January 2011

Backgrounder

Life cycle assessments of oilsands greenhouse gas emissions

A checklist for robust analysis

Jeremy Moorhouse, Danielle Droitsch, Dan Woynillowicz

At a Glance

- Life cycle assessments (LCAs) provide decision-makers with information that can be critical in making important decisions about policy and infrastructure that impact global greenhouse gas emissions.

- Because of the unique issues associated with oil sands, decision-makers need a clear understanding of how an LCA might be used for oil sands to compare to other sources of transportation fuel, evaluate alternatives, and provide a robust analytical basis for informing decisions.

- Currently available greenhouse gas LCAs of the oilsands are either incomplete or insufficient, leading to confusing or misleading interpretations. Existing studies, while providing useful information, often use different assumptions, datasets and comparisons that can lead to widely divergent results.

- Because existing greenhouse gas life cycle assessment of oilsands were not designed to support major infrastructure decisions, decision-makers should consider conducting LCAs considering the unique issues associated with oil sands.

This backgrounder provides a general overview of life cycle assessment, examines the various analyses of oilsands GHG emissions conducted to date, and concludes with a recommended checklist for performing a robust life cycle assessment of oilsands GHG emissions to inform public policy decisions.

Introduction

Life cycle assessment (LCA) of greenhouse gas (GHG) emissions has been promoted as a tool to inform numerous decisions related to Canadian oilsands development, including low-carbon fuel standards, the proposed TransCanada Keystone XL pipeline, and the development of the European Fuel Quality Directive. While life cycle assessments of transportation fuels have been performed for over two decades, not until recently has LCA been used as a basis for fuel policies such as low-carbon fuel standards and renewable fuel standards.

Decision-makers will need to understand the usefulness and purpose of LCAs. This backgrounder is intended for decision makers considering GHG LCA of crude oil products derived from oilsands, and considers the following questions:

1. What is life cycle assessment?
2. Why use life cycle assessment of the oilsands?
3. What segment of the life cycle should be considered?
4. Why are there so many different life cycle values for oilsands production? And are the results from current studies accurate, complete, and transparent enough to use?
5. If existing studies aren't good enough, what would a robust study look like?

The backgrounder answers each of these questions and provides a checklist for how to perform a rigorous oilsands GHG LCA.

What is a greenhouse gas life cycle assessment?

A greenhouse gas life cycle assessment determines the total emissions of greenhouse gases over the birth, use and death of a product. Most people find it easier to understand the life cycle of a solid product like a paper cup than energy products like oil. In the case of a paper cup, its life cycle would consist of seven key stages:

1. Growing the tree;
2. Cutting it down;
3. Processing it;
4. Producing the cup;
5. Transporting the cup to its place of use, (e.g., a restaurant);
6. Using the cup; and
7. Disposing of the cup.

If we wanted to compare two cup manufacturers on GHG emissions we would add up the GHG emissions for each of these steps, and would likely find that one brand had lower GHG emissions. This information might result in labelling of one brand of cup versus the other.

At a basic level, assessing the greenhouse gas life cycle of oilsands is the same as for a cup, except in this case the stages are the production, upgrading, refining and delivery of gasoline or diesel (birth) plus the combustion of the fuel, usually for transportation (use and death).

Life cycle analysts have developed specific terminology when referring to the different segments of the life cycle of oilsands or any other oil source. This terminology is described below and depicted in Figure 1.

- **Well-to-wheels (WTW):** All GHG emissions, from the oil wells to combustion in the car, including: production (wells), upgrading, refining, transportation and dispensing at gas stations and combustion in the vehicle (wheels).
- **Well-to-tank (WTT):** Same as above, but without combustion emissions (wheels).
- **Tank-to-wheels (TTW):** Only the GHG emissions from combustion in the vehicle; in other words, just the emissions from driving the car.

