. 98). Contextualizing a hypothetical standard in its spheres of influence through the holistic approach taken by this thesis allows for flexibility when considering and interpreting its potential form. Also, as Cargill and Bolin (2007) explain, examining the complex forces acting within the standards setting environment allows for the investigation of the relationship between input and potential outcomes rather than post-implementation effects.

This thesis was approached from the standpoint that the voluntary standard is an innovative approach to enhancing credibility in Canada's oil and gas industry, while recognizing that no one solution will be capable of addressing all of the issues facing the industry. The role of particular technologies and specific public policy responses lay outside of the scope of this thesis, although analysis of these omitted areas would be needed to inform a Canadian PCR if it were to be pursued.

1.1 Life Cycle Assessment

LCA is a decision-making tool to calculate the environmental impacts of a product, process, or service over its entire life cycle, either from "cradle-to-grave" or from the extraction of resources to the disposal of unwanted residuals (Henrikke & Tillman, 2004). This thesis focuses on the use of LCA to calculate GHG emissions of functionally-equivalent products such as transport fuels derived from crude oil, using heavy oil (bitumen) extracted from Alberta's oil sands as a case study. In any LCA, emissions may be divided between three phases (WRI &WBCSD, 2006):

- Scope 1 – for all direct emissions from a site;
- Scope 2 – for indirect emissions from the purchase of energy products of electricity, heat, and/or steam; and
- Scope 3 – for additional indirect emissions not included in Scope 2, such as for materials produced by external suppliers.

Crude oil producers do not typically conduct full "well-to-wheels" (WTW) LCA on their products by considering all three scopes, with the exception of those who wish to determine the impact of an LCA-based policy on their products. For regulatory reporting, Alberta producers submit data from primary facility emissions (Scope 1) to Alberta Environment Sustainable Resource Development (AESRD) and Environment Canada (EC), and add external system inputs of imported electricity (Scope 2) to these values when calculating emissions for their sustainability reports. Certain jurisdictions incorporate full WTW LCA in policies to compare between different crudes, requiring refineries to calculate the emissions of every stage of production and end-use for all the components of their particular crude oil mix. Examples of such policies are California's Low Carbon Fuel Standard (LCFS) (CARB, 2013) and the European Commission's Fuel Quality Directive (FQD) (European Commission, 2009). Due to their political nature and their implications on international trade, LCA methods to measure GHGs are subject to debate. Currently, the life cycle calculations used to support these policies are based on values that are perceived by some in Alberta's oil sands industry as being unrepresentative of the actual emissions for oil sands products. This thesis examines the potential for a Canadian PCR to provide benefits to industry, government, and the public by improving the quality and usability of emissions data for crude oil calculated through LCA.

1.2 Proposed PCR standard

The standard that this thesis examines is a Canadian PCR for crude oil, a standards initiative being pursued through the formal voluntary standards development process at the CSA. A Canadian PCR for crude oil would be a standard or a document containing requirements and guidelines for calculating the life cycle GHG emissions, or the carbon footprint, of crude oil using life cycle methods. In this thesis, the CSA is specifically studied in connection with the PCR instead of another or a hypothetical SDO due to the direct influence of the credibility of the promulgating institution on the credibility of the final standard. Due to the wide variability in the credibility of these organizations – arising from differences in methods for the standard setting process (Section 2.2.1) – studying the specific SDO that is proposing this standard allows for a more thorough and relevant analysis of its potential.

Currently, the CSA is considering the proposed PCR as a formal voluntary standard rather than a document. This would require a more rigorous process than is typically used to develop PCR, and would lead to a more robust and comprehensive PCR that is seen as a requirement to meet the high level of anticipated scrutiny of a Canadian PCR for crude oil.[1] If the proposal is successful, the CSA would lead the development of this PCR toward an officially promulgated national standard, which is currently expected to establish voluntary rules and guidelines for reporting GHG emissions from crude oil producers to the CSA.

The goal of a Canadian PCR would be to improve the credibility of claims made between products derived from petroleum by enhancing the accuracy and transparency of life cycle emissions estimates. It would be developed at the CSA through a consensus process involving multiple stakeholders. The document would specify the methods for practitioners primarily in government and industry to improve the comparability of crude oil emissions calculations. It could also be used to create environmental product declarations (EPD) according to ISO 14025. Guidance in the PCR would be based on the ISO 14040 series of standards for conducting an LCA by specifying methods and providing guidance on data collection and interpretation.

As rules and guidelines to be used for LCA, such a PCR would apply to the entire life cycle of the product, using a WTW approach that considers emissions from all stages of extraction,

[1] Personal correspondence with the CSA, 12 March 2013.

upgrading, transport, refining, and end-use. Its specifications in terms of LCA methods and data would be divided in two stages, for (1) extraction through to delivery at the refinery gate for the crude oil production phase, and (2) emissions from the refining process. Individual companies would submit GHG emissions data from operations – calculated by using the same methods – in a standardized form to the PCR Program Operator, who would also set requirements for data verification. The PCR would be for primarily business-to-business communication, such as between crude oil producers and refineries, but could also be used for regulatory purposes or for business-to-consumer emissions claims. After its development, the standard could be considered by the International Organization for Standardization (ISO) to form the basis of a similar international guideline. This would follow a similar undertaking as the recent the bi-national effort between Canada and the United States, led by the CSA, to develop a standard for the geological storage of carbon dioxide in CSA Z741. Recently finalized, the CSA Z741 standard is currently under review by ISO for consideration to be modified as an international standard.

One potential function of a Canadian PCR for crude oil is presented in Figure 1, which shows the use of the standard for communicating emissions data from companies with oil sands operations to refineries under the jurisdiction of an LCA-based policy. This includes the breakdown of the two stages of emissions data to be collected and used according to the PCR, the intended use of the PCR by each organization or entity, and the processing and transport of bitumen. Factors that introduce challenges for the PCR in Stage 1 are the site uniqueness and differences in upgrading requirements, such as for products extracted through steam-assisted gravity drainage (SAGD) versus those which are mined. For Stage 2, complicating factors include the differences in the crude oil mix at refineries as well as the refinery type.

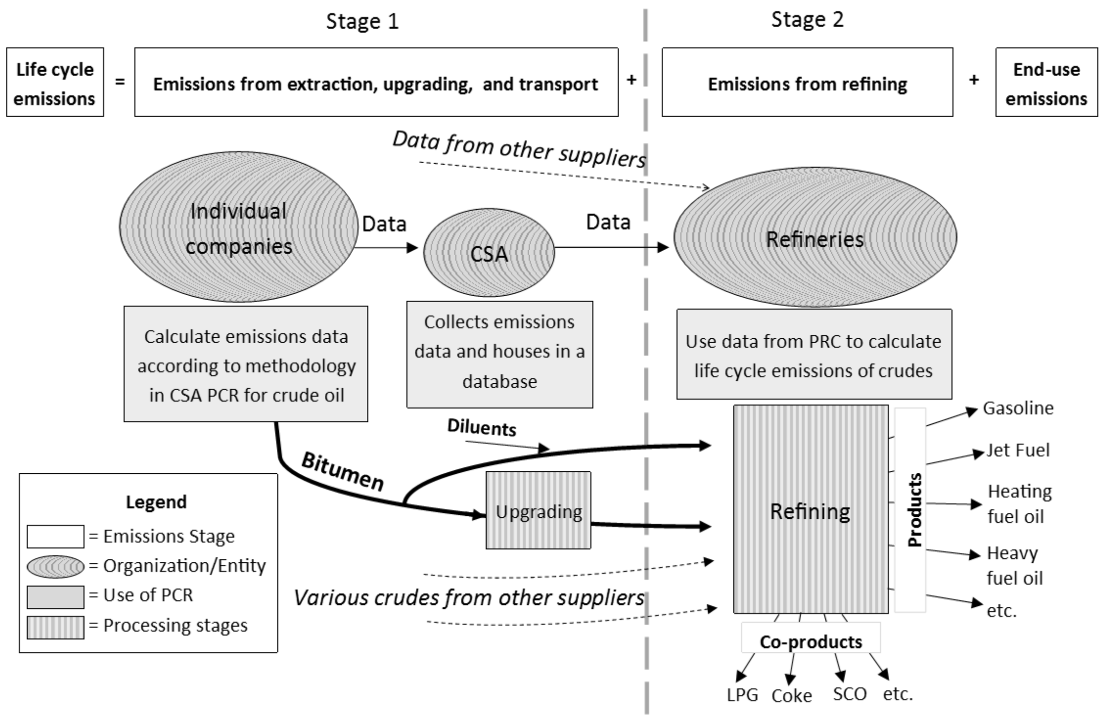

Figure 1: Example of one potential function of a CSA PCR for crude oil

1.3 Thesis Outline

This thesis has a total of five chapters. This first chapter highlights its motivation and structure and specifies how the problem will be approached. The second chapter is a literature review which begins with standards nomenclature, followed by the development of hypotheses related to the challenges and opportunities revealed by review of standards and standards literature. Chapter three details the methods for this thesis and specifies the limitations of the study. Following this, chapter four presents a case study through six key interview findings and their comparison with the hypotheses. Finally, the Conclusions chapter summarizes the main findings of the thesis, answering the research questions and ending with suggestions for further research. A list of references and the appendices conclude the thesis.

Chapter 2: Literature Review

This chapter provides an introduction to standards nomenclature and develops key hypotheses by which to compare the findings of the interview analysis in the case study. These are presented in order from more general literature on standards to that which is specifically related to the case study area of a CSA PCR for crude oil. Corresponding to the findings of the interview analysis, the five areas examined in this section are: (1) credibility in SDOs and in the oil sands, (2) standard revision, (3) industry support of voluntary standards, (4) harmonization and alignment of voluntary standards, and (5) consensus issues facing LCA. For each of these areas, the section proceeds by detailing the key issues identified by central studies that summarize the area, followed by the presentation of hypotheses in each sub-section on how these findings will influence the potential for a formal voluntary Canadian PCR standard for crude oil. Materials used in this section include literature on standards, voluntary standards, and relevant reports from government and non-governmental organizations (NGOs).

2.1 Defining Standards

Between standards literature and published definitions by SDOs, no universal definition of a "standard" exists. Standards literature contains various interpretations of the ISO definition of a standard. In literature, standards are often defined based on their purpose, characteristics, or by the organization which sets them. ISO has a much more narrow definition of a standard, as a:

> "Document, established by consensus and approved by a recognized body, that provides, for common and repeated use, rules, guidelines or characteristics for activities or their

results, aimed at the achievement of the optimum degree of order in a given context." (ISO/IEC, 2004, definition 3.2).

ISO expands this definition by noting that "standards should be based on the consolidated results of science, technology and experience, and aimed at the promotion of optimum community benefits" (ISO/IEC, 2004). In contrast, the definition of standards in literature moves beyond that of being a "document," as they can be defined as "norms" (Farrell & Saloner, 1985, p. 34; Salter, 1995a, p. 20) or "technical specifications" (David & Greenstein, 1990, p. 4). Similarly, standards' desirability and effects are also defined differently, as these have described as tools for comparison and decision-making (Salter, 1995a) or for deployment to create economic effects (David & Greenstein, 1990).

This thesis uses the term "formal voluntary standards" to refer to those standards developed at an SDO through a formal consensus process. A summary of standards definitions based on purpose and characteristics is presented in Table 1. Definitions based on institutional characteristics of organizations that affect the standard development process are detailed later, in Section 2.2.1.1, as these form part of the hypotheses regarding institutional credibility. In this current section, relevant literature was used to compile proposed technological influence and market effects of standards (Table 1), arranged by definition according to a standard's purpose and characteristics. Two blank boxes that are presented in the table are due to the absence of discussion for these areas in the literature reviewed. Further research is necessary to determine whether this is because of an absence of an effect in these areas, or if the effects are not well understood due to lack of study.

2.1.1 Prescriptive vs. Performance

Voluntary standards are differentiated according to their purpose and characteristics in a number of ways. The potential impacts of standards on markets and technology are presented in Table 1, according to standard purpose and characteristics and based on information from relevant sources (Blind, 2004; Breyer, 1982; Hawkins, 1995; Repussard, 1995; Sinn, 1996; Swann et al., 1996; Weiss & Sirbu, 1990). While *prescriptive* standards specify methods by which to accomplish certain tasks regarding information or design, *performance* standards set goals without stipulating how those are to be reached. An example of prescriptive standards are those in the ISO 14040 series, which specify principles, frameworks, guidelines, and requirements for conducting LCA. In contrast, the emissions reduction goals set for countries by the Kyoto Protocol may be considered performanace standards, for they set required reduction amounts without detailing how these are to be reached. The *degree* of prescriptiveness of a standard refers to where it falls on a spectrum from being completely voluntary to being mandated by regulation.

Salter (1995b) distinguishes between voluntary *prescriptive* and *performance* standards, where environmental *prescriptive* standards focus on emissions, industrial design, or operation and are implemented before the activities occur. Prescriptive standards are akin to *information* standards, as defined by Blind (2004), and also encompass design standards in that they describe particular methods or details (Table 1) rather than establishing goals for observable outcomes. Salter (1995b) states that prescriptive standards also require extensive record-keeping and organizational intervention to serve their intended purpose. As well, when required to specify design requirements, David (1995) claims that creating prescriptive standards can be approached as either attempts to regulate for purposes of uniformity or with a focus on coordination to enable progress in systems through compatibility. In contrast, *performance* standards specify the method of meeting goals as well as the goals themselves, accounting for public exposure to the by-products of industrial activities (Salter, 1995b). Performance standards that relate to the environment can be referred to as "impingement" standards (Salter, 1995b, p. 32), as they focus on the point at which industrial activities begin to negatively impact the public or the environment.

Table 1: Potential impacts of different types of standards on markets and technology.

Standard Type		**Prescriptive**			**Performance**
Standard Function		**Design**		**Information**	
Common Standard Name		Compatibility Interface	Variety reduction	Information Safety Health Environmental	Quality Safety Health Environmental
Potential Influence on Technological Change	Positive	Combination of system elements	Cost reduction	Information on technology status Source for innovation	Increase information Eases acceptance of new products Permits flexibility and change
	Negative	Slows change	Reduces variety		Lock-in
Potential Market Effects	Positive	Promote trade within industry Open national markets Growth Decrease time to market Lowers production costs	Aides economies of scale		Competitive advantage Promote trade within industry Open national markets Facilitate international trade[2]
	Negative			Consumers receive suboptimal information	Bureaucracy Trade barriers Monopoly Erosion of consumer protection[3]

[2] With common standards
[3] If government relaxes regulatory constraints to give industry a competitive lead

The concepts of *prescriptive* or *information* standards and *performance* standards are intertwined. David (1995) describes information standards as those which seek to standardize information requirements and dissemination to enhance communication. Blind (2004) explains that successful performance standards are those which increase the amount of information on monitoring and operational characteristics available to interested parties, seeking benefits by the enhancement of product quality for the common movement toward particular goals. Promoting greater information by modifying measurement and reporting protocols for LCA through the use of prescriptive standards can lead to more clearly-defined or rigorous goals, and David (1995) states that prescriptive standards may influence industry performance if this information is used to change managerial actions. Information and performance in themselves are closely linked by the connection between monitoring and management, and reporting and goals. Performance standards which are design standards can enable more cost-effective solutions and permit greater adaptability and change (Breyer, 1982). As design standards, *compatibility* standards can promote intra-industry trade (Swann et al., 1996), and *variety reduction* standards can reduce transaction costs (Blind, 2004), although these effects may be created by standards that are either performance or prescriptive in nature.

2.2 Credibility in Voluntary Standards

Credibility is integral to the perception and effects of formal voluntary standards. This section discusses a number of areas that contribute to the credibility and transparency of formal voluntary standards. First, it discusses SDOs, in terms of literature that has analyzed the formation of credibility in SDOs, and then describes the structure and function of the CSA. The definition of a CSA PCR for crude oil is then expanded upon, given standards definitions by characteristics and institutions. Following this, this chapter examines literature on dynamics and outcomes of standards committees, and efficiency and effectiveness of the development process are discussed. This chapter concludes by highlighting definitions of guiding principles for governance within Alberta's oil sands, focusing on credibility and legitimacy.

2.2.1 Standards Developing Organizations

2.2.1.1 Development Goals, Principles and Guidelines

Standards are often defined according to the institution which creates them or the process by which they were formed. Table 2 presents a synthesis of literature on the differences in standards types according to their promulgating institution (Blind, 2004; Cargill & Bolin, 2007; Egyedi & Blind, 2008; Hawkins, 1995; Salter, 1995b). This thesis discusses SDOs, which lead standards development through a formal consensus process. SDOs are also referred to as "standards develop*ing* organizations" in standards literature (see, for example, de Vries, 1997). Cargill and Bolin (2007) similarly define standards setting organizations (SSOs) as institutions which promulgate standards and instil legitimacy in specifications, which de Vries (1997) see as differing in terms of openness of the standardization process and decision-making rules. Consortia standards are one type of standard developed at SSOs (Salter, 1995b). For purposes of simplicity, this thesis only refers to SDOs, where these are responsible for enabling the development of formal voluntary standards, and share common objectives, principles, and guidelines, which manifest both in the process and outcomes of standards setting.

Table 2: Differences in standard types, platforms, scope, participants, and credibility, by promulgating institution.

Standard Name	Platform	Platform Example	Scope	Participants	Credibility
Governmental	Government organizations	Alberta's Specified Gas Emitters Regulation	Municipal Regional State Provincial National	Varied	Implicit
Formal **Voluntary** **Consensus** ***De jure*** **Registration** **Regulatory**	Standards setting organizations (SSO) Standard developing organizations (SDO) National standards body	Canadian Standards Association (CSA) International Organization for Standardization (ISO) European Committee for Standardization (CEN)	Regional National International	Major producers (vendors/industry) Major consumers (industry/public) Government Labour Public representatives Independent experts	SDOs have implied legitimacy Consensus process
Informal **Consortia** **Proprietary** ***De facto*** **Guideline** **Objective** **Code** **Criterion**	Industries Firms	Canadian Association of Petroleum Producers (CAPP) American Petroleum Institute (API) American National Standards Institute (ANSI)	Varies	Firm representatives Individuals	Market acceptance

Primary goals and objectives of SDOs have been described differently in literature. Salter (1995b) discusses the goal of SDOs as being the production of effective mechanisms to minimize harm. Contrastingly, Leveque (1995) explains that the objectives of SDOs are to reduce industry transaction costs. Similar to this is Cargill and Bolin's (2007) view, where the goals of SDOs are seen as being to "facilitate interoperability" in response to industry needs (p. 310). Naemura (1995) describes a set of general principles of SDOs, as (1) openness, where the standard's development is broadly communicated, (2) a multi-staged approach, with a shifting focus from user input to greater technical specificity as the standard moves closer to finalization, (3) availability of standards, and (4) diverse opportunities for user involvement, through both direct and indirect membership as well as through interrelated organizations in the standardization process. The objectives of their members have been described by Breyer (1982) as being shared by all, but to differing extents dependent on the vested interests of participants. Importantly, Simcoe (2007) challenges this idea in recent literature, claiming certain actors may be involved to see that the standard is not developed. This strategic involvement is discussed throughout the following sections as an important hypothesis.

SDOs must balance both public and private interests. The US Office of Technology Assessment (1992) describes the development of standards as "a societal choice of significant consequence" (p. 14, Footnote 23). SDOs have a "quasi public-service" nature (Repussard, 1995, p. 63), where both private and public representatives are involved in the consensus process of standards setting. Cargill & Bolin (2007) deem the standardization process to be an "impure public good" (p. 297) in that the government has an interest in ensuring that it is "effective and responsive" (p. 297) to industry needs due to the promotion of public benefits by private interests in SDOs.

The potential for industry to approach standards development through consortium standards exists as an alternative to setting formal voluntary standards at SDOs, and the selection of the institution at which the standard is to be developed is a reflection of its perceived legitimacy given these competing alternatives. Simcoe (2007) views differences in legitimacy of standards setting institutions, as well as strategic options available, as influential in the choice of venue. In this thesis, both *de facto* standards set by industry and *de jure* standards developed at SDOs will be referred to as "voluntary standards." This is in comparison with governmental standards (Table

2), which are often referred to as *de jure* standards but which are mandated by legislation and thus not voluntary in nature.

Consortia are defined by Hawkins (1999) as an “informal alliance” (p. 161) of industry members financed by membership fees with the goal of coordinating technologies and markets, where informality is a component. Although accountable only to their own members, consortia operate across the boundary between public and private sectors by focusing on a particular product or service category with public implications (Hawkins, 1999). Consortia involvement in standards setting at SDOs can be cooperative, although it may diminish input from other stakeholders or research groups (Blind, Gauch, & Hawkins, 2010). The formation of *de facto* standards can be very similar to that for formal voluntary standards. However, similarities between processes to develop *de facto* standards within consortia and those processes for developing *de jure* standards at SDOs are said by Hawkins (1999) to have not been sufficiently recognized by consortia. As well, *de jure* and *de facto* standards may have similar effects. Egyedi and Blind (2008) describe how *de jure* standards have the same effects as *de facto* standards under certain conditions, and Blind, Gauch, and Hawkins (2010) state that *de facto* standards may have greater impacts. This is expanded upon in Section 2.2.2 in terms of dynamics and outcomes of standards setting.

2.2.1.2 The Canadian Standards Association

The focus of this thesis is upon the CSA, as a Canadian SDO which develops consensus-based, voluntary standards and where a Canadian PCR for crude oil is being considered. The CSA is a non-profit, private institution based on membership that serves “business, industry, government, and consumers in Canada and the global marketplace” (CSA, 2011). The organization is accredited by the Standards Council of Canada (SCC) to develop National Standards of Canada

(NSC) through a consensus process approved by the SCC.[4] It is responsible for the technical content of its standards (CSA, 2006), and represents the SCC in ISO committees (CSA Group, 2013).

Salter (1995a) describes the role of the CSA in the standards development process as a mediator for the discussions of representatives on standards setting committees. The organization describes itself as a "neutral third party" which selects representatives of relevant interest groups to form committees of volunteers, and which establishes a consensus process through "principles of inclusive participation and respect for diverse interest and transparency" (CSA, 2012). Its standards are differentiated from either government or consortia standards by scope, participants in the development process, and the ways in which their credibility is instilled or acknowledged (Table 2). The NSC that the CSA produces:

> "reflect a consensus of a number of capable individuals whose collective interest provide, to the greatest practicable extent, a balance of representation of general interests, producers, regulators, users (including consumers), and others with relevant interests, as may be appropriate to the subject at hand" (CSA, 2006).

These formal voluntary standards "reflect a national consensus of producers and users" (CSA, 2006), and participants directly involved within the development process in standards setting committees include major producers and users of the product or industry facing standardization, labor, and government (Salter, 1995b). Consumer representatives can offer background

[4] Established in 1970, the SCC has a mandate to "promote efficient and effective standardization in Canada" (SCC, 2012, p.3). The SCC is Canada's ISO member body (ISO, 2009) and a federal Crown corporation (SCC, 2012) which coordinates Canada's National Standards System (CSA, 2006). The SCC may also be considered a National Standardization Organization (NSO), as it is the national member of ISO for Canada (de Vries, 1997), and as a member body has full voting rights on ISO committees and may base its own national standards on ISO standards (ISO, 2009).

information on advisory panels, but are not part of the process to achieve consensus (Salter, 1995b). The CSA submits standards drafts before publication for a public review of at least sixty days (CSA, 2012). As of 2006, it included upwards of 7000 committee volunteers and 2000 “sustaining memberships,” which support the CSA’s objectives (CSA, 2006). Committee volunteers are those who vote on standards development commitees, advisory members contriute to committee work but do not vote, and sustaining members pay membership dues to support standards development.

