EMD Oil (Tar) Sands Committee

EMD Oil (Tar) Sands Mid-Year Committee Report

Debra K. Higley, Ph.D., Chair

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Committee Activities

Introduction

The following introduction and synopsis are divided into the following sections:

1. How much bitumen is currently being produced and what is the forecast for future production?
2. What are the sources of funding for current and planned activity (private industry, government, consortia)
3. What kinds of research are occurring and by whom?
4. Which companies are considered the leaders?

5. What is the focus of recent activity?

6. What are the estimated U.S. and international resources/reserves and what is the strategic impact of these resources?

7. What are the critical technology needs and how are these being addressed?

8. What are the critical environmental or geohazard issues and how are these being addressed?

9. What EMD technical sessions, publications, workshops, etc. exist or are planned that are relevant to this commodity?

10. Selected references

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Oil (Tar) Sands Distribution

Extra-heavy (bitumen) and heavy oil deposits occur in more than 70 countries across the world, with the largest deposits located in Canada and Venezuela (Dusseault et al., 2008; Hein and Marsh, 2008; Hernandez et al., 2008; Marsh and Hein, 2008; Meyer et al., 2007; Villarroel, 2008) (Figure 1). The only active commercial oil sands accumulations are in the Western Canada Sedimentary Basin, in northeastern Alberta, Canada (Hein et al., 2008). Other areas most likely for future oil sands growth include the northwestern portion of Saskatchewan in the Western Canada Sedimentary Basin; the Colorado Plateau, Uinta and Paradox basins of Utah; the North Slope of Alaska; the Black Warrior Basin, Alabama; the Maverick Basin, southwest Texas; the Borderland Basins of California; the Eastern Interior and Appalachian basins of Kentucky and Illinois; and the Tri-State, Mid-Continent region of Kansas, Missouri and Oklahoma, U.S.A.

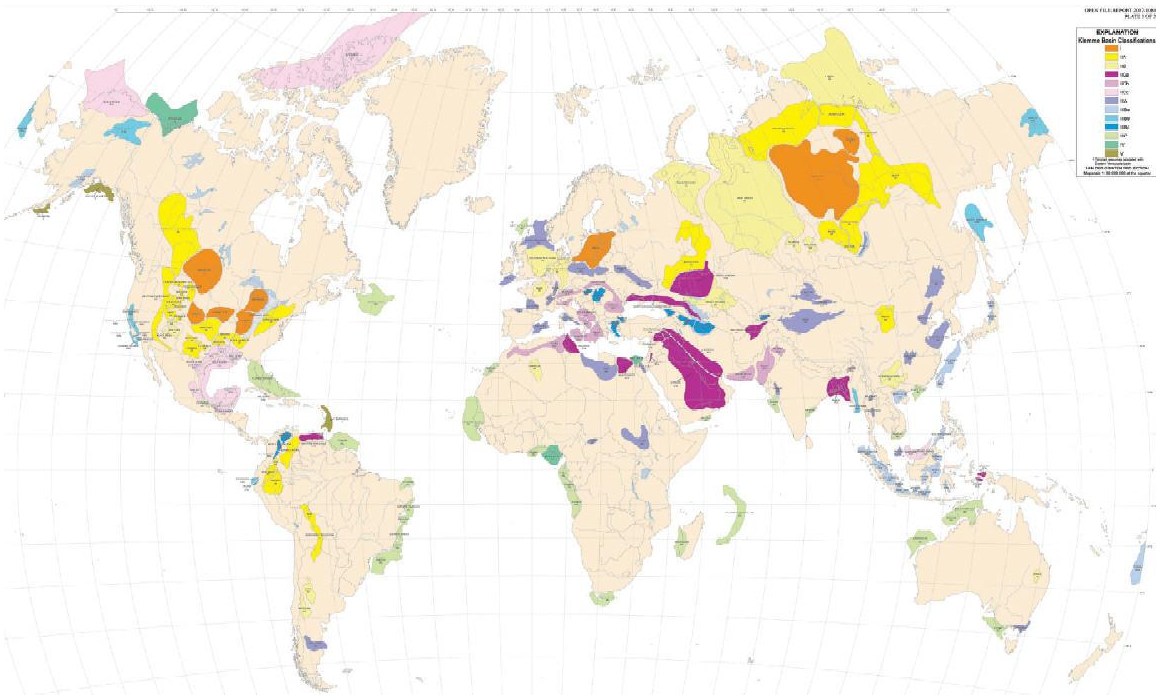

Figure 1. Klemme basin classification assigned to basins across the World that report heavy oil and (or) bitumen (modified from Meyer et al., 2007).

