March 2012

Briefing note

Oilsands, heavy crudes, and the EU fuel-quality directive

At a Glance

The European Union's fuel-quality directive currently proposes to assign a default emissions value to natural bitumen (oilsands) that is higher than the value for conventional crude oil, in recognition of the increased greenhouse gas (GHG) emissions resulting from the production and upgrading of oilsands.

This briefing note shows that there is a very clear distinction between the GHG intensities of natural bitumen and conventional crudes in the vast majority of production. The life cycle GHG emissions intensity (emissions per unit energy from "well to wheel") of oilsands ranges from around 12 to 40 per cent higher than the average intensity of conventional fuels used by Europeans. Only a small volume of conventional crudes have emissions intensities within the range of oilsands; however, all conventional crudes have consistently lower emissions intensities than the average oilsands. Even when comparing the oilsands with a subset of the heaviest crudes entering Europe or sources with high levels of illegal or unregulated flaring, there is a clear difference between averages. Given this clear distinction, the treatment of 'natural bitumen' as a separate feedstock is well justified.

Overview of the fuel-quality directive

The European Union's fuel-quality directive is part of the EU's commitment to a 20 per cent reduction in carbon emissions by 2020.[1] To help fulfill this goal, suppliers of transport fuels must reduce the life cycle greenhouse gas intensity of their products — gasoline, diesel, etc. — by six per cent by 2020, relative to 2010.

The challenge underlying the proposal to implement the EU fuel-quality directive is balancing the goal of reducing GHG emissions by accurately accounting for all emissions from fuel sources (feedstocks, or the raw material used to manufacture fuel), and developing a policy broad enough to be implemented across the entire European Union. The feedstock approach is a sound compromise between not accounting for any differences between emissions intensities of crudes and differentiating all possible pathways.

Fuels produced from various feedstocks can have significantly different GHG emissions intensities because of differences in the extraction and refining processes. Failing to account for the significant differences among crude supplies from various feedstocks could undermine any efforts to reduce overall emissions.

An implementation measure of the fuel-quality directive currently proposes to assign a default emissions value to natural bitumen (oilsands) that is higher than the value for conventional crude oil, in recognition of the increased greenhouse gas (GHG) emissions resulting from the production and upgrading of oilsands. Those opposed to this differentiation argue that some heavy crudes have comparable life cycle emissions to natural bitumen, yet are treated as conventional fuels. This briefing note will outline the importance of fair comparisons of emissions using weighted average values, and the results that show that the treatment of 'natural bitumen' as a separate feedstock is justified.

Why does the fuel-quality directive differentiate fossil fuels?

Fuels produced from various feedstocks can have significantly different GHG emissions intensities because of differences in the extraction and refining processes. The fuel-quality directive uses basic fossil fuel categories including conventional, coal-to-liquid, gas-to-liquid, shale oil, and natural bitumen. Once categorized, each fossil fuel receives a default GHG intensity based on the 'average' or 'most likely' value for that feedstock.

In reality, each feedstock category may have a range of emissions intensities such that the highest sources may come close to the lowest sources from another feedstock category. However, this approach works for the overwhelming majority of fossil fuel sources because most sources have emissions very close to their feedstock average and there is a wide difference between the average values of each feedstock.

The feedstock approach is a sound compromise between not accounting for any differences among emissions intensities of crudes and differentiating all possible pathways (i.e. each individual crude source).

How does the fuel-quality directive differentiate among fossil fuels?

The fuel-quality directive differentiates among transportation fuels based on the types of feedstock from which they are produced. For example, fuels produced from shale oil and fuels produced from natural bitumen are in different categories than conventional oil. The distinctions separating these categories are based on the physical properties of the feedstock, not their geographic origin.

The proposed fuel-quality directive implementation measure[2] defines oilsands or 'natural bitumen' as a separate feedstock from conventional crude due to the distinct and clear differences observed by comparing the physical and chemical characteristics of crude oil and bitumen. In simple terms, while conventional crude is in liquid state underground and flows readily when pumped, natural bitumen deposits more closely resemble a solid and cannot be pumped to the surface under normal conditions.[3] In the directive, natural bitumen is defined according to two main criteria: density (American Petroleum Index or API gravity) and viscosity (for a given temperature).

