TO THE ENDS OF THE EARTH

TAR SANDS

TAR SANDS OR **OIL SANDS** CONSIST OF A THICK, DENSE TYPE OF OIL CALLED BITUMEN MIXED WITH SAND, WATER AND CLAY.

EXTRACTION REQUIRES ENORMOUS AMOUNTS OF ENERGY AND WATER, RELEASES VAST AMOUNTS OF GREENHOUSE GASES AND OTHER POLLUTANTS AND IS DEVASTATING HUGE TRACTS OF BOREAL FOREST AND WETLANDS IN CANADA.

HOW IS IT EXTRACTED?

Tar sands can be extracted and processed using a variety of techniques which can be classified as 'surface mining', where the tar sands are dug out and transported for crushing and processing, or in-situ (underground) techniques, where the oil is made to flow by injecting steam, solvents and/or hot air into the sands.

In shallower deposits, surface strip mining with huge shovels and trucks can be used. The resulting mixture of bitumen, sand and water is then taken to a crusher. Once broken up the bitumen is separated from water and other materials.

Deeper deposits, below around 225ft (69m), are extracted using various in-situ techniques. The most commonly used, Steam Assisted Gravity Drainage (SAGD) and Cyclic Steam Stimulation (CSS) involve injecting the deposit with steam, which heats the bitumen to make it flow. The bitumen is then pumped out and transported for further processing. Of the two methods, SAGD is cheaper and has been widely adopted by the tar sands industry. Other in-situ processes have been experimented with, such as using solvents instead of steam, and Toe to Heel Air Injection (THAI), where the bitumen is ignited underground.

Once the bitumen has been extracted and separated from the sand and water it is then either diluted with light oil or natural gas liquids to make 'dilbit' (diluted bitumen) which can be piped to refineries, or 'upgraded', where it is partially refined to produce 'syncrude' (synthetic crude).

All forms of tar sands extraction require huge amounts of energy and water, and are highly carbon intensive. However, in-situ processes, which will be increasingly required to access most of the tar sands deposits, use even more resources than surface mining, and have resulted in oil spills as heated, pressurised bitumen escapes into the environment (see 'Oil Spills' section below).

WHAT IS IT?

Tar sands, also known as oil sands or bituminous sands, are a mixture of sand, water and clay with a dense, sticky, semi-solid form of crude oil called bitumen. Although very similar in appearance, technically bitumen is not the same as tar, which is a man made product. Bitumen needs to be heated or diluted to make it flow, which distinguishes it from 'extra-heavy crude', another form of high density unconventional oil, the largest deposits of which occur in Venezuela's Orinoco Belt (see 'Extra heavy oil' in 'Other Unconventional Fossil Fuels' factsheet).

Most of the world's tar sands are found in Canada where extraction is taking place on an enormous scale, with devastating effects on the local environment and critical implications for climate change. Most of the Canadian tar sands are in three major deposits in Northern Alberta which together cover more than 140,000 km^2, an area larger than England. In 2011, Alberta's bitumen production reached over 1.7 million barrels (270,278 m^3) per day.[1]

Tar sands also occur in other parts of the world, with the next largest deposits in Kazakhstan and Russia. Exploration and test projects have been carried out in Russia, Madagascar, Congo (Brazzaville), and Utah in the USA.

UPGRADING AND PETCOKE

Tar sands require much more processing than conventional crude oil to convert them into useful products such as petroleum. In many cases an upgrading process, which involves taking out impurities and adding hydrogen, takes place near to where the tar sands are extracted. This 'hydro-processing' converts the bitumen into synthetic crude, which can then be transported to refineries for further processing.

The upgrading of tar sands produces 'petcoke' (petroleum coke)', a coal-like substance which is also a by-product of oil refining. At least 15 % of bitumen (by volume) ends up as petcoke.[2] Canadian petcoke production at upgraders in Alberta and Saskatchewan alone (excluding petcoke produced at Canadian refineries) was nearly 9 million tonnes in 2011. This has led to huge stockpiles forming. At the end of 2011, 72.3 million tonnes of petcoke was stockpiled in Alberta, an amount that is growing by about 4.4. million tonnes a year.[3]

Petcoke can be burned for energy, and it is mostly used alongside coal in power plants and to provide energy for cement production. However, when used as fuel it has been estimated to produce about 7% more CO_2 per unit of energy than coal, making it a highly carbon-intensive energy source.[4] In addition, some pollutants, such as heavy metals, become more concentrated in the petcoke.[5] This means that when it is used with coal for power generation it increases the already substantial toxic emissions that result from burning coal.

