Carbon Intensity of Crude Oil in Europe

EXECUTIVE SUMMARY

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THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

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The International Council on Clean Transportation is an independent nonprofit organization that works directly with regulatory agencies and policy makers in the world's ten largest vehicle markets to control greenhouse gas emissions and conventional pollution in the transportation sector.

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The International Energy Agency (IEA) predicts that global consumption of crude oil will increase 27% over the next two decades, from 83 million barrels per day (MMbbl/d) in 2009 to 105 MMbbl/d in 2030 (IEA, 2009). Extracting, transporting, and refining crude oil on average account for about 18% of well-to-wheels greenhouse gas (GHG) emissions (U.S. Environmental Protection Agency, 2009; European Commission, 2009). On a global scale, that equates to a very large amount of GHG emissions: about 2.8 billion metric tonnes of CO_2 equivalent per year, equal to about four times the CO_2 emissions of the U.K. from fossil fuels, five times those of Germany, or 50% of all U.S. CO_2 emissions from fossil fuels in 2008. In other words, improvements in the processes of extracting and refining crude oil would mean substantial progress toward reducing overall transportation-sector GHG emissions.

> Extracting, transporting, and refining crude oil on average account for about 18% of well-to-wheels greenhouse gas (GHG) emissions.

To accurately quantify these emissions from the wellhead to the refinery output gate (henceforth termed extraction-to-refining GHG emissions), we developed emission factors for five components of petroleum production: extraction, flaring and venting, fugitive emissions, crude oil transport, and refining. Our goal is to highlight the greatest potential opportunities for reducing or avoiding GHG emissions from oil extraction. The focus is on the European market, as the European Commission is currently considering how best to address extraction-to-refining emissions from petroleum fuels under the Fuel Quality Directive.

EXTRACTION-TO-REFINING GREENHOUSE GAS EMISSIONS

Europe receives crude oil from a large number of oilfields all over the world. We have modeled the carbon intensity of crude oil from over 3,000 oilfields located in countries that supplied oil to Europe In 2009. Figure 1 is a scatterplot that shows the variation among individual oil fields in extraction-to-refining emissions against the cumulative volume of crude oil production[1]. The carbon intensity of crude oils ranges from 4 to 50 grams of CO_2 equivalent per megajoule (g CO_2 eq./MJ)[2] with an average of 12 g CO_2 eq./MJ. The additional GHG emissions from fuel combustion in motor vehicles are about 73 g CO_2 eq./MJ for both gasoline and diesel. Increasing reliance on the highest-intensity crudes to produce vehicle fuels could result in an increase in total well-to-wheels emissions of up to 45% relative to crudes of average carbon intensity.

1 This assumes that if a country supplies X% of its oil to Europe, X% of the oil from each individual oilfield in that country is supplied to Europe.

2 There are some very small fields that might have values in excess of this, but the volumes of oil coming from such fields will be relatively insignificant.

For the remaining small volume (0.3 MMbbl/d), there is a sharp rise in carbon intensity, ranging from 19 to 50 g CO_2 eq./MJ. This volume represents an attractive target for GHG reductions.

In 2009, Europe imported about 13 MMbbl/d of crude oil. For discussion purposes, we divide the imported crude into three broad categories based on extraction-to-refining GHG emissions per energy content of the fuel (Fig. 1). About half of the total (6.4 MMbbl/d) has extraction-to-refining emissions of 4 to 9 g CO_2 eq./MJ, meaning that production is associated with little or no flaring of natural gas, minimal fugitive emissions, high API gravities, and in some cases substantial amounts of oil condensates.[3] (The importance of flaring and venting, fugitive emissions, and API gravity are explained below.) Approximately another half (6.4 MMbbl/d) has a carbon intensity range of 9 to 19 g CO_2 eq./MJ. Included in this range are crude oils mainly with high API gravities and/or substantial flaring and fugitive emissions and a lack of oil condensates.