1. How much bitumen is currently being produced and what is the forecast for future production?

All of the bitumen being commercially produced in North America is from Alberta, Canada. Estimated in-place resources are 1804 billion barrels (286.6 billion cubic meters), and estimated ultimate recovery is 315 billion barrels (50.0 billion cubic meters) (ERCB [Alberta Energy Resources Conservation Board], 2010, p. 3). Alberta's 2007 crude bitumen production totaled 482.5 million barrels (76.7 million cubic-meters), which was equivalent to 1.32 million barrels per day (210 thousand cubic-meters per day). Of this total bitumen production, 59% (284.7 million barrels) was from surface mining and 41% (197.8 million barrels) from *in-situ* production. The bitumen that was produced by surface mining was upgraded to synthetic crude oil (SCO). In-situ bitumen production was marketed as non-upgraded crude bitumen (ERCB, 2008).

In 2008, total bitumen production decreased by 1% compared to 2007; surface mineable bitumen production was down by 8%, but bitumen in-situ production increased by 9%. Because the overall volume of bitumen production is higher in the surface mineable area compared to the in-situ thermal area, there was an overall decrease by 1% for total bitumen production in the province (ERCB, 2009). From 2008 to 2009 cumulative production increased 7% for mineable and 9% for in situ bitumen; 2009 annual bitumen production was 48 million cubic meters mined and 39 million cubic meters in situ recovery (302 and 245 million barrels, respectively) (ERCB, 2010).

Alberta bitumen production has more than doubled in about the last decade, and is expected to increase to greater than 3 million barrels per day (> 0.48 million cubic meters) over the next decade. In 2006 the production of raw bitumen and SCO accounted for 62% of Alberta's total crude oil and raw bitumen production. Over the last 10 years, the contribution of bitumen to Alberta's total crude oil and raw bitumen production has increased steadily, with an expected increase to 86% by 2016 (ERCB, 2008). Bitumen production is estimated to more than double by 2019, and the share of non-upgraded bitumen and derived synthetic crude oil (SCO) is expected to increase from 69 percent in 2009 to 89 percent by 2019 (ERCB, 2010). Figure 2 shows the increasing contribution of bitumen and SCO to Alberta's petroleum supply. This production through time is associated in Figure 3 with SCO price.

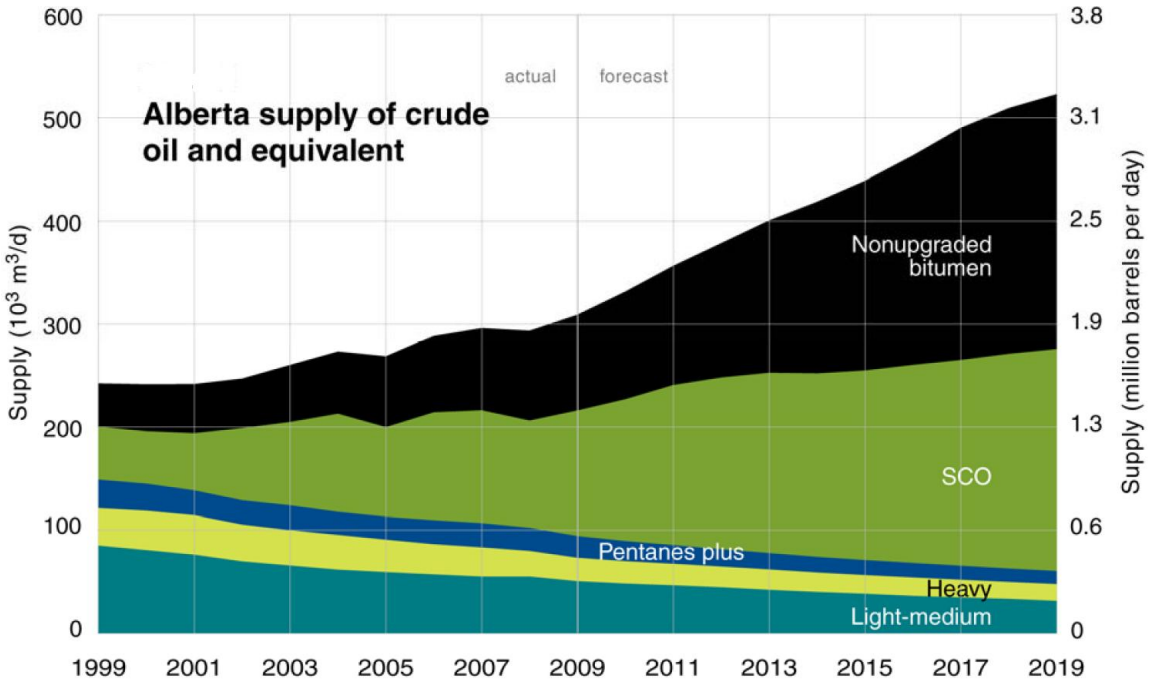

Figure 2. Alberta supply of crude oil and equivalents (ERCB, 2010, Figure 3). SCO refers to synthetic crude oil produced from bitumen.

