Canadian Oil Sands Primer

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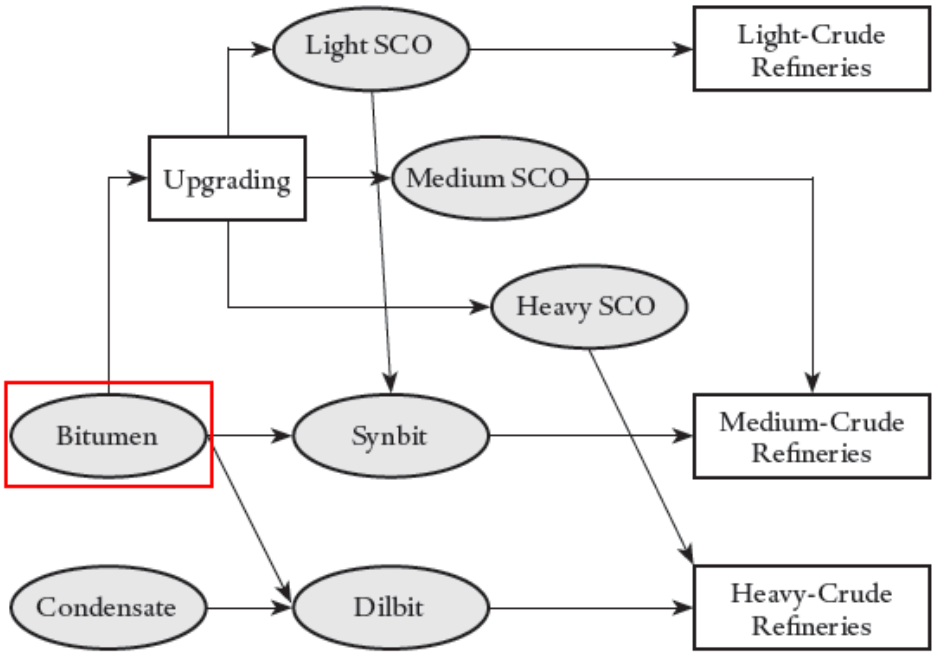
This primer draws on various reports and ENE analysis to present an overview of the Canadian oil sands: how oil sands are processed; the greenhouse gas emissions associated with each stage of processing and consumption; and, the level of emissions that will remain unregulated absent coordinated regulation in the U.S. and Canada.

The Basics

- Oil sands deposits are composed of sand, silt and clay, water and between 10-12% bitumen which can be processed into synthetic crude oil.
- Globally, Canada is second only to Saudi Arabia in proven oil reserves – 175 of 179 billion barrels of Canadian reserves are located in the oil sands.[1]
- Canadian oil sands currently produce approximately 1 million barrels per day (bpd). In 2006, oil sands production constituted 6% of total U.S. oil consumption and 9% of U.S. oil imports.[2] Production estimates for 2030 range from 3.5 million to 5 million bpd.
- Oil sands are being developed primarily in the Canadian province of Alberta.
- Recent reports estimate the breakeven cost for new oil sands projects at $60-$70/barrel, down from $80-$100/barrel. Existing projects remain profitable at world oil prices above $35-$40/barrel.[3]
- In 2000, total GHG emissions from the oil sands industry were estimated to be 23.3 megatonnes (Mt) CO_2.[4] In 2006, the industry accounted for approximately 5% of Canada's total emissions or 36.1 Mt.[5] The Pembina Institute projects emissions will grow to 57-97 Mt in 2015 and 83-175 Mt in 2030.[6]

Figure 1: Supply Chain from Oil Sands Bitumen to Synthetic Crude Oil (SCO) to Refined Product.



Source: Council on Foreign Relations, *Special Report No. 47*, p. 10.

Glossary

Oil sands: naturally-occurring mixtures of bitumen, water, sand and clay.

Bitumen: semi-solid or solid petroleum in natural deposits which must be heated or diluted with lighter hydrocarbons to flow. At room temperature it is heavy and thick like molasses.