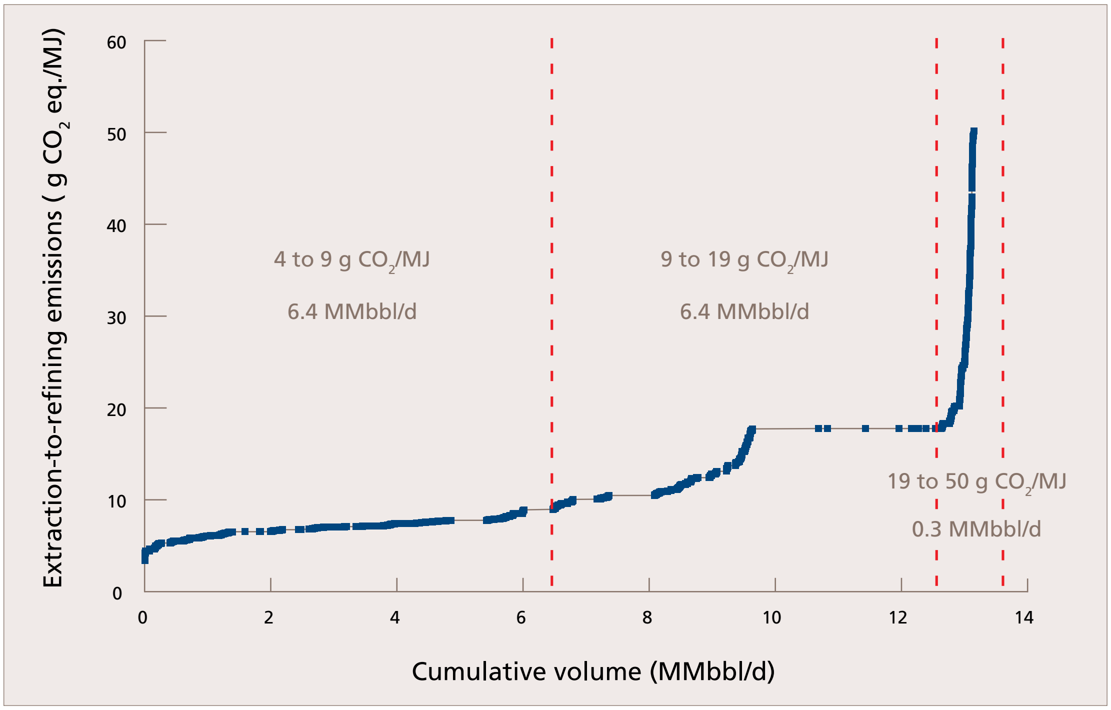


FIGURE 1. Extraction-to-refining GHG emissions associated with imported crude oil.

3 Oil condensates are lighter liquid crude oils obtained from reservoirs that mostly contain hydrocarbons in vapor phase. They normally consist of short-chain alkane hydrocarbons. They are easy to clean up and refine.

For the remaining small volume (0.3 MMbbl/d), there is a sharp rise in carbon intensity, ranging from 19 to 50 g CO_2 eq./MJ, due to either substantial levels of flaring or exploitation of tar sands. This volume represents an attractive target for GHG reductions.

Flaring contributes to GHG emissions in two ways: through the CO_2 released during combustion, and through the presence of methane in unburned gas when combustion is less than 100% efficient. Methane has a global warming potential 25 times that of CO_2.

Production of crude oil from tar sands involves energy-intensive extraction (surface mining or steam-assisted gravity drainage) and upgrading.[4] (In this study, it is assumed that upgrading of tar sands occurs at the oil field and hence is counted as part of extraction emissions.) Tar sands are one of a group of new fossil fuel feedstocks typically referred to as "unconventional oil"; other feedstocks in this group are shale oil and extra-heavy oil. Producing crude from these sources requires more energy-intensive technologies and processes than from conventional oil sources. The U.S. Energy Information Administration (EIA) currently projects that about 8% (8.9 MMbbl/d) of the world's oil supply will come from unconventional oil in 2035 (EIA, 2010).

As discussed above, two primary drivers contribute to the highest upstream GHG emissions: the presence of high levels of flaring of natural gas, and unconventional oil such as tar sands. To clarify the ranges of GHG emissions for crude oil extraction involving flaring and tar sands projects, in Figure 2 extraction emissions are broken down into crude oils with flaring, crude oils without flar-

4 Bitumen (tar sands) consists of complex chains of hydrocarbon. It is rich in carbon but deficient in hydrogen. Bitumen is upgraded to remove carbon and add hydrogen to obtain valuable hydrocarbon products. Upgrading results in synthetic crude oil, which can be transported easily via pipeline to refineries.

ing, and tar sands. The cumulative volume for each category is divided by the total volume to show normalized cumulative volume in percent (percentage of total imported volumes for each category are also shown in Fig. 2). In general, production of oil from tar sands results in higher GHG emissions than from conventional crude, even from fields that flare natural gas, except when the flared volumes are large in proportion to the oil production (on the right side of the graph).

California's Low Carbon Fuel Standard (LCFS) requires additional reporting for any crude oil with extraction GHG emissions in excess of 15 g CO_2 eq./MJ ('high carbon intensity crude oil', HCICO). Conventional oil produced without flaring falls below that limit.

Figure 2 also shows the weighted average of total extraction-to-refining emission for each category of fuel. The averages are assigned uncertainty ranges by considering the minimum and maximum plausible alternative values of key parameters. It can be seen that although flaring emissions in particular are subject to substantial uncertainty, it can still be asserted with confidence that the average emissions from tar sands projects are higher than the average emissions from projects that flare, which are higher than the average emissions from projects that do not flare.