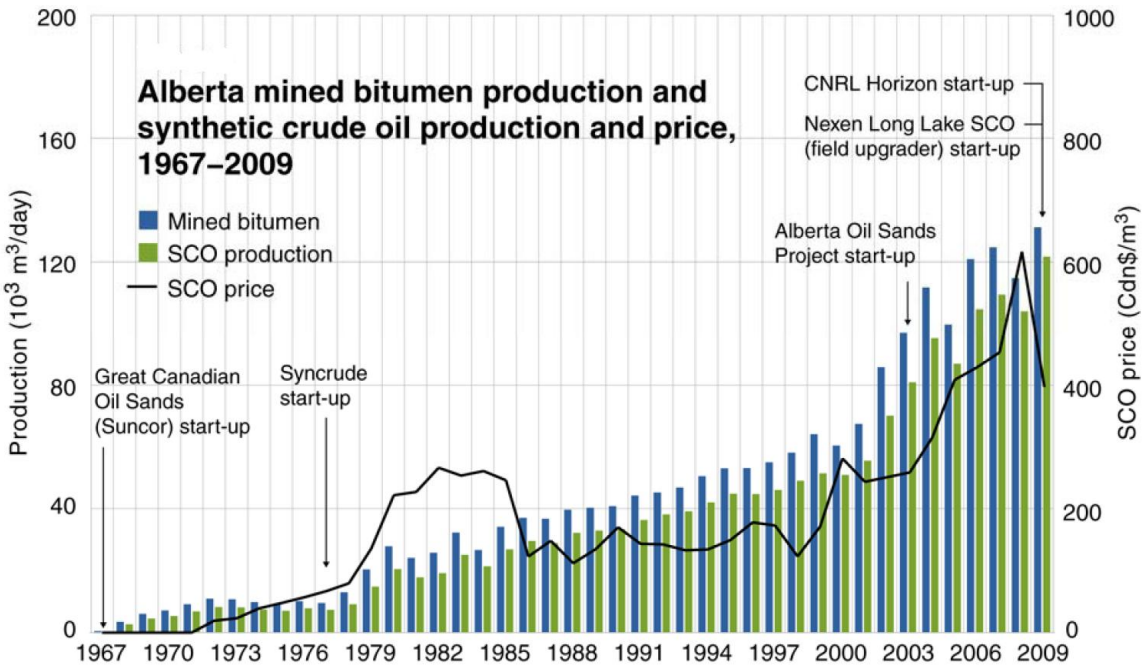

Figure 3. Alberta mined bitumen production and derived SCO production and price (ERCB, 2010, Figure 9).

2. What are the sources of funding for current and planned activity (private industry, government, and consortia)?

It is difficult to find all the sources of funding for oil sands research. For Canadian federal funding, refer to the following website: www.InnovationCanada.ca. U.S.A. federal funding sources include the U.S. Department of the Interior, Bureau of Land Management (www.blm.gov), and the National Science Foundation (www.nsf.gov; info@nsf.gov). A comprehensive list of funding for oil sands research in Canada, the U.S.A., and other countries (with location, granting agency, purpose, and website/email addresses) was provided in the EMD oil (tar) sand committee chair report for the 2007 Annual Meeting in Long Beach (see EMD site postings).

In Alberta the Alberta Energy Research Institute (AERI@gov.ab.ca) promotes joint industry-government-university energy research, technology evaluation and technology transfer in areas including heavy oil and oil sands. AERI promotes consortia by building knowledge networks and integration of knowledge, skills and investment potential of industry players, federal and provincial governments, other research providers and universities and supports applied research that will lead to technology implementation to secure the future sustainability of Alberta's energy industry. AERI also advises the Minister of Advanced Education and Technology and the government of Alberta on energy research policy. Recent AERI-funded projects in heavy oil and oil sands include: (1) thickened tailings field trials (paste technology) for tailings management improvement; (2) further research into in-situ steam-assisted gravity drainage (SAGD) with gas push and addition of solvents; (3) on-site viscosity measurements from drill

cutting samples and newly extracted core, with forensic fingerprinting of subsurface fluid migration (University of Calgary and Gushor; Larter et al., 2006, Huang et al., 2008); (4) the AOSTRA-Taciuk process (ATP) that uses a dry-retorting process for extracting bitumen in surface mining operations, then moving the oil sand through a rotating drum, and using heat to crack the bitumen into lighter hydrocarbons; (5) the OSLO Cold Water Extraction (OCWE) that separates bitumen from oil sands in the surface mineable area. This technology avoids the use of caustic to improve the bitumen extraction, and operates at ambient temperatures; and, (6) for carbonate-bitumen deposits laboratory experimental trials for in-situ thermal-coil heating of the bitumen for extraction (Laricina Energy Ltd.).

