National Commission on Energy Policy

A PROJECT OF THE
BIPARTISAN POLICY CENTER

Unconventional Fossil-Based Fuels

ISSUE BRIEF

FROM THE STAFF OF THE NATIONAL COMMISSION ON ENERGY POLICY

ISSUE BRIEF #1

INTRODUCTION

The National Commission on Energy Policy commissioned the RAND Corporation to explore several of the key economic and environmental issues surrounding unconventional fuels production from coal and oil sands. This briefing paper summarizes and interprets the key findings of this study. Readers should note that while the data presented here are drawn entirely from the RAND report, the presentation and interpretation of these data and the conclusions drawn in this briefing paper are the responsibility of Commission staff and should not be ascribed to the RAND authors.

Top: Oil sands open pit mining operation.

Bottom: Athabasca River, Alberta, Canada.

This issue brief was prepared by the staff of the National Commission on Energy Policy. The views expressed here do not necessarily reflect those of each of the Commissioners of the National Commission on Energy Policy.

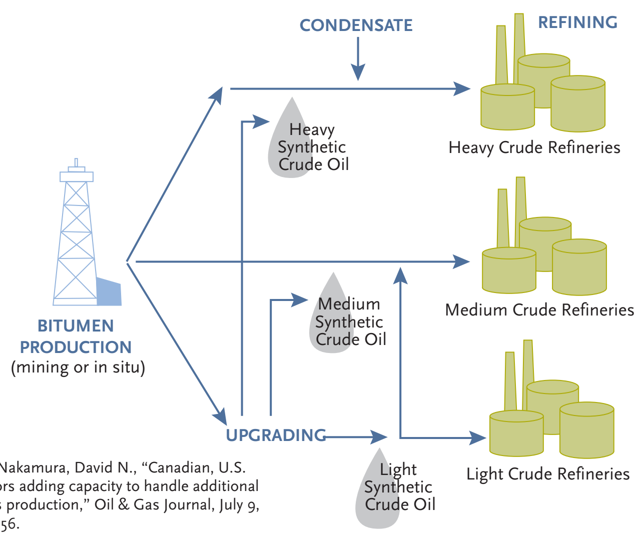
Unconventional sources of oil, such as oil sands, oil shale, and coal-to-liquids, clearly represent one option for expanding global petroleum supplies.

In its 2004 report, *Ending the Energy Stalemate: A Bipartisan Strategy to Meet America's Energy Challenges,* the National Commission on Energy Policy (NCEP) identified oil security and global warming as two of the most important and difficult energy policy challenges confronting the United States in the 21st century. To address the former, the Commission recommended a combination of efforts to expand and diversify available supplies of transportation fuels, while simultaneously pushing for significant improvements in motor-vehicle fuel economy. Unconventional sources of oil, such as oil sands, oil shale, and coal-to-liquids, clearly represent one option for expanding global petroleum supplies and easing upward price pressures in world oil markets. But the Commission also cautioned that current methods for accessing these resources raise significant environmental concerns—particularly with respect to global climate change and water use.

Interest in a wide range of alternative energy sources has only intensified in the years since the Commission released its original report. With world oil prices recently well over $100 per barrel (and widely predicted to rise even higher), potent market incentives already exist for expanded investment in unconventional resources—both renewable and non-renewable. In this context, the Commission felt it was timely to undertake a more detailed assessment of the longer-term production potential, cost-competitiveness, and environmental implications of expanded reliance on unconventional, fossil-based motor fuels. The RAND Corporation study summarized in this briefing paper was sponsored by the Commission to explore these issues, with a specific focus on two likely options: oil sands and coal-based petroleum-like fuels (often described as coal-to-liquids or CTL).

This briefing paper summarizes key findings from the RAND study; and draws policy-relevant conclusions in light of the Commission's previously articulated positions regarding the importance of pursuing energy policy strategies that, at best, advance multiple societal objectives and, at a minimum, avoid working at cross-purposes (in the sense that they "address one problem while exacerbating another"). Readers should note that while the data presented here are drawn entirely from the RAND report, the presentation and interpretation of these data and the conclusions drawn in this briefing paper are the responsibility of Commission staff and should not be ascribed to the RAND authors. A full copy of the RAND report can be accessed at http://www.rand.org/pubs/technical_reports/TR580/.

Figure 1: Oil Sands Production Process



Source: Nakamura, David N., "Canadian, U.S. processors adding capacity to handle additional oil sands production," Oil & Gas Journal, July 9, 2007, p. 56.

KEY FINDINGS

Fuel tankers.

