REVIEW OF STUDIES ON OIL SANDS AND OIL SHALE

Prepared For:

European Commission
DG Climate Action
1049 Bruxelles
Belgium

Prepared By

(S&T)^2 Consultants Inc.
11657 Summit Crescent
Delta, BC
Canada, V4E 2Z2

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Executive Summary

In late 2010, the European Commission contracted the preparation of two studies to establish average greenhouse gas emission values for oil sands and oil shales. Adam Brant of Stanford University undertook the studies.

Brandt has utilized the best sources of data available at the time for the two different papers.

The paper on the Estonian oil shale industry found insufficient information on that industry to establish an industry average GHG emission intensity and instead relied on US studies to establish a wide range of possible values. It would appear that very little oil shale is finding its way into transportation markets at the present time and that the structure of industry is quite different than the traditional petroleum sector. For these reasons, a GHG emission intensity for Estonian oil shale derived transportation fuels should be determined on a full lifecycle basis and not as an amendment to one stage of the traditional petroleum lifecycle.

The Brandt analysis of the Canadian oil sands sector focuses on the production of synthetic crude oil and not on the average output of the sector. There is more crude bitumen exported from Canada than there is synthetic crude. The bitumen has a lower GHG emission intensity as it is delivered to the refinery gate and thus the most likely value for the emission intensity identified by Brandt for synthetic crude oil does not represent the industry average value for all oil sands derived crude oils.

Synthetic crude oil and bitumen will have very different refining profiles and comparing these and other crude oils just on the basis of their production intensities and assuming that the refining emissions do not change is highly problematic and is not aligned with the ISO LCA principles of comparing systems on an equivalent basis. Brandt correctly identifies two significant uncertainties with respect to the overall GHG emission intensities for transportation fuels produced by unconventional crude oils;

- Varying product slates from different crude oils, and
- The overall GHG emission impacts in the region of less residual oil production.

The two different crude oils produced from oil sands will respond differently in a refinery with respect to these two areas of uncertainty. Synthetic crude oil should benefit (lower refining GHG emissions) from a higher proportion of high value refined products being produced and by the lack of residual oil production as well as from the low sulphur content of the crude oil. The bitumen, on the other hand will have higher refining emissions due to its sulphur content and density and it will still produce residual oil.

There are approaches that can be employed to normalizing the GHG emission intensities of different crude oils to account for the refining differences caused by sulphur, density and residual oil production. These should be applied to all crude oils used by the European refining industry so that a more accurate assessment of the GHG emission intensity of each crude oil can be identified.

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1. INTRODUCTION

In late 2010, the European Commission contracted the preparation of two studies to establish average greenhouse gas emission values for oil sands and oil shales.

The Commission wishes to assess the scientific and technical credibility of the reports entitled "Upstream greenhouse gas (GHG) emissions from Canadian oil sands as a feedstock for European refineries" and "Greenhouse gas emissions from liquid fuels produced from Estonian oil shale". To this end the Commission would like to know whether:

1. Ample pertinent scientific and technical data (existing in mid-2010) have been taken into account in the preparation of the studies;
2. The analysis contained in the reports supports the most-likely industry-average greenhouse gas emission values concluded for Canadian oil sand and Estonian oil shale to be used as refinery feedstocks for producing transport fuel in the EU in the near future (i.e. the next 1 to 4 years)?
3. The values represent industry-average greenhouse gas emissions or, if not, whether they should be marginally or substantially higher or lower;
4. Any other information has been omitted in preparing the reports that, if taken into account, would have a material impact on the average greenhouse gas emission values concluded for oil sand and oil shales;
5. On the basis that Canadian deposits constitute an overwhelmingly higher portion of recoverable oil sands than any other source (e.g. Venezuelan), is it appropriate to conclude that the average upstream greenhouse gas intensity for Canadian oil sands presented in the study is representative of oil sand-derived fuel most likely to be consumed in the EU?

In addition, The Commission has supplied comments on the Oil Sands report from Natural Resources Canada and comments are provided with respect to that information as well.

1.1 CONTEXT

The studies were conducted to help inform the development of European policy as regards greenhouse gas intensity of transport fuels.

In April 2009, Directive 2009/30/EC was adopted which revises the Fuel Quality Directive [Directive 98/70/EC]. It amends a number of elements of the petrol and diesel specifications as well as introducing in Article 7a a requirement on fuel suppliers to reduce the greenhouse gas intensity of energy supplied for road transport (Low Carbon Fuel Standard).

A number of aspects of the Directive require further work. As a result the Commission has recently published a consultation on the implementation of various issues relating to Article 7a.

The three main goals of Article 7a are to provide an incentive to:

- optimize GHG performance of biofuels,
- encourage the use of lower GHG intensity fuels,
- reduce GHG emissions from fossil fuel pathways.

The elements dealing with the calculation of GHG emissions for biofuels are already included in Annex IV of the Directive. However, the methodology for the calculating and reporting of

GHG intensity of other energies and fuels were not included in the Directive but are instead foreseen to be adopted through the comitology procedure.