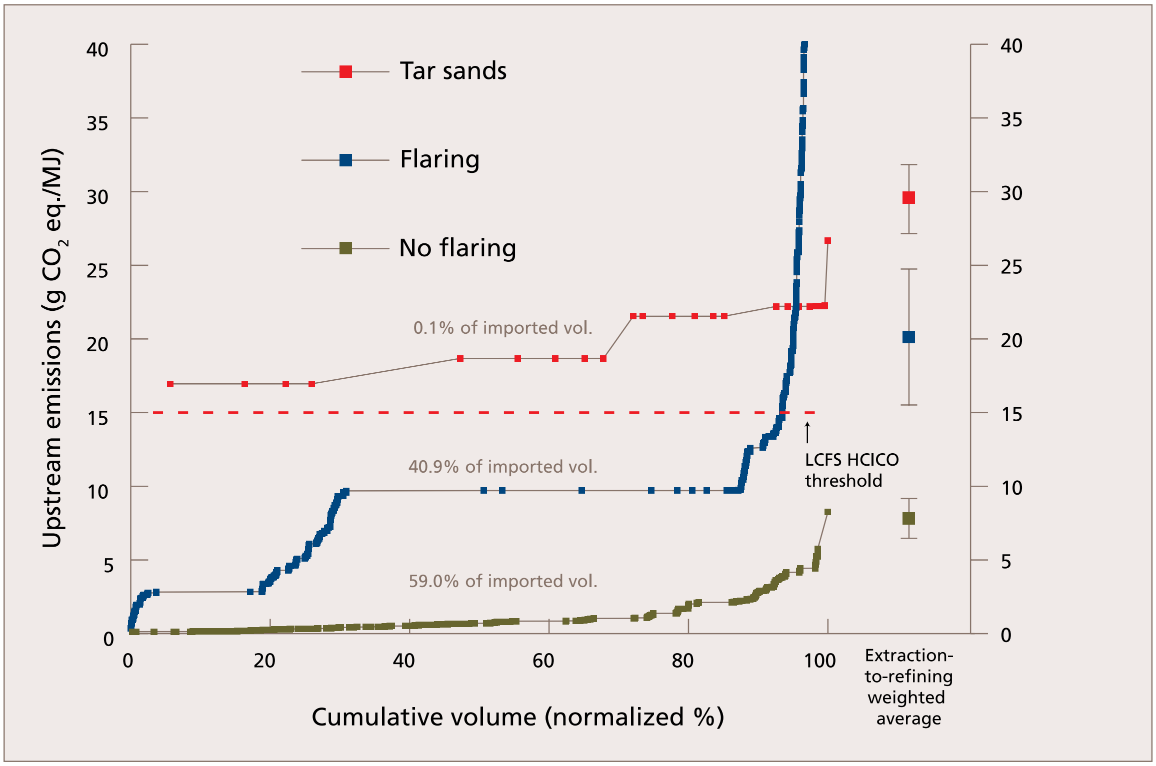


FIGURE 2. ***Left:*** Extraction GHG emissions for imported conventional crude oil (with and without flaring) and tar sands. ***Right:*** Weighted average extraction-to-refining GHG emissions for imported conventional crude oil (with and without flaring) and tar sands, with uncertainty ranges for the average values.

Figure 3 (see pages 8-9) illustrates the results of this analysis with specific cases. The selected oil fields show the wide range in total extraction-to-refining GHG emissions and in the relative contributions from five components of the petroleum life cycle considered in this study. The area of each pie chart in Figure 3 reflects carbon intensity (g CO_2 eq./MJ). Daily production volumes are included in the description of each field. The oil fields are selected to represent a range of geographic regions, production levels [42 to 5320 kbpd (thousand barrels per day)], flaring levels, feedstocks, and development types.

Emissions vary by a factor of 5 across the oil fields in Figure 3. In Canada, the difference between the Steepbank and Hibernia fields shows the effect of the additional energy needed to extract tar sands: Steepbank has four times the emissions of Hibernia, a conventional oil field. An oil field with high levels of flaring (e.g., Kupal) can have GHG emissions comparable to or higher than those of tar sands. Countries where flaring is common include Iran and Russia (Buzcu-Guven et al., 2010). For conventional crudes with minimal flaring, it is the refining step that contributes most to extraction-to-refining GHG emissions. The highest potential GHG reduction opportunities for these crudes are likely to be at the refinery. Note that in this analysis, as explained below, energy use and GHG emissions in refining vary only according to API gravity.

> Two primary drivers contribute to the highest upstream GHG emissions: the presence of high levels of flaring of natural gas, and unconventional oil such as tar sands.

