Tar Sands Report

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Tar Sands or “Oil Sands” are a type of petroleum deposit, where the oil compound Bitumen (a hydrocarbon, naturally occurring in a mixture of sand, water and clay) is found. The largest deposit currently being mined is in Alberta Canada, with substantial deposits also found in Venezuela, Kazakhstan and Russia (Meyer, Attanasi, Freeman, 2007). The extraction and refinement of bitumen is an extremely dirty process that requires a lot of energy, money and has significant impact on the surrounding environment, which is why the Tar Sands are so controversial (Taylor, 2014). These reserves normally occur close to the surface, in Alberta the Bitumen is being extracted via surface mining. Surface mining, often referred to as “Open Pit Mining” or “Strip mining” creates large pits resulting from the physical removal of the oil, sand, and clay mixture. To extract bitumen deposits found deeper in the earth, In-situ mining is used. This process requires the ‘heating up’ of bitumen, accomplished through the use of heating probes or steam injection into deeper holes in the tar sands. When heated, the bitumen mixture is fluid enough to be pumped out of the earth for refining. To be usable, the Bitumen must be separated from the clay, sand, and water regardless of the extraction process. The refinement process has several steps; first, the mixture is pumped with hot water to separate most of the sand and clay from the bitumen. Second, Naphtha dilutes the mixture to further isolate the bitumen and make it fluid enough for efficient transport. Lastly, the mixture is upgraded on site or transported to a facility where the bitumen can become usable synthetic crude oil. (Rudzinski, 2015)

Transportation is a costly process and has potentially irreversible environmental effects. As of now, the most efficient method of transporting the bitumen/Naphtha mixture from Alberta to a Port city is via pipeline. This eliminates the excess emissions of CO_2 from vehicles transporting the mixture, as well as the safety hazard of driving with extremely flammable materials. However, if the pipeline were to be damaged, there would be significant amounts of oil leaking into the environment. This potential danger brings much controversy as well as the social implications of constructing pipelines on Indigenous land (Firempong, 2018). The Wet'suwet'en defenders have been some of the most vocal Canadians attempting to combat the

construction of this pipeline through their home. However, it is important to distinguish these protests into two issues, as they are both protesting against the potentially hazardous pipeline, as well as defending their right to live on their own land. Due to the significant environmental, social and political concerns surrounding this energy source, much research into alternative fuel sources, methods of extraction that cause less environmental harm, and the reduction of petroleum use, are all needed to prevent the further degradation of our environment.

Economics and Investments

Canada has the world's third largest oil sand deposits capable of producing 170 billion barrels of oil, such that between 2019 to 2029, the oil sand industry is estimated to contribute about 1 trillion towards Canadian economics ("Canada's Oil Sand", 2019). Most projects of this nature are funded by various private sectors from different parts of the world, and as a result the Canadian tar sand projects not only contribute to the Canadian economy, but also the global economy as a whole (Canada, 2016).

Tar sand mining is a huge endeavor requiring large amounts of investments which all vary depending on the extraction method used, refinery process, and maintenance. For example open pit mines are usually larger projects requiring greater operation costs, whereas in situ mining projects are relatively smaller requiring less investments for operation (Heyes et al., 2018). Following the extraction operation, companies have to decide on the final products produced. Depending on the transportation and refinery process, the products price may rise or fall. This process, known as the discount rate, represents the oil price at which companies can expect a 10% revenue in capital expenditure. However, the discount rate for Western Canada Trade and the Western Light trade is determined by the West Texas Intermediate (WTI), which is different from the other benchmarks in other parts of the globe (Heyes et al., 2018).

Aside from project investments, companies are also responsible for other costs such as carbon emission, land reclamation, royalties, and taxes (Heyes et al., 2018). Royalties and taxes paid to the government can be then used towards health care, education, and various public services, which directly benefits Canadian communities. An additional benefit to Canadian comes in the form of employment opportunities. In 2017 about 200,000 employees were working

in the oil sand industry, as both direct and indirect employees. Canadian oil sand productions being situated in Alberta, this industry obviously brings the most direct benefits to this province. Above average wage, greater employment opportunities, and productivity, are all benefits Alberta gains through the tar sand industry. ("Canada's Oil Sand", 2019) Although the oil sands provide benefits to the Canadian economy and communities, there are many other aspects such as environmental harm that also deserve to be considered. Paying taxes and environmental fees may advance the Canadian economy, but the ensuing environmental damages are not easily ignored.

