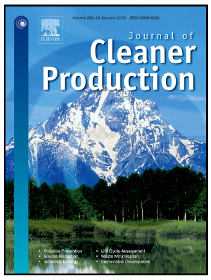
Accepted Manuscript



Unpacking carbon accounting numbers: A study of the commensurability and comparability of corporate greenhouse gas emission disclosures

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PII:	S0959-6526(18)33559-5
DOI:	10.1016/j.jclepro.2018.11.156
Reference:	JCLP 14915
To appear in:	*Journal of Cleaner Production*
Received Date:	06 June 2018
Accepted Date:	17 November 2018

Please cite this article as: Matthew Wegener, Réal Labelle, Lambert Jerman, Unpacking carbon accounting numbers: A study of the commensurability and comparability of corporate greenhouse gas emission disclosures, *Journal of Cleaner Production* (2018), doi: 10.1016/j.jclepro.2018.11.156

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Acknowledgement

This study is based on the third essay of Matthew Wegener's doctoral dissertation (Information as regulation) with Réal Labelle as his supervisor. We would like to acknowledge Michel Magnan, Sophie Tessier, and Claude Francoeur for the advice, help, feedback and support they offered while on the doctoral committee. We would also like to thank Anne Jeny-Cazavan for the comments she offered as the external examiner at the doctoral dissertation defense. This project has been realized thanks to the financial support of the Institute for Governance of Private and Public Organizations and the Stephen A. Jarislowsky Chair in Governance. The usual caveat applies.

November 13, 2018

Wordcount: 10 556 (9 999 without appendices)

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Abstract

The purpose of this study is to challenge the ability of carbon accounting to work as a commensuration process by exploring the ability of quantified greenhouse gas emissions data to communicate comparable—and therefore highly commensurable—carbon performance information. Comparability and commensurability are examined through the case study of a major oil and gas firm, and an empirical comparability test of the greenhouse gases emissions reported by oil and gas facilities from 19 different corporations between 2004 and 2015. Comparability ratings between facilities are developed based on mandatorily reported emissions and production levels. We provide evidence of a lack of comparability, and therefore commensurability, in reported greenhouse gas emissions. Information related to corporate-level greenhouse gas emissions could potentially mislead users into believing the firm has lower regulatory costs and/or less regulatory risk than it actually has. This study suggests that the collection and consolidation of facility level direct greenhouse gas emissions estimation could fail to produce highly commensurable and hence meaningful greenhouse gas emissions reports.

Keywords – Environmental reporting, carbon accounting, commensuration, comparability, greenhouse gas emissions

1.0 Introduction

There is a growing body of research looking at carbon accounting (Ascui and Lovell, 2012) with greenhouse gas (GHG) emissions reporting being an area of particularly high interest (Comyns and Figge, 2015). In this paper, we aim to explore the ability of GHG emissions data to communicate meaningful carbon performance information. By doing so, we want to contribute to the discussion on the quality of GHG reporting and its helpfulness in evaluating companies' environmental performance. Based on the analysis of corporate GHG disclosures, we add new insights to help understand why environmental accounts are sometimes described as relatively poor or lacking completeness (Jackson and Belkhir, 2018) and credibility (Gray 2013).

Vesty, Telgenkamp and Roscoe (2015) suggest that the suitability, and hence meaningfulness, of GHG emissions data depends fundamentally on the ability of those numbers to "commensurate" reality and so to act at a distance on individuals, such as decision makers and investors. According to Espeland and Stevens (1998, p. 314), commensuration means "the transformation of different qualities into a common metric." In the case of GHG emissions, it can be defined as the reduction of the physical complexity of the release of GHG into a single quantitative scale that can help to assess the environmental performance of a company. However, Kolk, Levy and Pinkse (2008) suggest that commensuration in GHG accounting is much more complicated for two main reasons. First, commensuration in this case is a more contentious and difficult to achieve process, as it is based on complex, and sometimes changing, procedures to determine which GHG reductions count (Kolk et al. 2008). Second, even if we have a better understanding of how investors actually use carbon disclosures in their decision making (Sullivan and Gouldson, 2012; CDP, 2017), it is still difficult to measure the impact a lack of commensurability may have on their decisions.

In addition, the absence of an international accounting standard and the current diversity in the allowable methods to estimate GHG emissions data has already given rise to concerns about the suitability of reported GHG emissions (Allini, Giner and Caldarelli, 2018). There are different potential explanations for this issue that range from the complexity of the physical definition (Chen, Huang, An, Zao and Zhao, 2018) and the practice of measuring GHG emissions (Akanni Olanrewaju and Mbohwa, 2017) to the diversity of acceptable reporting frameworks being implemented since the Kyoto Protocol (Jackson and Belkhir 2018). This great diversity echoes the fact that multiple scale-specific definitions of carbon accounting (Stechemesser and Guenther 2012) appear in the literature, allowing its discussed topics and purposes to vary. It is worth noting that comparability issues related to using multiple reporting methods would still exist if the GHG Protocol, the leading framework for the collection and reporting of GHG emissions data,[1] were to be followed by all firms.

Indeed, a thorough examination of the protocol reveals that it allows for discretion in the choice of collection and reporting methods not only at the corporate level, but also at the facility level (World Resources Institute [WRI] and World Business Council for Sustainable Development [WBCSD], 2004, Chapter 6). This flexibility inherent in the reporting standard (Haslam, Butlin, Andersson, Malamatenios and Lehman, 2014) allows the GHG information risk or estimate to vary not only between firms, but also between facilities under the same corporate umbrella. These issues potentially threaten the ability of GHG emissions reporting to provide both meaningful and comparable data to assess the environmental performance of a company.

In this paper, we examine and compare the mandatory facility level direct GHG emissions disclosures versus the voluntary corporate level direct GHG emissions disclosures reported by Encana, a Canadian oil and gas company. Encana offers a compelling case as they are a historically significant company in Canada that follows best practices in GHG reporting. As a leader in GHG reporting, their reports should be more comparable than other firms. Thus the identified issues are likely relevant to less CSR versed firms. This corporate case study is followed by a quantitative analysis of firms' ability to produce comparable direct GHG emissions data at the facility level. We provide an empirical test of the comparability of the direct GHG emissions data in order to assess their degree of commensurability, i.e., their reduction to a standard metric within a single company. We do this by analyzing mandatory corporate reports of direct GHG emissions at the facility level. We map the direct GHG emissions disclosed through Environment and Climate Change Canada[2] (ECCC) to the production information disclosed in Annual Information Forms (AIF). Using the results from the mapping process, we develop comparability ratings between facilities. Finally, we regress the comparability ratings on facility level characteristics which should have a clear impact on the production of direct GHG emissions to support the comparability of reported emissions.

[1] The GHG Protocol is recommended by both the Global Reporting Initiative and the Carbon Disclosure Project.
[2] The Canadian authority in environmental matters.

Our investigation makes three contributions. (1) Our study contributes to the literature by providing evidence that the mandatory facility level direct GHG emissions disclosures can be used to assess environmental performance against similar benchmark facilities. This result is important as it suggests that the relevance of GHG accounts for investors and decision makers could be improved by integrating facility based measures. (2) We also contribute to current research on carbon accounting practices. We find limited support that facilities operated by the same corporation will be more comparable than facilities operated by a different owner. Our support is isolated to comparisons between conventional oil and gas facilities. This suggests that commensuration at the facility level can be achieved to a sufficient level, but may be restricted to specific industries or specific operating processes. (3) This study also has managerial and practical implications. It suggests that a potential option to overcome the commensuration issue would be to amend regulations to include direct GHG emissions in the annual information forms. This way, firms could disclose GHG emissions next to production information, which would allow stakeholders to easily identify the relationship between the firm's production and its emissions for any of its important fields. Alternatively, ECCC could amend GHG emissions disclosure policy and require facilities to provide production information. We also recommend that managers can improve their voluntary disclosures by including a table that identifies how each of their facilities contributed to their consolidated GHG emission values.

The paper is structured as follows. We first discuss the linkages between commensurability and comparability in carbon accounting. Next, we elaborate more specifically on the two main issues (i.e. multiple estimation methods and varying operational processes at the facility level) that pose a threat to the comparability and commensurability of corporate-level GHG emissions estimates. Then, we develop hypotheses on comparability. This is followed by the third section, which describes the methodology and sample used to support our hypotheses. Our data collection process also raises concerns pertaining to the inadequacy of the disclosures currently being made. This section provides the results of our comparability tests. The final section includes both a discussion of the results and the conclusions.

