Major Sources of US Oil Supply: The Challenge of Comparisons

SPECIAL REPORT™

IHS®

CERA

About This Report

Purpose. This IHS CERA report assesses the challenge of comparing US oil supply in terms of energy security and environmental aspects. Security of supply has long been a policy focus. Now, environmental aspects are also factoring into the discussion on US energy policy. The Canadian oil sands are at the center of this debate. But oil security and environmental comparisons are encumbered by the challenge of collecting accurate data and establishing uniform and relevant metrics among major suppliers. The environmental perspective is focused on factors related to production and does not cover transport issues.

Context. This is one in a series of reports from the IHS CERA *Canadian Oil Sands Energy Dialogue 2011.* The dialogue convenes stakeholders in the oil sands to participate in an objective analysis of the benefits, costs, and impacts of various choices associated with Canadian oil sands development. Stakeholders include representatives from governments, regulators, oil companies, shipping companies, and nongovernmental organizations. The 2011 Dialogue program and associated reports cover three oil sands topics:

- **Major Sources of US Oil Supply: The Challenge of Comparisons**
- **Assessing Regulation in the Oil Sands**
- **Life-cycle Greenhouse Gas Emissions Reexamined**

These reports and past Oil Sands Dialogue reports can be downloaded at

www2.cera.com\oilsandsdialogue.

Methodology. This report includes multistakeholder input from a focus group meeting held in Calgary, Alberta, on May 4, 2011, and participant feedback on a draft version of the report. IHS CERA also conducted its own extensive research and analysis, both independently and in consultation with stakeholders. IHS CERA has full editorial control over this report and is solely responsible for the report's contents (see end of report for list of participants and IHS CERA team).

Structure. This report has five major sections, following the Summary of Key Insights:

Part I: Introduction: What Is Foreign Oil?

Part II: Oil Supply: Past, Present, Future. Where does US oil supply come from today? What are likely future sources of US oil supply?

Part III: Environmental Aspects of US Oil Supply. How do the largest sources of US crude oil compare on enviromental aspects? Is it even possible to make these types of comparisons?

Part IV: Security Aspects of US Oil Supply. How do the largest sources of US crude oil compare in terms of supply risk?

Part V: Conclusion.

We welcome your feedback regarding this IHS CERA report or any aspect of IHS CERA's research, services, studies, and events. Please contact us at info@ihscera.com or +1 800 IHS CARE (from North American locations) or at customer.support@ihs.com or +44 (0) 1344 328 300 (from outside North America).

For clients with access to **IHSCERA.com,** the following features related to this report may be available online: downloadable data (excel file format); downloadable, full-color graphics; author biographies; and the Adobe PDF version of the complete report.

MAJOR SOURCES OF US OIL SUPPLY: THE CHALLENGE OF COMPARISONS

SUMMARY OF KEY INSIGHTS OF IHS CERA'S ANALYSIS

Security of oil supply has long been a policy focus. Now, environmental aspects of oil are also factored into US energy policy discussions. The Canadian oil sands are at the center of this debate, but objectively making environmental and security comparisons is a challenge.

- **A major challenge in comparing various sources of US oil supply is gathering enough data for meaningful comparisons on environmental aspects as they relate to oil production such as water use, biodiversity impacts, and greenhouse gas (GHG) emissions.** The Canadian oil sands are at the forefront of having meaningful data readily available. If US policy aims to differentiate crudes by environmental aspects, then accurate measurement, verification, and reporting are needed across all sources of oil supply. Data availability is shaped by differing data requirements, regulatory environments, and industry structures across countries. Although a lack of public data does not inherently indicate a lack of concern or care for the environment, it does mean that comparisons are difficult and not even possible in some areas.

- **Environmental comparisons across crude oil supply sources are encumbered by the challenge of establishing uniform and relevant metrics.** Even when data are available, environmental aspects—including water and land use—are not easily compared. For example, the water intensity of oil production is not enough for a proper assessment; local water availability must also be considered. The impact of oil development on a region's biodiversity varies by ecosystem; disturbance in a desert environment is not directly comparable to disturbance in a northern boreal forest, on a prairie, or in the ocean.

- **Canada is a low-risk supplier of oil to the United States.** Security is still an important characteristic of oil supply, as demonstrated by the civil war in Libya and the resulting oil supply disruptions and oil price increases.

- **Supply from the Canadian oil sands has come under considerable scrutiny based on its environmental footprint.** However, to objectively differentiate crude supplies by environmental factors, all major sources of US oil supply must be considered. A significant international data gathering and vetting exercise is needed to for such an exercise. Otherwise, policies that seek to reduce environmental impacts could instead shift emissions to countries or sectors with mischaracterized environmental footprints.

—October 2011

55 Cambridge Parkway, Cambridge, Massachusetts 02142.

PART I: INTRODUCTION

WHAT IS FOREIGN OIL?

What is “foreign oil”? The term often creates an image of oil imported from a distant land. The United States currently imports over 9 million barrels per day (mbd) of foreign oil. The volume of imports is often portrayed as a national weakness rather than as a means of providing fuel to propel the American economy.* But where does oil imported into the United States come from—and how do these sources differ in terms of geography, perceived security, and environmental characteristics? And how does foreign oil compare to domestically produced oil? Canadian oil is indeed “foreign,” but the oil is produced closer to some US consumers than some domestic production—and Canadian supply is connected by pipeline. “Foreign oil”—as well as domestic production—represents a range of geographies and security, economic, and environmental characteristics that are important to the US economy and to US consumers.

Distinctions among sources of US oil supply—and imports in particular—have become an increasingly important matter. US policy debate is already moving in this direction—differentiating crude supplies by life-cycle GHG emissions. Broader environmental factors associated with oil and gas development, including water use and impacts on biodiversity, are also part of the discussion.

Environmental aspects are an emerging issue for imported oil, but security of supply—the reliability and volume of oil supplied to the United States—has long garnered the attention of decision makers. Can one compare different sources of supply based on environmental and security aspects? Can accurate comparisons be made? Are relevant data available and verifiable? Developing appropriate metrics is a big challenge, but one that must be addressed if environmental regulations and security concerns are to be dealt with in a transparent and constructive manner. Otherwise, policies—particularly environmental—could use data and metrics that mischaracterize environmental and security aspects, with the result being counterproductive to the intended policy outcomes.

The purpose of this paper is to inform the discussion on US oil imports by assessing the challenges of comparing the environmental and security aspects of Canadian oil sands—one of the largest sources of US oil imports—to other major sources of current and future US oil supply (see the box “Oil Sands Primer”).

This paper has five parts including this introduction:

- Part 1—Introduction: What Is Foreign Oil?
- Part 2—US Oil Supply: Past, Present, Future

---

*Includes crude oil, condensates, and natural gas liquids (NGLs). Does not include biofuels or refined product imports. Refined product imports are excluded because refined products are not necessarily derived from crude oil produced in-country. For example, US refined imports from Canada are produced mostly from imported oil, so dropping the refined products more clearly shows importance of supply from each country. Source: US Energy Information Agency (EIA).

