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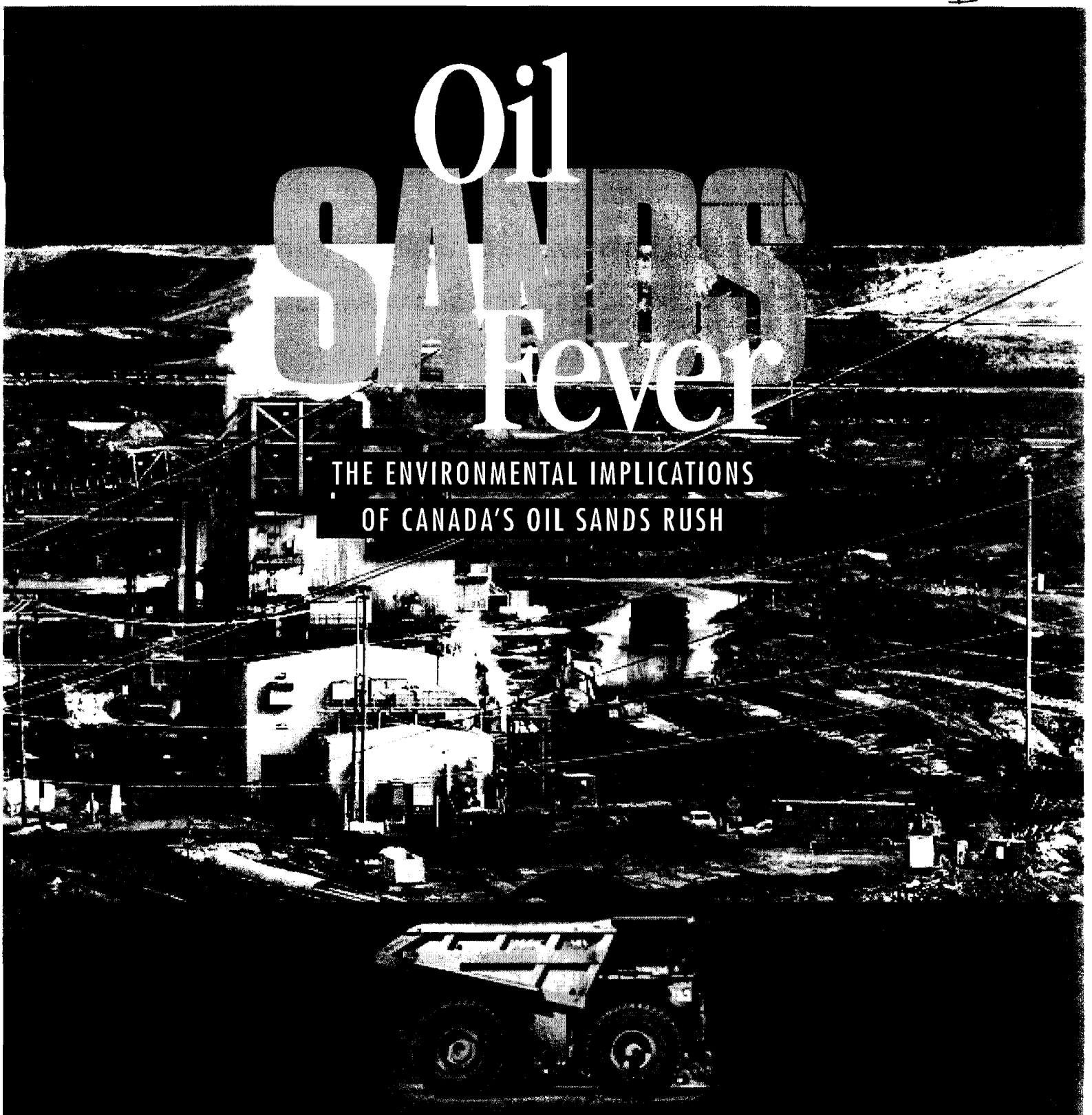
Oil Sands Fever

THE ENVIRONMENTAL IMPLICATIONS OF CANADA'S OIL SANDS RUSH



BY DAN WOYNILLOWICZ

CHRIS SEVERSON-BAKER • MARLO RAYNOLDS

November 2005

the PEMBINA institute

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The Environmental Implications of Canada's Oil Sands Rush

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ii About The Pembina Institute

The Pembina Institute creates sustainable energy solutions through research, education, advocacy and consulting. It promotes environmental, social and economic sustainability in the public interest by developing practical solutions for communities, individuals, governments and businesses. The Pembina Institute provides policy research leadership and education on climate change, energy issues, green economics, energy efficiency and conservation, renewable energy and environmental governance. More information about the Pembina Institute is available at **www.pembina.org** or by contacting **info@pembina.org.**

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PHOTOS: DAVID DODGE, THE PEMBINA INSTITUTE

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vii Foreword

Until recently the oil sands were a vast but largely inaccessible resource. In the last 15 years this has changed dramatically. After advancements in technology significantly improved the economics of oil sands production, government and industry implemented an ambitious strategy in 1995 to increase production. Central to this strategy were commitments by both federal and provincial governments to significantly reduce royalties and taxes to spur investment.

Ambitions of producing one million barrels per day of oil from the oil sands by 2020 have been greatly exceeded: this goal was surpassed in 2004. This intense rate of development is being driven by a steadily rising market price for crude oil, growing uncertainty about the global supply of oil and rapidly growing demand from the United States and Asia. Canada's so-called "black gold," now regarded as an abundant, secure and affordable source of crude oil, is the focus of international attention. With international attention, comes international responsibility. A feverish rush of oil sands investment and development, not unlike the gold rush that swept through North America in the 19th century, is underway. This new wealth comes at a cost.

Managing the environmental impacts arising from this pace and scale of development is a considerable challenge that must be urgently addressed, particularly in light of the new goal of producing five million barrels per day by 2030. As Alberta's northern boreal forest is torn up for oil sands development, the environmental impacts to air, land and water in Alberta are increasing rapidly. Not surprisingly, Alberta is now Canada's pollution capital for industrial air pollutants. And the oil sands are the single largest contributor to greenhouse gas emissions growth in Canada.

A more positive future is possible.

Until now the story of Canada's oil sands has only been partially told. Tales about the vast economic potential of development have been told and re-told by the oil industry, government, energy analysts and the media, but there has been a dearth of information about the environmental consequences. *Oil Sands Fever: The environmental implications of Canada's oil sands rush* fills a critical gap by providing a comprehensive overview of the impacts and making recommendations regarding their management.

The natural resources of our country are ours to decide how best to manage. This report should compel Canadians to demand that the governments of Alberta and Canada ensure that sound environmental management and protection accompany the economic opportunities arising from oil sands development. Furthermore, the intensity of energy requirements and environmental impacts of development are clear indications that we need to fundamentally re-evaluate how we produce and consume transportation fuels. Now is the time to focus our resources on implementing energy systems that allow us to restore our environment and build healthy and resilient communities.

The rapid and unconstrained oil sands expansion now before us risks squandering a publicly owned resource and creating a legacy of environmental degradation and long-term environmental liabilities. To combat these challenges and further the positive legacy desired by the public, politicians and industry, we have put forward recommendations to improve the environmental management of the oil sands while calling for an accelerated transition towards sustainable energy in Canada.