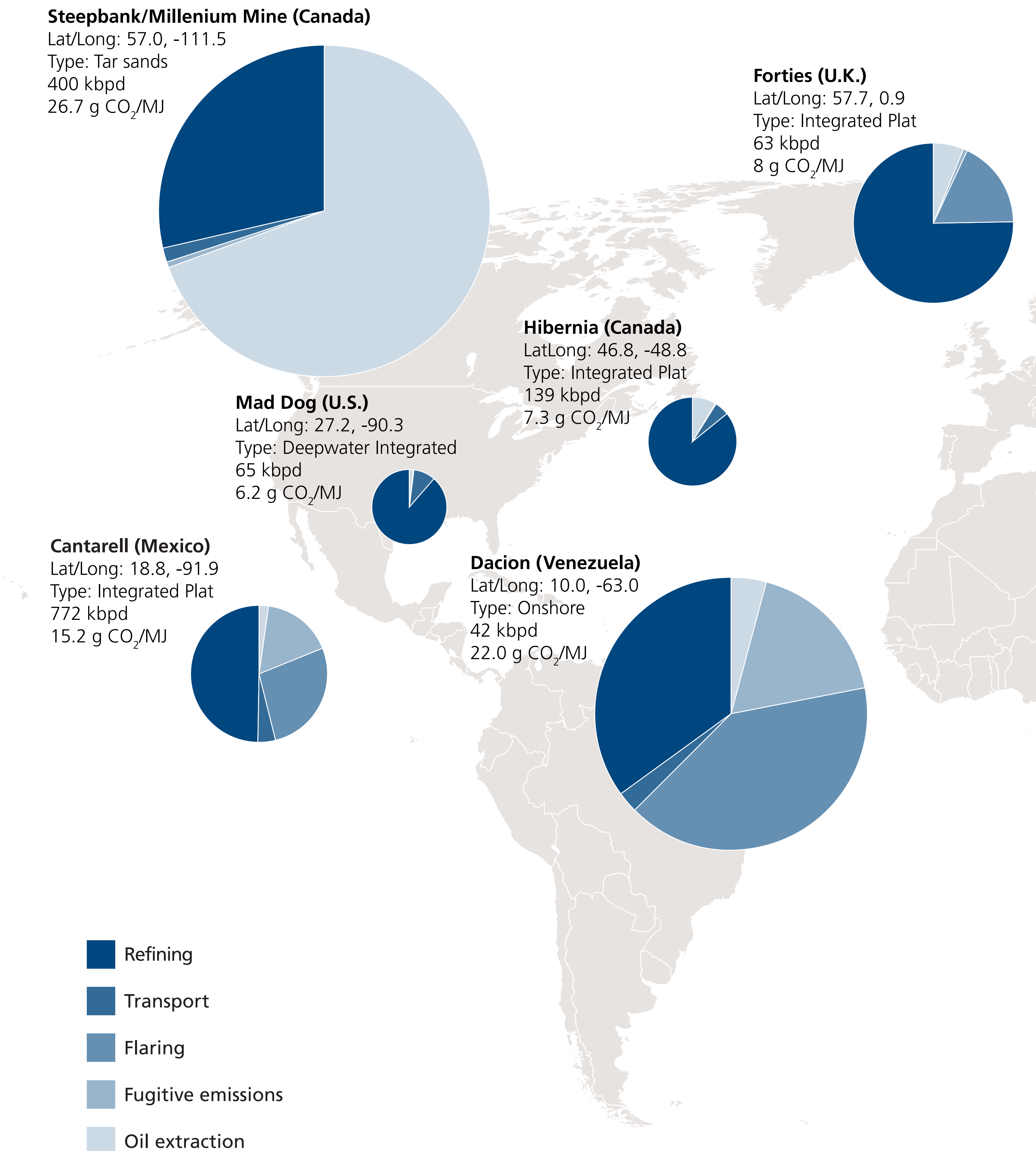
Grouping the oil fields in Figure 3 into low-, medium-, and high-intensity fields illustrates the relationship between key parameters and extraction-to-refining GHG emissions.

Low-intensity fields (6 to 8 g CO_2 eq./MJ) are characterized by little or no flaring or fugitive emissions and high API gravity (crudes with API > 26 are referred to as light crude oils; high API gravity means that refining emissions are lower). Although refining emissions are small for these oil fields, they are still the dominant factor in determining overall extraction-to-refining GHG emissions, as other emissions (including extraction) are even lower.

For medium-intensity oil fields (12 to 15 g CO_2 eq./MJ), extraction-to-refining GHG emissions are larger predominantly because of higher contributions from either flaring or fugitive emissions. For example, Duri has fugitive emissions of 2.7 g CO_2 eq./MJ and flaring emissions of 2.0 g CO_2 eq./MJ. Likewise, Samotlor has flaring emissions of 3.1 g CO_2 eq./MJ. Crude oils produced in Duri and Cantarell are heavy (API gravity < 26) and contribute to relatively higher refinery emissions. Duri uses an energy-intensive steam-flooding technique to extract crude oil. Hence, emissions from extraction are larger than expected.

High-intensity oil fields (22 to 31 g CO_2 eq./MJ) either have higher flaring and venting or produce unconventional crude oil. For example, Kupal and Dacion have higher extraction-to-refining emissions due to substantial flaring and venting. Steepbank, on the other hand, is a tar sands project, which requires more energy for extracting bitumen and upgrading it to synthetic crude oil. Refining emissions for Dacion and Steepbank are higher because they produce heavy crude oils (API gravity < 26).

Aggregate GHG emissions are determined by the interplay of various parameters. As Table 1 shows, these vary substantially from one field to another. As a result, any attempt to assign default emissions based on a single characteristic or a limited number of simple characteristics is likely to misspecify emissions substantially in some cases. By providing rigorous and enriched data on oil extraction, fugitive emissions, and flaring for a large number of oil fields that supply Europe, this study attempts to fill the data gap in life-cycle analysis of petroleum fuels and contribute to the identification of emission reduction opportunities.