- Part 3—Environmental Aspects of US Oil Supply
- Part 4—Security Aspects of US Oil Supply
- Part 5—Conclusion

Oil Sands Primer

The immensity of the oil sands is their signature feature. Current estimates place the amount of oil that can be economically recovered from Alberta's oil sands at 170 billion barrels—enough oil to solely supply 25 years of US oil demand.* The oil sands are grains of sand covered with water, bitumen, and clay. The oil in the oil sands is called bitumen, extra-heavy oil with high viscosity. Given their black and sticky appearance, the oil sands are also referred to as "tar sands." Tar, however, is a man-made substance derived from petroleum or coal.

Oil sands are unique in that they are produced via both surface mining and in-situ thermal processes.

- **Mining.** About 20 percent of currently recoverable oil sands reserves lies close enough to the surface to be mined. In a mining process similar to coal mining, the overburden (primarily soils and vegetation) is removed and the layer of oil sands is excavated using massive shovels that scoop the sand, which is then transported by truck, shovel, or pipeline to a processing facility. Slightly less than half of today's production is from mining, and we expect this proportion to be roughly steady through 2030.
- **In-situ thermal processes.** About 80 percent of the recoverable oil sands deposits are too deep to be mined and are recovered by thermal drilling methods. Thermal methods inject steam into the wellbore to lower the viscosity of the bitumen and allow it to flow through the production well to the surface. Such methods are used in oil fields around the world to recover very heavy oil. Two thermal processes are in wide use in the oil sands today: steam-assisted gravity drainage (SAGD) and cyclic steam stimulation. SAGD made up about 22 percent of 2010 oil sands production and is expected to grow to more than 40 percent by 2030. Innovations in thermal recovery methods have reduced the amount of energy needed to recover bitumen, and such innovations are likely to continue in the future.

---

*Assumes average US petroleum demand (excluding biofuels) is 18.7 mbd.

PART II: OIL SUPPLY: PAST, PRESENT, FUTURE

US OIL PRODUCTION AND DEMAND TRENDS

The United States has long been among the largest oil-producing countries in the world. During the first century of the oil age—beginning in the 1860s—the United States was the world's largest oil producer and exporter. During World War II the United States accounted for two-thirds of total world oil production and was the most important supplier of oil to the Allied war effort. From the 1950s through the 1970s, oil imports soared as US demand rose well above the level of domestic production. In 1975 the United States imported 4.2 mbd of oil from 18 countries, equivalent to 30 percent of total US oil consumption. US oil imports reached their high point of 10.5 mbd in 2005—equivalent to 60 percent of domestic oil consumption.*

In recent years, US oil production has increased and demand has weakened. From 2008 to 2010, the United States recorded the largest gain in oil production by any single country in the world. On the demand side, the Great Recession and the growing use of biofuels have pushed oil demand down (2009 US petroleum demand was 2.4 mbd lower than in 2005). Still, US oil imports are large; in 2010 oil imports averaged 9.4 mbd—the world's highest and equivalent to 55 percent of total American demand for crude oil, condensates, and NGLs. The United States will remain a significant importer of oil for many years to come.

In this section, we identify the major current and possible future sources of US oil supply. In the coming decades, the US oil supply picture will evolve. Some of today's major suppliers will grow in importance, while others will be unable to maintain current export levels. Moreover, new major US crude oil suppliers are likely to emerge.

CURRENT SOURCES OF US CRUDE OIL

Today, domestic production is the largest source of US oil supply, and the major suppliers of imported oil are Canada, Mexico, Saudi Arabia, Nigeria, and Venezuela. Canada is by far the largest source of US oil imports. If oil sands are split from the Canadian total—oil sands alone are one of the largest sources of US imports (see Table 1).

FUTURE MAJOR SOURCES OF US OIL

Globally, numerous oil producers are expected to increase supplies. To identify potential major new suppliers to the United States, we focused on those with the most potential for export growth. We included in our analysis any foreign supplier likely to increase net exports by more than 1 mbd over the next 20 years (including crude oil, condensates, and NGLs). Five suppliers met this requirement: Iraq, Brazil, Saudi Arabia, Kazakhstan, and Canada. For US domestic oil supply, production only was considered—exports are not anticipated. Figure 1 highlights the projected growth for each supplier (green oil barrels in Figure 1).

---

*All estimates of US imports are on a net basis and include crude, condensates, and NGLs and do not include biofuels or refined product imports, unless otherwise noted.

Table 1

Breakdown of US Oil Supply, 1975 and 2010*

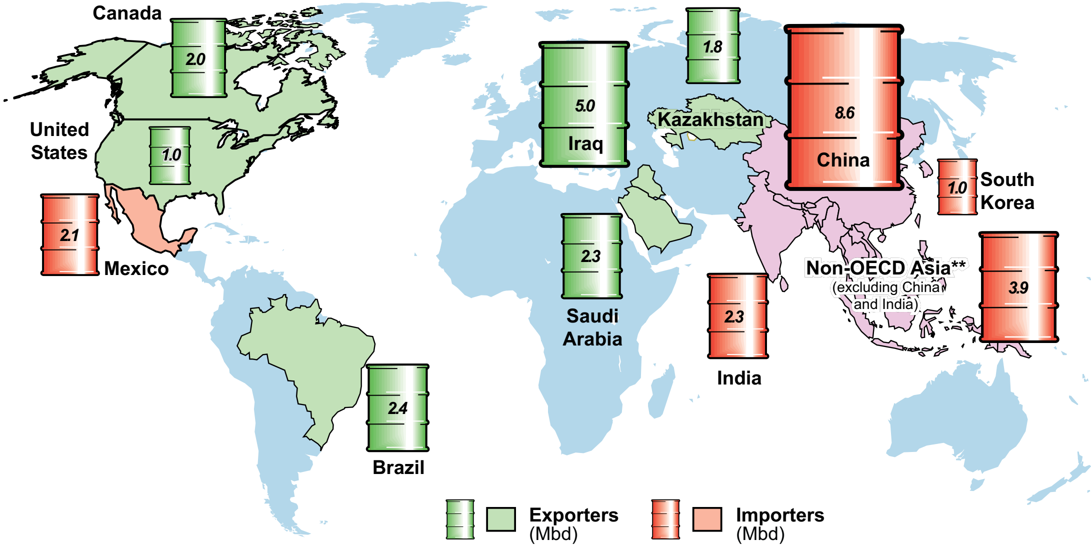
1975	Thousand Barrels per Day	Percent of Supply	2010	Thousand Barrels per Day	Percent of Supply
Domestic:	10,008	70%	Domestic:	7,548	45%
Imports:			Imports:		
Nigeria	746	5%	Canada total (including oil sands)	2,084	12%
			Canadian oil sands only*	1,100	6%
Saudi Arabia	701	5%	Mexico	1,167	7%
Canada	600	4%	Saudi Arabia	1,083	6%
Venezuela	395	3%	Nigeria	984	6%
Indonesia	379	3%	Venezuela	918	5%
Total imports	4,217	30%	Total imports	9,392	55%
Total crude supply (imports + domestic)	14,225	100%	Total crude supply (imports + domestic)	16,940	100%
Total number of countries importing crude to United States	18		Total number of countries importing crude to United States	41	

Source: US EIA, Canada NEB, IHS CERA.
*Includes crude, condensates, and NGLs.

