# ALBERTA DEPARTMENT OF ENERGY

## POLICY REVIEW

## Jacobs Consultancy: EU Pathway Study (2012)

*Research & Technology*
*Resource Development Policy Division*

May 2, 2012

Government
of Alberta ■

This paper was prepared by the Research and Technology Branch, Alberta Energy, to discuss policy implications arising from the findings of the Jacobs Consultancy's "*EU Pathway Study: Life Cycle Assessment of Crude Oils in A European Context (2012)*" report (known hereafter as "the Study"). The Government of Alberta shall have no liability whatsoever to third parties for any defect, deficiency, error or omission in the contents, analyses and evaluations presented in this paper.

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# EXECUTIVE SUMMARY

Greenhouse gas (GHG) emissions and contribution to climate change is a source of discussion around the world. As various jurisdictions debate carbon management policies that will potentially have wide-spread economic and environmental consequences, it is important to have all the facts possible before them in order to make informed decisions.

In 2009, the European Union Council and Parliament adopted a Climate and Energy package that aims to achieve a 20% reduction in GHG emissions in Europe by 2020. It contains a proposed regulation known as the Fuel Quality Directive (FQD) that requires fuel suppliers make a 6% reduction in the lifecycle GHG intensity of fuel and other (electric) energy supplied for use in road vehicles and of fuel for use in non-road mobile machinery by 2020. During 2011, the FQD was further developed, but in a manner that is viewed as discriminatory to heavy crude oils produced in Canada.

To facilitate further understanding and ensure that the proposed FQD is based on sound scientific and engineering evidence, the Government of Alberta contracted Jacobs Consultancy, an internationally recognized technical expert in the field of crude oils and lifecycle analysis evaluations, to assess crude oils used in the EU as well as those produced in Alberta. Jacobs Consultancy is a specialized management, technical, and consulting division of Jacobs Engineering Group Inc., and is one of the world's largest and most diverse providers of technical, professional, and construction services.

## FQD assumptions inaccurate

Based on Jacobs Consultancy's *EU Pathway Study: Life Cycle Assessment of Crude Oils in a European Context (2012*) the Government of Alberta finds the current FQD proposal's default values and crude oil categorization to be neither a comprehensive, nor an equitable analysis.

Using reasonable assumptions for crude production methodologies, the default carbon intensity measures underlying the FQD are understated for crude oils used in the EU and overstated for Alberta heavy crude oils, and the difference between them is much less significant.

Specifically, Jacobs' findings show that the average wells-to-wheels carbon intensity of gasoline and diesel from Alberta oil sands-derived crude oils are within 12% of the carbon intensity of gasoline and diesel from crude oils refined in Europe and, in the case of some oil sands crude, within 5% of EU crude oils.

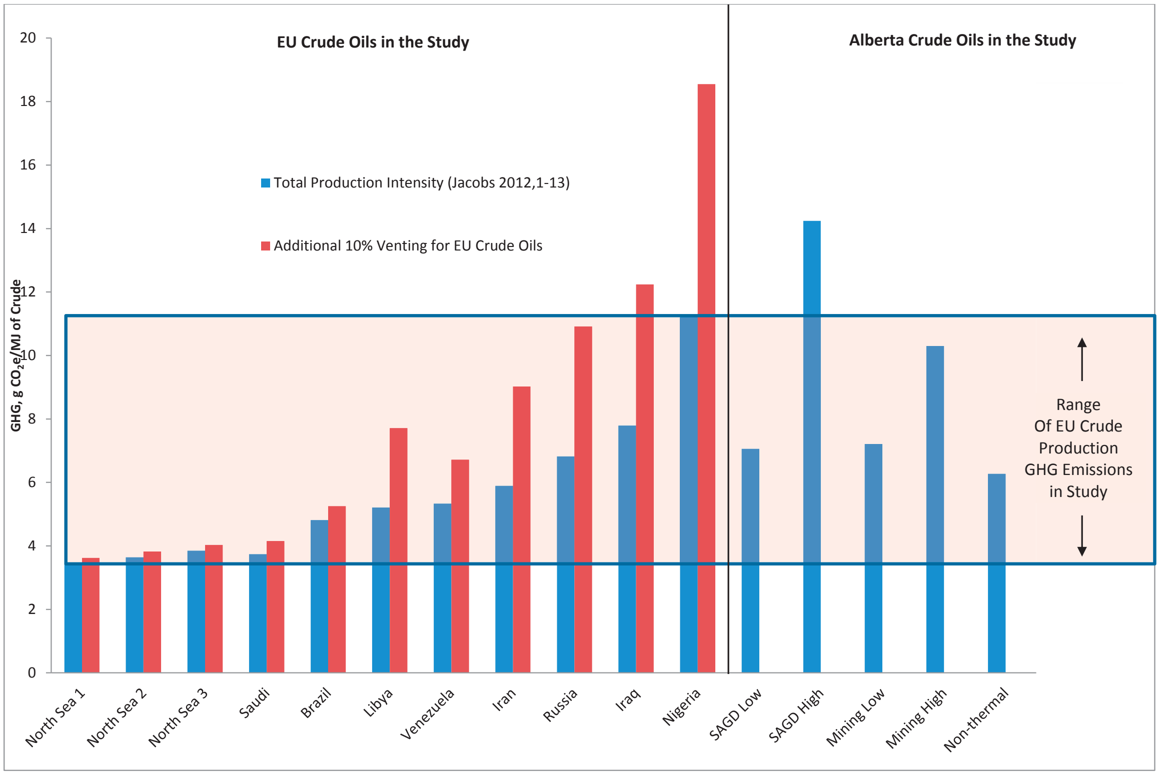
## Poor data quality

Jacobs compared the wells-to-wheels carbon intensity of crude oils from a variety of sources around the globe, taking into account everything from the GHG emissions of the extraction process, to emissions in the refining and transportation process and ultimately GHG emissions from consumer or industrial use of the fuel. This is termed the wells-to-wheels or life-cycle assessment analysis and considers all data.

However, not all data are hard facts.  Some of the data used by Jacobs are estimates based on engineering models.  This is because some jurisdictions do not require or provide hard data relative to flaring and venting, and what is reported must be estimated using satellite imagery. Alberta, on the other hand, has a regulatory framework that requires industry to provide regular, verifiable reporting of data that is audited by a third party and can be checked against life cycle assessment engineering models. *(See Table 2, Wide Range of Data Sources Used in the Study – Page 11)*

Flaring and venting add significantly to the carbon intensity of EU fuels, which needs to be accounted for in a comprehensive life cycle assessment analysis.  Given the increased uncertainty in EU crude oil production emissions data when compared with Alberta, reasonable assumptions in flaring and venting show it is possible for the GHG production emissions of EU crude oils to be as high as, or higher than, the heavy crudes produced from Alberta's oil sands region.

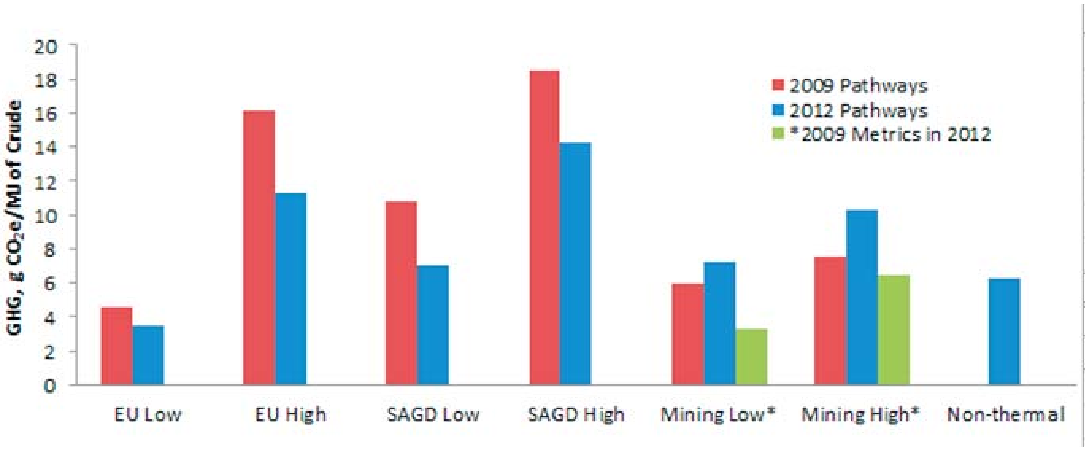
**FIGURE ES-1**
**CARBON INTENSITY OF CRUDE OIL PRODUCTION FOR EU CRUDE ASSUMING 10% VENTING**



## Closing the gap

Another significant finding of the Jacobs study is that energy improvement in bitumen production is leading to reduced carbon intensity of transportation fuels from bitumen produced by mining and in-situ (SAGD) methods.  New SAGD production methods such as mechanical lift instead of gas lift, high efficiency steam production and reservoir management resulting in reduced steam-to-oil ratios, and mining extraction methods such as paraffin froth treatment are bringing the wells-to-wheels carbon intensity of gasoline and diesel for Alberta crudes within 4% of the upper range of EU crude oils.  These production trends continue to improve efficiencies resulting in lower carbon intensity.

**FIGURE ES-2**
**COMPARISON OF ESTIMATED GHG EMISSIONS FROM CRUDE OIL PRODUCTION FOR JACOBS 2009 AND 2012**



*Note: Jacobs 2009 metrics do not include fugitive emissions, land use, and tailings emissions

## Conclusion

The Jacobs study provides the most comprehensive comparison to date of wells-to-wheels carbon intensity emissions of transportation fuels refined from various crude oil sources.  It is a scientific study that utilizes the best available data and where comparative data is not reported, uses accepted engineering models to reach the best estimates of carbon intensity possible.