Dr. Marlo Raynolds, Executive Director
Calgary, November 2005

▲ SOURCE: PHOTO BY MELINA MARA. © 2005, THE WASHINGTON POST. REPRINTED WITH PERMISSION

1 Canada's Oil Sands Rush

1.1 Location and Scale

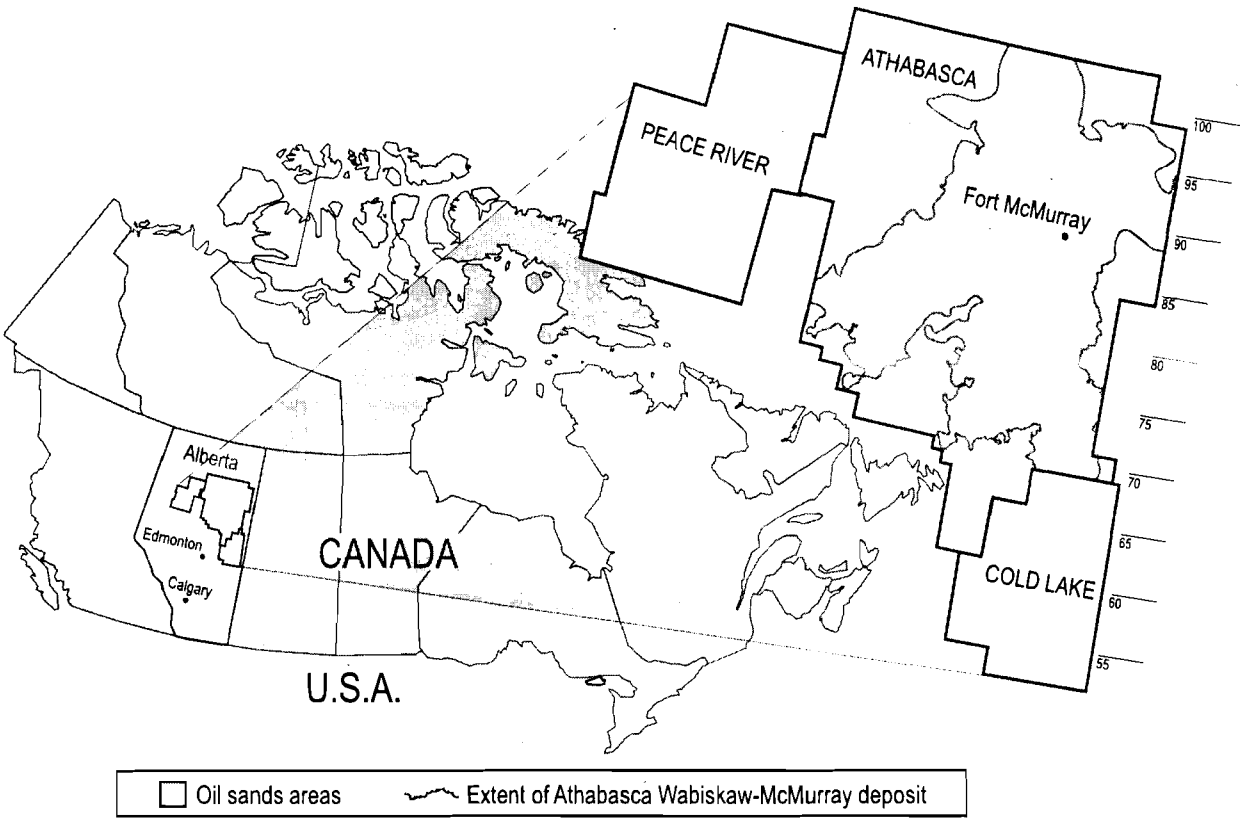

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FIGURE 1: Alberta's oil sands deposits

SOURCE: © 2005 ALBERTA ENERGY AND UTILITIES BOARD

The vast majority of Canada's oil sands are located in Alberta and underlie an area larger than Florida. Oil sands are found in three deposits: Peace River, Cold Lake and Athabasca (Figure 1, Table 1). Collectively these deposits underlie approximately 149,000 square kilometres of Alberta's northeastern boreal forest – roughly 23% of the province.[1,2] The Regional Municipality of Wood Buffalo, more specifically the city of Fort McMurray (population 61,000), serves as the regional hub for oil sands development.[3]

This report will focus on the largest and most heavily developed Athabasca oil sands deposit, which includes all the deposits that can be surface mined and extensive in situ (in place) reserves.

The Alberta Energy and Utilities Board (EUB) estimates that approximately 1.7 trillion barrels of crude bitumen (the technical term for the fossil fuel extracted from the oil sands) are in the oil sands but predicts that only 19% of this total (315 billion barrels), will ultimately be recovered. A smaller amount, 174 billion barrels, could be recovered using today's technology and under current and anticipated economic conditions. This amount is counted as established oil reserves.[4,5]

[illegible]	[illegible] volume of crude bitumen in place (barrels)	[illegible] (square kilometers)
Athabasca (in situ + surface mineable)	1.37 trillion (110 billion is surface mineable)	102,610 (2,800 is surface mineable)
Cold Lake	201 billion	29,560
Peace River	129 billion	17,250
Total Oil Sands	**1.7 trillion**	**149,420**

▲ *TABLE 1: Area and bitumen resource of Alberta's oil sands deposits*[7]

1.2 A Brief History

TAR SANDS: A FUNDAMENTALLY DIFFERENT TYPE OF OIL

"It's the single largest hydrocarbon deposit on the Earth, and it's next door to the biggest market for oil products, the United States. What's wrong with it? It's crap oil.... You've got to use a lot of energy and a lot of pots and pans to extract it from the sand, and you have low-quality oil. It's a high-cost business and a lot of capital and a lot of operating costs."

Neil Camarta, former Senior Vice President, Oil Sands, Shell Canada[6]

In 1944, the Alberta government partnered with a company called Oil Sands Limited to build a pilot oil sands extraction plant at Bitumount, a site north of Fort McMurray where much early experimentation had occurred. When the costs for the construction of the plant doubled to $500,000 in 1948, Oil Sands Limited pulled out, and the government of Alberta took over sole control of the plant. After successfully demonstrating extraction of bitumen from the oil sands in 1949, the government then sold the Bitumount complex at a loss for $180,000.[8]

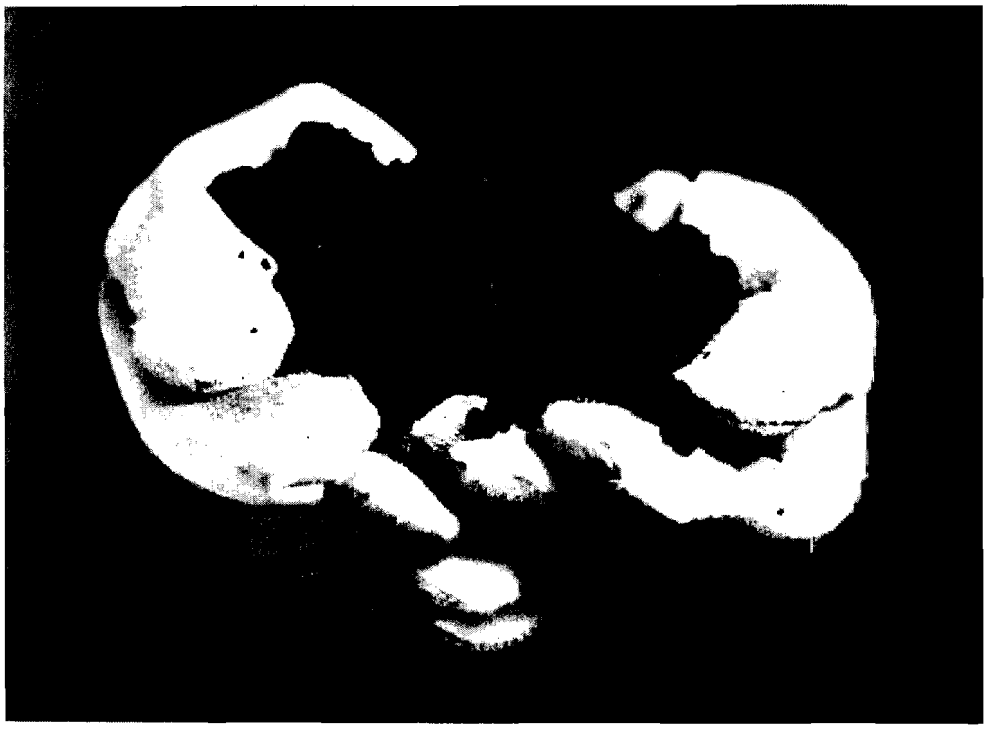
Commercial development did not begin until 1967 when the Great Canadian Oil Sands Company (now Suncor) started the first open pit surface mines in the Athabasca deposit.[9] In 1973, the Alberta government invested in the oil sands again by forming the Alberta Energy Company (AEC), a 50/50 partnership between the government of Alberta and its citizens. The AEC became a direct equity investor in Syncrude's original operations through an 80% ownership of the pipeline carrying oil from Syncrude to Edmonton, a 50% ownership in Syncrude's power facility and a 50% ownership in the Syncrude plant.[10] By 1978 Syncrude was also producing oil from the oil sands.[11]