In situ: In situ recovery refers to various methods used to recover deeply buried bitumen deposits. Cyclic steam stimulation (CSS) and steam assisted gravity drainage (SAGD) are in-situ recovery methods, which include thermal injection through vertical or horizontal wells, solvent injection and carbon dioxide methods. Other emerging technologies are pulse technology and vapour recovery extraction (VAPEX).

Surface Mining: Oil sands are mined using trucks and shovels. The oil sands are crushed and transported to an extraction plant where bitumen is separated from water and sand. Some facilities have the capability to upgrade the bitumen into a synthetic product – a light crude oil that can be processed by a refinery.

Extraction process: Oil sand is mixed with hot water, creating a slurry. The slurry is fed into a separation vessel where it separates into three layers – sand, water and bitumen. The bitumen is then skimmed off the top to be cleaned and processed further.

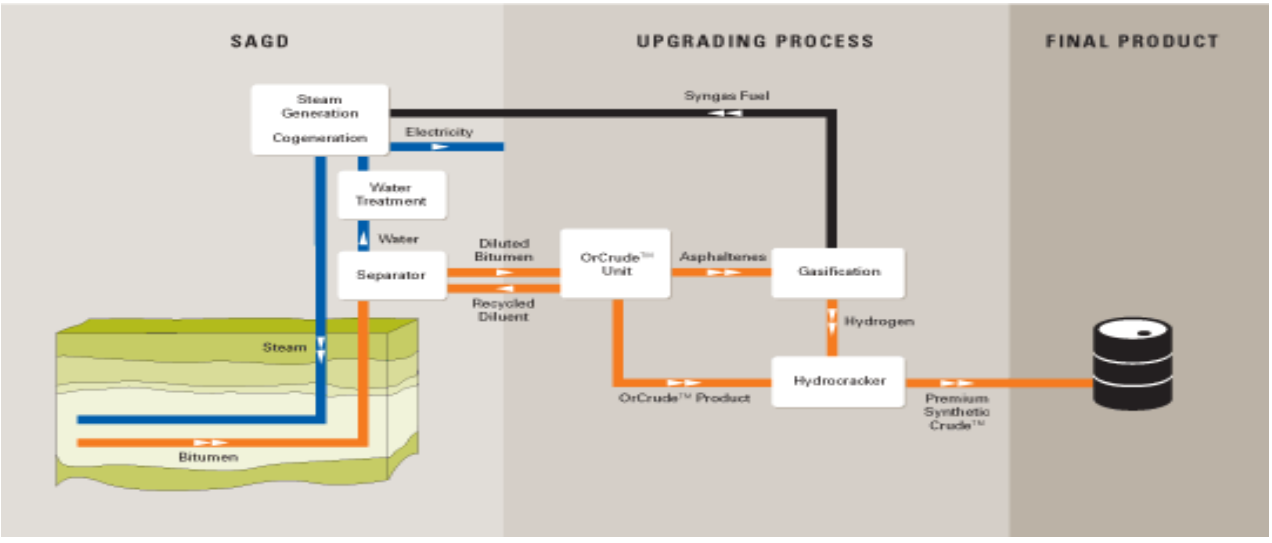
Upgrading: Bitumen is a complex hydrocarbon made up of a long chain of molecules. In order for bitumen to be processed in refineries, this chain must be broken up and reorganized. Bitumen is carbon rich and hydrogen poor. Upgrading means removing some carbon while adding additional hydrogen. This is done using four main processes: coking, distillation, catalytic conversions and hydrotreating. The end product is synthetic crude oil, which is shipped by underground pipelines to refineries across North America.

Synthetic crude oil: a mixture of hydrocarbons, similar to crude oil, derived by upgrading bitumen from oil sands (also known as bitumen crude oil).

Crude oil: the raw material refined into gasoline, heating oil, propane, petrochemicals, jet fuel, and other products.

Source: Canadian Association of Petroleum Producers (CAPP) Web site: http://www.canadasoilsands.ca/en/glossary.aspx

Figure 2: In Situ Bitumen Recovery Using Steam Injection (Steam Assisted Gravity Drainage)



Source: www.nexeninc.com

Process for Extraction, Upgrading, and Refining

Bitumen Extraction

In Situ Method

Deeply buried bitumen is made to flow to wells using steam injection (CSS, SAGD), solvent injection, CO_2 methods, or vapor recovery extraction (VAPEX).