2.0 Accounting for GHG emissions: comparability and commensurability

It is difficult to identify what the scope of social and environmental accounting should be (Ascui and Lovell, 2011). GHG emissions research commonly focuses on the determinants and/or relevance of carbon measures and disclosures without "a comprehensive and detailed definition of 'carbon accounting' covering the different scales" at stake (Stechemesser and Guenther, 2012). We propose to step back and examine the ability of accounting to work as a commensuration process, i.e., its ability to provide comparable and so highly commensurable data to assess the release of GHG emissions.

2.1 From the comparability of GHG emissions data to their commensurability

The release of GHG emissions is believed to be one of the main culprits responsible for global warming (Bebbington and Larrinaga-Gonzalez, 2008). As a result, GHG emissions have been framed as an important component of corporate environmental performance (Dragomir, 2012). But in order to produce comparable environmental information, GHG emissions reporting relies on complex estimation methods (Akanni Olanrewaju and Mbohwa, 2017)—complex enough to provide the full picture of the environmental performance of the firm.

These estimation methods have varying costs and multiple determinants. The cost of using a more accurate estimation method can outweigh its benefits and may explain why the quality of GHG emissions reporting hasn't improved over time according to Comyns and Figge (2015) and Qian, Horisch, and Schaltegger (2018). Due to this, GHG emissions reporting protocols generally allow for discretion in the choice of estimation methods (Depoers et al., 2016), not only at the corporate level, but at the facility level as well (WRI and WBCSD, 2004, Chapter 6). The use of source estimates determined at the facility level may result in potentially varying measurement errors. In addition to this measurement issue, consolidating GHG emissions at the corporate level could potentially obscure eco-efficiency gains and losses related to specific facilities. When the parent company is diversified, the GHG emissions from each facility are expected to be different. This creates an environment where poor performance at any particular facility can be obfuscated by the fact that related facilities produce low levels of GHG emissions by nature, which results in non-commensurable GHG emissions data.

In fact, GHG accounting works as a twofold standardization process that makes the commensurability of GHG emissions data questionable. This process has to ensure the representational faithfulness and relevance of reported GHG emissions. The sources of GHG emissions at the individual facility level need to be turned into quantified data following the same collection protocol and then measured with a single standard (Espeland and Stevens, 1998). This leads to the creation of new standardized objects—GHG emissions data for each facility—that represent commensurable aggregates of GHG emissions. This data is then consolidated at the corporate level to be integrated into the company's general environmental disclosure. In terms of commensuration, this second stage leads to a deeper abstraction of GHG emissions through the production of consolidated accounts. Then GHG emissions data is once more altered by the mediation of the consolidation protocol into new aggregates that represent a final stage of standardization (Espeland and Sauder 2007).

2.2 Macro- and micro-obstacles to commensuration of GHG disclosures

Even a quantifying technique such as accounting can face some obstacles to provide a high degree of commensurability. Indeed, Deegan (2016) argues that even if there has been an increase in the number of environmental reporting standards used, many studies provide evidence that it cannot be related to a significant improvement in the quality of environmental reports. This issue is further aggravated by the complexity of providing relevant guidelines to produce meaningful environmental accounts (Gray and Milne, 2015).

Critical works can help to understand these discrepancies as failures in the commensuration of GHG disclosures that can be overcome through compromise at a more microscopic level. Following Huault and Rainelli (2011), Millo and MacKenzie (2009) present an example of such a compromise in the widespread success of the Black-Scholes model for options valuation. Millo and MacKenzie (2009) show how the Black-Scholes model can build connections between different types of actors that have conflicting interests by representing a formulation that is acceptable to all of the values it measures. While traders, firms and regulators—that look like actors in this other particular network of calculation—had different and sometimes contradictory aims, the model worked as a way to reconcile all actors and acted as a means of commensurating options risk. Building on the same logic, the protocol framing the collection of GHG emissions data and their consolidation at the corporate level can provide the flexibility inherent in a formulation acceptable to all the different actors involved in GHG emissions reporting.

In the case of GHG emissions, each of a company's facilities has to produce its own GHG emissions records. This data is then collected and consolidated at the corporate level in a common disclosure. GHG accounting is thus more than a technical and automatic quantifying operation. Multiple actors, places and contexts form a network in the production of GHG disclosures. The existence of a single protocol for the collection of GHG emissions data has to frame the dynamic of this network in order to overcome obstacles. But the flexibility allowed by the implementation of the protocol (Haslam et al., 2014) at both the facility and the corporate levels requires that each part of this network runs as a "centre of calculation," to use the term coined by Latour (1987). In fact, the comparability of GHG reporting is conflicted, as it requires a subtle balance between the flexibility and homogeneity of GHG accounting methods to achieve a high degree of commensurability. While commensurability requires flexibility in estimation methods to achieve representational faithfulness, it also needs standardized and uniform accounting methods to provide relevant GHG information to investors. Ultimately, commensuration requires the merging of two paradoxical properties.

2.3 Testing GHG emissions comparability to challenge their commensurability

Finally, the evaluation of GHG emissions reporting is also a complicated process, as issues in the gathering, compiling and disclosing of GHG emissions data involve multiple organizational fields (Bowen and Wittneben, 2011). While there is a general consensus on the existence and implications of these emissions, they are difficult to track, as they consist of gases which are released into the environment (Ascui and Lovell, 2011). Therefore, there is an inherent uncertainty involved in the quantification methods used in their estimation (Marquez-Riquelme, van der Steen, Balzer and Mass, 2010). On a national GHG inventory level, Rypdal and Winiwarter (2001) evaluate the estimation error at more or less 5 to 20%. While there are methods to reduce this uncertainty (Marquez-Riquelme et al., 2010), calculation approaches can at times be "unavailable or prohibitively expensive" (WRI and WBCSD 2004, p. 42). Due to this problem, the GHG protocol allows for discretion in the choice of collection and reporting methods. This flexibility in reporting standards allows the GHG information risk or estimate to vary not only between firms, but also between facilities under the same corporate umbrella. This information risk is exacerbated by the fact that each facility or source of GHG emissions is not required to use the same collection method (WRI and WBCSD, 2004, Chapter 6).

3.0 Case study: Examining the relationship between facility and corporate level GHG emissions, The Encana case

Encana is historically significant to the oil and gas industry in Canada. The company was formed in 2002 following a merger between PanCanadian Energy Corporation and Alberta Energy Company Ltd. While both PanCanadian Energy Corporation and Alberta Energy Company Ltd.

were formed in the 1970s, PanCanadian Corporation's roots stem back to the 1880s when the Canadian Pacific Railroad made Alberta's first natural gas discovery. Therefore, Encana has over 125 years of history and is connected to some of the world's oldest petroleum companies.

Encana provides an interesting case study to examine the comparability and commensurability of reported GHG emissions for two main reasons. (1) Encana highlights current practices in the reporting of GHG emissions highly correlated to changes in regulation, and (2) they own and operate a great diversity of facilities that could jeopardize commensuration. The combination of diverse operations with strong reporting practices makes Encana a relevant case to challenge the comparability of facility-level GHG emissions and their relationship to consolidated disclosures.

Encana represents a company that has continuously evolved its CSR reporting to meet the needs of its stakeholders. According to their 2004 CSR report, Encana "commissioned the development of a software program, Emissions Manager™, to establish a baseline and understand its emissions profile" (Encana 2004, p. 13). In 2011, they improved upon this GHG emissions reporting system by moving from "an outsourced emissions management and reporting solution to an in-house application" (Encana 2011, p. 22). This is interesting as it shows how CSR reporting, and GHG reporting by extension, represents a key matter of interest in the communication of the company. Refining GHG forecasting and reporting model is even presented, year after year, as one of Encana's top priorities (Encana 2011, p.19 & p.58). Its corporate social responsibility reports follow the Global Reporting Initiative[3] guidelines and are audited each year by one of the big four accounting firms[4]. They are also consistently identified as climate disclosure leaders by CDP.[5]

Yet despite their efforts to disclose high quality GHG emissions data, Encana acknowledges constant changes in regulation may have an impact on the comparability of reported GHG emissions. Indeed, the historical record of reporting requirements shows eight significant changes in the Canadian regulation from 2004 to 2015, both in the inventory of pollutants and in the definition of reporting requirements, mainly thresholds and criteria companies have to follow to initially measure and then consolidate GHG emissions data. This could create uncertainty in the preparation of GHG reporting and interfere with its comparability as it has an impact on reporting systems, GHG forecasting and reporting model. Appendix 2 summarizes these main changes during the period. In addition, the uncertainty surrounding the implementation and enforcement of these legislations (Encana 2015, p.46), and their varying nature or purpose depending on their regional, provincial or national scale (Encana 2015, p.3), are presented as challenges that may lower the comparability of GHG emissions. In particular, differed implementation and moving guidelines between US[6] and Canadian regulations are reported by Encana over the years (Encana 2013, p.31; Encana 2015, p.46). This is interesting as it shows how regulations could threaten the comparability of GHG reporting for different years and thus represents a potential obstacle to commensuration.