Providing an option between government regulation and an absence of legislative or voluntary regulations, SDOs such as the CSA seek to instil credibility in standards through a transparent process developed to meet industry needs. Through the CSA, Canada has successfully led bi-national and international development initiatives for environmental management standards, including leading the aforementioned geological storage standard and as the International Secretariat for TC 207, which includes the ISO 14020 and ISO 14040 series. The CSA is slated to be the Program Operator for the proposed CSA PCR, as a trusted third-party to facilitate the development of PCRs, in additional to initiating and moderating the standard development process (CSA Group, 2012a).

Based on the information presented above, the following hypotheses on credibility of SDOs are put forward:

- A standard’s credibility is instilled by the transparency of its development process; and
- Establishing credibility is integral, as SDOs balance public and private interests.

2.2.1.3 Defining a CSA PCR

Given the common reference to collaborative relationships and multi-stakeholder developments in standards literature presented in this section, this thesis proposes that standards development is best seen as something that has inputs at the pre- and post- development stages in addition to the actual development process, rather than viewing this development as something which begins and ends with a formal process at an SDO. This supports referring to the proposed CSA PCR as a standard, and allows for a more thorough examination of potential stakeholder strategy, motivations, and mitigating efforts in the standard's development process.

In addition to the CSA's reference to the proposed CSA PCR as a standard, both the ISO definition of standards and literature on standards nomenclature supports referring to the PCR as a standard rather than a document. PCR documents are typically formed through a consensus process involving multiple stakeholders in a similar way to standards, and according to Table 2 (Section 2.2.1) would typically be considered *de facto* standards because they are guidelines. However, the proposed PCR is classified in this thesis as a hypothetical *de jure* standard to be created through a consensus process at an SDO. Referring to a PCR as a standard is also supported in by literature on standards nomenclature, where scholars such as Swann et al. (1996) refer to the permeability of definitions and interchangeability of the effects of informal and formal, or *de facto* and *de jure*, standards.

As well, according to the nomenclature based on standard purpose and characteristics developed in Section 2.1.1, the potential PCR for crude oil could also be referred to as a *prescriptive* rather than a *performance* standard. It could also be deemed an *information* standard, as it would require the submission of emissions information from companies to the CSA, as its Program Operator.

2.2.2 Dynamics and Outcomes of Standards Committees

The credibility of standards is impacted by the organization which promulgates them and by which actors participate in the development process, in what Salter (1995a) has deemed “policy communities” (p. 38). Cargill and Bolin (2007) detail how SDOs convey their own legitimacy onto the standards they produce, and Tamm Hallström and Boström (2010) see the conscious construction of legitimacy in the development process as being integral to their standards due to their lack of enforceability. Legitimacy in standards setting is sought to establish credibility and continuity (Suchman, 1995), where Botzem and Dobusch (2012) state that this legitimacy is particularly important for transnational standards due to the absence of regulation at such levels. However, with respect to environmental standards, Breyer (1982) believes that these desired perceptions of legitimacy on behalf of the standards setting agency may lessen the environmental effectiveness of a standard due to difficulties in determining the appropriateness of diagnostic tools and methods by which to gauge compliance.

The actors who are present also affect the decisions made in the standardization process at SDOs. Swann (2000) states that maintaining a balanced set of stakeholder interests is necessary to developing standards that are not “shortsighted” (p. vi) in neglecting any long-term considerations, although trade-offs exist between inclusivity and efficiency in the process. An approach which identifies and examines the vested interests of actors in the standards setting process can contribute to a greater understanding of collaborative relationships in multi-stakeholder developments (Cargill & Bolin, 2007). This may be particularly relevant for the oil sands industry, as there has been an increasing tendency toward industry coordination, identified in Section 2.4.1. However, as Salter (1995a) states, the affiliations of committee members may be difficult to ascertain, where Leveque (1995) cautions that certain members may be present solely to prevent the standard from going forward if it is not in their best interest. As well, firms may create information asymmetries if they choose to withhold information so that standards may be developed in their favour (Leveque, 1995).

Simcoe (2007) suggests that knowledge of *de facto* standards setting can aide in the understanding of interactions between the development of *de facto* standards and the formal voluntary standards process. Blind, Gauch, and Hawkins (2010) note certain benefits to *de facto* standards, as such standards developed through consortia may have greater impacts than formal voluntary standards due to the greater information that comes with having access to more specific expertise than SDOs may have. However, they also identify scenarios where formal voluntary standards are preferable, including if consortia membership comes with high costs and is exclusionary, or if the outputs of a consortia are generally viewed negatively (Blind, Gauch, & Hawkins, 2010).

Efficiency in standards setting will depend on many factors. According to Simcoe (2007), these include the number and perspectives of participants, its technical or economic significance, the available design alternatives, rules governing the consensus process, the complexity of technologies considered, and its relationship with other standards. When a standards committee is small and meets relatively frequently, consensus can occur more rapidly. Greenstein and Stango (2007) state that the involvement of consortia in SDOs establishes a trade-off between delays in consensus and standards wars that can occur in the formation of *de facto* standards. However, as elaborated by Breyer (1982), efficiency in the development of voluntary standards is less certain than for regulatory standards, due to the influence of stakeholders with diverse interests and the iteration of standards versions.

Standards outcomes may have undesirable market effects due to their development process (Table 1, in Section 2.1). For example, Wakelin (1997) states that monopolies can be created from strategic involvement of industry consortia and associations in the standard development process despite the involvement of multiple companies. Similarly, monopolies can also arise from anticompetitive effects after standards are implemented (Breyer, 1982). If proprietary information from select companies is that which is communicated with the standards setting committees, then the finalized standards may reflect information or performance attributes that are either currently met by those companies alone or which are difficult for others to implement in order to achieve market gains sought from standardization. Developed with input from industry members, formal voluntary standards are capable of creating similar technological and market effects as *de facto* standards (Swann et al., 1996). Through the creation of voluntary standards with anticompetitive characteristics, Breyer (1982) explains that barriers can be erected to market entry in the industry by new players due to increased costs of compliance for competitors once standardization becomes pursued by a large or established firm. In this case, Egyedi and Blind (2008) state that *de jure* standards have the same effects as *de facto* standards. Such market barriers can be particularly prominent for industries dominated by a few large companies and in pursuit of a series of standards (Breyer, 1982). Undesired effects that may arise for all industry as an outcome are identified by Farrell and Saloner (1985) as being the trapping of industry into compliance with suboptimal standards due to incomplete information in the decision-making, and by Leveque (1995) as the creation of high costs of compliance.

Based on the information presented above, the following hypotheses on credibility and dynamics of the standards development process are put forward:

- In the dynamics of the standards development process, credibility is instilled through legitimacy, balancing divergent interests in committee members, and efficiency; and
- A lack of credibility in the process may lead to standards with monopolistic effects or prohibitive costs.

2.2.3 Guiding Principles for Alberta's Oil Sands

A number of principles required for oil sands metrics, data, and monitoring programs have been defined by recent government review panels and NGO initiatives. The initiatives examined here are the Alberta Environmental Monitoring Panel (AEMP) and the Joint Canada-Alberta Implementation Plan for Oil Sands Monitoring, both of which base definitions on Cash et al. (2003) and Cash et al. (2002). As well, reports from the Pembina Institute and the Oil Sands Advisory Panel are examined. Taken together, these sources outline the consensus on guiding principles and values driving recent changes in oil sands environmental monitoring, which reflect the wider sentiment about environmental management in the sector. While these studies discuss a broad set of environmental impacts and not GHG emissions, which are the focus of the proposed CSA standard, it is assumed that similar guiding principles will be used by stakeholders external to the development process to scrutinize an emerging CSA PCR for GHG emissions from crude oil.

AEMP was announced in January 2011 as a novel approach to environmental monitoring, beginning in the Lower Athabasca Basin. This followed the creation of the Oil Sands Advisory Panel, which developed a report for the Federal Government in 2010 that examined the current state of "scientific research and monitoring" (Oil Sands Advisory Panel, 2010, p. 4) and assessed strengths and weaknesses in current monitoring of the oil sands' environmental impact. The Pembina Institute is an Environmental NGO (ENGO) with the mandate to "advance clean energy solutions through innovative research, education, consulting and advocacy" (Pembina Institute, n.d.). The Institute compiled their "Oilsands Metrics Thought Leader Forum Summary Report: Audiences and Design Principles" based on a forum held in 2011 that included government, industry, academia, and NGOs to discuss the intended audience for and principles for developing oil sands metrics.

Credibility is defined as a required principle by which to govern Alberta's oil sands. Definitions of credibility by the Pembina Institute (2011) included maximum transparency of metrics and their development processes, the reputation of the metrics compiler and host, independence, and openness to public scrutiny. The AEMP (2011) bases their definition of credibility on Cash et al. (2003) and Cash et al. (2002) , stating that credibility of data requires that stakeholders perceive it to be "scientifically sound and free of bias or perceived bias" (AEMP, 2011, p. 28). This requires that programs are driven by science, through all stages of "design, execution, evaluation, and reporting" (AEMP, 2011, p. 28). Scientific rigour is defined by the Oil Sands Advisory Panel (2010) as such an approach, which uses "robust indicators, consistent methodology, and standardized reporting… that will result in independent, objective, complete, reliable, verifiable and replicable data" (p. 7). Independence from bias, as "government, industry, and special interests" (AEMP, 2011, p. v), is central to defining legitimacy, which the Government of Canada and Government of Alberta (2012) state is established by fair treatment and respect of stakeholders' values.

Transparency is also defined in these reports. AEMP highlights the centrality of transparency as a key contributor to credibility, noting that "free access to data is a fundamental requirement for openness and transparency, and is likely to generate substantial additional unpaid input to the critical analysis and review process" (AEMP, 2011, p. 32). The Oil Sands Advisory Panel highlights transparency as a guiding principle, along with accessibility, as an approach that "produces publicly available information in forms (ranging from raw data to analyses) in a timely manner that will enable concerned parties to conduct their own analysis and draw their own conclusions and that will make the basis for judgement and conclusions explicit" (2010, p. 7).

Relevance was another common principle, defined by the Pembina Institute (2011) as stakeholder engagement throughout the metrics system, alignment of metrics with all levels of issues, objectives, and goals, comparability between companies and sectors, and review and modifications of metrics as expectations evolve. From Cash et al. (2003) and Cash et al. (2002), AEMP defined relevancy as meeting the needs of stakeholders "in a comprehensive, understandable, useful and timely manner" (AEMP, 2011, p. 29).

A number of other important principles were noted in these reports. *Accuracy* is defined by the Pembina Institute (2011) as the mechanisms and frequency of auditing of metrics, whereas the Oil Sands Advisory Panel (2012) define *adaptive* and *robust* as the ability for evaluation and revision in response to changing "knowledge, needs, and circumstances" (p. 7) while being supported by sustainable funding. *Communication* is a desired principle in order to compare performance across sectors and to drive improvements (Pembina Institute, 2011). The Oil Sands Advisory Panel (2010) also notes the importance of *inclusivity* and *collaboration* that engages those concerned "in the design and execution, including the prioritization of issues and setting ecosystem goals" (p. 7).

Based on the information presented above, the following hypothesis on credibility as a guiding principle for governance in Alberta's oil sands is put forward:

- Credibility is developed through transparency, institutional representation, scientific validity, absence of bias, and stakeholder respect and inclusivity.

2.3 Change and Voluntary Standards

An effective standard requires the adequate consideration of technology and technological change, and must be revised throughout its life cycle to maintain its quality and appropriateness. This section discusses the revision and effects of formal voluntary standards, with respect to technology considerations and committee dynamics in subsequent standards versions.

2.3.1 Technology Interactions

Standards can influence technology choice and innovation, as they can connect technologies to emissions abatement. Technical superiority is defined in standards literature in terms of the economy, effectiveness, efficiency, compatibility, and functionality. Weiss and Sirbu (1990) define a superior technology as one which creates results at a lower cost, in a shorter timeframe, and with greater compatibility with existing standards than competing technologies. Technologies embedded in a standard depend on the representation of participants in the standards setting process. The challenge on behalf of SDOs when formal voluntary standards are the preferred solution by industry is stated by Breyer (1982) as being the development of standards that encourage supporting technology and that can be easily implemented, but which "prevent an unfair competitive advantage" (p. 107). Vendors in the process may influence the decisions such that the standard adopts technologies that offer strategic advantages in the future rather than those which are currently superior. Katz and Shapiro (1986) believe this influence should be counterbalanced in the standards development process by considering installed base and compatibility.

Information relating to technology in standards can heavily influence their effectiveness and ability to be revised in the future. This affects standards which are based either on current technical capability or on the potential of forecast technologies. Standards which have incorporated forecast technologies are referred to as *anticipatory* (Blind, 2004; David, 1995) or *technology-forcing* (Breyer, 1982), and are intended to push industry to innovate or adopt technologies upon the decision to adopt a standard. While they are defined differently in literature, anticipatory standards all perform the same function, with what David (1995) describes as incentivizing collective industrial research and development. Naemura (2005) states that standards which require the use of proprietary technologies can lock users into vendors, as they instil compatibility requirements in design features. Performance standards may have the same lock-in effects (Breyer, 1982), where if future technical improvements are not anticipated abatement levels may be set too low and fail to create an incentive for firms. Breyer (1982) has noted that, despite the potential issues of technology-forcing standards, standards setting agencies frequently continue with the mantra that "'progress' requires a stricter standards and a new technology to meet it" (p. 107).

Finding a middle ground between standards which are anticipatory or technology-forcing and those which lock-in suboptimal technologies is integral to a successful standard. Naemura (1995) states this can be aided by obtaining more information in the standards setting process on the state of a technology. Particularly, consideration of the installed base is of critical importance when developing standards for industries where equipment is capital intensive and any changes require consideration of system compatibility (Farrell & Saloner, 1985, 1986; Katz & Shapiro, 1986), such as the crude oil production and refining process. Farrell and Saloner (1985) state that firms can be trapped into compliance with technically suboptimal standards if information asymmetries exist on behalf of firms as to other firms' preferences in the decision-making process. This is said to result in delays in adoptions of new technology, even if doing so is desired by all firms. Introducing coordination, in the form of communication between firms in the standards setting process, can help to overcome the likelihood of this inertia occurring only if preferences between firms do not differ (Farrell & Saloner, 1985).

Based on the information presented above, the following hypotheses on required considerations for technology in a CSA PCR are put forward:

- To drive improvement and enable innovation, a standard must reflect a:
    - Consideration of installed base, including technologies and infrastructure; and
    - Awareness of the motives of technology vendors in its development process.
- Sharing information on technologies and firms' technology preferences in the development process will be useful as long as there is agreement between firms.
- Requiring the use of proprietary tools to follow the standard will lock users into the standard and may impede innovation and increase costs.

2.3.2 Revision Process and Committee

Standards must be frequently updated with revisions throughout their life cycle (Naemura, 1995), and this may be complicated by a number of factors. The difficulty in revising standards is influenced by problems regarding the nature of the standards setting process, including what Breyer (1982) identifies as information, negotiation, close connection to precedent, and extensive time requirements. De Vries (1997) determines that task allocation between adjacent committees in an SDO can present challenges that are proportionate to the diffusion of tasks, and that its effectiveness influences participant engagement. As such, institutional complexity can lead to time delays, and can result in a lack of participant engagement (de Vries, 1997). Kumar and Fenema (1998) state that challenges for coordination are exacerbated for projects that are globally distributed and involve multiple institutions, where projects that are geographically dispersed face gaps of differences in physical location, cultural, infrastructural, and regulatory differences. Bounded rationality and opportunism, the independence and complexity of tasks, and uncertainty in development processes and outcomes are all factors which influence the ability to coordinate tasks (Kumar & Fenema, 1998). De Vries (1997) suggests the use of Information and Communication Technology (ICT) as one way to transcend physical barriers to collaboration and to improve coordination.

Based on the information presented above, the following hypotheses on the revision process and committee for a CSA PCR are put forward:

- The revision of the standard will be successful if participants are engaged throughout the process; and
- Participant engagement, and therefore the standard's revision, will be aided by an effective coordination of tasks.

2.4 Industry Support of Voluntary Standards

Industry support is required for formal voluntary standards to succeed. This section discusses conditions for industry support and engagement in the formation of voluntary standards, covering both incentives and challenges for engaging industry members and leveraging this support.

2.4.1 Incentives

One measure of effectiveness of voluntary standards is identified by Salter (1995a) as the mobilization of firms. Compared with self-regulation through consortia standards, Breyer (1982) perceives that formal voluntary standards can provide greater benefits to industry than alternative standards mechanisms in terms of communicating project information when faced with government, market, or consumer pressures for improvement, and Egyedi and Blind (2008) believe that such standard can offer a competitive market advantage for complying firms by influencing economic sectors. Standards are important to the function of the global marketplace, and can answer the need for both coordination and market competition (Salter, 1995a). Although Salter (1995a) states that international standards are integrated with international market strategies, Swann et al. (1996) sees it as necessary for the benefits of voluntary standards for firms to be gauged in terms of national market share within the industry. A market-led approach is deemed the most effective for formal voluntary standards by Swann (2000), where SDOs should be "efficient at responding to market needs" (p. 36), develop standards that "help the industry to prosper" (p. 36), and where the role of government is minimal and restricted to the "determination of requirements and harmonization targets" (p. 36).

Industry can cooperate to help market participants meet market requirements in an organized method that offers benefits for each participant. Blind, Gauch, and Hawkins (2010) describe the strategic motivations of industry involvement in in consortia standardization efforts as being influenced by the predicted effects of *de facto* standards in comparison with standards development at alternative institutions such as SDOs. One consortium involved in Alberta's oil sands include Canadian Association of Petroleum Producers (CAPP), focused on enhancing the economic sustainability of the oil and gas industry while maintaining environmental and social responsibility through communication and engagement with relevant government and public stakeholders (CAPP, 2012). Another consortium with industry members from Alberta's oil sands is Canada's Oil Sands Innovation Alliance (COSIA), which has a goal of collaboration to mitigate environmental effects from operations through collaborative innovation (COSIA, n.d.). COSIA's work is primarily in environmental areas, although the organization is developing a GHG Environmental Priority Area, where information will be governed closely by comprehensive non-disclosure agreements (NDAs).

The cooperation of many companies in the oil sands industry within consortia such as CAPP and COSIA suggests a willingness within the industry to collaborate toward mutual improvements. These actions differ from historical approaches to industry cooperation. Breyer (1982) gives an example of these previous approaches, where the automobile industry in the 1930's unilaterally committed to ceasing to advertise comparative safety between companies after it was found that benefits of making these comparisons for individual firms was disproportional to the damage this caused to the industry as a whole. Although the oil sands industry is often viewed and judged collectively, especially internationally, the collaboration of companies such as COSIA toward environmental improvement is a recognition of the need for doing so and reflects a proactivity on behalf of the industry.

Based on the information presented above, the following hypotheses on industry support of a CSA PCR are put forward:

- Industry will be involved out of strategic interests to the standard if the following conditions are met:
  - Perceived market benefits to collaborating in the process at both national and international levels are greater than for *de facto* or government standards;
  - Public, market, and regulatory pressure is sufficient; and
  - A lack of collaboration toward a *de facto* standard is present.

2.4.2 Challenges

A number of challenges exist to gaining industry support of formal voluntary standards andto indudstry's constructive engagement in the development process. Alternatives to standardization at an SDO provide competition to the formal voluntary standards mechanism. As previously discussed, one alternative is for industry to lead the standardization process to develop consortia, *de facto* standards. Industry may be motivated to self-regulate in such a way when faced with public or regulatory pressure and when positive market gains may be achieved by doing so (Leveque, 1995). There is no indication that government alternatives to standardization at an SDO for a Canadian PCR for crude oil are a viable option, as industry currently does not report emissions values on a life cycle basis to government at any level in Canada and no literature could be found on any considerations for the Alberta or Canadian Governments in changing these requirements.

Challenges have also been identified during the standardization process with respect to industry support. De Vries (1997) states that industry will always participate in standards setting out of self-interest, expanded upon by Simcoe (2007) in that certain participants with vested interests in seeing the standard not going forward may be present in the development process due to their desire to maintain the status quo. Challenges may arise if industry committee members do not share the required information for a successful standard. Firms may create information asymmetries if they choose to withhold information so that standards may be developed in their favour (Leveque, 1995), adding to the potential for standards to have monopolistic effects, as discussed in Section 2.4.2. Literature discusses this particularly in relation to technology, as the information available to representatives as well as the degree of involvement of participants on standards development committees will influence decisions over which technology or criteria will be embedded in standards (Section 2.3). Industry may withdraw from the process if government plays a large role in a standard's development, as Swann (2000) states that this is likely to create time delays and a standard that does not adequately meet market needs. While it is beneficial for the oil sands industry to cooperate toward environmental improvement in terms of monitoring and management, cooperation with respect to GHGs that requires the sharing of proprietary information may be more difficult to achieve.

Based on the information presented above, the following hypotheses on challenges to industry support of a CSA PCR are put forward:

- Industry support and interest in the standard will be challenged if there is a lack of efficiency in its development process; and
- Government involvement in the development process will lead to inefficiencies, challenging industry support.

2.5 Harmonization and Alignment of Voluntary Standards

Successful voluntary standards must be harmonized and aligned with relevant regulations and standards. Here, harmonization and alignment are considered to be the sufficient agreement of the standard with relevant regulations and standards. This section discusses the use of standards to support regulations, recent regulatory streamlining initiatives affecting the oil sands, and the situation of PCR in the ISO standards series. First, literature on the effects of standards according to their degree of prescriptiveness is discussed, as this is at the centre of debates on use of standards to support regulations. Next, upcoming regulatory changes affecting Alberta's oil sands are outlined. Finally, the ISO standards series in the context of which such a standard would be developed is discussed according to (1) requirements for comparability in ISO 14040 and ISO 14044, and (2) how PCR function within ISO 14025 for EPD.

2.5.1 Standards and Regulations (Prescriptiveness)

Voluntary standards establish criteria above those required by regulations with the goal of modifying industrial design, information, or performance. Formal voluntary standards achieve a middle ground between government regulations and an unregulated environment, and which Salter (1995b) states differ from informal, consortia, proprietary, or *de facto* standards in being set through SDOs. Their promulgation by a formal standard development institution enhances perceptions of credibility. An empirical study by Botzem and Dobusch (2012) supports that standards that begin as voluntary can become "binding rules" (p. 741), given the "interdependence of standard formation and diffusion" (p. 741) in combination with the actions of SDOs.

Attempting to improve regulation through the use of standards is one of the many possible policy initiatives that involve standards, as identified by Swann (2010). As well, widely-acknowledged standards can also be used as support for regulatory functions (Swann et al., 1996) without a formal uptake by regulation. According to Salter (1995b), governments support SDOs and the standards they produce due to the market benefits of standards, where Salter (1995a) identifies how standards are often integrated into market strategies as they can answer market needs for both coordination and competition. As such, voluntary standards are of regulatory interest, and may be strategically deployed to have deliberate effects on trade.

Using standards to support regulations can have mixed effects. Particularly, national standards have been the subject of study with respect to their effects in the international market. Blind (2004) states that idiosyncratic national standards are less effective than international standards in influencing foreign trade, as these differ from standards governing other jurisdictions. Voluntary standards may also form barriers to trade, in the presence of competing national standards in trading countries. Measures to avoid these effects are embedded in the doctrines of the regulatory system of the European Commission, which seeks to employ policies to “eliminate the use of standards as barriers to trade” (Repussard, 1995, p. 63). Positive effects of using standards with or for regulations are identified by Brannigan and Spivak (1999), who state that the use of standards to support regulation can decrease administrative costs and complexity for government. This is particularly true when responsibility of verification and auditing is assigned to recognized voluntary schemes. However, industry can experience increased transaction costs from the absorption of these additional administrative costs, which can hamper a regulation’s economy and ultimate effectiveness (Breyer, 1982; Weseen, 2006). Despite the close involvement of government in SDOs, Cargill and Bolin (2007) note instances where voluntary standards have failed to produce public benefits. This can challenge the public support of the use of such standards for regulation, and contributes to public scrutiny of the credibility of voluntary standards.