Bitumen is then pumped to the surface and transported via pipeline to an upgrading facility.

Approximately 82% of Alberta's oil sands can only be developed using in situ methods (NRDC, 2007) – SAGD is the most common (see Figure 2).

Surface Mining Method

From open pit mines, oil sands are mined using trucks and shovels, crushed, and transported to an extraction plant.

Bitumen is extracted by mixing oil sands with hot water.

Upgrading may take place at an extraction plant or at a separate upgrading facility (see Figure 3).

Upgrading to Synthetic Crude Oil

Some oil sands projects have on-site upgraders; others transport bitumen to another complex, similar to a refinery, where it is upgraded in two stages:

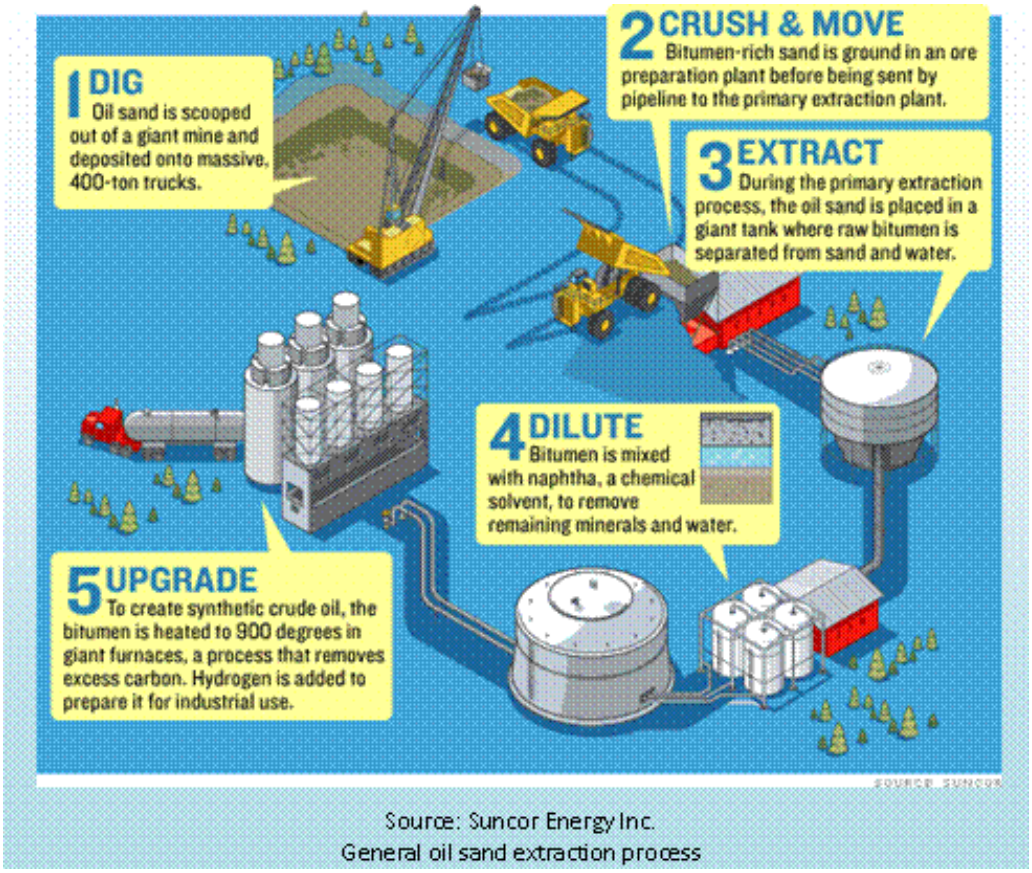
1. Heavy bitumen hydrocarbons are converted into petroleum derivatives by (a) coking (excess carbon is removed at high temperatures); (b) hydrocracking (adding hydrogen to bitumen molecules); or (c) a combination of both processes.
2. Hydrotreating uses a catalyst and high pressure and temperatures to remove nitrogen, sulfur, and other metals.

The upgrading process is energy-intensive and uses large amounts of water. Coke, one byproduct of the process, may be gasified to offset natural gas requirements (see Figure 4).