3. What kinds of research are occurring and by whom?

Only about 22% of the established oil sands reserves in Alberta can be recovered through surface mining, with the remaining 78% recoverable using in-situ, mainly thermal technologies. The most common in-situ recovery technologies are Cyclic Steam Stimulation (CSS, used mainly at Cold Lake and Peace River oil sands areas) and Steam Assisted Gravity Drainage (SAGD, used mainly in the Athabasca oil sands area).

In Alberta, SAGD was originally developed between 1986 and 1998. It was largely collaboration between the Government of Alberta, through AOSTRA (Alberta Oil Sands Technology Research Authority) and industry partners. Pilot tests were done at the Underground Test Facility (UTF) Dover-site near Fort McMurray, Alberta.

In 1999-2000, a number of the original development partners were licensed to use SAGD technology and announced commercial ventures worth a total of over $3.4 billion (AERI@gov.ab.ca). These include:

- Suncor - $750 million investment
- Gulf - $1.3 billion investment in Surmont
- PanCanadian - $370 million investment in Christina Lake
- Alberta Energy Company - $240 million investment in Foster Creek
- Amoco - $500 million at Primrose
- Japex - $200 million expansion at Hangingstone
- Projects are also proceeding with Northstar Energy at Dover and Petro-Canada at McKay River (AERI@gov.ab.ca).

The vast extent of the oil sands has been well documented. Improved methods of reserves estimates and mapping of reservoir heterogeneities using multidisciplinary approaches (geology, geochemistry, engineering, high-resolution shallow geophysics, etc.) have led to improved methods for identification of the developable oil sands deposits (Bauman, 2009; Bellman et al., 2009). Recent research interests relate to SAGD-development in areas of thin overburden and elsewhere, in which other factors such as cap-rock integrity, influence of karsting, glaciotectonics and the presence of Quaternary channel-fills as potable aquifers have to be assessed for development strategies in the Alberta oil sands areas (Collins, 2005; Hein et al., 2009; Marsh et al., 2009).

Much of the current technological research concerns enhanced development of SAGD technology for in-situ thermal recovery of the clastic-hosted bitumen. This includes:

(1) enhanced development of SAGD technology for in-situ thermal recovery of clastic-hosted bitumen;
(2) prediction of flow distribution and steam migration in SAGD schemes using permanently installed fiber-optic monitoring (Krawchuck et al., 2006);
(3) experimental in-situ thermal coil heating of carbonate-hosted bitumen (www.laricinaenergy.com); use of developing technologies to cut SAGD fuel (and water) costs while reducing greenhouse gas emissions (Budd, 2006);
(4) improvements concerning tailings disposal (Keyser, 2009); and
(5) remediation of landscape to return the sites to a biodiversity at least equal to the biodiversity index prior to mining or in-situ extraction.

In early February 2009, the Energy Resources Conservation Board (ERCB) issued Directive 074 that outlines new cleanup rules and harsh penalties for non-compliance regarding tailings ponds regulations for the oil sands areas. This directive resulted from the ERCB acknowledgment that, although operators invested heavily in improved tailings reduction strategies, targets set out in the original development applications have not been met. Firm performance criteria defined for reclaiming the tailings ponds, with performance inspections, and subsequent penalties due to neglect, omission or commission.

List of Specialists in Western Canada

- Dr. Clayton Deutsch, The University of Alberta, Edmonton: Numerical modeling, geostatistics and simulation of oil sands reservoir engineering and in-situ technologies;
- Dr. Martin Fowler, Geological Survey of Canada – Calgary, Natural Resources Canada (NR-Can): Geochemistry and fingerprinting of oil sources, biodegradation;
- Dr. Murray Gingras and Dr. S. George Pemberton, The University of Alberta, Edmonton: Ichnology (trace fossils) and depositional models for the oil sands;
- Dr. Murray Gray, The University of Alberta, Edmonton: Oil sands production technologies and development of clean transportation fuels;
- Dr. Jacob Masliyah, Dr. Zhenghe Xu, and Dr. Jan Czarnecki, The University of Alberta, Edmonton: Engineering theory and practice of bitumen recovery from Alberta oil sands;
- Dr. Frances J. Hein, Rick Marsh, and Dr. Farhood Rahnama, Alberta Energy Resources Conservation Board (ERCB), Calgary: Regional geologic framework, depositional models of the Alberta oil sands and reserves estimates; with Corey Froese and Kristine Haug, Alberta Geological Survey, ERCB, Edmonton: cap-rock integrity in areas with shallow overburden, karsting, glaciotectonics and bedrock channels that host Quaternary potable aquifers;