According to this definition, sources that are more dense (heavier) and also more viscous than the cut-off are categorized as natural bitumen. For example, large portions of extra-heavy crudes from Venezuela's Orinoco belt meet the density and viscosity cut-off and would, therefore, also be assigned the natural bitumen default value.[4] Crudes that are either less dense or less viscous are placed in the 'conventional' category. The proposal notes that employing both criteria together should remove any ambiguity, and that these criteria can be applied uniformly across all crude sources.

Any producer that out-performs the default emissions value for their feedstock can choose to obtain their own value by supplying the relevant data. This creates an incentive for innovation and rewards past improvements.

How are crudes defined by their density?

Crudes are often compared by their density using the American Petroleum Index (API gravity). While there are some variations in cut-offs, a general breakdown is:

- light crude — API gravity greater than 20°,
- heavy crude — API gravity 10-15°,
- extra heavy, such as oilsands bitumen — API gravity in the range 5 to 10° (Athabasca bitumen average = 8° API).

Source: *Enhanced Recovery Methods for Heavy Oil and Tar Sands*, Glossary & Chapter 1, 14.

How do oilsands GHG intensities compare to conventional crude?

The physical differences between the oilsands feedstock and the conventional crude feedstock, notably the higher density and viscosity of oilsands, mean that oilsands requires much more energy to extract and process. As a result, oilsands generally have much higher life cycle GHG emissions than conventional crudes. Assessments to date consistently demonstrate that the life cycle GHG intensity of oilsands production is among the highest of crude supplies.[5] Specifically, the oilsands GHG life cycle intensity ranges from around 12 per cent to 40 per cent higher than the European average.[6] This broad range is reflective of the different projects and different production technologies.[7]

According to a peer-reviewed study financed by the European Commission, average oilsands — reflecting the current mix of production methods — are approximately 23 per cent more GHG-intensive than the average conventional crude on a life cycle basis.[8] This is illustrated in Figure 1 below.

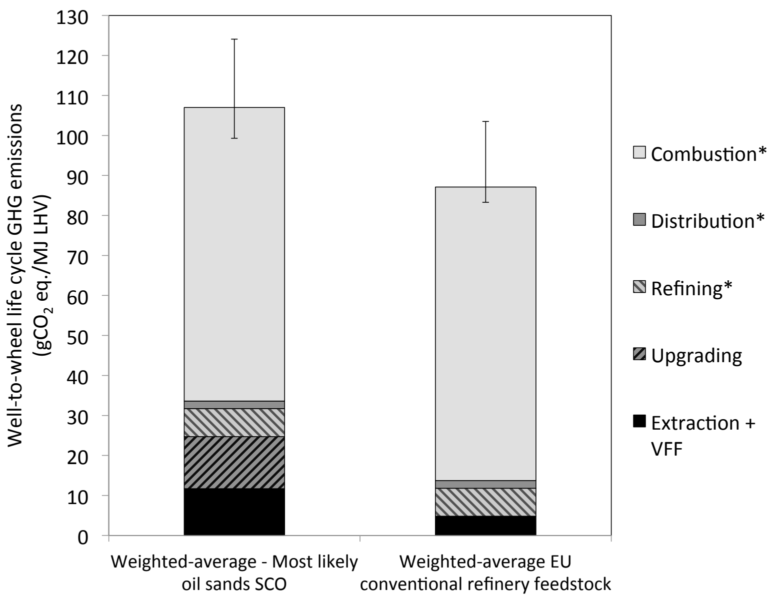

Figure 1: Life cycle GHG intensity comparison between the weighted-average most likely oilsands emissions and the weighted average conventional EU refinery feedstock.

Source: *Upstream greenhouse gas (GHG) emissions from Canadian oil sands as a feedstock for European refineries,* Figure 13.

How consistent is the difference between oilsands and conventional crudes, in terms of GHG emissions intensities?

