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An Economic and Environmental Analysis of Oil Sands Development Projects

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Abstract:

This paper explores the recent expansion of oil production in the tar sands of Alberta, Canada. The purpose of this paper is to evaluate the oil sands development projects in terms of economic and environmental impacts. This paper considers available studies and data, and acknowledges the need for peer-reviewed studies concerning environmental impacts of oil sands' development. This study provides guidance to policy makers and stakeholders in Alberta's oil sand development projects. It is hoped that greater balance between environmental protection and economic growth be realized. The economic impacts of tar sand developments need to include qualitative measures rather than Rely solely quantitative considerations.

Keywords: Oil sands, ecological impacts, energy policy, energy subsidies, carbon tax

1. Introduction

Ecology and economics share the same Greek root word 'oikos', which means house or household. Ecology is the study of nature's household, and economics is the management of man's household. Nature requires many similar elements to mankind, namely clean air, water, soil as well as a source of energy to perform tasks. As a fundamental player in both systems, energy provision is of paramount importance as a fuel for economic activity as well as life itself. This paper will address this relationship between critical factors for environmental health, as well as human health, by focusing on energy production.

Energy is the driving force behind all of life's processes, as well as a prerequisite to all economic activity. The vast majority of the world's energy continues to be supplied by fossil fuels, which is not likely to change anytime soon. While conventional oil production is already in the process of declining production, unconventional oil sources will be relied on to both make up for the decline in conventional oil production as well as meeting growth in future demand.

This paper explores the recent expansion of oil production in the tar sands of Alberta, Canada. The tar sands are the biggest capital project on earth. (Hatch and Price, 2008; Nikiforuk, 2008) Tar sand production is predicted to reach 5.3 million barrels per day by 2030, supplying 5% of global demand. Current expansion in tar sand activity will lock in production for decades to come, and thus, presents an ideal opportunity to compare the ecological and economic partnership in meeting our energy needs. This paper will first assess the impacts that tar sands oil production has on healthy water, air and food and then discuss these implications.

Of notable omission in this paper will be reference to the hotly contested global warming issue. While the precautionary principle supports man's need to act at reducing global warming threats, this paper posits the need to transition toward renewable energy solely based on the need for a healthy future for our life systems, and to create an economy providing meaningful and satisfying jobs for a prosperous future.

2. Methods

This paper considers research associated with the economic as well as environmental impacts of oil sands development. Environmental monitoring of tar sands' effects is in need of greater emphasis in determining large scale effects, and long-term conclusions. Due to the lack of environmental monitoring in Alberta, studies on health impacts are limited. This paper considers available studies and data, and acknowledges the need for peer-reviewed studies concerning environmental impacts of tar sands' development. Economic data has been compiled and analyzed from published reports.

3. Results

The next section begins with an overview of oil and tar sands' current role in energy provision. Next, we explore the tar sands project from an environmental perspective, including impacts on air quality, water quality, soil health, and animal effects. Lastly, we explore the effects from an economic perspective, including the benefits of job creation as well as lowering fuel prices for consumers. The final section concludes.

3.1. Oil's Role in Providing Energy

Oil is a crucial source of energy and is supplied by conventional and unconventional oil sources. The world consumed 85.7 million barrels of oil per day in 2011, and is expected to reach 104 million barrels per day by 2030. 'Conventional' oil, also called crude oil, refers to oil extracted from wells, and remains the dominant source of oil supply in

the world today. Conventional oil production grew at approximately 1.5% per year from 1995- 2005, after which has plateaued with more recent increases in world oil supply deriving from unconventional sources such as natural gas liquids, oil sands, and tight oil. Unconventional oil sources extract and process oil using alternate methods than the flow of oil from underground wells, and is expected to shoulder a growing share of future global oil production.

While the timing of conventional oil production peaking is not unanimously agreed, most estimates forecast production decreases before 2030, with many forecasting that we are already beyond peak production (IEA, 2012). The decline in conventional oil production coupled with increasing world demand ensures increasing production from unconventional sources. Unconventional oil is anticipated to comprise 13.6% of global oil production by 2035 (IEA). The oil sands of the Athabasca Basin in Alberta, Canada, is already an important contributor to the global oil supply, and is predicted to supply 5.2 million barrels per day by 2030 (CERI, 2014).

3.2. Tar Sands Oil Production

The tar sands are a near-surface mixture of sand, water, clay and bitumen, the latter of which is the heaviest, thickest form of petroleum. Current production in Alberta uses surface mining or various in-situ methods involving the use of steam. Surface mining uses enormous trucks to haul away tones of material to processing facilities for extracting the bitumen from the mixture. In-situ forces steam down shafts to liquefy bitumen for extraction. Bitumen contains more impurities than conventional crude oil, such as nitrogen, sulphur and heavy metals. In order to produce an intermediate product, called synthetic crude oil, which can be transported for further processing, these impurities must be removed.