- Dr. Steven Larter, The University of Calgary: Biodegradation of oils, recovery processes of heavy oil and bitumen, alternative underground in-situ recovery and refining methods; heavy oils and tar sands (HOTS) fluid research;
- Dr. Jennifer Adams, The University of Calgary and Gushor: Measurement, documentation and interpretation of vertical and lateral viscosity variation in heavy oil and oil sands deposits;
- Dr. Alex Turta, Alberta Research Council, Calgary: Toe to Heel Injection Process (THAI) in situ process, comparisons with Steam Assisted Gravity Drainage (SAGD);
- The University of Calgary, Institute for Sustainable Energy, Environment and Economy (ISEEE) and the Alberta Ingenuity Centre for In Situ Energy: Cleaner and more efficient ways to producing bitumen and heavy oil, underground refining.
- Dr. Kent Barrett and Mauro Cimolai, Laricina Energy Ltd., Calgary: Mega-porosity/mega-permeability laboratory testing and core experiments on in-situ thermal coil heating and geologic analysis of carbonate-bitumen deposits, www.laricinaenergy.com;
- Dr. Derald G. Smith, University of Calgary (Emeritus and Consultant), Geomorphological reconstruction of Cretaceous fluvial paleo-meander belts with application to oil sands deposits;
- Dr. Stefan Bachu, Alberta Research Council, Edmonton: CO2 sequestration and co-generation in oil sands and heavy oil development areas;
- Government of Saskatchewan, www.ir.gov.sk.ca\

List of Specialists in the United States.

- R.E. Blackett, Utah Geological Survey, Utah Department of Natural Resources: Tar-sand resources of the Uinta Basin, Utah;
- James W. Bunger, Bunger and Associates with Anton R. Dammer, on contract to U.S. Department of Energy, Washington, D.C.: Production Planning for U.S. Tar Sands;
- Thomas E. Ewing, Frontera Exploration Consultants, San Antonio, TX: Tar sands and heavy oil in the southwest Texas heavy oil province;
- P.A. Freeman, U.S. Geological Survey (USGS): Heavy oil and natural bitumen resource estimates (World and USA);
- Patrick J. Gooding, Kentucky Geological Survey, University of Kentucky, Lexington, KY: Tar sand exploration in the Appalachian and Illinois basins of Kentucky;
- Dr. William H. Green, Massachusetts Institute of Technology: Using unconventional hydrocarbons in oil sands and oil shales;
- Dr. Michael D. Lewan, U.S. Geological Survey, Denver, CO: Rock Eval and hydrous pyrolysis kinetics on oil sand source rocks, and geochemical research on oil sands;

- L.C. Marchant, J.J. Stosur, and C.Q. Cupps, U.S. Department of Energy, Laramie Energy Technology Center, Laramie, Wyoming: Recent activities in U.S.A. tar sands;
- R.F. Meyer, U.S. Geological Survey (USGS): Heavy oil and natural bitumen resource estimates (World and USA);
- M.C. Noger, Kentucky Geological Survey, University of Kentucky, Lexington, KY: Tar sands occurrences of Western Kentucky;
- Dr. Sarah Pietraszek-Matter, Indiana University, Bloomington, Indiana: Biodegradation of crude oils in the Illinois Basin;
- Dr. G.V. Wilson, Alabama Geological Survey: Physical and chemical characteristics of Alabama tar sands.

4. Which companies are considered the leaders?

Unless otherwise indicated the main oil sands offices are in Calgary, Alberta, with field offices in Fort McMurray, Cold Lake, or Peace River, Alberta. Included in the following list are the bitumen (extra-heavy) and heavy oil leaders.

1. CNRL (Canadian Natural Resources Ltd.);
2. Chevron Texaco Energy Research and Technology Co.;
3. China National Offshore Oil Corp.;
4. Conoco Phillips;
5. Eco-Petrol (Columbia);
6. EnCana Corp.;
7. Husky Energy Inc.;
8. Imperial Oil Resources Ltd.;
9. JACOS (Japan Canada Oil Sands Ltd.);
10. KNOC (Korean National Oil Corp.);
11. Laricina Energy Ltd.,
12. Lukoil-Overseas Venezuela Ltd. (Caracas, Venezuela);
13. Nexen Inc.;
14. Oil Sands Quest (Saskatchewan, Canada);
15. Ossum; PDVSA (Caracas and Maracaibo, Venezuela);
16. Petro-Canada; Petro-China Co.;
17. Petrozuata; Shell International Ltd. & Shell Canada; STATOIL (Norway);
18. Suncor Energy Inc.;
19. Syncrude Canada Ltd.;
20. Temple Mountain Energy Inc. (Utah);
21. Total E & P Canada Ltd.;
22. UTS Energy Corp.;
23. Western Oil Sands.