Data from the 2011 Brandt study show clear and substantial differences in GHG emissions intensities from oilsands and conventional crude, as illustrated in Figure 2 below.

The following conclusions can be drawn from this figure:

- There is a clear difference in life cycle GHG emissions between the current EU average conventional crude and the average value for oilsands crude (23%).
- The overwhelming majority of conventional crudes have substantially lower emission intensities than the oilsands.
- The compromise of using averages for default values means that sources on the extreme ranges of emissions intensities (high and low) will be represented by the default value. However, this effect is essentially cancelled out because it happens for all feedstocks. For example, the source of conventional crude supplied to the EU that has the highest emission intensity (Nigeria) is similar to the low range of oilsands emission intensities, this source represents only three per cent of conventional inputs and is clearly an outlier. While this outlier will receive the benefit of the lower default value associated with conventional crudes, this effect is cancelled out by the fact that the highest emitting oilsands will also benefit from their default value.
- *All* conventional crude sources in the current EU input stream, including Nigeria, are less GHG-intensive than the 'most likely' average value identified for oilsands.

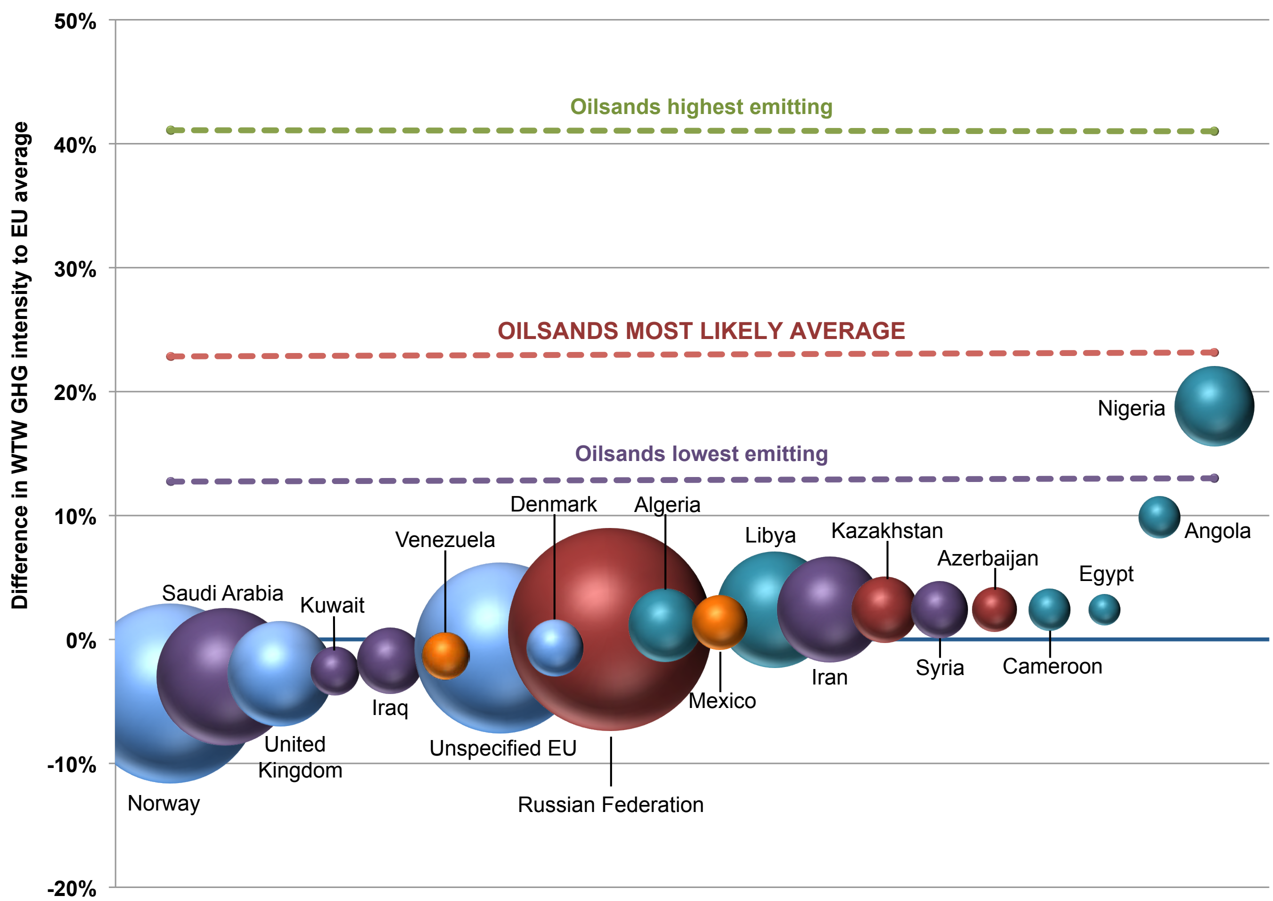

Figure 2: GHG emissions intensity of conventional EU refinery inputs by source country relative to their weighted average value[9].

Circles: various types of conventional crudes (feedstocks) being imported into Europe; size denotes how much of the total supply of EU conventional crude is produced from that source.