The extraction and refining of the oil sands requires much more energy than does the extraction and refining of conventional oil. Bitumen has a high resistance to flow, similar to that of molasses. This requires additional energy-intensive processing in order to refine bitumen to allow it to flow through pipelines. The large energy requirements for producing useable fuel from the oil sands have spurred discussion of constructing nuclear power plants in Fort McMurray, Alberta, to supply the tar sands' energy needs (Gold, 2006; Simpson 2007).

3.3. Tar Sand Oil Extraction's Adherence to Life Systems

Both man and nature require clear air, clean water, and healthy food. Recent studies have suggested that tar sands development impedes these basic tenets of life.

3.3.1. Healthy Life Systems Require Healthy Water

Water comprises most of the human body and is required in vast amounts for tar sand oil production. Freshwater usage will increase by 170% if production estimates are met by 2030. The Athabasca River water withdraw has nearly doubled in the last 12 years (Alberta Environment and Sustainable Resource Development, 2012). With the water flow expected to decrease 30% by 2050 from climate change, the water system's future is threatened.

More than 95% of water used in tar sands activities is drawn from the Athabasca River, which is an integral part of one of the largest watersheds in the world. When water is withdrawn is extremely important. Low flow winter months have a greater impact, which affects the reproductive patterns of fish and other aquatic species (Dyer et al., 2013). Tar sands companies are not required to stop withdrawing from the Athabasca River even when fragile aquatic habitats are at risk. (Dyer, 2013) In addition, an estimated 11 million liters of toxic waste seep into the Athabasca River and watershed daily. (Environment Defense Canada, 2008)

A challenge exists in assessing the oil sands' effect on the Athabasca River and watershed. Inadequate water monitoring has prevented sufficient data to draw conclusions in many instances. Independent research continues the attempt to fill in these research gaps, and has recently revealed that fish and other species' growth and reproductive cycles are being negatively impacted by tar sand activities (Society of Environmental Toxicology and Chemistry North America, 2012). Water that does not meet provincial quality standards containing lead, mercury, zinc, PAHs were discovered by University of Alberta researchers downstream from tar sands operations. (Kelly et al., 2010)

Approximately 250 million liters of wastewater are produced everyday processing oil sands in Alberta. The vast majority of waste water gets stored in tailing ponds along with process wastes including salts, naphthenic acids, ammonia, mercury, arsenic, lead, toxic hydrocarbons, and pollutants. As tailing lakes settle, water is removed from the top of these ponds, which results in the ponds becoming increasingly more toxic.

Tailing ponds are visible from outer space, and cover 220 square kilometers in northern Alberta (CBC, 2015; Weber, 2015). These massive collections of heavily polluted water require enormous dams for containment, including the world's largest damn responsible for containing wastewater from a single tar sands project (U.S. Department of the Interior, 2012).

The future threat of tailing ponds polluting the watershed from containment failure is of serious concern, though its adverse effects are already happening. These ponds contain toxic chemicals such as arsenic, benzene, lead, mercury, naphthenic acid, and ammonia (Nix and Martin, 1992).

Arsenic

Exposure to arsenic is becoming a national issue, and potentially a national crisis (Timoney, 2007). In 2009, the tar sands produced 322 tonnes of arsenic (Vanderklippe, 2010). Arsenic is a known carcinogen, and has been linked with bile duct, liver, urinary tract, and skin cancers as well as vascular diseases and Type II diabetes (Guo, 2003). Drinking water with high levels of arsenic have long-term effects of thickening and discoloration of the skin, nausea and diarrhea, decreased production of blood cells, abnormal heart rhythm and blood vessel damage, and numbness in the extremities. Short-term exposure can result in gastro-intestinal disorders, muscle cramping or pain, skin rashes, numbness or burning

sensations in the extremities, loss of movement and sensory responses, among others. Exposure is primarily through food, followed by water, soil and air.

3.3.1.1. PAHs

It is of some concern that levels of PAHs in sediment of the Athabasca River are about twice that observed to induce liver cancers in fishes (Myers et al. 2003). Laboratory studies on animals have demonstrated PAH exposure can lead to reproductive and birth defects, decreased body weight and harmful effects on skin, body fluid and the immune system. Many PAHs are known or expected human carcinogens (ATSDR, 1995). Fish hatching alterations, increases in mortality, spinal malformations, reduced size, cardiac dysfunction, edema, and reduction in the size of the jaw and other craniofacial structures have been observed in fishes exposed to PAHs (Tetreault et al. 2003; Colavecchia et al. 2004, 2006, 2007; Incardona et al. 2004).

Areas of the Athabasca watershed now exceed Canadian standards for 7 PAHs, including benzo(a)pyrene, which has been linked to cancer, genetic damage, reproductive impacts including birth defects and organ damage (2012 National Academy of Sciences). Extreme concentrations of PAHs present in tailings may lead to the evaporation of those PAHs into the ambient air. Further, the releases of PAHs into the ambient air from tar sands upgrading facilities discussed above are finding their way into the Athabasca River and its numerous tributaries (National Academy of Sciences, 2014).