Refining

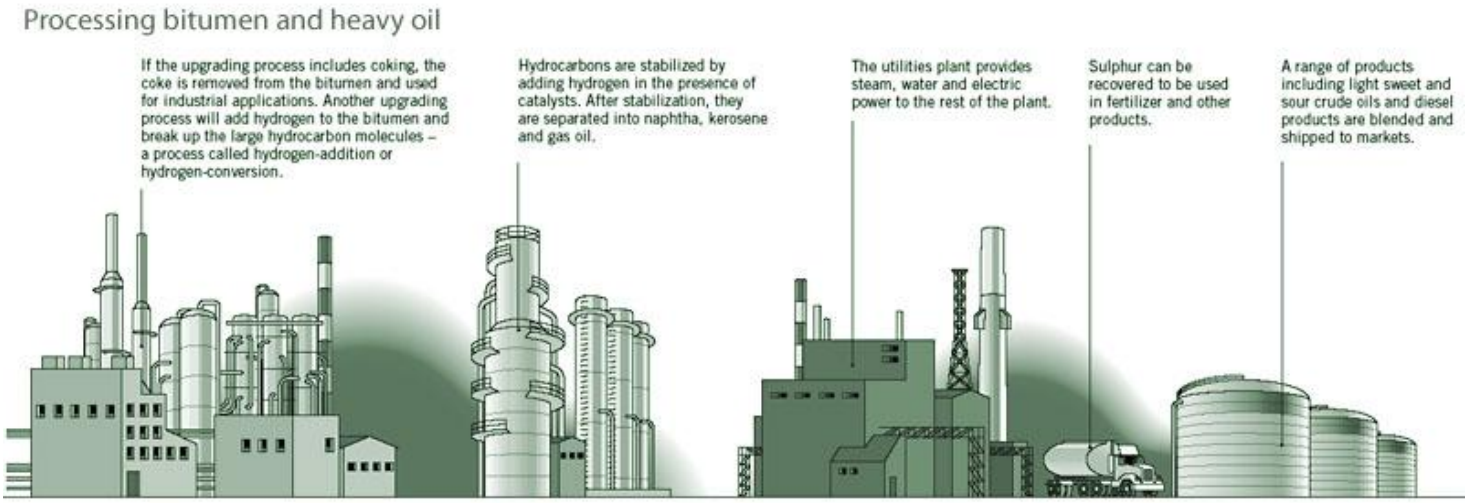
Synthetic crude oil, Synbit and Dilbit are refined into gasoline or diesel fuel in Alberta and other parts of Canada and the U.S. Sometimes refineries must be modified to handle oil sands crude.