Vertical placement of circles: difference (in %) compared to the average weighted GHG intensity from all conventional crudes currently supplied to the EU.

Solid line at 0%: EU default value for conventional crude proposed for the fuel-quality directive.

Dashed lines: range of GHG emissions intensities from oilsands. 'Most likely average' for life cycle GHG emissions to produce gasoline from synthetic crude oil derived from Canadian oilsands (107 gCO_2/MJ or 23% higher than the EU average) is the proposed value for bitumen-derived crude products under the fuel-quality directive.

Figure produced using data from Brandt, *Upstream greenhouse gas (GHG) emissions from Canadian oilsands as a feedstock for European refineries,* Tables 6-7. For more information on data sources in Brandt, see Data Sources box, below.

The importance of comparing average emissions values for policy decision-making

As there are a number of sources of conventional crudes and a variety of ways oilsands are produced, there is a range of emissions intensities across both feedstocks. It is essential to select appropriate life cycle emissions intensities as representative values. To compare the range of oilsands and conventional crude sources, life cycle studies generally use one of two methods to calculate these values: pathways or averages.

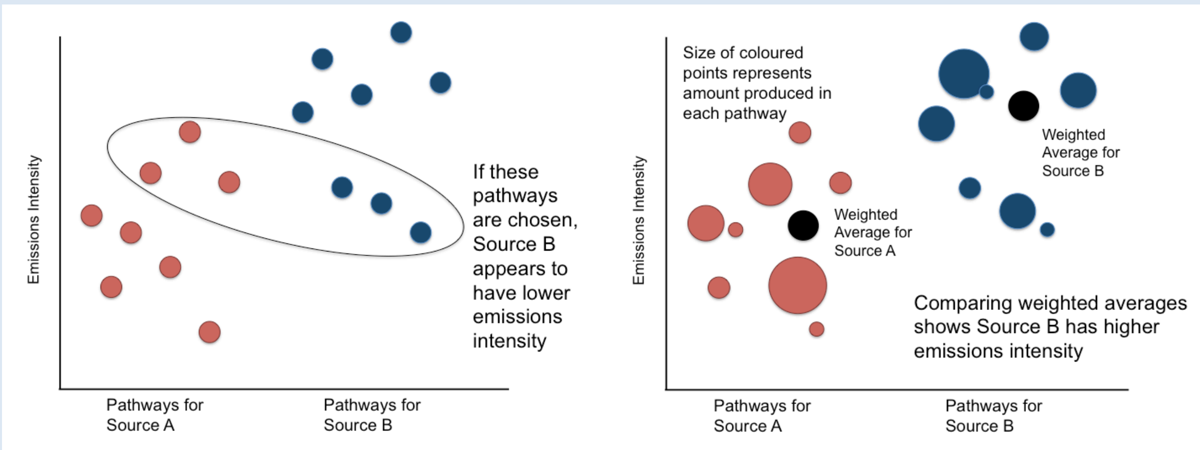

Figure 3. Approaches to comparing emissions intensities: Pathways vs. Averages

The pathway approach compares a select group of conventional crude sources (pathways) to a select group of oilsands pathways. The results are highly influenced by which pathways are chosen from each feedstock for the comparison.