[3] The Global Reporting Initiative is the most widely accepted framework for the production of corporate social responsibility reports.
[4] Early reports were audited by PricewaterhouseCoopers. In 2011, they switched to Deloitte.
[5] CDP, formerly the Carbon Disclosure Project, is a not-for-profit organization that hosts the most comprehensive collection of self-reported environmental information in the world.
[6] Encana had significant US operations during the sample period. However, we focus only on the Canadian operations as they have self-identified comparability issues between US and Canadian data.

In addition to their strong CSR reporting, both Encana's diverse operations and its historical change in this diversity create an interesting case study setting. Due to the growing proportion of its production from higher energy-intensive extraction processes, coping with the increase of GHG intensity has been presented as a major challenge for Encana (Encana 2005, p.7). Prior to 2009, they mainly dealt with this situation through the implementation of a large sequestration project (Encana 2004, p.17). Since 2009, Encana has spun off its oil operations and has become a primarily natural gas company. Encana does not hesitate to present this strategic move as a way to lower GHG emissions (Encana 2015, p.3). To this effect, the case study progresses as follows. First we examine the comparability of Encana's GHG emissions reporting when its operations included both oil and gas production (2004-2008). Afterwards, we assess Encana's GHG emissions reporting when they focused their operations exclusively on natural gas (2009-2012).

Illustration 1 maps Encana's 2008 Canadian operations. The company had nine active fields in 2008, which were mainly found in the province of Alberta. According to Encana's 2008 AIF, Greater Sierra, Cutbank Ridge, Big Horn, CBM Integrated and Shallow Gas are all conventional natural gas producing locations. Pelican Lake and Weyburn are conventional oil producing sites, and both Christina Lake and Foster Creek are oil sand operations.

INSERT ILLUSTRATION 1
INSERT GRAPH 1

Graph 1 presents the GHG emissions[7] disclosed by Encana in both its corporate social responsibility and Environment and Climate Change Canada (ECCC) reports. When comparing Graph 1 to Illustration 1, it should become immediately apparent that a high percentage of Encana's operations were not required to disclose GHG emissions through ECCC between 2004 and 2008. This is potentially due to mandatory disclosure thresholds. Between 2004 and 2008, only facilities with estimated GHG emissions greater than 100,000 tonnes of CO_2 were required to disclose their emissions through ECCC. The size of the difference between the emissions reported through Encana's corporate social responsibility reports and the emissions reported through ECCC is problematic. While Encana reports over 5 million tonnes of CO_2-equivalent GHG emissions in all years between 2004 and 2008, the sum of its reporting facilities does not exceed 1.3 million tonnes of CO_2-equivalent GHG emissions. From Encana alone, Canada's disclosure regulations are failing to capture roughly 3.7 million tonnes of CO_2-equivalent GHG emissions.

INSERT GRAPH 2

Graph 2 illustrates the potential loss of information that can occur due to the consolidation process. It displays the percentage of change in emissions for Encana's Canadian division, Christina Lake, Foster Creek, and Weyburn. While the change in emissions reported through Encana's corporate social responsibility reports seems very modest, there are dramatic increases in the emissions reported at the facility level. The largest increase in emissions in Encana's Canadian division is a 13.1% increase from 2006 to 2007. During the same time period, Foster

[7] GHG emissions presented are GHG-equivalent emissions, which include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6).

Creek's emissions increased by 51.86%, and Weyburn's increased by 284.38%. It should be noted that the Weyburn facilities emissions increase is related to a dramatic increase in flaring in 2007 and that it dropped by about the same amount the following year when flaring went back to previous levels. Christina Lake's emissions, on the other hand, decreased by 1.71%. The increase in overall emissions would signal a potential increase in regulatory costs. However, the reported magnitude of change in the corporate social responsibility reports is lower than the likely increase in exposure. Regulatory costs occur at the facility level. For instance, in the province of Alberta, where Christina Lake and Foster Creek are located, facilities that produce more than 100,000 tonnes of GHG emissions have been required to lower GHG intensity since 2007.[8]

INSERT GRAPH 3

Graph 3 displays the GHG intensity of Encana's Canadian division as reported in its social responsibility reports, and estimated GHG intensities for its Christina Lake, Foster Creek and Weyburn facilities. Estimated GHG intensities are calculated by dividing the direct GHG-equivalent emissions reported through ECCC by the total facility-level production reported in Encana's AIFs.[9] When comparing Encana's overall GHG intensity to the estimated GHG intensities at its higher-GHG-emitting facilities, we can see that it is generally lower. Encana's overall GHG intensity is also more stable than the estimated facility GHG intensities. The high degree of change in estimated GHG intensities between 2006 and 2007 is at least partly related to reported production levels. While not tabulated, production levels at all three reported facilities dropped significantly from 2006 to 2007, yet reported GHG emissions increased. Speculating as to why this occurred goes beyond the scope of this study.

On November 20, 2009, Encana spun its integrated oil operations, including Christina Lake, Foster Creek and Weyburn, into an independently operated company named Cenovus. Therefore, Encana itself is no longer exposed to potential future regulations related to the above-mentioned conventional and oil sands operations. Furthermore, since 2009, Encana has been focusing on natural gas. Since Encana has reduced the diversity in its operations, the GHG-reporting issues created by the consolidation process should be lessened.

INSERT TABLE 1

Mandatory GHG emissions disclosure rules also changed in 2009. Prior to 2009, any facility producing more than 100,000 tonnes of GHG emissions was required to disclose its emissions. During 2009, the required level was reduced from 100,000 to 50,000 tonnes of GHG emissions. While we suggested Encana's reporting issues should have lessened, Table 1 indicates that it is still difficult to discern facility-level performance from consolidated disclosures even for corporations with more homogeneous facilities. Direct emissions and reported emission intensities are provided in Table 1 Panel A for Encana as they were disclosed through Encana's

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[8] It should be noted that the climate change regulation example is provided to highlight the facility-level nature of climate change regulations. The increase in emissions at the facility level between 2006 and 2007 would not have triggered any actual regulatory cost, as the regulations did not come into effect until 2007, and since they are based on GHG intensity, as opposed to direct GHG emissions, production information would be required to estimate the future impact.

[9] Production is converted to cubic metres of oil equivalent for consistency with the GHG intensity data in Encana's social responsibility report.

corporate social responsibility reports. Table 1 Panel B displays the direct GHG emissions disclosed through ECCC for Encana's Greater Sierra facility and its estimated GHG intensity. Comparing Panel A with Panel B reveals that Encana discloses a GHG intensity that is almost three times higher than the GHG intensity from its largest, in terms of absolute value, GHG producing facility. As with the review of historical data for Encana, the emissions reported through ECCC account for a very small fraction of the direct GHG emissions disclosed through its corporate social responsibility report. Finally, Table 1 Panel C provides direct GHG emissions data from ECCC for facilities identified as being Encana's responsibility that are not identified in Encana's AIFs. This represents a disconnect between disclosures made through varying channels that warrants further investigation. The names of fields disclosed in a company's AIFs should be harmonized with the names of facilities mandatorily disclosing GHG emissions through ECCC to help facilitate stakeholders' evaluations of a firm's climate change performance. Being able to align GHG emissions with facility level production information could potentially mitigate a firms' ability to conceal high emitting sites through the consolidation process. However, the value of facility level emissions data is limited if the corresponding production information is absent. As the case of Encana has demonstrated, very large emitters in terms of absolute values, such as Encana's Greater Sierra facility can have very low GHG intensities.

The flexibility of estimation methods and/or varying business processes represents a potential threat to the comparability of corporate-level GHG emissions disclosures. Not only is there potential for the discretion allowed in the GHG Protocol to be exploited, but the magnitude of increases in pollution at high-emitting active sites appears to be concealable through the consolidation process. In the next section, we develop hypotheses based on facility-level characteristics that should have a clear impact on GHG production to empirically test this comparability issue.

4.0 Empirical test of comparability

Rather than examining comparability in terms of consistency in the development of the GHG emissions estimates as in Dragomir (2012), or in terms of the completeness of reporting as in Comyns and Figge (2015), we examine GHG emissions estimates to determine the extent to which *de facto* comparability exists within the data. In this regard, the current study is more similar to Harangozo and Szigeti's (2017) comparison of carbon footprint calculators. Harangozo and Szigeti (2017) found carbon footprint calculators to be unreliable as entering similar inputs would produce varying results for both direct and indirect GHG emissions estimations. We build upon Harangozo and Szigeti (2017) by examining the comparability of mandatorily reported facility level direct GHG emissions.