As already noted, the RAND study focused on oil sands and coal-to-liquids (CTL) technologies. (Technologies for developing oil shale were judged by RAND to be too immature for a comparably rigorous assessment within the 2025 timeframe chosen for the study.) For both of these resources, RAND undertook a bottom-up assessment of the state of technology development, future production potential, estimated current and future production costs, and environmental impacts. In the case of oil sands—which are already being exploited on a commercial scale using a variety of technologies—RAND was able to draw on information from actual field experience to date.

Left: Dragline at a coal surface mining operation.

Bottom right: Tailing pond from oil sands production.

In the case of CTL, which is currently being produced only on a limited commercial scale in South Africa using older technologies, RAND relied more heavily on engineering studies and informed projections about how the technology might evolve in the future.

State of Technology

- Two general methods are used to extract oil sands: mining or in-situ extraction. The former technique is akin to strip mining: the oil sands deposits are physically removed and transported to another site where they are then upgraded into a low-quality crude product that can be sold on the market or refined further. Alternatively, extraction can occur on site (in-situ) using a variety of techniques. Generally, this approach involves drilling one or more wells through which high pressure steam is injected to reduce the viscosity of the oil sands deposits so that they can be pumped out. Natural gas is typically used to generate the steam needed for in-situ extraction.

- Oil sands development is fully commercialized, with substantial production (1.3 million barrels per day in 2007) already underway in Canada. The industry is focused on technology improvements that would reduce the substantial natural gas and water requirements associated with current methods of production.

- CTL production typically involves a process called indirect coal liquefaction. Coal is first gasified to produce a "syngas" composed of hydrogen, carbon monoxide, and carbon dioxide. The syngas then undergoes a cleaning process to remove any pollutants or impurities. This step produces a relatively pure stream of carbon dioxide that can be captured for geologic storage or vented to the atmosphere. After cleaning, the syngas is directed to a Fischer-Tropsch reactor where catalysts form hydrocarbon chains. These hydrocarbons can then be converted to a variety of fuels such as synthetic diesel or naphtha.

A price on carbon significantly affects the cost competitiveness of CTL technologies.

- CTL technology is at an earlier phase of development (i.e., not yet widely commercialized) and significant technological and economic uncertainties remain. A number of projects have been publicly announced in the United States and have reached the "front-end engineering design" phase, a critical first step toward resolving cost and technical issues and obtaining financing. Commitment to this phase does not, however, guarantee that plants will be constructed.

Production Potential

- Canada has very large oil sands reserves (the estimated recoverable resource base is 173 billion barrels, which would be second in volume only to Saudi Arabia's oil reserves). Substantial reserves also

Pipelines transporting steam and bitumen for oil sands production.

exist in the United States and Venezuela but they are different in character and have not been assessed as extensively. Various sources, including EIA, estimate that production will grow to 3–4 million barrels per day in the 2015–2020 timeframe.

- The coal resource base, globally and in the United States, is enormous and unlikely to pose a constraint for future CTL production. That said, CTL production on a commercial scale would consume very large amounts of coal: a plant producing 30,000 barrels per day would require coal inputs totaling approximately 15,000 tons per day (roughly the amount consumed by a 2 gigawatt conventional coal power plant). Production at 2 million barrels per day would require an additional 400 million tons of coal per year (current U.S. coal production is roughly 1.1 billion tons per year, nearly all of it for use in power plants).

Cost

- Current costs for producing synthetic crude from oil sands are estimated to be around $34 per barrel for mining extraction and around $37 per barrel for in-situ extraction (in 2005$). Without carbon management (and excluding any increased expenditures for addressing local environmental concerns), future production costs (in 2025) are estimated to range from $28 to $34 per barrel for mining and $31 to $35 per barrel for in-situ extraction. Future costs will be affected by a number of factors including depletion of the highest-quality sites, further technology improvements through learning by doing, and input costs. RAND estimates that implementing carbon capture and storage at major point sources in the production process would add approximately $3–$6 to the per-barrel cost in 2025 assuming mining extraction, or $4–$9 per barrel in the case of in-situ extraction.

- RAND estimates that fuel production costs in 2025 using CTL technology, assuming co-production of electricity that can be sold back to the grid, will range from $1.47 to $1.76 per gallon of diesel-equivalent (in $2005), not including costs of carbon capture and storage.[1]

[1]Note that costs for CTL are given per gallon, rather than per barrel, because the CTL process examined by RAND yields finished petroleum products. By contrast, the oil sands process yields a synthetic crude oil that can be converted to different finished products. For purposes of converting barrels to gallons, it is useful to note that a barrel contains 42 gallons. A barrel of crude oil, however, will produce something less than 42 gallons of finished product because of losses during the refining process.