The more useful and accurate method is to compare weighted averages from both feedstocks. This approach evaluates the whole range of sources within a feedstock and then produces an average value, weighted according to the total production volumes by source, that reflects what the emission intensity is for the majority of the production from that feedstock. Some sources may be above the average or below average, but overall this only affects a small portion of sources on each extreme and the effect is essentially cancelled out because it occurs on both sides of the average. As such, if two feedstocks have significantly different averages, policy makers can be confident that the overwhelming majority of crude produced from one feedstock will have different emissions from a crude produced in the other feedstock.

How do the heavy crudes defined as "conventional" compare to oilsands?

Heavy crudes — crudes that are more dense (lower API gravity) — can in some cases require more energy to extract in comparison to the lighter sources of conventional crude and thus may have emissions intensities that are higher (closer to those of oilsands). The central question is whether or not the EU is using significant volumes of these heavy (high-emissions) crudes and, if so, how these should be treated in the implementation measures for the fuel-quality directive.

In fact, the comparison between oilsands and conventional crudes supplied to the EU (shown in Figure 2) already includes heavy conventional crudes. This comparison shows that the average value for the GHG intensity of oilsands is 23 per cent higher than average conventional crude on a full life cycle basis. Further, Figure 2 shows that the overwhelming majority of conventional crude sources, including heavy conventional crudes, are well represented by the weighted average for conventional. Only approximately three per cent of the conventional crude sources have emission intensities that stand out from the rest.

Heavier crudes supplied to EU refineries have little impact on the overall weighted-average GHG intensity for conventional crudes, in part because they represent a relatively small portion of the total volume. As shown in Figure 4, around 80 per cent of the crude supplied to the EU has an API gravity in the range of 30° to 40°. Very little, by contrast, falls in the range below 20°.

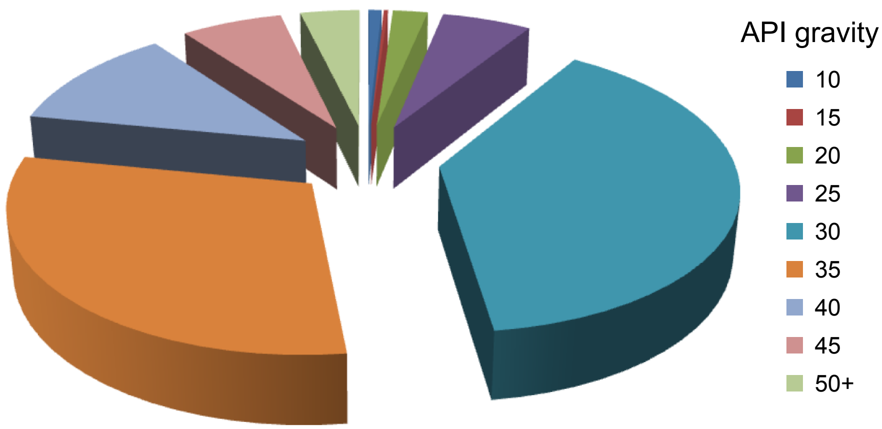

Figure 4: Crude inputs to EU refineries in 2010 displayed according to API gravity.
Figure adapted from Energy Re-defined LLC – For the ICCT, *Carbon Intensity of Crude Oil in Europe* (Washington, DC: International Council on Clean Transportation, 2010), 52, Figure 19.

However, as will be shown below, even if only the heavier portion of EU crude input is compared to oilsands, there remains a clear distinction in their respective emissions intensities.

The International Council on Clean Transportation (ICCT) conducted a life cycle comparison of crude supplies to the EU,[10] similar to the Brandt study produced for the fuel-quality directive. Figure 5 illustrates emissions intensities from a subset of the ICCT data representing only the heavier conventional crudes entering EU refineries (API gravity below 20°) compared to oilsands emissions.