Based on the information presented above, the following hypotheses on a standard's prescriptiveness with respect to harmonization and alignment of a CSA PCR are put forward:

- The standard may:
    - Be of interest to the Canadian Government to support international market strategies;
    - Reduce administrative burden on regulators;
    - Be an idiosyncratic national standard that may face challenges in harmonizing with international policies or other PCR for crude oil;
    - Introduce prohibitive costs for certain industry members; and
    - Fail to produce public benefits.

2.5.2 ISO 14040 Series

Together, ISO 14040 and 14044 specify methods and guidelines for practitioners to consider during each stage of LCA. ISO 14040 provides the principles and framework for conducting LCAs, covering four phases of goal and scope definition, the life cycle inventory analysis (LCI), life cycle impact assessment (LCIA), and interpretation. It also includes suggestions for reporting and critical review, and conditions for the use of value choices and optional elements. ISO 14044 contains more comprehensive requirements and guidelines for the same four phases. Together, the standards stipulate standards for data collection and allocation, and discuss impact category selection and impact category calculation rules.

The ISO 14040 series does not include a comprehensive discussion of LCA techniques or methodologies to examine phases at discrete points in the LCA, and has not addressed all methodological issues facing practitioners creating comparative assertions, such as regarding critical review or weighting (ISO, 2006b). Rather, the standards cover only the intended application in the initial stages of an LCA, without discussing the application itself. Their subjective nature is deemed necessary by Baumann and Tillman (2004), as the standards must leave room for a variety of choices such that it is applicable to a wide range of LCA.

For comparative studies, ISO (2006c) dictates that system equivalence must be examined before results are interpreted. This equivalence depends on the same scope, functional unit, and methodological considerations, including "performance, system boundary, data quality, allocation procedures, and decision rules on evaluating inputs, and outputs and impact assessment" (ISO, 2006c, p. 11). Additional measures must be taken for comparative assertions directed to the public, in that (1) the study must be critically reviewed, and (2) additional reporting requirements, including the scientific and technical validity of impact categories used, the study's uncertainty, and data precision, completeness, and representativeness, and system equivalency.

Based on the information presented above, the following hypothesis on the requirement for a CSA PCR to develop comparable LCA studies is put forward:

- Further specification is necessary to supplement the ISO 14040 series for the development of comparable studies by LCA practitioners.

2.5.3 PCR and ISO Standards

PCR based on relevant ISO standards are intended for use in EPD. The PCR that is the focus of this thesis is a proposed standard to be used in conjunction with ISO 14025, developed through the CSA, to standardize the calculation and communication of GHG emissions for crude oil products that fulfill the same function as market competitors. PCR can be used to support ISO 14025 for EPDs, to make the application of ISO 14040 and 14044 more specific, and to apply ISO 14067 to products. Baumann and Tillman (2004) see EPDs as being able to provide the necessary prerequisites of acceptability, credibility, and comprehensibility for effective environmental market information.

Emissions derived according to a PCR could be used for Type III EPD, which are third-party verified and contain the results of LCA completed by following standardized methods. Type III EPDs are based upon PCR, and establish agreed-upon requirements for products that are functionally equivalent. They are standardized by ISO 14025 (2006a), which outlines principles and procedures for Type III environmental declarations. ISO 14025 specifies how Type III EPD and their programmes should be developed, using the ISO 14040 standard series and without discussing sector-specific provisions (ISO, 2006a).

While PCR are typically associated with EPD, other potential applications are possible for product rules not associated with ISO. One example is product rules for consumer labeling, which are often guided by non-ISO standards such as the “Product Life Cycle Accounting and Reporting Standard” developed by the World Resources Institute (WRI) and World Business Council for Sustainable Development (WBCSD) (WRI & WBSCD, 2012). In comparison, PCR, which are intended for use with ISO standards, provide a number of unique benefits in terms of “consistency and comparability,… modularity of assessment scope, transparency of requirements and in the development process, guidance and clarity to users undertaking assessments within product sector, and flexibility of use by any entity" (Subramanian et al, 2012, p. 839). PRC reflect "agreement within the relevant industry" (SETAC Europe LCA Steering Committee, 2008, p. 87), and provide a starting point to apply EPD.

EPD set requirements, select parameter categories, and define third-party involvement and the external communication formats for results of LCA based on PCR (Baumann & Tillman, 2004). Standards for EPD allow for structure and consistency in the communication of product attributes so that results of LCAs may be compared more easily and accurately. EPD are created after PCRs are developed by the Program Operator and are reviewed through a process of verification by a third party (ISO, 2006a). They are developed according to ISO 14025 through a process that integrates LCA and PCR with the end goal of enabling for a document or report that is thorough, transparent, and consistent with other EPDs for the particular PCR at hand. The PCR will specify system boundary and the level of detail for the LCA to be used in an EPD, to be determined by the subject and the intended use of the PCR (ISO, 2006a). Normative references in Type III EPDs, as those developed according to ISO 14025, are to relevant PCR and the PCR program to which the EPD is registered (CSA Group, 2012a), and a separate PCR must be developed for each functional unit. The PCR Program Operator is responsible for setting the minimum requirements for the validator, who verifies the EPDs of companies operating within the EPD program and sets the validation criteria. The three components of validation are: (1) conformance of the PCR with ISO 14025 and the LCA with ISO 14040 and 14044, (2) comprehensiveness and completeness of data evaluation, and (3) completeness and accuracy of LCA data and any additional or supporting information.

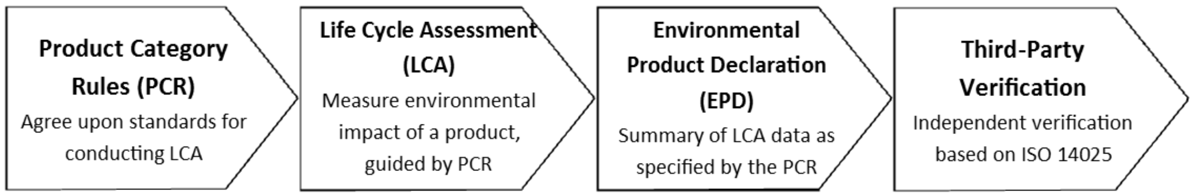

Figure 2: Process for developing an EPD (Adapted from CSA Group, 2012b)

The verification that EPDs must undergo will be either external or internal. The validator themselves may be internal to the EPD Program Operator (for EPDs that are purposed for business-to-business communication), or an external third-party (for EPDs designed for business-to-consumer communication). Only in the case of business-to-consumer declarations, where ISO (2006a) defines "consumer" as "individual member of the general public purchasing or using goods, property or services for private purposes" (p. 3), does this verification have to come from a third-party (referred to as "external verification"). Oil sands exports are not directly to "consumers," as defined in ISO 14025, but rather the refineries which receive Canadian heavy crudes would constitute other businesses, such that the potential standard would be for business-to-business communication. The Program Operator is responsible for setting the minimum requirements for the validator, who verifies the EPDs of companies operating within the EPD program, as well as the validation criteria. The validator must have not been involved with any of the work involved in forming the EPD, including the LCA, and must have no conflict of interest. Due to the multiple elements contained within the EPD, the verifier must be competent with LCAs and EPDs as well as standards, requirements, and the product itself (ISO, 2006a).

Subramanian et al. (2012) state that the international alignment of PCR is critical due the global nature of many product supply chains. Harmonization should be promoted by Program Operators through the consideration of existing PCR documents "in the same product category and appropriate market area" (ISO, 2006a, p. 8). ISO 14025 (2006a) states that in cases where a new PCR is to be developed, it must be done so based on content rather than origin of any alternative PCR. In an examination of eleven different PCRs across five different product categories, Subramanian et al. (2012) found a number of duplicate PCR for the same product categories, as well as a wide variance in PCR scope, system boundaries, impact categories, technical criteria, and terminology. The presence of duplicate PCRs within the same product category has the potential to "threaten the legitimacy of environmental labels and ultimately stifle product claim comparison" (p. 899) due to the foundational goal of deploying PCR to standardize parameters. However, the only relevant search result for existing PCR for crude oil products was what appeared to be a draft of a PCR for gasoline developed by an unknown institution in Korea (Unknown, n.d.), such that consideration of existing PCR in the formation of a CSA PCR for crude oil at the current time will not be necessary.

Based on the information presented above, the following hypothesis on development of a CSA PCR with consideration to the ISO standards system is put forward:

- The ISO standards system, including standards for LCA and Type III EPDs, will provide a sound framework for the development and operation of the standard.

2.5.4 Regulatory Streamlining Affecting the Oil Sands

Two major initiatives are underway in Alberta to streamline monitoring and regulation related to the oil sands. The first of these is the new Environmental Monitoring Agency, announced in late 2012 as an arm's-length organization to establish a credible and science-based monitoring system (Alberta Government, 2012). The Agency is intended to address criticisms over inadequacies of existing monitoring in the province. The second of these initiatives is the "Responsible Energy Development Act" (2012), under which the Alberta Energy Regulator (AER) is proposed and which would make the AER responsible for all ERCB statutes. The Act harmonizes and streamlines the regulation of all aspects of energy and oil in Alberta, collapsing the mandates and decision-making authority of the Energy Resources Conservation Board (ERCB) and Alberta Environment and Sustainable Resource Development (AESRD) into the AER. Despite these initiatives, studies such as Gosselin et al. (2010) have noted the potential for regulatory interest regarding the oil sands at the federal level to waver. Prior to these initiatives, the federal government had been criticized by Ogilvie et al. (2010) for the absence of a Canadian Energy Strategy, which would benefit national benchmarking and international commitments. As well, the Gosselin et al. (2010) criticize the federal government for not being proactive in communicating the responsible development of Alberta's oil sands.

Based on the information presented above, the following hypothesis on the effects of regulatory streamlining on a CSA PCR is put forward:

- Harmonization and alignment of the standard with regulations will be difficult due to:
    - Regulatory uncertainty; and
    - A lack of federal initiative in strategizing and communicating to external markets.

2.6 Consensus on LCA Methods and Data Requirements

Despite the presence of ISO standards on LCA, conducting LCA for comparison purposes within sectors requires additional guidelines to ensure consistency in assessments (Subramanian et al., 2012). This section covers the state of consensus on LCA methods and data in literature, and highlights issues with comparability between LCA studies on GHG emissions of oil sand-derived crude oil. After a brief overview of LCA uses for GHG emissions, issues facing consensus on LCA data and methods are examined based on relevant literature. Uncertainty and variability in LCA of oil sands GHG emissions are discussed, followed by issues of uncertainty in the use of LCA in policies.

2.6.1 Issues Overview

Reap et al. (2008a) define LCA problems that challenge its improvement by phase. Those most relevant to a CSA PCR for GHG emissions of crude oil are focused on here. *Boundary selection* and *functional unit definition* are problematic in the goal and scope definition phase, and are capable of influencing a study's outcome. *Functional unit definition* is critical for comparability of LCA results (Reap et al., 2008a), as it defines the relationship between inputs and outputs of a product system. As decisions on these two areas are partially dependent on study goals, they cannot necessarily be overcome by "scientific and technical consensus building" (Reap et al., 2008a, p. 291). During the LCI phase, *allocation* is another "critical problem" (p.290), whereas *cut-off criteria* and *local technical uniqueness* of the system being studied are less prominent issues. *Uncertainty* in the decision process, during the LCI phase, and *data availability and quality* in general are also problematic (Reap et al., 2008a).

2.6.2 System Boundary

The chosen system boundary delineates what processes and activities are included in an LCA, and is influenced by unit processes and time horizons.[5] Studies with "a well-justified and transparent selection of boundaries" (Reap et al., 2008a, p. 294) will achieve greater credibility and have increased certainty than those without. Reap et al. (2008a) describe the central problems with respect to system boundary choice as being scientific justification, where the boundary must sufficiently encompass the process being studied. Inappropriate boundaries may result in "incorrect interpretations or comparisons" (Reap et al., 2008a, p. 293), or may decrease confidence in the study by decision-makers. For unit process boundary selection, the ISO 14040 standards series allows for subjectivity in how boundaries are chosen, with consideration to the study's goal, scope, purpose, audience, assumptions, constraints, and a cut-off criteria based on contribution of the element to the system (ISO, 2006b). While relevant data and available studies, or a small LCA scope, can aide practitioners in choosing an appropriate boundary, Reap et al. (2008a) state that doing so is challenging in cases of emerging technologies or when relevant studies are based on proprietary data.

Based on the information presented above, the following hypotheses on boundary selection in the development of a CSA PCR are put forward:

- Transparency and appropriateness of rules on boundary selection in the standard:
  - Will increase credibility of LCA studies;

[5] Considerations of time dynamics in LCAs occur in system dynamics as temporality and in time horizons. ISO 14044 (ISO, 2006c) states that the exclusion of temporality in the LCIA stage can challenge comparisons between studies, whereas Reap et al. (2008b) go further to state that LCA cannot accurately represent historical data and is incapable of accounting for "environmental and industrial dynamics" (Reap et al., 2008b, p. 378). The time horizon chose can impact which technologies appear to be more environmentally favourable (Reap et al., 2008b).

- Will be achieved if the specified scope is to be small and relevant data or studies exist; and
- Will be challenged in cases of emerging technologies or where studies have used proprietary data.

2.6.3 Allocation

Allocation is the procedure of associating inputs or output flows of a complex process to its different functions or products. The issue of allocation arises during the LCI phase of an LCA, and is "one of the most controversial" and deeply-rooted issues of LCA (Reap et al., 2008a, p. 296). This phase involves selecting the model's parameters, such as GHG emissions. Reap et al. (2008a) note the presence of multiple definitions of "the allocation problem" (p. 296) in literature. The multiplicity of acceptable approaches toward allocation increases the possibilities for incorrect allocation decisions and unrepresentativeness of results, and can lead to little consideration in the selection of approaches (Reap et al., 2008a).

ISO 14044 (2006c) recommends a four-step procedure for practitioners to approach allocation. First, allocation should be avoided whenever possible through either (1) subdividing processes and gathering associated input and output data, or by (2) system boundary expansion to include additional functions related to the co-products. System expansion, or subdivision, as an approach to avoiding allocation entails expanding the system boundary by either adding or subtracting the outputs of alternative production methods (Reap et al., 2008a). In comparison with allocation, Weidema and Schmidt (2010) argue that system boundary expansion succeeds in preserving carbon, mass, and energy balances in most cases through the scaling of unit processes because they are not artificially partitioned as in allocation. However, while this approach can be useful for processes with multiple functions without independent sub-processes, Ekvall and Finnveden (2001) state that it can be problematic due to its reliance on requirements for additional data from alternative production systems beyond the one being studied. Reap et al. (2008a) summarize trade-offs between model simplicity using allocation approaches and size, complexity, and data requirements for system boundary expansion, where the latter is said to require greater resources and “potential data quality uncertainty” (p. 298) in exchange for increased accuracy.

If allocation cannot be avoided, ISO 14044 (2006c) states that relationships based on physical properties should be used first. Reap et al. (2008a) note a general agreement among LCA practitioners on the guidance in ISO to base allocation on these causal physical relationships when issues remain after system boundary expansion. However, the possibility for the approach to lead to significantly different results exists, and has been interpreted as being a scientific knowledge gap or an instance of “causalities” (Reap et al., 2008a). Weidema and Schmidt (2010) identify one of these possibilities as being the under-examined issue of allocation being unable to maintain carbon, mass, and energy balances due to their artificial partitioning in allocation.

As a last resort, ISO 14044 (2006c) recommends that relationships based on non-physical properties should be used in allocation if physical relationships cannot be. Examples of relationships here may include energy or exergy content or economic value. Although this is the least preferable approach to allocation and is said to be capable of resulting in inadequate reflections of actual processes, Ekvall and Finnveden (2001) state that allocation based on non-causal relationships are the predominant approach taken within the LCA community.

Based on the information presented above, the following hypotheses predict consensus regarding allocation in a CSA PCR:

- The system boundary expansion method has greater accuracy than allocation if properly applied, but can result in greater data quality uncertainty.
- Multiple definitions of the allocation problem will:
  - Increase the possibilities for inappropriate allocation decisions;
  - Increase the likelihood of poor decision making based on poor study results; and
  - Decrease the consideration given to the selection of approaches.
- The least desirable allocation approach according to ISO 14044, of allocation based on non-physical relationships, will be the most common practice by LCA practitioners

2.6.4 Uncertainty and Variability

The consideration of uncertainty is integral to the reliability of GHG emissions claims. Reap et al. (2008b) define uncertainty in LCA as a "lack of knowledge about the true value of a quantity, true form of a model, [or] appropriateness of a modeling or methodological decision" (p. 381). Comparative LCAs are more likely to be inconclusive if uncertainty is modeled "comprehensively and conservatively" (Reap et al., 2008b, p. 382), to the extent that comparisons between competing alternatives may be rendered indistinguishable if probability distributions are wide. The same inconclusiveness may also arise for LCA with weak uncertainty analysis and data. A lack of detail in publicly-available datasets for refining also create uncertainty when proprietary refining models cannot be accessed (Brandt, 2012). Brandt (2011) notes that refining is simplified in most LCA studies, attributed in part to an absence of public refinery models and historical treatment of crudes as a single national average rather than a mixture of individual crudes. Uncertainty in results can also arise from uncertainty in cogeneration, which Brandt (2012) identifies as being due to challenges in determining the quantities of co-produced power for allocating an accurate credit for exported electricity, where such offsets are often accounted for ambiguously.

There is disagreement within literature on the use of LCA to support policies due to its associated uncertainties. While Finnveden (2000) recognizes the near impossibility of achieving a scientific comparison between the environmental preference of two products using LCA, they state that it is beneficial for policies to use LCA as one input into the decision making process rather than waiting to act until greater certainty can be achieved. This is reaffirmed by Reap et al. (2008b), who support the use of LCA as a "rational and comprehensive approach" (p. 385) to make relative assessments for policy purposes. In contrast, although decision-makers acknowledge that aggregation is necessary to choose between competing options (Reap et al., 2008b), Brandt (2011) views policies that use LCA based on national averages to be "problematic for future regulation" (p. 31), requiring analysis that is aggregated at least by crude oil type. Other research, such as by Plevin (2010), supports that policies such as the LCFS which use LCA do not "recognize the limits of scientific analysis" (p. 174) in being complex and specific. Currently, no frameworks exist to be able to balance comprehensiveness with usability for decision making in uncertainty analysis within LCA (Reap et al., 2008b).

GHG emissions calculations for crude oil derived from Alberta's oil sands vary significantly. This is due to what Brandt (2012) identifies as different scopes and methods used in

LCA, extraction efficiency assumptions, differences in the assumed fuel mix for extraction and upgrading, consideration of secondary emissions such as venting and flaring, and whether or how "ecological emissions sources" (p. 1253) such as land-use are accounted for. Charpentier, Bergerson, and Maclean (2009) state that the magnitude of this variation points to the lack of a consensus on determining GHG emissions for the oil sands by using LCA.

Based on the information presented above, the following hypotheses on consideration of uncertainty regarding LCA in the development of a CSA PCR are put forward:

- LCA can be a useful input into the decision-making process despite challenges facing uncertainty and accuracy of results for comparisons; and
- Existing policies based on LCA have not properly considered uncertainty of those studies they are based upon.

2.6.5 Data availability and quality

Data descriptions are central to an LCA's reliability and interpretation (ISO, 2006b). Data quality is defined in ISO (2006b) as "characteristics of data that relate to their ability to satisfy stated requirement" (p.4), and ISO (2006c) states that requirements for data quality must enable an LCA using these requirements to meet its intended goal and scope. There requirements should include time-related, geographic, and technology coverage, precision, completeness, representativeness, consistency, reproducibility, data sources, and uncertainty (ISO, 2006c, p. 10).

Data quality is one of the primary creators of uncertainty, affecting all stages of LCA (Reap et al., 2008b). Reap et al (2008) define data quality issues as inaccuracy, gaps, the use of proxies, and "uncertainty about LCA methodological choices" (p. 383). Among LCA practitioners, a consensus exists that data for LCI phases is lacking and not of high quality (Reap et al., 2008b). Finnveden (2000) states that data from energy inputs can be included without resulting in significant data gaps, although Ayres (1995) predicts that obtaining such data from external sources may be challenging due to its proprietary nature and commercial sensitivities. As well, external data is often of unknown quality, where uncertainty is often unknown, as are data limitations, "accuracy, reliability, collection method, and frequency of measurement" (Reap et al., 2008b, p. 383). While proprietary data can be more detailed, Charpentier et al. (2009) note difficulties in using data reported by companies without additional inputs due to concerns over completeness and system boundary considerations. Reap et al. (2008b) see value in ISO guidelines for data source documentation to help to overcome data quality issues during the LCI phase, although companies may still take shortcuts by extrapolating data or ignoring data gaps. More serious issues from data quality are created in the LCIA phase, where ISO recognizes that a lack of scientific knowledge limits the ability of data used in studies to accurately reflect environmental realities (ISO, 2006c).

Environmental and technical uniqueness are influential in the quality of data that can be obtained for LCA. For the former, Reap et al. (2008a) state that data will be site-specific and will be influenced by "local sensitivities in LCA" (p. 387), and that special variation is enhanced through increasingly accurate models of extraction geometries such as reservoir characterizing. Categorizing local technical uniqueness as a data quality issue, Reap et al. (2008a) see issues arising due to variation in technologies from extraction to end-of-life stages between locations, although these are not deemed to be as influential as allocation decisions taken during the LCIA phase.

The quality and availability of data from environmental impacts associated with Alberta's oils sands has been recently scrutinized by a number of government, academic, and NGOs. The majority of this has focused on environmental monitoring, which does not include GHG emissions as these are reported based on calculations of energy inputs rather than monitored. The National Pollutant Release Inventory (NPRI) emissions data was only one of two organizations, along with databases on non-GHG air quality housed by the Wood Buffalo Environmental Association (WBEA), deemed by the RSC to offer data that is "readily accessible" (Gosselin et al., 2010). A study by the Pembina Institute noted an absence of voluntary GHG abatement targets, exemplifying ISO 14001 as being one such program that could be employed to improve upon this (Dyer, Moorhouse, Laufenberg, & Powell, 2008). As well, CAPP's RCE Advisory Committee recommended that CAPP should work toward establishing benchmarks to compare GHG emissions, to compare with petroleum industries in other countries (Ogilvie et al., 2010).

Data for LCA practitioners can also be derived from Environmental Impact Assessments (EIAs). While there is a legislative formalization of how to conduct an EIA, Manuilova, Suebsiri, and Wilson (2009) state that these are site-specific by nature and do not have any particularly method associated with them, as do LCAs. The Alberta Government states that the preparation of an EIA report is "the most comprehensive and transparent form of environmental review" ("Alberta's Environmental Assessment process," 2013), although individual project EIAs have been criticized by Gosselin et al. (2010) as not being uniformly and readily accessible or standardized. Calls have been made for results of data collected for approvals and monitoring to be communicated or made transparently and publicly available in useful formats (for example, by AEMP, 2011; Gosselin et al., 2010; Oil Sands Advisory Panel, 2010). This supports the lack of quality in data available for practitioners in LCI. As well, a significant data gap exists for land-use in general, as an impact category. Finnveden (2000) states that what data does exist for land-use is inconsistent, and that such categories are usually not included in LCA.