Considering the conclusions of the Jacobs study, and the trend to more efficient oil sands production, Alberta believes that the EU current FQD 7a proposal relies on an oversimplified methodology, which is discriminatory to Alberta crudes and may not result in effective carbon emission reductions.  In order to regulate all crude oils at the same levels to achieve carbon management policy, the EU needs to ensure that crude oil production practices are fairly monitored based on accurate reporting of all relevant data.

# INTRODUCTION

The analysis of the carbon intensity (CI) of various forms of energy production is an emerging technical practice. Through ongoing refinements and verification with actual data, it is envisioned the analysis will mature and become a commonly used technical tool, i.e. a life cycle assessment (LCA) tool.

Jacobs Consultancy's (known hereafter as "*Jacobs*") EU Pathway Study (Jacobs, 2012) is one of, if not the most, comprehensive studies undertaken on the LCA of the GHG emissions associated with crude production, but it represents only the beginning of the discussion of LCA, not the end. The Study raises more questions than answers and provides good primary data upon which to assess and understand the policy implications of how to manage carbon.

One of the key observations made by Jacobs is that *"poor data quality limits comparison of crude pathways"* (Jacobs 2012, ES-20). When this finding is put into context with the well-known management adage that *"you can't manage what you don't measure,"* it becomes questionable whether the various carbon management policies being considered today will be effective and without unintended consequences.

A common message throughout the Study is that the data for crude production in Alberta that is publicly available is greater than for other crude producing jurisdictions considered in the Study. Hence, Alberta crude production can be compared and analyzed with greater certainty. The reason why Alberta has such information is because of its transparent approach to resource development. The Government of Alberta acts as stewards of the energy resources on behalf of all Albertans (the owners) without taking an active role in production (Canada has no government oil companies). It regulates the industry through a quasi-judicial arm's length regulator and obtains a fair return through royalties. To ensure that the industry is operating in an appropriate fashion, and an appropriate return is collected for Albertans, industry must fulfill extensive reporting requirements. This information is used to manage the industry (i.e. we manage, because we measure).

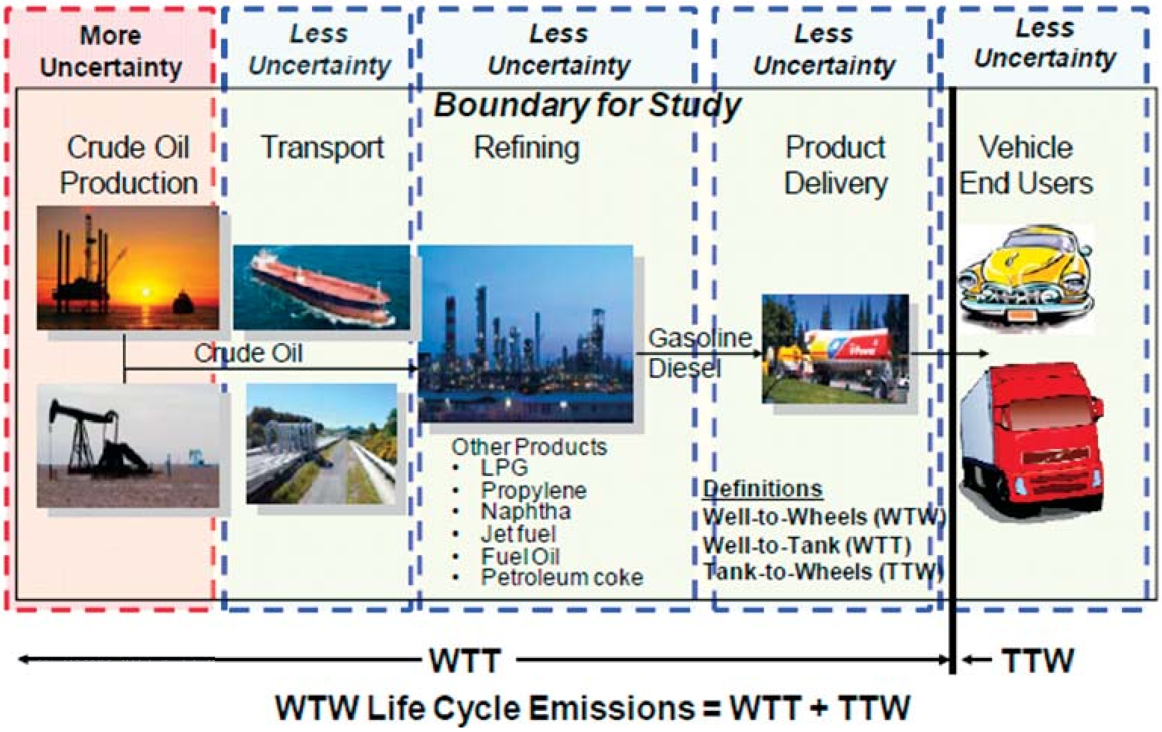
This paper examines various aspects of the Jacobs report to help identify potential policy implications. It begins by exploring in depth data availability and accuracy issues, progresses to a discussion of LCA methodologies, and then raises various administrative and regulatory policy issues in the context of the EU FQD proposal.

## LIFE CYCLE ASSESSMENT OF CRUDE OILS

The primary objective of Jacob's EU Pathway Study: Life Cycle Assessment of Crude Oils in a European Context (known hereafter as "the Study") was to provide a LCA of GHG emissions for both major crudes processed in the European Union (EU) and potential Canadian heavy crude oil pathways from Alberta (Jacobs 2012, p. 1-3). Jacobs provided a first-order (not a "meta-assessment") technical assessment of the well-to-wheel (WTW) CI (expressed as gCO2e/MJ of fuel) of gasoline and diesel fuel pathways in a North American and European context, more specifically, the representative product specifications, transportation distances and refinery configurations.

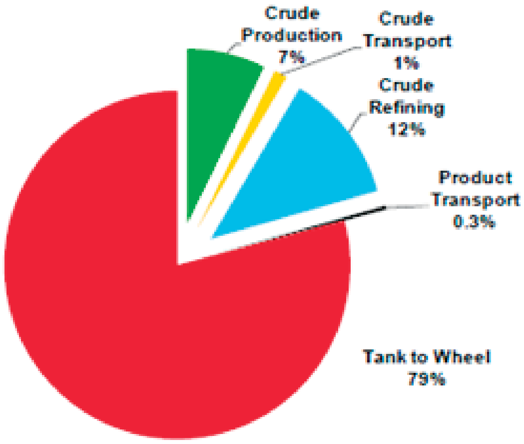
Carbon emissions of a crude oil pathway are based on the WTW LCA of GHG emissions from production of a specific crude through consumption and use of that crude as transportation fuel in a vehicle. Key components of LCA are determining the energy consumption and emissions in each stage. A life cycle schematic, including confidence levels, for gasoline and diesel fuel pathways is outlined in Figure 1.

**FIGURE 1**
**LIFE CYCLE SCHEMATIC AND DIFFERENT LEVELS OF CONFIDENCE IN WTW COMPONENTS**



Source: (Jacobs 2012, p. ES-3)

**FIGURE 2**
**WTW CI EMISSION CONTRIBUTION FOR PRODUCING GASOLINE AND DIESEL FUEL**



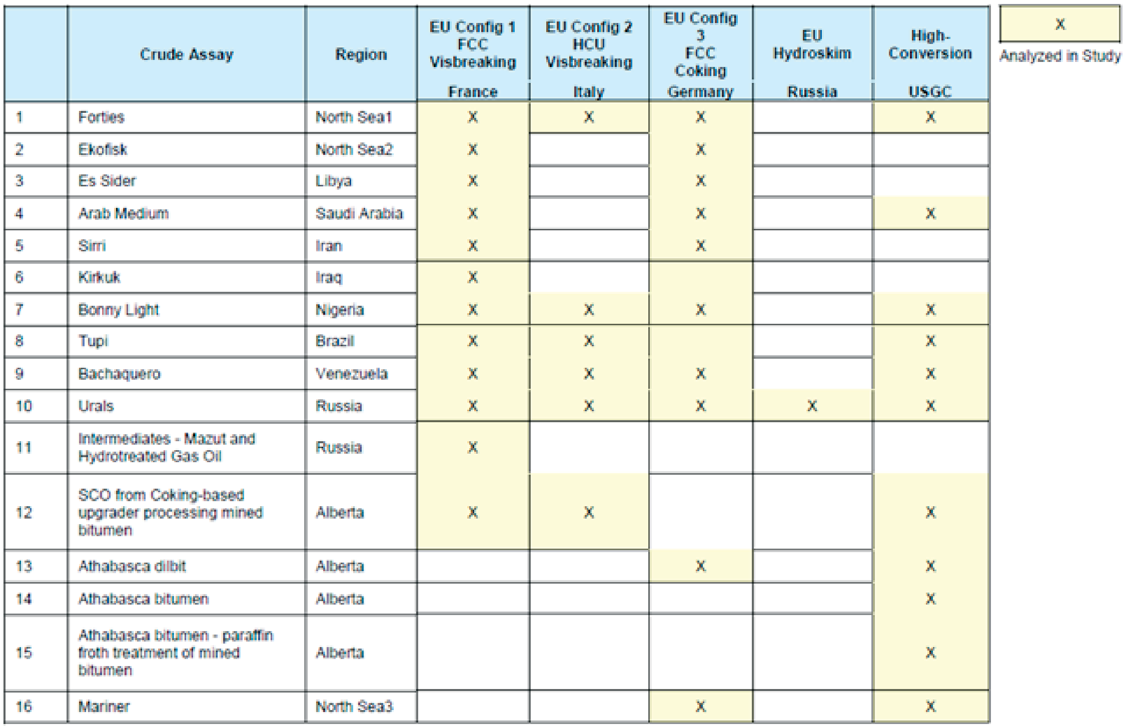
Source: (Jacobs 2012, p. ES-3)

Figure 1 shows the various steps of WTW life cycle emissions and respective uncertainty of each stage. Figure 2 shows the contribution of each stage to total WTW emissions for the Study. With a well-defined understanding of transportation, refining and fuel use, Jacobs identified one of the more difficult aspects was determining the emissions associated with crude oil production. (Jacobs 2012,12-2). Prior to beginning the Study, Jacobs had identified the stage of crude oil production in its WTW assessment as a significant challenge, due to the thousands of reservoirs that produce crude oils and the difficulty in determining crude pedigrees (Jacobs 2012, A1-2). The uncertainty associated with crude oil production GHG emissions is reiterated in Jacobs' analysis and key conclusions for the Study.