In the figure below, the curves represent the various sources of oilsands production and heavy conventional crude production. Each point represents one source of crude; points are distributed horizontally in terms of their contribution to the total volume of production for each category. For example, the section of the curve ranging from 0 to 0.5 on the horizontal axis represents the 50 per cent portion of heavy crude with the lowest emissions. Note that, unlike figures above, this figure reflects only the upstream portion of the life cycle: from extraction (including upgrading for oilsands) to refining. The remainder of the life cycle should be roughly equivalent for all crudes.

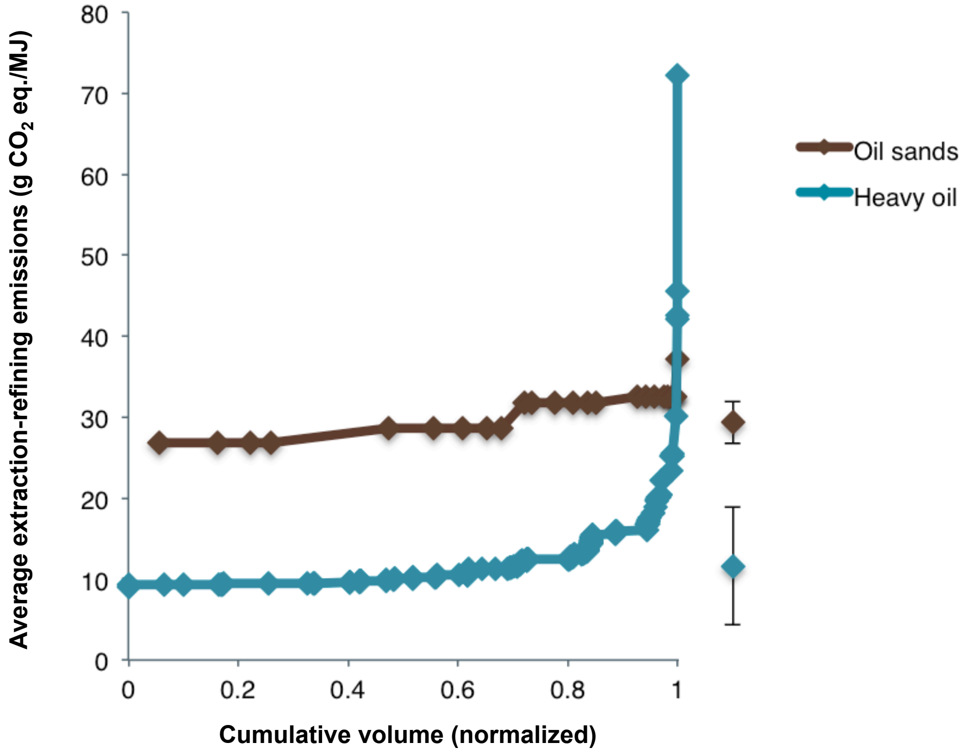

Figure 5: Emissions intensities associated with extraction to refining processes for oilsands and EU-refined crudes with API gravity values below 20°, with values normalized according to total production volumes.
Figure provided by the ICCT & Energy Re-defined LLC through personal communication (Nov, 2011) – based on data from *Carbon Intensity of Crude Oil in Europe Crude*, 2010.

The following conclusions can be drawn from this figure:

- There is still a distinct difference between the average GHG intensity of oilsands and the average of heavier EU crudes.
- Only a minute portion of heavy crude sources have emissions intensities similar to oilsands. In fact, only around 2% of heavy crude production has emission intensities within or above the oilsands emission intensity range.

It should also be noted that some of the heavy crudes illustrated in this figure have higher emissions that are likely due to flaring — an issue treated separately in the fuel-quality directive and discussed below.

How does flaring factor in?