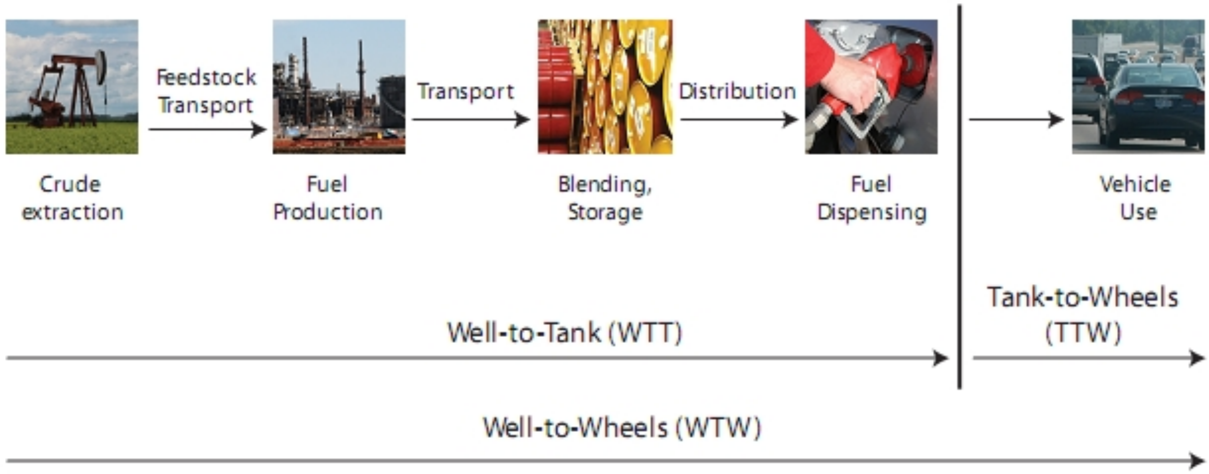

Figure 1. Comparison of different segments of the life cycle of oil

Many of the differences in the results of various life cycle studies come from the use of, and sometimes confusion among, these different terms.

Why use life cycle assessment of the oilsands?

Decision-makers who are assessing any project or policy related to oilsands development, and who consider GHG emissions an important criteria, should consider life cycle GHG emissions of oilsands for several reasons:

1. Location doesn't matter: All GHG emissions contribute to global warming. A project or policy in the United States that leads to increased emissions in Canada increases global GHG emissions.

2. Oilsands are GHG-intensive: All oilsands life cycle assessments have concluded that oilsands-derived gasoline and diesel are more GHG-intensive than average gasoline and diesel produced in the United States. Any increase in oilsands production will increase GHG emissions.

3. Alternatives must be considered: For decision-makers, there is value in determining the difference between alternatives. For example, when comparing crude oil sources or alternative energy sources with oilsands, only a life cycle approach can account for the true GHG emissions from the options.

4. The difference is significant: The emissions from increased oilsands production could erode benefits from clean energy initiatives like the renewable fuel standard.[1]

Ignoring life cycle emissions means not accounting for a significant source of carbon pollution — imagine estimating the price of gasoline by considering only the cost of selling the gas while ignoring the production and refining costs.

What segment of the life cycle should be considered?

Some of the confusion over LCA stems from the fact that life cycle values can answer different type of questions. For example, some studies are trying to determine which oil source is the most GHG-intensive, others to determine what transportation fuel source, including fuels like oil and biofuels, are the least GHG-intensive. To know what life cycle values to use, decision-makers must first define their question and then determine what segment of the life cycle to examine to best answer that question. Table 1 summarizes the types of questions decision-makers are asking along with the life cycle segment that is most useful.

Table 1: Types of life cycle questions and the segment of the life cycle that should be used

Question	Life cycle segment	Rationale
Where are the most significant emissions sources in the production and use of transportation fuel? Where can emissions be reduced most effectively in the production and use of transportation fuels?	well-to-wheels	• GHG reductions should take place where they are most cost effective. • Changes in one part of the life cycle may cause unintended changes in another (e.g. land use change); therefore the whole system should be considered.
What are the GHG differences between oil and alternatives like biofuels, electricity and hydrogen?	well-to-wheels	• The whole system must be considered because each segment results in different emissions. Some fuels also require vehicles that are inherently more efficient (e.g., internal combustion engine vs. electric engine).
What source of oil will have the lowest GHG emissions?	well-to-tank	• Oil sources differ in the production, distribution and refining parts of their life cycle. When the refined fuel is put into the tank of a car,

[1] Simon Mui, "Tar Sands and GHG Emissions: Setting the Record Straight," Switchboard: Natural Resources Defense Council Staff Blog, November 16, 2010, http://switchboard.nrdc.org/blogs/smui/tar_sands_and_ghg_emissions_se.html

		however,the resulting combustion emissions are the same, regardless of oil source.
What's the difference in GHG emissions between different oilsands technologies and products?	well-to-tank	• Different types of oilsands production (in situ drilling vs. mining) and different products (diluted bitumen vs. synthetic crude oil) can lead to a range of life cycle emissions over the activities in the WTT segment.

Why are there so many different life cycle values for oilsands?

Recent LCAs of oilsands GHG emissions provide a wide range of results that may lead decision-makers to conclude that life cycle assessment is too imprecise to be a useful decision-making tool. For example, one study may claim oilsands life cycle emissions are only 6% higher than U.S. average emissions while others claim oilsands well-to-tank (or upstream) emissions produce up to three times the emissions of conventional oil sources. The huge range in life cycle results can be traced to several factors: the objective of the study, the types of oilsands technologies and pathways considered, the boundary of the study, the data quality, and the assumptions made. However, the primary culprits for the perceived range of results are the segment of the life cycle presented, the specific oilsands pathway (i.e. how the bitumen gets from Alberta to the tank of a car) and assumptions made by the life cycle analysts.

Which segment of the life cycle was used?

The following two statements are from the same report.[2]

a. Oilsands emissions are 5 to 15% higher than average crude in the United States.
b. Oilsands fuel production produces 40 to 70% more emissions per barrel of oil than average sources in the United States.