The increased production of petcoke from the processing of bitumen and heavy oils in the last decade has led to a sharp rise in its use in coal power stations. This has had the effect of both making the highly polluting coal power stations more economical to run, and further increasing their already massive CO_2 emissions.

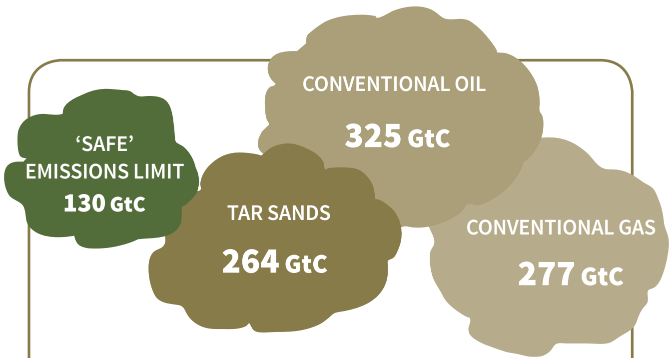
Aside from tar sands, petcoke produced from conventional oil refining is a serious global issue, and huge volumes of it are being burned in China for energy.[6]

CLIMATE CHANGE

The extraction of tar sands produces three to four times the greenhouse gas (GHG) emissions of conventional oil extraction,[7] making its total lifecycle emissions (including all emissions generated in extraction, transportation and end use) 8% to 37% higher than conventional oil.[8] These may well be underestimates, as a full 'well to wheels' analysis should include emissions from all sources, some of which, such as methane emissions from tailing ponds, land-use change (particularly wetlands) and the emissions from refining and upgrading (particularly downstream upgrading) are difficult to quantify and not included in some studies.

The tar sands industry has been keen to point out that it has reduced emissions intensity (emissions per barrel). However, these reductions are mainly from switching to natural gas to fuel operations (which happened in the early 2000s), and it remains a highly carbon-intensive process. Overall emissions from tar sands have actually increased as reductions from intensity improvements are negated by increased production rates. In addition, as surface mining to remove the more easily accessible deposits is replaced by in-situ extraction, with higher CO_2 emissions, the carbon-intensity of tar sands is starting to increase again.[9 10 11]

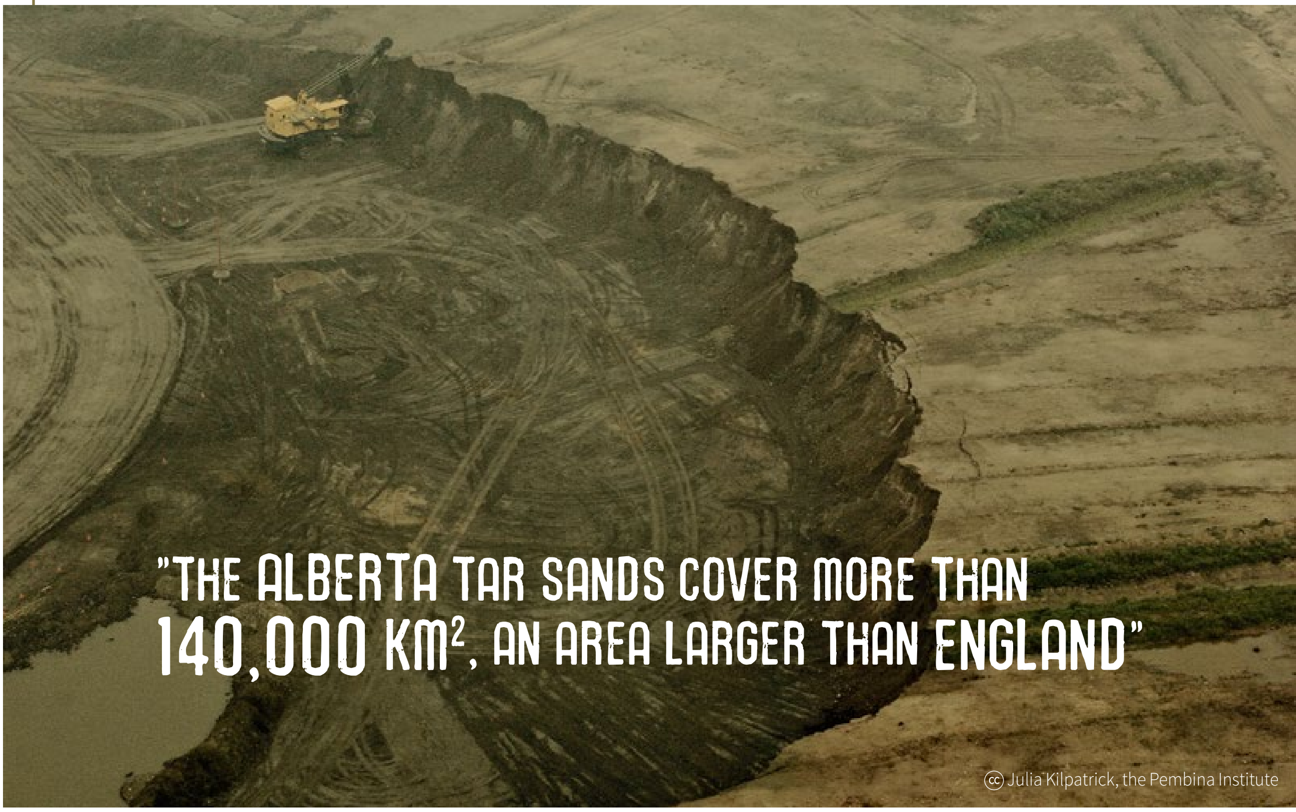
Regardless of how they compare to conventional crude, the Canadian tar sands represent a huge source of carbon which if fully exploited would result in billions of tonnes of CO_2 being added to the atmosphere, putting us firmly on the path to irreversible catastrophic climate change. This has made the Canadian tar sands a major focus for climate campaigners across the world.