Stakeholders' views have been solicited on a number of issues including:

- Part 1: article 7a(5a): A methodology is needed for fuel and energy that does not encourage any unwanted behaviour such as counting only a part of the savings achieved, and one that, as reasonably as possible, reflects the actual emissions from different fuels. Article 7a(5a) requires that this methodology is established for calculating GHG intensity of fuels other than biofuels and for energy supplied to road transport and non-road machinery.

  At this stage two approaches have been identified for calculating the GHG emissions of fuels and energy as well as a hybrid of both of these approaches. The first approach would be to establish fixed values (i.e. default values) for the various fuel and energy sources. The second approach would be to establish a methodology for calculating the GHG intensity of every consignment of fuel. A hybrid approach would broadly mimic the approach taken for biofuel GHG calculations where a default value is established but the possibility exists for suppliers to use another methodology if they can demonstrate that their fuel performs better than the default value.

- Part 2: Article 7a(5b) requires the establishment of the baseline GHG intensity against which future GHG intensity is to be measured. The baseline shall be based on the EU average level life cycle GHG emissions per unit of energy from fossil fuel products in 2010. EU average could be based on weighing determined by volume, mass, or energy.

A number of proposed default values were included in the public consultation paper and some of these are shown below.

Table 1-1 Proposed Draft Default Values

	GHG (gCO_2eq)/MJ (LHV)				Reference
	Extraction	Refining	Transport Distribution and Combustion	Total	
Petrol	4.5	7	1+73.3	85.8	
Diesel	4.6	8.6	1+73.2	87.4	
LPG				73.6	WTT app 1
CNG				76.7	WTT app 1
Electricity (EU Average)	120 = [48g] adjusted for vehicle efficiency				WTT app 1
Tar Sand	25	8.6	73	107	Based on Trucost Research Note
CTL	100	1	70.8	172	WTT app 1
CTL with CCS	9	1	70.8	81	WTT app 1
GTL	25	1	70.8	97	WTT app 1

Most of the values are derived from the JRC Wells to Wheels life cycle studies that were carried out between 2004 and 2009 (JRC).

The JRC used an EU-wide refinery model developed by CONCAWE to document the GHG footprint of the marginal EU petrol and diesel production. The CONCAWE model represents the EU refining industry through 9 refineries each having the aggregate capacity and complexity of all actual refineries within a certain region. The use of an average refinery and average crude slate has advantages from an administrative perspective, but it must also be recognized that the average value is not necessarily representative of any given refinery. Nor will it reflect changes in a given refinery from year to year through emission improvement activities, changing product slates, and changing crude oil quality or sources of crude oil.

It must also be recognized that default values remove market signals that could encourage emission reduction activities within the sector. The introduction of unique emission intensities for specific crude oils, as contemplated for shale oil and oil sands, starts to reduce the administrative advantages of default values.

1.2 LCA PRINCIPLES

It is useful to consider seven basic principles in the design and development of life cycle assessments as a measure of environmental performance. The seven principles outlined below are the basis of ISO Standard 14040:2006:

- Life Cycle Perspective (the entire stages of a product or service);
- Environmental Focus (addresses environmental aspects);
- Relative Approach and Functional Unit (analysis is relative to a functional unit);
- Iterative Approach (phased approach with continuous improvement);
- Transparency (clarity is key to properly interpret results);
- Comprehensiveness (considers all attributes and aspects);
- Priority of Scientific Approach (preference for scientific-based decisions).

The Relative Approach and Functional Unit principle is particularly important for this work, since the crude oils under study are being compared to the existing slate of crude oils refined in European refineries, and the desired objective is to be able to look at the crude oils in isolation of the refining system.

1.2.1 Life Cycle Perspective

LCA considers the entire life cycle stages of a product or service, including: extraction and acquisition of all relevant raw materials, energy inputs and outputs, material production and manufacturing, use or delivery, end-of-life treatment, and disposal or recovery. This systematic overview of the product “system” provides perspective on the potential differences in environmental burden between life cycle stages or individual processes.

1.2.2 Environmental Focus

The primary focus of a LCA is on the environmental aspects and impacts of a product system. Environmental aspects are elements of an activity, product, or service that cause or can cause an environmental impact through interaction with the environment. Some examples of environmental aspects are: air emissions, water consumption, releases to water, land contamination, and use of natural resources. Economic and social aspects are typically outside the scope of an LCA, although it is possible to model some of these elements. Other tools may be combined with LCA for more extensive analysis.

1.2.3 Relative Approach and Functional Unit

LCA is a relative analytical approach, which is structured on the basis of a functional unit of product or service. The functional unit defines what is being studied and the life cycle inventory (LCI) is developed relative to one functional unit. An example of a functional unit is a light-duty gasoline vehicle driving an average kilometre (with other details of time, geography, trip characteristics, and potential fuels added). All subsequent analyses are then developed relative to that functional unit since all inputs and outputs in the LCI and consequently the LCIA profile are related to the functional unit.