The difference is that statement 'a' is a well-to-wheels number and statement 'b' is a well-to-tank number. Reports on emissions of oilsands tend to pull from different assessments and quote well-to-wheels, well-to-tank, well and sometimes well-to-refinery depending on the context and questions they are trying to answer. The result is a range of values that can confuse policy makers and the public. Decision-makers must ensure that they are using the right type of comparison for the question they are answering (as noted in Table 1, above).

[2] IHS CERA, *Oil Sands, Greenhouse Gases, and US Oil Supply: Getting the numbers right* (2010) 47, www2.ihscera.com/docs/Oil_Sands_Energy_Dialogue_0810.pdf

Which oilsands pathway was chosen?

Bitumen can take several different pathways to get from Alberta to the tank of a car in the United States. Each of these pathways has a different GHG profile and accounts for some of the variation in oilsands life cycle results. For example, one pathway that is sometimes identified with lower GHG emissions is actually a mixture of energy sources called dilbit (***dil***uent, a natural gas condensate, plus ***bit***umen from oilsands). The diluent is added in order to transport the viscous and sticky bitumen through pipelines. Producing diluent produces fewer GHG emissions than producing bitumen. Mixing the low-GHG diluent with the relatively higher-GHG bitumen reduces the apparent life cycle oilsands emissions of the mixture by about 6% on a well-to-wheels basis. Mixing a barrel of conventional crude oil with a barrel of high-GHG crude oil like oilsands can also result in the "average" barrel appearing to be lower. This is analogous to mixing a glass of cold water and hot water to produce a glass of warm water. Like the temperature of the source of the hot water, though, the carbon-intensity value of the specific source of crude oil (bitumen) does not change.

What assumptions were made?

The types of data that life cycle analysts choose to use in their reports can significantly change the results of a LCA. One important data choice is the steam-oil-ratio or SOR. The SOR measures the amount of steam used to produce a given amount of bitumen at an oil sands facility. Since steam is created by combusting natural gas, which creates GHG emissions, it's also a major determinant of the GHG intensity of the facility (a higher SOR correlates to higher GHG emissions). SORs in the oilsands range from 2 to over 7 with a weighted average of 3.6.[3] However, most studies use lower SORs in the range of 2.5 to 3. The choice of SOR can influence the well-to-wheels oilsands life cycle by around 3%.

Are the results from current studies accurate, complete, and transparent enough to use?

None of the existing studies were designed to answer the types of questions they are being used to answer. As a result, no existing study, or the combination of studies, is accurate, complete or transparent enough to use for major infrastructure and public policy decisions. Most current studies attempting to evaluate or compare GHG emissions do not account for all significant emissions or they uniformly use the same assumptions and data sets. Some of these gaps are described in more detail below and are also documented by Charpentier et al.[4] The incompleteness of the studies may also reflect the lack of information on specific projects, as well as analyst decisions of what emission sources to include and what not to include. In many cases, studies report estimates but are not transparent about the sources

---

[3] Based on reported steam usage and bitumen production tables for 2009 for the industry, published by the Energy Resources Conservation Board (2010) in *ST-53 Alberta Crude Bitumen In Situ Production Monthly Statistics.*

[4] A. Charpentier, J. Bergerson and H. MacLean, "Understanding the Canadian oilsands industry's greenhouse gas emissions," *Environmental Research Letters* 4 (2009). Available at: http://iopscience.iop.org/1748-9326/4/1/014005/pdf/1748-9326_4_1_014005.pdf.

of data used, such that results cannot be reproduced or verified. Decision-makers should use care to fill in gaps when using results from current studies and, for regulatory purposes, require specific project and industry reporting of emissions.

In some cases, the assumptions, data and results reflect the research question being considered. For example, the consultant studies conducted by the Alberta Energy Research Institute (now Alberta Innovates) attempted to answer the question of how oilsands compares to a handful of other crude oil sources. This perspective is useful but due to its general application could not be used to answer questions like, "What is the net increase in GHG emissions coming from the increased oilsands production that will fill the Keystone XL pipeline?" Other studies, like the CERA analysis, modify the results of primary studies to attempt to reduce the variation between results. However, as discussed above, the analysis does not provide enough information to reproduce the results or to understand how primary studies were modified.

What does a robust GHG LCA of oilsands look like?

The necessary elements of a rigorous oilsands GHG LCA can be pulled from the existing body of oilsands LCAs. The following checklist is intended for those providing direction to LCA consultants, as a guide for LCA practitioners working on oilsands LCAs, and as guide for evaluating existing reports.