If we are to reduce carbon emissions to anything like the levels required to maintain a reasonably habitable planet we must move away from all forms of fossil fuel as fast as possible. Measuring from the start of the industrial revolution (around 1750), a maximum of 500 Gigatonnes of carbon (GtC) can be emitted to the atmosphere while still avoiding most serious impacts and the risk of irreversible and uncontrollable changes to the climate.[12] Between 1750 and now (2014), we have already emitted about 370 GtC leaving a limit of 130 GtC that could be further added.[13]

In order to stay within this limit we have to leave the vast majority of the remaining conventional oil, coal and gas in the ground. Estimates vary significantly, but remaining conventional coal reserves alone are well over 500 GtC.[14]

Fully exploiting the tar sands would add around 264 GtC to the atmosphere.[15] Therefore developing tar sands and releasing the enormous amounts of carbon they contain, is absolutely incompatible with staying below the limit outlined above.



The tar sands and Carbon Capture and Storage (CCS)

Proponents of unconventional fossil fuels often argue that with CCS technologies, these new energy sources could be exploited at the same time as reducing greehouse gas (GHG) emissions. However, even if the huge problems with CCS technology are overcome (and this currently looking extremely unlikely), it would not change the fact that we need to move away from all forms of fossil fuel, conventional and unconventional, as soon as possible.

In the most optimistic (and highly implausible) scenario, CCS could be used to reduce a small proportion of emissions from fossil fuels. In reality, the promise of CCS being implemented in the future is being used to allow the continued expansion of fossil fuel production, to prevent alternatives from being developed, and to deflect attention away from approaches which tackle the underlying systemic causes of climate change and other ecological crises. Ultimately CCS is a smokescreen, allowing the fossil fuel industry to continue profiting from the destruction of the environment. (see 'Carbon Capture Storage' factsheet for more information).

In particular, CCS has been cited by tar sands companies as a means of avoiding criticism over GHG emissions. For example, Shell's Quest project in Alberta, Canada aims to do precisely this. The CCS project at Shell's Scotford Upgrader is used to boast about the company's commitment to the environment yet the company nevertheless exploits the Albertan tar sands, perhaps the most environmentally destructive extractive project on the planet.