## DATA AVAILABILITY AND QUALITY

In evaluating and comparing the pathways for the Study, 16 crude assays were evaluated (four of which originate in Alberta) in five different refinery combinations, shown in Table 1.

**TABLE 1**
**CRUDE PATHWAYS FOR STUDY**



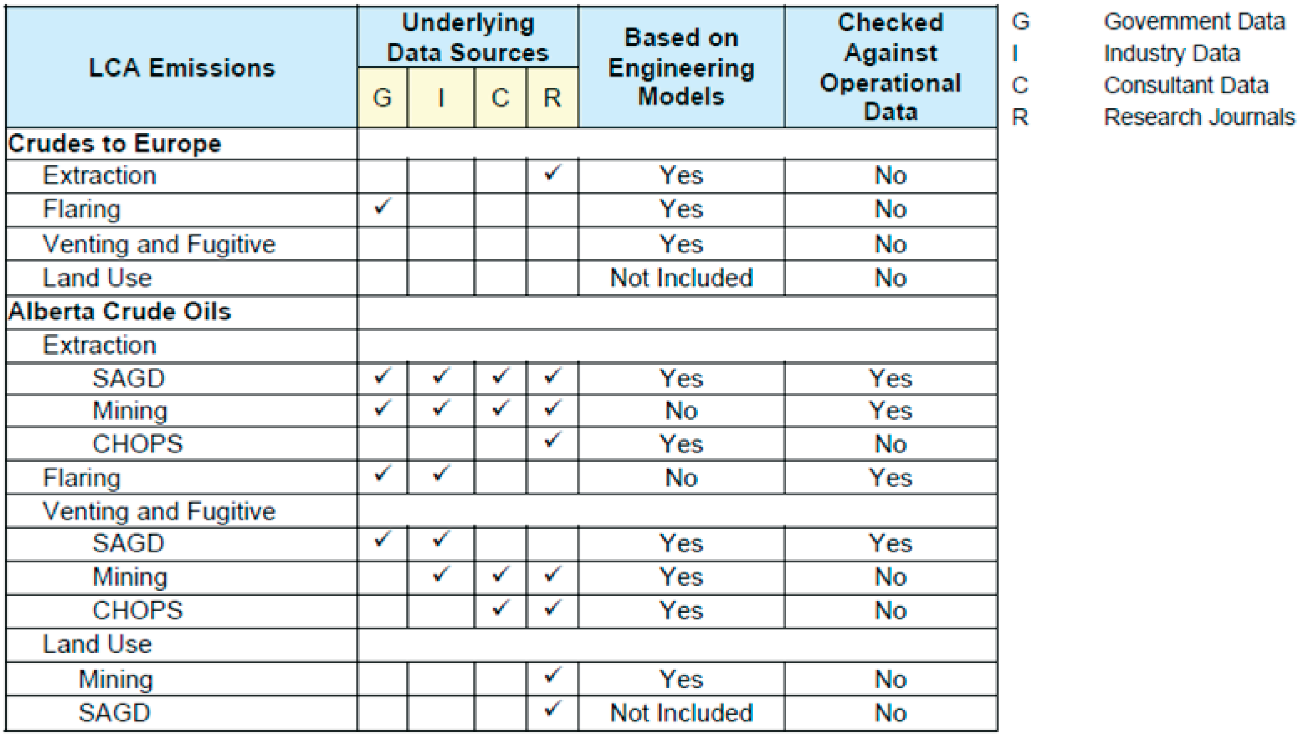
| | Crude Assay | Region | EU Config 1 FCC Visbreaking | EU Config 2 HCU Visbreaking | EU Config 3 FCC Coking | EU Hydroskim | High-Conversion |
|---|---|---|---|---|---|---|---|
| | | | France | Italy | Germany | Russia | USGC |
| 1 | Forties | North Sea1 | X | X | X | | X |
| 2 | Ekofisk | North Sea2 | X | | X | | |
| 3 | Es Sider | Libya | X | | X | | |
| 4 | Arab Medium | Saudi Arabia | X | | X | | X |
| 5 | Sirri | Iran | X | | X | | |
| 6 | Kirkuk | Iraq | X | | | | |
| 7 | Bonny Light | Nigeria | X | X | X | | X |
| 8 | Tupi | Brazil | X | X | | | X |
| 9 | Bachaquero | Venezuela | X | X | X | | X |
| 10 | Urals | Russia | X | X | X | X | X |
| 11 | Intermediates - Mazut and Hydrotreated Gas Oil | Russia | X | | | | |
| 12 | SCO from Coking-based upgrader processing mined bitumen | Alberta | X | X | | | X |
| 13 | Athabasca dilbit | Alberta | | | X | | X |
| 14 | Athabasca bitumen | Alberta | | | | | X |
| 15 | Athabasca bitumen - paraffin froth treatment of mined bitumen | Alberta | | | | | X |
| 16 | Mariner | North Sea3 | | | X | | X |

Source: (Jacobs 2012, 1-8)

One of the key conclusions of the Study was that there is a wide range in available data and in data quality used to determine crude oil production GHG emissions (Jacobs 2012, ES-19 to ES-21). Furthermore, understanding the associated uncertainty and variability of this input production data is critical for recognizing the limitations in current WTW LCA studies to date.

Jacobs reviewed publically available data from four primary sources, including 1) government data, 2) industry data, 3) consultant data, and 4) research publications. Table 2 shows data sources used for both EU and Alberta crude production used in the Study and shows that the quantity and quality of data sources for crude production available for all EU and Alberta crudes analyzed in the study are subject to significant variability.

**TABLE 2**
**WIDE RANGE OF DATA SOURCES USED IN THE STUDY**



| LCA Emissions | Underlying Data Sources | | | | Based on Engineering Models | Checked Against Operational Data |
|---|---|---|---|---|---|---|
| | G | I | C | R | | |
| **Crudes to Europe** | | | | | | |
| Extraction | | | | ✓ | Yes | No |
| Flaring | ✓ | | | | Yes | No |
| Venting and Fugitive | | | | | Yes | No |
| Land Use | | | | | Not Included | No |
| **Alberta Crude Oils** | | | | | | |
| Extraction | | | | | | |
| SAGD | ✓ | ✓ | ✓ | ✓ | Yes | Yes |
| Mining | ✓ | ✓ | ✓ | ✓ | No | Yes |
| CHOPS | | | | ✓ | Yes | No |
| Flaring | ✓ | ✓ | | | No | Yes |
| Venting and Fugitive | | | | | | |
| SAGD | ✓ | ✓ | | | Yes | Yes |
| Mining | | ✓ | ✓ | ✓ | Yes | No |
| CHOPS | | | ✓ | ✓ | Yes | No |
| Land Use | | | | | | |
| Mining | | | | ✓ | Yes | No |
| SAGD | | | | ✓ | Not Included | No |

| | |
|---|---|
| G | Government Data |
| I | Industry Data |
| C | Consultant Data |
| R | Research Journals |

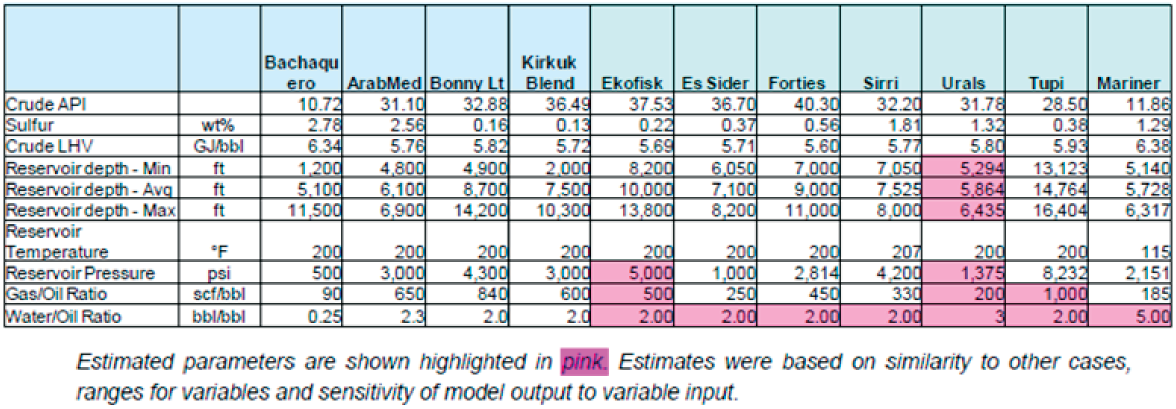
Source: (Jacobs 2012, 11-3)

For EU crude production, the chart shows that:

- No industry or government reported emissions data for EU crude oil extraction in the Study.
- The only data sources for EU production were research publications (with the exception of flaring data).
- Flaring data is based on World Bank/NOAA (government) estimates, which are based on flame luminosity estimates gathered from satellite data, not actual, reported, or verifiable data.
- No data sources for venting and fugitive emissions
- Engineering models were not checked against operational (field) data due to lack of reporting.