For several decades, Suncor and Syncrude faced numerous challenges such as breakdowns, freeze ups, fires and high costs. But by 1986 advancements in technology had reduced the operating costs of producing synthetic crude oil from Cdn$35 to Cdn$13 per barrel.[12]

1.3 Tar Sands Makeover

Until the mid-1990s, development of the tar sands, the original name for oil sands, was still considered risky and unprofitable. Then in 1993, the Alberta Chamber of Resources convened the National Oil Sands Task Force (the Task Force), a collective of oil industry and government representatives, to draft a framework for making the oil sands an economically attractive resource. In its 1995 report entitled *The Oil Sands: A New Energy Vision for Canada*, the Task Force laid out a 25-year strategy that envisioned tar sands production doubling or tripling to reach between 800,000 and 1.2 million barrels per day by 2020.[13] The strategy also called for efforts to improve public perception of the dirty sounding "tar sands." The term "oil sands" was selected as the new brand name for tar sands, and they were framed as "a national prize."[14]

In 1997, the governments of Alberta and Canada implemented a key recommendation of the Task Force by introducing a generous royalty regime and federal tax breaks for oil sands development. The Alberta government's Generic Oil Sands Regime collects only 1% of total revenue until all capital costs (for new projects and expansions) are recovered, at which time 25% of total revenue is collected. This creates strong motivation for rapid re-investment and expansion. Similarly, the tax breaks introduced by the federal government



"The Task Force has identified a clear vision for growth and answered – affirmatively – the fundamental question: Should oil sands development proceed?"

"To attract investment, the Task Force has embarked on a carefully calculated, new course for development."

"The industry must develop an active and on-going program to change outdated perceptions of the oil sands and create an informed, supportive public that understands the value and potential of the oil sands."

National Oil Sands Task Force, The Oil Sands: A New Energy Vision for Canada (1995)[15]

▲ *Raw oil sands. The tar-like bitumen found in these sands becomes oil only after an expensive and intensive feat of engineering succeeds in washing the bitumen from the sand and converting it into a synthetic crude oil.* SOURCE: SUNCOR

have made the oil sands industry the envy of Canada's industrial sector.

Only five years after the release of the Task Force's recommendations, the necessary conditions for an oil sands boom were in place. Further reductions in operating costs and rising crude oil prices also heightened industry interest. Numerous expansion plans and new projects were launched. A wave of significant new expansion began to unfold. The scale of this new development greatly exceeded expectations. Fuelled by strong growth in demand for transportation fuels, particularly in the United States, and a favourable fiscal regime, oil sands production more than doubled to approximately 1.1 million barrels per day between 1995 and 2004 – 16 years ahead of the anticipated timeline.[16]

1.4 Global Attention

BILLIONS INVESTED

To date, four of the five largest publicly traded oil companies in the world – Royal Dutch/ Shell, ExxonMobil, ChevronTexaco and TotalFina[17] – have invested or committed to invest billions of dollars in oil sands development.

In the first half of 2005, Chinese oil companies signed three deals to tap into Canada's oil sands reserves by purchasing stakes in two start-up oil sands companies and a proposed pipeline to transport synthetic crude oil from the oil sands to the Pacific coast for shipping to China.[18]

Alberta's oil sands have become a frequent destination for foreign politicians, bureaucrats and energy executives seeking to see firsthand the scale of the resource.

The United States' Energy Information Administration (EIA) and the *Oil and Gas Journal* took notice and formally recognized Canada's oil sands as an economically viable resource in 2003, vaulting Canada's oil reserves from 21st position in the world to 2nd (Figure 2). The oil sands, lavishly described as "black gold," "resources beyond belief" and "the eighth wonder of the world,"[19,20,21] were seen as an abundant, accessible and affordable source of crude oil.

Not surprisingly, the world has also taken notice. Major powers are positioning themselves to ensure their access to the oil sands, which have been described by the U.S. Energy Policy Development Group as "a pillar of sustained North American energy and economic security."[22]

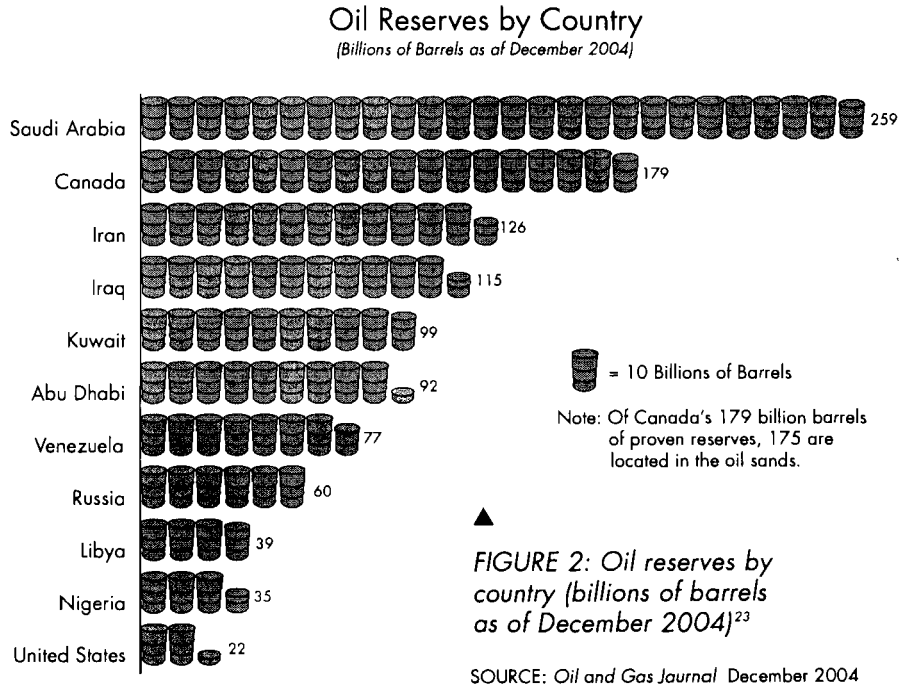


FIGURE 2: Oil reserves by country (billions of barrels as of December 2004)[23]

SOURCE: *Oil and Gas Journal* December 2004

1.5 New Goals and Speculation

From 1999 through 2004, Suncor and Syncrude both expanded their surface mining operations. Four new surface mines and seven new in situ operations were also approved in the Athabasca oil sands region.[24] This wave of development is projected to increase production to more than two million barrels per day by 2010-2012.[25]

With increasing confidence that oil prices are likely to remain high, wild speculation abounds regarding potential production. The Canadian Association of Petroleum Producers (CAPP) has projected that production could reach 2.7 million barrels per day by 2015.[26] In 2004, the Alberta Chamber of Resources put forward a vision of producing five million barrels per day by 2030 (Figure 3).[27] More recently, the government of Canada has envisioned producing six million barrels per day of production by 2030, and some energy analysts have projected production as high as eleven million barrels per day by 2047.[28,29] For the purpose of this report, we will assume the more conservative projection of five million barrels per day by 2030.