Despite supposed industry enthusiasm for the technology, research shows there are fundamental limits on the GHG emissions reductions that can be offered by using CCS in tar sands production. This is partly because most of the emissions from tar sands, such as from trucks used in mining, or waste gas from burning natural gas, are not well suited to CCS.[16] Even the most optimistic industry estimates have suggested that overall reductions from upstream operations could be in the 10 – 30% range at only the best locations by 2020, and 30 – 50% by 2050, whereas reductions of around 85% would be required to make tar sands emissions comparable with the average for conventional oil production.[17] Considering there are 264 Gt of carbon locked up in tar sands, even with the most optimistic reductions from CCS there would still be more than enough carbon released to easily blow the 130 Gt remaining budget (see climate section above). On top of this CCS would not be ready to be fully implemented for decades to come, far too late to effectively reduce emissions. With or without CCS, tar sands development is disastrous for the global climate.

OTHER SOCIAL AND ENVIRONMENTAL ISSUES

Water

Tar sands extraction is extremely water intensive, requiring about three barrels of water to produce a barrel of tar sands using surface mining techniques[18] and more than a barrel for in-situ techniques.[19] Canadian tar sands production in 2011 used around 170 million cubic metres, [20] almost none of which can be returned to the water cycle.[21] Production of the Athabascan Tar Sands in Canada also draws large volumes of water from the Athabasca river basin and there are concerns that this may already be over taxing the river system and that there will not be sufficient water to support future expansion.[22] [23]

Contaminated water from tar sands production is either pumped back underground, or stored in enormous tailings lakes ('tailings' refers to waste material suspended in water). These lakes now cover an area of 176km^2, with an estimated 11,000 cubic metres of contaminated water seeping from tailings lakes into adjacent surface and groundwater each day. Liquid tailings are expanding at a rate of 200 million litres every day.[24] The tar sands industry currently has no plans for how to deal with liquid tailings.

Waste from tar sands production contains a number of toxic and carcinogenic substances including naphthenic acids, polycyclic aromatic hydrocarbons (PAHs), phenolic compounds, ammonia and mercury.[25] There is strong evidence demonstrating how these substances are entering the environment. Independent research has found that levels of PAHs have dramatically increased in lake sediments since the production of tar sands began,[26] and that PAHs and heavy metals such as mercury, arsenic and lead from tar sands production have been polluting rivers.[27] Federal research has confirmed that toxic chemicals in water from tailings lakes are leaching into groundwater and seeping into the Athabasca River.[28]

Air pollution

As well as GHG emissions, tar sands operations produce large volumes of air pollutants. These include nitrogen oxides and sulphur dioxide, which cause acid rain, volatile organic compounds (VOCs) and particulate matter which are known to affect human health.[29] [30] In 2014 a study published in the Proceedings of the National Academy of Sciences showed that production in the Athabasca oil sands region is leading to the airborne emissions of levels of polycyclic aromatic hydrocarbons (PAHs) one hundred to one thousand times greater than previously thought.[31]

Athabasca region Healing Walk

Most air pollution from tar sands production comes from refineries used to upgrade bitumen, but other sources, such as emissions from vehicles, also cause significant pollution. The vast tailing lakes, where liquid waste from operations is stored, also pollute the air, as volatile organic compounds evaporate from the surface.

Natural gas use

Tar sands production requires a huge amount of energy, most of which is currently provided by natural gas. In particular producing steam for in-situ techniques such as SAGD requires a lot of gas. According to the National Energy Board (NEB), it takes about 34 cubic metres (1200 cubic feet) of natural gas, enough to heat the average Canadian home for over 4 days, to produce one barrel of bitumen from in-situ projects.[32]

Natural gas consumption from tar sands production in Canada is estimated to increase to 45 million cubic metres per day in 2015 (1.6 billion cubic feet),[33] enough to heat over 6 million Canadian homes.[34] This is taking up a significant proportion of Canada's natural gas supplies, and if projected increases in tar sands production take place, nuclear power or unconventional gas may be needed, further increasing the environmental impact of tar sands extraction.