> *"Flaring and venting are an important source of GHG emissions from oil fields. When crude oil is extracted, gas dissolved in crude oil is released, which can be used for meeting energy needs in extraction, captured and sold as product, or flared and vented. Flaring refers to disposal of associated gas produced during extraction through burning. Venting refers to intentional releases of gas and the release of uncombusted gas in flaring (the combustion efficiency of flaring is not 100%, so some methane is left in the exhaust gas)."*[11]

The fuel-quality directive proposal acknowledges that some of the crudes in the conventional feedstock with the highest GHG emissions have emissions intensities close to or within the range of oilsands emission intensities. The proposal also notes that this is largely due to uncontrolled or illegal flaring and venting practices.[12]

The proposal further explains that high emissions resulting from flaring are not due to naturally occurring differences among the physical properties of the feedstock sources, but rather inappropriate management of the produced gas extracted with the conventional crudes. Therefore, the fuel-quality directive addresses flaring independently from the default values associated with feedstock differentiation by providing additional incentives for crude suppliers to reduce flaring.

As shown in Figure 6, crudes produced with high levels of uncontrolled flaring have substantially higher emissions intensities than the conventional crudes — and represent all of the crudes that have emissions intensities within the GHG intensity ranges for oilsands. If the flaring incentives provided by the fuel-quality directive are effective, the gap between conventional crude (including the heavier crudes) and oilsands could become significantly more pronounced. In fact, recent analysis suggests that global gas flaring is already on a downward trend.[13]

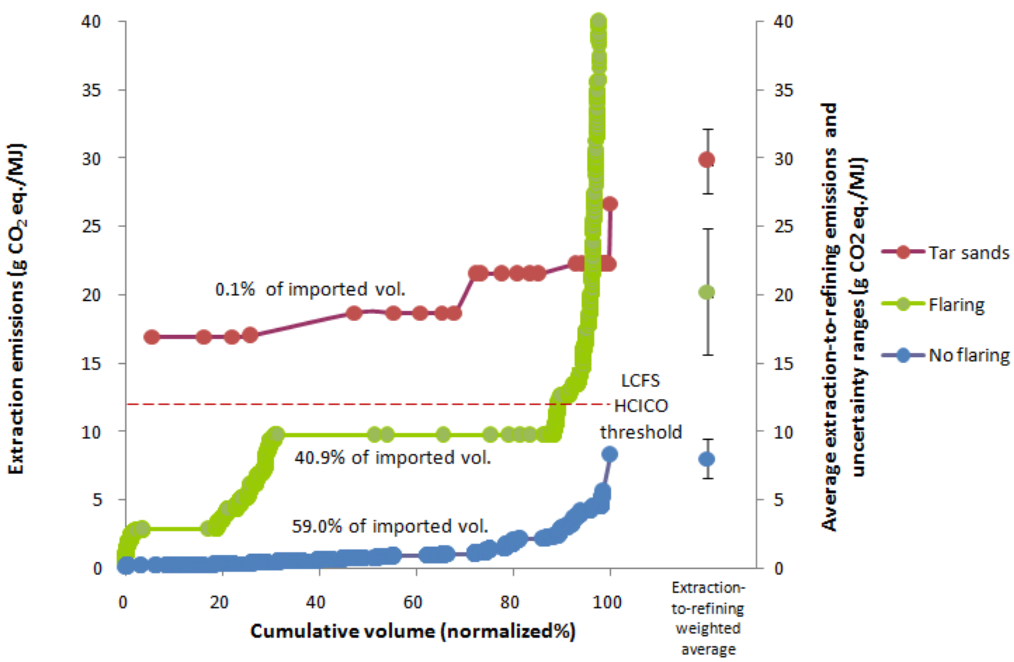

Figure 6: Emission intensities associated with extraction (normalized distribution curves) and extraction to refining processes (average values and ranges) for oilsands (Tar sands), EU crudes with flaring (Flaring) and EU crudes without flaring (No flaring).

Source: *Carbon Intensity of Crude Oil in Europe* (2010), 56, Figure 24.

Note that the data illustrated in the figure above reflect only a portion of the life cycle processes: the extraction emissions (including upgrading for oilsands) for the normalized distribution curves at left; and emissions from extraction to refining for the weighted averages and production ranges at right.