A checklist for oilsands GHG life cycle assessments

Each of the checkboxes must be checked when undertaking a LCA of oilsands GHG emissions that is sufficiently rigorous and robust enough to support major infrastructure decisions and public policy discussions. The checklist covers:

- ☐ Goal definition and study design
- ☐ Appropriate technologies and pathways
- ☐ Defining the boundaries
- ☐ Data sources and quality requirements
- ☐ Allocation
- ☐ Critical review and transparency

For each item, a recommended approach, International Organization for Standardization (ISO) guidance[5] and lessons learned from existing LCA studies of oilsands GHG emissions are provided. This checklist is intended to supplement, not replace, ISO LCA requirements and guidance.

❒ Goal definition and study design

Recommended approach: The objective and design of the GHG LCA oilsands study must reflect the intended use of the study results. For example, if a study's results will be used to make a decision on major infrastructure such as a pipeline, then the objective of the study and its design should determine the life cycle GHG intensity of oilsands for that particular pipeline considering and, if applicable, compared against other crude oil sources and other alternatives to the pipeline. The scope, data quality, rigour, assumptions, level of transparency and critical review should all be designed to support the objective of the report.

Why this recommendation?

LCA practitioners base all major decisions, including scope, data quality, assumptions, cost estimates and time commitment, on the goal or objective of the study. They follow ISO requirements that the goal and scope of the study be clearly stated and consistent with the intended application of the results. The process is similar to asking an engineering firm to design a bridge with the objective that it supports pedestrian traffic only. If you subsequently used the pedestrian bridge designs as the basis for a vehicle bridge, the

[5] As presented in ISO 14044:2006 *Environmental Management - Life Cycle Assessment - Requirements and Guidelines*, 54. and ISO 14040:2006 *Environmental Management - Life cycle assessment - Principles and framework*, 28.

structure would likely collapse. Similarly, decisions based on LCA studies not designed to support those decisions will fail to achieve expected results.

Existing GHG LCA of oilsands were not designed to support major infrastructure decisions or as the basis of public policy in the United States.[6] The results of these studies should be used with caution and as preliminary values only while more rigorous assessments are performed.

❐ Appropriate technologies and pathways

Recommended approach: The assessment must explicitly justify including or excluding any of the three primary oilsands extraction technologies: steam assisted gravity drainage (SAGD), cyclic steam stimulation (CSS) and mining and upgrading (coking and hydrocracking). It must also include the different oilsands pathways. For example, bitumen produced by any of the production technologies can be upgraded and transported as synthetic crude oil or dilbit (bitumen combined with diluent). The carbon intensity of diluent (or other crude oil sources) should be reported separately.

Why this recommendation?

Oilsands technologies and pathways have different well-to-tank GHG emissions that can vary by up to 40%. For example, the Jacobs study's oilsands pathways ranged from 48 kg CO_2eq/MJ gasoline for SAGD with upgrading to 35 kg CO_2eq/MJ gasoline for mining.[7] This variation reflects the actual GHG emissions of different oilsands technologies and pathways. The life cycle GHG emission value or values used to make a decision or design policy must be based on the specific question of the study.

---

[6] For example, the Jacobs study stated as its goals:

> "Enhance generic well-to-wheel life cycle assessment of transportation fuel production and consumption with an assessment that more properly reflects differences between crude oil production, upgrading, and refining, for a representative basket of benchmark crudes processed in the United States.
>
> "Ensure transparency of results, methodology and underlying data by using public and defendable data sources and recognized and transparent LCA methodology and model – similar to what is used in California for LCFS and other well vetted life cycle studies."

(Jacobs Consultancy and Life Cycle Associates, *Life Cycle Assessment Comparison of North American and Imported Crudes*, prepared for Alberta Energy Research Institute (2009), http://www.albertainnovates.ca/media/15753/life%20cycle%20analysis%20jacobs%20final%20report.pdf)

Another frequently cited study, CERA, *Oil Sands, Greenhouse Gases, and US Oil Supply,* stated its goal as

> "The objective of this report is to provide an independent perspective on the life-cycle GHG emissions of oilsands compared with other crudes; on the evolving discipline of estimating life-cycle GHG emissions, particularly for oilsands; and on the growing trend of using life-cycle GHG analysis in policy. These policies have the potential to affect the market for Canadian oilsands and other sources of carbon-intensive crude oil."

[7] Jacobs Consultancy, *Life Cycle Assessment Comparison,* 178.

ISO LCA guidelines do not provide specific guidance on what types of technologies or fuel pathways should be considered. However, existing studies have explored available production techniques and tend to consider similar oilsands production technologies and fuel pathways. Most studies include mining, steam assisted gravity drainage (SAGD), cyclic steam stimulation (CSS) and upgrading technologies. Upgrading is sometimes divided into coker and hydrocracking, the two main upgrading techniques used in the oilsands.[8] In terms of fuel pathways, bitumen produced by either mining, SAGD or CSS is either upgraded to synthetic crude oil and/or mixed with other hydrocarbons to produce either dilbit or synbit. The Jacobs and TIAX reports both do a thorough job of characterizing current technologies and oilsands pathways but were limited by the data provided on the projects. For example, the two largest mining projects, comprising the majority of existing mining production output, were not included in the studies.