Figure 1

Major Sources of Supply and Demand Growth: Projected Growth in Oil Export, Domestic Production, and Import Volumes from 2010 to 2030

(petroleum only*)



Source: US EIA (historical); IHS CERA (forecast).
*Petroleum only (includes NGLs, condensate, and crude oil).
**Non-OECD Asia excludes China, India, and OECD Asia.
10809-1

US domestic production is already an important pillar of US oil supply, and recent growth in onshore liquids production (crude oil, NGLs, and condensate) is fueling a revival in US output. "Tight oil" production in the United States from plays such as the Bakken play in North Dakota and the Eagle Ford play in south Texas combined with higher NGL output from gas shales is an important source of future liquids supply growth.* By 2030 US production is expected to grow by 1 mbd, and therefore, the United States is considered a major source of new supply growth. It's possible that tight oil production could still exceed our current estimate.

For the foreign suppliers, only part of their growing exports will be US bound, as other countries with rising oil demand will also seek these supplies. To identify growing oil demand centers, we isolated all regions expected to increase net imports by more than 1 mbd over the next 20 years. Five met this requirement; China, non-OECD Asia (excluding China and India), India, South Korea, and Mexico. Figure 1 highlights the growth in imports for these jurisdictions over the next 20 years (see the red oil barrels in Figure 1).

Considering the IHS CERA outlook in Figure 1, both Iraq and Brazil are poised to become new "major" US oil suppliers. Kazakhstan has strong supply growth; however, because of

---

*New US oil supply is being unlocked by new technology. Oil-bearing formations that were previously too tight for oil to flow to the wellbore are now being produced using horizontal drilling with hydraulic fracturing technology.

its geographic location and the resulting high cost of transportation to the United States compared with other potential markets, it is less likely to ship large volumes of oil to the United States.

In view of this analysis, the largest current and possible future US oil suppliers include US domestic production, Canada, Mexico, Saudi Arabia, Nigeria, Venezuela, Brazil, and Iraq. These eight suppliers are compared on environmental and security aspects in sections III and IV of this report. To learn more about the outlook for each of these suppliers, see the box "Outlook for Current and Future Major Sources of US Oil Supply."

Outlook for Current and Future Major Sources of US Oil Supply

Considering both current and future sources of US crude oil supply, some suppliers have the potential to further grow exports, while others are projected to remain static or decline.

Suppliers with potential to grow oil supply to the United States:

- **US domestic.** Production reached 7.5 mbd in 2010, 45 percent of total US crude oil supply.* Domestic crude oil continues to be the largest source of US oil supply. New supply from tight oil and higher NGL output (from gas shales) are important sources of future liquids supply growth.
- **Canada.** The United States imported over 2 mbd in 2010, 12 percent of total US crude oil supply. Buoyed by growth in production from the Canadian oil sands, supply from Canada is expected to climb by 2 mbd over the next 20 years. However, the growth in US imports from Canada is uncertain, partly because of differing views on the environmental impacts of oil sands development.
- **Saudi Arabia.** The United States imported 1.1 mbd in 2010, 6 percent of total US crude oil supply. The Kingdom has recently expanded productive capacity. However, with the country's growing domestic demand and proximity to Asia, only part of the new supply will be US bound. According to Saudi Aramco reports, Saudi Arabia is already the largest foreign oil supplier to China—providing roughly 1 mbd in 2010.**
- **Iraq.** The United States imported 0.4 mbd in 2010, 2 percent of total US crude oil supply. Iraq has by far the world's greatest potential to grow crude oil supply—IHS CERA estimates that production could grow from 2.6 mbd currently to 8 mbd by 2030. However, Iraq's export growth is expected to mirror its neighbor, Saudi Arabia—a good part of the new supply will likely flow to Asia.
- **Brazil.** The United States imported 0.3 mbd in 2010, 2 percent of total US crude oil supply. In 2010 Brazilian oil production (excluding biofuels) increased by 140,000 barrels per day (bd), and this trend is expected to continue. New offshore developments should propel Brazil into becoming one of the world's largest producers of oil—from producing 2.7 mbd currently to over 5 mbd in 2030. Owing to Brazil's proximity to the US market, a significant part of this future supply is likely to be imported by the United States.

---

*All US oil supply mentioned in this box comprises crude oil, condensates and NGLs, and does not include biofuels or refined product imports.

**Saudi Aramco Annual Review, 2010.

Outlook for Current and Future Major Sources of US Oil Supply (continued)

Suppliers with potential to maintain current exports to the United States:

- **Nigeria.** Nigerian imports were 1 mbd in 2010, 6 percent of total US crude oil supply. The country continues to struggle to maintain production while coping with security challenges (which have caused a sizable portion of supply to be shut in at times over the past decade). New offshore developments should help Nigeria offset declines. The IHS CERA outlook is for relatively flat production capacity over the next 20 years.

Current suppliers from which exports to the United States are likely to decline:

- **Venezuela.** The United States imported 0.9 mbd in 2010, 5 percent of total US crude oil supply. Venezuelan oil production has fallen from a peak of 3.2 mbd in 1997 to about 2.5 mbd currently. Investment has not been sufficient, so far, to return to the production levels of the 1990s. Even considering newly awarded exploration blocks and ample oil reserves, exports to the United States are expected to decline, owing to growing domestic oil demand, challenges in executing new oil development projects, and the potential for more of Venezuela's oil to be diverted to Asia.
- **Mexico.** The United States imported 1.2 mbd in 2010, 7 percent of total US crude oil supply. Mexico could become a net importer of oil in the latter part of this decade, however, assuming the current rate of production decline (primarily the result of declines in the Cantarell field), a continued increase in domestic oil demand of approximately 2 percent per year, and minimal investment in developing new oil supplies.

PART III: ENVIRONMENTAL ASPECTS OF US OIL SUPPLY

CHALLENGES OF COMPARISIONS

This section addresses the challenges in comparing environmental aspects of oil production in terms of water use, land disturbance, and GHG emissions. In most cases, objective comparisons are difficult because of differences in data requirements among countries.