5. What is the focus of recent activity?

In Alberta, as of December 2008, the bitumen reserves under active development (mainly by surface mining) accounted for only 15% of the remaining established reserves at 21

billion barrels (3.3 10^9 m^3). To unlock the huge potential of the remaining bitumen resources other in-situ technologies will have to be improved upon. The most commonly used in-situ technologies are Steam Assisted Gravity Drainage (SAGD) and Cyclic Steam Stimulation (CSS). Both SAGD and CSS have high demands for both energy and water to produce steam, the need for good permeability (both vertical and horizontal), relatively thick pay zones (> 10 m), and an absence of barriers (cemented zones, thick, laterally-continuous shales) and the lack of significant top/gas or bottom water thief zones.

Some of the focus of recent *in-situ* technology and advances includes:

- Integration of future oil sands with emerging oil shale co-production in the western U.S.A.;
- New developments concerning *in-situ* recovery and underground refining technologies for oil sands in western Canada, including underground combustion and refining;
- Use of Cold Heavy Oil Production with Sand (CHOPS) as a specialized primary type of production where progressive cavity pumps assist is lifting bitumen and sand to surface, and utilizing production of sand to produce wormholes in the reservoir to increase permeability;
- Search for alternative sources of energy for steam production, including the development of nuclear industries in conjunction with oil sands *in-situ* production plants (Peace River, Alberta).
- Further development and use of technologies, including Vapour Extraction (VAPEX), Toe-to-Heel-Air-Injection (THAI), Supercritical Partial Oxidation (SUPOX), and various hybrid developments, including CO_2 flooding.

Meyer et al. (2007) evaluated the world-wide distribution of heavy oil and natural bitumen resources, with a classification of their occurrence in different geological basins. A regional geologic overview of the Canadian oil sands is given in, among other sources, Hein (2006), Hein and Marsh (2008), Hein et al. (2007), and Marsh and Hein (2008). On a world wide basis, in addition to the vast oil sands of Canada, extra-heavy oil in Venezuela and oil sands of the Western U.S., China, and Russia are of interest.

A comprehensive, two-volume edition book entitled: "Handbook on Theory and Practise of Bitumen Recovery from Athabasca Oil Sands" is currently in the final stages of production, planned for release in 2009: www.ualberta.ca/cmeng/os-handbook (Masliyah et al., in press). The main focus of the handbook is the extraction of bitumen from oil sands mainly using surface mining methods, although there is a chapter on in-situ processes as well. Volume I covers the basic scientific principles of bitumen recovery, froth treatment, diluents recovery and tailings disposal; while Volume II is devoted to industrial practices (editor, Jan Czarnecki, at jc7@ualberta.ca).

Current economics and transportation, current research is conducted on transportation alternatives for heavy crude and bitumen using new and existing infrastructure of pipelines and railways. Such integration has been called a virtual "pipeline on rails" to get the raw and upgraded bitumen to U.S. markets (Perry and Meyer, 2009).

6. What are the estimated U.S. and international resources/reserves and what is the strategic impact of these resources?

World resources of bitumen and heavy oil are estimated to be 5.6 trillion barrels, of which more than 80% are located in Venezuela, Canada, and the U.S.A. (Figure 4, Table 1, Hein, 2006). The largest accumulation of oil sands in the world is located in Alberta, Canada, with in-place bitumen estimates ranging from 270 billion cubic meters (Marsh and Hein, 2008) to 286.6 billion cubic meters (ERCB, 2010). Of this huge resource, it was estimated that 27.5 billion cubic meters (or about 173 billion barrels) was recoverable from the currently mined and drilled areas using current commercial technologies (ERCB, 2008). The ERCB (2010) estimated ultimate recovery from Alberta accumulations is 50.0 billion cubic meters (315 billion barrels).