Social concerns

There are a number of large social concerns regarding the tar sands, most of which stem from environmental issues created by the tar sands themselves. The Athabasca river and surrounding lands have long been used by Dene, Cree First Nations, and Métis peoples as a practical space to hunt and gather and as well as an important place spiritually and culturally, holding traditional significance dating back many generations (Thomas-Muller Clayton 2008). While part of the agreement with the canadian government stipulates the land must be reclaimed eventually (NRCan 2019), right now much of the land is off limits to anyone not working on the tar sands; with even more of the land almost completely destroyed as the forest is cleared and toxic waste is dumped in pools next to the river. The land that many families grew up on, is now unrecognizable and traditional ways of life rendered impossible as the ecosystem is destroyed. Air pollution and acid rain are real concerns for locals, and some Athabascan people are blaming an increase in the heart disease of their youth on the tar sands. (NatGeo 2019) As new issues continue to arise and effects spread to the physical wellbeing of the surrounding people, a tax on the quality and viability of life for Canadian's in this area is added to the list of concerns for the tar sands.

The Athabasca river was also a key part of the environment in this area, providing a home for fish and waterfowl as well as a source of safe drinking water for both the people and animals who live and migrate through this area. This water source is now compromised by the tar sands as Biological scientist David Schindler reported, "elevated levels of mercury, lead and eleven

other toxic elements in the oil sands' main freshwater source, the Athabasca River, refuting long-standing government and industry claims that water quality there hasn't been affected by oil sands development." (Globe and Mail 2010) While everything surrounding the tar sands is well regulated and documented, with restoration to come during and after the tar sands mining is finished, it is difficult to ignore the serious cost currently being born by the people and wildlife of this region. It is reassuring that if all goes well the Athabasca river and surrounding lands will be restored at some point in the future, but this does little to console the people torn away from the homeland they grew up on for the sake of fossil fuel.

Environmental Impacts

Although tar sands are a major contributor to our economy and energy supply, they have a significant impact on our environment affecting the air, water and land. "The tar sands have become the fulcrum of Alberta's energy economy and the large scale of the expansion of the mined area has created serious environmental impacts" (Carter, 2010, p.5). The tar sands operations are known to be dirty when compared to other types of oil extraction, as they are "estimated to release at least three times the greenhouse gas emissions per barrel as compared to production of conventional crude oil" (Bruno, 2010, p.7).

The tar sands are located beneath Canada's globally significant boreal forest which represents "one quarter of the world's remaining intact forests" (Woynillowicz, 2007, p.2). Boreal forests are a complex ecosystem made up of coniferous forests, inland water and wetlands. Not only do these forests provide a habitat for many species to live, they also are extremely important when it comes to removing carbon dioxide from the atmosphere. Tar sands development has had a substantial impact on the boreal forests and habitat, while further development projects suggest the expansion of the tar sands will continue. Alberta's oil sands cover 140,000 square kilometers, with approximately 760 of those being heavily disturbed through the process of surface mining. Although the damage is not permanent, the primary extraction method (surface mining) only allows 20% of the oil sands to be recovered. In-situ process on the other hand allows 80% to be recoverable. Alberta has land management and reclamation programs said to ensure disturbed lands can be productive and able to support

similar aspects of the environment as they did prior to disruption. To help guarantee the restoration of the land, companies must follow strict environmental standards shown by figure 1. (Poveda & Lipsett, 2013, p.580).