Steepbank/Millenium Mine (Canada)
Lat/Long: 57.0, -111.5
Type: Tar sands
400 kbpd
26.7 g CO_2/MJ
Forties (U.K.)
Lat/Long: 57.7, 0.9
Type: Integrated Plat
63 kbpd
8 g CO_2/MJ
Hibernia (Canada)
LatLong: 46.8, -48.8
Type: Integrated Plat
139 kbpd
7.3 g CO_2/MJ
Mad Dog (U.S.)
Lat/Long: 27.2, -90.3
Type: Deepwater Integrated
65 kbpd
6.2 g CO_2/MJ
Cantarell (Mexico)
Lat/Long: 18.8, -91.9
Type: Integrated Plat
772 kbpd
15.2 g CO_2/MJ
Dacion (Venezuela)
Lat/Long: 10.0, -63.0
Type: Onshore
42 kbpd
22.0 g CO_2/MJ
Refining
Transport
Flaring
Fugitive emissions
Oil extraction

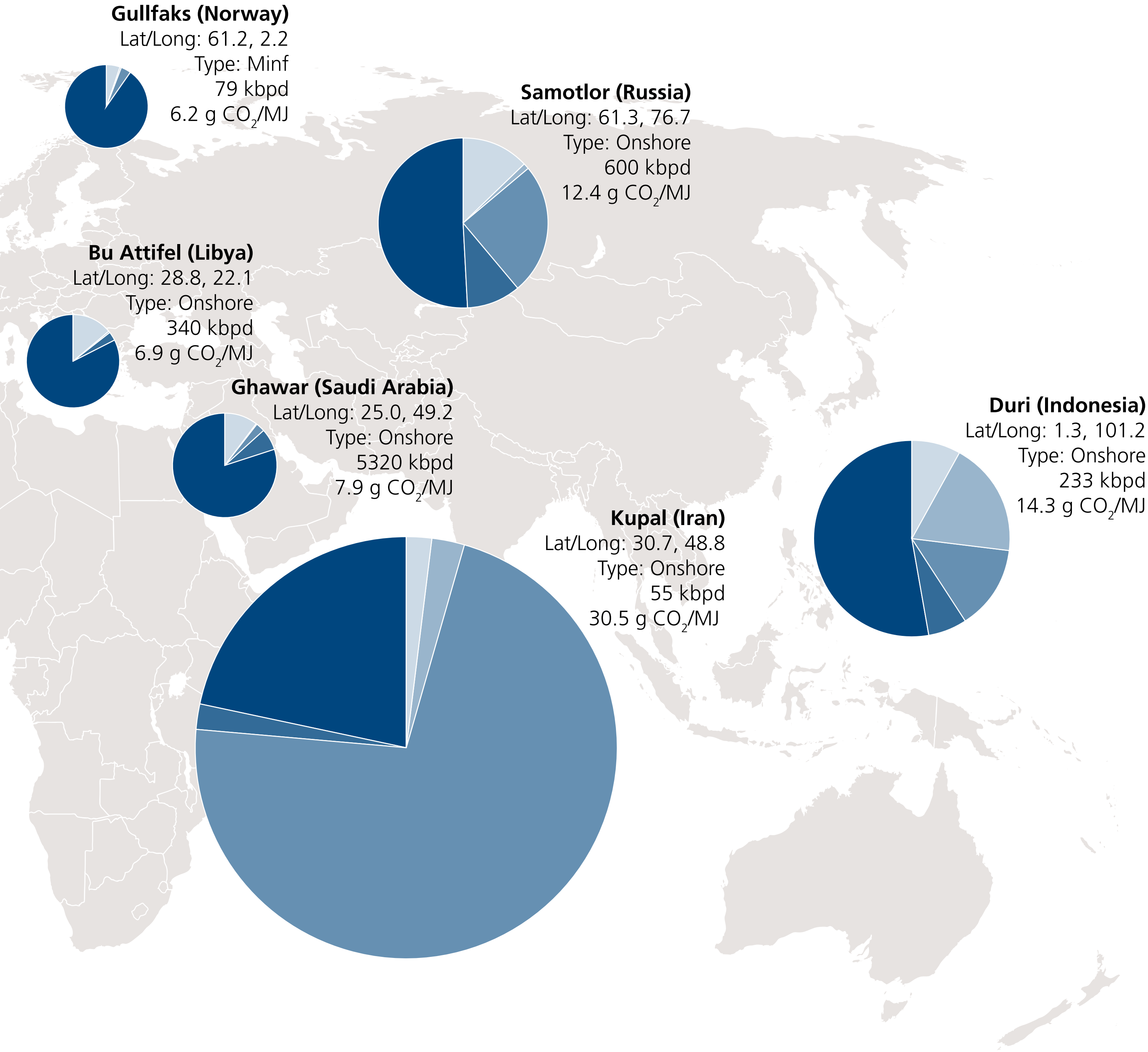


FIGURE 3. Carbon intensity by contributing components for selected oil fields.

TABLE 1. Characteristics of crude oil and levels of flaring and fugitive emissions for representative oil fields.