Based on the information presented above, the following hypotheses on considerations for data availability and quality in a CSA PCR are put forward:

- Data on energy inputs from external sources or companies may be difficult to obtain and of uncertain quality;
- Local technical uniqueness will create only minor data issues;
- Challenges from data issues exacerbate issues faced with the loss of certainty in system boundary expansion; and
- Data from Alberta's EIAs has multiple inadequacies, and a significant gap exists for land-use data.

2.6.6 Terminology

Standardizing the terminology of the oil sands is deemed necessary by a recent RSC report. The RSC determined that this "oil sands lexicon" should include terms for "equivalent land capability, reclamation, and restoration are critical for establishing end land use goals, expectations, and requirements" (Gosselin et al., 2010, p. 10). The development of such "key technical and policy terms" (Gosselin et al., 2010, p. 19) is deemed to be integral to minimizing the confusion that can stem from differences in interpretation among stakeholders. According to Gosselin et al. (2010), existing projects will require the careful consideration of these terms as they've been previously used. As well, they determine the terms for land-use reclamation to be unclear to stakeholders due to lack of standardization, calling for greater clarity in terms including “end land use” and “equivalent land capacity” (p. 10). Also, while the ISO 14040 series of standards specifies terminology for LCA practitioners, there exists a lack of standardization of terminology across GHG standards.

Based on the information presented above, the following hypothesis on terminology regarding considerations of the oil sands in a CSA PCR is put forward:

- The oil sands lexicon requires standardization, particularly for key technical and policy terms and those related to land use.

Chapter 3: Methods

This study is purposed to develop and contextualize a narrative of a contemporary issue in a case study. This is a holistic approach to study a proposed standard as an entity in itself constructed of many parts and one which interacts with its surrounding environment, allowing for its development and effects to be considered within a wider context. Case studies are a useful method when analyzing phenomena that are influenced by their surrounding context (Stake, 1995), as they can contextualize issues in order to give them meaning (Agranoff & Radin, 1991). As well, they can be useful when studying contemporary events (Yin, 1984), and can be useful for public administration by connecting theory and practice (Agranoff & Radin, 1991).

Similarly, the narrative approach is beneficial to examining policy issues, such as the use of LCA to govern markets for crude oil, by allowing for the examination of roles, responsibilities, methods, timelines, and motivations (Kaplan, 1986). Narratives can help to divulge policy weaknesses, and are the best method of specifically showing the predicted operation of a program and its intended outcomes to those who must decide on resource allocation (Kaplan, 1986). They also provide benefits when the area of study does not have sufficient pre-existing external criteria (Kaplan, 1986), such as when studying a potential PCR for crude oil. The use of open-ended interview questions within narratives is particularly useful when interviewing experts (Kaplan, 1986), and is described by Agranoff and Radin (1991) as being able to "translate raw experience into interpretation" (p. 119). As well, to check for accuracy and completeness of conclusions, as highlighted by Agranoff and Radin (1991), interviewees were sent a copy of the interview findings before the final draft of this thesis was completed.

3.1 Interviews

Interviews were conducted with 24 experts from academia, industry, and government. Respondents had experience or expertise in the conduct or use of LCAs, as chairs or technical experts within national and international SDOs on environmental standards, or in communicating GHG emissions from the oil sands industry. This provided a sample that was comprised of those familiar with the standards setting process, and those who represented the interests and backgrounds likely to be present on a committee tasked to develop a Canadian PCR for crude oil.

3.1.1 Participant Selection

Interview participants were carefully selected and pre-screened. Recruitment was initially done by networking with experts at events held in Calgary in November 2012 attracting professionals working in the oil sands industry – the Canadian Science Policy Conference, the Oil Sands Leadership Initiative Bigger Ideas Forum, and the Petroleum Technology Alliance Canada's Oil Sands Forum. The CSA was helpful in connecting with select individuals who had been involved in CSA Z741. A snowball technique was used to expand the number of interviewees, where those interviewed were asked if they had recommendations for others who could provide more details on a particular point of interest or who would be more relevant.

This study received ethics approval from the Conjoint Faculties Ethics Research Board (CFERB) at the University of Calgary. Participants were protected by following a number of requirements set by the CFERB. One-third of participants wished to remain anonymous, 13 allowed for their names to be used, and 16 chose to allow their company's name and their affiliation to be used.

3.1.2 Questionnaires and Interview Conduct

Semi-structured interviews were used, rather than more structured interviews or surveys, due to the motivation of this study and the expertise of participants. Different questionnaires were developed for academia, industry and government, and standards experts (see Appendix B). Academic interviews were conducted first in order to frame future interviews – the expertise of these interviewees was both highly-focused and easily determined from relevant publications, which helped to develop more precise questions and limit the scope for subsequent interviews with members of government and industry. For the majority of interviews, discussion areas were: (1) the issues facing the standardization of data, governance, and communication for Canada's oil sands, (2) government or industry measures that might mitigate these issues, (3) the potential for a formal voluntary standard to mitigate these issues, and (4) anticipated problems in the development of such a standard. For the two interviewees who had been involved in the setting of CSA Z741, questions involved (1) the nature and duration of their involvement with this process, (2) any issues that arose and whether they could be attributed to the process or to the nature of carbon dioxide sequestration, and (3) problems they could anticipate in the development of a CSA PCR for crude oil.

3.1.3 Interviewee Typology

Interviewees were equally distributed between three main areas of expertise related to GHG emissions: (1) LCA, (2) regulation, strategy, and communication, and (3) standards setting (Table 3). All interviewees employed by an academic institution were currently involved with LCA or the Canadian oil sands industry, such as in the development of new LCA tools or through serving on government review panels for assessing the environmental impact of the oil sands.

Table 3: Interviewee typology

<table>
<tr><th>Area</th><th>Expertise</th><th>Type of work</th><th>Sector</th><th>Number of Respondents</th></tr>
<tr><td rowspan="2">LCA</td><td rowspan="2">Technology assessment

Comparative studies</td><td>Practitioners</td><td>Industry
Academia</td><td>5</td></tr>
<tr><td>Users
Comparators</td><td>Industry</td><td>4</td></tr>
<tr><td rowspan="3">Regulation and Strategy</td><td rowspan="2">LCFS
FQD
Albertan
Canadian</td><td>Design
Evaluation</td><td>Academia</td><td>2</td></tr>
<tr><td rowspan="2">Advocacy
Communication

Planning</td><td>Government</td><td>1</td></tr>
<tr><td>Company strategy</td><td>Industry</td><td>3</td></tr>
<tr><td rowspan="2">Communication</td><td>Policy</td><td rowspan="2">Inform
Advocacy</td><td>Government</td><td>1</td></tr>
<tr><td>Public</td><td>Industry</td><td>2</td></tr>
<tr><td rowspan="2">Standards setting</td><td rowspan="2">LCA
GHGs
CCS</td><td rowspan="2">Lead
Participant</td><td>Academia</td><td>4</td></tr>
<tr><td>Industry</td><td>2</td></tr>
</table>

All interviewees currently employed by an academic institution (“academics”) were currently involved with LCA or the Canadian oil sands industry. Three were involved primarily in academia through teaching and research in LCA-related areas for crude oil, and worked on developing new tools to make comparisons between products with greater accuracy, investigated uncertainty and variability, and evaluated technology comparisons using LCA. One interviewee held leading roles at both the CSA and at ISO. Environmental interests were represented by two other academics, including one who had served as a member of both the Federal Oil Sands Advisory Panel and AEMP. Academics’ institutions included the Universities of Calgary, Alberta, and Toronto.

Interviewees currently employed within industry or government were all involved with the oil and gas industry. Those directly involved in the industry were employed by a company.

Representatives of four major companies, including Shell, Nexen, and Suncor, were interviewed. These respondents all had high-ranking positions. Others in the industry were from industry consortia, such as the Canadian Association of Petroleum Producers (CAPP) and the Canadian Energy Pipeline Association (CEPA). The majority of these respondents also worked on impact assessment, scenario building, and strategic planning, and were involved with governments at the provincial and federal level on policies or regulations. Of these, a few also had experience working with the government with California or British Columbia's LCFS and the European Commission's FQD. Individuals employed by consulting firms were also interviewed, and specialized in GHG measurement, LCA policy analysis, and carbon capture and storage (CCS) research. The majority were Directors at their respective firms, which included (S&T)[2] Consultants, Energy Strategy: IHS CERA, Advanced Resources International, and BACH Enterprises.

Eight of the interviewees had been a part of a standards development process at the CSA or ISO for carbon-related standards. These people were highly knowledgeable and familiar with the development process. Of these, three interviewees were involved in consulting, either owning their own firm or consulting independently. Four were subject matter experts, and had been involved with either CSA and ISO on standard development committees on LCA, GHG, CCS, or carbon footprint standards. Two were also part of the CSA, one as a voting member and one as a member of its policy board. These people discussed the standards development process, what committees exist and how they work, what issues typically arise and which have arisen in the past, and how these issues are avoided or mitigated. A list of those interviewees who agreed to have their name and their affiliation and/or expertise disclosed is presented in Appendix A.

3.2 Case Study Development

To develop the case study, interview findings were compared with what was predicted by the hypotheses developed in the literature review. The relevance of attributes from interview findings in the study was gauged by the frequency with which they were mentioned, any disagreement or agreement on the same points across interviewees, and the perceived importance of the attribute. Generalizations were then made as key findings, by identifying attributes that were both common and unique (Kennedy, 1979) according to the area being discussed or the interviewee typology.

Analysis of these key findings was expanded by applying them to hypotheses from the literature review, and similarities and discrepancies were noted. Differences were considered to be (1) findings that were opposed to what was predicted, (2) findings which added to issues predicted in the literature, and (3) findings which specified further details than predictions to better define how the literature relates to this specific case study. Due to the narrative structure of findings, hypotheses are referred to in a holistic manner which allows the focus to remain on the relationship between interview findings, as the main component and contribution of this thesis. Conclusions and recommendations were then made, according to the research questions, to identify necessary considerations in the development of a formal voluntary Canadian PCR for crude oil.

3.3 Limitations

There were four limitations to this thesis in terms of its methods. The first is its wide scope due to the hypothetical nature of the CSA PCR standard, where uncertainty about its content often led to a broad range of interpretations by interviewees. While this challenged a focused scope of analysis, it also mirrored responses of participants to what they envisioned such a standard would look like and allowed for a wide range of potential effects to be considered.

The second limitation is the absence of responses from any individual at the CSA who would be involved in the development of such a standard. As the CSA has a mandate to serve the needs of industry, however, a CSA PCR standard would be driven by industry needs and with industry input, whereas CSA representatives would be involved in guiding the process and ensuring that credibility is maintained.

The third limitation was that it was not certain if any of those interviewed would be involved in the process of developing a CSA PCR, such that it had to be assumed that their experience, qualifications, expertise, and interests were such that they could potentially be involved in the process as a key stakeholder.[6]

Finally, the fourth limitation was the lack of interviewees available that were knowledgeable with PCR development and their interaction with ISO standards. This was assumed to be a relatively minor limitation, due again to the nascency of the proposed standard, the direct similarity between the development of a PCR and building consensus on LCA methodologies, and the particular focus of the PCR for Canadian crude oil products.

[6] Excluding those who were experts in standards setting without any direct connection to the oil sands or to LCA.

Chapter 4: Case Study

This chapter presents a case study on the potential for a formal voluntary Canadian PCR for crude oil to meet issues facing LCA in Alberta's oil sands. It contains the analysis of interview findings, followed by the comparison of these findings with the hypotheses generated in the literature review. Findings are presented in the structure of a narrative to establish continuity across a diverse range of topics, rather than being addressed according to questions posed in the interview.

4.1 Interview Findings

The following six key findings emerged from the analysis of interviews, regarding the potential for a CSA PCR for crude oil:

- Consensus on LCA methods and data quality requirements will be challenging;
- Comparisons based on LCA are often used improperly, misleading, and ill-understood;
- Industry and government support of the standard is required for the standard's development to succeed;
- The standard must sufficiently align with existing regulations, standards, and best practices;
- The process of developing this standard must be viewed as being credible and transparent; and
- The standard must be able to be frequently, easily, and successfully revised, with adequate consideration to existing and future technologies.

These findings are elaborated upon in the following sections.

4.1.1 Consensus on LCA methods and data quality requirements will be challenging

The issues mentioned facing the standardization of LCAs used for the oil sands were similar across interviews. The most prominent of these were boundary selection and data quality and source requirements. Participants discussed the state of agreement on methods, including boundary selection and decisions on allocation. Data, as an input into LCA models, was widely discussed in terms of quality, accessibility, and usability. LCA models were mentioned, but there was a general agreement that choice of model was not as influential as methods or data.

4.1.1.1 Methods and Models

Major challenges were identified for LCA methods in general, including their use in regulations, and were discussed by eight participants. These most often related to a lack of settlement or consensus upon different ways to conduct LCAs. There was consistency across interviews with regard to methods being perceived as being in a state of flux, exemplified by the perceived lack of academic agreement even in many well-cited studies. Responses, across all interview results but particularly prominent with respect to methods, pointed to the subjective nature of LCA, encompassing the choice of boundaries, scope, inclusion and exclusion, and theory. This is elaborated upon in Section 4.1.2.6. Methodological choices were mentioned to be, akin to all science, a "very human process."

In the case of Canada, one interviewee mentioned a need for a clear definitive model of the life cycle of crude oil that covered the whole WTW, seeing no agreement nor a full understanding currently of what the model and actual GHG emissions in each and every stage are. At the company level, an interviewee from Suncor stated that the company had been observing the evolution of different models, internally evaluating their relative strengths for the purpose of developing a consistent internal method for identifying opportunities to increase efficiencies. They felt that, in general, the number of models used should be minimized to reduce the number of different decisions that could be made based on life cycle evaluations.

The presence of different LCA models was mentioned to be particularly relevant due their interconnection with policy and regulation and implicit link to trade. A major finding was that two well-informed interviewees stated that there is no existing standard by which to even compare such a standardized method for crude oil to. Another predicted that this inability for stakeholders to agree on a common model would never be overcome, and that these contentions would be perpetuated in the standards setting process. However, two interviewees noted that differences in models are not fundamentally problematic to LCA, particularly when examining the influence of an LCA model on regulation. Both of these individuals, who had extensive experience with meta-analyses of a large number of LCA studies, saw the data input into the model as being much more important in defining outcomes. As well, it was notable there is international cooperation or discussion between those developing popular LCA models, including the US DOE's GREET, and NRCan's GHGenius.

Although models were seen as computationally similar while being designed for different data inputs, these inputs are correlated to the purpose of the model, such as for the use of data specific to Canada in GHGenius and the data from the US DOE used in GREET. One respondent noted that a proprietary model used for LCAs for the Alberta Government had been built by using the firm's own refining experience, and that this was calibrated against industry to test for accuracy. An interesting finding was the use of a different model by Alberta Energy for their renewable fuel standard program than for their oil sands sector. The former of these uses the publicly available GHGenius model, which is funded by NRCan, while the latter uses a proprietary model from Jacobs Engineering. It can be suggested from this that such differences may have potential implications on the transparency with which Alberta's LCA calculations for the oil sands are perceived internationally.

4.1.1.1.1 System Boundary Selection

The selection of the system boundary was widely seen as being fundamental in developing LCAs that are appropriate and comparable. Seven interviewees discussed the importance of boundary selection, all without going into detail. Those involved with related regulations discussed how the LCA approaches taken by the Alberta Government, CARB's LCFS, and the EC's FQD had a WTW scope. This approach was said by two interviewees to reflect the Alberta and Federal Government's agreed-upon scope of LCA, encompassing all stages, from extraction through to upgrading and refining and finally end-use, of the product life cycle. However, this does not reflect agreement of system boundary, and leaves room for wide discrepancies in what system boundaries are selected and the potential for a subsequent inconsistency across studies.

4.1.1.1.2 Approaches toward Allocation

Agreement on how to approach allocation was deemed necessary. Six interviewees spoke to this, and there was contention over which of the two main approaches to conducting allocation in LCA should be used, particularly for calculating life cycle GHG emissions of crude oil. These are allocation, also referred to as "co-production," and system boundary expansion, also referred to as the "displaced product" approach.[7] The issues identified were a need to improve (1) the rules by which to decide which allocation method to use, and (2) transparency in these calculations. The first of these was spoken to by those who conduct LCAs, and the second by those who compare LCAs in meta-analyses and for consortia sustainability reports, including IHS CERA's Special

[7] It was noted that this terminology requires standardization

Report Oil Sands and CAPP's RCE reports. One academic practitioner mentioned that there has been debate about which approach to take for "decades"; this disagreement would necessarily continue when discussing what approach to take for a PCR for crude oil.

All but one interviewee who spoke to issues regarding allocation were LCA practitioners themselves, with two being from academia and four from industry. One industry interviewee experienced issues with this in performing a meta-analysis to compare existing LCA studies for crude oil. The other two in the same category had performed LCA studies for the Alberta or Canadian Governments, and one of the academic practitioners was closely involved with an LCA-based policy outside of Canada. The final industry interviewee was from Suncor, involved in energy and climate change policy. Suncor was mentioned by three other interviewees, as being subject to typical discussions of how to determine the main impacts of synthetic crude oil (SCO) from oil sands products. This debate on which allocation method to employ in deciding the association of GHGs emissions with either SCO or electricity was said by one practitioner to arise constantly.

There was a marked disagreement between opinions of LCA practitioners interviewed regarding the best way to approach allocation. The use of allocation, or co-production, was said by academic LCA practitioners to have many flaws. The choice between the economic and exergy-based allocation, as two of the possible methods of accomplishing allocation using the allocation approach, was said to be highly dependent on the discipline of the practitioner. A separate practitioner noted that a third option of co-product allocation, used for co-generation, was said to be arbitrary, lacking in rules and subject to gaming, such as by ascribing an intention to follow methods in hindsight but not in practice.

The issue of allocation methods likely influences, and is influenced by, regulations using LCA. The majority of practitioners who spoke on this issue had dealt with the use of LCA to support regulations, both within and outside of Canada. One academic practitioner believed that the “best practice” approach is to use the choice that best reflects policy intention. However, a number of respondents showed disagreement with the use of LCA to support regulation. For example, one interviewee who had worked for both government and industry with emerging regulations like the FQD and LCFS, explained that LCA doesn’t “mesh well” with regulatory regimes, in that it can’t easily capture offsets, cogeneration credits, commitments to technology investment, or technological improvement. These sentiments were echoed by many others, as highlighted in Section 4.1.2.7.

4.1.1.1.2.1 System Boundary Expansion

While it was noted that the ISO 14040 series suggests the system boundary expansion (displaced product) approach, there were mixed opinions over whether this is best to use when dealing with refineries for crude oil. Respondents noted a number of benefits to this approach. An academic LCA practitioner saw consensus over the preference of this method, corresponding with ISO suggestions. The rationale for this was its ability to simplify the determination of co-production values at the refinery stage by using hydrogen content as a reflection of emissions. A separate academic practitioner used Suncor as an example of a company deploying this approach, where the company will assume electricity produced alongside SCO has the carbon intensity of Alberta grid electricity to determine the carbon intensity of SCO.

When considering refinery method decisions, the opinion of industry practitioners differed. One with experience in developing LCA reports for the Alberta Government saw a high degree of variation across LCA practitioners to treating the co-products that are considered during this phase, such as for coke, liquefied petroleum gases (LPG), and other materials proceeding as a result of producing gasoline or diesel as end products. The industry practitioner developing Canada's federal LCA model said that system boundary expansion is rarely used with respect to refineries, although it has been used in the past, such as for one study done by Shell. This approach was said to give benefits to SCO over crudes that produce heavy fuel oil, for which "bottoms" must be considered by market displacement methods. Disagreement was noted over which market products should be used for these bottoms, where governments in Europe tend to suggest the use of gas as a displacement option, which can give substantial advantages in the final life cycle emissions intensity of products without bottoms. As such, using the system boundary expansion approach at the refinery stage in LCA was said by this practitioner to "help narrow the gap created by SCO from oil sands and conventional crude oil," despite distinct impact values associated with these two products. This demonstrated the influence that the potential to choose between options using the system boundary approach may have on LCA outcomes, and reaffirmed the need for a PCR for crude oil to define a common approach to allocation.

4.1.1.1.2.2 Allocation

Accounting for co-production through the use of allocation was spoken to by a member of industry with experience in meta-analyses of LCA studies, with respect to the complications brought to this by operator differences. This was similar to issues discussed by the synthesizer of CAPP's RCE regarding what emissions are considered as being inside or out of the "fence." An example used was the inclusion or exclusion of emissions from power generation depending on whether it is generated on-site, or else generated off-site but at an operator-owned facility. They compared the sustainability reports of Syncrude with those of Suncor, partially ascribing the fact that all power generation occurs on-site to Syncrude's higher GHG emissions per barrel from their oil sands facilities. Suncor, who has commercial agreements with third-party power suppliers that govern the appropriation of its emissions at certain sites, was said to consider emissions from power generation as being "outside of the gate" in their sustainability report. This was said by the interviewee to contribute to lower emissions than if these had been otherwise included. Citing difficulties that such intricacies created in their own meta-analyses, the interviewee stated the need for greater transparency in sustainability reports to show whether emissions from off-site power generation were accounted for. In contrast, another noted that emissions are clearly defined in Suncor's sustainability reports as including all direct and indirect emissions, in contrast for regulatory reporting where emissions are reported only for facilities that the company owns or operates. This was seen as being important to understanding the differences seen between the companies regulatory reporting and sustainability reporting, and it was noted that the latter will be comparable to those of other companies so long as emissions are reported in a similar manner.

4.1.1.2 Data Availability and Quality

Fifteen interviewees discussed issues of data quality and source requirements as they relate to LCA comparisons and a prospective PCR for crude oil. Industry and academia sectors were represented, including a wide range of areas of expertise across consortium of CEPA and CAPP, large companies Nexen, Shell, and Suncor, and consulting firms. The majority of those interviewed with experience in leading standards development processes also spoke to the issue of data. Different data sources and qualities were mentioned, as were requirements for having data of different types. These discussions were strongly tied to regulatory requirements and differences between countries.

An expert in GHG-related standardization believed that the degree of challenge represented by data availability in the standards setting process will be dependent upon the type of standard being developed. The developer of the GHGenius model, who had consulted with the CSA on this potential standard, elucidated the predicted data requirements for a CSA PCR for crude oil. Data requirements were expected to be specified for either primary or secondary data, divided between two phases of (1) extraction, upgrading, and transport to the refinery gate, and (2) refining. He explained that the necessary steps for setting acceptable data requirements in such a way would require (1) the definition of how crude oil data is sent through to the refiner, and (2) that the refiner has data from all suppliers, not just for one crude pathway. One industry LCA practitioner saw the primary challenge for this potential standard as being how to adequately determine which GHG emissions are assigned to each crude oil at the refinery stage, which was predicted to be challenged by difficulties related to the complexity in refining processes. This was due to (1) differences in processing between heavy crude oil and lighter crudes at the same refinery, (2) the mix of a range of crudes into each refinery, and (3) differences between refineries in terms of crude mixes, process complexity, and end products.

The wide variability in data quality and availability, as well as differences in database quality, were common issues cited. These most directly affected LCA practitioners, but were also mentioned by those who worked with these studies to compare GHG emissions between operators, companies, products, and countries. While issues of this comparability often intersected with data issues, comparability is focused on in greater detail in Section 4.1.2.