ENVIRONMENTAL DATA AVAILABILITY

Data requirements and availability are critical for environmental comparisons among US crude oil suppliers. Although averages attained from rules of thumb or broad assessments can be helpful for general discussion, they are not nearly specific enough to support policy. If US policy aims to differentiate crudes by environmental attributes, more accurate measurement, verification, and reporting of data are needed. A lack of public environmental data does not inherently indicate a lack of concern or care for the environment, but it does mean that comparisons are difficult and perhaps not even possible.

Data reporting requirements and availability vary considerably among jurisdictions—shaped by government policy needs and the approach to oil development. Some governments have, by design, checks and balances between government agencies and the public; these governments have oil and gas regulators that are typically arms-length government agencies, and the availability and transparency of data are an important priority. The approach to oil and gas development also influences data availability. Jurisdictions open to investment by independent companies generally provide more oil and gas data, while countries that rely on national oil companies (NOCs) or joint ventures with NOCs typically have different practices regarding data requirements and public availability because of a different industry structure.

When comparing the data availability among crude oil suppliers, it's critical to recognize this distinction—data availability is driven by industry structure, and regulatory and investment environments.

Of the eight sources of US oil supply included in our analysis, currently only half provide enough environmental data to make meaningful comparisons on environmental aspects of oil production—such as water-use, biodiversity impacts, and GHG emissions from oil developments. Of all the jurisdictions compared, the Canadian oil sands have the highest level of readily available, online data.

- **US domestic.** The United States depends on independent investment to produce its oil and gas reserves. In addition, it has a regulatory system with multiple arms-length government agencies. Consequently, transparency of data is important and environmental data is generally available. The ease of accessing data varies by state, or—for production from federal lands—with the federal regulatory authority. In most cases, basic figures on oil production or injection data are available—often on government Internet sites. However, environmental information—site-specific information on biodiversity changes, detailed groundwater and soil analysis, air monitoring, water consumption and quality, waste disposal, or metrics regarding plant operation or energy consumption—are mostly not available online. Where data are not readily available, a data request can be made to the oil and gas regulator.

- **Canada.** Like the United States, Canada depends on independent investment for oil development and has multiple arms-length government agencies that regulate the oil and gas sector. As a result, data are generally available. Like the United States, the ease of accessing data varies by the type of data requested. For the province of Alberta—home to the Canadian oil sands—detailed oil production, GHG emissions, and injection data are available from the regulator. For in situ operations, the regulator makes detailed site-specific operations data available online. And large oil sands operators voluntarily publish GHG emissions or water consumption data in sustainability reports (and parts of the data in these operator reports are also subject to external review or assurance). For oil sands mining projects, annual environmental reports are publically available at the government library. Compared with other sources of current or possible future US oil supply, the Canadian oil sands has the highest level of readily available environmental data, and online data availability is set to further improve—a new oil sands portal is schedule to launch in 2011. The portal will include environmental data covering production, water use, GHG emissions, disturbed lands, and all current and past environmental approval documents. To access other data, a request must be made to the oil and gas regulator (similar to the US system).

- **Mexico.** Oil is produced by Mexico's NOC, PEMEX. In such cases, data requirements often differ from jurisdictions where private or independent investment is the main driver. Historically, data availability in Mexico has been lower than in the United States and Canada; however, changes in government policy have increased the focus on oil and gas data transparency. In 2008 Mexico created the National Hydrocarbon Commission (CNH), Mexico's first independent upstream oil and gas regulator. One of the mandates of the CNH is to provide the public transparency and access to oil and gas information—including environmental data. IHS CERA received field-level injection data through this process, and other environmental data are also available.

- **Saudi Arabia.** Saudi Arabia's NOC, Saudi Aramco, controls almost all of the Kingdom's oil and gas activities.*As a result of Saudi Arabia's regulatory and investment environment, the needs for data availability are different compared with Canada and the United States. Saudi Aramco provides high-level country aggregate oil and gas production data (as well as information on future plans) in its annual reports. More detailed data, such as field-level production or environmental data, are generally not available to the public.

- **Nigeria.** Nigeria's NOC, the Nigerian National Petroleum Company (NNPC), both regulates and participates in domestic oil developments. NNPC relies on joint ventures with independent companies to develop its oil and gas reserves. In Nigeria, data is

---

*There is one exception; in 2004, Saudi Aramco started four joint ventures with international oil companies to explore for gas in the country's so-called Empty Quarter. So far, these ventures have not found significant commercial quantities of gas.

less available than Canada and the United States—the regulatory and investment environment requires less data. Until recently, NNPC published field-by-field production figures. However, because of an ongoing reorganization at NNPC, the field-level data are currently not available. Other data can be derived from the reports of operating companies. Typically, environmental data are not available, and, if US policy were to require it for comparisons, a process to supply the information must evolve.

- **Venezuela.** Venezuela's NOC is PDVSA. Although independent companies can participate in the development of Venezuela's oil and gas reserves, participation is limited to joint ventures with PDVSA. In Venezuela data availability is less than in Canada and the United States. In July 2010, for the first time, PDVSA published an environmental and social report—27 pages were dedicated to its environmental performance. The reported data are mostly aggregated at the company or major project level—including air quality, waste production, and water disposal. If more detailed environmental data are required, Venezuela lacks a process to request this information from either the Ministry of the Popular Power for the Environment (the government body responsible for keeping record of all environmental issues in the country) or PDVSA. This process would need to evolve if US policy demanded data.

- **Brazil.** Brazil has a NOC, Petrobras, that also has a degree of private ownership. Generally, Brazil allows for independent investment in developing its oil and gas reserves.* The oil and gas regulator is the Brazilian National Petroleum Agency (ANP). One of ANP's mandates is providing oil and gas data to the public. Owing to Brazil's regulatory and investment environment, generally data are available. ANP posts a considerable amount of data on its website, including field-level environmental and production information. If the data are not available online, the public can contact the regulator to request the information.

- **Iraq.** Iraq's oil ministry controls oil and gas production and development through three operating companies; and the country relies on foreign investment to develop its oil and gas reserves. **Field-level production data are available, but public accessibility to other data on oil and gas developments is limited.

ENVIRONMENTAL COMPARISONS

This section examines three measures of environmental performance—water use, land disturbance, and GHG emissions. To be sure, this is not a comprehensive list of environmental metrics for oil and gas developments. For instance, effects on local air quality, biodiversity, and groundwater are also important. However, these three serve as illustrative case studies, demonstrating the level of data available and the complexity of comparisons.

Comparing Water Use

To compare water use in oil production more easily from different supply sources, there is a desire to create simple, comparative metrics. Water intensity—the amount of water consumed

---

* The only exception is the presalt region; here independent companies must partner with Petrobras.

** One exception to Iraq's oil ministry control is the Kurdish area in the north.

per barrel of oil produced—is the most frequent comparison (see the box "How Does Water Use in Oil Sands Compare with Other Fuel Types?" for examples of water-use intensity). Although water intensity metrics are appealing, they should be used with caution—a proper assessment must consider the local context. Comparing data across countries or even within countries is unlikely to be a meaningful exercise without taking into account the local context of water demand and supply. For each oil source, it is critical to consider—is there sufficient water in the region to meet industry, agricultural, and domestic needs without causing environmental damage?