Jacobs concluded that outside of Alberta crude assays outlined in Table 1 *"Information on energy use and GHG emissions from crude oil production is not readily available for many of the crude oil production sites"* (Jacobs 2012, 1-10). In such cases, Jacobs used engineering models to estimate GHG emissions, using reservoir parameters outlined in Table 3.

## TABLE 3
## RESERVOIR PARAMETERS FOR CRUDE OILS EVALUATED



| | | Bachaquero | ArabMed | Bonny Lt | Kirkuk Blend | Ekofisk | Es Sider | Forties | Sirri | Urals | Tupi | Mariner |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Crude API | | 10.72 | 31.10 | 32.88 | 36.49 | 37.53 | 36.70 | 40.30 | 32.20 | 31.78 | 28.50 | 11.86 |
| Sulfur | wt% | 2.78 | 2.56 | 0.16 | 0.13 | 0.22 | 0.37 | 0.56 | 1.81 | 1.32 | 0.38 | 1.29 |
| Crude LHV | GJ/bbl | 6.34 | 5.76 | 5.82 | 5.72 | 5.69 | 5.71 | 5.60 | 5.77 | 5.80 | 5.93 | 6.38 |
| Reservoir depth - Min | ft | 1,200 | 4,800 | 4,900 | 2,000 | 8,200 | 6,050 | 7,000 | 7,050 | 5,294 | 13,123 | 5,140 |
| Reservoir depth - Avg | ft | 5,100 | 6,100 | 8,700 | 7,500 | 10,000 | 7,100 | 9,000 | 7,525 | 5,864 | 14,764 | 5,728 |
| Reservoir depth - Max | ft | 11,500 | 6,900 | 14,200 | 10,300 | 13,800 | 8,200 | 11,000 | 8,000 | 6,435 | 16,404 | 6,317 |
| Reservoir Temperature | °F | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 207 | 200 | 200 | 115 |
| Reservoir Pressure | psi | 500 | 3,000 | 4,300 | 3,000 | 5,000 | 1,000 | 2,814 | 4,200 | 1,375 | 8,232 | 2,151 |
| Gas/Oil Ratio | scf/bbl | 90 | 650 | 840 | 600 | 500 | 250 | 450 | 330 | 200 | 1,000 | 185 |
| Water/Oil Ratio | bbl/bbl | 0.25 | 2.3 | 2.0 | 2.0 | 2.00 | 2.00 | 2.00 | 2.00 | 3 | 2.00 | 5.00 |

*Estimated parameters are shown highlighted in pink. Estimates were based on similarity to other cases, ranges for variables and sensitivity of model output to variable input.*

Source: (Jacobs 2012, p. 1-11)

In contrast, crude production data outlined in Table 2 for Alberta shows:

- Numerous data sources for production data (includes ERCB, ADOE, Industry data, internal consultant data, research journals).
- Operational data is provided for both in-situ and mining operations.
- Ability to check engineering production models against select data that is reported.
- Information for flaring, venting and fugitive emissions is reported (not based on estimates).
- Many of the Alberta data sources are 3rd party audited.

Jacobs also comments on the relationship of data availability and uncertainty.

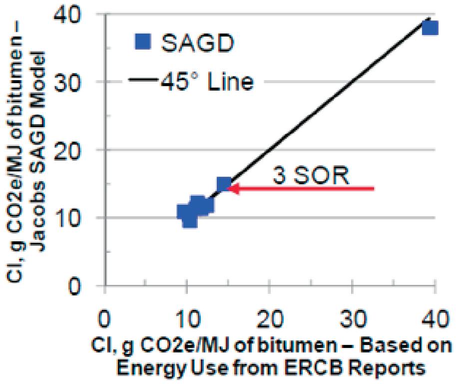
*"In other parts of the world (outside of Alberta), the ability to gather reliable information about crude oil production is much more limited, which leads to greater uncertainty in the estimates of carbon intensity…"* (Jacobs 2012, p. ES 17)

*"…lack of public information on energy consumption, gas flaring in crude oil production in the rest of world outside of Alberta forced us to estimate energy and GHG emissions using our models."* (Jacobs 2012, p. 1-64)

There are a number of reasons why information on crude production is limited. Jacobs cites concerns about competition, the lack of suitable information being measured, the aggregation of data, and the dynamic nature of reservoir response over time (Jacobs 2012, p. 1-10). Often specific EU crude types (eg. Urals) are aggregates of numerous production sites, in which the pedigree of specific data is difficult to ascertain, resulting in the need for crude models, estimates, and assumptions.

This is not the case for Alberta based data, where reporting of crude oil production emissions is not only required for regulatory purposes, but also audited by third parties for royalty purposes. Crude production data in Alberta is often not only reported on a project basis, but detailed information can be obtained down to the well-head. As shown in Figure 4, Jacobs was able to check its engineering-modeled results against reported emissions parameters (steam-to-oil ratios, SORs) such as current in-situ (steam assisted gravity drainage, SAGD) operations to ensure accurate estimates. Due to no reported data for EU pathways (Table 1) in the study, such a check was not possible for EU crude production data, an area of the greatest uncertainty.

**FIGURE 3**
**CI FROM REPORTED GHG EMISSIONS VS. CI FROM REPORTED ENERGY**

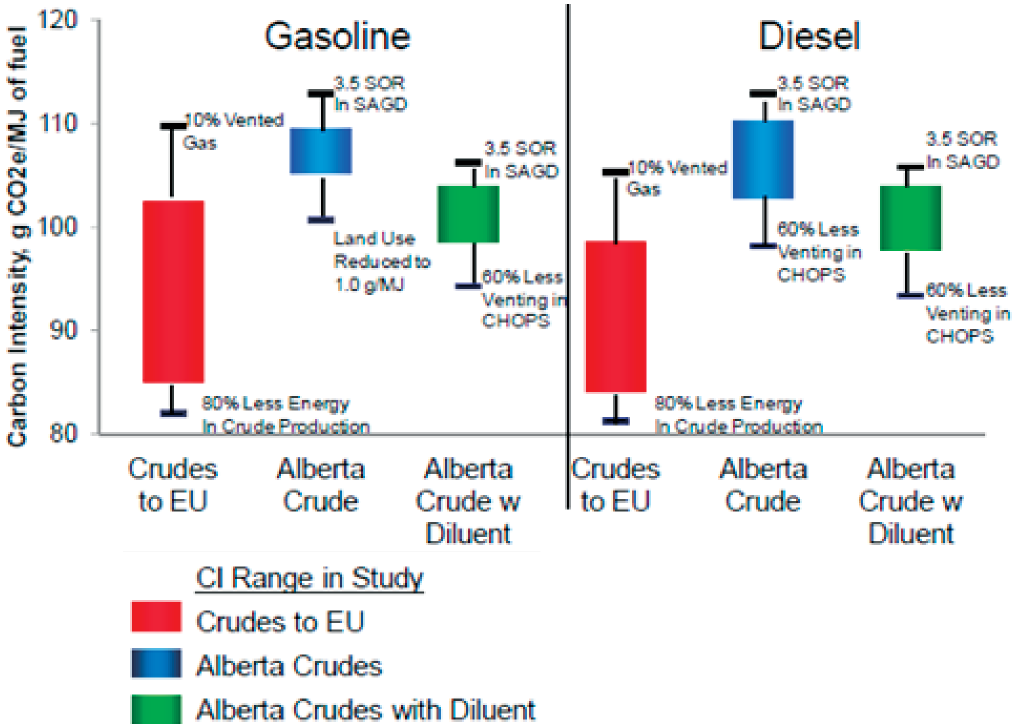


Source: (Jacobs 2012, 1-19)

## IMPACT OF DATA UNCERTAINTY

Table 2 outlines the best available public data sources underlying the Study for both EU Crude and Alberta Bitumen, and reflects the varying degrees of data availability. The main conclusion from the chart is that input data for EU crude feedstocks are subject to a higher degree of uncertainty and have a significant impact on WTW GHG emissions estimates (Figure 4). Key assumptions in crude oil production GHG emissions, for example flaring and venting which the JEC[1] indicates is attributable to 50% of crude oil production GHG emissions (JEC 2011, p. 19), have a significant impact on the GHG emissions of select pathways. The impact of such assumptions gives significant insight into potential upper limits of WTW GHG emissions of the various crude assays.