❐ Defining the boundaries

Recommended approach: The boundaries of an assessment are determined by deciding which activities will be included and which excluded. Consistent cutoff criteria must be used, such as requiring that all activities that contribute more than 1% of total life cycle emissions be included. Oilsands life cycle assessments typically exclude several emission sources that likely surpass this 1% threshold, such as:

- electricity and natural gas supply chains
- venting, flaring and fugitive emissions (e.g., tailings ponds and mine face)
- land use change (e.g., forest or wetland clearing)
- upgrading at refineries

Why this recommendation?

It is considered best practices, based on ISO LCA guidance documents and other LCA guidance documents, to use a 1% threshold.[9] Life cycle studies that do not apply the 1% cutoff could significantly underestimate well-to-wheel or well-to-tank emissions. All existing oilsands life cycle assessments appear to exclude some or all of the emission sources noted in the recommendation.

Some existing studies have used the 1% threshold. For example, a study by the U.S. Department of Energy defined the boundary as including "significant" emission sources

[8] For example, Jacobs Consultancy, *Life Cycle Assessment Comparison,*178 includes both coker and ebulating-bed hydrocracking for the upgrading process.

[9] David T. Allen et al, *Framework and Guidance for Estimating Greenhouse Gas Footprints of Aviation Fuels*, interim report to the Aviation Fuel Life Cycle Assessment Working Group, Air Force Research Laboratory, United States Air Force, AFRL-RZ-WP-TR-2009-2206 (2009), http://www.netl.doe.gov/energy-analyses/pubs/EstGHGFtprntsAvFuels2009.pdf

contributing more than 1% to the total energy used by the process.[10] In another example, the U.S. Department of Defense established the following sources as being within the boundary of their LCA: [11]

- Raw Material Acquisition: Includes land-use changes, the extraction of raw feedstocks from the earth and any partial processing of the raw materials that may occur
- Raw Material Transport: Includes emissions associated with transport of the raw materials from the end of extraction/pre-processing to the refinery gate.
- Liquid Fuels Production: Includes emissions directly occurring at the refinery associated with the product as well as emissions associated with acquisition and production of indirect fuel inputs. Indirect fuel inputs include, for example, purchased power and steam, purchased fuels such as natural gas and coal, hydrogen plant feedstock and fuels produced and subsequently used in the refinery.
- Product Transport and Refueling: Includes emissions associated with product transport, storage, delivery, and dispensing.
- Vehicle Operation: Includes end-use combustion of the liquid fuel.

In addition to the direct or on-site emission sources for each of the life cycle segments, the following sources would likely meet the 1% significance threshold and should be included in LCA of oilsands. Table 2 below provides some estimates from literature for these emission sources, as well as from additional activity sources.

Table 2: Typically excluded emission sources and life cycle emission contribution

Activity Source	Issue	Estimates		Data
		g CO2e/MJ gasoline	% change in WTW emissions	
Land Use Change	Emissions from the removal of vegetation and treas, soil, and peat is significant particularly for mining practices	0.8 to 2.3	0.9 - 2.5%	Yeh et al. (2010)
Fugitive Emissions	Tailing Ponds (mining)	0 - 7.9	0 - 9%	Yeh et al. (2010)
	Leaks	0 - 0.9	0 - 1%	NRCan (National Inventory Report: 1990 - 2008)
Venting and Flaring	Venting and flaring emissions are generally higher for mining versus in-situ	0.5- 3.3	0.5 - 3.6%	TIAX (2009)
Natural Gas and Electricity Supply Chain	Emissions from producing natural gas off-site for oil sands can be significant	4 - 5.3	4.3 - 5.7%	Jacobs (2009)
Refinery Upgrading and Processing	Upgrading at refineries tend to increase emissions	4.6 - 12.1	5- 13%	NRCan (2008), Jacobs (2009), Tiax (2009): Dilbit versus SCO
Steam Use	Weighted industry average is currently closer to 3.6 SOR (steam oil ratio) rather than 2.5 or 3 SOR	2.9	3%	ERCB (2010)
Construction	Construction of facilities, machinery, vehicles and roadways for the capital-intensive infrastructure are currently not captured	n/a	9 - 11%	Bergerson and Keith (2006)

Table 3 compares existing life cycle studies by activities included. This table updates information first reported by Charpentier et al.[12]

[10] U.S. Department of Energy, National Energy Technology Laboratory, *Development of Baseline Data and Analysis of Life Cycle Greenhouse Gas Emissions of Petroleum-Based Fuels* (2008) 4, http://www.netl.doe.gov/energy-analyses/pubs/NETL LCA Petroleum-based Fuels Nov 2008.pdf

[11] Allen et al, *Framework and Guidance for Estimating Greenhouse Gas Footprints of Aviation Fuels.*