Water quality is also important. For example, is consuming a barrel of nonpotable, saline, groundwater—referred to as brackish water—equal to consuming a barrel of fresh water? The answer to the quality question is also a local issue. In a location with ample supplies of fresh water, using large volumes of brackish water could be inconsequential. However, in an environment with limited fresh water supplies, brackish water could be a valuable resource.

Comparing only water consumption data across the eight oil suppliers in this analysis and assuming a significant data-gathering and vetting exercise were conducted, water intensity could be calculated for the United States, Canada, Mexico, and Brazil (see Table 2). Other major sources of US oil supply do not provide enough public information for this calculation. The Canadian oil sands supply (through operator published sustainability reports and online data from the regulator) is the only source with sufficient online data to gauge water intensity.

Comparing Land Disturbance

The land disturbance from oil developments is often compared using a "percent of disturbed land" metric—the fraction of land affected by the oil and gas development compared with the total land area. With the advent of easily accessible global satellite images, the land disturbance from an oil and gas development anywhere in the world can be estimated—therefore, data availability in a particular jurisdiction is no longer a limitation. However, this type of metric can still be uncertain:

- **Accuracy.** Measurement by this method (using publicly available satellite images) can be subjective. The data are most often of low granularity, and there is human judgment involved in determining the metric—for instance, drawing the boundary around the parameter of the oil and gas development and defining what land is actually disturbed. In comparing oil developments, a consistent methodology must be applied.

- **Dissimilar land types.** A simple metric, such as the percent of land disturbed, does not consider the predevelopment land use and biodiversity. The natural state of land in the oil sands region is boreal forest. Evergreen trees dominate the landscape, and 30 to 40 percent of the area is wetlands. The forest is home to many animals, including caribou, bear, wolves, moose, deer, and countless types of birds. This is different from a desert environment in the Middle East where much of that region's crude supply originates. In the desert, plant and animal life is more dispersed and therefore, in absolute terms, desert oil and gas developments will have an impact on less biota. However, as the desert ecosystem is fragile, this lower threshold of disturbance to plants and animals could still be consequential.

- **Volume of energy produced.** A simple metric, such as percent of land disturbed, does not account for energy intensity of the disturbance. Oil wells are not all equal in their ability to produce oil. For example, the average oil sands SAGD well pair produces over 570 bd, while an above-average onshore conventional oil well produces between 50 to 100 bd; although the percentage of land disturbed for most conventional developments is lower, in situ oil sands production has less of an impact per barrel of oil produced (see the box "How Much Land Is Used for Oil Sands Development?").
- **Not directly comparable for offshore developments**. A land disturbance metric is not relevant for comparisons with offshore developments. Yet both offshore and onshore developments can have impacts on biodiversity.

Comparing Life-cycle GHG Emissions of Crude Oils

The life-cycle (also known as "well-to-wheels") emissions for a petroleum fuel cover all GHG emissions from the production, processing, and transportation through to the final consumption of the fuel. Unlike water and land, GHG emissions are a global, not local, issue. Regardless of where the GHG is emitted, it has the same effect on the environment.

Distinctions among GHG emissions associated with US oil supply—and imports in particular—have become an increasingly important topic. California's Low Carbon Fuel Standard (LCFS) could restrict future imports of crudes with high carbon intensities—including the Canadian

How Does Water Use in Oil Sands Compare with Other Fuel Types?

Although oil sands projects have been criticized for being water intensive, they are not alone in requiring significant amounts of water for production—many types of energy production use a great deal of water. Figure 2 depicts the water use of several liquid fuel and electricity production methods on an equivalent energy basis.

Currently, net water use in oil sands production averages about four barrels of fresh water per barrel of bitumen for mining operations and 0.7 barrels of water per barrel of bitumen produced from in situ operations.* For in situ operations, almost half of the water is sourced from brackish water. Conventionally produced oil can use up to 1.5 barrels of water per barrel of oil produced, while water use for enhanced oil recovery ranges from similar to oil sands to significantly higher.

Oil alternatives can also be water intensive (see Figure 2). Ethanol produced from irrigated crops such as corn can use more than 500 barrels of water per barrel of ethanol, and coal-to-liquids can use 10 barrels of water per barrel of finished product.**

---

*For mining operations, includes water from the Athabasca River and water collected from site runoff and mine dewatering.

**Sources: US Department of Energy (DOE), December 2006; Argonne National Laboratory, Energy Systems Division, *Consumptive Water Use in the Production of Ethanol and Petroleum Gasoline,* 2011 Update; and IHS CERA.

Table 2

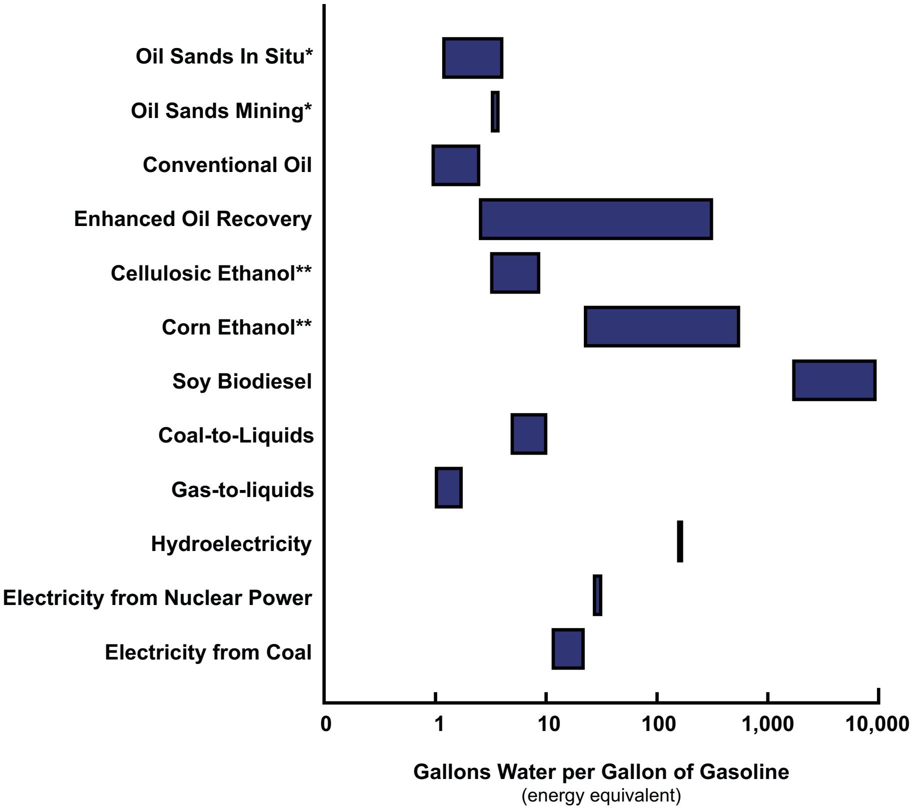
Water Consumption Data Availablity and Source