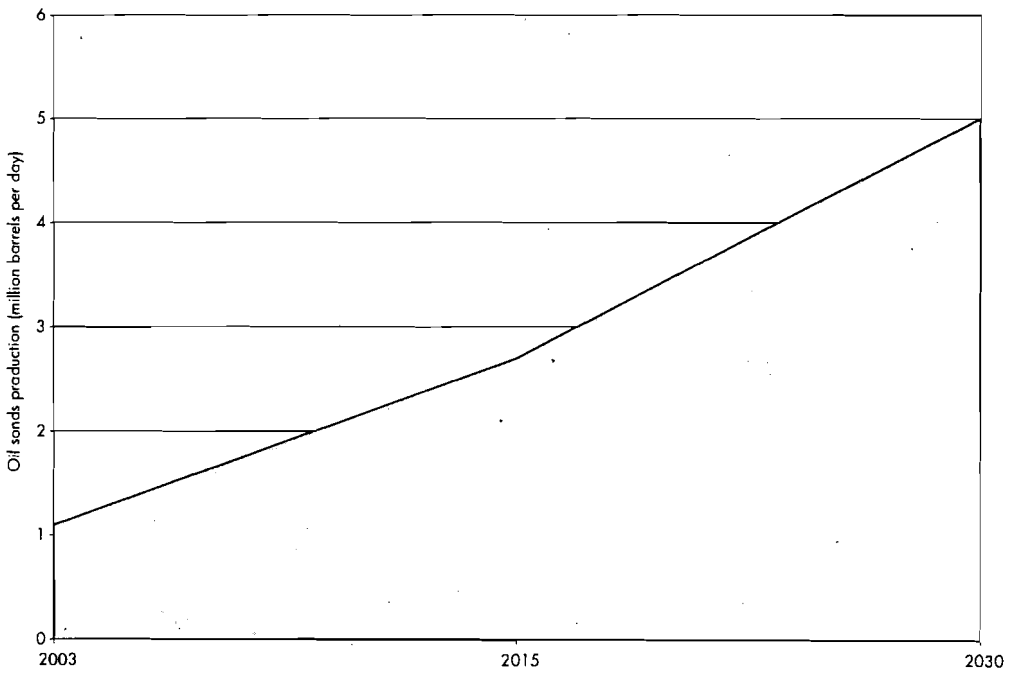
1.5.1 Oil Sands Domination

In 2001, crude bitumen production exceeded conventional crude production in Alberta for the first time.[30] This trend is predicted to continue (Figure 4). By 2003 oil sands represented 54% of Alberta's total oil production and one-third of Canada's total oil production.[31] In 2005, oil sands production will represent about half of Canada's total production of crude oil.[32] The Canadian Association of Petroleum Producers (CAPP) predicts that by 2015, three out of four barrels of oil produced in Canada will be from the oil sands.[33]

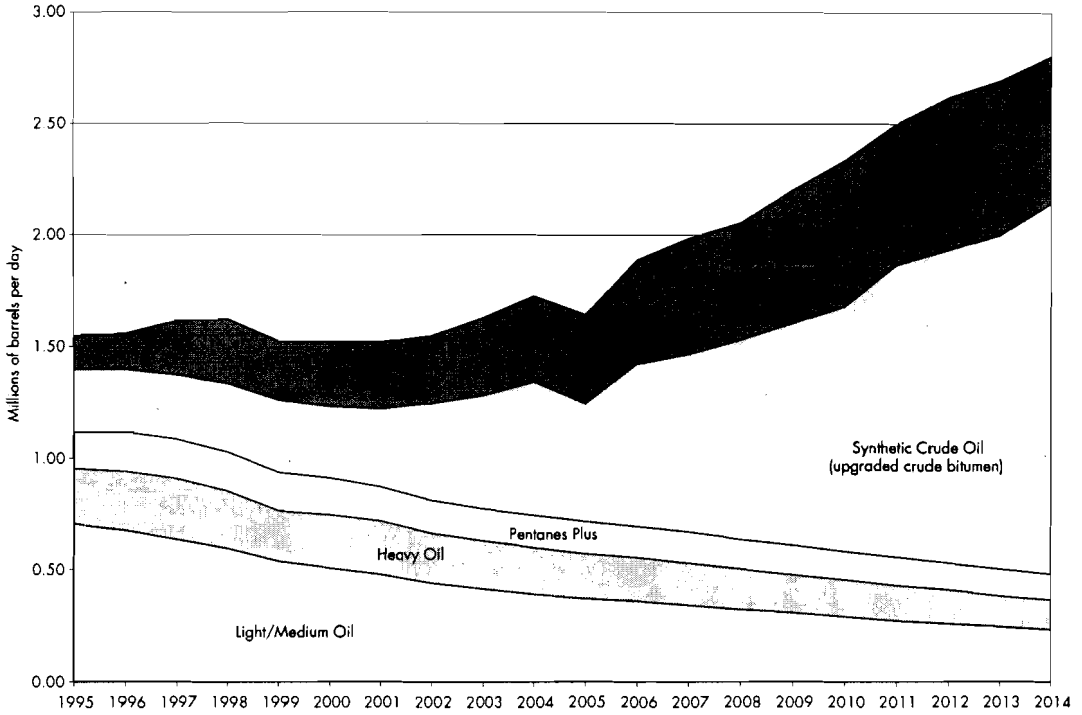
New growth in oil production is being driven by global demand for oil, with domestic demand in Alberta representing only a small fraction of total production (Figure 5). In the short term, growing demand for

"We appreciate the fact that Canada's tar sands are now becoming economical, and we're glad to be able to get the access toward [sic] a million barrels a day, headed toward two million barrels a day."