Table 3: Summary of oilsands LCAs and included activities

Study/Model	Pathways		Included in the Well-to-Wheels Analysis?							Data Sources
	Surface Mining & Upgrardin g	In-Situ w/ Upgrading	Natural Gas Supply Chain	Electricity Supply Chain	Venting & Flaring	Fugitives: Leaks	Fugitives: Tailing Ponds	Land Use	Construction	
NRCan/GHGenius	√	√	Yes	Yes	Yes	Yes	Yes	?	no	Shell Jackpine, Total Joslyn, Suncor, Syncrude
US DOE ANL/GREET	√	√	Yes	Yes	?	?	?	no	no	Alberta Chamber of Resources (2004)
US DOE NETL	√	√	?	?	Yes	Yes	?	?	no	Imperial Oil and Syncrude
MIT-TIACA/GREET	√	√	Yes	Yes	?	?	?	no	no	Deer Creek Energy, Synenco Energy, Shell Canada
Brandt and Farrell	√		?	?	no	no	no	no	no	Publicly available data/GREET
TIAX	√	√	Yes	Yes	Yes	Yes	Yes	no	no	CNRL Horizon and Primrose, NEXEN Opti Long Lake, Imperial Oil Cold Lake, EnCana Christna Lake, Petro-Canada MacKay River
Jacobs Consulting	√	√	Yes	Yes	?	?	no	no	no	Process modeling with inputs based on various industry sources and estimates
McCulloch et al	√	√	?	?	?	?	?	?	no	CNRL Horizon, Imperial Oil, Flint (2004), ACR (2004)
Furminsky	√	√	no	no	no venting	no	no	no	no	Modeling
CERA	√	√	no	no	?	?	no	no	no	Other studies (adjusted)

Most, if not all, exclude numerous activity sources that can be significant. The exclusion of specific sources contributes to discrepancies between LCA studies and generally results in reducing the apparent carbon intensity of oilsands development.

All LCA studies of oilsands GHG emissions have excluded construction-related emissions, emissions due to human activity, and accidental releases. In some cases these may be significant. Construction and capital-related emission have been estimated to add an additional 20 to 25% to the direct production emissions, or an additional 9 to 11% of well-to-wheels.[13] As Charpentier states, "excluding these activities has been common practice in life cycle studies to date, although it is not necessarily recommended for future studies of technologies with large infrastructure requirements such as the oilsands."[14]

❐ Data sources and quality requirements

[12] A. Charpentier et al., "Understanding the Canadian oilsands industry's greenhouse gas emissions."

[13] J. Bergerson and D. Keith (2006). "Life Cycle Assessment of Oil Sands Technologies." Paper No. 11 of the
Alberta Energy Futures Project. University of Calgary; J. Bergerson's (2007), "The Impact of LCFS on Oil Sands
Development: Hybrid LCA Methods, Presentation at the InLCA/LCM Conference, October 2, 2007. Unversity of
Calgary. http://www.lcacenter.org/InLCA2007/presentations/LCFS-Bergerson.pdf.

[14] A. Charpentier et al., "Understanding the Canadian oilsands industry's greenhouse gas emissions."

Recommended approach: Data for each of the processes should be based on information that can be reviewed by regulators and the public. The data sources should be customized to suit the question of the study. Ideally the data sources should be third-party verified and/or reviewed by way of a scientific or technical journal publication, and be based on aggregated operating data (as opposed to hypothetical data) for all of the activities included in the boundary.

Why this recommendation?

Much of the uncertainty associated with oilsands GHG LCAs stems from data choices and data quality. Data and data quality must be chosen to enable the LCA goal and objective to be met. Decision-makers considering major infrastructure projects or public policy must base their decisions on current and accurate data. No current oilsands GHG LCA uses the appropriate data and data quality necessary to fully and accurately answer major infrastructure and public policy questions. Some studies consider hypothetical data based on a single project. Additional justification and guidance is provided below.

ISO LCA documents provide some guidance on data sources and data quality. In general "data quality requirements shall be specific to enable the goal and scope of the LCA to be met." ISO recommends evaluating data on ten different indicators.[15]

In general, current LCAs use data from several data sources — primary operator data, primary analyses from third party sources, government publications and other academic and technical reports. GHG emission estimates for oilsands are typically based on top-down estimates (i.e., derived from regional or national data) or bottom-up estimates (i.e., derived from an inventory of sources for specific projects). These data sources are discussed in more detail below.

- **Primary operator data** includes project applications and accompanying Environmental Impact Statements (EIS),[16] project emissions data, as well as submissions to the Government of Canada's Greenhouse Gas Emissions Reporting Program, Alberta Greenhouse Gas Reporting Program, and Voluntary Challenge and Registry (VCR). Typically, the reporting and accounting method for site emissions differ from company to company and by reporting program. Much of the operator data represent only direct site emissions as opposed to indirect emissions from the natural gas and electricity supply chains.
- **Primary third party analysis** include publications based on unpublished data, data obtained through confidentiality agreements with operators, or consulting studies based on primary operator data. For example, the Canadian Industrial Energy End-use Data and Analysis Center (CIEEDAC) at Simon Fraser University has published several

[15] ISO 14044:2006, 54.