Data quality and availability was often referred to at the sectoral level. One GHG consultant noted difficulties in gathering data that can be sufficiently harmonized or homogenized to develop an industry benchmark. Two industry interviewees – one from IHS CERA and one from CEPA – experienced difficulties in how data for emissions facilities are calculated differently, and called for the measuring and gathering of data in such a way from companies, at the industry level, and for regulators that it is "relatively comparable." An industry practitioner saw difficulties in obtaining high-quality data from both the production and refining stages when conducting LCA. It was mentioned by industry interviewees that this data quality variability within Canada faces larger issues of policies that attempt to govern all crude oil and in comparison with renewables by using LCA to assign default values. Internationally, ensuring all crude providers are treated equivalently only if they have the same degree of data quality was the most important issue for many, as is expanded upon in Section 4.1.2.

One interviewee noted that the data collection challenge, which was acknowledged to exist for LCA, was also challenging in general in science and analysis. As the "rule rather than the exception" in analysis, this respondent had experienced challenges of data sources or use in an LCA model. Another mentioned that, for environmental oil sands impacts, monitoring was relatively straightforward when compared with data analysis in terms of interpreting or contextualizing that data and communicating a message from it. For GHGs, however, while there are some direct monitoring sources for GHGs, many sources cannot be measured directly, such as emissions in mining operations from the combustion of diesel fuel for trucks. In these cases, assumptions must be made based on fuel inputs.

Participants spoke to three different "levels," "tiers," or "spokes" of data.[8] These were said to be differentiated by data quality and potential GHG emissions savings. It is notable that the participants who spoke to these, specifically using this terminology, were those who has been involved with standards setting initiatives including those related to LCA, GHGs, or CSA Z741 Academic and industry LCA practitioners, as well, spoke to separating data by different sources.

[8] These levels of data are not to be confused with definition of life cycle into phases mentioned in Section 1.1, which can be used to define the scope for both direct and indirect emissions (WRI & WBSCD, 2012).

These three levels of data are differentiated by distance in the supply chain from the main product, and are (1) for primary data collection, which is undertaken directly from the source; (2) for secondary materials or processes, produced external to the company; and (3) tertiary data from suppliers or databases.

4.1.1.2.1 Primary Data

Primary data collection, as defined by participants with experience in standards development, consists of emissions from processes and inputs of energy into the system. Data for this stage captures or measures all the GHGs that a company or process directly emits as a result of whatever process is being examined. It was broken down into three different data sources, of decreasing quality: (1) direct access from operations; (2) data collected from organizations other than that of the operation being examined, such as proprietary databases; and (3) indirectly through literature or other sources, such as EIAs, where data sources are not always easily traceable. The following presents interview findings according to each of these data sources.

4.1.1.2.1.1 Collected by Operations

Four LCA practitioners across government and industry discussed using data directly from organizations. A standards expert noted that this type of data is usually well-documented and of the highest quality, and three practitioners noted a preference to get this "real operating data" directly from a producer rather than from external sources. These proprietary data are obtainable by partnering with a company or signing a non-disclosure agreement, for example. Interviewees noted mixed success in obtaining access to this information in this way.

4.1.1.2.1.2 Proprietary Databases

Data obtained from other organizations, external to the company or process being studied, was said to be the alternative to primary data obtained directly from operations. These organizations were categorized by one academic practitioner as groups who collect and process data, such as government institutions or companies who house proprietary databases that span different companies and processes. Data from these sources are often blended so confidentiality agreements are not breached.

Proprietary databases were mentioned as a source of primary data that is external to the company being examined. Benefits of these were noted by two interviewees who worked at firms where such databases were developed. These two stated that, to check for quality and consistency, comparisons were often made between the data derived from these proprietary databases and that available from companies and governments. In the case of one practitioner familiar with refining and engineering models, this resulted in what was said to be a “high degree of confidence” in the in-house refining model, whose results were “calibrated against industry.” However, academic LCA practitioners noted issues with the use of proprietary databases (and often resulting models) to support regulatory processes, such as the LCFS. These proprietary tools were said to create challenges with credibility in the regulatory progress due to criticism over lack of transparency and public availability. Other drawbacks to such proprietary tools were their high cost, and their lack of standardization and widespread use in North America in comparison to places such as Europe where they were seen as being quite popular. Two academic practitioners stated that regulatory tools should be open-source and based on public data, moving away from proprietary data sets and tools.

4.1.1.2.1.3 Government Databases

LCA practitioners mostly focused on Alberta's ERCB to speak about data quality from government institutions, although the National Energy Board (NEB) and the Oil Sands Research Information Network (OSRIN) were mentioned as well. Data from the ERCB on primary emissions is available in EIAs, and reflects emissions estimates from projects in the planning stage. Academic respondents noted that EIA data is often used when proprietary information is not accessible or available for equipment, energy, or emissions. They can be useful for LCA for evaluation of different technologies proposed, from extraction through to processing and possibly transportation, although results were said to be typically high-level. Interviewees who spoke of EIAs unanimously agreed that that it was beneficial for this data to be in the public domain and easily accessible, and one respondent formerly involved with the program believed that EIA are achieving their goal of providing information from the project proponents' point of view about project impacts and mitigation measures.

However, all respondents who spoke of EIAs stated that their data is not the best representation of real operational characteristics. As a result, one academic practitioner said their information becomes quickly obsolete, and another that their lack of standardization made them difficult to use. The respondent who had been involved with the program noted that, over time, EIA reports have become more a summary and synthesis of information, providing little raw data, which makes it difficult for doing detailed analytical work using the data contained within. It was suggested by an industry LCA practitioner that sections of EIAs be updated if developments greatly diverge from initial plans to ensure quality of information, and that such addendums could be issued either directly pre- or post-commissioning of the project component that generates the change.

4.1.1.2.2 Secondary Data

The second tier of data is that which is external to the company in the supply chain. Power, energy, chemicals, and packaging material are examples of these, which can be excluded in an LCA depending on the system boundary and whether they are produced at a separate facility or by a separate company. These can come from a variety of sources. Data on energy inputs, for example, can be obtained from supply chain partners, potentially complicated by the need for NDAs and lack of perceived value in participating. Databases for materials and processes can also be used, where differences between public and private databases emerged again in terms of the need to evaluate the quality and appropriateness of data for a particular study. It was stated by two interviewees that it is easier to do LCAs for manufacturing than it is for the life cycle of crude oil, due to two reasons: (1) more information is available for secondary data than for primary data, due to a more extensive body of knowledge existing from academic research, and (2) steps for manufacturing are more easily and discretely traced than those for production. As a means of estimation, one expert on ISO’s 14040 standard series stated that practitioners may use acceptable proxies so long as these only represent a small percentage of emissions.

4.1.1.2.3 Tertiary Data

Tertiary data includes emissions from subcontractors and vendors, and was not discussed in any detail.

4.1.2 Comparisons based on LCA are often used improperly, misleading, and ill-understood

Comparisons based on LCA are challenged by all of the issues specific to LCA on which consensus is difficult to reach. This was discussed by seventeen respondents across sectors in terms of comparisons between operations, companies, and products, as well as with respect to government reporting and sustainability reports. Uncertainty and variability of LCA calculations was mentioned, and the need for a common benchmark or yardstick to compare the oil sands against other products was commonly referenced. These issues were reflected in multiple participant observations of the poor quality and use of many LCAs, which is discussed last in this section.

4.1.2.1 Comparison between Operations

Comparison between operations was said to be difficult by four members of industry, including those from CAPP and Suncor. Reasons for this were stated as (1) the existence of different operational configurations and integration opportunities at facilities, and (2) economic competitiveness due to operational efficiencies associated with GHG reductions. The combination of these two factors was said to make disclosing proprietary information difficult, and to challenge the conduction of LCAs with industry data, or embedding transparency in studies done with this data. This was described by one interviewee as the nexus between energy efficiency and economics, where efforts toward greater energy efficiency can lead to decreased costs, although this is challenged by reservoir characteristics.

Operational characteristics are dependent upon reservoir characteristics and design. Reservoir characteristics are spoken to primarily in terms of steam-to-oil ratio (SOR), which influence the efficiency by which crude oil can be extracted and thus the emissions from extraction in a manner that is beyond the control of the operator. Reservoir characteristics were said to be highly divergent, particularly for in situ operations. Other operational factors that affect energy efficiency at different facilities were also mentioned, including location and water availability. Design includes decisions about (1) input fuels, integration, and technologies, (2) the facility's production of dilbit, SCO, or intermediates, and (3) final products. Four industry members working with LCA and policy stated that comparison between operators is particularly challenging due to different site set-ups and facility integrations, which result in efficiency differences. These differences create various opportunities for GHG reduction in each facility, such that it is more appropriate to use LCA to evaluate progress made in GHG reduction on an asset-by-asset analysis and compared against a historical baseline for each. Certain industry members indicated that they would not support a standard if it were to eventually lead to comparison between operators, due to the inability for operators to influence many factors which contribute to their emissions profiles.

The economic association of differences in efficiencies between operators poses problems to the standardization of LCAs for crude oil. A respondent from Suncor noted that integration, such as of oil sands mine operation with an upgrader, are driven by technology and its associated reliability rather than primarily toward GHG reduction. This was noted by another interviewee, from CAPP, who pointed out that industry investment and collaboration on technology development, which is done for purposes of increasing revenues, also can reduce a company's GHG footprint. It was observed by an LCA standards expert as well that companies are optimizing their energy use, which in turn reduces GHG emissions. Combined, these were said by an interviewee from Suncor to be a primary reason as to why a standard for meeting GHG emission reduction requirements would not be effective. As well, one interviewee noted that the use of a PCR may have an unintended effect of decreasing water recycling by companies in those that may produce greater emissions from increased energy use in reducing water consumption. This was predicted due to the inability for LCA to normalize for uncontrollable factors in energy use and emissions.

4.1.2.2 Reporting to Government

Differences in reporting requirements and calculation methods for different levels of government were discussed by seven interviewees across academia and industry, including LCA practitioners, those associated with CAPP or CEPA, and standards experts. Comparison between data collected by government was said to be difficult because the oil sands are subject to multiple reporting requirements to different entities that require different submissions. Data and values submitted to the AESRD, NEB, ERCB, EC, and NRCan were said to be all calculated differently, and to be the focus of substantial resources. Both an academic LCA practitioner and the interviewee working with CAPP's RCE report stated that use of these values by academia or industry is complicated. This was identified by the academic due to a lack of transparency in data from government sources despite reporting requirements being standardized, and specifically by the industry member in the lack of communication from government as to how allocation is considered during aggregation.

Comparability of products under the same regulatory regimes was found to be challenging, as were industry submissions for government benchmarking. For instance, one academic practitioner saw a lack of transparency in reporting for sources and sinks to EC for a federal GHG inventory, the National Inventory Report (NIR). A member of CAPP noted challenges in disassociating industry emissions submitted to their annual RCE report to compare with those aggregated and published in the NIR. Regulatory and industry metrics should be made more comparable, said the interviewee associated with CEPA, in measuring and gathering data from companies, at the industry level, and for regulators. Three others reinforced the need for this enhanced comparability when examining differences between GHG emissions data from Alberta's Specified Gas Emitters Program, NPRI, NRCan, and EIAs from the ERCB. It was noted by two industry members that regulatory compliance is different at the Alberta and federal levels and is very time-intensive. One interviewee from Suncor stated that reporting to different government entities requires different considerations of boundary and scope, although these are clearly defined in terms of direct and indirect emissions. An expert on GHG-related standards saw Alberta's GHG program as having been developed with inadequate financial investment and lacking in standards and tools to support the implementation of its policies.

4.1.2.3 Sustainability Reports

Sustainability reports were mentioned by six interviewees who had experience in developing them or in using the data contained within for LCA studies. Their intention of communicating GHG data by contextualizing it, with the public as a specific audience, was noted by industry LCA practitioners. Comparison between companies' sustainability reports was said to be most difficult because their development is voluntary, with no required method. An interviewee with experience in meta-analyses of LCA using such reports stated that usually a hybrid approach is taken between what is done for submissions to different levels of government to develop company sustainability reports. One academic LCA practitioner noted how a lack of standardization for individual company sustainability reports made it difficult to use the data contained within for their own assessments.

One reason given for differences between sustainability reports was that companies calculate emissions primarily to comply with provincial and federal regulations, and for their sustainability reports they "may choose one methodology or another, or a combination of both." A concern mentioned by a member of CAPP was the perceived inadequacy of data contained within sustainability reports for doing meta-analyses of LCA studies, where biases will carry forward from the sustainability reports to the findings of the meta-analysis. This data was not seen as being "raw" or objective, and in cases where multiple comparisons were made over a series of reports the interviewee noted it should be made explicitly clear that their results may not be directly comparable. This was supported by another industry interviewee, who viewed the use of data from sustainability reports as being inappropriate for such an exercise due to the requirements for more precise data to be used in LCA. As well, a respondent who had a role in sustainability reporting at Suncor spoke to the importance and necessity of contextualizing and summarizing data, while acknowledging the importance of raw data for those who understand and work with it. The decision of the analyst as to how to contextualize and interpret this data was noted by both this participant and for one working with CAPP's RCE report, where another believed that such reports are purposed to share high level information and context instead of technical data, and that this is required to maintain readership. This issue was summarized by this Suncor employee as the "biggest challenge we face – how do we get that message out in way that people will understand, believe and process to make informed decisions on what they think about the oil sands?"

4.1.2.4 Comparison between Countries

Comparison between countries was said to be very difficult because of differences in data quality and transparency that result from differences in regulations affecting emissions. This was discussed by eleven interviewees across sectors. There was widespread agreement between the industry members involved in oil sands exports who spoke to these issues that data consistency, amount and quality was highly divergent between places like Canada, the US, and Australia with other regions such as Russia, Africa, Venezuela, Mexico, the Middle East, and Europe. Two interviewees mentioned that, in comparisons with Canada's oil sands crudes and certain heavy

Californian crudes, Canada has higher-quality data for energy consumption during crude production, which was said by another to be more publicly available. An LCA practitioner saw the issues with such comparisons as being not with oil sands data but from inadequate data for conventional crudes from other countries. One interviewee from CAPP called for “equity, non-discrimination and transparency” in regulations that govern using comparisons between countries.

Data accuracy is central to these discussions, with particular respect to estimations for flaring. Lack of reporting was often mentioned as being one of the fundamental causes of challenges in between-country comparisons, and was strongly tied to the use of estimations. A lack of a standardized way of reporting energy consumption or production of crudes was noted by an LCA practitioner from Shell. This was seen as a particular issue for flaring, where a lack of credible data from many market competitors to Alberta’s oil sands industry necessitates the use of satellite images to estimate emissions from flaring. Another industry LCA practitioner elaborated, describing that estimations are challenged by the lack of detail that can be derived from satellite images. The methane content of emissions cannot be determined by examining only flared light from venting, and was said to be totally unsupported by data. The practitioner responsible for Canada’s GHGenius model supported this finding, describing the American Petroleum Institute (API) emissions factor for this flaring as being “totally unrealistic.” One interviewee from Suncor spoke of strategies of many countries to counter efforts to estimate emissions from flaring by ceasing to flare emissions, which results in emissions being vented as methane. This was seen as being problematic in that methane has a higher GHG intensity than flaring gas as carbon dioxide and that the vented methane is undetectable by satellite imaging.

4.1.2.5 Comparison between Products

Comparison between the oil sands and lighter crudes or biofuels were said to be problematic. This is related to the topic of LCA methodologies and data. This was discussed by industry and academia who had been involved with policy initiatives affecting Canadian oil sands. Interviewees differed greatly on their perceptions of whether oil sands crudes should be subject to different or the same methodologies as other crudes and biofuels. A representative from CAPP stated that comparisons of the oil sands are the industry's "greatest challenge," and called for equitable treatment with other producers of heavy crudes or high-carbon producers. They perceived how an LCA is conducted as being will be how the industry is treated as a result of its conclusions, and that industry will support the use of LCA to compare between products if it is be done equitably, transparently, and in a non-discriminatory manner.

Three interviewees involved with LCA and regulation noted that the LCFS treats biofuel producers and those producing non-renewable fuels differently, with one perceiving biofuel producers as seeking special treatment. A common yardstick or benchmark by which to compare different products was seen by respondents as helping to improve the accuracy of comparisons. Two believed that industry should have the same yardstick as other industries to promote international credibility, and a third that the FQD is flawed because the approaches taken to biofuels and crude oil are not consistent. One interviewee believed that an effective standard for comparison is one which creates the need for similar efforts to be taken on behalf of all those sectors it affects, such that all actors must work to improve their emissions in order to meet the standard. This approach would aim to avoid singling out individual sub-sectors while encouraging broad based actions to reduce GHG emissions.

4.1.2.6 Uncertainty and Variability

Uncertainty and variability was discussed by eight interviewees, in relation to both physical properties being measured and the conduct of LCA. Uncertainty in both LCA methods, including land-use impact, and geological reservoirs was mentioned.

Two involved with LCA in companies stated that, although LCA has become gradually more accurate and needs increasingly fewer factors and estimators, uncertainty still persists. One saw these fuel factors as being consistent across the industry, while the other believed the presence of factors spoke to uncertainty in calculations and was therefore a reason for the improper use of LCA across companies in regulation. This point is discussed in further detail in Section 4.1.2.7. Two noted that it is not uncommon in LCA to get error bars larger than the actual values. Approximately a quarter of interviewees referred to LCA and the wider contextualization of GHG emissions values being more an art than a science, supporting views that LCA outcomes can be highly variable depending on the tools and technique of the practitioner. Disagreement over GHG emissions from land-use was noted, where it was stated by an industry LCA practitioner that industry has different opinions than the academic work by Yeh et al. (2010), which was used by two interviewees in LCAs involving Alberta's oil sands. One who undertook a meta-analysis of LCA studies stated that those who do academic LCA frequently add the numbers for land-use from this study onto existing operator estimates where land-use impact may have already been included, and whether or not this has been done is often unclear due to a lack of transparency. These differences in opinion regarding land-use calculation methods were seen by one participant to occur within industry as well as within departments of the Government of Alberta.

Variability in emissions, particularly with respect to geological reservoirs, was noted by five participants. More particularly, this was defined as variability of SORs, which are still ill-understood despite being the biggest contributor to GHG emissions. Different energy intensity requirements for extraction are created by variability in SORs, and the ability to better understand them is compounded by changes in reservoir quality and characteristics over time. The factors contributing to variability in SORs is elaborated upon in Section 4.1.2.1.

4.1.2.7 Poor Quality and Inappropriate Use of LCAs

Both poor quality LCAs and the inappropriate use of LCAs were a major area of contention for many interviewees, of which nine industry members and one government interviewee went into detail in describing. LCA misuse encompassed the use of studies for purposes other than they were intended, or in application to places where they should not be applicable. Most agreed that, while LCA is useful in certain cases, such as for intra-company comparison and improvement, it should not be used for regulatory purposes, either to the extent that it is today, or whatsoever. Misinformation and misunderstanding of LCA, the oil sands, and energy systems in general was widely noted.

4.1.2.7.1 Use of LCA in Regulation

This perceived misuse of LCA for comparative purposes was spoken to with respect to California's LCFS and the European Commission's FQD, particularly with respect to transparency, accuracy, and penalties. The FQD was seen by an interviewee from Suncor as being discriminatory in that the crudes that currently comprise the European crude supply slate, regardless of their specific LCA value, are grouped under one single LCA value that reflects a lower carbon intensity, while oil sands crudes are singled out at a higher carbon intensity. This was said to be done to avoid political ramifications of negative effects of the regulation disrupting European supply. Although efforts taken by the Alberta Government in commissioning their own LCA report for the European Commission were viewed positively, the report was seen by one academic practitioner to have a lack of transparency. Their rationale for this was that, although the assumptions in the Jacobs report were clear and adequate, the model was not public and as such did not work well for commenting in a public process on regulatory formation in the EU. They contrasted this with a public model such as Canada's GHGenius, where the openness of the model allows for leaders in LCA modeling to argue over benefits and drawbacks to particular approaches. Contrastingly, an industry practitioner supported the Jacobs report for openly presenting results, clearly identifying energy use for crude oil and production, and appropriately referencing assumptions and data. They perceived benefits of such proprietary models as access to more recent data than GHGenius, which was said to be problematic in part due to its aggregation of data and its treatment of flaring. The equal treatment of bitumen extracted through mining and that extracted through SAGD in GHGenius was seen by one interviewee as being problematic, as these typically have different upgrading requirements and thus emissions profiles.

The inappropriateness of crude oil categories used in LCA to support regulations was frequently noted. This was seen as the use of generalizations in the poor definition of "buckets," "categories," or "bins" for crude oil, where these definitions were said to be politically motivated. Interviewees from Shell, Nexen, Suncor, and CAPP took issue with current binning methods. Most interviewees stated that bins are too large and highly-aggregated. Oversized bins were seen as an oversimplification by an interviewee from Shell, who believed that more than one or two bins should be used to be a better reflection of how carbon intensities of crudes differ more by "a continuum than a step function." These were supported by an interviewee from Suncor, who saw regulations such as the LCFS as penalizing certain producers by oversimplifying crude pathways in an attempt to minimize administrative burden on behalf of the regulators. As well, an interviewee from Nexen saw the oversized definition of bins as being inappropriate to reflect complex refinery choices, ascribing the choice of as bins as reflecting an intentional bias to discriminate against particular crude sources. They stated that the FQD separates crudes derived from oil sands from all other crudes, whereas the LCFS establishes a emissions baseline from which oil sands are excluded. The differential treatment of the oil sands by the LCFS was exemplified in the inclusion of heavy California crudes extracted by using thermally enhanced oil recovery (TEOR) for in its baseline calculation, a process which was said to have similar emissions profiles as bitumen extracted through the use of SAGD.

These two policies were criticized by seven respondents for being inefficient in reaching their goal of reducing GHGs from transportation, offering no incentive to either end-consumers or poorly-performing producers. The ineffectiveness of the LCFS in changing the transportation mix due to its over-complexity was noted by a member of industry. Another said that both the LCFS and the FQD offered no incentive for those producers who receive a default value that is lower than their actual emissions to supply actual data, which was supported by an academic LCA practitioner who stated that the LCFS incentivizes high emitters to happily accept the assigned default value. Yet another believed that, while the LCFS perceived the default values assigned to countries without data as being quite conservative in an effort to penalize those who do not submit adequate or transparent data, it is impossible to know if these defaults are higher or lower than actual emissions. Refinery choices for these regulations were mentioned by two respondents as being oversimplifications, where they artificially break up the value chain instead of balancing selection from a whole slate of different crude oils based on price and priorities. Two industry respondents and one academic LCA practitioner noted that market forces are efficient at choosing where crude oil will be accepted, such that if these regulations disrupt market flow Alberta heavy crude will be diverted to another location and that oil sands production faces no barriers for increasing in response to growing demand.

Uncertainty in LCA was noted by four interviewees with respect to its use in regulations. This uncertainty was thought by one to prohibit definitive scientific results, by an academic practitioner to create issues with overly-exact baselines such as those used in the LCFS, and by an industry practitioner to create flaws in such regulations due to the dependency of outcomes on the data input. The latter interviewee believed that if the LCFS and FQD in their current forms become more common worldwide, the challenges they create for Alberta's oil sands will be exacerbated. An interviewee from Suncor supported this finding, believing that it is arbitrary and undesirable for regulations to determine a highly-specific value for production emissions for crudes while using a common default refining value with a potentially large margin of error. They suggested an alternative regulatory mechanism, which would provide an infrastructure-pull towards the goal of fuel mix diversification by assigning a single LCA value to broader fuel types such as gasoline and diesel, and for electrical vehicles.