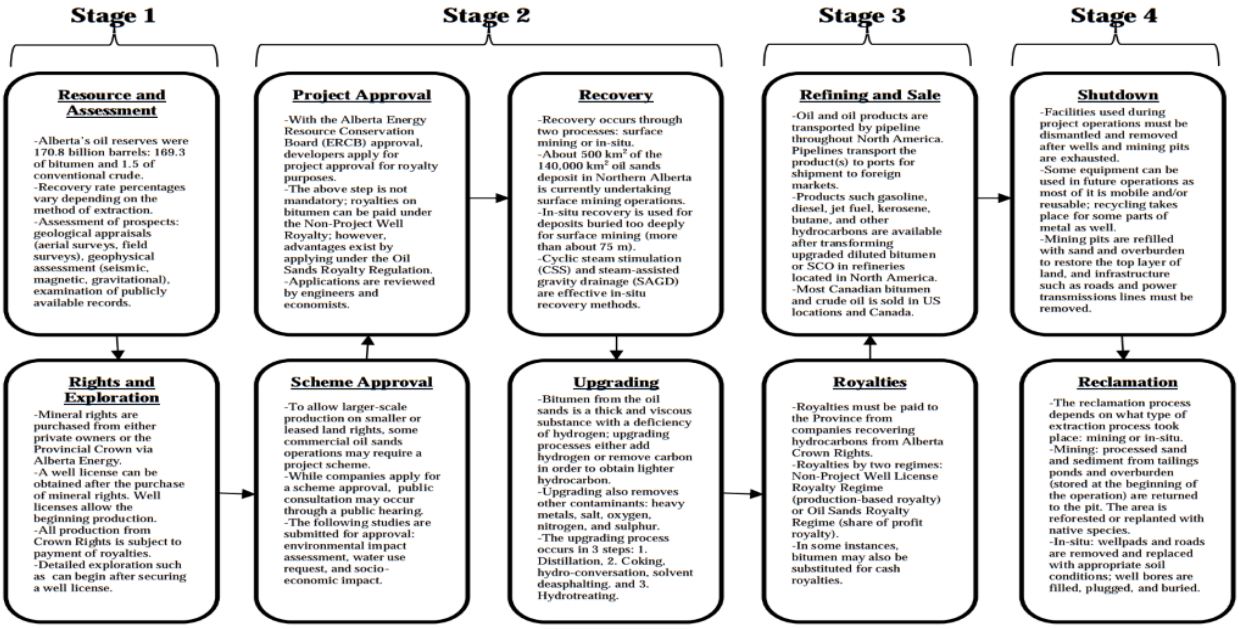

Figure 1: Oil sands resource life cycle.

Poveda and Lipsett (2013) state "currently, only 67 km^2 of disturbed land have been reclaimed but not certified, which indicates less than 10 percent of the total disturbed area" (p.581). In comparison to the rapid development of tar sands, the speed of the restoration process is not able to keep pace with the destructive nature of their operations, meaning it is difficult to ensure these areas will be habitable again.

Water resources have been affected by the tar sands in various ways from water consumption, quality and quantity of groundwater, and contamination of water sources. The amount of water used during the oil extraction process is dependent on the method of extraction. In-situ method uses between 2 to 4.5 barrels of water per barrel of bitumen produced with approximately 90% being recycled. Surface mining uses 7.5 to 10 barrels of water with only 70% being recycled. In both operations large amounts of waste are produced and disposed in

landfills, tailing ponds, or injected underground. The tailing ponds act as a disposal area "for coarse and fine tailings, to allow water to separate from solid waste materials, to store water from recycling, and to hold contaminants" (Poveda & Lipsett, 2013, p.582). The more significant risk is from the waste called tailings, which are composed of water, sand, clay, residual bitumen, contaminants, and hydrocarbons. "Contaminants in the tailings include naphthenic acids, polycyclic aromatic hydrocarbons, phenolic compounds, ammonia, mercury, and other trace metals" (Bruno, 2010, p.11). Not only are these contaminants toxic to aquatic life, they are also a threat to migratory birds that land on the tailing ponds. Another environmental concern regarding these ponds is leakage and contamination into groundwater. Bruno et al. (2010) suggests "that as much as four billion liters of tailings leak each year" (p.11). There are specific tailing pond management procedures in play to reduce the risk for wildlife and to help move the ponds into reclamation sooner. Some protection techniques used for waterfowl landing on tailing ponds are "cannons, scarecrows, decoy predators and radar/laser activated acoustic deterrent systems like those used at airports to scare birds away" (CAPP, 2019). The reclamation process for the tailing ponds "represent an immense long-term reclamation challenge for the industry," (Bruno, 2010, p. 12) and because of this, the government requires financial assurance from the oil companies ensuring reclamation plans are in order and ready to be executed.