[16] See, for instance: CNRL, *Horizons Oil Sands Project Application for Approval* (2002).

reports using confidentially-obtained data.[17] This work involved coordination between individual operators and Statistics Canada to develop a consistent dataset of energy consumption and emissions. Recent work by TIAX Consulting, for instance, relies heavily on primary operator data combined with modelling of specific processes.[18]

- **Government and industry publications** include the a handful of government and industry publications based on a combination of publicly available operator data as well as private data obtained through confidentiality agreements. The 2004 *Oilsands Technology Roadmap* by the Alberta Chamber of Resources, for instance, relies heavily on LENEF and McCann values as well as in-house calculations.[19] Natural Resources Canada has also published a number of relevant reports, including the "2008 Crude Oil Production Update for GHGenius" which relies on Canadian Association of Petroleum Producers (CAPP) reports, the CIEEDAC report mentioned above, and their own 2006 *Canada's Energy Outlook*.[20]
- **Secondary sources: Academic and technical reports** include those that rely or build upon existing reports and datasets. Of particular note in this category are several reports published by Brandt and Farrell,[21] Mui,[22,23] CERA,[24] and Larsen and Wang.[25] Larsen and Wang relies on industry-level data from the Oilsands Technology Roadmap to produce top-down, average estimates of the energy use from tar sands extraction and upgrading. CERA, for instance, relies on a review of primary operator datasets and literature values, adjusting these using internal assumptions to generate emission values.

Overall, reliance on these different data sources and methodologies — though necessary in practice — results in variations in the reported emission sources and resulting values. Government reporting standards and guidance, together with requirements for transparency, are necessary to achieve more consistent reporting and accurate accounting.

---

[17] CIEEDAC, *A Review of Energy Consumption in Canadian Oil Sands Operations, Heavy Oil Upgrading 1990, 1994 to 2001* (2003).

[18] TIAX LLC and MathPro Inc, *Comparison of North America and Imported Crude Oil Lifecycle GHG Emissions*, Final Report, prepared for Alberta Energy Research Institute (2009), http://www.albertainnovates.ca/media/15759/life%20cycle%20analysis%20tiax%20final%20report.pdf; Jacobs Consultancy, *Life Cycle Assessment Comparison*.

[19] Alberta Chamber of Resources, *Oilsands Technology Roadmap: Unlocking the potential* (2004), http://www.acr-alberta.com/Portals/0/projects/OSTR_report.pdf

[20] GHGenius, http://www.ghgenius.ca/

[21] A.R. Brandt and A.E. Farrell, "Scraping the bottom of the barrel: greenhouse gas emission consequences of a transition to low-quality and synthetic petroleum resources," *Climatic Change*, 84 (2007):241-263.

[22] Mui et al., *Setting the Record Straight: Lifecycle Emissions of Tar Sands,* (Natural Resources Defense Council, 2008), http://docs.nrdc.org/energy/ene_10110501.asp.

[23] Mui et al., *GHG Emission Factor for High Carbon Intensity Crude Oil,* (Natural Resources Defense Council,2010), http://docs.nrdc.org/energy/files/ene_10070101a.pdf.

[24] CERA, *Oil Sands, Greenhouse Gases, and the US Oil Supply*.

[25] R. Larsen, M. Wang et al., "Might Canadian Oil Sands Promote Hydrogen Production for Transportation? Greenhouse Gas Emission Implications of Oil Sands Recovery and Upgrading," *World Resource Review*, 17, no.2 (2005): 220-42.

❐ Allocation

Recommended approach: Allocation of emissions among different products must be done carefully, following ISO guidelines. Allocation procedures should not be pulled directly from existing studies as most studies conclude that their allocation procedures are preliminary or not discussed in sufficient detail.

Why this recommendation?

In most life cycle assessments, the analyst must distribute emissions between different products. For example, a refinery produces diesel, gasoline, jet fuel and a number of other fuels and chemicals. Should the GHG emissions from the refinery be allocated based on the volume, the mass, the energy content or the financial value? This type of choice comes up often and is a significant source of variability between oilsands GHG LCAs. Most recent oilsands GHG LCAs note that the treatment of allocation in their own and in other studies is insufficient and requires further consideration. Decision-makers relying on existing studies that have not appropriately addressed allocation risk making poor decisions. Additional justification and specific recommendations for oilsands GHG LCAs is provided below.

Allocation procedures must be addressed when the study system generates co-products like excess electricity or coke in oilsands studies. Some of the environmental burden of the system should be attributed to these co-products, but the method of doing so is often uncertain and a source of variation when comparing different LCAs.

For example, Charpentier found that accounting, allocation and crediting are insufficiently discussed in existing oilsands life cycle assessments and must be explored in more detail.[26] ISO provides guidance on allocation methods, recommending first "wherever possible, allocation should be avoided" by either dividing the unit processes (e.g., understanding the specific unit processes within a refinery required for processing gasoline and diesel) or expanding the product system (e.g., considering how coke is used and what other products like coal it displaces).