Comparability refers here to the representational faithfulness and suitability of GHG reports for decision making. Since GHG emissions are a by-product of the business process, we map the reported GHG emissions to production and examine whether or not facilities with similar characteristics produce more comparable GHG emissions estimates. Being able to detect similarities between facilities would support *de facto* comparability. Since we define comparability as an attribute that allows information users to distinguish between operational similarities and differences, our hypotheses are based on facility characteristics that should have a clear impact on the site-level production of GHG emissions. Where these characteristics are common between facilities, we would expect our comparability rating to improve.

4.1 Hypothesis development

While we acknowledge that our list of factors is not complete, we restrict our hypotheses to two characteristics that have data available and should have a clear impact on comparability according to the literature: production process and corporate behaviour. Our hypotheses aim to provide avenues to further investigate the extent to which GHG emissions accounting works as a commensuration process.

4.1.1 Production process

Our sample includes three different types of facilities that may all be owned by an integrated oil and gas firm. Since each type of facility has a very different business process, the different types will produce and are hence expected to estimate different levels of GHG emissions per unit of production. The three facility types examined are conventional facilities, unconventional facilities and refineries. The facilities listed as "conventional" include natural gas wells that produce using normal pumping methods. "Unconventional" production facilities are *in-situ* oil sand facilities, and "refineries" are facilities that convert crude oil to useable products such as gasoline. This hypothesis provides evidence of the complexity of the calculations involved in the commensuration of GHG emissions. Since the business process for each type of facility is different, we expect the emissions reported by facilities belonging to the same category to be more comparable than the emissions disclosed by facilities in different categories.

> H1: The GHG emissions disclosed by facilities using the same production process will be more comparable than the GHG emissions disclosed by facilities using different production processes.

In terms of commensuration, we assume here that the costs of producing commensurable GHG emissions data are lower when facilities use the same production process.

4.1.2 Corporate behaviour

The second characteristic that should impact the comparability of GHG emissions reported by facilities is the corporate group to which the facilities belong. The majority of oil and gas firms have robust energy efficiency programs (Nordrum**,** Lieberman, Colombo, Gorski and Webb, 2011). The energy efficiency programs represent a part of an organization's procedures and policies that shape its environmental capabilities (Berchicci, Dowell and King, 2012). Evidence suggesting that manufacturing firms with strong environmental capabilities target facilities with poor environmental performance for acquisition (Berchicci et al., 2012) provides additional support for these environmental capabilities being transferable between a corporation's facilities. Facilities under the same corporate umbrella should also use similar environmental management accounting tools which have been shown to be positively associated with improve corporate carbon disclosure quality (Qian, Horisch, and Schaltegger, 2018). Therefore, our second hypothesis is as follows:

H2: GHG emissions reported by similar facilities in the same corporate group are more comparable than GHG emissions reported by similar facilities operated by different corporate groups.

4.2 Methodology

As the objective of this study is to examine whether GHG emissions data produced at the facility level are appropriate for comparing global environmental performance between firms, it involves comparing the GHG estimation process between facilities. We use existing disclosures to model the estimation process and then use the model to develop our empirical measure of comparability. From a practical standpoint, it is difficult to collect data on the estimation processes for a large sample of firms or facilities, as they are unobservable. In contrast, our measure of comparability, which is based on DeFranco, Kothari and Verdi (2011), is calculated using publicly available facility-level GHG emissions data. To test our comparability hypotheses, we restrict the sample to pairs-of-data observations with available data to proxy for GHG emissions comparability, which is our dependent variable.

4.2.1 Data collection

The sample base includes all facilities identified as either oil and gas extracting (NAICS[10] code 21111) or petroleum refining (NAICS 324110) that provided mandatory GHG emissions[11] data to ECCC for at least four years between 2004 and 2015. The facilities we examine are considered upstream, midstream, or downstream in the integrated oil and gas industry. The larger oil and gas companies own multiple facilities of each type. While not tabulated, we first considered comparing all 159 facilities with four years of mandatory GHG emissions disclosures through ECCC. Production information was hand-collected from the firms' AIFs. These AIFs were retrieved from either SEDAR or the companies' websites. However, 14 facilities needed to be removed due to being privately owned, and thus did not have production information available. An additional 95 facilities could not be included in our sample as they did not produce the facility-level information required by National Instrument 51-101: Standards of Disclosure for Oil and Gas Activities. As a result, our sample consists of 2,450 observations or pairs of comparable facility-level GHG emissions data from 50 facilities. Of these facilities, 26 are conventional oil and gas extracting facilities, 13 non-conventional oil and gas extracting facilities, and 11 petroleum refineries.

Table 2 displays the number of facilities broken down by corporate group ownership and production process. They belong to nineteen different corporate groups. Thirteen of the corporate groups have only one facility. The remaining six corporations have multiple facilities. Four of these corporations have facilities in more than one type of process. The facilities do not represent all of the facilities owned by the identified corporate groups.

INSERT TABLE 2

[10] The North American Industry Classification System (NAICS) is a business classification system based on the process of production.
[11] GHG emissions used in the study are GHG-equivalent emissions, which include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6).

Our empirical test examines the relationships between these 50 facilities. To this effect, our actual sample size is 2,450 observations. While not tabulated, 916 of our observations consisted of comparisons between facilities with similar processes and 222 relationships were between facilities belonging to the same corporate group.

While a rigorous process was followed for the collection of data, a disclosure issue resulted in limiting our facility comparisons to 2,450 pairs of facilities observations. The ending sample size is related to a lack of production information being provided for the facilities disclosing their GHG emissions. Since National Instrument 51-101: Standards of Disclosure for Oil and Gas Activities requires these facilities to disclose production information in Canada, 65.5% (95/145) of the facilities in our sample that belonged to publicly listed companies needed to be removed due to missing production information. This issue impacts the availability of data as opposed to the quality of data, it should not impact our test of comparability beyond the generalizability issue related to having a small sample size. However, this is an issue that should receive more attention.

4.2.2 Measuring comparability

To assess the comparability of GHG emissions reporting, we use a multiple-step method that begins by following a similar approach to that taken by DeFranco et al. (2011) in their analysis of the comparability of financial statement information. We use this method to compare the GHG estimation process between facilities. The comparability measure we develop, using the methodology explained below, is one-directional. For any pairwise comparison between facilities in our sample, there are two GHG comparability ratings. One GHG comparability rating measures the comparability between Facility A and Facility B based on Facility A's production. The other GHG comparability rating for Facilities A and B measures their comparability based on Facility B's production. Therefore, the number of observations in our sample is equal to the number of facilities examined times the number of facilities examined minus one (2,450).

The analysis of comparability starts by modelling the relationship between GHG emissions and each facility's business process. While Busch (2010) recommends that GHG emissions in the oil and gas industry be compared based on sales, the Petroleum industry guidelines for reporting greenhouse gas emissions point out that sales in the oil and gas industry are highly related to the price of crude oil. This makes comparisons based on monetary values undesirable. We follow the recommendations of the Petroleum industry guidelines for reporting greenhouse gas emissions and model the production of GHG emissions based on physical output as in Equation 1.

$$GHG_{it} = \beta_{1i} Prod_{it} + \varepsilon_{it} \tag{1}$$

Where GHG_{it} is the facility's (i) disclosed GHG emissions in Period (t) and Prod is the facility's level of annual production measured in barrels of oil equivalent. Equation 1 is run for each facility in the sample. Then, the GHG collection process is proxied for by $\hat{\beta}_{1i}$ for Facility i (Equation 2).

$$E(GHG)_{iit} = \hat{\beta}_{1i} Prod_{it} \quad (2)$$

Similarly, the GHG collection process for Facility j is proxied for by $\hat{\beta}_{1j}$ (Equation 3). The comparability between two facilities is then determined by the distance between Equations 2 and 3.

$$E(GHG)_{ijt} = \hat{\beta}_{1j} Prod_{it} \quad (3)$$

Both equations employ the production (*Prod*) from Facility i in Period t, but Equation 2 uses the estimates for the coefficients from Equation 1 for Facility i, and Equation 3 uses the estimates for the coefficients from Equation 1 for Facility j. The GHG emissions comparability between Facilities i and j (CompGHG) is then determined by:

$$CompGHG_{ij} = -1/t \times \sum_t \left| E(GHG)_{iit} - E(GHG)_{ijt} \right| \quad (4)$$

Greater values of CompGHG represent greater comparability of GHG emissions between the facilities. Facility i is compared to all other facilities in the sample. This process is performed for each facility in the sample. Finally, the resulting CompGHG values from Equation 4 are compared through the use of a cross-sectional OLS regression analysis using the following model:

$$CompGHG_{ij} = \alpha + \beta_1 Process_{ij} + \beta_2 Group_{ij} + \beta_3 CoGen_{ij} + \beta_4 Diff_{ij} + \beta_5 Barrels_i + \varepsilon_{ij}$$
(5)

In Model 5, *Process* is the variable of interest for Hypothesis 1. *Process* is a dummy variable coded 1 where the two facilities being compared perform the same operational processes and coded 0 otherwise. For example, when the relationship in the cross-sectional analysis is between two refinery facilities, the *Process* variable is coded 1, while the *Process* variable for the comparability of a refinery facility and a conventional oil and gas extracting facility is coded 0. Since a *Process* variable coded 1 represents a comparison of two facilities with similar operational procedures, and each operating procedure has a different projected GHG intensity (Timilsina et al., 2006), a positive coefficient for the *Process* variable would represent the GHG estimation process being capable of capturing the similarities and differences in GHG intensities related to the production process. Therefore, a positive coefficient would support Hypothesis 1.