There is considerable uncertainty about these cost estimates, however. Including carbon capture and storage adds $0.07 to $0.35 to the per gallon cost in 2025. Note that this incremental cost is small because the CTL production process necessarily entails separating the carbon dioxide generated during the coal gasification process before the syngas is converted to liquids. Extra electricity would be needed to compress the captured carbon dioxide in preparation for transport, but otherwise the added costs of carbon storage are limited to transport and injection into a permanent geologic repository.

Table 1: Ratio of Full Fuel-Cycle Greenhouse Gas (GHG) Emissions for Unconventional Fossil-Based Fuels Relative to Conventional Low-Sulfur, Light Crude Oil

Oil Sands Technology[a]	Synthetic Crude Oil/ Conventional Crude Oil (low GHG estimate)	Synthetic Crude Oil/ Conventional Crude Oil (high GHG estimate)
Mining, no CCS[b]	1.13	1.22
Mining with CCS	0.98	0.99
In-situ extraction, no CCS	1.19	1.26
In-situ extraction, with CCS	0.98	0.99
CTL Technology	**Coal-Based Liquid Fuel/ Conventional Liquid Fuel (low GHG estimate)**	**Coal-Based Liquid Fuel/ Conventional Liquid Fuel (high GHG estimate)**
CTL, no CCS	2.2	NA
CTL, with CCS[c]	0.82	1.1

[a] Ranges for oil sands are based on observed variability of oil sands production facilities.
[b] CCS=carbon capture and storage.
[c] Results for CTL include carbon credit for co-production of electricity.

Absent a price on carbon, oil sands production is likely to be cost competitive even at conventional oil prices considerably below current levels.

Environmental Impacts

- Without carbon capture and storage, full fuel-cycle carbon emissions for synthetic crude produced from oil sands are in the range of 10–30 percent higher than for conventional crude oil. The carbon balance for CTL is considerably worse: without capture and storage, full fuel-cycle carbon emissions for coal-based liquid fuels are more than two times higher than for conventional fuels.

- The carbon balance for oil sands and CTL can be substantially improved by storing and capturing carbon emissions generated during the upstream production of these fuels. But this does *not* make the fuels carbon-neutral. At best, implementing carbon capture and storage during fuel production brings full fuel-cycle emissions for oil sands and CTL back into rough parity with those of conventional petroleum. Because the carbon content of the resulting synthetic fuels is similar to that of conventional petroleum products, both alternatives produce roughly the same amount of carbon dioxide emissions when used in vehicles.

- Development of either oil sands or CTL has the potential to cause significant local environmental impacts as well, including large-scale disturbances of land and habitat in the course of mining and related activities. Specifically, the damage to the Boreal forest ecosystem must be considered in the context of oil sands production. Both mining and in-situ development of the oil sands convert what was once a part of one of the world's last forested, intact ecosystems into an industrialized zone of pipelines, processing facilities and waste ponds. In

Table 2: Estimated Range of Carbon Prices (in $/ton CO2) that Make Oil Sands and CTL without Carbon Capture and Storage Uncompetitive with Conventional Oil in 2025

Unconventional Oil Technology	Production Cost Scenario for Unconventional Technology	Conventional Oil Price Assumptions (from EIA Annual Energy Outlook 2007 Reference and High Oil Price cases)[2]	
		$56/barrel crude,$1.74/gallon diesel	$94/barrel crude, $2.51/gallon diesel
Oil Sands[(a)]	reference case ($28–$31/barrel)	$310-$490	$770-$1140
	high cost case ($34–$36/barrel)	$170-$240	$500-$630
CTL	reference case ($1.22/gallon)	$33	$81
	high cost case ($1.76/gallon)	$0	$47

[(a)] Ranges for oil sands indicate cost differences between mining and in-situ technologies

addition, the Boreal forest is the world's largest terrestrial reservoir of carbon. Because mining for oil sands has the most detrimental impact of any industrial activity on its sensitive and carbon-laden peat soils, any disturbances to the Boreal forest will result in the loss of the carbon from the soil, which contribute additional carbon dioxide emissions beyond production emissions. Moreover, another significant environmental issue for oil sands is that current production methods require very large quantities of water.

Cost Competitiveness with Conventional Oil

- Absent a price on carbon, oil sands production is likely to be cost competitive *even at conventional oil prices considerably below current levels*. The competitiveness of CTL without a carbon price is more dependent on realizing further reductions in the cost of this technology.