	Water Consumption Data Availability	Can Project-level Water Intensity Metric Be Calculated?	Water Source for Oil Production
US Domestic	Publically available by request, in most states not online	✓	Source of water varies by development type: ocean water, fresh and brackish groundwater
Canadian Oil Sands—Mining	Publically available and online	✓	Fresh surface water
Canadian Oil Sands—SAGD	Publically available and online	✓	Fresh and brackish groundwater
Canadian Oil Sands—CSS	Publically available and online	✓	Fresh surface water, fresh and brackish groundwater
Mexico	Publically available by request (not available online)	✓	Source of water varies by development type: ocean water, fresh and brackish groundwater
Saudi Arabia	Limited data		Groundwater is mostly brackish, and ocean water
Nigeria	Limited data		Onshore water injection is not typical; some offshore developments use ocean water
Venezuela	Recent enviroment and sustainblity report provides country-level data, project level data is not available		Limited data, mostly fresh surface water
Brazil	Publically available by request (not available online)	✓	Water injection is not typical; some offshore developments use ocean water
Iraq	Limited data		Few fields use water injection; some new southern developments plan to use sea water

Source: IHS CERA.

Figure 2

Life-cycle Water Intensity of Various Energy Sources



Sources: US Department of Energy, *Energy Demands on Water Resources: Report to Congress on the Interdependency of Energy and Water,* December 2006.
*Source: IHS CERA, based on operator reports. Mining values are net fresh water river withdrawals only. Added 1 barrel to upstream numbers to account for refining.
**Source: Argonne National Laboratory, Energy Systems Division, *Consumptive Water Use in the Production of Ethanol and Petroleum Gasoline, 2011 Update.*
10809-3

oil sands.*A high-carbon-intensity crude produces GHG emissions that are above a certain standard or average. In addition to California, several other US states are considering a LCFS. Together the states implementing or considering an LCFS represent 50 percent of all of the gasoline consumed in the United States.

In September 2010 IHS CERA published the Special Report *Oil Sands, Greenhouse Gases, and US Oil Supply: Getting the Numbers Right,* which puts 13 publicly available life-cycle

---

*California's LCFS went into effect in 2010. The law requires average transportation fuel consumed to have 10 percent lower life-cycle GHG emissions by 2020 compared with 2010. Higher-carbon crudes (like the Canadian oil sands) will struggle to meet this mandate; they require greater volumes of scarce low-carbon fuels to offset their higher carbon intensities. The California LCFS does not treat all high-carbon crudes equal—some California domestic production has a carbon footprint similar to other high-carbon crudes, but this supply is grandfathered under the LCFS. See the IHS CERA Special Report *Oil Sands, Greenhouse Gasses, and US Oil Supply: Getting the Numbers Right*.

How Much Land Is Used for Oil Sands Development?

Oil sands land use concerns vary by oil sands production method:

- **Oil sands production from mining.** While an area is being mined, 100 percent of the land is disturbed. After the area is mined out, the land must be reclaimed. The definition of reclaimed land and the pace of reclamation are open questions for many who want the land restored as quickly as possible to its predisturbance state.
- **Oil sands production from in situ.** IHS CERA estimates that the disturbed area of a SAGD project averages about 7 to 15 percent of the lease. This compares favorably to mining and is generally—but not always—higher than conventional oil development; in comparison, the land disturbance from five conventional oil and gas jurisdictions ranged from 1 to 17 percent of the lease.*

---

*IHS CERA compared a group of onshore developments in Mexico, Saudi Arabia, Nigeria, Venezuela, and Brazil using satellite images.

studies into a consistent framework with the goal of providing a broader comparison than any single study (to download this report, please visit www2.cera.com\oilsandsdialogue).* For most countries, only limited estimates of the GHG emissions from oil production are available. For instance, the GHG emissions from Venezuelan partial upgrading is based on one data source—a dated study with limited information on assumptions or inputs (see Figure 3).** For example, studies for Canada Bow River, for oil sands production using the CCS method, and for Middle East heavy oil also have limited sources. Further, even if multiple studies exist, they are based on estimates. For many sources of oil supply, getting accurate industrywide or even field-level data describing energy consumption, production, or injection rates is not possible—and a very significant international data-gathering and vetting exercise would need to be put in place to do so (see the Environmental Data Availability section, above). The challenge of accurately estimating life-cycle GHG emissions is further reflected in the wide range of results across the 13 studies analyzed by IHS CERA. Estimates of well–to–retail tank emissions for specific crudes varied by as much as 45 percent (or 10 percent on a life-cycle or well-to-wheels basis). Although estimates for GHG emissions for various crude sources exist (and are highlighted here), they are best estimates—helpful for general discussion, but not nearly specific enough to support policy.