Group is the variable of interest for Hypothesis 2. *Group* is a dichotomous variable coded 1 for facilities that belong to the same corporate group and coded 0 otherwise. As Kolk and Levy (2001) point out, the response to climate change varies between oil and gas firms. Since facilities under the same corporate umbrella follow similar strategies regarding the production of GHG emissions and should be able to benefit from the green capabilities of the corporate group, the comparability between two facilities under the same corporate umbrella is expected to be greater than the comparability between facilities operated by different corporate groups. Therefore, a positive coefficient would support Hypothesis 2.

Diff is the absolute value in terms of the difference in production between the two facilities being compared. Since different levels of production represent differences in the operations between firms, it may potentially impact the estimation of GHG emissions. Therefore, it is included as a control variable. *Diff* is large when the observation compares a high-producing and a low-producing facility, but small when the observation compares facilities that are either both high-producing or both low-producing. To this effect, it is not a measure of size, but rather controls for comparing large versus small facilities. The control variable *Barrels,* on the other hand, is closely aligned with size, as it is equal to the production level used in determining CompGHG. Since the methodology employed in this study estimates the comparability for each firm based on its level of production, precision errors in the estimates will be magnified for firms that produced a greater number of barrels per day. The inclusion of *Barrels* is intended to control for this potential modelling impact.

4.3 Results of the empirical tests

Table 3 provides the descriptive statistics for the 2,450 pairwise facility comparisons. At first glance, the range of values for the comparability ratings appears to be quite extreme (maximum -87; minimum -11,422,900). However, this is related to the form of our hypothesis and supporting methodology. The comparability ratings in our sample were calculated using both facilities that were very similar and facilities that were very different. Since a comparison between very similar facilities will create a rating approaching zero and a comparison between very different facilities will create a large negative rating, the large range of values is expected. Of the 2,450 pairwise comparisons, 37.4% are between facilities with common operational process and 9.1% are between facilities with common corporate ownership. The *Barrels* variable captures the annual production level, in barrels of oil equivalent, for the facility in each comparison where production is being used to estimate the *GHGcomp* variable. It is included as a control variable to block the variation in our tests that is created due to model estimation errors being magnified at higher production levels. It also provides indication of the variation of facility sizes included in the sample. The smallest facility only produced 3,035 barrels of oil equivalent while the largest produced 268,666 barrels. Difference in production (*Diff*), on the other hand, measures the difference in size between the facilities being compared. The maximum value of *Diff* is the comparison between the largest (268,666 barrels) and smallest (3,035 barrels) facilities. The *Diff* variable controls for differences in the GHG estimation process related to differences in production.

INSERT TABLE 3

Table 4 displays the results of the cross-sectional analysis. The tolerances for all variables are well above 0.20, and the variance inflation factors (VIF) are below 2, which suggests that multicollinearity is not an issue. The adjusted R^2 of the model is 0.577, which supports the model being a good fit. Both *Process* and *Group* represent similarities in operations. Thus, positive coefficients indicate that the impacts from these similarities are being captured by the GHG emissions estimation process at the facility level. As expected, the *Process* variable has a positive coefficient that is statistically significant at a p-value of less than 0.01. This provides support for Hypothesis 1 and implies that the current estimations of GHG emissions are accurate enough to capture the differences in the production of GHG emissions between the different types of facilities. However, although the *Group* variable coefficient is positive as expected, it fails to meet statistical significance at conventional levels. This fails to provide support for Hypothesis 2.

INSERT TABLE 4

4.4 Additional tests

Further regression analysis as well as non-parametric tests were run to find support for the *Group* hypothesis. Table 5 displays the results of OLS regressions run for *Process* specific comparisons. In all three cases, results were consistent with the main test. The *Group* variable is not significant for any of the processes. However, Table 5 also reports the significance level results from the non-parametric Kruskall Wallis tests we ran for the *Group* variable for comparisons between similar facilities. While we cannot support *Group* being statistically significant for non-conventional processes or refineries, the Kruskall Wallis test does support the *Group* variable being statistically significant for conventional facilities. This suggests that the accuracy of the GHG emissions estimation process at capturing a corporation's environmental strategy is dependent upon the type of operational process that is creating the GHG emissions.

INSERT TABLE 5

5.0 Discussion

By supporting hypothesis 1, the results of the empirical tests suggest that the mandatory facility level GHG emissions disclosures can be used to assess environmental performance against similar benchmark facilities. This adds to current discussions on the metrics and the difficulty to find an integrated approach to measure GHG emissions (Côté and Liu, 2016). If different models are mathematically explored (Jackson and Belkhir, 2018) or compared in the literature (Akanni Olanrewaju and Mbohwa, 2017), we provide evidence that estimation models should take facility characteristics into account to produce highly commensurable GHG emissions data.

This suggests that the current identified difficulties in defining environmental reporting quality (Qian et al., 2018) could be overcome by moving the analysis to the facility level. There is a need to move beyond the absence of a single global accounting standard (Allini et al., 2018) to explain the current discretion in the choice of collection and GHG reporting methods and acknowledge that in depth examinations of the measurement practices at the facility level are required. The significance of our *Process* variable suggests that the discussion of the suitability of reported GHG emissions (Comyns, 2016; Depoers et al., 2016) may find new avenues by moving to the facility level, examining how the complexity and uniformity of the operational measurement process of GHG emissions may have an influence on their commensurability.

However, we also find a disconnect between the disclosures made through ECCC and the disclosures made through security regulators. This issue was highlighted in the Encana case study. The direct GHG emissions Encana voluntarily reported were significantly higher than the sum of the direct GHG emissions mandatorily reported through its high GHG emitting facilities.

While explaining this difference goes beyond the current study, it should be investigated further in future studies. This disconnect will make it very difficult to align production information with GHG emissions information for many oil and gas facilities. Oil and gas companies are unique in Canada in that they are required to disclose production information for significant fields. The value of these mandatory facility level GHG emissions disclosures are diminished when there is no production information to help assess environmental performance. This has different implications for future research. By comparing the mandatory facility level GHG emissions disclosures versus the mandatory facility level financial disclosures reported in our sample, we observe that a large number of facilities or fields are reported through ECCC that are not disclosed in their respective AIFs and vice versa. Given the case of Encana, and our comparison of their mandatory facility level GHG emissions disclosures to their voluntary corporate level GHG emissions disclosures, it suggests that even if proactive corporate behaviour can support the voluntary disclosure of GHG emissions data, it does not provide any assurance regarding their reliability. Without production information for a corporation's facilities, we cannot estimate their individual GHG intensities and hence eco-efficiency. A company that appears to be a good environmental performer at the corporate level could potentially have varying performance at the facility level. Seemingly "good" environmental performance may be related to having "good" environmental performance at facilities, or simply varying GHG intensities where "good" performance at some facilities offsets "bad" performance at others. Ultimately, the information related to corporate-level GHG emissions could potentially mislead the user into believing the firm has lower regulatory costs and/or regulatory risk than they actually have. This could explain current uncertainties on how investors actually use carbon disclosures in their decision making (Sullivan and Gouldson, 2012). Current skepticism on the quality of GHG disclosures despite the increase in the number of reporting standards used (Deegan, 2016; Jackson and Belkhir, 2018) could also be explained by decision-makers having already internalised the lack of comparability in GHG emissions and the resulting low level of commensurability.

Second, in hypothesis 2 we predict and find limited support that similar facilities operated by the same corporation will be more comparable than similar facilities operated by a different owner. Our support is isolated to comparisons between conventional oil and gas facilities. We cannot support any improvements in comparability for comparisons between unconventional oil and gas facilities or between refineries. Nor can we support an improved comparability between different facility types related to common ownership. This suggests that the standardized objects required for commensuration at the facility level can be created to a sufficient level, but they may be restricted to specific industries, or more importantly specific operating processes. However, the lack of statistical significance could be related to our tests, and thus the relationship should be further investigated. This is of interest as it suggests the ability of accounting to produce a high degree of commensurability can't be considered as automatic. Future research should then investigate in-depth what makes corporate-level GHG reporting a weak instrument for decision making (Qian et al., 2018), since it cannot deliver comparable information (Kolk et al. 2008).