An LCA does not attempt to develop an absolute inventory of environmental aspects (e.g. air emissions inventory) integrated over an organizational unit, such as a nation, region, sector, or technology group.

1.2.4 Iterative Approach

LCA is an iterative analytical approach. The individual phases of an LCA (Goal and Scope Definition; Inventory Analysis; Impact Assessment; and Interpretation) are all influenced by, and use the results from, the other phases. The iterative approach within and between phases contributes to a more comprehensive analysis and higher quality results.

1.2.5 Transparency

The value of an LCA depends on the degree of transparency provided in the analysis (for example: the system description, data sources, assumptions and key decisions). The principle of transparency allows users to understand the inherent uncertainty is the analysis and properly interpret the results.

1.2.6 Comprehensiveness

A well-designed LCA considers all stages of the product system (the “reach”) and all attributes or aspects of the natural environment, human health, and resources. Tradeoffs between alternative product system stages and between environmental aspects in different media can be identified and assessed.

1.2.7 Priority of Scientific Approach

It is preferable to make decisions from an LCA analysis based on technical or science reasoning, rather than from social or economic sciences. Where scientific approaches cannot be established, consensual international agreement (e.g. international conventions) can be used. The power of the technical or scientific approach lies in the proper attribution of facts to sources and the potential reproducibility of these facts under scientific conditions. While the scientific approach is typically more objective than economic or social values, it does not preclude the use economic or social values for informing LCA decisions.

2. OIL SHALE STUDY

A short paper on the "Greenhouse gas emissions from liquid fuels produced from Estonian oil shale" was prepared by Adam Brandt for The Commission – Joint Research Center.

2.1 STUDY CONCLUSIONS

Brandt found no estimates of GHG emissions from Estonian oil shale operations that generate liquid hydrocarbons. He concluded that given the similarity of various oil shale technologies that the emissions are likely to fall within the range of 1.4 to 1.6 times that of conventional oil based on other papers that he has written or referenced (Brandt, 2008, 2009, 2010 and Burnham 2006).

2.2 REVIEW

A number of the references identified by Brandt and additional sources of information were reviewed. While many of the Brandt papers on oil shale have more detail than the information available for Estonian oil shale, the information must still be considered speculative as it is based on engineering studies or pilot plants and not on commercial operations. The papers note that since the properties of oil shales vary from deposit to deposit, the emissions are also likely to vary.

The major producer of shale oil in Estonia would appear to be Viru Keemia Grupp AS. In addition to a range of specialty chemicals, their products include heavy fuel oils that are reported to be used in industrial boilers and in marine transport. The oils have a low viscosity and low pour point in spite of their high density. There is no indication that the oil is currently used in traditional oil refineries for the production of road transportation fuels.

The company does have plans to upgrade their refining process to produce EURO V diesel fuel and MARPOL 2015 fuels. The technologies for these upgrading steps are currently being evaluated.

A smaller producer, Kiviolo Keemiatoostuse OU, manufactures chemicals and oils for paving. Their website does not indicate that any fuels are produced.

There are several issues that should be considered when evaluating the life cycle emissions of Estonian oil shale. First, Brandt states that the oil shale liquid fuel producers have access to low cost mining residues. This raises allocation issues in the oil shale mining process; would this material have been produced even if it weren't processed into oil, does it provide benefits to the other oil shale processors? The answers to these questions could have a significant impact on the emissions attributed to the feedstock for shale oil.

Secondly, the retorting of the oil shale produces liquid oil, producer gas, and char and thus some allocation of the emissions to the various products is required, not all of the papers take this approach in their calculations. Since they are all energy products, allocation by energy content could simplify the issue without too many unintended consequences.

Finally, the refining of the crude shale oil produces a range of high value chemicals as well has some unique fuel oils. Again, the allocation of the refinery emissions may present some special challenges. Allocation by energy content may not be appropriate at this stage since many chemicals are very energy and emission intensive and a displacement approach to allocation, while more complicated, will produce more realistic results.

We would conclude that there is insufficient data available to be able to derive a reliable GHG emission intensity for oil produced from Estonian oil shales. Given that shale oil refineries will produce some high value (and high emission intensive) chemical products, as well as potentially some diesel fuel, it is possible that a LCA using the displacement approach to co-products could result in a significantly lower GHG emission intensity than suggested in the Brandt review.

It would appear that any transportation fuel that might be produced in the future from this resource is likely to be produced in a stand alone facility, and not from a traditional refinery that co-processes conventional crude oil and shale oil. Koel (1999) notes that;

> *Catalytic processes which consume hydrogen are used to saturate olefines, to eliminate heterocyclic compounds (containing atoms of O, N, S), and stabilize oils to reduce tendency for oxidation and gum formation as a result of exposure to air and temperatures. Schemes know in petro-chemistry to get motor fuels of high quality from crude oil could not be used in case of shale oils due to the wide boiling range of heterocompounds present not only in heavy fractions but also in lighter ones.*

Given that the shale oil production process will not produce a crude oil product that can be refined in a conventional refinery, it would probably be more appropriate to do a complete LCA analysis on this unique process rather than trying to establish a carbon intensity for just the production stage of Estonian shale oil. Since the crude oil produced and the refining processes required are not equivalent to the existing crude oils and refineries, the only way to satisfy the LCA principle of Relative Approach and Functional Unit is to determine the carbon intensity for the finished fuel and chemical products.