FIELD AND COUNTRY	PRODUCTION VOLUME (KBPD)	API GRAVITY	SULFUR (%)	DEPTH (FT)	START YEAR	BTU/SCF OF ASSOCIATED GAS	INITIAL PRESSURE (PSIG)	DEAD CRUDE VISCOSITY (cP)	GOR (SCF/BBL)	FUGITIVE EMISSIONS (g CO_2/MJ)	FLARING AND VENTING (g CO_2/MJ)	TYPE	OVERALL WELLHEAD-TO-REFINERY EMISSIONS (g CO_2/MJ)
Cantarell, Mexico	772	22	3.7	8,528	1981	1,370	941	8	887	2.5	4.2	Integrated platform drilling	15.2
Mad Dog, USA	65	42	0.8	20,190	2005	1,012	12,141	1.8	322	0.02	0.0	Deepwater integrated	6.2
Steepbank/ Millennium Mine, Canada	400	10	1	50	2005	1,267	10	5,000	-	0.1	-	Tar sands	26.6
Hibernia, Canada	139	35	0.2	12,500	1984	1,257	7,517	0.8	2,200	0.03	0.0	Integrated platform drilling	7.3
Kupal, Iran	55	32	2	10,500	1970	2,232	2,191	7.3	3,800	0.8	21.9	Onshore	30.5
Ghawar, Saudi Arabia	5,319	34	2.2	6,920	1951	1,255	3,957	1.6	570	0.03	0.2	Onshore	7.9
Dacion, Venezuela	42	20	1.3	6,000	1953	1,794	2,600	11	750	3.9	8.9	Onshore	22.0
Bu Attifel, Libya	340	41	0.04	14,000	1972	1,622	7,209	5.2	2,400	0.04	0.0	Onshore	6.9
Samotlor, Russia	600	34	1.1	5,800	1970	1,456	2,255	3.4	240	0.1	3.1	Onshore	11.8
Duri, Indonesia	233	22	0.2	770	1958	1,362	267	144.1	1,200	2.7	2.0	Onshore	14.3
Forties, U.K.	63	37	0.3	7,000	1975	2,851	3,128	2.2	400	0.1	1.4	Integrated platform drilling	8.0
Gullfaks, Norway	79	41	0.4	5,709	1987	1,557	2,551	2	700	0.04	0.2	Minimum facility	6.2

Note: This study did not consider sulfur content for determining refinery emissions, although it does affect energy use in refining.

Data sources (not an exhaustive list): *API gravity, sulfur content, viscosity:* PennWell, institute of Energy, Society of Petroleum Engineers, U.S. Energy Information Administration, Petroleum Intelligence Weekly, U.S. Geological Survey (USGS). *Depth, pressure*: PennWell, USGS, Institute of Energy, Society of Petroleum Engineers. *Production*: U.K. Department of Energy, U.S. Minerals Management Service, Norwegian Petroleum Development/Ministry of Energy, PennWell, company reports, various other government organizations. *Flaring*: GGFR, NOAA, Energy-Redefined LLC, various company sustainability reports. *Fugitive emissions*: CAPP, API, various company sustainability reports. *Start year and GOR*: PennWell, company reports, conference proceedings, various geological societies. *Type of development/ feedstock*: PennWell, Norwegian Petroleum Development/Ministry of Energy, company reports, Society of Petroleum Engineers, conference proceedings.

MAJOR CRUDE OIL EXPORTERS TO EUROPE

Crude oils used in Europe come from many countries and all major geographic regions. As Figure 4 illustrates, Russia is by far the largest exporter of oil to Europe. Russian facilities flare off a substantial amount of natural gas (46 billion m^3 in 2009) (Buzcu-Guven et al., 2010); reducing that volume represents an important opportunity for reducing life-cycle GHG emissions of petroleum fuels in Europe. Similar opportunities also exist in other top-10 exporting countries, such as Libya, Nigeria, and Kazakhstan.

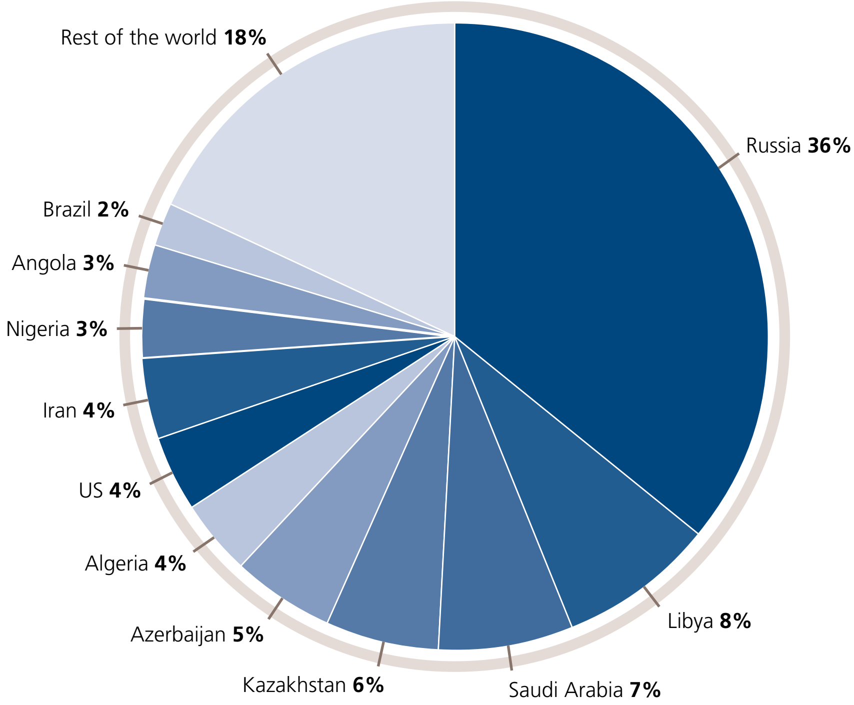


FIGURE 4. Major crude oil exporters to Europe in 2010.