**FIGURE 4**
**IMPACT OF UNCERTAINTY ON GASOLINE AND DIESEL CARBON INTENSITY**



Source: (Jacobs 2012, p. 11-8)

In the absence of data for reported volumes for flaring, Jacobs used satellite images (converting light measurements to the amount of combusted gas) from the World Bank/US National Oceanic and Atmospheric Administration (NOAA) to estimate flaring related GHG emissions for all EU crude assays (Table 1). Of note is that the flaring efficiency assumed within the World Bank/NOAA data is not explicitly stated (Jacobs 2012, p. 5-22). Flaring efficiencies (volume flared to CO2 to volume vented as methane) have a large impact on crude production GHGs. According to the Study, *"There was little or no flare efficiency information on the amount of*

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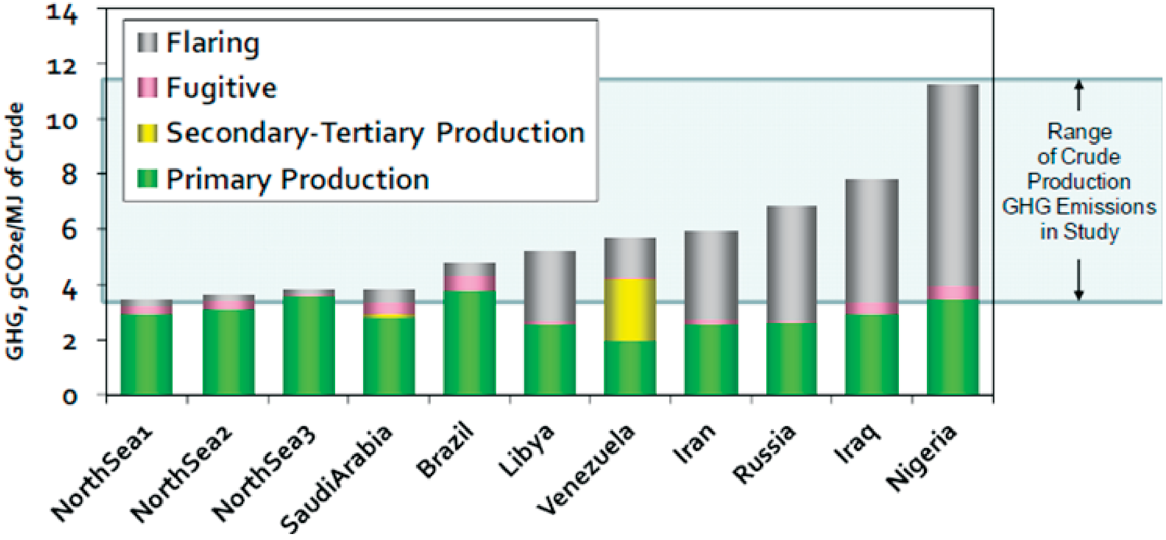
[1] The JEC Consortium is comprised of the European Commission Joint Research Centre (JRC), European Council for Automotive R&D (EUCAR) and Conservation of Clean Air and Water (CONCAWE)

*gas lost due to venting and fugitive emissions from crude oil production."* (Jacobs 2012, 11-4). Jacobs asserts that if 10 percent of gas is vented (90 percent flare efficiency) instead of flared, the flaring related GHGs for all EU crude assays in the study (Table 1) would double (Jacobs 2012, ES-15). Figures 5 and 6 show the resulting GHG intensities under the two different assumptions. The first, Figure 5, uses the reported base-line information used by Jacobs. The second, Figure 6, illustrates the potential increase in GHG is 10% of the associate gas is vented instead of flared.

**FIGURE 5**
**CARBON INTENSITY OF CRUDE OIL PRODUCTION FOR EU CRUDE (SEE TABLE 1 FOR CRUDE ASSAYS)**



Source: (Jacobs 2012, 1-13)

### FIGURE 6
### CARBON INTENSITY OF CRUDE OIL PRODUCTION FOR EU CRUDE ASSUMING 10% VENTING

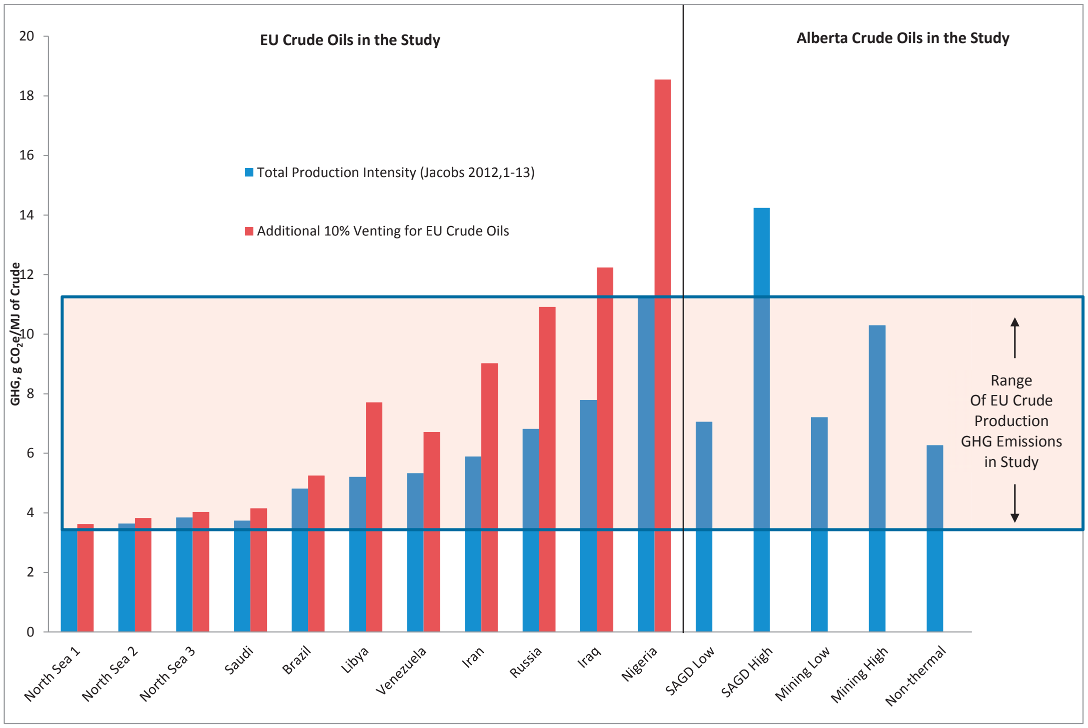


Figure 6 shows that not all crude oils have the same level of flaring, even though they may have similar CI. For example, Saudi Arabia which had a better GHG intensity than the North Sea 3 under the base assumptions, is actually higher is 10% venting occurs. This is also true of the relationship between Libyan and Venezuelan crude production and related to the lower amount of associated gas that is produced with heavier crudes. The effect of doubling the GHG intensity of flaring, when an additional 10% of gas is vented rather than flared results in an average overall increase in emissions of 31%, which has a significant impact as outlined in Figure 4. For the top 3 flaring countries in Figure 6, this emission increase is magnified to an average of 60%.

Lack of transparency and limited availability of global flaring, venting and fugitive emissions data continues to be prevalent in many jurisdictions, with coordination and collaboration between regulators and industries remaining a challenge. The World Bank – Global Gas Flaring Reduction (GGFR) initiative, a global partnership, continues to get more clarity on flaring values and is providing a push to various jurisdictions to obtain more data, but reported levels of flaring for numerous jurisdictions is still required.

### TABLE 4
### TOP 10 FLARING COUNTRIES

| Country Ranking | Russia | Nigeria | Iran | Iraq | Algeria | Angola | Kazakh. | Libya | Saudi Arabia | Venez. | Top Ten | Global Flaring |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | - | - |
| 2010 Flaring (bcf) | 35.2 | 15.2 | 11.3 | 9.1 | 5.4 | 4.1 | 3.8 | 3.8 | 3.7 | 2.8 | 94.4 | 134 |

Source: (NOAA Satellite Data 2010)

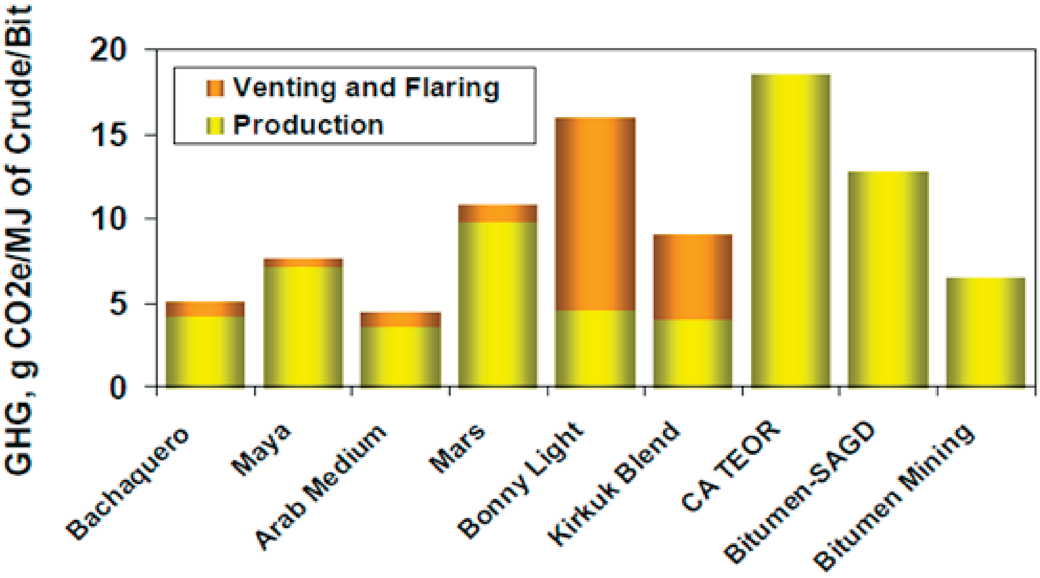
Countries with little reporting requirements such as those in Table 4 are responsible for over 70% of total global flaring volumes, and provide more than 80% of the EU's current crude supply.  In many cases, the GGFR references the reporting requirements and regulatory models of Canada (Alberta), a world leader in flaring and venting reduction practices, as a basis for other jurisdictions (World Bank 2008, p. 28-39).  Reporting requirements for flaring and venting emissions based on measured data would reduce the uncertainty associated with EU crude production.