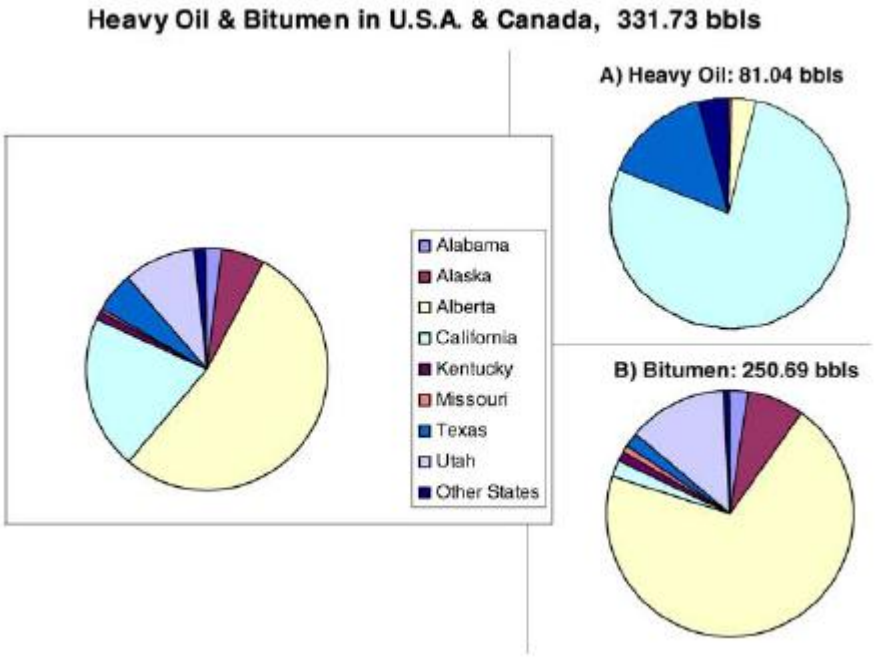

Figure 4. Pie charts showing the distribution of combined heavy-oil/bitumen resources for the U.S.A. and Canada, with breakdown insets: (A) heavy oil; and (B) bitumen resources (see Table 1, from Hein (2006).

Table 1. Bitumen Resources of North America (from Hein, 2006).

Location	Bitumen billion barrels (bbls)	Bitumen Per Cent (%)
Alberta	174.5	69.61
Utah	32.33	12.90
Alaska	19.00	7.58
Alabama	6.36	2.53
Texas	5.44	2.17
California	5.34	2.31
Kentucky	3.42	1.26
Missouri	2.07	0.83
Other States	2.23	0.89
Totals	250.69	100.00

Bitumen accumulations are not currently commercially produced in the U.S.A., beyond local use on roads and similar surfaces. U.S. occurrences are estimated at 6.1 billion barrels of recoverable bitumen (Meyer and Attanasi, 2003). At present, Canada is an important strategic source of bitumen and synthetic crude oil (obtained by upgrading bitumen). A United States goal for energy independent should include existing oil sand deposits (Table 1); these could be commercially produced by surface mining or *in-situ* extraction, and be part of U.S. commercial daily oil production.

7. What are the critical technology needs and how are these being addressed?

Critical technology needs include enhancing current and developing new more-environmentally-friendly methods of extraction, production, and upgrading of oil sands. For surface mining operations this involves emphasis on reclamation on tailings and consolidated tailings and re-vegetation of open pit mine sites. Most of the bitumen resources are extracted by in-situ technologies (mainly thermal, such as Steam Assisted Gravity Drainage and Cyclic Steam Stimulation). Because there is significant co-production of greenhouse gases with bitumen production and upgrading, critical technology needs involve research into: 1) alternative sources of heat for generation of steam (i.e. geothermal, nuclear, burning of slag); 2) methods to reduce the viscosity of the bitumen so it will flow to the well bore or through pipelines more easily (i.e. diluents, catalysts, microbial and nanotechnology); 3) underground in-situ extraction, refining and upgrading; and 4) co-sequestration of greenhouse gases by injection into abandoned reservoirs or other deep geologic sites. At present, there is an excess supply of sulfur above what is used in agricultural and other markets. Excess sulfur is stockpiled that is associated with bitumen production and upgrading.

The main researchers' contact information and website postings (under the above point 3) contain advances in these regards. Companies actively involved in bitumen production and associated reclamation are listed in point 4.

8. What are the critical environmental or geohazard issues and how are these being addressed?

The critical environmental issues relate to the balance among greenhouse gas emissions and water/energy usage and the recovery, production and upgrading of bitumen. Specifically, the critical environmental focus is how to cleanly, efficiently, and safely extract, produce, and upgrade the bitumen. Goals include 1) reduction in the use of energy to heat the water to steam; 2) the greenhouse gas emissions are reduced and remaining emissions are compensated for by carbon trading and (or) CO_2 sequestration; and 3) the extraction, production and upgrading of the bitumen is done by efficient and economic means. Some of the areas of focus include: land reclamation in surface mining; tailings and consolidated tailings disposal and reclamation; co-production of other products from tailings and bitumen upgrading (such as vanadium, nickel, sulphur, etc.); in-situ recovery, and underground refining. In Canada oil sand developers are working to reduce CO_2 emissions by 45% per barrel by 2010, compared to 1990. Also in Canada, developers are legislated to restore oil sand mining sites to at least the equivalent of their previous biological productivity. For example, at the Syncrude mine site near Fort McMurray, Alberta, the Fort MacKay Indian band has reclaimed much of the previous tailings pond areas into grasslands that are now supporting a modest bison herd (~ 500 – 700 head).