Endnotes

[1] Commisioner for Climate Action, The EU climate and energy package, European Commission, http://ec.europa.eu/clima/policies/package/index_en.htm (accessed March 5th, 2012).

[2] The Committee on Fuel Quality, *Draft Commission Directive../…/EU of […] laying down calculation methods and reporting requirements pursuant to Directive 98/70/EC of the European Parliament and of the Council relating to the quality of petrol and diesel fuels* (Brussels, Belgium: European Commission, 2012), available at http://ec.europa.eu/transparency/regcomitology/index.cfm?do=search.documentdetail&XOvfOQKYHt67nl0gDR9EQ0pDU4MfDGIJHglKuEmrBsSBuE2177sL3dMBpRfefPrJ

[3] Bitumen is immobile at formation temperatures and must be stimulated (often thermally) for recovery. Source: James Speight, *Enhanced Recovery Methods for Heavy Oil and Tar Sands* (Houston, TX: Gulf Publishing Company, 2009), 215.

[4] Based on deposit density and viscosity presented in:

Richard Meyer, et al., *Heavy Oil and Natural Bitumen Resources in Geological Basins of the World* (Reston, Virginia: U.S. Geological Survey, 2007) 17–34. Available at http://pubs.usgs.gov/of/2007/1084/OF2007-1084v1.pdf

[5] Comparisons are drawn from Adam Brandt, *Upstream greenhouse gas (GHG) emissions from Canadian oil sands as a feedstock for* European refineries, Executive summary (Stanford, CA: Department of Energy Resources, Stanford University, 2011), 42, https://circabc.europa.eu/d/d/workspace/SpacesStore/06a92b8d-08ca-43a6-bd22-9fb61317826f/Brandt_Oil_Sands_Post_Peer_Review_Final.pdf; and *Life Cycle Assessment Comparison of North American and Imported Crudes* (JACOBS Consultancy, prepared for Alberta Energy Research Institute, 2009), 178. Note: There is a small degree of overlap of oilsands GHG intensities with other high GHG intensity crudes from locations like Venezuela, Nigeria and Angola.

[6] *Upstream greenhouse gas (GHG) emissions from Canadian oil sands as a feedstock for European refineries*, Executive summary.

[7] Oilsands can be extracted by mining or through in situ techniques and there are variations within both major methods (such as project fuel mix) that lead to variations in GHG profiles.

[8] *Upstream greenhouse gas (GHG) emissions from Canadian oil sands as a feedstock for European refineries*, 41.

[9] All data presented in Figure 3 is from the EC-commissioned study by Adam Brandt, *Upstream greenhouse gas (GHG) emissions from Canadian oil sands as a feedstock for European refineries.* For conventional crude inputs, the study uses upstream emissions data from the U.S. National Energy Technology Laboratory (NETL), matched to average EU refinery feedstock. For the "most likely" value for oilsands, the study uses upstream emissions estimates from GHGenius (a public model funded by the Government of Canada), applied to the current split between mined (95%) and in-situ (5%) synthetic crude oil production.

Both conventional EU inputs and oilsands are assigned common downstream emissions values for refining and processing; transport and distribution; and combustion, based on JEC studies.

[10] Energy Re-defined LLC – Produced for the ICCT, *Carbon Intensity of Crude Oil in Europe* (Washington, DC: International Council on Clean Transportation, 2010), 52, Figure 19.

It should be noted that the data provided by this report is not public and has not undergone an external peer review; the results may have increased levels of uncertainty. For this reason, this data should not be directly compared with results from the Brandt, 2011 study; it is, however, sufficient to provide meaningful relative comparisons among crude supplies.

[11] Energy Re-defined LLC, *Carbon Intensity of Crude Oil in Europe*, 13.

[12] Fuel Quality, *Draft Commission Directive*, 6.

[13] Global Gas Flaring Reduction, *The News Flare –Issue No. 12* (Washington, DC: The World Bank, 2011). Available at http://siteresources.worldbank.org/INTGGFR/Resources/GGFR_Newsletter_March_October2011.pdf