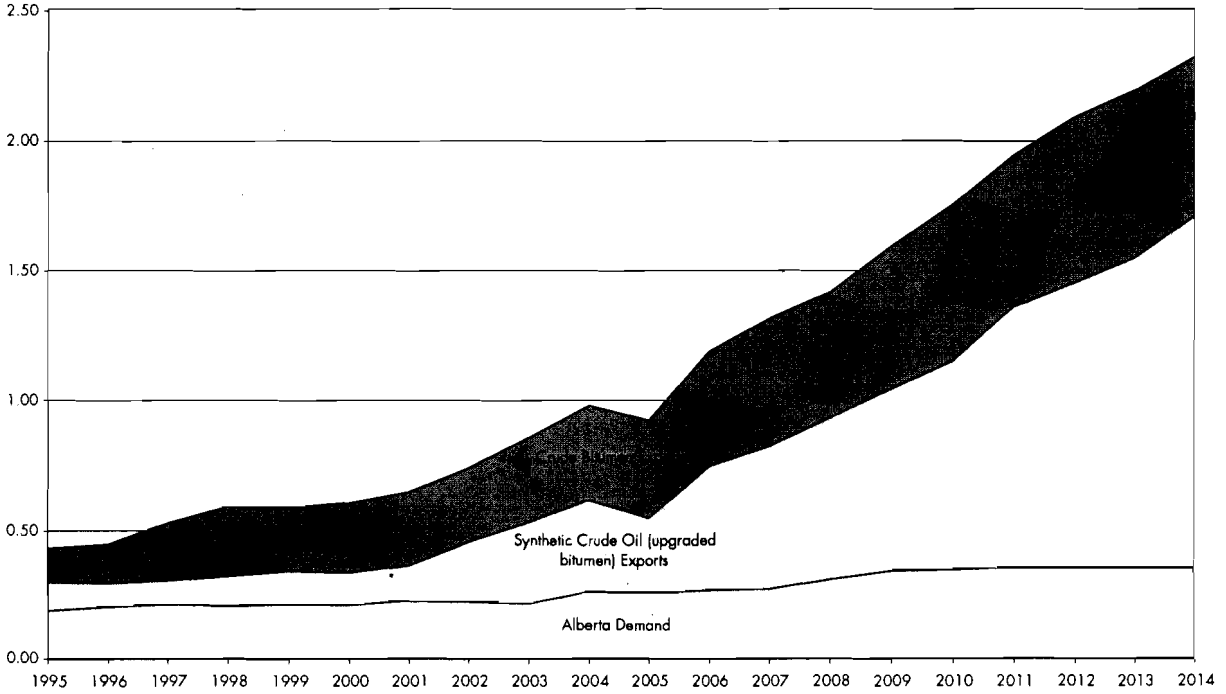
U.S. President George W. Bush, March 23, 2005[34]



▲ *FIGURE 3: Projected growth in oil sands production to 2030*



▲ *FIGURE 4: Crude oil production in Alberta 1995–2014*[35]

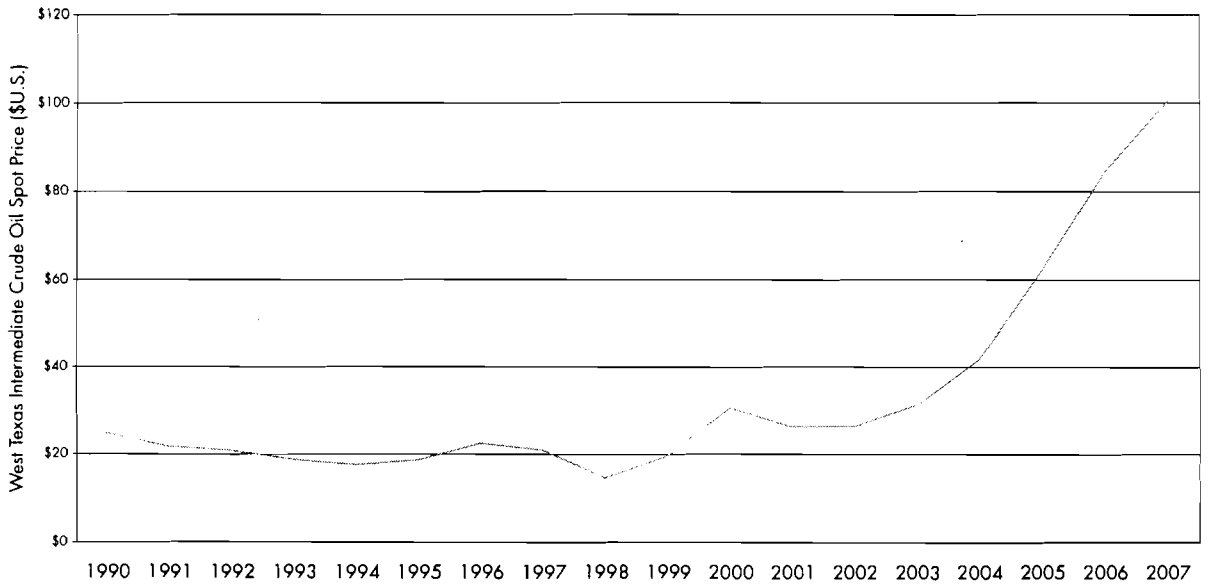


▲ *FIGURE 5: Alberta demand and export of crude bitumen and synthetic crude oil (upgraded bitumen) 1995–2014*[36]

synthetic crude oil is projected to come from existing markets in the American Midwest and Rocky Mountain regions but may also expand to potential markets on the U.S. East and West coasts and the Far East.[37] The Canadian National Energy Board predicts that by 2015 there will be a 90% increase to 2.8 million barrels per day of Canadian crude oil exports to the United States, with about 70% coming from the oil sands.[38]

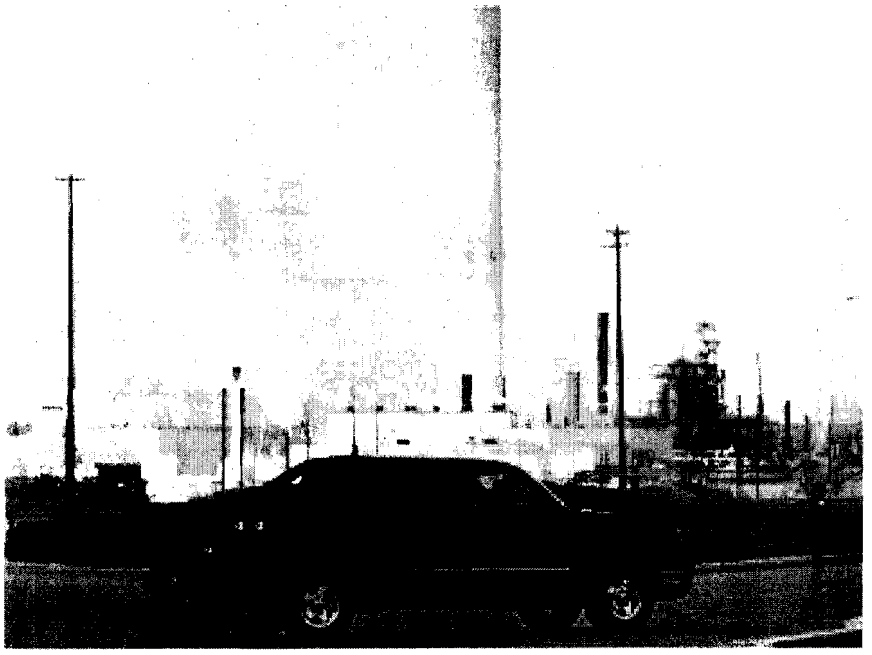
1.5.2 Rising oil prices

Neither the Task Force nor the governments of Alberta and Canada predicted that geopolitical instability in the Middle East and surging global demand for oil would drastically increase oil prices (Figure 6) – a trend many energy and financial analysts suggest will continue.[39] In September 2005, the Canadian Imperial Bank of Commerce reported that the price for oil might average US$84 per barrel in 2006 and US$100 by the fourth quarter of 2007.[40] Even the Toronto Dominion Bank, which projected that slowing economic growth in the United States would lead oil prices to drop to $US45 in early 2007, has acknowledged that the world has entered a new era of sustained higher crude prices.[41] With estimates that the oil sands will be profitable as long as the price of oil stays above $US25, there is little doubt that producing synthetic crude oil from the oil sands will remain a highly profitable venture.[42] This prediction is confirmed by the commitment of billions of dollars of investment by the world's most powerful oil companies.