Figure 3: Surface Mining Bitumen Recovery



Source: Suncor Energy Inc.
General oil sand extraction process

Figure 4: Overview of Oil Sand Upgrading Process

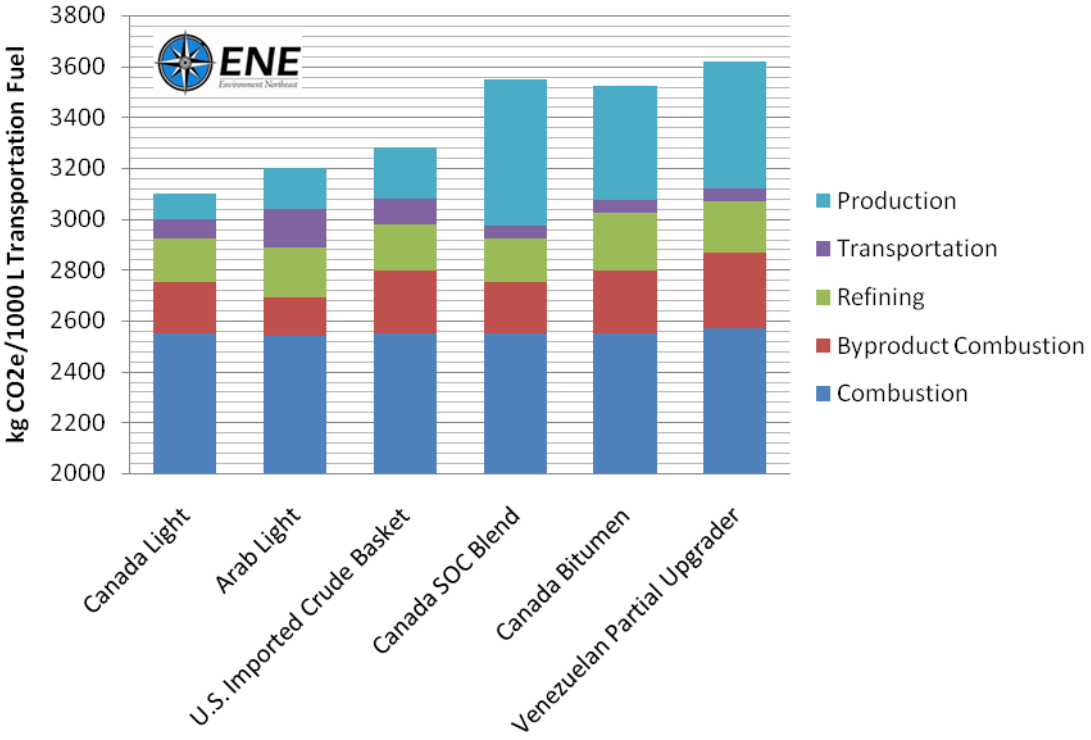


Source of Image: ©Petroleum Communication Foundation/
Canadian Centre for Energy Information 2000

Emissions

Based on total lifecycle analysis, synthetic crude oil from oil sands emits between 5% and 12.5% more GHGs than conventionally derived petroleum products. Total lifecycle GHG intensity for the Canadian oil sands is approximately 3,600kg CO_2e/barrel, compared to 3,280kg CO_2e/barrel for the average barrel of oil imported to the U.S.

Figure 5: Comparative Crude Oil Lifecycle GHG Emissions (CO_2e) by Type and Source

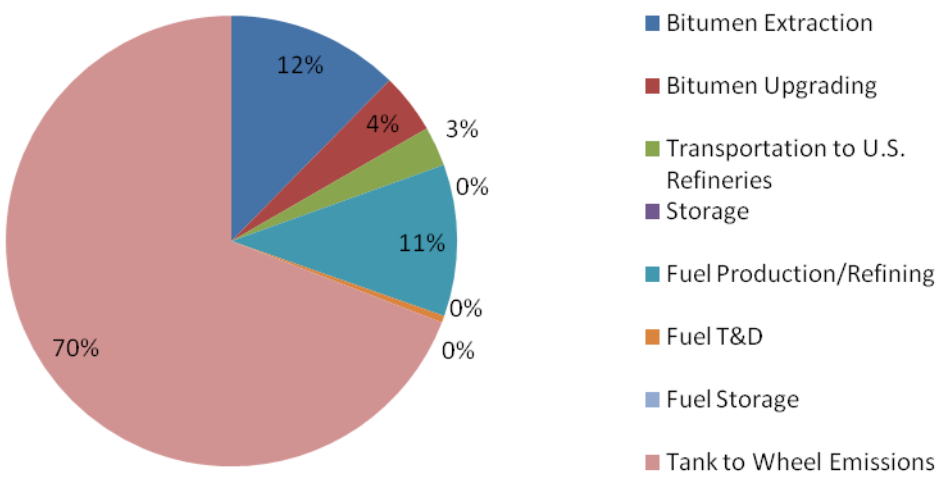


Source: Government of Canada Sector Sustainability Tables

- 70-80% of total oil sands emissions come from the "downstream" (end-use) combustion of refined products. (Downstream GHG emissions levels for refined gasoline or diesel fuel are the same regardless of whether the fuel derives from oil sands or conventional crude.)

- The balance of 20-30% of total oil sands GHG emissions comes from the "upstream" (or production) process (*i.e.*, extraction, upgrading, transporting, storing, refining and delivery [T&D]). The average GHG intensity of synthetic crude oil production from the oil sands compared to conventional crude production is 85.5 kg CO_2e/barrel versus 28.6 kg CO_2e/barrel.[7] (Upstream processes can be 30-70% more GHG-intensive than conventional oil processes.)