For oilsands LCAs, allocation must be considered for three key processes: cogeneration at the production facility, and refining and coke production both at upgrading and refining facilities. No oilsands LCA has provided a widely-supported approach for allocating cogeneration emissions or addressing coke. Jacobs, for example, concluded "the treatment of co-products such as petroleum coke and cogenerated electricity is complex, and this Study treated such emissions in a preliminary manner to indicate the need for more rigorous and comprehensive analysis in future work. "[27]

There appears to be sufficient information and experience at the refinery level to determine the energy requirements for specific products like gasoline and diesel. The

[26] A. Charpentier et al., "Understanding the Canadian oilsands industry's greenhouse gas emissions."

[27] Jacobs Consultancy, *Life Cycle Assessment Comparison,* 178.

Jacobs study used this approach in its modelling. To our knowledge Jacobs' approach is widely supported in the LCA community and is one of the key benefits of their report.

❐ Critical review and transparency

Recommended approach: An oilsands LCA with the goal of supporting major infrastructure decisions and public policy development must be submitted to a third-party critical review. That third party must have the resources and expertise necessary to review the assessment and the authority to approve the assessment. In addition, the third party's comments must be public, along with all of the data used and any assumptions with rationale. Where necessary confidential information is used, a third party must review the data and provide public comments as to its appropriateness for the study.

Why this recommendation?

Critical reviews and transparency are an essential aspect of public LCAs that make "comparative assertions." (for example, whether one oil source is less GHG-intensive than another). Not only because this is supported by ISO, which recommends "… a panel of interested parties shall conduct critical reviews on LCA studies where the results are intended to be used to support a comparative assertion intended to be disclosed to the public," but also to enhance the credibility of the study and provide necessary detail for public scrutiny. In addition, the level of critical review and transparency must align with the goal of the study.

To date, oilsands LCAs have appeared in a number of publications with varying degrees of transparency and levels of critical review. For example, a steering committee reviewed and helped direct the Jacobs and TIAX reports. Their comments were also made public. However, these groups were not funded and therefore had a limited ability to adequately engage. A life cycle critical review requires time that must be supported both in the schedule and funding of an LCA. GHGenius, NETL and Charpentier reports all received critical reviews as well. However, none of these analyses were designed to answer the types of questions decision-makers are asking specifically to support public policy.

From a transparency perspective, ISO provides clear guidance on how data sources, data quality, calculations and assumptions should be presented. In general, sufficient transparency should be provided such that a third party could replicate the results. LCAs may require confidential information and could therefore not be made public. In this situation a third party would vouch for the information.[28] Most LCA reports provide data transparency; however, some essential information is often missing. For example, Mui was

[28] ISO 14044:2006, 54.

unable to determine how CERA adjusted numbers from primary literature sources in their oilsands LCA meta-analysis.[29]

[29] Simon Mui *Tar Sands: Why Alberta Has A Credibility Problem* (2010) http://switchboard.nrdc.org/blogs/smui/tar_sands_why_alberta_has_a_cr.html

Current LCA studies

Many groups have prepared LCAs of oilsands-derived fuels. Table 4 lists the studies reviewed for this backgrounder. All of these reports have contributed to the debate on how oilsands LCAs should be developed and reported, and what the final values are. Some reports determined new oilsands LCA values (Referred to as "Calculated" in the type of analysis in Table 4) and others have combined results from other LCA reports ("Meta-analysis" in Table 4).

Table 4: Summary of reports reviewed

Report	Type of analysis
Charpentier, Alex, Joule Bergerson, and Heather MacLean. "Understanding the Canadian oilsands industry's greenhouse gas emissions." *Environmental Research Letters* 4 (2009).	Meta-analysis
DOE/NETL. *Development of Baseline Data and Analysis of Life Cycle Greenhouse Gas Emissions of Petroleum-Based Fuels* (2008).	Calculated
Jacobs Consultancy and Life Cycle Associates. *Life Cycle Assessment Comparison of North American and Imported Crudes*. Prepared for Alberta Energy Research Institute (2009),	Calculated
CERA. *Oilsands, Greenhouse Gases, and US Oil Supply* (2010).	Meta-analysis
Mui, Simon et al. *GHG Emission Factors for High Carbon Intensity Crude Oils*. (Natural Resources Defense Council, 2010).	Meta-analysis
TIAX LLC and MathPro Inc. *Comparison of North America and Imported Crude Oil Lifecycle GHG Emissions*, Final Report. Prepared for Alberta Energy Research Institute (2009).	Calculated
Natural Resources Canada. GHGenius v.3.19. 2010.	Calculated
Argonne National Laboratory, GREET 1.8d.1. 2010.	N/A

All of the studies listed in Table 4 have calculated LCA values for oilsands GHG emissions, but none satisfy all of the requirements discussed above.