4.1.2.7.2 Misinformation and Misunderstanding

Misinformation and misunderstanding of LCAs, and the oil sands more generally, were said to persist in various and unexpected areas by numerous interviewees. Those subject to receiving misinformation included the public, consumers, graduate students, and government, and even included those within companies (between senior executives and technical staff doing LCA). One interviewee ascribed this to how people who have the best intentions to base their opinion on an educated understanding the oil sands do not have adequate or correct information on which to base this. Another stated that this lack of understanding was perpetuated not just on stories conceived in the media but on an inability for people to know who to trust for unbiased information. A causal factor for this was suggested by two interviewees as being the contextualization of LCA in the communication of GHGs. It was noted by two interviewees that one can "cherry-pick" what they want the story to tell, leading to a bias from the mandate of any given organization, be it industry, government, or NGO, to use a study in self-interest. Doing so was seen to result in trust being established by value judgements, being opinions-based rather than facts-based.

4.1.3 Industry and government support of the standard is required for the standard's development to succeed

It is clear from interview findings that prolonged industry interest, understanding, and engagement will be necessary for a CSA PCR for crude oil to be successfully developed. Three-quarters of interviewees discussed this. This was also said to be important for government and the public, but support from these stakeholder groups are expanded upon in Sections 4.1.4.2 and 4.1.5.3, respectively. Respondents indicated that interest must be gained and understanding must be furthered through outreach activities of the CSA to inform and educate industry as to the purpose of the standard and its predicted benefits. As well, engagement was said to require contextualizing the standard, highlighting its usefulness, and providing specific details as to the nature of involvement.

4.1.3.1 Misunderstanding and Context-setting

While voluntary standards were supported by at least some degree by industry interviewees, they were commonly viewed by those knowledgeable with the standards setting process as being misconceived. A lack of understanding of voluntary standards was admitted by a number of participants in industry. Many participants spoke to a lack of stakeholder understanding around voluntary standards, which was predicted to undermine the standard's desirability. Voluntary standards were seen by one to require support in the form of educating and reporting to demonstrate that they are being used and to prove their value. For this particular standard, it was made clear by one industry LCA practitioner that exactly what a PCR is, its associated benefits, and how it will not increase work or bureaucracy must be communicated with industry. This requires that industry understand the purpose of the standard and its intended use, as well as information, time, and effort requirements and industry benefits.

Setting the context in which the standard is considered was mentioned as being important to having stakeholders understand the motivation for the standard, its process, and its content. This was also seen as beneficial for promoting engagement with the standard by a wide range of stakeholders, including the industry as a whole, potential committee members, government, and the public. Two industry members stated that the standard's usefulness must be framed within a wider context, including benefits to the use of the standard with respect to regulations like the LCFS and FQD, carbon taxes, and emissions reporting to government on a life cycle basis. Recent initiatives within the industry toward greater collaboration were thought to increase interest in the standard, with respect to actions taken in response to market barriers that affect profitability. It was noted by another interviewee who had been involved in CSA Z741 that an opportunity should be offered for stakeholder groups to participate in context-setting. This was added to by an industry interviewee who saw engagement upfront as integral to the resulting standard's success.

4.1.3.2 Establishing Industry Buy-in

Expanding upon regulatory benefits, it was found that efforts must also be taken to promote the standard's predicted benefits with regard to business aspects, such as cost-effectiveness. The standard's implementation and use may create additional costs for companies which would require justifying. A lack of stakeholder engagement was noted as a key issue by many respondents, where the success of the standard requires achieving "buy-in." This was seen as important by multiple interviewees from the proposal development phase until the standard's implementation, as well as post-implementation.

For the standard to be successful, it was found that buy-in must be gained across the industry, and subject matter experts must be engaged throughout the standards development phase. Six interviewees discussed the importance of and the difficulties associated with achieving this. While it was noted that the standard would be unlikely to achieve the engagement of all stakeholders, as many may be against it or would not want to participate, it was made clear that stakeholder engagement upfront was key to success. Involving subject matter experts was mentioned by an industry LCA practitioner as being particularly integral in achieving direction as to how to move forward on the standard, while others stressed the need for such continued involvement throughout the entire development and revision process.

Stakeholder involvement was predicted to be resource-intensive, in terms of time and money. A need for adequate funding was noted by two interviewees, due to the time constraints of these individuals and the high costs of tapping into their expertise. One member of industry noted that existing resources of oil and gas companies are closely focused on meeting regulatory requirements, as their "primary workload," and another that industry may hesitate to become involved with this standard due to it being an additional effort. Those with experience in standards setting believed that commitment over time from the same individuals would be challenging, and that the replacement of representatives in the course of development would create time delays. A definite business case for the standard was said to be necessary, as were clear expectations as to the resource demands on stakeholders, including time, effort, and money.

4.1.3.3 Lack of Industry Support

Findings indicate that difficulties may arise due to a lack of industry support for the proposed standard. While one member of government interviewed and many LCA practitioners supported the standard, three participants believed that the standard would be difficult to impossible to establish. This was supported in part by an expert in the standards setting process, who saw a lack of confidence in standards throughout industry. One government interviewee said that this incapacity to agree on LCA methods would prevent even a mandatory standard from addressing issues of LCA comparability in the oil sands. An industry LCA practitioner with experience in developing LCA studies for the Alberta Government believed that such a standard would be infeasible given the inability to adequately account for all complexities of refineries in a way that they suspected the standard would promote. Another industry practitioner, who was familiar with the proposed PCR, believed that the standard would have issues in its application and would have to fit well with the existing data recording systems of industry. One interviewee from industry saw LCA as a useful tool when used for a single facility to measure ongoing progress in energy efficiency, but for the establishment of a PCR stressed that industry would assume that standard would be used for comparison between the performances of different companies, to eventually drive behavioural change or investment in energy efficiency. Supported by others, the interviewee perceived the inability for LCA to drive these changes due to their influence by factors beyond the control of operators, which was predicted to lead to the central question what the goal of the standard would be and the benefits it would have for companies.

One industry interviewee had knowledge of PCR and had worked with the CSA to gauge initial interest for it in a select group of government and industry. They noted no agreement whatsoever between any of the interviewees spoken to. Responses ranged from "enthusiastic support," to a lack of perceived value due to data problems lying external to Canada, and where government respondents were "unconvinced" that the standard would be advantageous. The participant noted the national compared with the international perspective on the issue, where one international representative only saw value in a potential PCR after talking to his domestic Canadian counterparts. These findings mirror those of this thesis, in that there was a wide range of support for the standard for similar reasons.

4.1.4 The standard must sufficiently align with existing regulations, standards, and best practices

Key findings suggest that aligning the standard with the existing suite of related regulations and best practices is integral to the standard's success. Respondents stated that consideration of the standard's fit with regulations for emissions reporting to provincial and federal government, and for regulations such as the LCFS and FQD, is required. As well, knowledge of fit with the relevant ISO standards (the ISO 14040 series, ISO 14025, and ISO 14067) was seen as mandatory. Familiarity with common supporting tools for LCA practitioners was said to be necessary, such as the WRI and WBCSD standards developed as GHG protocols for inventories and projects. Challenges in this area were predicted to lead to an inappropriate standard that has no uptake at the domestic or international level.

Interviewees noted a number of actions that they believed would be beneficial for government to take to mitigate issues facing LCA in the oil sands, which speak to the necessary support system for this standard. These included streamlining regulations, both within provincial government departments and between federal and provincial governments, to improve data quality and promote consensus on bins and models to be used in LCA. Industry called for government to communicate the high data quality and transparency of Alberta industry internationally and take actions to promote improvement in data availability and transparency in other jurisdictions. Other roles of government were seen as developing ways to incentivize good actors and penalize poor actors without being overly restrictive, and in enabling mechanisms that promote technology development. Multiple interviewees noted that continued government focus on the oil sands is doubtful but must be sustained if the industry is to prosper.

4.1.4.1 Potential Form

A wide variety of forms and uses of the standard were envisioned, particularly with respect to its interaction with regulation. From synthesizing recommendations across interviewees, there is a general consensus that a useful standard would delineate methods and data quality requirements for practitioners, create definitions for different products along the crude oil production chain, and describe what to do along each step of production. The standard was expected to provide transparency in LCA studies by guiding their development through a known method and by using agreed-upon data sources for each stage of an LCA for crude oil.

It was understood by multiple LCA practitioners interviewed that a CSA PCR for crude oil would be designed to provide guidance for LCA practitioners when conducting LCAs to calculate the GHG emissions of crude oil. This would specify what had to be collected and how emissions were to be calculated, such as for "grid-average" electricity for allocation. As the proposed standard would be for full WTW LCAs, a government interviewee believed that standards for conducting the LCA must be set for each of the steps within the value chain. It was envisioned that a company would submit a completed template, based on the PCR, to the CSA, as the PCR Program Operator. Other LCA practitioners, who were unfamiliar with the proposed standard but still spoke to its potential form, suggested it should define the procedure of applying LCA to a product as well as the way to properly use those results such that they are compared fairly in some sort of structured system. An expert in ISO LCA standards noted that it would be logical to use the ISO 14040 series and ISO 14067 as a backbone to develop the standard. Quality assurance and verification were deemed necessary to ensure confidence in claims, where another believed that a neutral third party would have to be tasked with regrouping and analyzing information to ensure confidence in claims.

A number of expected benefits were noted. A member of IHS CERA stated that the standard would be useful for providing consistency and a more precise breakdown of emissions sources. Other perceived benefits from non-practitioners were for reporting and grouping emissions and for more clearly identifying the different market products such as dilbit, bitumen, and SCO. One industry LCA practitioner believed it would be useful if it helped to change inaccurate perceptions of the oil sands, in promoting unbiased data to importers and helping to show that Canada’s oil sands performance is significantly improving. An academic LCA practitioner saw it as being helpful in standardizing communication with the public, and another from industry saw similar benefits through its use for sustainability reporting. Other benefits in promoting better communication and understanding through the standard were seen in terms of sharing information so people can better understand the difference in numbers resulting from LCA studies, and for the creation of meaningful comparative claims.

4.1.4.2 Use with Regulations

Thirteen respondents viewed the standard's effectiveness as being dependent upon interaction with regulations. Respondents indicated that an effective standard could be used to support regulations, and would require some degree of government support. There was a lot of discussion over the prescriptiveness of a standard of this type, particularly over whether it should be mandatory or voluntary and how it would interact with regulation. Industry and government interviewees were more confident than academics interviewed that a purely voluntary standard would be seen as credible in that it would work the same way as regulation if properly crafted.

For a number of academic interviewees, the standard was seen as something that could begin as a voluntary standard and then become more regulated or prescriptive over time. Two academic LCA practitioners noted that the standard could be a useful starting place to begin having standardization discussions regarding LCA for crude oil, which was echoed by another from industry. Once set, however, these academics believed that it should be transitioned to a mandatory standard. A number of ways to accomplish this were mentioned. One academic interviewee stated that the optimal standard would be one that could either (1) help to achieve policy goals or (2) have its degree of prescriptiveness or pace of development increased through legislation if needed. An academic LCA practitioner with involvement in LCA-based policies suggested a mechanism by which the standard could be voluntary if used domestically, such as for market access of Alberta's heavy crudes to British Columbia in support of the province's LCFS. Then, for export to markets governed by regulations such as the LCFS or the FQD, the standard could be mandatory in order to support claims, providing regulatory and economic benefits.

Contrastingly, two industry members with experience in formal voluntary standards indicated that they would prefer a voluntary standard to a regulation, and that it could be quite effective. One of these was heavily involved with the Cumulative Environmental Management Association's (CEMA's) Water Management Framework for the Athabasca River. As a voluntary standard, the Framework was developed through a multi-stakeholder process of approximately fifty members to improve the submission of data for water withdrawals from the river by the surrounding oil and gas industry. Parties involved included fifteen companies that were a part of CEMA, First Nations communities, Metis groups, select environmental groups, and government representatives. The framework was accepted by government, and complying companies reported to government yearly, although this was not required by law. While the interviewee perceived the standard as being followed quite closely by the industry, the standard is being revised to become part of the Government of Alberta's Lower Athabasca Regional Plan (LARP) due to perceptions by certain stakeholders (notably certain groups who were excluded from the initial development process) that its voluntary nature was not appropriate. The respondent indicated that the standard might have remained effective in its voluntary form had these stakeholders been involved in its development, which highlights the importance of the voluntary standards setting process on the outcome and effectiveness of resulting standards. Two interviewees mentioned nuclear safety standards, where one elaborated that voluntary standards for the nuclear industry were developed in 1981 before being adopted by NRCan, after which they were widely used and successful in using a process of iteration and re-evaluation.

An interviewee from CEPA, with expertise on voluntary standards, suggested a successful standard that incentivized performance improvements could be voluntary as well. They saw successful voluntary standards as being governed by effective systems that can enhance performance over time in the same way that improved regulations are capable of doing, by encompassing learning and feedback. However, they believed that this standard could not be set as a minimum if it was to be effective. If this could be achieved, the standard was seen as being preferable to a regulatory standard, which was expected to be set at a minimum such that it would be implementable by all industry actors. A clear voluntary standard, which could also be referred to as a guidance note or best practice, was predicted by this interviewee to achieve credibility with stakeholders and to improve performance by providing the ability to compare between companies and improve transparency. This was also supported by the interviewee involved in LARP, who saw benefits in the creation of standards that incentivize good performance, and by a government interviewee who believed that the effectiveness of a standard is not dependent upon whether it is in a regulation or is a voluntary mechanism. Contrastingly, an industry LCA practitioner believed that the standard could be ineffective if it goes beyond setting guidelines for conducting LCA to become too specific or prescriptive. It is notable that the pipeline sector, through CEPA Integrity First, was said to be advancing "industry practices," as voluntary standards, to capitalize on the experiences from practices across companies. Such a standard would "confirm an outline of appropriate practice that can be then used in a 'fit-for-purpose' manner for the industry."

Influence in multiple directions between the proposed standard and regulation were noted with respect to its effectiveness. Four respondents saw it as being necessary that the standard not be completely voluntary if it were to be used in support of regulatory processes. An academic who had worked on provincial and federal environmental review panels believed that if the standard was not enforced by any legislation it would not gain sufficient interest. An industry LCA practitioner believed that government support was required for a successful standard, and another respondent with involvement with government replied that, even if the standard was perfectly designed, it would be "useless" if regulations do not properly uphold it.

In contrast, a number of industry interviewees predicted that issues would arise if the standard were to be adopted by government. An expert on the standards setting process stated that government involvement should be as a stakeholder in the process rather than driving toward a particular policy-related outcome, while another from industry believed that government and regulatory representatives would likely be on the standard committee. Another questioned whether this standard could be associated closely with emissions reporting regulations above a certain threshold, such as for Alberta's Specified Gas Emitters Program, and believed that governments should continue to focus on cumulative effects and promoting improved technical systems with lower GHG emissions. One industry interviewee, from IHS CERA, believed that the standard could not be directly adopted to support either the Specified Gas Emitters Regulation or the NPRI. It was predicted to be ineffective in helping these entities to meet their policy goals, as they were created to support policy rather than for enabling comparison across different crudes via a comparable data set. A member of CEPA identified a risk of tension developing between regulatory action and those pursuing a voluntary standard, particularly one which drives performance improvement and that was developed by collaboration of the whole industry. They predicted that issues would arise for the industry if the standard was adopted as a performance requirement prematurely, which was believed to undermine companies' ability to innovate around this recent standard and minimize performance improvements in the long term.

4.1.4.3 Standard Fit, Compatibility, and Harmonization

Interviewees placed importance on the standard's alignment across companies, its compatibility with current and emerging regulations, awareness of and fit with existing measurement tools, and its situation and harmonization with supporting standards at the national and international levels.

Knowledge of other standard endeavors and contextualization was seen as important. Multiple interviewees from industry stressed the importance of the CSA being fully informed with respect to other resources available, which one standards expert specified as being consideration to (1) how these have been developed, (2) where this proposed standard will fit, and (3) the importance of considering alignment with other activities surrounding the oil sands. ISO, with a mandate of providing harmonization to promote trade, was said to use this process in beginning by identifying the reason and need for an international standard. This was said to be typically either the presence of competing standards that cause problems for trade or a clear demand for the standard internationally. These findings indicate that an unawareness of the CSA to complementary tools and best practices used by the LCA community may contribute to the inadequate consideration of how a CSA PCR can be harmonized with these. However, it was the experience of one interviewee that the CSA developers are "intimately familiar with other major international standards," and that they "try to align these as much as possible."

Three standards or standards series were said to be important to consider in the standard's development. These reflect what one saw as the necessity for the standard to be considered at the international level with respect to multiple stakeholders. The first of these are standards from the WRI and WBCSD, which were viewed positively by two industry experts on the standards setting process. These standards were developed as initial GHG Protocols for inventories and projects, and provided guidance when ISO was developing ISO 14064, for the specification and guidance for quantification and reporting of GHG emissions and removals. Said to be developed through a more self-prescribed process than ISO standards, they were seen as being effective in engaging LCA practitioners and are viewed across North America as being a useful compliment to ISO standards by providing more detailed method guidance to ISO's recommendations and auditing requirements. The second of these standards to consider is the Climate Change Reporting Framework for integrated reporting from the International Integrated Reporting Council (IIRC). This system of standards was seen as being effective in its frequent modification and as being well-supported by financial and non-financial resources by large organizations who want the system to be well-implemented.

The final standard series whose consideration was necessary was the ISO 14000 series, particularly the ISO 14040 series and ISO 14067. These were not viewed as positively as the latter two standards series, due to disagreement over their usefulness and perceived inadequacies in the transparency of the standards setting process. One academic LCA practitioner noted disagreement within the academic community as to the best way to apply standards in the ISO 14040 series, and agreed with another academic practitioner that when put into practice they do not necessarily result in achieving comparable results between studies. The failure of ISO 14067 for carbon footprint verification was spoken to by two interviewees who had participated in its development process. One of these, an industry LCA practitioner, suggested that that this failure represents the loss of a framework that would benefit the development and international agreement or compatibility of a CSA PCR. This was said to create the risk that, if a PCR for crude oil were developed, it would have to be "reinvented" and could result in "inconsistency" due to the hierarchies and associated level of detail build into the ISO 14000 series. Predicted issues were noted by two interviewees if the standard is moved to the international level, as (1) a potential lack of country representation due to inability for countries such as India, Russia, and China to have adequate resources for participation, and (2) its potential failure given how India and China "vehemently opposed" ISO 14067 for fear that the standard would be used to promote barriers to trade. The concerns of these countries regarding trade barriers were seen as valid by the interviewee who mentioned it.

The “innovativeness” of the proposed standard was mentioned by three interviewees with respect to its similarities and differences with existing standards used for LCA in the industry. Two industry interviewees believed that difficulties would be created if the standard was to be brand new and unrelated to other methods, where an interviewee from CEPA elaborated that the “degree to which [the proposed standard] is comparable to like standards is very important for simplicity and clarify.” They believed that standard should be harmonized to be as comparable as possible with standards in other jurisdictions for reporting of GHG emissions, for the end-purpose of all reporting was seen as some variant of tracking, benchmarking, and comparison. Another member of industry with expertise with GHG standards believed that the standard will require a mitigation management standard to support its ultimate purpose of reducing emissions, and that the orchestration of this system of standards would be challenging. One industry LCA practitioner mentioned that CAPP had considered existing reporting protocols quite effectively in the development of their own reporting methods for producers to comply with, and that the alignment of this standard with existing protocols should be considered much in the same way.

Many spoke to the requirement of aligning the standard with government methods and priorities. It was said that the standard must be associated with existing work, such as how calculating is done for reporting purposes. This was mentioned by multiple interviewees such that the standard did not provide unreasonable administrative burden in the resources needed by industry to comply with it, given existing reporting requirements to different levels of government. Considering regulatory fit in standard development was said to be potentially challenged by changes and shifts in regulations, which create an uncertain future regulatory environment. Three interviewees, two of whom were involved in environmental regulations, questioned how the standard would fit with regulation, given emerging changes to environmental oversight for the industry. The standard was seen as being potentially at odds with Alberta's new monitoring agency, described by one academic as being "custom built to serve the particular needs of the problem at hand," whereas the CSA is "part of a different structure of power and authority."

4.1.5 The process of developing this standard must be viewed as being credible and transparent

The credibility of the proposed standard was said to be instilled by its institution, and dependent upon its development process. It was found that the credibility of the standards setting institution is integral to the success of the standard, in terms of its content, uptake, and effectiveness. Interviewees across sectors stressed that the process must be transparent and multi-stakeholder, and be open to public scrutiny. Findings indicate that relevant stakeholders must be (1) engaged early on in the development process, and (2) adequately represented through committee composition. As well, an awareness of the vested interests of participants must exist.

4.1.5.1 Internal stakeholders and committees

Interviewees predicted that the wide range of stakeholder groups and variety of interests present with those associated with the oil sands will make creating a neutral standard difficult, and outcomes will be influenced by whose views are represented during decision-making. The aptitude of the standard development chairs and facilitators was noted by two respondents as an integral part of a successful process. Their role was seen as being difficult due to the need to push the standards through a short time-frame, moderating dialogue and debate, and "crystalizing the essence of what was needed."

Interviewees acknowledged the presences of biases and vested interests within committees. This was predicted to be particularly prominent in the case of the oil sands, where it was said that a number of groups have “clear biases and perspectives” that will create challenges for developing a standard through a multi-stakeholder process that is perceived as being fair. Four interviewees noted that some degree of bias in the members of these committees is unavoidable, with one elaborating that stakeholders’ “built-in biases and assumptions” make presenting data openly, transparently, and impartially difficult even with the best intentions. Interviewees also spoke to different actions that will be taken by participants who see themselves as either benefiting from or being harmed by the standard. Actions taken in self-interest were said to be recognized by committee members and chairs, and acceptable so long as a participant is not exclusionary, such as a technology vendor attempting to promote their own technology while diminishing the possibility for others to be part of the standard. One standards expert noted that it is important to have a few members of a committee who are not necessarily associated with any sort of interest group, such as certain subject matter experts.

An unbalanced stakeholder representation or input during the standards setting process was the most commonly-noted problem with stakeholders and committees. Participants saw the potential for the committee composition to have an overrepresentation of interests for certain stakeholders, which may unduly influence the standard. This was noted as being likely for a CSA PCR for crude oil especially, as the standard relates to market access and, as part of the wider area of GHG measurement, a wide range of actors and stakeholders were said to exist and to have vested interests in the standard’s outcome. These interests were said to arise either because certain groups will be applying the standard themselves, such as a government or regulators, or will be examining the outcome of the standard being in place, such as for NGOs or international watchdogs. A separate industry interviewee felt that it was important for the government to be involved indirectly as a stakeholder rather than driving the standard toward a particular policy outcome. Value was seen in having stakeholders from appropriate sectors represented, such as from industry and the environmental community, which are likely to have differing views. However, one interviewee stated that NGOs may feel coerced into participating, and others spoke to the high resource commitments required for participation.

Four interviewees discussed the influence of challenges of disclosure and proprietary information facing committee transparency. These issues were predicted to arise due to concerns over confidentiality. Two industry interviewees saw it as inevitable that companies will closely protect their information on emissions and emerging technologies due to comprehensive NDAs. Another two with familiarity of the standards setting process spoke to confidentiality issues as well, with one acknowledging that some companies may be "particularly reluctant" to share all the information required for the development of a standard for LCA given the financial nature of GHG emissions. An academic LCA practitioner stating that the political nature of LCA will challenge openness and collaboration suggested this as well.