▲ *FIGURE 6: Spot prices for West Texas Intermediate crude oil 1990–2007*[43]

1.6 The Impacts of Irresponsible Demand



▲ *Growing demand for transportation fuels is being driven by inefficient use in gas guzzling vehicles. Approximately 65% of a barrel of synthetic crude oil goes to making gasoline and diesel fuel.* SOURCE: DAN WOYNILLOWICZ, THE PEMBINA INSTITUTE

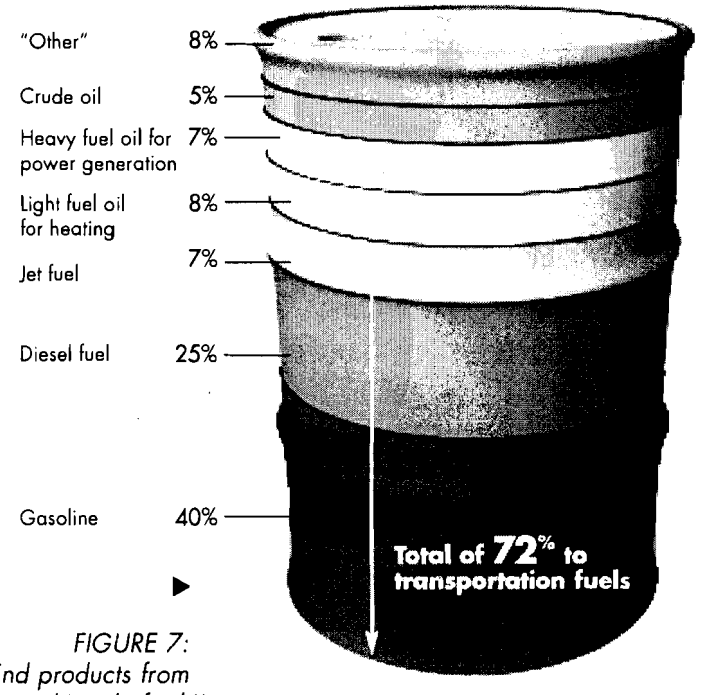


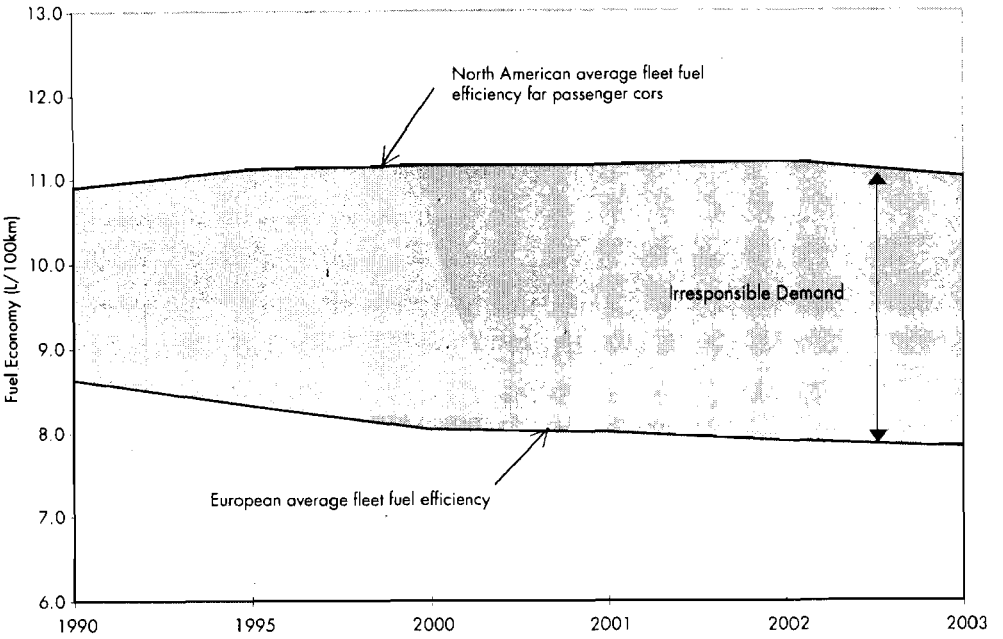
FIGURE 7: End products from a barrel of oil[44]

North Americans are starting to see the oil sands as a source of cheap and locally available oil that will meet their demand for transportation fuels. As illustrated in Figure 7, most of the synthetic crude oil from the oil sands goes to producing transportation fuels.

As we struggle with the concept that the era of abundant oil may be drawing to a close, a dangerous mythology is emerging about the role of oil sands in perpetuating highly inefficient transportation fuel consumption.

CAPP's predicted oil sands production of 2.7 million barrels per day in 2015 would only meet 11% of the United States' projected demand.[45] Looking to 2030, the five million barrels per day of projected oil sands production projected would only fulfill 16% of North American demand in 2030, or less than 5% of global demand.[46,47] Global transportation fuel consumption is rising so quickly that even feverish oil sands development will not be able to keep pace. The oil sands are not, as some may suggest, the proverbial silver bullet that will allow our affection for inefficient personal vehicles to persist. Globally, we face a significant energy challenge, in part because of our fleet of inefficient vehicles.

The average fleet fuel efficiency of North America's personal vehicles in 2005 is 11.2 liters per 100km.[48] The peak average fuel efficiency in North America, 10.7 litres per 100 km, occurred in 1986 before automakers began selling large volumes of sport utility vehicles (SUVs). Today, the



▲ *FIGURE 8: Irresponsible demand for private-vehicle fuel in North America (L/100 km)*

average fleet fuel efficiency is the same as it was in 1981. The difference between North America's average fleet efficiency and the European average is 3.4 litres per 100 kilometres, which is a conservative estimate of the amount of wasted fuel.[49] This wasted energy is what we refer to as irresponsible demand. The irresponsible demand for fuel between 1990 and 2003 is shown in Figure 8.

Given the magnitude of impacts associated with producing fuel from the oil sands, Canadians should be concerned with this inefficient use of their natural resource. As an emerging global energy supplier, Canada should take responsibility and show leadership by providing incentives for responsible consumption. Canada could set an example by adopting its own best available technology fleet fuel efficiency standard.

"These Canadian oil sands will help keep American SUVs running in the years to come."

Knight Ridder Newspapers, October 2005[50]

"In the long run, rich countries and emerging countries are going to have to be much more discriminating about what we use oil and coal for."

Former U.S. President Bill Clinton, October 2005[51]

1.7 The Untold Story

In 1995, the Task Force gave relatively little heed to the question of how to mitigate the environmental impacts of producing one million barrels per day from the oil sands. Perhaps they assumed that they would have 25 years to address this question. They did not. Production exceeded this target in less than a decade. With a new goal of producing five million barrels per day by 2030, the question of how to manage the associated environmental impacts becomes even more urgent.

Oil Sands Fever documents the environmental and climate change challenges arising from the oil sands development that occurred between 1996 and 2004 and describes the even greater consequences of the immense development now contemplated. The regulatory agencies responsible for ensuring development that is "fair, responsible, and in the public interest" are overwhelmed by the sheer pace of development. These agencies must be empowered to effectively and proactively manage the growth. To do so the government must shift its efforts and priorities to ensuring that irreversible environmental harm is prevented through proactive management.

In 1995, the Task Force deemed the principal risk for the oil sands to be "that the full economic and social potential of the resource will not be realized in public and private wealth creation."[52] In our opinion, a decade later it is clear that the greatest risk associated with the oil sands is the long-term environmental and climate implications arising from the current pace and approach to exploiting this resource.