3. OIL SANDS STUDY

The Canadian oil sands sector is considerably larger and more complex than the oil shale industry in Estonia. There are several different deposits, with different characteristics, two major families of crude oils produced and multiple processes employed within each family of crude oil produced. These characteristics make the derivation of a single number for the carbon intensity of oil sands derived crude oils problematic.

Brandt accurately characterizes the Canadian oil sands industry in section 3 of his report. There are two very different crude oils produced, bitumen and synthetic crude oil, and a variety of extraction and upgrading methods are employed.

Section 4 of the Brandt report summarizes the major studies that have been undertaken on the GHG emission intensity of oil sand production systems.

3.1 STUDY CONCLUSIONS

Brandt concludes that;

1. The most likely emissions for oil sands are 25.0 g CO_2eq/MJ (LHV) for extraction, upgrading and venting and flaring emissions. This is compared to the EU default value of 4.6 g CO_2eq/MJ (LHV). The range of emissions for specific projects range from 15.9 to 40.6 g CO_2eq/MJ (LHV).
2. There is likely a range of values for conventional crude oils ranging from 1.0 (Norway) to 21.1 (Nigeria) g CO_2eq/MJ (LHV) and thus there is some overlap between the range of Canadian oil sands oil and the existing conventional sources.
3. GHG emissions from oil sands production as significantly different enough from conventional oil emissions that regulatory frameworks should address this discrepancy with pathway-specific emissions factors that distinguish between oil sands and conventional oil processes.
4. There remains some uncertainty with respect to the Canadian oil sands emission rates with respect to;
    a. Treatment of electricity cogeneration is variable across studies, and is uncertain because of a lack of data on amounts of co-produced power, and difficulty in determining the correct co-production credit for electricity exports.
    b. Detailed treatment of refining is lacking in publicly available models, due to lack of access to proprietary refining models.
    c. Market considerations are lacking, which have important effects on co-product and by-product disposition, including the fate of produced coke.
5. GHGenius is the preferred model for modelling the emissions from oil sands derived fuels.

The Brandt conclusion focuses exclusively on the production of synthetic crude oil from oil sands and not on the production and refining of bitumen, the other major product produced by Canadian oil sands operators.

3.2 DATA COMPLETENESS

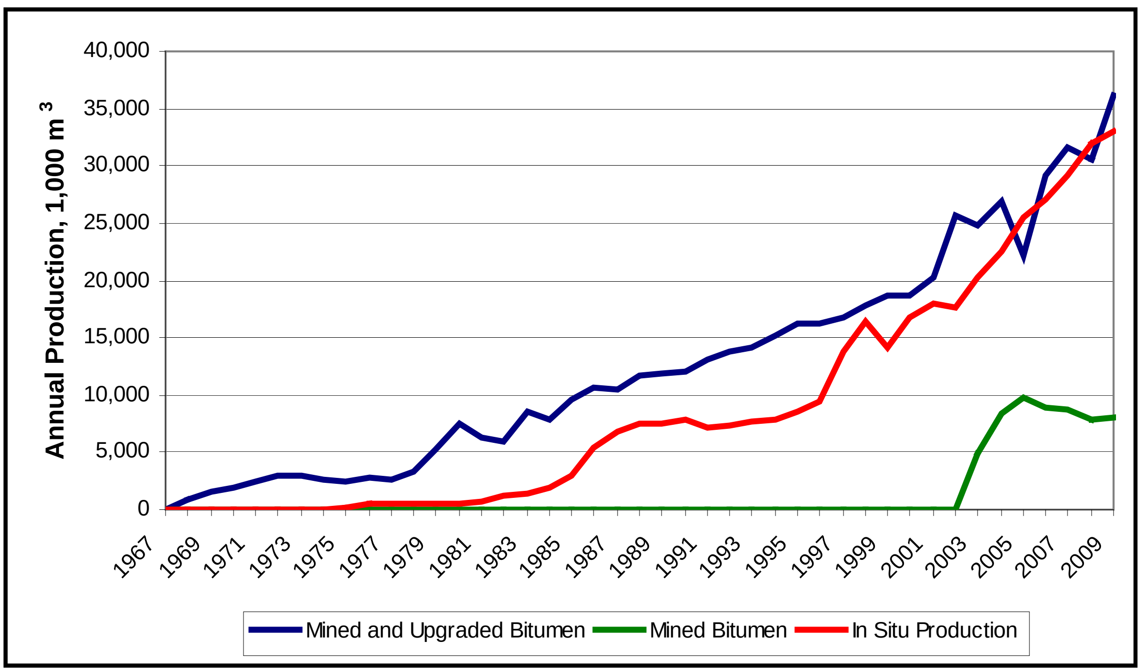
The Brandt report does discuss the major works that have been undertaken in the past several years that have looked at the GHG emissions of Canadian oil sands. These include the Jacobs and TIAX reports undertaken for the government of Alberta, the CERA report, the NETL report and the results from the GREET and GHGenius models.