Pipelines

The Albertan tar sands have already resulted in huge pipelines networks being built across Canada, with other major pipelines such as the Keystone XL and Energy East pipelines planned. Pipeline construction on such a scale has a significant direct impact on the local communities and environment, but there is also the risk of leakages and oil spills. In Alberta, the oil and gas industry averaged 762 pipeline failures per year between 1990 and 2005, for a total of 12,191 failures.[35]

Oil spills

Oil spills occur both at the sites of tar sands extraction, such as the spills at Cold Lake, Alta36 and along the routes of pipelines, with devastating effects on the local environment. The Kalamazoo tar sands disaster in 2010, where an Enbridge pipeline carrying diluted bitumen from the Canadian tar sands burst, was one of the largest and costliest onshore spills in US history. It resulted in well over a million US gallons (4.5 million litres) of oil flowing into Talmadge Creek,[37] a tributary of the Kalamazoo River in Michigan, and cost over a billion dollars to clean up.[38]

Destruction of habitats and landscape

The areas of Canada where tar sands are found are covered in primary boreal forest and wetlands, home to sensitive ecosystems and a wide variety of wildlife. The Canadian boreal forests represent huge globally significant stores of carbon, and the greenhouse gasses released through deforestation and destruction of peatlands for tar sands production are unlikely to ever be recovered.[39]

False industry promises

Tar sands extraction in Canada is leaving a toxic legacy of vast tracts of devastated habitats and huge toxic tailings lakes that will last long after the companies have left. Only a tiny percentage (0.15%)[40] of the land affected by tar sands production has been certified as reclaimed[41] and the certification of 'reclaimed' land itself has come under strong criticism.[42] Many areas, such as boreal forests, will never recover to their previous state.[43]

In addition, the reclamation of peatlands (fens or bogs) in the Athabasca Boreal region has never been demonstrated to be possible[44] and according to the Pembina Institute there is no demonstrated long term way to deal with liquid tailings.

Impact on Indigenous (First Nations) populations

Almost all the land on which tar sands extraction is occurring in Canada is on or near indigenous territories. This, along with associated projects such as the Northern Gateway pipeline and Keystone XL pipelines which also threaten indigenous lands, has seriously threatened the cultural heritage, land, ecosystems and health of Canadian First Nations peoples. Despite signing up to the UN Declaration of Rights of Indigenous People's (UNDRIP), the Canadian government routinely ignores the right of 'Free, Prior and Informed Consent' (FPIC) of Indigenous People enshrined in the declaration. Many First Nation communities have responded with legal action and widespread protest and resistance (see 'Resistance' section below).

Impact on public health

The tar sands developments in Canada have raised various public health concerns related to water and air pollution (see 'Water' and 'Air pollution' sections) and worries over higher rates of rare cancers in areas polluted by tar sands production. In 2006, unexpectedly high rate of rare cancers were reported in the community of Fort Chipewyan. In 2009, an investigation by the Alberta Cancer Board found higher than expected rates of biliary cancers, but said that it was not enough to be a cause for concern and called for further monitoring.[45] However, the report did not investigate any possible relationship with environmental exposures related to tar sands production.[46] Serious concerns remain around the impact of tar sands operations on local public health.[47]

Syncrude oilsands facility

WHERE AND HOW MUCH?

Global oil in place: 2,511 billion barrels, natural bitumen reserves estimated at 250 billion barrels.[48]

About 70% of the world's tar sands reserves are in Canada (169 billion barrels),[49] most of which can be found in three major deposits in Northern Alberta: the Athabasca-Wabiskaw oil sands, the Cold Lake deposits, and the Peace River deposits. Together these cover more than 140,000 km^2, an area larger than England. Tar sands extraction in Canada is now a major industry, producing 1.7 million barrels of bitumen per day in 2011.[50] However, while there are huge remaining resources, future production is currently limited by the country's ability to export tar sands in crude form. Various pipelines aimed at increasing export capacity are in construction or planned, such as the Keystone XL pipeline which would link the tar sands to the refineries in the Gulf Coast of the US, and there are plans to increase tanker exports to Asian markets by expanding ports.

Tar sands also occur in other parts of the world, with the next largest deposits in Kazakhstan (42 billion barrels of bitumen reserves), and Russia (28 billion barrels).[51] Exploration and test projects have been carried out in Russia, Madagascar, Congo (Brazzaville), Utah in USA, and Trinidad and Tobago.

COMPANIES INVOLVED

A wide variety of companies are involved in tar sands projects, from small local producers, to multinational 'supermajors' such as Shell and BP. Notable tar sands companies include: Suncor Energy, Syncrude Canada, Canadian Oil Sands Limited, Canadian Natural Resources, Shell, BP, Exxon Mobil, Connoco Philips and Total.