9. What EMD technical sessions, publications, workshops, etc. exist or are planned that are relevant to this commodity?

The AAPG Hedberg Research Conference on "Heavy Oil and Bitumen in Foreland Basins – From Processes to Products" was held in October, 2007, in Banff and Calgary, Alberta (Suter et al., 2007; Hein et al., 2007). At the 2009 AAPG Annual Meeting in Denver an EMD poster session on oil (tar) sands was part of the unconventional sessions; a similar EMD session was included in 2010 AAPG Annual Meeting in New Orleans. Fran Hein, previous Chair of the EMD Oil (Tar) Sands Committee, was the AAPG EMD co-chair for the AAPG International Conference & Exhibition (ICE), held in Calgary in September, 2010. EMD sponsored sessions included a full day on unconventional, which included morning and afternoon sessions on Heavy Oil/Bitumen and the Bakken, and a plenary talk by Dr. Dale Leckie on Nexen's Long Lake SAGD project in northern Alberta. Fran Hein is currently overseeing an oil sands AAPG memoir that includes papers from the 2007 Hedberg conference and other research on oil sands; proposed title is "Heavy Oil/Bitumen Petroleum Systems in Alberta & Beyond." Submittal of the reviewed chapters to the AAPG Publications Committee is planned for early 2011.

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11. Web Links for oil sands/heavy oil organizations and information

The following provides updates to the Members-Only Webpage. The following can replace the entries located at http://emd.aapg.org/members_only/oil_sands/index.cfm

Alberta Energy Resources Conservation Board (ERCB): www.ercb.ca

Alberta Chamber of Resources: www.abchamber.ca

Alberta Department of Energy: www.energy.gov.ab.ca

Alberta Department of Sustainable Resource Development: www.srd.alberta.ca

Alberta Energy Research Institute: www.aeri.ab.ca

Alberta Environment Information Centre: www.environment.gov.ab.ca

Alberta Geological Survey: www.ags.gov.ab.ca

Alberta Government: www.alberta.ca

Alberta's Industrial Heartland Association: www.industrialheartland.com

Alberta Ingenuity Centre for In Situ Energy: www.aicise.ca

Alberta Innovation & Science: www.aet.alberta.ca

Alberta Research Council: www.arc.ab.ca

Alberta Sulphur Research Ltd.: www.chem.ucalgary.ca/asr

Athabasca Regional Issues Working Group: www.oilsands.cc

Canadian Association of Petroleum Producers: www.capp.ca

Canadian Energy Research Institute: www.ceri.ca

Canadian Geoscience Council: www.geoscience.ca

Canadian Heavy Oil Association: www.choa.ab.ca

Canadian Institute of Mining, Metallurgy & Petroleum: www.cim.org

Canadian Petroleum Institute: www.cppi.ca

Canadian Society of Petroleum Geologists: www.cspg.org

Canadian Well Logging Society: www.cwls.org

CanMet Mining and Mineral Sciences Laboratories: www.nrcan.gc.ca

Careers: The Next Generation: www.nextgen.org

Climate Change Central: www.climatechangecentral.com

EnergyInet: www.energyinet.com

Environment Canada: www.ec.gc.ca

Fort McMurray Chamber of Commerce: www.fortmcmurraychamber.ca

Freehold Owners Association: www.fhoa.ca

Geological Survey of Canada: http://gsc.nrcan.gc.ca/

Institute for Sustainable Energy, Environment and Economy: www.iseee.ca

International Energy Foundation: www.ief-energy.org

National Energy Board: www.neb-one.gc.ca

National Research Council's Industrial Research Assistance Program: www.irap-pari.nrc-cnrc.gc.ca

Natural Resources Canada: www.nrcan-rncan.gc.ca

Oil Sands Discovery Centre: www.oilsandsdiscovery.com

Petroleum Society of Canada: www.petsoc.org , www.spe.org/canada

Petroleum Technology Alliance Canada: www.ptac.org

Petroleum Technology Research Centre: www.ptrc.ca

Saskatchewan Industry and Resources: www.ir.gov.sk.ca

Saskatchewan Government: www.ir.gov.sk.ca

Saskatchewan Research Council: www.src.sk.ca

Seeds Foundation: www.seedsfoundation.ca

Small Explorers and Producers Association of Canada: www.sepac.ca

Society of Petroleum Engineers: www.speca.ca

The Canadian Society of Exploration Geophysicists: www.cseg.ca

The Environmental Association of Alberta: www.esaa.org

U.S. Energy Information Administration: www.eia.doe.gov , http://search.usa.gov/search?affiliate=eia.doe.gov&v%3Aproject=firstgov&query=oil+sands

U.S. Geological Survey: http://pubs.usgs.gov/of/2007/1084/OF2007-1084v1.pdf

U.S. Bureau of Land Management: www.blm.gov

Utah Heavy Oil: http://www.heavyoil.utah.edu/outreach.html; http:/map.heavyoil.utah.edu/