The data gaps and issues with system boundaries in all of these reports are discussed and documented. Most of the reports studied specific projects or technology types and therefore do not necessarily represent “industry average” performance. It was only in 2010 that some public information started to become available on some of the aspects of the oil sands production process and this new information is not reflected in earlier reports.

The most likely emission case is built on an assumption of 55% mined and 45% produced in situ bitumen is upgraded to synthetic oil from GHGenius version 3.13. The newest version of the model, 3.20, is based on current production profiles that have about 95% of the bitumen produced by mining. This is not expected to change significantly in the one to four year time period that has been specified by the Commission.

The major shortcoming of the analysis is that it doesn’t consider the emissions of non-upgraded bitumen. This is a significant resource and production volumes approach that of mined and upgraded oil sands for synthetic oil production as shown in the following figure (CAPP, 2011).

Figure 3-1 Historical Bitumen Production



Note that significant amounts of raw bitumen are produced and shipped directly to refineries for production of transportation fuels. This bitumen has a significantly different emission profile and it is produced by a combination of cold production, enhanced oil recovery methods, and the two thermal approaches, steam assisted gravity drainage (SAGD) and cyclic steam stimulation (CSS).

The 2009 production and disposition of these two types of crude oil are summarized in the following table. The 2010 data is not yet available but bitumen production has increased faster than synthetic oil production and more synthetic oil (and less bitumen) are being refined in Canadian refineries. This means that in 2010 bitumen exports represent an even larger share of oil sands derived products.

Table 3-1 Oil Sands Production and Disposition

	Bitumen	Synthetic
	1,000 m^3	
Production	33,381	44,330
Refined in Canada	2,580	21,140
Exported	30,801	23,190

It is clear from the table that bitumen and not synthetic crude oil is the major export product from the Canadian oil sands. The emission profile for this product is not the focus of the Brandt report. The GHG emissions of this bitumen production from GHGenius 3.20 are 13.3 g CO_2eq/MJ (LHV), significantly lower than 24.8 g CO_2eq/MJ (LHV) that the model produces for synthetic oil, even though 63% of the bitumen production uses thermal production techniques rather than the current 5% for synthetic oil production.

3.3 Most Likely Average GHG Emission Intensity

Brandt's most likely average value of 25.0 g CO_2eq/MJ is a good value for the synthetic crude oil that is being produced in Canada. The problem is that it is only representative of about 40% of the oil sands derived crude oil that is exported from Canada. The remainder being bitumen that is diluted with condensate (so that the viscosity is suitable for pipeline shipments). This bitumen has a lower carbon intensity of about 13.3 g CO_2eq/MJ (based on the latest GHGenius model). The average value for all oil sands derived crude oil (synthetic crude oil and bitumen) produced in Canada is only about 20 g CO_2eq/MJ. The average value for crude oil exported is even lower at 18.3 g CO_2eq/MJ (excluding the diluent). If the 30% diluent were included then the GHG emission intensity of the oil sands derived crude oil produced would be about 17 g CO_2eq/MJ, only 68% of the Brandt value.

These exports are almost exclusively to the United States, as no Canadian oil is transported further east than Ontario in Canada and thus cannot be exported to Europe directly with the existing infrastructure. Small quantities of crude oil are shipped from the west coast of Canada but most of this also goes to the United States. The United States represents more than 99% of Canadian crude oil exports at the present time and this is unlikely to change in the next 1 to 4 years.

3.4 Other Information

Two of the uncertainties identified by Brandt are significant and important; the refining of the crude oil, and the products produced from the refinery. The issue of electricity export is not as significant as the sector, on a whole, is still a net power consumer and GHGenius does model co-generation appropriately. It is also capable of modelling power exports, in contrast to the statement in the Brandt report.