These challenges with a balanced and transparent committee were predicted to feed into issues regarding scientific consensus on LCA methodologies and data quality requirements. In many interviews, it was predicted that such consensus will be challenging given the site-specific nature of GHGs, competition, proprietary information, and perceived fragmentation between sectors. An expert in LCA standards stated that requirements in the standard must be supported by sound science, echoed by a government interviewee who believed that a "common science and fact-based knowledge" should be combined to overcome challenges facing consensus in the process. It was predicted that the question of the technical achievability of this kind of measurement, given the tools available today, will be challenging, and plagued by defensiveness and "value judgments" given the site-specific nature of GHGs and the perceived certainty that some actors would be benefited and others penalized when being judged by the same standard. Cooperation between different actors and groups, seen by one government respondent as being critical to agreeing on a common scientific view, was described as facing challenges from what they saw as the extreme fragmentation of Canada's innovation system. They perceived the current fragmentation of industry, government, and academia as resulting in the use of "different parameters, language, and yardsticks," which complicate decisions over which sources of information to trust. If the standard was moved to be developed internationally, predicted issues in this area were the inadequate validation of subject matter experts from other countries and differences in scientific bases for understanding LCA between Arabic or Islamic science and Western science. As well, it was noted that the ISO process, while it claims to be scientific and policy neutral, is affected by political interests to a great extent, particularly for standards that have an immediate or direct financial benefit.

4.1.5.2 Goal, Scope, and Definitions

Reaching a consensus or setting the standard's (1) purpose, goals or objective, (2) scope or boundary, (3) language, and (4) clarifying assumptions at the beginning of development was found to be integral to an effective standards setting process, enabling for a common understanding and starting point for all participants. Doing so was presented by participants as part of addressing committee members' different expectations, understandings, experiences, ideologies, and philosophies, as well as a way to create consistency between committee rounds in reassuring members of the intent of the standard, especially with respect to its prescriptiveness. One expert on setting LCA standards explained that methods of consensus on goals and scope development are "critical" to the standard's credibility, both to those involved and external stakeholders, and its boundary must be "correct and appropriate." Another industry member with experience in standards setting noted that doing so correctly was "extremely important," particularly in identifying and communicating the degree of divergence of the standard from what already exists. One interviewee spoke from experience with managing the Canadian Raw Materials Database to develop a method for measuring the life cycle impacts of various materials. Here, a balance had to be struck between the innovativeness of the method and its degree of independence from existing approaches for it to be perceived as credible. As well, a separate standards expert stated that identifying and communicating the type of standard upfront and early on in the development process will be beneficial for stakeholders. It was said that setting the purpose of the standard may increase participation at an early stage, particularly if the standard is to be used for legislation. Standardizing language to be used in the process is also seen as important, where one standards expert stated that setting definitions is laying the "foundation from which everything else had to flow," such that if definitions were not correct, "there would be a general weakness in the whole system."

A number of difficulties in defining the standard and its terms were expected by interviewees, based on past experience with standards development. Many of these were mentioned by members of industry who had participated in committees. An interviewee from CAPP noted that it would be easy to "bog down" conversations with discussions about the goal of the standard, such as about calculation methods or benchmarks. This was supported across other interviews, as participants frequently questioned the type and goal of the standard before elaborating on answers. Regarding the standardization of language, an interviewee from CEPA spoke of their experience on standards committees and the "endless difficulty" to work clause by clause to ensure language is exceedingly clear and unambiguous. One standards expert believed that setting the scope will be challenging due to the interrelatedness of GHGs with other issues facing Alberta's oil sands. Other challenges were predicted by a member of industry due to the uncertainties of committee members as to their own beliefs and what they seek to achieve with the standard. Despite best efforts in the standardizing process, it was noted that issues regarding the standard's boundary may still arise. This was said to have occurred for CSA Z741, which assumed an acceptance of commercial development and deployment of CCS, beginning with a premise that CCS works and is commercially available. Despite this, unanticipated contextual issues were said to have arisen midway through the standards setting process, on what boundary should be set for the standard with respect to fit with regulatory frameworks and liability.

4.1.5.3 External Stakeholder Scrutiny

Multiple interviewees mentioned that stakeholder scrutiny and controversy, from those external to the standards setting process, will be important to the content and success of the standard. It was agreed that this adds credibility to a good process and promotes more effort and attention to detail throughout development. This supports the previous finding that open LCA models and publicly-available data are central to the transparency of LCA studies. One of these groups was predicted to be other energy carriers competing with the oil sands, who are expected to scrutinize the process to find holes and whose inspection will require that the process be carefully conducted. Another interviewee noted that the public is also capable of shooting holes through the standard or taking it out of context, particularly if there is not a strong understanding of why something is done or what it is to be used for. The standard's credibility was said to be benefitted by its development through an open, transparent process, in combination with a period for public review and commenting before its finalization. For one academic interviewed, education on voluntary standards was said to be particularly important for the public, where supporting information should be given to contextualize the standard such that the public can then choose whether the numbers resulting from LCAs using the standard are credible. Ways to mitigate the degree of external controversy generated by a standard were also mentioned as gaining stakeholder buy-in through early engagement by one interviewee, and by adding credibility by approaching a wider set of stakeholders to test the standard by another.

4.1.5.4 Perceived Credibility of the CSA

The reputation of the CSA was also noted as being important in perceptions of the transparency of a process and a standard. The association was mentioned a few times specifically, although the questionnaire for industry and government interviewees had kept the standard hypothetical and removed from any particular SDO such as the CSA. The reputation of the organization was said by one interviewee to be dependent on whether the CSA is more widely viewed as an industry organization, or as a government organization that is at "arms-length" from industry. Findings indicate that the CSA and its process are generally viewed positively in comparison with ISO and other countries' SDOs. One academic LCA practitioner stated that the perception of the association as being removed from industry results in the CSA having more credibility that most SDOs. The CSA was seen by a standards expert as having the characteristics required for the difficult task of creating a standard that will be used in the oil sands, as the association is perceived as having a "historic, tested, multistakeholder, and independent" process.

Respondents indicated that, in SDOs, balanced committee representation may be challenged by inadequate resources, in terms of time and money, to secure continued commitment. Representation of organizations on committees at the CSA was viewed as somewhat more balanced in comparison to ISO, where the government funding of the CSA by the SCC allows the organization to be more inclusive of organizations with fewer resources to devote to the process by helping to offset costs of participation. However, there were a couple instances where the CSA was said to be perceived by potential stakeholders in ways that were not conducive to its credibility. As noted by two separate standards experts, the CSA was said to be often misperceived as not being involved in developing more technical standards, and that their GHG committee would be benefited by a greater membership. The latter of these was said to be due in part to the committee being comprised largely of volunteers, which can create challenges for developing standards that are intended to be the best practice within the marketplace due to the high resource demands and time constraints for those employed within industry to participate.

4.1.6 The standard must be able to be frequently, easily, and successfully revised, with adequate consideration to existing and future technologies

Standard revision, after the finalization of the standard, was spoken to by numerous interviewees, including both standards experts and those from industry. The standard assessment and revision process occurs at the CSA and at ISO a minimum of 5 years after a standard is finalized. There was agreement that good standards are able to be easily revised and changed in response to assessments that the standard requires modification or updating. As part of best practice, two interviewees stated that close attention to maintaining the quality of documents and moving the standard in parallel with business realities is necessary for a standard, particularly to balance competing objectives which can occur via more frequent meetings after the finalization of the standard. One industry respondent noted parallels between standards from SDOs and improved regulations, in terms of being increasingly embedded with effective management systems that allow for an iterative and interactive approach to regulating.

4.1.6.1 Technology

Standard revision was said to be particularly important with respect to technology interactions, such that the standard does not impede innovation or to have to be updated as new technologies emerge. This is particularly relevant for the oil sands industry, where respondents noted that the technology used in any particular project will have been chosen years, or even decades, before the project comes online. This creates a need for what one academic LCA practitioner described as the standard to be forward-looking and attune to the needs of industry. One standards expert stated that consideration must be given to revision prior to the five-year mark if the pace of innovation changes. This would be necessary if new emissions reduction technologies come to market, or even at the demonstration or pre-commercial phase, where technologies may be precluded from applying to the standard if the standard was not designed to accommodate them. Incorporation of these technologies is complicated by what one industry member saw as the need to better understand the process of identifying successful technologies, including their actual emissions savings, cost, and time to market. The potential inability to successfully consider the right technologies in the standard was predicted to result in the creation of technical barriers, where the standard could reduce market access and speed to market.

4.1.6.2 Revision Committee

Committee membership in the standard's review process post-development was found to be very important to ensuring its integrity is not compromised. This was stressed by two interviewees. In the revision process, one LCA standards expert noted that it may be difficult to maintain the same energy and participation from different stakeholder groups as there was when the standard was developed. They mentioned that it is important to "maintain a balanced matrix of interests," with high-quality experts, in this revision process. This was said to require historical knowledge of the standard and prolonged interest by industry and government. Engaging those who sat on mirror committees in voting on the standard's revision was also deemed to be important, as these people were said to have "historic knowledge" on its development, such as why certain things were made to be normative or otherwise. A lack of this background can lead to items being changed inappropriately, which was predicted to be especially likely if specific interests influence the review process. Efficiency of the process was also mentioned as being important, for when negotiations are drawn out committee members can be replaced and require more time to catch up, according to a member of industry who had been involved with development processes for standards related to LCA.

4.2 Comparison with Hypotheses

The following presents the comparisons of interview findings with hypotheses developed in the literature review of this thesis to situate the case of a CSA PCR for crude oil in standards literature. The extent to which key findings corresponded to hypotheses is noted, and any instances where findings are different than were predicted are briefly discussed.

4.2.1 Credibility

Findings support hypotheses on credibility in most instances, in that the requirements for credibility for a CSA PCR fit those predicted in literature and that the CSA, as the institution at which it would be developed, can instil this credibility. Due to the scrutiny of the oil sands industry, a CSA PCR must meet the needs of industry stakeholders by meeting the requirements of the markets and the public for credibility, which the CSA is seen as being capable of providing.

Through the CSA, the standard would have a period where it is open for review and scrutiny, which was predicted to contribute to its credibility, as was the transparency of its development process. While the degree of transparency of committee members will be questionable, given the proprietary nature of information on emissions, the CSA was viewed as being capable of preventing a biased outcome by balancing the representation of relevant stakeholder groups throughout decision-making. The organization was also viewed as being aware and able to intervene accordingly when vested interests threaten to negate these efforts to establish balance and fairness in the process, which findings predict will be likely given the nature of this PCR. Importantly, difficulties with achieving scientific consensus under expected conditions in the development of this standard may limit its legitimacy, where findings agreed with predictions that such an outcome would have limited use and may be detrimental to the oil sands industry.

4.2.2 Consensus on LCA

Challenges facing scientific consensus in LCA for crude oil will complicate the development of a CSA PCR. Hypotheses regarding consensus on LCA methodologies were supported by interview findings to a large extent. Findings cut across discussion of issues according to LCA phases, identifying trade-offs between data availability, reliability and transparency that coincided with different approaches to allocation. In agreement with hypotheses, boundary selection was found to be integral to the comparability of LCA studies, although this was not elaborated upon in comparison with more contentious issues of allocation, data, and uncertainty. Determining allocation method for stages of extraction to transport and for refining in the standard is likely to be much more contentious, as widespread disagreement as to the best approach was found between informed LCA practitioners. This supports interview findings on the difficulties facing the standard due to the complexity created by site and refinery differences. Flaws in accuracy and transparency for both allocation and system boundary expansion approaches were said to be influenced by practitioner choice, supporting the hypothesis that the allocation problem can lead to inappropriate studies for decision-making. A major finding not predicted by hypotheses was the perpetuation of poor decisions toward allocation due to the multiple ways allocation can be chosen based on the interpretation of policy, supported by an inability for LCA to capture many of the alternative compliances and improvements of producers recognized by certain regulatory regimes.

Findings supported hypotheses regarding data, in that LCA practitioners external to a company or firm experienced challenges in obtaining high-quality proprietary data for Alberta's oil sands. Primary data in public government databases was not seen as being the most desirable, demonstrated by the low usability for very complex SAGD data without hiring private help to aide in interpretation, as well as in the uncertain accuracy of data from EIAs when used for LCA. Land-use data, important for calculating emissions from bitumen extracted via mining, was additionally quite uncertain, as findings from literature predicted. Differences in opinion regarding published land-use values in academia were compounded by a lack of transparency in the calculation of land-use in sustainability reports. One novel finding is that the use of emissions values in sustainability reports is complicated by biases created in differences in calculation and contextualization of the data. As well, contrary to the prediction that data issues would be much greater than those of technical uniqueness, findings indicated that a central issue in the comparability of LCAs and the development of a PCR will be how site-specific technologies are considered, as these influence approaches toward allocation. Emerging technologies or the presence of previous studies based on proprietary data will not only make boundary selection more challenging, as hypotheses predicted, but will also influence approaches toward allocation and the transparency of the resulting study as a whole.

Contrary to the prediction that LCA could be a useful input into the decision-making process for comparisons between products, findings suggest that LCA should not be used in its current state of development, or whatsoever, due to its subjectivity and uncertainty. This does support the perception that policies based on LCAs have inadequately considered uncertainty, going farther to stress the importance of both transparency and accuracy if LCAs are to be used for regulatory purposes, as well as the necessity for those using LCA studies to be aware of their limitations for use in decision-making. Another notable finding is the lack of standardization surrounding key terminologies related to LCA, which will create challenges in the development of a CSA PCR for crude oil. These challenges are likely to be exacerbated by the disjointedness of policy and technical terms for the oil sands noted in literature, particularly with respect to the interview finding that setting definitions is central to beginning a productive and efficient standard development process.

4.2.3 Industry and Government Support

The most fundamental issue going forward in the development a CSA PCR will be stakeholder engagement, particularly in terms of gaining the interest of industry, and maintaining this interest throughout the entire development process. Industry support of the standard was predicted by the hypotheses in most areas. Alternatives to a CSA PCR for crude oil, as *de facto* or government standards, do not appear to be a viable alternative to the standard in terms of offering greater perceived benefits to collaborating in standards development. Findings supported the prediction that the solution to enhancing credibility of emissions claims in Alberta's oil sands must be one that allows for greater openness and transparency than current initiatives or any alternative solution. This solution was also seen as one that must also allow government and industry stakeholders to respond effectively to public scrutiny. It is evident that public, market, and regulatory pressure from importing jurisdictions may create a motivation toward a standard solution through a CSA PCR, and that collaboration toward a *de facto* or regulatory standard with the same goal is lacking due to a perceived lack of proactivity on behalf of government and industry. Initiatives to date to collaborate to improve the credibility of the industry's GHG emissions have not been sufficient, and efforts are said to be fragmented and isolated, although the few recent developments by industry alliances are viewed positively. Stakeholders interviewed called for planning, clarity, strategy, and foresight on behalf of government and industry toward a common standard, who must collaborate to develop a standard and effective tools to improve the market situation for the oil sands. Findings also supported predictions that industry would be involved in the standard if their participation served to further their strategic interests, and that industry will continue to engage in the development process so long as it remains efficient. Contrary to what was expected, government was desired to be either involved in the development process or to support the standard to enhance its desirability for industry and its perceived credibility, rather than remaining at a distance due to the creation of additional bureaucracy and time delays that literature suggested government involvement may create.

4.2.4 Harmonization and Alignment

Hypotheses on the requirements for and effects of adequate harmonization and alignment of a CSA PCR for crude oil were supported by findings to a great extent. The potential standard is viewed as a useful tool to support international market strategies, by both industry and government, although its potential to reduce administrative burden on regulators was not widely noted. Benefits were predicted in harmonizing the methods by which GHG emissions values are calculated and submitted across Alberta's oil sands industry, due to current methods being different from differences in sites and company databases. Importantly, certain worries were expressed with the standard not adequately aligning with international policies, although overall it was viewed as a useful starting point to begin discussions and to eventually drive international change, either in the form of regulatory change or through the formation of a related ISO standard to which Canadian industry could readily adhere.

Hypotheses were also supported in that the use of relevant ISO standards to develop a CSA PCR was deemed to be useful, while the need for government to support and communicate the standard was seen as mandatory despite concerns over whether the Canadian Government would maintain a prolonged interest in the oil sands. Notably, in support of predictions from literature that an uncertain regulatory environment would complicate successful standard development, the findings stressed that the standard must be able to anticipate emerging regulatory changes governing the jurisdictions to which it would apply. Again, this speaks to the necessity of the standard to be easily revisable and questions over whether a national or international standard would be best. Another important finding was the disagreement between industry and academia over whether the standard would be best to gradually become more prescriptive and adopted into regulation, and this divide was not predicted in literature.

4.2.5 Technology Considerations in Revisions

Varying from the hypothesis regarding the importance of considering installed bases, technical change and the consideration of technologies were spoken to primarily in terms of subsequent PCR versions rather than in its initial development. However, findings were aligned with predictions on the importance of awareness of motivations of technology vendors in this process, and that this can be detrimental in terms of limiting the flexibility of major users of the standard as well as long-term technological change. Regarding the common benefits to stakeholders from sharing information only if there is agreement on the desired path, findings are insufficient to indicate whether or not this would be the case for a CSA PCR. What is evident is that there will likely be marked disagreement between committee members in the standard's development, in areas from allocation method to data sufficiency, as well as a hesitancy or refusal to disclose certain confidential information.

4.2.6 Revision Process and Committee

Important factors in the re-evaluation and revision of a CSA PCR for crude oil were predicted by interviewees. Findings on the revision process and committee members were much richer than information gathered from literature in the area. There was agreement with the prediction that prolonged stakeholder engagement in this revision process is necessary and will be aided by an efficient process. In addition to this, novel findings are the benefits that can accrue in having committee members with historical knowledge of the standard involved during its revision, and the increased potential for the standard to become biased in its revision due to a potential lack of interest from many parties. As well, tremendous importance was placed on the need for the standard to be easily revised in accordance with emerging technologies, new information, and changing contexts in which the standard is deployed, as well as for the ability for a wide range of stakeholders to call for these updates.

Chapter 5: Conclusions

5.1 Main Findings

A successful CSA PCR for crude oil would enhance the comparability across LCA studies for products derived from crude oil, while allowing for a high degree of accuracy in those studies. Central to gauging the potential of this standard is the ability for scientific consensus on LCA to be achieved in a way that is perceived as credible, complicated by the current dichotomy between achieving maximum transparency and accuracy in LCA. The following are the conclusions of this thesis, according to the three research questions posed.

1. **What are the current issues facing the oil sands industry in Alberta with respect to standardization of data, governance, and communication?**

The multiple issues facing Alberta's oil sands with respect to standardization of data, governance, and communication are multiple and interconnected, and will challenge the successful development of such a standard. Challenges facing consensus on LCA methods and data quality requirements are at the centre of widespread lack of support for the use of LCA in policies based on LCA which govern trade. There exists widespread disagreement between LCA practitioners as to the optimal approaches in LCA, which may greatly influence study outcomes.

The greatest issues affecting the oil sands in these areas were also found to be the most influential in the standards setting process, as comparison between LCAs depends on consensus among practitioners. Taken together, these issues are seen as perpetuating a fundamental lack of understanding in a wide variety of stakeholders, and an ensuing lack of trust in the oil sands and formal voluntary standards. Transparency is conducive to credibility in both LCA and the standards setting process, which is challenging for both given the proprietary nature of emissions data and industry competition. The Government of Alberta faces issues between transparency and accuracy in communicating to jurisdictions governed by LCA-based policies, experiencing trade-offs between the reduced transparency and increased accuracy of using proprietary data and more nuanced refining models.

2. **To what extent might a CSA PCR for crude oil help to mitigate these issues, given alternatives of regulations or industry standards?**

A CSA PCR for crude oil would be a positive starting place to begin to address these issues, albeit indirectly and partially. Government and industry are not seen as having sufficiently mobilized or collaborated to provide a viable alternative to such a standard. It is unclear as to whether the standard, once developed, would continue to be effective in its voluntary form. Serious industry concerns exist that such a standard may continue to entrench LCA in policies that set the precedent for environmental governance, and that, as a national standard, it may promote trade barriers rather than help to alleviate them. Predicted issues with achieving scientific consensus on LCA may complicate the development of an ISO PCR for crude oil at the international level, and the recent failure of ISO 14067 for calculating the carbon footprint of products may foreshadow a similar international failure. Thus, such a standard may not be able to give Alberta’s oil sands industry the international credibility in GHG emissions calculations it requires to improve access to international markets.

3. Given anticipated issues in the development of such a standard, how would this standard be most effectively developed?

A CSA PCR would be most effectively developed by establishing early and sufficient stakeholder engagement, engaging in education and outreach activities, establishing a transparent and credible process, and anticipating the standard's future revision. The effects of existing incentives and penalties for different actors who feel they have something to gain or lose by providing information, which influence both the accuracy of LCAs and the content of a potential CSA PCR, are likely to be exacerbated if negotiations continue at the international level.

For this standard to be successful, it must exhibit many of the same characteristics desired in the emerging environmental governance of the oil sands. The standard must be (1) *credible*, as free of bias, based on scientific knowledge, and legitimate (2) *transparent*, as developed through an open process, with balanced committee membership, and able to be used with public databases, (3) *relevant*, through the engagement of stakeholders, timely development, usefulness for product comparisons, and alignment with existing databases and regulations and goals, and (4) able to be *revised* to reflect emerging knowledge. The transparency of the standard, of the data collected through it, and of LCA created based on it are associated with the credibility of final emissions numbers, and the ability for externals to scrutinize both the standard and the LCA process increases credibility. To be credible and to gather industry interest, the standard must be supported by government, and there is support for it to be used as regulation so long as it doesn't further penalize industry under existing policies which govern markets by using LCA.

5.2 Author's Opinion

After considering the findings of this thesis, it is the opinon of the author that a CSA PCR standard has the potential to create more meaningful comparative assertions for GHG emissions of crude oil products. However, its successful development will be challenged by a wide range of divergent stakeholder interests, which may create an inefficient and lengthy development process if it is pursued. These issues will be compounded by the high degree of technical and logistical complexity of accounting for different refining characteristics of products and refinery configurations. It is inevitable that stakeholders involved in the process will do so in self-interest. Given the high stakes and proprietary nature of data used in LCA for GHG emissions, this process may become unbalanced despite the best efforts of those moderating the process at the CSA, which would result in a biased standard. This standard may nevertheless be perceived as being credible despite these issues, given the reputation of the CSA and the perception of many actors that such standards are scientifically neutral. However, its political influences would be seen in its deployment, as certain members of industry would be benefited and others hindered. Additionally, the concerns of interviewees that the standard would eventually be used as a performance standard to create emissions reductions goals appear to be valid, and the environmental benefits of attempting to impose reduction requirements with such a standard appear to be minimal. In the author's opinion, the uncertainty surrounding regulations with which the standard would have to be harmonized is one of the largest barriers to its successful development, due to the industry hesitancy this creates and the high potential for any changes to these regulations to make the standard irrelevant. Despite these potential issues, a CSA PCR for crude oil may offer significant benefits to government and industry if these predicted issues in its development can be mitigated, and as such its potential should be further explored.

5.3 Suggestions for Further Research

A number of areas for further research emerged in the development of this thesis. Further examination of the potential for a CSA PCR for crude oil will require consideration of the potential role of particular technologies in the standard and policy responses to the initiative. With respect to the literature on standards, investigating technological choice and committee dynamics in the revision of standards will help to better understand and predict the requirements for maintaining credibility in this process. This is particularly necessary in cases where the industry that will be using the standard faces considerable uncertainty in terms of regulatory and technological change, where the standard affects a large number of stakeholders with divergent interests, and where stakes are high and information closely guarded. As well, the use of voluntary standards or PCR to support regulations based on LCA has not been widely studied, particularly with respect to policies governing crude oil markets. Further examination of the use of such standards, or series of standards in certification schemes, for alternative GHG emissions calculations in policies such as the European Commission's FQD would help to shed light on the strategic use of standards based on LCA to support political motivations. Finally, while this thesis examined a case study of a single potential standard, a cross-case analysis of the potential CSA PCR with the developed CSA Z741 standard would provide further insight into issues facing standards development, highlighting similarities and differences by juxtaposing two unique standards with similar contexts within the Canadian energy industry.