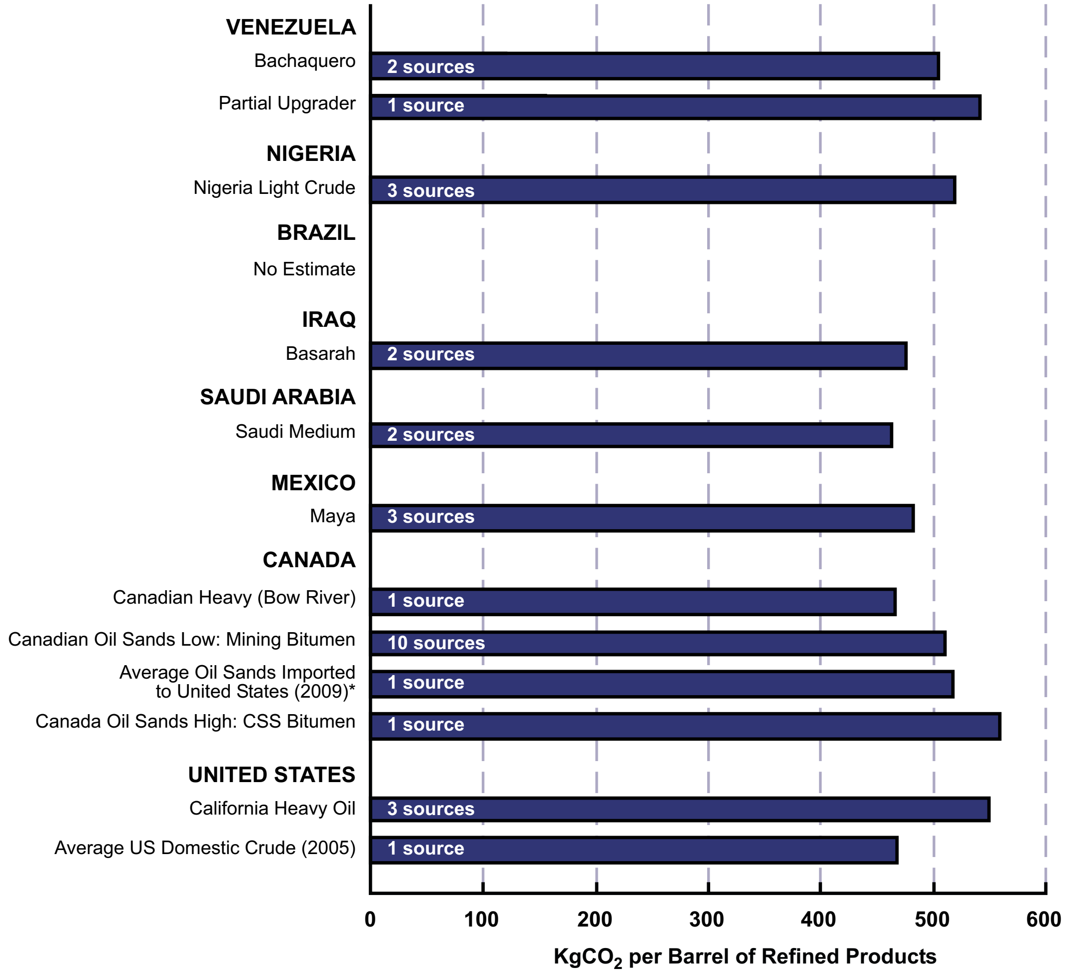
---

*Original studies included within the IHS CERA analysis are Jacobs Consultancy, *Life Cycle Assessment Comparison of North American and Imported Crudes* (July 2009); TIAX LCC, *Comparison of North American and Imported Crude Oil Life-cycle GHG Emission*s (July 2009); DOE/National Energy Technical Laboratory, *Development of Baseline Data and Analysis of Life Cycle Greenhouse Gas Emissions of Petroleum-Based Fuels* (November 2008); McCann and Associates, *Typical Heavy Crude and Bitumen Derivative Greenhouse Gas Life Cycles* (November 2001); RAND Corporation, *Unconventional Fossil-Based Fuels: Economic and Environmental Trade-Offs* (2008); National Energy Board, *Canadian Oil Sands: Opportunities and Challenges* (2006); Canadian Association of Petroleum Producers, *Environmental Challenges and Progress in Canada's Oil Sands* (2008); GREET Version 1.8b, (September 2008); *GHGenius 2007 Crude Oil Production Update Version 3.8, Syncrude 2009/10 Sustainability Report; Shell Sustainability Report* (2006); and IHS CERA data.

**The GHG emissions estimate for oil supply from the Venezuelan Partial Upgrader was published in 2007 and was based on a partially completed 2001 study by McCann Associates Ltd. Limited data are provided for the Venezuelan project; the paper states that the study was based on a model of the Petro Zuata project with data provided by an undisclosed early participant in the research. Other GHG estimates also have limited sources.

Figure 3

Well-to-wheels GHG Emissions from Crude Oil



Source: IHS CERA.
Data Sources:
Venezuela: Bachaquero—Jacobs-AERI (2009); TIAX-AERI (2009).
Venezuela: Partial Upgrader—McCann (2007).
Nigeria: Nigeria Light Crude—McCann (2007); Jacobs-AERI (2009); TIAX-AERI (2009).
Iraq: Basarah—Jacobs-AERI (2009); TIAX-AERI (2009).
Saudi Arabia: Saudi Medium—DOE/NETL (2008); Jacobs-AERI (2009).
Mexico: Maya—DOE NETL (2008); Jacobs-AERI (2009); TIAX-AERI (2009).
Canada: Canadian Heavy (Bow River)—TIAX-AERI (2009).
Canada: Canadian Oil Sands Low: Mining Bitumen—TIAX-AERI (2009); McCann (2007); GREET; GHGenius; RAND (2008); Jacobs-AERI (2009); Syncrude (2009/10); Shell (2006): NEG (2008): CAPP (2008).
Canada: Average Oil Sands Imported to United States (2009)—.
Canada: Canada Oil Sands High: CSS Bitumen—TIAX-AERI (2009) (assumes SOR of 3.35).
United States: California Heavy Oil—Jacobs-AERI (2009); TIAX-AERI (2009); IHS CERA.
United States: Average US Domestic Crude (2005)—DOE/NETL (2008).
10809-2

PART IV: SECURITY ASPECTS: US OIL SUPPLY

FACTORS SHAPING OIL SUPPLY SECURITY

From the perspective of an oil consumer, oil security is about adequate and reliable supply. Although oil supply security is shaped by many factors, resource endowment, the historical performance record, and perception of political stability are important.

First and most importantly, a secure supplier must be sufficiently endowed with oil reserves. Although large endowments of oil resources are a function of geological forces, producing the oil reliably is not. The potential for stable oil production is shaped by many factors—type of resource, geographic location, technology, and the country's political and fiscal environment, to name a few.

Among today's major suppliers of US oil, both Mexico and Venezuela have ample reserves, yet they are struggling to maintain supply. In the past five years, Venezuela's production has dropped 500,000 bd, and Mexico's has fallen by 600,000 bd. In large part, these declines are due to the political and investment climate. In Venezuela, past expropriation of assets and changes to fiscal terms have contributed to reduced oil production. In Mexico, a lack of investment and limited access to the newest technology have been factors.

The historical performance record—the reliability of supply—is another concern. Because of security challenges, Nigeria has struggled to maintain its production. Militant groups have repeatedly shut-in oil developments there—often taking hostages. Moving production offshore was thought to reduce this risk; however, militants have disrupted offshore production as well—although to a much lower degree than onshore.

To analyze the relative security associated with major current and future sources of US oil supply, we used the IHS Petroleum Economics and Policy Solutions (PEPS) service. In addition to providing regulatory, legislative, economic, and commercial data, PEPS provides political risk rankings for 125 countries. The IHS political risk index considers the political, socioeconomic, and commercial aspects for each country and is an indication of the relative risk of future supply.*

This supply risk assessment is an effort to assess and rank countries based on the current situation at a particular point in time. This is simply a snapshot, and as demonstrated by the Arab Spring, an unexpected development can set in motion events that can alter the political landscape of a region. Moreover, it is clear that the length of time a government has maintained power or the current level of risks is not necessarily an indication of the future. The nature and level of political risk in any particular country can change quickly. Indeed, there is uncertainty in future oil supply for all countries compared.