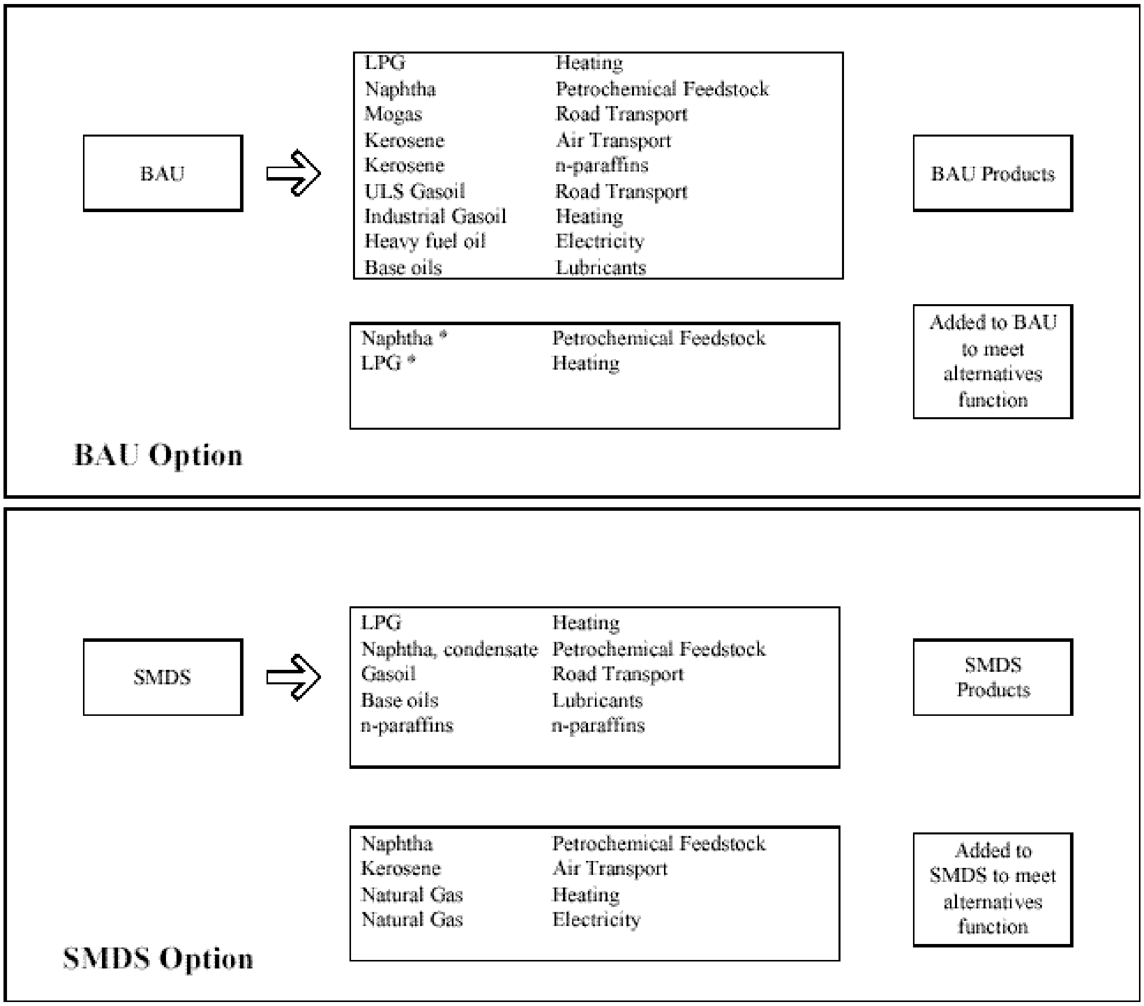
Brandt discusses the impact of crude oil quality on refining emissions. Both the sulphur content and the crude oil density are important, but not the only parameters that impact the refining emissions. If the intention is to apply the same refining emission to each crude oil source, then the crude oils need to be equalized so that the reported emissions have the same functional unit. This is done throughout the world for the price of crude oils. The price for oil from any given well is adjusted for the deviation in the sulphur and density from a marker crude oil. This is a reflection of the cost of refining and the value of the slate of refined products that are produced. A similar concept could be applied to crude oil where the marker crude is the average European crude (32.4 API and 1.2% S, Purvin and Gertz, 2008).

Under this system, crude oils with lower sulphur contents would get a bonus and crude oils with higher sulphur contents would get a penalty. The situation with respect to density would be the same, a bonus for crude oils lighter than 32.4 degrees and a penalty for heavier crude oils. A system similar to this is the only way that crude oils can be compared on an equivalent basis and thus be compliant with ISO LCA principles.

The other issue identified by Brandt is that of varying product splits from different crude oils. There are actually two aspects to this. The first is that the allocation of refinery energy to individual products would be changed if there were more diesel and gasoline produced from the crude oil and less low value residual oil produced. This would lower the refining emissions attributed to the transportation fuels. The second aspect, which is more significant, is that if no residual oil is produced, another fuel such as natural gas, would be used in its place and the difference in GHG emissions for the combustion of the residual fuel and the natural gas would be a credit for the crude oil that produces fewer bottoms. This concept has been applied before for LCA studies on transportation fuels in Europe (PriceWaterhouseCoopers, 2003).

The approach used in the PWC study on a gas to liquids project for Shell (SMDS) study is to make the two systems functionally equivalent. This requires the addition of a number of products to each option. In particular the SMDS case has the combustion of natural gas added for thermal energy requirements and power generation. This approach is demonstrated in the following figure.

Figure 3-2 Functional Equivalence for Oil Refinery and SMDS Process



The GHG bonus for products with lower bottoms would be the difference in natural gas lifecycle emissions and heavy fuel oil lifecycle emissions times the difference in the fraction of heavy fuel oil products produced from the average crude and the study crude. In the PWC case this amounted to about 8.5 g CO_2eq/MJ for the GTL product. Since synthetic crude oil also has no bottoms, it would achieve a similar bonus. These values could be updated with more recent information.