References

Agranoff, R., & Radin, B. A. (1991). The comparative case study approach in public administration. In M. David (Ed.), *Case study research* (Vol. 3, pp. 109-134). London: Sage Publications.

AEMP. (2011). *A world class environmental monitoring, evaluation, and reporting system for Alberta.* Edmonton, AB: Alberta Environmental Monitoring Panel.

Alberta Government. (2012, 17 October). Alberta to establish arm's-length environmental monitoring agency. Retrieved 28 February, 2013, from http://alberta.ca/acn/201210/33115701C6E68-EBBC-DF50-F7CCA9C17B88AC98.html

Ayres, R. U. (1995). Life cycle analysis: A critique. *Resources, Conservation and Recycling, 14*(3–4), 199-223. doi: http://dx.doi.org/10.1016/0921-3449(95)00017-D

Barbour, A. K. (1995). Process environmental audits and the proposed British standard on environmental management systems. In R. Hawkins, R. Mansell & J. Skea (Eds.), *Standards, innovation and competitiveness* (pp. 75-85). Brookfield, US: Edward Elgar.

Baumann, H., & Tillman, A.-M. (2004). *The hitch hiker's guide to LCA: An orientation in life cycle assessment methodology and application.* Lund, Sweden: Studentliteratur.

Baumol, W. J., & Oates, W. E. (1971). The use of standards and prices for protection of the environment. *The Swedish Journal of Economics, 73*(1), 42-54.

Blind, K., Gauch, S., & Hawkins, R. (2010). How stakeholders view the impacts of international ICT standards. *Telecommunications Policy, 34*(3), 162-174. doi: 10.1016/j.telpol.2009.11.016

Blind, K. (2004). The economics of standards: Theory, evidence, policy. Cheltenham, UK and Northhampton, MA, USA: Edward Elgar.

Botzem, S., & Dobusch, L. (2012). Standardization cycles: A process perspective on the formation and diffusion of transnational standards. *Organization Studies*, *33*(5-6), 737-762. doi: 10.1177/0170840612443626

Brandt, A. R. (2011). *Upstream greenhouse gas (GHG) emissions from Canadian oil sands as a feedstock for European refineries.* Stanford, CA: Department of Energy Resources Engineering, Stanford University.

Brandt, A. R. (2012). Variability and uncertainty in life cycle assessment models for greenhouse gas emissions from Canadian oil sands production. [Research Support, Non-U.S. Gov't]. *Environmental Science & Technology, 46*(2), 1253-1261. doi: 10.1021/es202312p

Brannigan, V. M., & Spivak, S. M. (1999). *ISO quality standards for participants in performance-based regulation*. Nashville, TN, USA.

Breyer, S. (1982). *Regulation and its reform*. Cambridge: Harvard University Press.

BSI. (2005). *A standard for standards – Part 1: Development of standards – Specification*. (Vol. BS 0-1:2005). British Standards Institute.

Charpentier, A. D., Bergerson, J. A., & Maclean, H. L. (2009). Understanding the Canadian oil sands industry's greenhouse gas emissions. *Environmental Research Letters, 4*(2009), 11.

CAPP. (2012). *CAPP's mission*. Retrieved 19 March 2013 from http://www.capp.ca/aboutUs/mission/Pages/default.aspx

CARB. (2013). *Low Carbon Fuel Standard Program.* Last reviewed March 26, 2013. Retrieved 4 April 2013 from http://www.arb.ca.gov/fuels/lcfs/lcfs.htm

Cargill, C., & Bolin, S. (2007). Standardization: A failing paradigm. In S. Greenstein & V. Stango (Eds.), *Standards and public policy* (pp. 296-328). New York: Cambridge University Press.

Cash, D. W., Clark, W., Alcock, F., Dickson, N., Eckley, N., & Jäger, J. (2002). *Salience, credibility, legitimacy and boundaries*. Harvard University, Cambridge, MA: John F. Kennedy School of Government.

Cash, D. W., Clark, W. C., Alcock, F., Dickson, N. M., Eckley, N., Guston, D. H., Jager, G., Mitchell, R. B. (2003). Knowledge systems for sustainable development. [Research Support, U.S. Gov't, Non-P.H.S. Review]. *Proc Natl Acad Sci USA, 100*(14), 8086-8091. doi: 10.1073/pnas.1231332100

COSIA. (n.d.). *Charter*. Retrieved 19 March 2013 from http://www.cosia.ca/charter

CSA. (2012). *CSA Media FAQ's.* Retrieved 4 April 2013 from http://www.csa.ca/cm/ca/en/news/newsroom/media-faqs/csa-media-faqs

CSA. (2011). *About CSA*. Retrieved March 7 2013 from http://www.csa.ca/cm/ca/en/about-csa

CSA. (2006). *CAN/CSA-ISO 14044:06 Environmental management - Life cycle assessment - Requirements and guidelines (ISO 14044:2006)*. Mississauga, ON: Canadian Standards Association.

CSA Group. (2013). *FAQ*. Retrieved 12 March, 2013, from http://www.csa-international.org/regulators/faq/

CSA Group. (2012a). *CSA Group product category rules (PCR) — Program operator administrative rules (CSA-SDP-5-12)*. Mississauga, ON: Canadian Standards Association.

CSA Group. (2012b). *Environmental product labeling and declaration factsheet*. Ottawa: CSA Group. Retrieved 12 March 2013 from http://www.csa.ca/documents/CSA-PCR-Factsheet.pdf

David, P. A. (1995). Standardization policies for network technologies: The flux between freedom and order revisited. In R. Hawkins, R. Mansell & J. Skea (Eds.), *Standards, innovation and competitiveness* (pp. 15-35). Brookfield, US: Edward Elgar.

de Vries, H. (1997). Standardization — What's in a name? *Terminology, 4*(1), 55-83. doi: 10.1075/term.4.1.05vri

Dyer, S., Moorhouse, J., Laufenberg, K., & Powell, R. (2008). *Under-mining the environment: The oil sands report card*. Calgary, AB: Pembina Institute.

European Commission. (2009). Directive 2009/30/EC of the European parliament and of the council of 23 April 2009. *Official Journal of the European Union*.

Egyedi, T. M., & Blind, K. (Eds.). (2008). *The dynamics of standards.* Northampton, MA: Edward Elgar.

Eisenhardt, K. M. (1989). Building theories from case study research. In M. David (Ed.), *Case study research* (Vol. 4, pp. 297-323). London: Sage Publications.

Ekvall, T., & Finnveden, G. (2001). Allocation in ISO 14041—a critical review. *Journal of Cleaner Production, 9*(3), 197-208. doi: http://dx.doi.org/10.1016/S0959-6526(00)00052-4

Farrell, J., & Saloner, G. (1985). Standardization, compatibility, and innovation. *The RAND Journal of Economics, 16*(1), 70-83.

Farrell, J., & Saloner, G. (1986). Installed base and compatibility: Innovation, product preannouncements, and predation. *The American Economic Review*, *76*(5), 940-955.

Finnveden, G. (2000). On the limitations of life cycle assessment and environmental systems analysis tools in general. *The International Journal of Life Cycle Assessment*, *5*(4), 229-238. doi: 10.1007/bf02979365

Frischknecht, R. (2000). Allocation in life cycle inventory analysis for joint production. *The International Journal of Life Cycle Assessment, 5*(2), 85-95. doi: 10.1007/bf02979729

Gosselin, P., Hrudey, S. E., Naeth, M. A., Plourde, A., Therrien, R., Kraak, G. V. D., & Xu, Z. (2010). *Environmental and health impacts of Canada's oil sands industry*. Ottawa, ON: Royal Society of Canada.

Government of Canada, & Government of Alberta. (2012). *Joint Canada-Alberta implementation plan for oil sands monitoring*. Available at http://www.ec.gc.ca/Publications/default.asp?lang=En&xml=47789FA4-67E0-4334-A850-15FFA1F8E8F2

Greenstein, S., & Stango, V. (Eds.). (2007). *Standards and public policy*. New York: Cambridge University Press.

Hahn, R. W., & Stavins, R. N. (1991). Incentive-based environmental regulation: A new era from an old idea? *Ecology Law Quarterly, 18*(1), 1-42.

Hawkins, R. (1999). The rise of consortia in the information and communication technology industries: Emerging implications for policy. *Telecommunications Policy, 23*(2), 159-173. doi: http://dx.doi.org/10.1016/S0308-5961(98)00085-8

Hawkins, R. W. (1995). Enhancing the user role in the development of technical standards for telecommunications. *Technology Analysis & Strategic Management, 7*(1), 21-40. doi: 10.1080/09537329508524193

ISO. (2010). *GHG schemes addressing climate change - How ISO standards help*. Geneva, Switzerland: International Organization for Standardization. Retrieved 12 March 2013 from http://www.iso.org/iso/ghg_climate-change.pdf

ISO. (2009). *Glossary of terms and abbreviations - Terms*. Retrieved 12 March 2013 from http://www.iso.org/sites/ConsumersStandards/en/5-glossary-terms.htm

ISO. (2006a). *ISO 14025: Environmental labels and declarations - Type III environmental declarations - Principles and procedures (ISO 14025:2006(E))*. Geneva, Switzerland: International Organization for Standardization.

ISO. (2006b). *ISO 14040: Environmental management - Life cycle assessment - Principles and framework (ISO 14040:2006(E)).* Geneva, Switzerland: International Organization for Standardization, ISO. (2006c). *ISO 14044: Environmental management - Life cycle assessment - Requirements and guidelines (ISO 14044:2006(E))*. Geneva, Switzerland: International Organization for Standardization.

ISO/IEC. (2004). *Standardization and related activities – General vocabulary (ISO/IEC Guide 2:2004(E))*. Geneva, Switzerland: International Organization for Standardization.

Kaplan, T. J. (1986). The narrative structure of policy analysis. *Journal of Policy Analysis and Management, 5*(4), 761-778. doi: 10.1002/pam.4050050406

Katz, M. L., & Shapiro, C. (1985). Network externalities, competition, and compatibility. *The American Economic Review, 75*(3), 424-440.

Katz, M. L., & Shapiro, C. (1986). Technology adoption in the presence of network externalities. *Journal of Political Economy, 94*(4), 822-841.

Katz, M. L., & Shapiro, C. (1994). Systems competition and network effects. *The Journal of Economic Perspectives, 8*(2), 93-115.

Kennedy, M. M. (1979). Generalizing from single case studies. In M. David (Ed.), *Case study research* (Vol. 2, pp. 3-19). London: Sage Publications.

Kumar, K., & Fenema, P. C. v. (1998). Barrier model: Towards a theory of managing geographically distributed projects. Paper presented at the European Council of International Schools conference.

Leveque, F. (1995). Standards and the standards setting processes in the field of the environment. In R. Hawkins, R. Mansell & J. Skea (Eds.), *Standards, innovation and competitiveness* (pp. 105-121). Brookfield, US: Edward Elgar.

Manuilova, A., Suebsiri, J., & Wilson, M. (2009). Should life cycle assessment be part of the environmental impact assessment? Case study: EIA of CO2 capture and storage in Canada. *Energy Procedia, 1*(1), 4511-4518. doi: 10.1016/j.egypro.2009.02.269

Naemura, K. (1995). User involvement in the life cycles of IT and telecommunication standards. In R. Hawkins, R. Mansell & J. Skea (Eds.), *Standards, innovation and competitiveness* (pp. 93-102). Brookfield, US: Edward Elgar.

Office of Technology Assessment. (1992). *Global standards: Building blocks for the future*. Washington, DC: Congress of the United States.

Ogilvie, K., Baer, W., DuPont, B., Elgie, S., Lounds, J., McLellan, A., Walker, R. (2010). RCE Advisory Group statement. Retrieved from http://www.capp.ca/rce/

Oil Sands Advisory Panel. (2010). *A foundation for the future: Building an environmental monitoring system for the oil sands*. Ottawa, ON: Environment Canada.

Pembina Institute. (2011). Oilsands performance metrics: Summary report. Audiences and design principles. *Oilsands Metrics Thought Leader Forum*. Calgary, AB: The Pembina Institute.

Pembina Institute. (n.d.). *About Pembina.* Retrieved 19 March 2013 from http://www.pembina.org/about/about-pembina

Plevin, R. J. (2010). Life Cycle Regulation of Transportation Fuels: Uncertainty and its Policy Implications. (Doctor of Philosophy in Energy and Resources), University of California, Berkeley, California.

Reap, J., Roman, F., Duncan, S., & Bras, B. (2008a). A survey of unresolved problems in life cycle assessment - Part 1: goal and scope and inventory analysis. The International Journal of Life Cycle Assessment, 13(4), 290-300. doi: 10.1007/s11367-008-0008-x

Reap, J., Roman, F., Duncan, S., & Bras, B. (2008b). A survey of unresolved problems in life cycle assessment - Part 2: impact assessment and interpretation. The International Journal of Life Cycle Assessment, 13(5), 374-388. doi: 10.1007/s11367-008-0009-9

Repussard, J. (1995). Problems and issues for public sector involvement in voluntary standardization. In R. Hawkins, R. Mansell & J. Skea (Eds.), Standards, Innovation and Competitiveness (pp. 62-66). Brookfield, US: Edward Elgar.

Responsible Energy Development Act, 2. The Minister of Energy (2012).

Salter, L. (1995a). Do reforms make a difference? Gearing methodology to assessments of standardization practices. In R. Hawkins, R. Mansell & J. Skea (Eds.), *Standards, innovation and competitiveness* (pp. 36-49). Brookfield, US: Edward Elgar.

Salter, L. (1995b). *Mandated science: Science and scientists in the making of standards*. Norwell, MA: Kluwer Academic Publishers.

SCC. (2012). *Standards Council of Canada.* Retrieved 11 February, 2013, from http://www.scc.ca/en/

SCC. (2009). *Canadian Standards Strategy (CSS) 2009-2012*. Ottawa, ON: Standards Council of Canada.

SETAC Europe LCA Steering Committee. (2008). Standardisation efforts to measure greenhouse gases and ‘carbon footprinting’ for products. *The International Journal of Life Cycle Assessment, 13*(2), 87-88. doi: 10.1065/lca2008.02.380

Simcoe, T. (2007). Delay and de jure standardization: Exploring the slowdown in internet standards development. In S. Greenstein & V. Stango (Eds.), *Standards and public policy* (pp. 260-295). New York, NY: Cambridge University Press.

Sinn, H.-W. (1996). The subsidiarity principle and market failure in systems competition. *Working paper 5411*. Cambridge, MA: National Bureau of Economic Research, Inc.

Stake, R. E. (1995). *The art of case study research.* Thousand Oaks, California: Sage.

Subramanian, V., Ingwersen, W., Hensler, C., & Collie, H. (2012). Comparing product category rules from different programs: learned outcomes towards global alignment. *The International Journal of Life Cycle Assessment, 17*(7), 892-903. doi: 10.1007/s11367-012-0419-6

Suchman, M. C. (1995). Managing legitimacy: Strategic and institutional approaches. Academy of Management. *The Academy of Management Review, 20*(3), 571-571.

Swann, P. (2010). *The economics of standardization: An update*. Report for the UK Department of Business, Innovation and Skills (BIS). May 27, 2010 (Version 2.2). Innovative Economics Limited.

Swann, P. G. (2000). *The economics of standardization - Final report for Standards and Technical Regulations Directorate, Department of Trade and Industry.* December 11, 2000. Manchester Business School, University of Manchester.

Swann, P., Temple, P., & Shurmer, M. (1996). Standards and trade performance: the UK experience. *The Economic Journal, 106*(438), 1297-1313.

Hallstrom, K. T., & Bostrom, M. (2010). *Transnational multi-stakeholder standardization: Organizing fragile non-state authority*. Northampton, MA: Edward Elgar Pub.

Unknown. (n.d.). *Gasoline (EDP 2002-30(1)).* PCR Library Website. Retrieved 21 March, 2013, from http://pcr-library.edf.org.tw/data/korea/gasoline.pdf

Wakelin, K. (1997). *Trade and innovation: Theory and evidence*. Northampton, MA: Edward Elgar Publishing.

Warshaw, S. I., & Saunders, M. H. (1995). International challenges in defining the public and private interest in standards In R. Hawkins, R. Mansell & J. Skea (Eds.), *Standards, innovation and competitiveness* (pp. 67-74). Brookfield, US: Edward Elgar.

Weidema, B. P., & Schmidt, J. H. (2010). Avoiding allocation in life cycle assessment revisited. *Journal of Industrial Ecology, 14*(2), 192-195. doi: 10.1111/j.1530-9290.2010.00236.x

Weiss, M. B. H., & Sirbu, M. (1990). Technological choice in voluntary standards committees: An empirical analysis. *Economics of Innovation and New Technology, 1*(1-2), 111-133. doi: 10.1080/10438599000000007

Weseen, S. (2006). Reducing transaction costs by regulating Canada's organic industry. *Current Agriculture, Food and Resource Issues* (7), 67-74.

WRI, & WBSCD. (2012). Product life cycle accounting and reporting standard. *Greenhouse Gas Protocol.* Retrieved 30 March 2013 from http://www.ghgprotocol.org/standards/product-standard

Yeh, S., Jordaan, S. M., Brandt, A. R., Turetsky, M., Spatari, S., & Keith, D. (2010). Land use greenhouse gas emissions from conventional oil production and oil sands. *Environmental Science & Technology 44*(22), 8766 – 8772.

Yin, R. K. (1984). *Case study research: Design and methods.* Beverly Hills, CA: Sage Publications

Appendices

Appendix A: Partial Interviewee List

While many chose to remain anonymous, the following thirteen interviewees agreed to have their name and their affiliation and/or expertise disclosed as written below. This list is presented, alphabetically, to indicate the applicability of the interviewees chosen to this thesis subject, in terms of their expertise and experience with Alberta's oil sands, development or use of LCA studies, or standardization at the CSA or ISO:

- Mr. Kevin Brady, industry LCA practitioner with lead role in the development of the ISO standards process on climate change and the ISO 14040 series of standards on life cycle assessment. Member of mirror committee on ISO 14067, and of the CSA Standards Policy Board.
- Mr. Steven Carpenter, Vice-President at Advance Resources International. Voting member of CSA and had lead roles in developing ISO 17024 under the guidance of 14064 and 14065 for carbon footprints, and CSA Z741 for geological storage of carbon dioxide.
- Mr. Claude Chamberland, Manager of Industry and Government Affairs, Heavy Oil (Oil Sands) at Shell. Manages emerging issues related to new environmental policies, including carbon intensity of crude oils.
- Dr. Alex Charpentier, industry LCA practitioner whose PhD dissertation compared the environmental performance of existing and developing oil sands technologies.
- Dr. Jenna Dunlop, Manager of Climate Change Policy at CAPP. Works with emerging issues, including LCA and FQD, and contextualizes GHG emissions data in CAPP's RCE.
- Dr. Chris Fordham, Senior Advisor of Sustainability Strategy at Suncor Energy. Involved in environmental and sustainability areas, and regulatory processes.
- Ms. Jackie Forrest, Senior Director of Global Oil at IHS CERA. Lead oil sands research and oversaw series of meta-analyses from the firm between 2009 and 2012.
- Mr. Martyn Griggs, Manager of Oil Sands at CAPP. Advocates on behalf of the oil sands industry.

- Dr. Bill Gunter, CEO of G BACH Enterprises Inc. Involved in CSA Z741 development process.
- Mr. Bill Keesom, industry LCA practitioner with experience in producing LCA reports for the Alberta Government.
- Dr. Andrew Miall, Professor, Fellow of the Royal Society of Canada (FRSC), University of Toronto. Member of both the federal and Alberta oil sands environmental monitoring advisory panels.
- Mr. Donald O'Connor at $(S\&T)^2$ Consultants Inc. Developed NRCan's GHGenius LCA model.
- Dr. Robert Page, current chair of ISO TC 207 (ISO 14 000 series – Environmental Management).

Appendix B: Questionnaires

B.1 Questionnaire for Academia

The following semi-structured questions are intended to gather your experience and opinions that are pertinent to a Life Cycle Assessment (LCA) standard through the Canadian Standards Association (CSA) and any challenges, either encountered or foreseeable, that you can identify for this process.

It is the intention of this project to discuss process issues that relate to the subject matter of these standards and the wider context in which they are developed. As such, this project is not an analysis of the management, operation, or efficiency of the CSA. Please keep this in mind when considering the following questions.

As per the Consent Agreement, you are free to skip any of these questions, or withdraw from the study, at any time.

1. In which ways, if any, are you involved with either the Canadian oil and gas industry, or with the Canadian Standards Association (CSA)?
2. What are the major issues that you see the Canadian oil and gas industry in general as currently facing? Which of these problems are unique to Alberta's oil sands?
    a. What are the implications of these issues? (i.e. lower market shares)
3. What government or industry action, if any, would help to rectify these issues?
4. To what extent do you perceive that formal voluntary standards, such as those that are developed through the Canadian Standards Association (CSA), could help you to address these issues?

5. What problems, if any, can you predict in the development of a voluntary life cycle assessment (LCA) standard through the Canadian Standards Association (CSA)?

B.2 Questionnaire for Government and Industry

The following semi-structured questions are intended to gather your experience and opinions that are pertinent to a Canadian formal voluntary standard for environmental product declarations for Alberta's oil sands. Such a standard would be used to communicate the results of greenhouse gas (GHG) emissions from Life Cycle Assessments (LCAs).

The purpose of the study is to develop a narrative of the key stakeholders potentially involved in the development of such a standard. It also seeks to capture any challenges, either encountered or foreseeable, that you can identify for the process of developing such a standard.

As per the Consent Agreement, you are free to skip any of these questions, or withdraw from the study, at any time.

1. In which ways, if any, are you involved with Alberta's oil sands, life cycle assessment (LCA), or greenhouse gas (GHG) measurement, verification, or communication?
2. What are major challenges that you see facing Canada's oil sands industry, with particular respect to standardization of data, governance, or communication?
3. What government or industry action, if any, would help to mitigate these challenges?
4. To what extent might a formal voluntary standard be a viable mechanism to address these issues?
5. What problems, if any, can you predict in the development of a Canadian formal voluntary standard to communicate the results of greenhouse gas (GHG) emissions from Life Cycle Assessments (LCAs)?

B.3 Questionnaire for Those Involved With CSA Z741

The following semi-structured questions are intended to gather your experience and opinions that are pertinent to a Canadian formal voluntary standard for environmental product declarations for Alberta's oil sands. Such a standard would be used to communicate the results of greenhouse gas (GHG) emissions from Life Cycle Assessments (LCAs). Particularly, this interview will focus on your recent involvement in the development of the Canadian Standard Association's (CSA's) recent Carbon Capture and Storage (CCS) standard.

The purpose of the study is to develop a narrative of the key stakeholders potentially involved in the development of such a standard. It also seeks to capture any challenges, either encountered or foreseeable, that you can identify for the process of developing such a standard.

As per the Consent Agreement, you are free to skip any of these questions, or withdraw from the study, at any time.

1. Please state the nature of your involvement with Carbon Capture and Storage (CCS) in Canada, or with the Canadian Standard Association (CSA). *(Other affiliations of interest include: involvement with Alberta's oil sands, life cycle assessment (LCA), or greenhouse gas (GHG) measurement, verification, or communication)*
2. In what ways, and to what extent, were you involved in the development of the Canadian Standard Association's (CSA's) recent Carbon Capture and Storage (CCS) standard?
3. What, if any, were issues that arose during this development process? To what extent were these due to the formal voluntary standard process, and/or to the nature of Carbon Capture and Storage (CCS)?

4. How were these issues mitigated?
5. What problems, if any, can you predict in the development of a Canadian formal voluntary standard to communicate the results of greenhouse gas (GHG) emissions from Life Cycle Assessments (LCAs)?