Considering the eight oil suppliers compared in this paper, low-risk suppliers include Brazil, Canada, Saudi Arabia, and the United States. All have ample reserves, and stable

---

* Political risks include factors such as potential for wars, unrest, internal violence, and regime instability. Socioeconomic risks are shaped by factors including economic stability, domestic energy demand and supply, and environmental opposition to oil and gas development. Commercial factors include stability of the contract and fiscal terms, openness for foreign investment, and stability of investment.

governments, and have historically proven to be reliable sources of oil supply. Medium-risk suppliers include Mexico and Venezuela. Although the countries have ample reserves of oil, both have limited access to foreign capital and have struggled to increase their oil supplies. Other risks include the potential for security issues (Mexico) and political instability (Venezuela). Higher-risk suppliers include Iraq and Nigeria. For both countries, lack of security continues to create supply risk, adding uncertainty to the amount of oil that can ultimately be produced.

PART V: CONCLUSION

Security of oil supply has long been a US policy concern. Security of supply is still important, as demonstrated by oil supply disruptions associated with the civil war in Libya. History illustrates the affects of oil shocks. In each past oil shock, panic and expectations of conflict have driven oil price increases, with negative consequences to the United States and the global economy. Canada is a low risk source of oil supply. Oil is a key element of deep economic links between the United States and Canada. Increasing supply from Canada offers the United States greater oil supply security.

Now, environmental aspects of oil are also factored into the US energy policy discussion. In terms of environmental comparisons—such as GHG emissions, water use, and land use—environmental data, availability, and government needs differ across jurisdictions making comparisons challenging. Comparing major sources of US oil supply, Canadian oil sands are at the forefront of readily available data. A second challenge with environmental comparisons is establishing uniform and relevant metrics. Even when data are available, environmental aspects—including water and land use—are often not comparable.

Supply from the Canadian oil sands has come under considerable scrutiny based on its environmental footprint. However, to differentiate crude oils by environmental factors objectively, all major sources of oil must be considered using accurate and verifiable data. Otherwise, policies that seek to reduce the environmental footprint could instead shift emissions to countries or sectors with mischaracterized environmental footprints. ■

REPORT PARTICIPANTS AND REVIEWERS

IHS CERA hosted a focus group meeting in Calgary, Alberta (May 4, 2011), providing an opportunity for oil sands stakeholders to come together and discuss perspectives on the key issues related to US oil supply sources. Additionally, a number of participants reviewed a draft version of this report. Participation in the focus group or review of the draft report does not reflect endorsement of the content of this report. IHS CERA is exclusively responsible for the content of this report.

Alberta Department of Energy
American Petroleum Institute—API
BP Canada
Canada West Foundation
Canadian Association of Petroleum Producers—CAPP
Canadian Natural Resources Ltd.
Canadian Oil Sands Limited
Cenovus Energy Inc.
Chevron Canada Resources
ConocoPhillips Company
Devon Energy Corporation
Energy and Environmental Solutions, Alberta Innovates
Fraser Institute
Imperial Oil Ltd.
In Situ Oil Sands Alliance—IOSA
Marathon Oil Corporation
Natural Resources Canada
Nexen Inc.
Peter Tertzakian (ARC Financial)
Shell Canada
Statoil Canada Ltd.
Suncor Energy Inc.
Total E&P Canada Ltd.
TransCanada Corporation
University of Alberta - Centre of Applied Business Research in Energy and the Environment (CABREE)

IHS CERA TEAM

James Burkhard, Managing Director of IHS CERA's Global Oil Group, leads the team of IHS CERA experts that analyze and assess upstream and downstream market conditions and changes in the oil and gas industry's competitive environment. A foundation of this work is detailed short- and long-term outlooks for global crude oil and refined products markets that are integrated with outlooks for other energy sources, economic growth, geopolitics, and security. Mr. Burkhard's expertise covers geopolitics, industry dynamics, and global oil demand and supply trends.

Mr. Burkhard also leads the IHS CERA Global Energy Scenarios, which combines energy, economic, and security expertise across the IHS Insight businesses into a comprehensive, scenarios-based framework for assessing and projecting global and regional energy market and industry dynamics. Previously he led *Dawn of a New Age: Global Energy Scenarios for Strategic Decision Making—The Energy Future to 2030,* which encompassed the oil, gas, and electricity sectors. He was also the director of the IHS CERA Multiclient Study *Potential versus Reality: West African Oil and Gas to 2020.* He is the coauthor of IHS CERA's respected *World Oil Watch,* which analyzes short- to medium-term developments in the oil market. In addition to leading IHS CERA's oil research, Mr. Burkhard served on the US National Petroleum Council (NPC) committee that provided recommendations on US oil and gas policy to the US Secretary of Energy. He led the team that developed demand-oriented recommendations that were published in the 2007 NPC report *Facing the Hard Truths About Energy.* Mr. Burkhard has also testified several times before US Congress on oil and energy issues. Before joining IHS CERA Mr. Burkhard was a member of the United States Peace Corps in Niger, West Africa. He directed infrastructure projects to improve water availability and credit facilities. Mr. Burkhard holds a BA from Hamline University and an MS from the School of Foreign Service at Georgetown University.

Jackie Forrest, IHS CERA Director, Global Oil, leads the research effort for the IHS CERA Oil Sands Energy Dialogue. Her expertise encompasses all aspects of petroleum evaluations, including refining, processing, upgrading, and products. She actively monitors emerging strategic trends related to oil sands including capital projects, economics, policy, environment, and markets. She is the author of several IHS CERA Private Reports, including an investigation of US heavy crude supply and prices. Additional contributions to research include reports on the life-cycle emissions from crude oil, the impacts of low-carbon fuel standards, and the role of oil sands in US oil supply. She led the team that developed the North American unconventional oil outlooks and recommendations the 2011 NPC report *Prudent Development of Natural Gas & Oil Resources*—including the Canadian oil sands, US oil sands, tight oil, oil shale, and Canadian heavy oil. Ms. Forrest was the IHS CERA project manager for the Multiclient Study *Growth in the Canadian Oil Sands: Finding the New Balance,* a comprehensive assessment of the benefits, risks, and issues associated with oil sands development. Before joining IHS CERA Ms. Forrest was a consultant in the oil industry, focusing on technical and economic evaluations of refining and oil sands projects. Ms. Forrest is a professional engineer and holds a degree from the University of Calgary and an MBA from Queens University.

Terry Hallmark, IHS Director of Political Risk and Policy Assessment. Dr. Hallmark has served as a consultant to major oil and service companies, financial institutions and governmental agencies. He has also lectured extensively on political risk assessment and has written on the subject for the *Petroleum Economist, Offshore* magazine, the *American Oil and Gas Reporter,* and the *Oil & Gas Law and Taxation Review.* He has also contributed to The Handbook of Country and Political Risk Analysis, which provides an overview of political risk assessment methodologies. Dr. Hallmark holds both a bachelor's and a master's degree from the University of Houston, and a doctorate from the School of Politics and Economics at Claremont Graduate University. For the past 22 years, he has been an adjunct faculty member in the University of Houston's Department of Political Science, and more recently has joined the University's Honors College, where he specializes in political philosophy, American political thought, and American foreign policy.