## UPDATE ON IN GHG ESTIMATES

One of the key objectives of the Study was to provide an update to Jacobs previous WTW LCA work *"Life Cycle Assessment Comparison of North American and Import Crudes"* conducted in 2009 (Jacobs 2009).  GHG emissions estimates for Jacobs' 2012 crude assays (Figure 8) were all significantly lower than those seen in the 2009 study (Figure 7), with an average decrease in CI of approximately 29% for crude production related GHG emissions.  Figure 9 highlights these improved estimates.  Of note is that land use, fugitive emissions and tailings ponds emissions were introduced into the Study to further the understanding of these mining related emissions (Table 2) on WTW LCA assessments. On a comparative basis, using the same metrics that were used in the 2009 study, low intensity mining reduced its CI by 45% while high intensity mining reduced its intensity by a 14% margin.

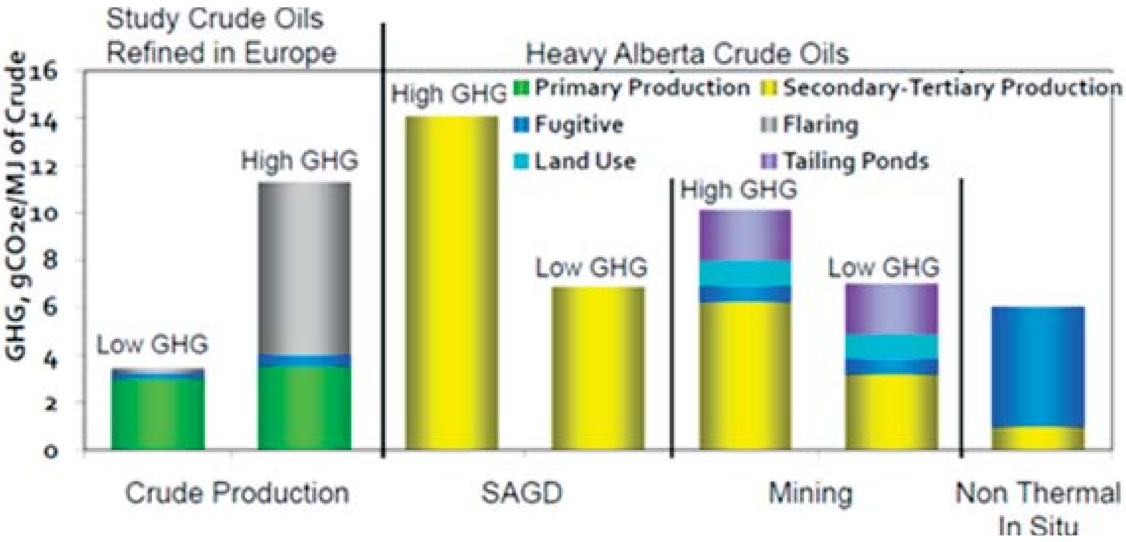
The CI reduction across the board is the likely result of continuous improvement to production technologies and industry best practices (ADOE 2012).

**FIGURE 7**
**GHG EMISSIONS FROM CRUDE OIL PRODUCTION (JACOBS 2009)**



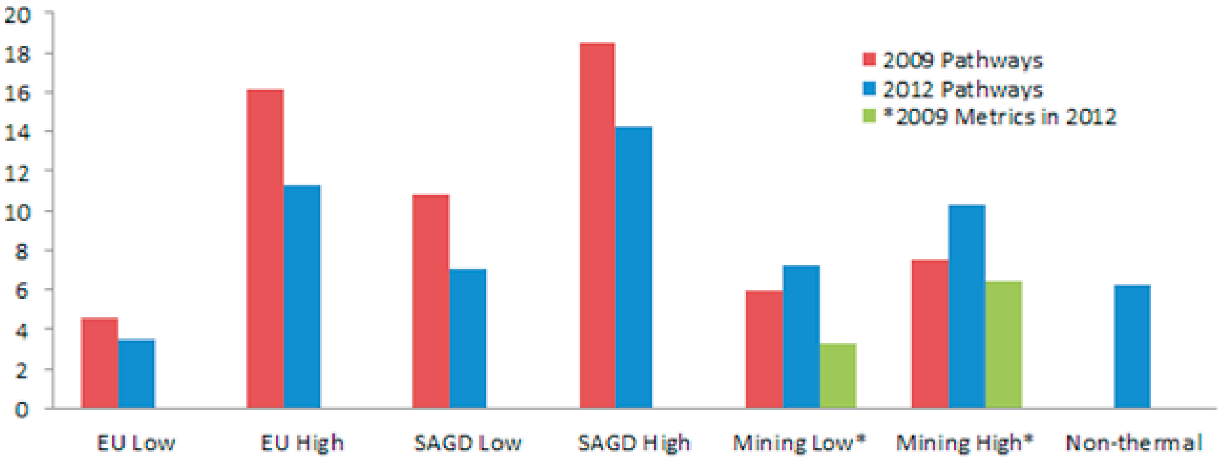
Source:  (Jacobs 2012, A1-4)

## FIGURE 8
## ESTIMATED GHG EMISSIONS FROM CRUDE OIL PRODUCTION (JACOBS 2012)



Source: (Jacobs 2012, ES-7)

## FIGURE 9
## COMPARISON OF ESTIMATED GHG EMISSIONS FROM CRUDE OIL PRODUCTION FOR JACOBS 2009 AND 2012



*Note: Jacobs 2009 metrics do not include fugitive emissions, land use, and tailings emissions

## LIFE CYCLE ASSESSMENT RESEARCH METHODOLOGIES

WTW LCAs interpret and analyze a wealth of input data and processes related to crude pathways.  Following the CI pathways of a crude oil requires many assumptions and determining those assumptions can result in a variance in the final CI.  Assumptions are made based on the purpose and goals of the study and the results of the lifecycle analysis cannot be considered outside of the context in which it was performed.  For example, the Jacobs study is an analysis of crude pathways in the European context and will result in different WTW carbon intensities for Alberta crudes for a comparable study considering an American context.

Jacobs used principles of engineering and modeling to provide a first-order technical assessment of crude pathways.  What this means that the data gathering, analysis and calculations were all done by Jacobs in a consistent manner across all pathways within the Study.  The engineering models and assumptions were developed according to company standards and the results reflect a consistent analysis of crude oils.  This is the first time a consistent methodology based on engineering models has been done for EU and Alberta crudes.

Numerous other studies, such as University of California-Davis, Brandt, CERA and NETL do not use a first-order analysis, but rather employ a method called “meta-analysis” (Jacobs 2012, A1-12) . Meta-analysis uses results from other studies, some first-order and other meta-studies, and attempts to “normalize” the data. All studies use different data and assumptions as inputs and compiling various methods requires data to be converted in order to be comparable.  How this data is compared, at what level assumptions are accepted or disregarded and how numbers are then compiled, impact the outcome of the lifecycle analysis.  Essentially, a meta-analysis involves conforming numbers from various external sources to meet the goal of the study instead developing standard calculations and models to determine carbon intensities.  The issue with such an approach is that uncertainty may be magnified because the individual studies invariably use different assumptions and methodologies.  This is a simplistic approach in which the WTW GHG emissions for production, refining and combustion GHGs may effectively be “mixed and matched” in coming up with CI values.  Accurate WTW GHG estimates require a consistent methodology applied to all fuel pathways and their individual WTW stages.

The complexities of LCA studies demonstrate the challenge in associating a definitive CI value to a crude oil. Instead, the CI of a crude oil should be viewed as a range that accounts for assumptions, data availability and methodology.

## OBSERVATIONS

In a policy context, the most important key messages in the Study are that *"WTW LCA to set fuel policy requires good input data and sound methodology"* (Jacobs, 2012, p. ES-9), and "*Poor data quality limits comparison of crude pathways*" (Jacobs, 2012, p. ES-20) ). It is important to be cognizant of the level of variability in data quality and availability in any comparison for crude pathways. The Study is the first time a lifecycle assessment uses a consistent, first-order WTW GHG analysis for both EU and Alberta based crude pathways (Jacobs 2012, p. A1-12). Through using a transparent methodology and detailed outline of assumptions (allocation and treatment of co-products), Jacobs outlines the data uncertainty involved in each of its pathways and shows that the confidence of estimated carbon intensities for crude pathways correlates with the quality of input data. Based on the results of the Study, there is a significantly higher degree of confidence and reduced uncertainty with GHG estimates for Alberta crude pathways. Decision making based on WTW LCA analysis of gasoline and diesel pathways must use sound information, and Alberta has some of the best regulatory practices and reporting requirements in the world for its crude oil production.

Table 5 highlights key messages, further observations and conclusions from the Study.

**TABLE 5**
**KEY MESSAGES, FURTHER OBSERVATIONS AND RECOMMENDATIONS:**

### FOUR KEY MESSAGES:

**Message 1** – WTW Life Cycle Analysis to set fuel policy requires good input data and sound methodology

**Message 2** – 85% of the GHG emissions in WTW LCA are well understood

- o Vehicle emissions
- o Refining emissions
- o Transport and delivery emissions

**Message 3** – There is a wide range in data quality used to determine crude oil production GHG - from audited reports to government to satellite estimates of gas flaring

**Message 4** – WTW CI of gasoline and diesel from Alberta crude oils are within 12% of the carbon intensity of gasoline and diesel from crude oils refined in Europe. New developments are closing the gap.