The application of a system of bonuses and penalties would lower the emissions for synthetic crude oil produced from Canadian oil sands but increase the emissions from bitumen produced from the same resource.

The challenge with 25.0 g CO_2eq/MJ of synthetic crude derived by Brandt is not just the value, but how it is used. The quality of the product is significantly different than that of the average crude oil refined in Europe, The density is about the same, but the sulphur content is lower, and refining it does not produce the same slate of products. A similar, but directionally opposite issue exists for the bitumen that is produced and exported. It has more sulphur and is heavier than the average crude.

In addition, it is not clear that the system boundaries or the quality of the data used to calculate the average crude oil in the Fuels Directive are the same as used in GHGenius to determine the emissions for synthetic crude oil or bitumen.

The energy required to produce crude oil used in the JRC calculations is 0.02 j/joule produced and the source is a personal communication with Shell Oil. The International Association of Oil and Gas Producers (OGP) has been publishing data on the emissions and energy consumption of their members for almost ten years. The most recent data (OGP, 2010) is from 2009 and they report that the energy consumed was 1.5 Gigajoule/tonne and the GHG emissions were 167,000 g CO_2eq/tonne (excluding N_2O emissions). The coverage is about 36% of the world's oil production and given the membership it is probably skewed to the largest, lowest cost producers.

A tonne of oil contains about 42 GJ (LHV) so the energy consumption is about 0.036 joules/joule and the GHG emissions are about 4.0 g CO_2eq/MJ (these would be direct GHG emissions and would not include any indirect emissions). The energy use is much lower than used in the default values although the GHG emissions are probably similar (or lower) when the indirect emissions are considered.

Brandt reports an emission intensity of 4.83 g CO_2eq/MJ for the average EU crude oil based on calculations by Skone and Gerdes. The source of data for the Skone and Gerdes work was the 2002 OGP data, which reported energy consumption of 1.14 GJ/tonne and GHG emissions of about 158,000 g CO_2eq/tonne (excluding N_2O emissions). This data is also used for the GaBi LCA model.

Using the crude oil slate in Table 7, GHGenius calculates the oil extraction emissions at 6.4 g CO_2eq/MJ using the 2007 IPPC GWPs. This indicates the differences that can exist in different models.

3.5 CANADA VS OTHER OIL SANDS

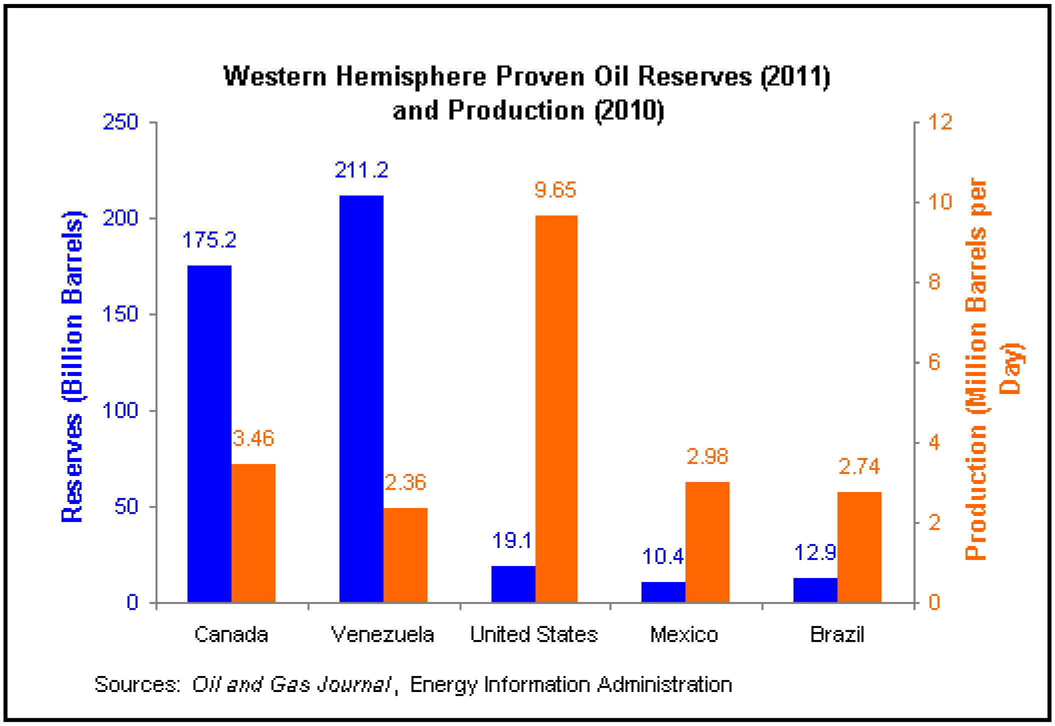
It is unlikely that Canadian oil sands derived fuel will be used in the EU in the 1-4 year time frame under consideration as the transportation infrastructure is not in place to facilitate exports to Europe. There have been some proposals to reverse certain pipelines in Canada and the US that would allow exports for the US east coast but there has been no progress made towards this actually happening. It is also probably that this would happen in stages, with the first stage allowing for increased Canadian use of Canadian crude oil and then the second stage involving the potential to export Canadian crude oils.