One of the major environmental issues regarding the tar sands are the effect they have on the air and greenhouse gas emissions. Poveda and Lipsett (2013) state "more than 1,400 known pollutants are emitted by oil sands operations, but only a few are monitored: sulphur oxides (SOx), nitrogen oxides (NOx), hydrocarbons, and fine particulate matter (PM2.5)" (p.581). Most of the air pollution comes from the greenhouse gases released during the oil extraction process, while other pollutants arise as a result of the tar sand mining operations themselves such as the usage of machinery and trucks. Since the extraction and upgrading processes of synthetic crude oil requires large amounts of energy compared to the production of conventional oil, global warming pollution is three times higher per barrel of crude oil produced. Not only is the production and upgrading procedure of the crude oil cycle causing higher greenhouse gas emissions, "the refinement, transportation, and consumption of oil cause 80 percent of the total emissions which occur at the end of the cycle from burning fuel" (Poveda & Lipsett, 2013, 581).

Although Canadian tar sand companies have reduced their carbon dioxide emission by 33% since 1990, it remains the fastest growing source of global warming pollution, accounting for 6.5% of the nation's total greenhouse gas emissions. Poveda and Lipsett (2013) state that “the GHG emissions per barrel have been reduced between 1990 and 2009 by an average of 29%; however, emissions of (SOx) and other sulphur compounds (NOx), as well as total hydrocarbons, have been rising for the past decade due to the growing increments in production” (p.581). Because tar sands are a major contributor to Canada’s economy and energy supply, and the rapid growth of the oil industry, the challenge to meet the required greenhouse gas emission reduction commitment, creates political challenges for Canada.

Sustainable Solutions- Syncrude Canada Ltd.

With the rise of climate change and the negative environmental factors mentioned, it is crucial to think of innovative ways to treat our environment better so we don’t feel the costs in the future. Many powerful companies and stakeholders have created innovative ways to become more environmentally friendly. Syncrude is one such company. One of Canada’s largest tar sand mining industries, Syncrude runs out of Fort McMurray and the Athabasca oil sands. Each year Syncrude provides a performance overview for the company, with a strong emphasis on environmental stewardship outlining their efforts to create a more sustainable operation. The specific areas of focus include: air quality, energy and climate change, biodiversity, land reclamation, and water and tailings management.

Emissions of sulphur dioxide originate from three fluid cockers and are managed though dry and wet scrubbing techniques (Syncrude, 2020). A flue-gas desulphurization unit captures and converts sulphur oxide into an ammonium sulphate (Syncrude, 2020). This unit uses the wet process to remove sulphur oxide which results in a high amount of water vapour traveling through the stack. The sulphur oxide recovery is currently around 96%, allowing for an overall 50% decrease of sulphur oxide emissions between the year 2013-2017 (Syncrude, 2020)!

Syncrude has also developed technology to reduce naptha losses. Naptha losses are volatile organic compounds which are a very flammable hydrocarbon mixture. Syncrude has the VOCs directed through wastewater streams, including storage tanks and Mildred Lake Settling

basin (Syncrude, 2020). The company also must comply with a leak detection and repair program through the Canadian Council of Ministers of the Environmental Code of Practice (Syncrude, 2020). In addition to sulphur oxide and VOCs, Syncrude also has a primary goal of minimizing nitrogen oxide emissions. To achieve this goal, they focus on fuel quality, engine selection, operating and maintenance practices, as well as mine plan efficiency (Syncrude, 2020).