RESISTANCE

Albertan tar sands

First Nations Canadians have been leading the resistance to tar sands operations in Alberta. Canada has treaty agreements that protect the First Nations people's rights to use the land for traditional practices such as hunting and fishing in perpetuity. Many indigenous communities have attempted to use the courts to uphold their treaty rights and prevent tar sands extraction. However, bills introduced by the Canadian government, primarily aimed at expanding tar sands developments, ignored the treaties and have prompted a huge protest movement against them. The Idle No More movement aims for environmental protection and indigenous sovereignty and has resulted in a wave of direct action and solidarity protests around the world.

The Keystone XL pipeline has become a major focus of protests in Canada and the US, with widespread civil disobedience and direct action targeting the project. Campaigners have identified it as a key strategic point of resistance, in an attempt to limit export capacity, and therefore further expansion of tar sands in Canada. Attempts to develop tar sands deposits in Utah, US have also been met with strong local opposition.

For more information on resistance see the Corporate Watch website (corporatewatch.org/uff/resistance)

ENDNOTES

1 'Alberta Energy: Facts and Statistics'. Accessed 25 February 2014. ‹http://www.energy.alberta.ca/OilSands/791.asp›

2 'Petroleum Coke: The Coal Hiding in the Tar Sands'. *Oil Change International* (Jan 2013). ‹http://priceofoil.org/2013/01/17/petroleum-coke-the-coal-hiding-in-the-tar-sands/›

3 'ST39: Alberta Mineable Oil Sands Plant Statistics -2011'. *Alberta Energy Regulator* (2011). ‹http://www.aer.ca/data-and-publications/statistical-reports/st39›

4 Op.Cit (*Oil Change International*, Jan 2013)

5 Pavone A, 'Converting Petroleum Coke to Electricity. *14th National Industrial Energy Technology Conference, Houston, TX* (April 22-23, 1992). ‹http://repository.tamu.edu/bitstream/handle/1969.1/92212/ESL-IE-92-04-47.pdf›

6 'US Exports to China Increasing Barrels of Petcoke, a Fuel Dirtier Than Coal - Businessweek'. Accessed 25 February 2014. ‹http://www.businessweek.com/articles/2013-12-05/us-exports-to-china-increasing-barrels-of-petcoke-a-fuel-dirtier-than-coal›

7 'Development of Baseline Data and Analysis of Life Cycle Greenhouse Gas Emissions of Petroleum-Based Fuels'. *DOE/NETL*-2009/1346 (2008), 13, table 2-4. ‹http://www.netl.doe.gov/energy-analyses/pubs/NETL%20LCA%20Petroleum-Based%20Fuels%20Nov%202008.pdf›

8 'Setting the Record Straight: Lifecycle Emissions of Tar Sands'. *Natural Resources Defense Council* (2010). ‹http://docs.nrdc.org/energy/files/ene_10110501a.pdf›

9 Marc Huot, Danielle Droitsch and P.J.Partington. 'Canadian Oilsands and Greenhouse Gas Emissions: The Facts in Perspective'. *The Pembina Institute* (2010) 7. ‹http://www.pembina.org/pub/2057›

10 'Beneath the Surface'. *The Pembina Institute* (Jan 2013). ‹http://www.pembina.org/pub/2404›

11 'Canada's Emission Trends (2012), 24 (table 5)'. *Environment Canada*. ‹http://www.ec.gc.ca/Publications/253AE6E6-5E73-4AFC-81B7-9CF440D5D2C5/793-Canada%27s-Emissions-Trends-2012_e_01.pdf›

12 Hansen, James, Pushker Kharecha, Makiko Sato, Valerie Masson-Delmotte, Frank Ackerman, David J. Beerling, Paul J. Hearty, et al. 'Assessing "Dangerous Climate Change":

Required Reduction of Carbon Emissions to Protect Young People, Future Generations and Nature'. Edited by Juan A. Añel. *PLoS ONE 8, no. 12* (3 December 2013): e81648. doi:10.1371/journal.pone.0081648. ‹http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0081648›

13 Ibid

14 Ibid

15 See ‹www.corporatewatch.org/uff/carbonbudget›

16 *Standing Committee on the Environment and Sustainable Development, House of Commons*, Canada, Evidence from Graham Thomson, March 30, 2010, Extracted from 40th Parliament, 3rd Session. ‹http://www2.parl.gc.ca/HousePublications/Publication.aspxDocId=4402785&Language=E&Mode=1&Parl=40&Ses=3#Int-3071313 ›