Third, our study also has managerial and practical implications. While the issue of distinguishing regulatory costs and/or regulatory risk could be easily circumvented by the inclusion of facility-level performance in the firm's GHG emissions disclosures, it would not necessarily achieve a high degree of commensurability. For instance, a potential option would be to amend regulations to include GHG emissions and/or GHG emissions intensities in the annual information forms.

This way, firms could disclose GHG emissions or intensities next to production information, which would allow stakeholders to easily identify the relationship between the firm's production and its emissions for any of its important fields. Since it is also common practice to disclose the percentage of ownership with this information, issues related to the setting of organizational boundaries would also be lessened, stakeholders would be free to compile corporate-level disclosures in a manner of their choosing. Alternatively, ECCC could require disclosing GHG emissions disclosing facilities to also report production levels. This additional data would allow the assessment of GHG emissions comparability to move beyond the oil and gas industry. It would also help GHG emission regulators identify areas that would benefit from targeted regulations. An option for progressive managers wishing to improve their disclosure quality would be to include a table in their voluntary disclosures breaking down the consolidated values into the facilities they are comprised of. However, while these recommendations would help in the identification of risk for investors, they would not eliminate the comparability issue.

The results of this study should be interpreted with caution. To start with, it examines the comparability of reported GHG emissions, not the level of GHG emissions or the environmental performance of the facilities. This comparison is based on the production of barrels of oil equivalent being associated with the production of GHG emissions in the oil and gas industry. Changing the means of comparison may alter the results of the study. However, we are unaware of any metrics that would be superior to barrels of oil equivalent as a common denominator in terms of comparing the performance of oil and gas facilities. Additionally, although all available information was used, the results are based on a relatively small sample of Canadian facilities. The methodology employed to provide support for our hypotheses might not have had enough power to detect meaningful differences in the GHG estimates related to a firm's corporate environmental behaviour. Furthermore, due to the small sample size and to its Canadian nature, the results are not necessarily generalizable to oil and gas facilities in other countries or to other industries.

Given our small base sample size, future research should replicate this study with a larger sample in Canada and abroad in order to support future statistical generalizations. While our results indicate that the GHG estimation process is only accurate enough to distinguish the impact of corporate behaviour on emissions for conventional oil and gas facilities, this could be due to the small sample size. Considering that this limitation is related to the number of years of available data, it should only be a matter of time before there is a large enough sample to avoid this potential statistical power issue. We also believe that the application of National Instrument 51-101: Standards of Disclosure for Oil and Gas Activities should be examined. The fact that 65.5% (95/145) of our initial sample needed to be removed due to missing production information gives the impression that the standard is voluntary rather than mandatory.

6.0 Conclusion

The examination of the relationship between facility and corporate level GHG emissions reported by Encana outlines the potential threat to obscure facility level performance. In the integrated oil and gas industry, companies like Encana aggregate GHG emissions from many individual facilities to estimate their GHG emissions disclosures. GHG emissions intensity will vary between facilities which ultimately means the corporations overall GHG emissions intensity will not be representative of the eco-efficiency of its facilities. This ultimately suggests that the ability of accounting for GHG to produce highly commensurable data should not be considered as automatic.

The paper makes three contributions. First, mandatory facility level GHG emissions disclosures can be used to assess environmental performance against similar benchmark facilities. As a consequence, the current identified difficulties in defining environmental reporting quality could be overcome by moving the analysis to the facility level. Second, there is a disconnect between the disclosures made through ECCC and the disclosures made through security regulators that could make it very difficult to align production information with GHG emissions information for many oil and gas facilities. Third, an option for progressive managers wishing to improve their disclosure quality would be to include a table in their voluntary disclosures breaking down the consolidated values into the facilities they are comprised of.

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Appendix 1: List of Abbreviations

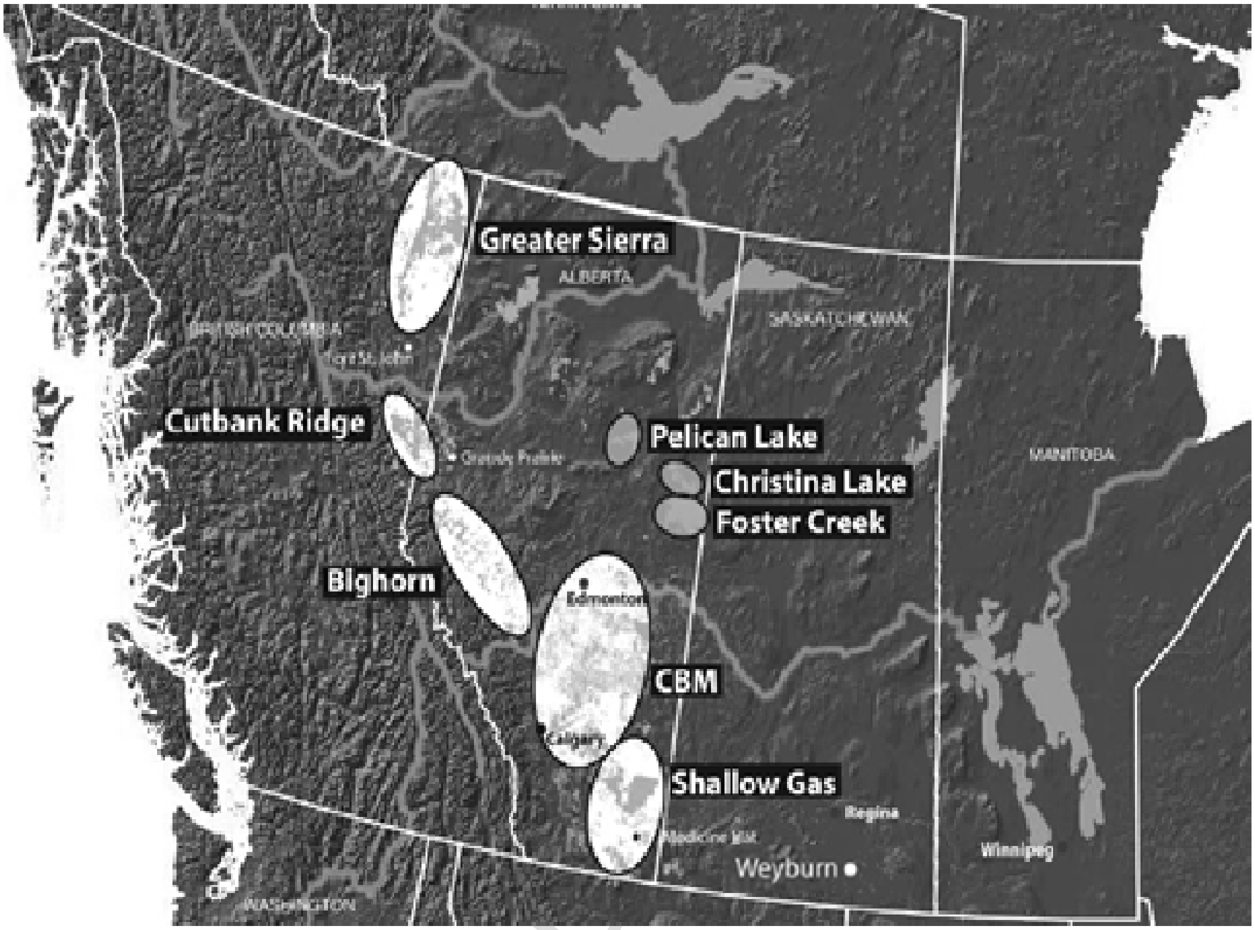
AIF	Annual Information Form
CDP	Carbon Disclosure Project
CO_2	Carbon Dioxide
CSR	Corporate Social Responsibility
ECCC	Environment and Climate Change Canada
GHG	Greenhouse Gas
NAICS	North American Industry Classification System
OLS	Ordinary Least Squares
SEDAR	System for Electronic Document Analysis and Retrieval
WBCSD	World Business Council for Sustainable Development
WRI	World Resources Institute

Appendix 2: GHG reporting related major changes in regulation, Canadian historical record