Figure 6: Sources of GHG Emissions in the Canadian Oil Sands Lifecycle



Source: NRDC data (2008) as presented by Dan Woynillowicz, Pembina Institute

Unregulated Oil Sands Emissions

Only some of the lifecycle GHG emissions from oil sands-derived fuels would be covered by the *American Clean Energy and Security Act of 2009* (ACES, formerly known as the Waxman-Markey bill), passed by the U.S. House of Representatives and now under consideration by the Senate.

Pursuant to the bill, producers and importers of liquid fuels would be required to hold carbon allowances in an amount equal to the emissions associated with the "downstream" combustion of the fuel (*i.e.,* one ton of CO_2 emissions requires the emitter to hold one allowance). Upgrading facilities and refineries located in the U.S. would also be required to hold carbon allowances in an amount equal to emissions from their facilities.

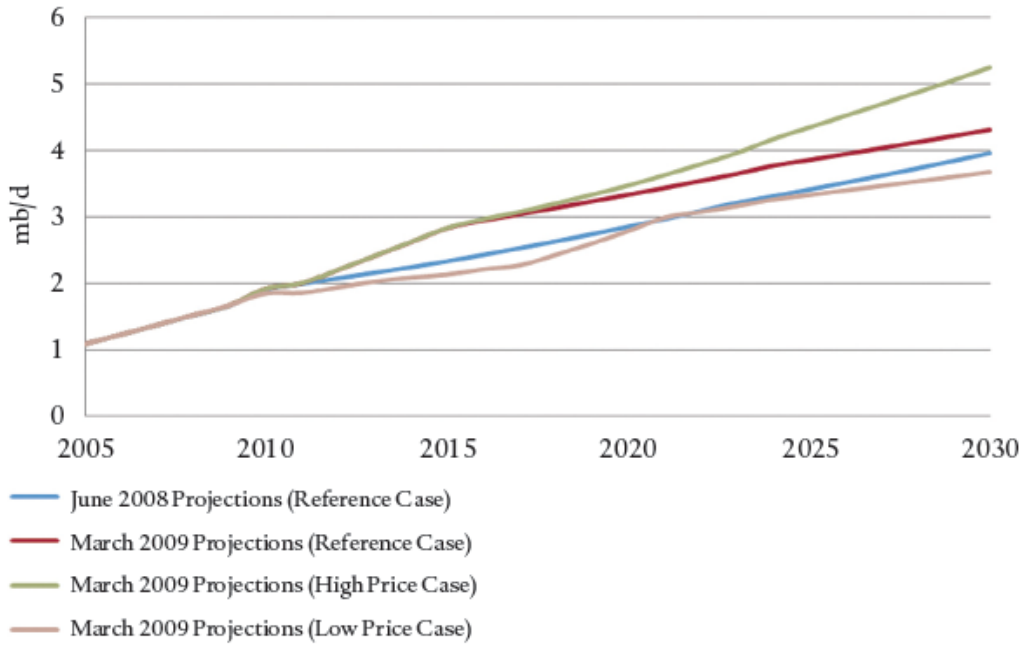
However, any amount of oil sands bitumen that is upgraded or refined in Canada before being imported to the U.S. for consumption would not be covered by the ACES carbon cap.

- The Canadian oil sands industry exports approximately one-third of total bitumen to the U.S. for upgrading, and two-thirds of oil sands synthetic crude oil is exported to the U.S. for refining.
- Assuming the bitumen upgraded in the U.S. is not shipped back to Canada for refining, from an overall industry perspective, on average **16.5% of emissions from oil sands–derived fuels consumed in the U.S. would not be subject to proposed U.S. cap and trade compliance obligations.**

Total Oil Sands Emissions Exported to the U.S.