17 'Carbon capture and storage in the Alberta oil sands – a dangerous myth'. *Cooperative Financial Services and WWF-UK* (Oct 2009). ‹http://www.co-operative.coop/Corporate/PDFs/Tar%20Sands%20CCS.pdf ›

18 'Water use in Canada's oil sands'. *Canadian Association of Petroleum Producers* (June 2012). ‹http://www.capp.ca/getdoc.aspx?DocId=193756›

19 J Kidd. 'Running out of steam - A Workshop on Oil Sands Development and Water Use in the Athabasca River Watershed: Science and Market-Based Solutions' *Kidd Consulting* (May 2007). ‹http://powi.ca/wp-content/uploads/2007/05/Final-Running-out-of-Steam-Meeting-Notes.pdf›

20 'Oil Sands Water Use' *Alberta Environment & Sustainable Resource Development, Oil Sands Information Portal* (accessed January 18, 2013). ‹http://environment.alberta.ca/apps/osip/›

21 Mary Griffiths, Amy Taylor and Dan Woynillowicz. 'Troubled Waters, Troubling Trends: Technology and Policy Options to Reduce Water Use in Oil and Oilsands Development in Alberta'. *The Pembina Institute* (2006). ‹http://www.pembina.org/pub/612›

22 Mario LÓpez Alcalá, Doug Cogan, Dinah Koehler, Yulia Reuter, Dana Sasarean. 'Canada's Oil Sands: Shrinking Window of Opportunity'. RiskMetrics Group, Ceres, (May 2010). ‹http://www.ceres.org/resources/reports/oil-sands-2010›

23 'Canada's Oil Sands - Opportunities and Challenges to 2015: An Update - Questions and Answers'. National Energy Board (last modified July 2010). ‹http://www.neb.gc.ca/clf-nsi/rnrgynfmtn/nrgyrprt/lsnd/pprtntsndchllngs20152004/qapprtntsndchllngs20152004-eng.html›

24 'Losing Ground -Why the problem of oilsands tailings waste keeps growing'. *Pembina Institute* (Aug 2013). ‹http://www.pembina.org/pub/2470›

25 P. G. Nix and R. W. Martin. "Detoxification and Reclamation of Suncor's Oil Sand Tailings Ponds". *Environmental Toxicology and Water Quality* 7, no. 2 (1992)

26 Joshua Kurek, Jane L. Kirk, Derek C. G. Muir, Xiaowa Wang, Marlene S. Evans, and John P. Smol. 'Legacy of a half century of Athabasca oil sands development recorded by lake ecosystems'. *Proceedings of the National Academy of Sciences of the United States of America*, published online before print on January 7, 2013 (201217675). ‹http://www.pnas.org/content/early/2013/01/02/1217675110.full.pdf+html›

27 Erin N. Kelly, Jeffrey W. Short, David W. Schindler, Peter V. Hodson, Mingsheng Ma, Alvin K. Kwan and Barbra L. Fortin. 'Oil sands development contributes polycyclic aromatic compounds to the Athabasca River and its tributaries'. *Proceedings of the National Academy of Sciences of the United States of America* 107 (2009). ‹http://www.pnas.org/content/early/2013/01/02/1217675110.full.pdf+html›

28 'River Metals Linked to Tar Sand Extraction' . *Nature News* (Accessed 25 February 2014). ‹http://www.nature.com/news/2010/100831/full/news.2010.439.html›

29 'Environmental and Health Impacts of Canada's Oil Sands Industry'. *Royal Society of Canada* (2009). ‹http://www.ianas.org/books/Environmental_and_health_impacts_of_canadas_oil_sands%20Industry.pdf›

30 'National Pollutant Release Inventory, 2007 Summary' *Environment Canada*, section 3.1.1.1 "Criteria Air Contaminants" (accessed January 29, 2013) .‹http://www.ec.gc.ca/inrp-npri/default.asp?lang=En&n=0D743E97-1›

31 Parajulee, A., and F. Wania. 'Evaluating Officially Reported Polycyclic Aromatic Hydrocarbon Emissions in the Athabasca Oil Sands Region with a Multimedia Fate Model'. *Proceedings of the National Academy of Sciences* (3 February 2014). doi:10.1073/pnas.1319780111. ‹http://www.pnas.org/content/early/2014/01/29/1319780111›