2014	**Addition to the substance list of:** 2-(2-Methoxyethoxy) ethanol, Thallium (and its compounds) **Deletion from the substance list of:** Allyl chloride, C.I. Solvent Orange 7, 3-Chloro-2-methyl-1-propene, Ethyl chloroformate, 1-Bromo-2-chloroethane **Modifications to reporting thresholds:** Eight substances or substance groups have been moved from Part 1, Group A to Part 1, Group B. The mass threshold for these substances has been reduced from 10t, and, in some cases (…) from 1%. (…) The 10t mass threshold has been reduced to 50kg for total polycyclic aromatic hydrocarbons (…) and 5kg for reporting quinoline itself. **Changes to Reporting Requirements:** (…) Only releases of total reduced sulphur to air are required to be reported.
2011	**Modifications to Reporting Thresholds:** The reporting thresholds for selenium (and its compounds) were modified to 100kg with a 0.000005% (0.05ppm) concentration threshold for quantities that are manufactured, processed or otherwise used, from the original 10t and 1% concentration thresholds
2010	**Modification to Existing Substance:** The listing for p,p'-isopropylidenediphenol has been changed to bisphenol A. (…). **Removal from the Substances List of:** Sulphur hexafluoride **Changes to Reporting Requirements:** Provincial identification numbers for facilities in the upstream oil and gas sector are required to be reported. Information related to updates of the pollution prevention plan and whether the plan addresses energy or water conservation is required to be reported. (…)
2009	**Reporting Criteria Change:** Addition of reporting requirements for substances contained in waste rock and tailings disposed of or transferred off-site for disposal. Requirements also applicable to the 2006-2008 reporting years. (…)
2008	**Reporting Criteria Change:** Addition of "Titanium dioxide pigment production using the chloride process"; to the list of activities for reporting (…)
2007	**Addition to the Substances List of:** Total reduced sulphur, expressed as hydrogen sulphide. 9 additional Polycyclic Aromatic Hydrocarbons. **Modifications to Existing Substances:** Dioxins and Furans as a group of substances was replaced by 17 Speciated Dioxins and Furans. **Changes to Reporting Requirements:** Requirement to report on each of the 17 Dioxins and Furans separately, in grams. (…) **Reporting Change:** The number of digits for Dioxin/Furan reporting was expanded, from three digits to six, to allow for more data capture and better harmonization with United States Environmental Protection Agency reporting requirements.
2006	**Definition Changes:** Definition of "facility" expanded to include portable facilities. Definition of "other use" expanded to include "release" of an NPRI substance. Pits and quarries defined. **Reporting Changes:** (…) New requirements for facilities to provide updates about changes to contact information and ownership. If facilities are already required (…) law to measure or monitor releases, disposals and/or transfers for recycling of any listed substances, they are also required to report this data to the NPRI.
2004	**Reporting Change:** Launch of the One Window to National Environmental Reporting System (OWNERS), for secure online reporting of environmental information and data by facilities (in 2005, for the 2004 reporting year). (…)

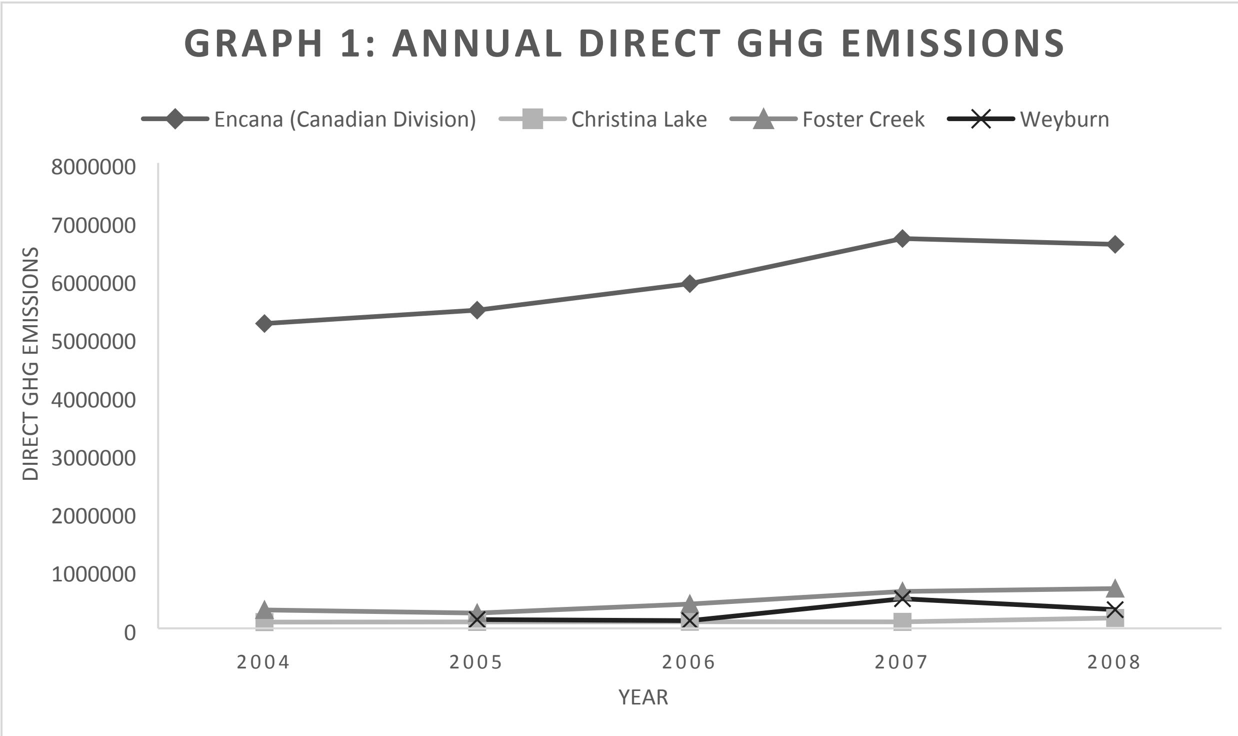
Source: History of reporting requirements: National Pollutant Release Inventory. Government of Canada, available at https://www.canada.ca/en/environment-climate-change/services/national-pollutant-release-inventory/substances-list/history-reporting-requirements.html

Illustration 1: Map of Encana's 2008 Canadian Operations

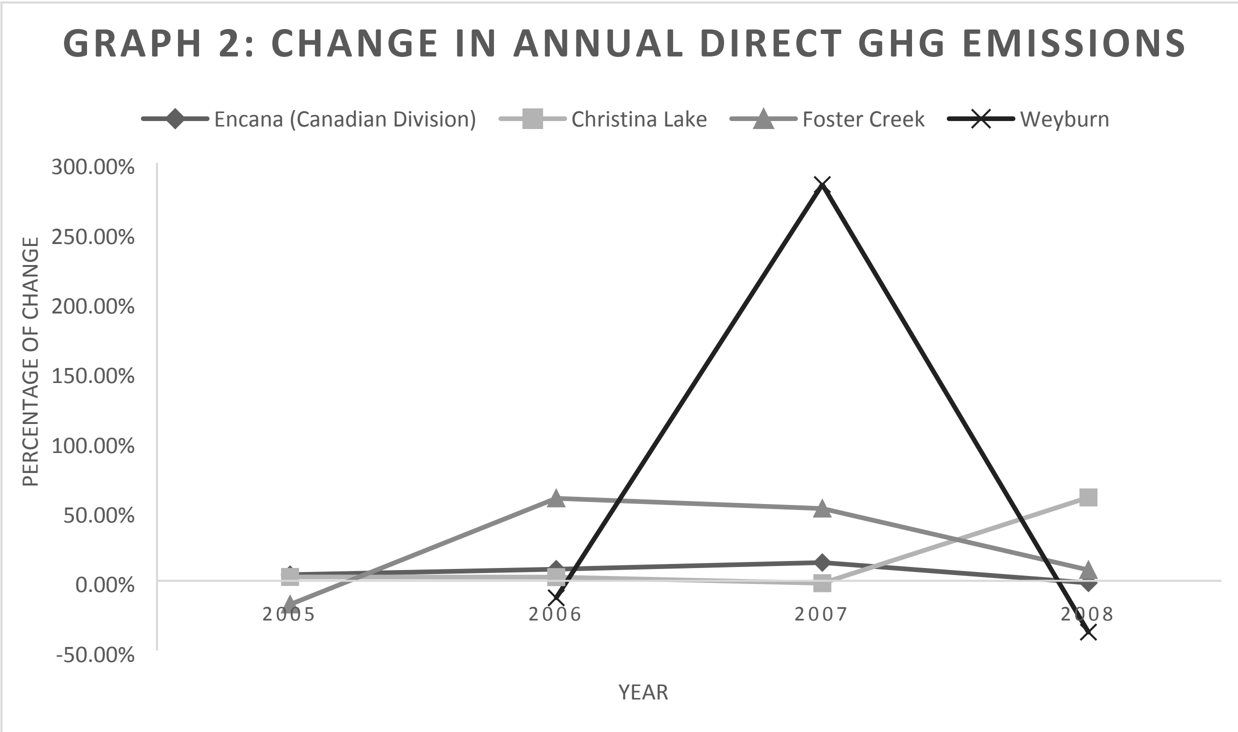


Source: Encana Annual Information Form (February 20, 2009). Retrieved from SEDAR.