"Higher oil prices are merely one of a long number of warning signs, natural, social and economic, all telling us that our addiction to fossil fuels is ecologically harmful, technologically backward, economically costly, and practically unnecessary.... The point is not whether the price rises but, rather, how we perceive that fact. What we face is not a threat so much as an opportunity, if not an epochal challenge. And when opportunity knocks it is time to open the door. As the oil system door closes we need to open a different door, one that opens the way to clean efficient energy."

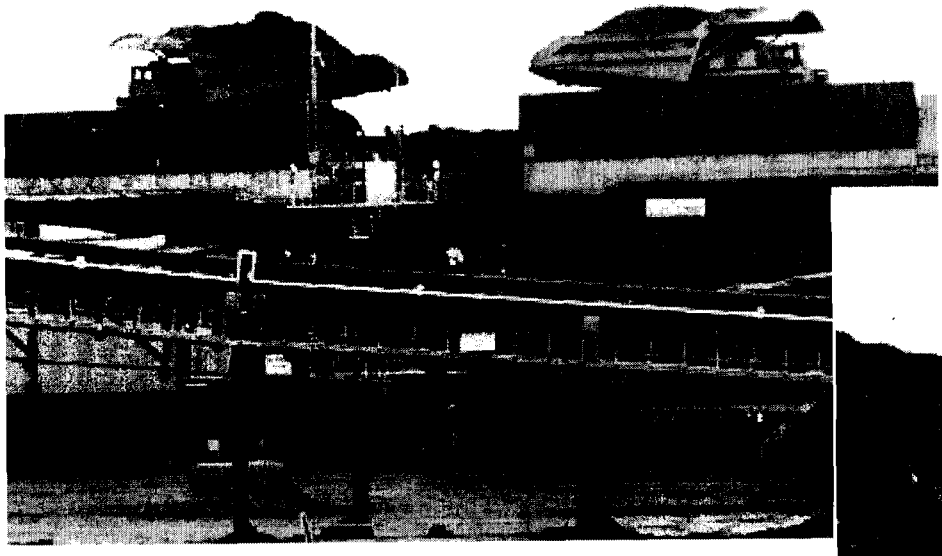
Vincent di Norcia, Editor, Corporate Ethics Monitor[53]

"Notwithstanding our commercial interests, Canadians stand to be harmed by a world that is polluted and depleted of energy resources. Thus, we must join policy makers everywhere to promote conservation and efficiency measures, as well as investment in alternative energy sources. Despite the fact that we in Canada have an abundance of oil, gas, uranium and hydroelectric power, our vast resources will not last forever."

David Kilgour, MP Edmonton – Millwoods / Beaumont, June 15, 2005[54]

2 From Tar to Tank

2.1 Making Oil from Tar



▲ *It takes two tonnes of oil sands ore to yield one barrel of oil.*
PHOTO: DAVID DODGE, THE PEMBINA INSTITUTE

Carrying 400 tonnes per load, oil sands mining companies use the biggest trucks in the world.
PHOTO: SUNCOR ENERGY

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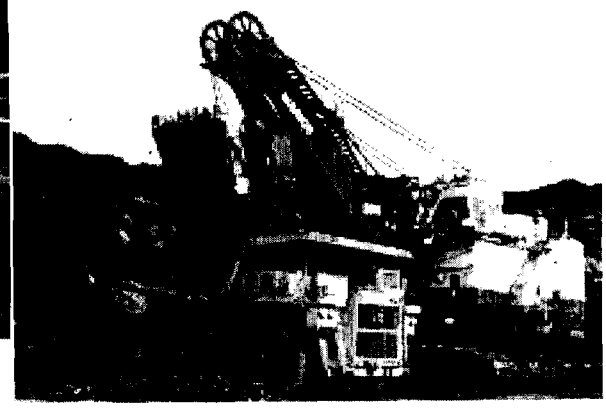

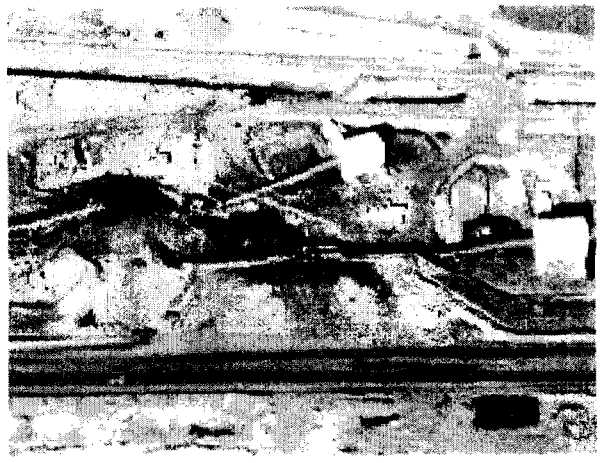

▲ *Millennium mine conveyors from air.*
PHOTO: DAVID DODGE, THE PEMBINA INSTITUTE

Oil sands deposits are composed of sand, silt, clay, water and about 10%-12% bitumen.[55] They have a dark color and a strong hydrocarbon smell. The technical term for the oil extracted from oil sands is crude bitumen, which is defined as a viscous (thick), heavy oil that will not flow to a well in its natural state.[56]

Depending on the depth of the reserves, oil sands are either surface mined (also known as strip mining) from open pits or heated so the bitumen can flow to a well and be pumped to the surface (in situ extraction). To be surface mined, the deposit must be less than 100 metres from the surface (Box 1, Figure 9).[57] The EUB has defined an area of 2,800 square kilometers as the surface mineable zone within the Athabasca deposit.[58] Crude bitumen is extracted from the mined oil sands through a process that essentially mixes the oil sands with hot water to wash the bitumen from the sand.

In situ recovery is used to access deeper deposits. The Alberta government estimates that approximately 93% of Alberta's oil sands can only be developed using in situ recovery.[59] But unlike

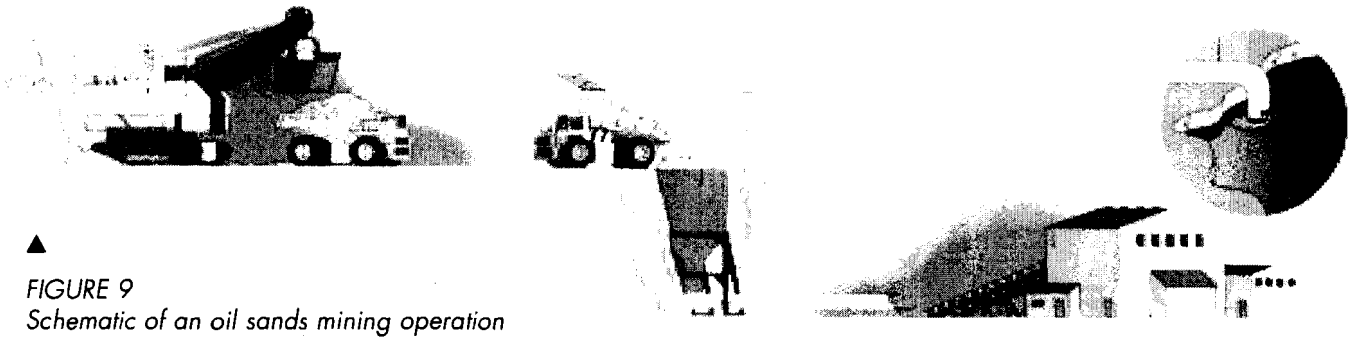

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FIGURE 9
Schematic of an oil sands mining operation
SOURCE: CENTRE FOR ENERGY

OIL SANDS SURFACE MINING

To mine the oil sands, wetlands need to be drained, rivers diverted, and all trees and vegetation stripped from the surface.