32 'NEB - Energy Reports - Canada's Oil Sands: Opportunities and Challenges to 2015 - Questions and Answers' (Accessed 25 February 2014). ‹http://www.neb.gc.ca/clf-nsi/rnrgynfmtn/nrgyrprt/lsnd/pprtntsndchllngs20152004/qapprtntsndchllngs20152004-eng.html›

33 ibid

34 A rough approximation is that 100 GJs of energy – or 2,700 cubic metres or 94,800 cubic feet of natural gas – is required to heat a newly built average-sized single detached home in Canada for one year (from here: http://www.nrcan.gc.ca/energy/sources/natural-gas/1233). 2700/365 = 7.4 cubic metres per day. 34 per barrel / 7.4 = 4.6 days. 45 million cubic metres per day / 7.4 cubic metres per home = 6 millions homes

35 Van Hinte, Tim, Thomas I. Gunton, and J. C. Day. 'Evaluation of the Assessment Process for Major Projects: A Case Study of Oil and Gas Pipelines in Canada'. *Impact Assessment and Project Appraisal* 25, no. 2 (June 2007): 123–137. doi:10.3152/146155107X204491. ‹http://commdev.org/files/1710_file_s5.pdflll.pdf›

36 'Leak at Oil Sands Project in Alberta Heightens Conservationists' Concerns'. *NYTimes.com*. Accessed 25 February 2014. ‹http://www.nytimes.com/2013/08/09/business/global/leak-at-oil-sands-project-in-alberta-heightens-conservationists-concerns.html?_r=0&adxnnl=1&adxnnlx=1393357691-QGkbMuiFkul+tJEnqTQlpQ›

37 'EPA Response to Enbridge Spill in Michigan'. *US EPA*. Accessed 25 February 2014. ‹http://www.epa.gov/enbridgespill/›

38 'Application for a Certificate of Need for a Crude Oil Pipeline'. *Enbridge Energy (Before the Minnesota Public Utilities Commission)*. Revised 16 Aug 2013. ‹https://www.edockets.state.mn.us/EFiling/edockets/searchDocuments.do?method=showPoup&documentId={F1B13575-3D71-4CAA-A86A-05CE1EBBCA38}&documentTitle=20138-90363-03›

39 Lee P and R Cheng. 'Bitumen and Biocarbon: Land use changes and loss of biological carbon due to bitumen operations in the boreal forests of Alberta, Canada'. *Global Forest Watch Canada* (2009), p.30

40 'Oilsands 101: Reclamation'. *Pembina Institute*. Accessed 25 February 2014. ‹http://www.pembina.org/oil-sands/os101/reclamation#footnote1_x43kjjk›

41 'Reclamation Illusions in Oil Sands Country'. *Parkland Post*. Accessed 25 February 2014. ‹http://parklandinstitute.ca/post/story/reclamation_illusions_in_oil_sands_country/›

42 Jennifer Grant, Simon Dyer, Dan Woynillowicz. 'Oil Sands Myths: Clearing the Air'. *Pembina Institute*, June 2009, p.23. ‹http://www.pembina.org/pub/1839›

43 Op. Cit. 'Oilsands 101: Reclamation'. *Pembina Institute*

44 Op. Cit. 'Oil Sands Myths: Clearing the Air'. *Pembina Institute*, June 2009

45 'Fort Chipewyan Cancer Study Findings Released'. *Alberta Health Services*. Accessed 25 February 2014. ‹http://www.albertahealthservices.ca/500.asp›

46 Ian Urquhart. 'Between the Sands and a Hard Place?: Aboriginal Peoples and the Oil Sands'. Buffett Center for International and Comparative Studies Working Paper No. 10-005: Energy Series, *Department of Political Science, University of Alberta*, November 2010, pp.9,12,13

47 'Alberta MD: Canada "Lying" About Tar Sands Health Impacts'. *Environment News Service*. Accessed 7 March 2014. ‹http://ens-newswire.com/2014/02/27/alberta-md-canada-lying-about-tar-sands-health-impacts/›

48 'Survey of Energy Resources 2010'. World Energy Council. ‹http://www.worldenergy.org/publications/3040.asp›

49 Ibid

50 'Alberta Energy: Facts and Statistics'. Accessed 25 February 2014. ‹http://www.energy.alberta.ca/OilSands/791.asp›

51 Op. Cit. (WEC 2010)