Graph 1: Annual Direct GHG Emissions by Year



Graph 2: Percentage Change in Annual Direct GHG Emissions by Year



Graph 3: Direct GHG Emissions Intensity by Year

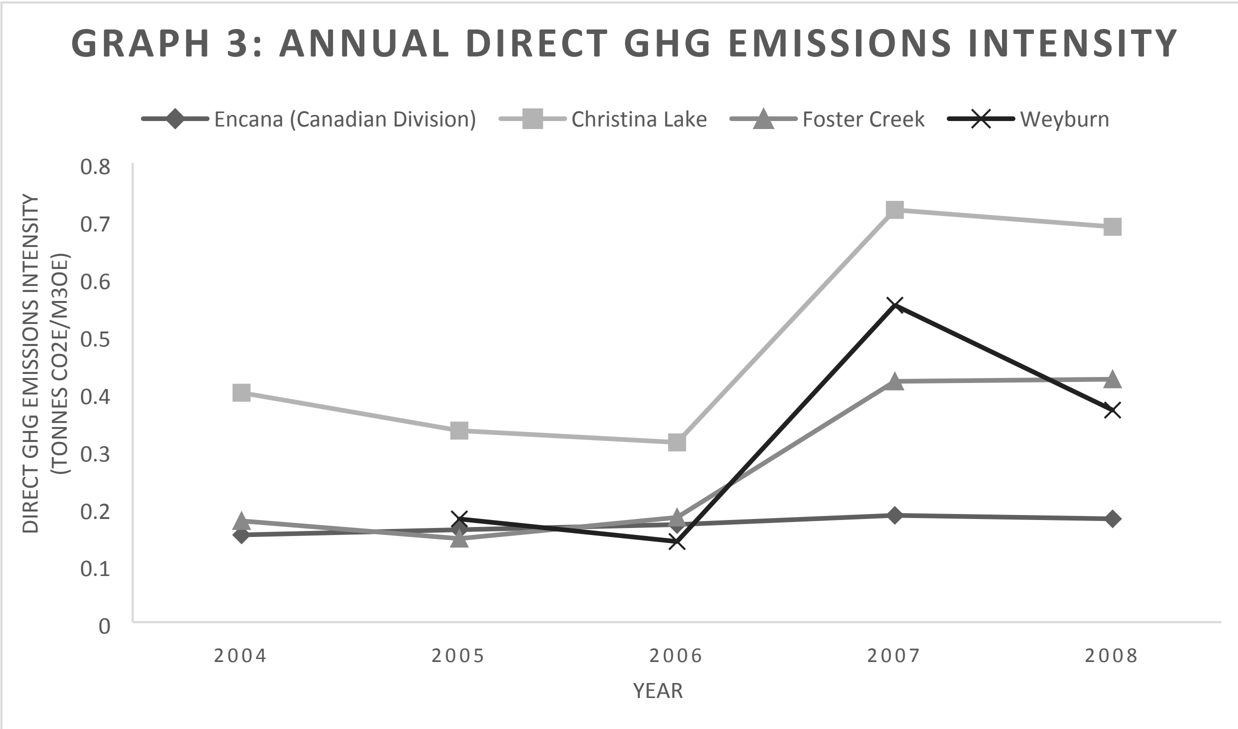


Table 1: Encana Direct (Scope 1) GHG Emissions and Intensity
Panel A: GHG disclosed in Encana's Corporate Social Responsibility Reports.

Year	Encana's Canadian Division (tonnes CO_2e)	Encana's Canadian Division Intensity (tonnes/m^3OE)
2009	2,734,000	0.16
2010	2,967,000	0.18
2011	3,074,000	0.16
2012	3,037,000	0.17

Panel B: Encana's facilities with GHG reported through Environment and Climate Change Canada with production information available in Encana's Annual Information Forms.

Year	Greater Sierra (tonnes CO_2e)	Greater Sierra Intensity (tonnes/m^3OE)
2009	128,283	0.06
2010	145,721	0.06
2011	130,764	0.05
2012	102,483	0.05

Panel C: Encana's facilities with GHG reported through Environment and Climate Change Canada with no disclosed production information in Encana's Annual Information Forms.

Year	Gunnell (tonnes CO_2e)	Resthaven (tonnes CO_2e)	Sexsmith (tonnes CO_2e)	Steeprock (tonnes CO_2e)
2009	66,556	60,989	84,070	78,532
2010	57,262	53,775	78,405	106,136
2011	-	57,923	70,915	97,073
2012	-	62,014	57,771	-

Table 2: Sample of Facilities by Corporate Group and Production Process for Facilities with 4 Years of Data

Corporate Group	Conventional Production	Non-Conventional Production	Petroleum Refinery	Total
Advantage	1	.	.	1
Bonavista	1	.	.	1
Chevron Canada	.	.	1	1
Connacher	.	1	.	1
ConocoPhillips	.	1	.	1
EnCana/Cenovus	3	2	.	5
Husky Oil Operations	3	1	3	7
Imperial Oil	1	1	4	6
Japan Canada Oil Sands	.	1	.	1
Keyera Energy	9	.	.	9
MEG Energy	.	1	.	1
Pengrowth	2	.	.	2
Penn West	1	.	.	1
Petro-Canada/Suncor	3	2	3	8
South Pacific Resource	.	1	.	1
Statoil	.	1	.	1
Syncrude Canada	.	1	.	1
Taqa	1	.	.	1
Veresen Energy	1	.	.	1
Total	26	13	11	50

Table 3: Descriptive Statistics of Sample Variables

Variable	Mean	Standard Deviation	Minimum	Maximum
Comparability (*CompGHG*)	-649647	1388366	-11422900	-87
Difference in production (*Diff*)	49529	53158	58	265631
Barrels (*Barrels*)	46133	50864	3035	268666
	Percentage of occurrence			
Process (*Process*)	37.4%			
Group (*Group*)	9.1%			
N	2450			

Table 4: Cross Sectional Analysis of the determinants of GHG emissions data comparability

Regression of comparability rating between facilities (CompGHG) on facilities having similar operational processes (Process) and facilities belonging to the same corporate group (Group).

Independent Variable	Predicted Sign	Coefficient	Standard Error	t-Stat	VIF	Tolerance
Process	+	236594***	38714	6.11	1.06	0.95
Group	+	53993	64270	0.84	1.02	0.98
Difference in production		-3.198***	0.421	-7.6	1.51	0.66
Barrels		-18.239***	0.432	-42.21	1.45	0.69
Intercept		256829***	32473	7.91		
N		2450				
F-statistic		837.423***				
R squared		0.578				
Adjusted R squared		0.577				

Notes:

Dependant variable (*CompGHG*) is the comparability rating between two facilities. The model is estimated using ordinary least squares regression.

Process (*Process*) = Dummy variable coded 1 where the two facilities being compared perform the same operational processes, 0 otherwise.

Group (*Group*) = Dichotomous variable coded 1 for facilities that belong to the same corporate group or 0 otherwise.

Difference in production (*Diff*) = Absolute value in terms of the difference in production, in barrels of oil equivalent per day, between the two facilities being compared.

Barrels (*Barrels*) = Production level, in barrels of oil equivalent per day, used in determining the dependant variable (*CompGHG*).

***p < 0.01, **p < 0.05, *p < 0.1

Table 5: Cross Sectional Analysis of the determinants of GHG emissions data comparability by process

Regression of comparability rating between facilities (CompGHG) with similar processes on corporate group (Group).

	Conventional		Unconventional		Refinery	
Independent Variable	Coefficient	t-Stat	Coefficient	t-Stat	Coefficient	t-Stat
Group	40662	1.151	-396826	-0.942	14683	0.258
Difference in production	-0.484	-0.701	-1.345	-1.286	-0.313	-0.479
Barrels	-6.158***	-9.359	-15.263***	-13.436	-2.468***	-4.681
Intercept	-20797	-0.943	148255	1.601	-46999	-0.774
N	650		156		110	
F-statistic	42.358***		106.454***		7.524***	
R squared	0.16		0.678		0.176	
Adjusted R squared	0.16		0.671		0.152	
Kruskall Wallis test significance	0.000		0.136		0.430	

Notes:

Dependant variable (*CompGHG*) is the comparability rating between two facilities. The model is estimated using ordinary least squares regression.

Group (*Group*) = Dichotomous variable coded 1 for facilities that belong to the same corporate group or 0 otherwise.

Difference in production (*Diff*) = Absolute value in terms of the difference in production, in barrels of oil equivalent per day, between the two facilities being compared.

Barrels (*Barrels*) = Production level, in barrels of oil equivalent per day, used in determining the dependant variable (*CompGHG*).

***p < 0.01, **p < 0.05, *p < 0.1