METHODOLOGY

To calculate extraction-to-refining GHG emissions, we conducted a life-cycle assessment (LCA) on approximately 3100 oil fields in countries that supply oil to Europe, using the global database of more than 6000 individual oil fields compiled by Energy-Redefined LLC. This study developed GHG emission factors for five elements of extraction-to-refining analysis: crude oil extraction, flaring and venting, fugitive emissions, crude oil transport, and refining. The central aspect of the analysis is to identify the parameters (Table 2) that influence GHG emissions throughout the petroleum life cycle and use them in estimating emission factors for each oil field, based on 2009 data.

The Energy-Redefined LLC oil field database was compiled from publicly available sources and through working relationships with the oil and gas industry. Where data were missing, Energy-Redefined LLC made estimates based on expert judgment and calculations and calibrated them with known data and available studies for verification.

Key parameters that affect life-cycle GHG emissions from different components of petroleum fuel are briefly summarized below.

Crude Oil Extraction

GHG emissions in the extraction phase are determined by the interactions of eight main parameters: age of oil field, gas-to-oil ratio, reservoir depth, pressure, viscosity, American Petroleum Institute (API) gravity (a measure of how "light" or "heavy" a crude is relative to water), type of feedstock (e.g., tar sands, conventional crude), and development type [onshore, offshore, surface mining, steam-assisted gravity drainage (SAGD)]. This study does not consider coal-to-liquid and gas-to-liquid methods or oil shale.

The ratio of the volume of gas in solution to the volume of crude oil at standard conditions is the gas-to-oil ratio (GOR). Higher values of GOR lead to higher production of natural gas. The gas

The age of an oil field influences GHG emissions because as fields mature, oil production declines; energy-intensive techniques such as water or gas injection must then be used to extend production levels.

produced can be used in extraction for meeting onsite energy needs, exported, and/or flared and vented. If it is flared and vented, it can substantially increase life-cycle GHG emissions. A high GOR can also correspond to production of substantial amounts of oil condensates.

The age of an oil field influences GHG emissions because as fields mature, oil production declines; energy-intensive techniques such as water or gas injection must then be used to extend production levels, resulting in increased GHG emissions.

Heavier crude oils (low API gravity) require more energy to extract, transport, and refine. Crude oils with higher viscosity require more energy for pumping. Reservoir depth and pressure also affect energy use in extraction. With a decrease in depth, friction losses increase in the drill pipe. As fields mature, the initial pressures tend to decline in the absence of intervention. Maintenance techniques such as water injection are required to maintain the initial pressure. These pumping or compression techniques involve pumping fluids back into the reservoir to extract crude oil. If the initial reservoir pressure is high, the energy required for maintaining the pressure will also be high.

Different amounts of energy are required to extract and upgrade crude oil from different types of feedstock. Tar sands and conventional oil require completely different extraction technologies. Among tar sands, differences exist between surface mining and in situ methods such as SAGD, resulting in different GHG emissions.

In addition, the type of oil field development [onshore/offshore, surface mining, thermally enhanced oil recovery (TEOR), etc.] determines the infrastructure required. Differences in infrastructure also influence energy requirements affecting GHG emissions during extraction of crude oil. For example, TEOR requires more energy than any other conventional form of offshore or onshore crude oil extraction.

Flaring and Venting

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).

In this study, the volume of gas flared is derived from GOR, energy use in the field, and the quantity of gas exported. Satellite data (e.g., from NOAA) and country-level emission factors [Global Gas Flaring Reduction (GGFR); World Bank, n.d.] were also used. Besides the volume of gas flared, gas specifications are important in determining GHG emissions from flaring. In general, gas with higher energy content per unit volume produces more GHG emissions when flared.

One can be reasonably confident about which oil fields are flaring and which are not from satellite data and the lack or presence of infrastructure. However, uncertainties exist with regard to the volumes of gas flared and vented.

Fugitive Emissions

Fugitive emissions represent unintentional or uncontrollable releases of gas—for example, from valves and mechanical seals. It is difficult to measure fugitive emissions. The usual practice is to base such measurements on emission factors suggested by the Canadian Association of Petroleum Producers (CAPP), the U.S. Environmental Protection Agency (EPA), and the International Association of Oil and Gas Producers (OGP). In this study, fugitive emissions were determined on the basis of CAPP emission factors (CAPP, 2003) for equipment fittings such as seals, valves, and flanges.

The use of such emission factors can result in significant errors. The alternative is to use leak detection methods, such as acoustic sensors and hyperspectral imaging, and optical methods such as tunable diode laser absorption spectroscopy and laser-induced fluorescence. The costs of monitoring and verification using these techniques can be high.

TABLE 2. Parameters affecting extraction-to-refining GHG emissions.