- A price on carbon significantly affects the cost competitiveness of CTL technologies because of their relatively high full fuel-cycle carbon emissions. By contrast, the cost competitiveness of oil sands is not strongly affected by carbon constraints unless the price imposed on carbon is extremely high. This is because the production process for oil sands is only moderately more carbon-intensive than that for conventional oil, while basic production cost is expected to be highly competitive. Table 1 shows the sensitivity of these unconventional fuel options—assuming production occurs without carbon capture and storage—to carbon prices. Specifically, it indicates the range of carbon prices that would render oil sands and CTL uneconomic relative to conventional oil absent upstream carbon capture and storage.

- If carbon dioxide emissions generated during the production of unconventional fuels are captured and sequestered, on the other hand, the imposition of a carbon price becomes much less relevant in terms of cost-competitiveness with conventional oil.[3] This is because, with greatly reduced upstream production emissions, the carbon characteristics of unconventional fossil-based fuels are essentially equivalent to those of conventional fuels (in other words, carbon-dioxide emissions at the point of combustion are similar). In that case,

[2]Note that current conventional oil prices are above the EIA's high price case. The higher the conventional oil price, the higher the carbon price that would render unconventional oil technologies uncompetitive.
[3]Of course, the imposition of a carbon price would still affect cost-competitiveness relative to lower carbon fuel alternatives, such as biofuels.

Unreclaimed open coal mine.

cost-competitiveness is largely a function of conventional oil prices.

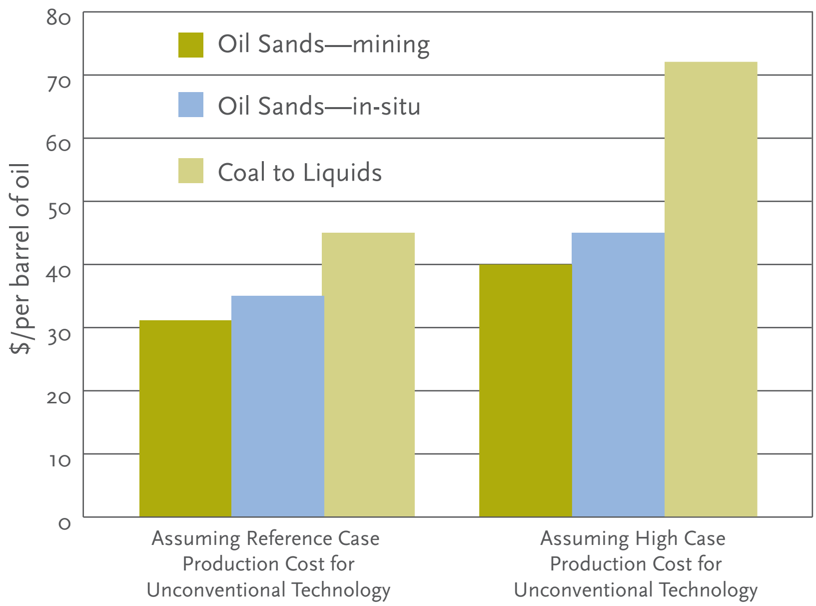
- In sum, there is much greater certainty about the future cost competitiveness of oil sands technologies—regardless of carbon price—than there is about the future cost competitiveness of CTL. Given only limited commercial experience (and hence greater uncertainty about future production costs) and given a much less favorable carbon profile, the economic competitiveness of CTL will be considerably more dependent on future oil prices, carbon sequestration costs, and the stringency of carbon control policies.

Key Constraints/Variables

- For oil sands, the most important constraints relate to local environmental impacts and water requirements. Future economics will be affected by natural gas prices—and conversely, by the industry's ability to reduce energy requirements (and/or find alternatives to natural gas)—but oil sands are likely to remain competitive with conventional oil even at natural gas prices well above current levels.

- For CTL, future carbon costs/constraints are a key variable. If carbon capture and storage can be commercialized at relatively low cost, then CTL with capture and storage is more likely to be cost competitive with conventional fuel, even in the context of carbon constraints.

Figure 2: Crude Oil Price Needed to Make Oil Sands and CTL Technologies *with* Carbon Capture and Storage Cost Competitive in 2025



POLICY IMPLICATIONS

The argument in favor of expanded development and deployment of oil sands and CTL technologies is generally rooted in economic and energy security rationales.

Increasing the supply of unconventional alternatives, according to this argument, will put downward pressure on world oil prices and reduce U.S. dependence on unstable or hostile regions of the world. Given current uncertainties about production potential and cost, however, the magnitude of these economic and energy security benefits is speculative at best. The price of motor fuels is set by a world market that is currently dominated by conventional oil. Unconventional fuel alternatives would need to gain a significant share of that market in order to have a major effect on world oil prices.