## FURTHER OBSERVATIONS

- The carbon intensity of gasoline and diesel from heavy Alberta crude oils fall within 10 to 12% of the carbon intensity of representative crude oils refined in representative refineries in the Study
- New heavy oil production methods are halving the carbon intensity gap between heavy Alberta crude oils and the Study crude oils
- Crude oils fall on a continuum of properties and production methods; Alberta crude oils fall on a continuum with other crude oils
- Carbon intensities of gasoline and diesel depend on how crude is produced and refined - There is no single dominant variable to assess carbon intensity
- GHG emissions from crude oil production depend on energy to produce crude, the amount of gas flared, and fugitive emissions
- GHG emissions from crude oil refining depend on crude oil properties and refining configuration. GHG emissions from refining are highly correlated with crude oil °API gravity and the refining intensity to make finished products. Heavy crude oils from Alberta fall on this continuum of refining GHG emissions with other crude oils.
- Life cycle carbon intensities of refined products vary widely, depending on how they are produced and the methodology used to handle emissions from coproducts.
- Poor data quality limits comparison of crude pathways
    - Energy used to produce crude oils outside of the oil sands region of Alberta are not publicly available and therefore it is not possible to check engineering estimates of GHG emissions against field data to determine the accuracy of the estimates. Energy and GHG emissions for crude oil production from the Alberta oil sands region by thermal means are reported to the Government of Alberta and there is good correlation of engineering estimates of energy consumption with this reported energy consumption.
    - Gas flaring is not routinely measured in much of the world and it was therefore necessary to estimate flaring based on country-wide assessments from satellite imaging. As a result, it is generally not possible to determine the GHG emissions from flaring at a particular reservoir. In contrast, data for crude oils produced in Alberta by thermal means and by mining are reported to the Government of Alberta, and indicate little or no flaring of gas.
    - There is significant uncertainty in the measurement of fugitive emissions from crude oil production. Fugitive emissions during crude oil production are from flanges, control valves, pumps, compressors, etc. Fugitive emissions are also a result of poor flare efficiency. Fugitive emissions are released from storage tanks and during crude oil transport. In bitumen mining, fugitive emissions

result from opening the mine face. During non-thermal in situ production of bitumen, fugitive emissions may be released from the equipment and storage tanks. Fugitive emissions during thermal production of bitumen are small and mainly from the equipment.

  - There is a wide range in estimated GHG emissions from tailing ponds used in bitumen production by mining and there is a wide range in emissions from preparing the land for mining and other surface facilities. There is a lack of consistency in the basis used to estimate emissions by different groups. Some include the long term impact of changes in the land. Others do not. The time horizon chosen for the estimated impacts also vary from group to group.

## RECOMMENDATIONS

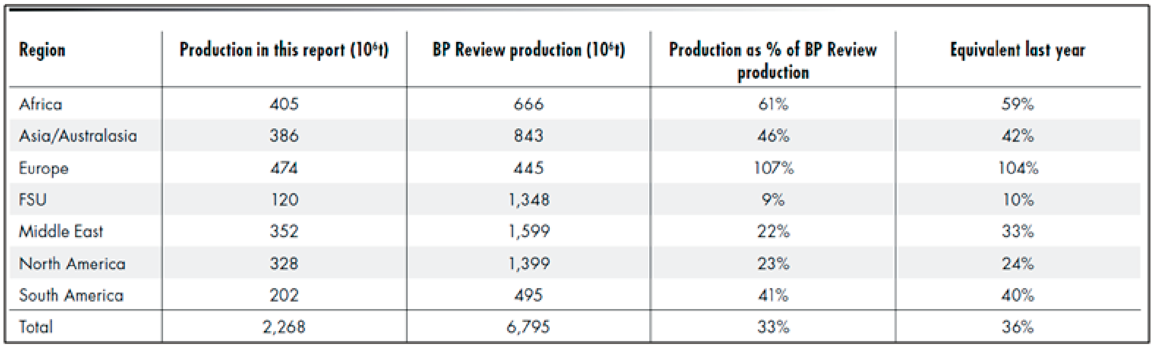
- Decisions based on WTW LCA analysis of gasoline and diesel pathways must use sound information
- Uncertainty and discrepancies in data demand that better information be made available especially to better define:
  - Crude production energy in regions that currently do not report or measure energy and GHG to produce crude oils
  - Flaring based on measurement of flaring on site instead of from satellite estimates
  - Fugitive emissions – use consistent methodology to estimate and report fugitive emissions from oil production
  - Land use and tailing ponds – resolve differences in estimates by different authors and agencies
  - CO2 emissions from carbon lost from the soil – determine the impact of carbon lost from the soil
  - Land reclamation – better estimate the net impact of land disturbance and reclamation in heavy Alberta oil production
- Data must be audited.

Source: (Jacobs 2012, p. ES-19 to ES-21)

## GLOBAL MARKETS, REPORTING AND REGULATORY ISSUES

The challenges associated with data availability and uncertainty is inherent in other prominent LCA studies as well.  Current estimates for 2010 crude production data from the International Oil & Gas Producers (OGP 2011, p. 31) suggests an average of only 33% (Table 6) of gross production data being reported by individual companies based on a review of global production. Similarly, the JEC's most recent 3C report, a key reference for the EU's current FQD proposal, highlights the poor range of emissions data for the EU (Table 7), with only 40% of crude production data publically available for the current EU crude oil supply.

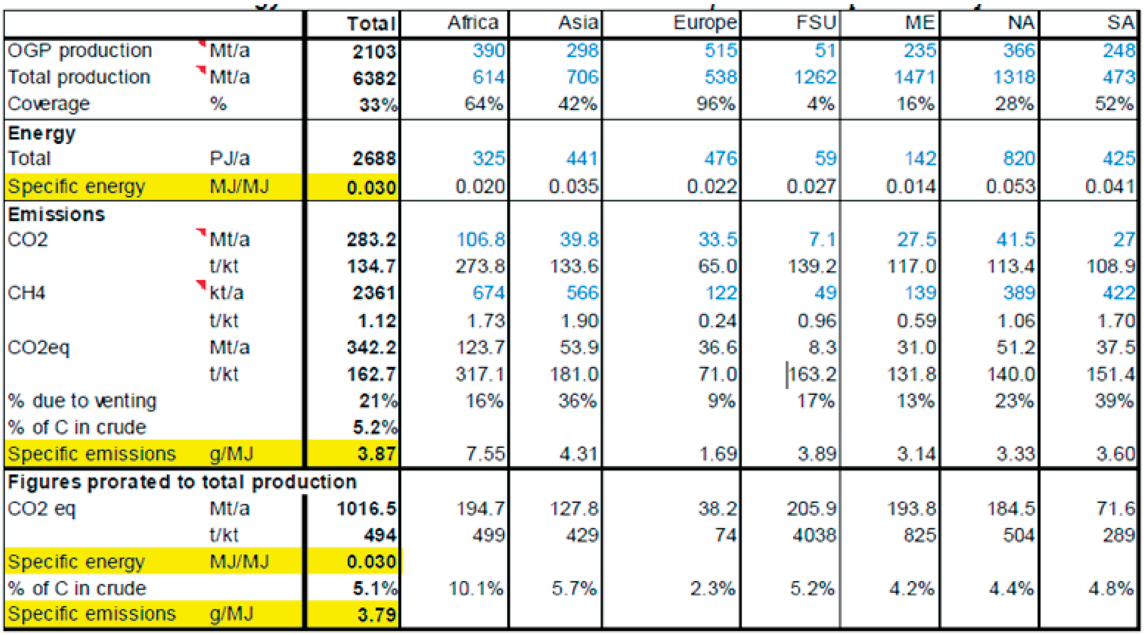
**TABLE 6**
**PRODUCTION ASSOCIATED WITH DATABASE AND 2010 PRODUCTION IN BP STATISTICAL REVIEW OF WORLD ENERGY BY REGION**



| Region | Production in this report ($10^6$t) | BP Review production ($10^6$t) | Production as % of BP Review production | Equivalent last year |
|---|---|---|---|---|
| Africa | 405 | 666 | 61% | 59% |
| Asia/Australasia | 386 | 843 | 46% | 42% |
| Europe | 474 | 445 | 107% | 104% |
| FSU | 120 | 1,348 | 9% | 10% |
| Middle East | 352 | 1,599 | 22% | 33% |
| North America | 328 | 1,399 | 23% | 24% |
| South America | 202 | 495 | 41% | 40% |
| Total | 2,268 | 6,795 | 33% | 36% |

Source:  (OGP 2011, p.31)