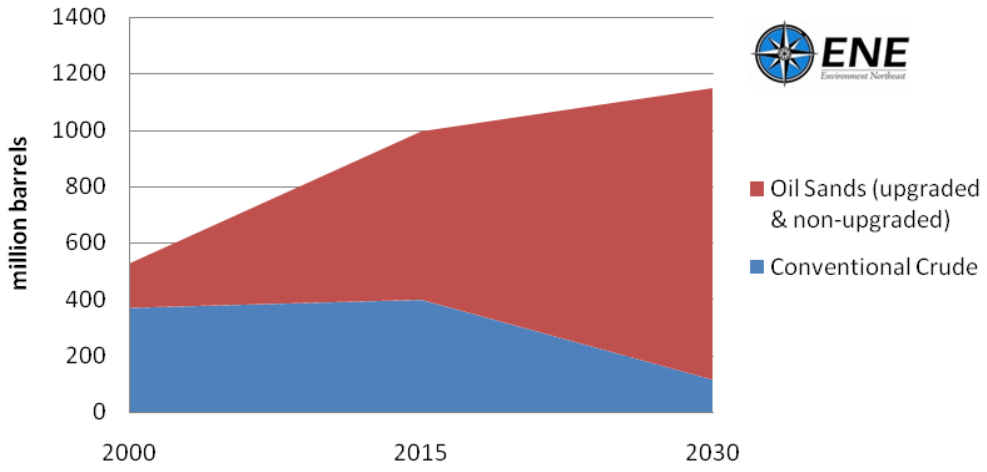
Projections of total production and exports of crude from Canada to the U.S. show that the quantity of oil sands will rise steeply in the next 20 years, and that the associated emissions will be significant.

Figure 7: Actual and Projected Oil Sands Production (million bpd) Based on Various Price Scenarios



Source: Council on Foreign Relations' Special Report No. 47, p7.

Figure 8: Projected Canadian Oil Exports to the U.S. – Conventional Crude and Upgraded and Non-Upgraded Bitumen.



Source: National Energy Board - Canada's Energy Future, Continuing Trends Scenario

- Compared to a scenario in which Canadian crude oil exports to the U.S. consisted of only conventional crude, a National Energy Board's projection of oil sands exports to the U.S. shows **7% higher emissions in 2015 (approximately 42 million tons of CO_2e) and 10% higher emissions (approximately 72.5 million tons of CO_2e) in 2030** (see Table 1).[8]

- Absent a Canadian regulatory system that limits upstream extraction, upgrading, and refining, the **unregulated emissions premium from imported oil sands products to the U.S. would be approximately 30 million tons CO_2e in 2015 and 51.5 million tons CO_2e in 2030**.

- The unregulated emissions premium is equivalent to **0.6% of the ACES cap in 2015** and **1.5% of the cap in 2030**.

Table 1: GHG Emissions Attributed to Projected Crude Oil Exports (Conventional and SCO) to the U.S in 2015 and 2030*

	NEB Projection** (tons CO_2e)	100% Conventional Crude (tons CO_2e)	100% Synthetic Crude (tons CO_2e)
2015	600,889,500	559,036,500	628,791,500
2030	717,473,800	645,037,800	725,523,800

* Emissions are based on 3200kg/1000L (or 0.561 tons/barrel) lifecycle emissions for conventional crude and 3600kg/1000L (or 0.631 tons/barrel) for Canadian synthetic crude – a difference of 12.5%.

** Based on National Energy Board (NEB) projected exports (Continuing Trends scenario) and share of oil sands output versus conventional crude in its Continuing Trends scenario is 60/40 in 2015 and 90/10 in 2030.

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[1] Woynillowicz, D., C. Severson-Baker, M. Raynolds. (2005). "Oil Sands Fever: The Environmental Implications of Canada's Oil Sands Rush." The Pembina Institute. www.pembina.org
[2] *Ibid.*
[3] Levi, M.A. (2009). "The Canadian Oil Sands: Energy Security vs. Climate Change." Council on Foreign Relations. Council Special Report No. 47. Available on-line at: http://www.cfr.org/content/publications/attachments/Oil_Sands_CSR47.pdf
[4] *Ibid.*
[5] Environment Canada, *National Inventory Report* (2007). Available at http://www.ec.gc.ca/pdb/ghg/inventory_e.cfm
[6] Woynillowicz *et al*, page 20.
[7] *Ibid.*
[8] See also Council on Foreign Relations finding that current oil sands production is "responsible for a premium of about 40 million tons of CO_2 emissions each year compared to conventional oil."