Approximately four tonnes of material (two tonnes of soil and rock above the deposit and two tonnes of oil sands) must be mined to produce one barrel (159 litres) of synthetic crude oil.[60] *The hydraulic shovels used in the oil sands are the largest in the world – each scoop of the shovel moves over 40 cubic metres of material.*[61]

Every two days, mining operations move enough oil sands to fill Toronto's Skydome or New York's Yankee Stadium.[62]

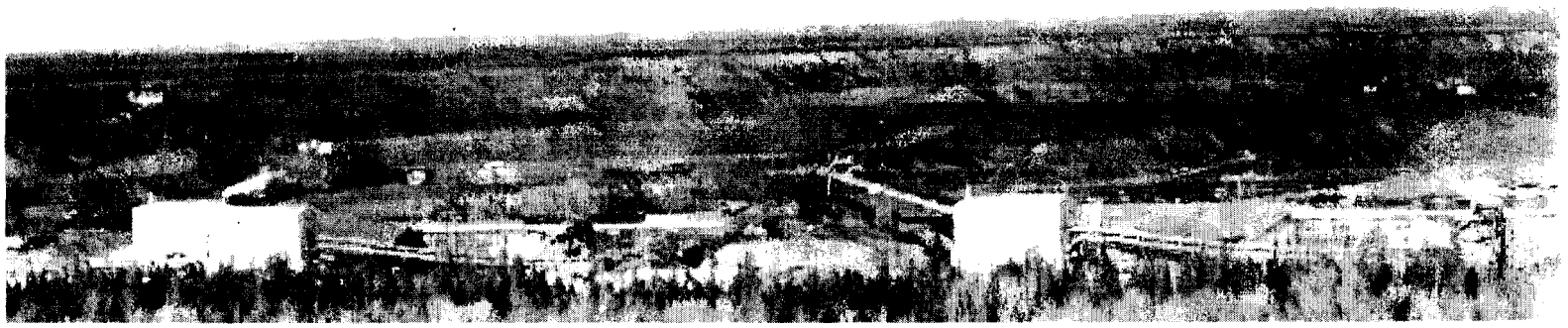
Oil sands mining trucks are 15 metres long by 7 metres tall, have 4-metre tall tires and are 40% heavier than a Boeing 747 airplane.[63,64]

Extracting a barrel of bitumen using surface mining requires

- *Two to five barrels of fresh water*[65] *(a barrel can hold 159 litres, a little more than an average bathtub)*
- *250 cubic feet of natural gas,*[66] *enough to heat a Canadian home for almost 1.5 days.*
- *The mining and extraction process recovers about 90% of the bitumen found in the deposit.*[67]

conventional crude oil, the thick, viscous bitumen cannot be recovered using conventional well drilling techniques. Special recovery methods, most commonly the injection of high-pressure steam, are needed to separate the tar-like substance from the sand. Heating the bitumen reduces its thickness so that it can flow to a well and be pumped to the surface. The predominant in situ technology is called steam assisted gravity drainage (SAGD) (Box 2, Figure 10).

▼ *Oil sand is mined from 100-metre deep pits and then fed into an extraction facility where hot water is used to wash the bitumen from the sand and clay.*
PHOTO: DAVID DODGE, THE PEMBINA INSTITUTE



After being separated from the sand, the bitumen must be upgraded before it can be refined into gasoline, diesel, jet fuel and other hydrocarbon products (Box 3, Figure 11). The upgrading process converts the bitumen from thick, molasses-like oil, through the addition of hydrogen, into a lighter, higher quality synthetic crude oil that can be sent to refineries.

IN SITU OIL SANDS PRODUCTION

The predominant in situ technology is Steam Assisted Gravity Drainage (SAGD).

Well pads ranging in size from one to seven hectares are cleared of all vegetation, and multiple pairs of horizontal wells are drilled into the bitumen-containing formation: an injector well and a producer well.

Well pads generally have between 4 and 10 well pairs (8 to 20 wells).

A large SAGD project can have up to 25 well pads spread over a 150-square-kilometre parcel of land crisscrossed by above-ground pipelines.[68]

A central facility produces high-pressure steam that is carried by above-ground pipelines to the well pads where it is injected into the formation to reduce the viscosity of the bitumen.

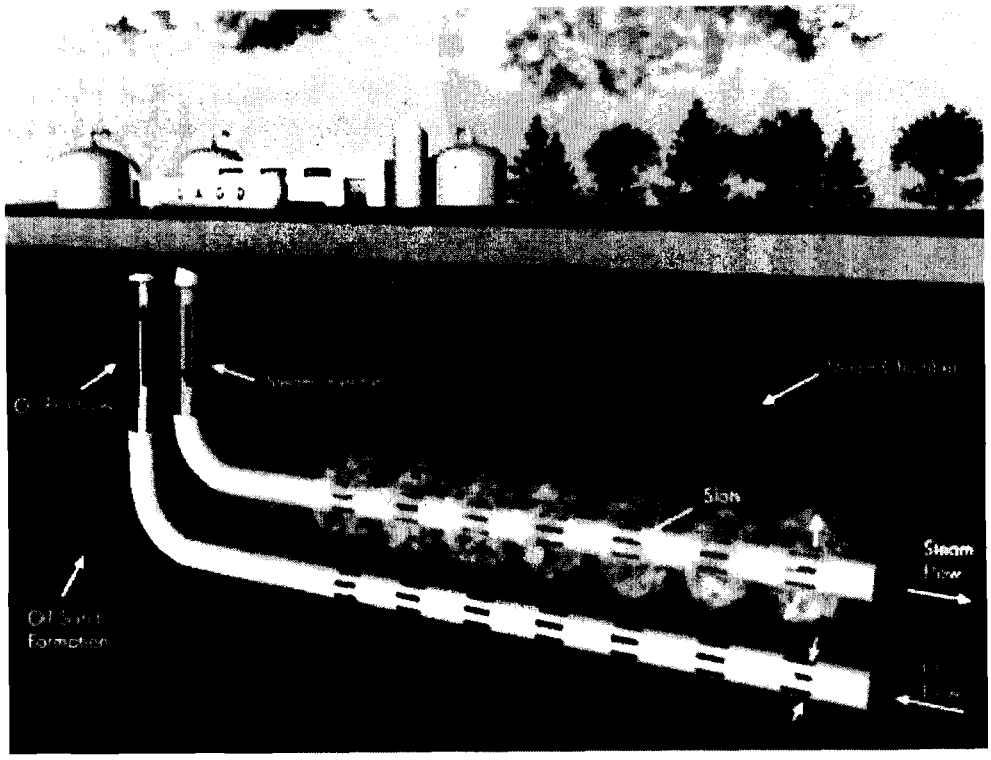
The bitumen and water (from the condensed steam) then drains by gravity to the lower producer well where it is pumped to the surface.

The water and bitumen are returned to the central facility by another above-ground pipeline, which separates the bitumen from the water and recycles the water to produce more steam.

Extracting a barrel of bitumen using SAGD technology requires

- *2.5 to 4 cubic metres of steam to produce 1 cubic metre of bitumen*
- *1000 cubic feet of natural gas,*[69] *enough to heat a Canadian home for about 5.5 days.*

The SAGD process recovers between 60%-80% of the bitumen found in the geological formation.



◀ *FIGURE 10: Schematic of a steam assisted gravity drainage (SAGD) operation*