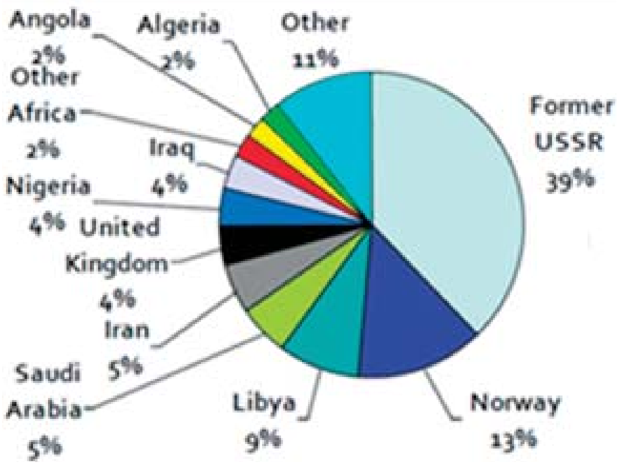
**TABLE 7**
**ENERGY AND GHG EMISSIONS FROM CRUDE OIL PRODUCTION (2005 PRODUCTION DATA)**



| | | Total | Africa | Asia | Europe | FSU | ME | NA | SA |
|---|---|---|---|---|---|---|---|---|---|
| OGP production | Mt/a | 2103 | 390 | 298 | 515 | 51 | 235 | 366 | 248 |
| Total production | Mt/a | 6382 | 614 | 706 | 538 | 1262 | 1471 | 1318 | 473 |
| Coverage | % | 33% | 64% | 42% | 96% | 4% | 16% | 28% | 52% |
| **Energy** | | | | | | | | | |
| Total | PJ/a | 2688 | 325 | 441 | 476 | 59 | 142 | 820 | 425 |
| Specific energy | MJ/MJ | 0.030 | 0.020 | 0.035 | 0.022 | 0.027 | 0.014 | 0.053 | 0.041 |
| **Emissions** | | | | | | | | | |
| CO2 | Mt/a | 283.2 | 106.8 | 39.8 | 33.5 | 7.1 | 27.5 | 41.5 | 27 |
| | t/kt | 134.7 | 273.8 | 133.6 | 65.0 | 139.2 | 117.0 | 113.4 | 108.9 |
| CH4 | kt/a | 2361 | 674 | 566 | 122 | 49 | 139 | 389 | 422 |
| | t/kt | 1.12 | 1.73 | 1.90 | 0.24 | 0.96 | 0.59 | 1.06 | 1.70 |
| CO2eq | Mt/a | 342.2 | 123.7 | 53.9 | 36.6 | 8.3 | 31.0 | 51.2 | 37.5 |
| | t/kt | 162.7 | 317.1 | 181.0 | 71.0 | 163.2 | 131.8 | 140.0 | 151.4 |
| % due to venting | | 21% | 16% | 36% | 9% | 17% | 13% | 23% | 39% |
| % of C in crude | | 5.2% | | | | | | | |
| Specific emissions | g/MJ | 3.87 | 7.55 | 4.31 | 1.69 | 3.89 | 3.14 | 3.33 | 3.60 |
| **Figures prorated to total production** | | | | | | | | | |
| CO2 eq | Mt/a | 1016.5 | 194.7 | 127.8 | 38.2 | 205.9 | 193.8 | 184.5 | 71.6 |
| | t/kt | 494 | 499 | 429 | 74 | 4038 | 825 | 504 | 289 |
| Specific energy | MJ/MJ | 0.030 | | | | | | | |
| % of C in crude | | 5.1% | 10.1% | 5.7% | 2.3% | 5.2% | 4.2% | 4.4% | 4.8% |
| Specific emissions | g/MJ | 3.79 | | | | | | | |

Source:  (JEC 2011, p. 20)

**FIGURE 10**
**2010 EU CRUDE SUPPLY AND RESPECTIVE DATA COVERAGE FOR CRUDE EXTRACTION**



Source: (Jacobs 2012, ES-4)

Table 7 and Figure 10 show that over 50% of the EU feedstock for the 2010 EU crude oil supply is shown to be "fair" or "patchy" in terms of data coverage (JEC 2011, p. 20). Furthermore, the JEC asserts that grouping publicly available production data groups and provinces into large regions is an oversimplification for deriving production CIs and subject to considerable uncertainty in estimating production related GHG emissions (JEC 2011, p. 20). As aforementioned, crude types are often aggregates of numerous production sites, in which the tracing emissions data from a particular site is difficult to determine.

## POLICY IMPLICATIONS OF THE EU FUEL QUALITY DIRECTIVE

The EU's current FQD Proposal (European Commission, 2012) aims for a 6% reduction in carbon emissions for transportation fuels between 2010 and 2020. The proposal defines 3 distinct categories for European crude feedstock, 1) Conventional Oil, 2) Natural Bitumen and 3) Oil Shale. Each of these categories is then designated a default GHG intensity on a wells-to-wheels (WTW) basis, determined by two primary references according to the current proposal. The Table 8 outlines the default values for petrol.

**TABLE 8**
**FQD CRUDE CATEGORIES**

| Fuel Source | Default GHG Intensity gCO2/MJ | Default Reference |
|---|---|---|
| Conventional | 87.5 (petrol) and 89.1 (diesel) | JEC |
| Natural Bitumen | 107 (petrol) and 108.5 (diesel) | The Brandt Study |
| Oil Shale | 131.3 (petrol) and 133.7 (diesel) | The Brandt Study |

Source: (European Commission 2012, p. 3)

There are a number of technical issues with such an approach to categorization outlined in Table 8, including:

- The two primary references (JEC 2011 and Brandt Study[2]) used in calculating the default values are meta-analysis (Jacobs 2012, p. A1-12), which means these two sources combine various studies and different assumptions in modeling WTW GHG emissions. The issue with such an approach is that it is not valid to directly compare the absolute GHG emission estimates among studies with different assumptions and methodologies. Meta-analyses use a simplistic approach in which production, refining and combustion GHGs may effectively be "mixed and matched" in coming up with a single default value. Accurate WTW GHG estimates require a consistent methodology applied to all fuel pathways and their individual WTW stages.

- The source of the 87.5 and 89.1 WTW g/MJ for petrol and diesel respectively is not clear or defined in the FQD proposal.

- The source of the default 107 and 108.5 WTW g/MJ for petrol and diesel respectively is not clear or defined in the FQD proposal.

- The American Petroleum Institute (API) gravity of Alberta Bitumen ranges from 6-18 degrees. Based on the language of the current FQD proposal, a share of bitumen falls under the Conventional Oil category outlined within the proposal.

- The only methods for bitumen production outlined in the proposal are thermal and mining extraction – no mention of CHOPS or other cold production technologies.

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[2] Brandt, A.R., *Upstream greenhouse gas (GHG) emissions from Canadian oil sands as a feedstock for European Refineries*, 2011.

- The report references the JEC work in regards to GHG production intensity for conventional oil, and states that all production intensity is attributed to extraction. There is a critical error in the FQD proposal citing this, as the JEC work indicates that 50% of GHG production intensity is attributed to pre-heating and extraction, and the remaining 50% is attributed to flaring and venting (JEC 2012, p. 20). The proposal understates flaring and venting, and in fact does not include it in production GHG values, yet according to its major reference (JEC 2011) flaring and venting is a significant contributor to Conventional Oil production GHGs. Further, any jurisdiction currently supplying EU feedstock that demonstrates improvements in flaring and venting is given a GHG reduction credit, effectively giving a "double-credit", as a result of no initial accounting for flaring and venting.

The findings of the 2012 Jacobs Study add additional technical insight into the current FQD 7a proposal, including:

- JEC work suggests that overall, only 40% of crude production data is publicly available for current EU crude feedstock. More than 60% of jurisdiction providing feedstock do not report any production data. (JEC 2011, p. 20)
- Jacobs is the only study to use both first-order engineering modeling and a consistent WTW GHG analysis to compare fuel pathways for current EU crude oil feedstocks versus bitumen.
- Current work shows that when producing petrol and diesel, crude oils (including EU crude oils and bitumen) fall on a continuum, or exhibit marginal differences in GHG intensity. Having 3 separate categories implies "step-change" difference with no overlap, which is not valid.
- Based on the availability and quality of crude production data, WTW GHG calculation of various pathways should reflect GHG ranges, not one specific default value. Additionally, Alberta ('natural bitumen') based crude production data is among the best available in the world, and third-party audited.
- WTW lifecycle analysis to set fuel policy requires good input data and sound methodology – poor data quality limits the comparison of crude pathways.
- Confidence in GHG emissions from crude oil production correlates with data quality. Better data means higher confidence in CI. There is a significantly greater level of confidence with Alberta based data.
- Based on the FQD's current GHG default values, Conventional Oil is understated (87.5 and 89.1 gCO2e/MJ) and Natural Bitumen is overstated (107 and 108.5 gCO2e/MJ) based on the findings of the Jacobs Study.

- With numerous refinery configurations within the EU, a single, base refinery configuration could be developed for the EU for simplicity, but it may understate refinery related GHG emissions. The current linear program (LP) model employed by the JEC is based on an optimal economic-based model is an example (it has an optimally modeled specific crude mix and refinery mix).

- Given the limited availability of EU crude production data, tracing a country's specific crude mix being exported to the EU is very complex process in certain instances and requires reporting (audited) of all production and transportation based emissions. Given the significant data quality issues that have been outlined in this paper, this would be a significant challenge due to variable reporting requirements and the limited production data that exists across jurisdictions (outside of jurisdictions such as Alberta).

- Crudes have varying fungibility, and as such, should a country fail to meet the proposed EU default value, a crude mix of equivalent specifications (API, sulfur, etc.) would be required to substitute that feedstock in the EU crude supply to meet demand.

- Although the proposed FQD suggests default GHG values for each country, there is a significant degree of complexity (tracing crude sources, uncertainty and variability in production data) involved in modeling.

The Jacobs Study shows significant overlap of WTW GHG emission ranges when a consistent and comprehensive methodology is applied to both 1) EU crude oil pathways ('Conventional Oil', Table 8) and 2) Alberta crude oil pathways ('Natural Bitumen', Table 8). Therefore, having three distinct categories is arbitrary and not supported by scientific and technical information. The review outlined within this paper details the methodology and the complexity involved in disaggregating individual country feedstocks (tracing GHG emissions) to determine GHG emissions, and supports the conclusion that using an approach in which one EU default value for all crudes (or baseline) is not technically justifiable.

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