In the event of an oil supply disruption, the prices of unconventional fuels are likely to follow conventional oil prices rather than vice versa. Moreover, the use of subsidies or other incentives to make otherwise more expensive alternative fuels competitive with conventional oil products would substantially erode any economic benefits associated with a small reduction in world oil prices.[4] In sum, to realize meaningful economic and energy security benefits, oil sands, CTL, and other unconventional oil alternatives must be (1) produced in sufficient quantity to affect *world* (not just U.S.) fuel markets, (2) be cost-competitive, and (3) be less vulnerable to disruption.

In the view of Commission staff, the RAND results underscore the point that developing fossil-based unconventional fuel alternatives like oil sands and CTL represents—at best—a problematic response to oil security concerns. Even if future costs and production potential are in line with optimistic assessments, any benefits these technologies might offer in terms of easing upward oil price pressures, reducing geopolitical dependence on the Middle East, and promoting local economic development must be balanced against substantial environmental concerns. In the case of CTL, in particular, the development of cost-effective means for carbon capture, transport, and storage must be viewed as a key enabling step—one that must be assured before CTL development can move forward. The carbon impacts of CTL absent capture and storage are otherwise simply unsupportable in the context of current concerns about climate change.

Left: Stockpiling coal after mining and preparation.

Policy-makers must also understand, however, that even with carbon capture and storage, oil sands and CTL are (at best) roughly equivalent to conventional oil in terms of climate impacts.

Policy-makers must also understand, however, that even with carbon capture and storage, oil sands and CTL are (at best) roughly equivalent to conventional oil in terms of climate impacts. In other words, even assuming zero carbon emissions during the production process, the combustion of these fuels in motor vehicles will still generate carbon dioxide emissions, boosting concentrations in the atmosphere and contributing to global emissions trends that most scientists agree must be reversed by mid-century to avoid potentially catastrophic consequences.

In this context, the Commission believes the emphasis of U.S. policy must be on (1) accelerating the development of cost-effective carbon capture and storage technologies, and (2) ensuring that the climate impacts of all energy options are internalized in market prices through the adoption of an economy-wide cap-and-trade program for greenhouse gases. Oil sands do not require added incentives to be cost-competitive in the near term and development is likely to proceed, where local conditions allow, in response to existing market drivers. For this reason it is extremely important to ensure, at a minimum, that the additional carbon liability associated with current methods of oil sands production is properly priced in the markets. An appropriate carbon price should also serve to ensure that cost-effective carbon capture and storage is implemented at oil sands projects as it becomes available. Finally, adequate policies must be in place to address the other local environmental impacts associated with oil sands projects, including especially land and water impacts.

The fact that political and market pressures in favor of CTL development are likely to intensify as oil price pressures and supply concerns grow more acute underscores the urgency of developing economic carbon capture and storage capability. Success in commercializing carbon capture and storage would largely address the substantial carbon penalty of coal-based options relative to conventional petroleum and could play an important role in addressing major emissions sources in other sectors, such as power plants. With capture and storage, moreover, other technology pathways may be viable that have a far more advantageous life-cycle carbon profile—such as combined fuel and power generation based on the gasification of mixed biomass and coal feedstocks.

In sum, the Commission's approach to unconventional fuels can be expressed as "First, do no harm." If expanded development of these alternatives is ultimately warranted on economic, energy security or other grounds, it will be critical to manage environmental impacts such that other key public policy objectives are not undermined. As the Commission stated in a 2007 update to its original recommendations: "while we do not take the view that all efforts to improve energy security must also contribute to climate goals, we also believe it would be deeply irresponsible and ultimately counterproductive to pursue policies that are at direct cross-purposes in the sense that they address one problem while exacerbating another." It is clear from the RAND analysis that this caution remains especially relevant, and the potential for unintended consequences especially large, in policy discussions concerning fossil-based liquid-fuel alternatives to conventional oil.

[4]Expanding domestic production of unconventional oil alternatives would improve the U.S. balance of trade, but at a potentially high cost if substantial subsidies or incentives were required to achieve that result. Meanwhile, the cost of providing subsidies or incentives would be primarily or entirely borne by U.S. taxpayers while the macro-economic benefits (in terms of a small reduction in world oil prices) would accrue to oil consumers all around the world.

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PHOTOS ON PAGES 2, 5, 6, AND COVER:
DAVID DODGE/THE PEMBINA INSTITUTE

Front cover: Drag-line and oil sands upgrading facility.

Left: Surface coal mine, Wyoming.

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