LCA COMPONENTS	PARAMETERS	UNDERLYING DATA
Crude oil extraction (8 parameters)	GOR, API gravity, viscosity, age of field, depth, pressure, type of development (in situ, surface mining, onshore/offshore), type of feedstock	Publicly available literature (industry data and government reports), PennWell data, consultant data (Energy-Redefined LLC)
Flaring and venting (5 parameters)	GOR, gas specifications, age of field, infrastructure for gas capture, infrastructure for export	Oil company reports, government reports, satellite data from NOAA, World Bank/GGFR country-level emission factors for flaring, consultant data (Energy-Redefined LLC)
Fugitive emissions (non-intentional) (2 parameters)	Type of development, equipment components	CAPP emission factors for fugitive emissions
Crude oil transport (3 parameters)	Distance, API gravity, mode of transport	PennWell data for API, PortWorld for distance, GREET for transportation emission factors
Refining (1 parameter)	API gravity	PennWell data, publicly available literature, consultant data (Energy-Redefined LLC)

Some of the most important emissions sources, such as flaring and fugitive emissions, are not fully monitored by oil companies.

Transport

GHG emissions from crude oil transport to a refinery are a function of distance, API gravity, and mode of transport. API data were taken from PennWell. Distances between oil fields and refineries were determined using PortWorld. Emission factors for a given mode of transport were taken from GREET (Wang, 2010).

Refining

GHG emissions from refining are a function of API gravity, sulfur content, and type of refinery. In general, heavy crudes (low API gravity) require more energy to process than light crudes. In this study, we applied the relationship devised by Keesom, Unnasch, and Moretta (2009), calibrated to European refineries, to estimate GHG emissions. The relationship between API gravity and energy consumption is not linear for API gravities above 45. GHG emissions also vary from one refinery type to another depending on the level of complexity and type of refined products produced. As a simplification, this study assumes that crude oils are refined in a notional refinery where GHG emissions are determined entirely by API gravity. The impact of sulfur content was not considered in this study.

UNCERTAINTIES IN THE ASSESSMENT

There are uncertainties involved in undertaking a carbon intensity assessment such as this. For instance, some of the most important emissions sources, such as flaring and fugitive emissions, are not fully monitored by oil companies, and where they are, the data may not be publicly available. Even where gas flaring and fugitive emissions are monitored, the measurement tools currently available are subject to a degree of inaccuracy determined by the physical characteristics of the measurement system. Flare efficiency may also be subject to factors beyond the control of oil companies, such as local wind conditions.

To test the robustness of the results, we undertook a sensitivity analysis in which key input parameters were varied for three typical cases (low-, medium-, and high-intensity fields). Emissions from high-intensity fields that flare are inevitably sensitive to the parameters that determine flaring emissions. For example, when we used the Canadian model of a default flaring value instead of estimating flaring on the basis of data about the oil fields, the intensity of the high-intensity case was reduced by nearly 30%. Varying other parameters resulted in changes of less than 10%.

OPPORTUNITIES FOR GHG REDUCTION

This assessment demonstrates the use of physical characteristics of oil fields in making detailed estimates of the carbon intensity of different crudes. These estimates are based on processes and process efficiencies, and hence this report points to opportunities for the biggest gains in reducing or avoiding GHG emissions from oil extraction by improving practices.

The greatest opportunities are in the highest-intensity crudes and involve emissions associated with unconventional oil extraction and flaring. Flaring is primarily an infrastructure problem; incentives to reduce flaring and fugitive emissions would enhance the value to oil companies of developing infrastructure and markets for excess gas. Operators could optimize flare tip efficiency to reduce methane emissions, move to reinjection of associated gas, or adopt capture and underground storage of CO_2 (Bergerson & Keith, 2010). Extraction of unconventional oil (e.g., tar sands) with current technologies is highly energy-intensive. However, the extraction emissions of unconventional oil could be reduced by limiting its exploitation, by improving energy and carbon efficiencies (such as using energy inputs with low carbon intensity) in extraction processes, or by implementing carbon capture and storage.

Energy-inefficient processes are costly not only to the environment but to the companies engaged in oil extraction. Requiring better measurement of energy use and carbon emissions is an important first step in reducing energy consumption. Measurement, management, and optimization of oil fields, including GHG emissions, can become an essential component in making better decisions, providing better results, and creating more opportunities.

Energy-inefficient processes are costly not only to the environment but to the companies engaged in oil extraction.

Older conventional oil fields often depend on old technology—one of the reasons that the Energy-Redefined LLC model predicts high emissions from these projects. For such oil fields, GHG emissions can be reduced by using efficient power/motor drives, integrated energy management approaches, and oil and gas field optimization. Old pumps may be less efficient; they may also be operating outside their optimal range because of turn-down (the ratio of the present capacity of a project to its design capacity). More modern equipment would in many cases deliver substantial carbon reductions. A similar situation can exist in countries such as Russia and Indonesia where locally built power generation equipment is far less efficient than the best alternatives on the market internationally; the gap in performance could be as wide as 20 to 35% in efficiency terms.

As with any industrial process, improvements in efficiency often can result from better house-keeping and use of the most modern technologies. The analysis presented here provides a valuable indicator of the types of oil fields—and, in some cases, specific fields—where prioritizing efficiency improvements or flaring and fugitive emission reductions could deliver the largest benefits.

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