Venezuelan oil sands are significantly different than Canadian deposits. The deposits are less degraded than Canadian deposits and have a higher temperature. The four large projects that are under development can produce the oil through horizontal wells using primary production methods. There are no mining activities and thermal recovery techniques such as SAGD and CSS are not required. The GHG emissions associated with the oil extraction are therefore expected to be less than they are in Canada.

The upgrading emissions should be similar to Canadian upgraders as the bitumen that is processed has a similar viscosity and sulphur content, however there are reports that the upgraders operate a less than capacity due to maintenance and safety problems (EIA, 2011). This could suggest a lower overall efficiency for the upgraders and higher GHG emissions. There is insufficient information available on the Venezuelan bitumen production and upgrading process to confirm the GHG emission profile of this resource. Skone and Gerdes reached the same conclusions citing some sources that had lower emissions than Canadian oil sand production and other sources with lower emissions.

It is not true that the Canadian oil sands have much higher recoverable reserves than Venezuelan oil sands. The Venezuelan reserves were significantly increased in 2009 and their total reserves are now larger than the Canadian recoverable reserves according to the US EIA and the Oil and Gas Journal (EIA, 2011)), as shown in the following figure.

Figure 3-3 Oil Reserves and Production Levels



4. NRCAN COMMENTS

Natural Resources Canada has submitted comments on the Brandt oil sands report and comments are provided here on the six main issues raised in their comments.

4.1 BRANDT VS. OTHER REPORTS

The NRCan position is that Brandt's conclusion that Canadian oil sands should be treated separately from other crude oils is not supported by other studies or by any evidence presented in the Brandt study.

The NRCan position is valid. Brandt relies on an analysis done by Geddes and Skone that shows a wide range of GHG emission intensities for various crude oils. The other studies reviewed by Brandt such as the Jacobs and TIAX studies also reach a similar conclusion. The GHG emission intensity for each oil field is almost unique and that there are other high intensity oil fields that have not been singled out for special attention.

The Geddes and Skone reports presents the GHG emissions on a per barrel basis and Brandt has assumed a constant volumetric energy content of 6.1 GJ/bbl in order to convert them to an energy basis. This approach will overstate the emissions of heavier oils as they contain more energy per barrel than lighter oils.

4.2 ARTIFICIAL DISTINCTIONS

NRCan states that Brandt's extension of energy intensive production methods equates to high GHG emission intensity and this is justification for special treatment of oil sands products. There are venting and flaring emissions associated with many crude oil fields throughout the world and in cases like Nigeria, these emissions dominate the GHG emission intensity profile. The NRCan complaint that energy intensity is not sufficient justification to warrant special treatment is valid.

4.3 INADEQUATE COMPARISON TO OTHER CRUDE OILS

NRCan states that "the Brandt study needs to assess more detailed information on other crude oils" in order to develop better comparators.

It is likely that identifying the emissions from the production of other sources of crude oil was outside the scope of Brandt's work. The NRCan point is valid but it is almost impossible to calculate the GHG emission intensity of most of the world's crude oil production with the same degree of confidence as exists for Canadian crude oils as the data is just not available. The best source of information on the energy and fugitive emissions for crude oil production in the world is the OGP data but there is no independent confirmation of the validity of this data. For some parts of the world the coverage is very low (the coverage for Russia, which supplies 21% of the EU oil, is only 10% of the oil produced in that region).

Many of the determinations of crude oil production emissions rely on theoretical models and not on primary data. The Jacobs, TIAX and recent Energy-Redefined study all rely on models (and arrive at different values).

4.4 EU PRODUCT SLATE ISSUES

NRCan point out that the refining emissions were not studies in the Brandt report and the different product slates from different crude oils could have an impact on the results. This is a valid point and one that was discussed in section 3.4. The impact is likely in the range of 1-2 g CO_2eq/MJ maximum.

4.5 INCONSISTENT DATA

NRCan identify that Brandt has used different data sources and results from different studies in the presentation of his findings. These lack a common basis for analysis, whether it is the time frame for data collection, the location, the system boundaries, or the treatment of co-products. This does make it difficult to make accurate comparisons.

4.6 CONCLUSIONS BASED ON NON-COMPARABLE METHODOLOGIES

The final NRCan point is similar in that the findings are based on different studies and methodologies. The most likely value for synthetic crude oil is from GHGenius; the lowest emissions are from the Jacobs study for an integrated mining and upgrading operation, and the highest value from the TIAX study of SAGD with the gasification of the bottoms to supply a portion of the energy requirements instead of using natural gas. Each of these studies used a different model, with different assumptions and thus some of the range may be due to methodology issues and not real fundamental differences.

Having said that, it is likely GHGenius would also produce a similar range for specific projects. It is noted that the latest version of GHGenius, which relies more on primary data and less on assumptions than the version used by Brandt, produces an emission intensity for synthetic crude oil production almost identical to the value cited by Brandt.

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