To date, Syncrude has reclaimed over 3,800 hectares of land and replanted around 8.5 million trees and shrubs (Syncrude, 2020). The company's reclamation initiative aims to make previous tar sand mines look exactly the same as how they left it. One project used to ensure the long-term support of native vegetation and wildlife habitats is through a fen-watershed. The watershed acts as a drainage basin to remove tailings sand, and is integral in reestablishing an ecosystem (Syncrude Sustainability Report, 2017). A fen-watershed supports peat soil which has a high storage capacity allowing it to be very fertile. The wetland in this area is characterized by many peat forming species as well as inhabited wildlife. Syncrude's environmental programs reflect their awareness of this ecosystem and value the biodiversity present.

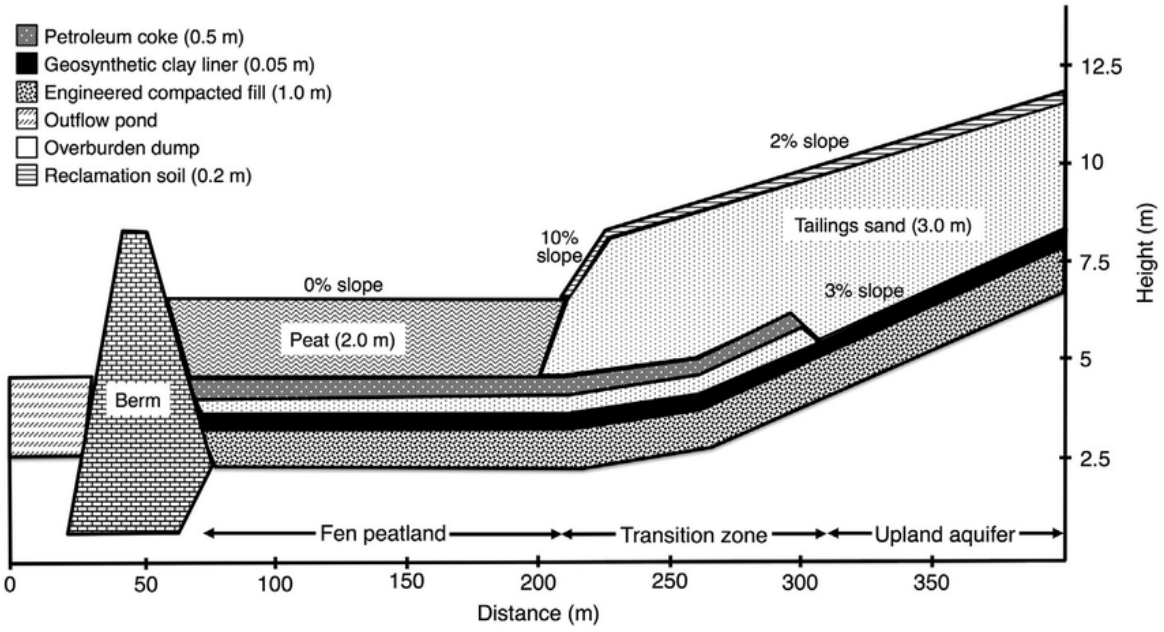

Figure 2: (Scott Keetchenson, 2016) Cross-section of the Nikanotee Fen watershed

Syncude must adhere to environmental regulations every 10 years, closely following the Alberta Environmental Protection and Enhancement Act, and the Alberta Wildlife Act. Several programs and research initiatives have been established to access and monitor the cumulative environmental effects at a regional scale (Syncrude, 2020). This work has been undertaken by the government, as well as Indigenous communities, health organizations, and environmental advocacy groups such as the Wood Buffalo Environmental Association(Syncrude Sustainability Report, 2017).

Syncrude gets its water from the Athabasca river. 15% of this water provides Syncrude with the liquid they need for cooling, generating steam and potable water, while the other 87% of the imported water goes towards the bitumen extraction process (Syncrude, 2020). Tailing ponds are the by-product of the hot water treatment process used to separate the oil from sand and clay in oil sands mining (CAPP, 2019). Due to the high input water use of the oil sands, tailings management is the primary focal point for improvement (CAPP, 2019). Canada's Oil Sands Innovation Alliance (COSIA) has collaborated with Syncrude and other oil producers in improving oil sand production. (Syncrude, 2020). Today, 85% of the water used in the bitumen extraction process is recycled from the tailing settling basins (Syncrude Sustainability Report, 2017). Although there are environmental consequences Syncrude cannot avoid, it is important to recognize the responsible and sustainable development goals this specific company has started to implement. Syncrude has upgraded their equipment with sustainable technology, uses adaptive monitoring techniques for wildlife, reclaims land and reestablishes ecosystems of the boreal forest that was previously mined, improved production efficiency, all while collaborating with many other stakeholders to help protect the air, water, and land of this environment.

Alternatives

Fossil fuels remain the dominant source of primary oil, with petroleum coming from tar sands production being the single largest fuel in the mix (Carson, 2011). Evidently, petroleum oil aids in most aspects of our life, through common uses such as heating our houses and fueling our cars even to the lotion we apply on our body all the way down to the shoes we wear on our feet.

Many petroleum based products we use on a daily basis are replaceable. An important factor is knowing what ingredients are prevalent in our products and being mindful that there are alternatives to petroleum based products already out there. An example of this could be looking for products that are natural, plant-based, or biodegradable. Most lip balms, lotions, soaps, deodorant, perfume, shaving cream, tooth paste, shampoo, and laundry detergent come from petroleum jelly which is not easy on your stomach or skin (Smarter living, 2010). For plastic products such as storage containers, packaging, and cups; remember to bring reusable grocery bags to the store, buy in bulk or reuse products whenever possible! Environmental change is possible if we as humans lesson the demand to lesson the supply!

Future of Oil Sands

Bitumen Remaining

There are still vast amounts of bitumen remaining in reserves around the world with estimates of global deposits in excess of 2 trillion barrels (Wikipedia), much of which can be found in Canada. Canada has roughly 70% of the world tar sands (Bauquis, 2006) and it has been hypothesized that if only 30% of Canadian bitumen oil could be extracted that this would provide North America with oil for 100 years, based on 2002 production rates (Wikipedia). A new production plant, the Frontier oil sands mine, is currently being planned to be built in Canada. Looking to the future, it is not likely that this resource will become depleted, however there are several other constraints which are likely to impact this resource. These come from production limitations as well as concerns for more environmentally sustainable production of tar-sands oil.

Production limitations

The future of the oil industry in general is dependent on market price vs. cost of production. The demand for oil is expected to remain high, meaning the limiting factor will be the cost of production. In terms of tar-sands oil, the limiting factor in production costs will come from market access (CAPP, 2019). To keep up with demand, production of oil in Canada from

tar-sands producers is expected to increase in the coming years (CAPP, 2019), meaning more oil will need to be transported from the production plant. Many oil-sands producers rely heavily on pipelines to transport oil, as it is the most cost effective in the long term and provides direct access from the production plant, and producers believe that this is the limiting factor in oil transportation. The pipelines remain a constant source of controversy as there is a conflict between economic benefit and environmental/ethical concerns.

Environmental constraints and new Technologies

The oil-sands are known for their high environmental costs and have been branded on the most destructive oil operation in the world (NatGeo, 2019). In order to mitigate future environmental impact by tar-sands production, an emission cap of 100Mt of GHG (greenhouse gas) emissions has been placed on oil-sand producers (REF). While this has been predicted to reduce potential oil production, it has prompted research into more sustainable methods of bitumen extraction and refinement. Carbon Capture and Storage (CCS) techniques have been developed to reduce the amount of CO_2 entering the atmosphere (CAPP, 2018). These CCS methods rely on directing the CO_2 produced, into geological formations in the ground.

Alternate heating technologies have been developed to replace the current method of burning natural gas, and can be implemented to allow for fewer emissions and less water consumption by oil producers. These technologies include: light hydrocarbon injection, heating bitumen underground by using electromagnetic waves (CAPP, 2018), and DCSG (Direct Contact Steam Generation). Light hydrocarbon injection relies on injecting a light hydrocarbon solvent, rather than steam, into bitumen reserves to dilute the bitumen so it will flow better (Marin Sr, 2015). DCSG uses recycled water to continue reheating bitumen in the ground and has been labelled as “virtually a closed loop” (NRCan, 2019). In terms of resource usage, this allows oil extraction to be both more environmentally sustainable, as well as more economical.

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