3.3.2. Healthy Life Systems Require Healthy Air

A person breathes between 20,000-30,000 times each day. Healthy air supplies necessary materials for life's processes. Furthermore, the air is a needed transportation system to remove wastes. Serious problems arise when polluted air prevents the delivery of needed elements to the body, compounded by the delivery of harmful chemicals in their wake.

Recent air quality studies reveal that tar sands are contributing high levels of dangerous airborne pollutants such as nitrogen oxides, mercury, sulphur dioxide and particulate matter. With plans to increase production to 5.2 million barrels per day by 2030, these problems stand to increase in magnitude and further deteriorate air quality in the region. Even the few regulations that are in place concerning air quality are lower than WTO international standards for healthy air, and are often entrusted to oil sand companies themselves to monitor. A 2013 study of air samples in Northern Alberta discovered cancer-causing volatile organic compounds (VOC) at concentrations 6,000 times higher than normal (Griffen, 2013). According to the United States Environment Protection Agency (USEPA), symptoms associated with VOC exposure include eye irritation, nose and throat discomfort, headache, allergic skin reaction, nausea, nosebleeds, fatigue, and dizziness. Some VOCs, like benzene, are highly carcinogenic in humans. The same study found increased incidence of rare cancers associated with these dangerously high levels of air pollution.

The tar sands produced 111,661 tonnes of sulfur dioxide in 2009 (Vanderklippe, 2010). Sulfur dioxide pollution makes it difficult to breathe, and puts additional strain on those suffering from disease-weakened heart and blood circulation systems. Short-term exposure to elevated sulfur dioxide levels is associated with reduced lung function, chest tightening, wheezing, shortness of breath, respiratory illness, deterioration of the lung's defense systems, and the aggravation of cardiovascular systems (EPA).

3.3.2.1. Nitrogen Dioxide

Nitrogen dioxide levels are reaching dangerous levels in Alberta's Lower Athabasca region (Dyer et al., 2013). While improvements have been made on pollution of nitrogen dioxide on a per barrel, total production amounts continue to rise as a result of increased production. According to the USEPA, nitrogen dioxide exposure impacts the respiratory system, including airway inflammation in healthy people and increased respiratory symptoms in people with asthma. It can cause or worsen emphysema and bronchitis, and can aggravate existing heart disease leading to premature death.

3.3.3. Food

Plants and animals are both affected by tar sands activities which diminish the ability to provide sustenance and energy to man. A major threat to plant life lies in the growing acidity in the soil as a result of emissions from tar sands activities. Animals carry toxins obtained from fundamental life processes such as eating, drinking, and breathing contaminants.

3.3.3.1. Threats to Food from Plant Life & Fish- Acid Rain

More than 150,000 tonnes of acid rain-causing gases every year, such as sulphur dioxide and nitrogen oxide, are produced by Alberta's tar sands (Weber, 2009). Studies suggest that about 70% of these gases blow into Saskatchewan, causing the majority of problems in regions downstream of tar sand activities. Rainfall samples from La Loche, Saskatchewan, located near the tar sands region, have shown pH levels about three times as acidic as unpolluted rainfall (Weber, 2012).

A 2008 study discovered that up to 12% of Alberta's forest soils reached limits on how much acid they could absorb, and that 2% of Saskatchewan soils downwind from Alberta were also at peak limits of acid absorption. This acidic deposit leads to damaging tree roots and leeches' nutrients too deep for plant life to access, resulting in loss of plant life.

3.3.3.2. Threats to Food Source- Animals

The effects of pollution from the tar sands affects animals in various ways. Contamination through food and water makes animal meat dangerous for human consumption, as well as causes health effects for animals. Polluted waterways present additional harms for aquatic life, which experience a host of health problems and are also made unfit for human consumption. Two serious threats to animal health are methylmercury levels as well as polycyclic aromatic hydrocarbons (PAHs). Tailing ponds present additional threats to fish and birds.

Contaminants such as mercury and arsenic are already causing deformities and impacting life cycles, and whose concentrations continue to rise. Research has found elevated levels of environmental contaminants arsenic, cadmium, mercury, and selenium, as well as PAHs in moose, ducks, and beavers (McLachlan, 2014). Fish and big game animals have been found covered with tumors and mutations.

Fish face particularly severe effects from tar sands activity due to their sensitivity to environmental factors. Fish deformities have begun to be linked to tar sands operations (CBC, 2010). Acid rain has serious implications on the loss of fish in acid sensitive lakes and streams.

3.3.3.3. Methylmercury

Methylmercury is a dangerous compound which the World Health Organization states that even small exposure may cause serious health problems. Recent studies have shown mercury levels rising in the tar sands region. (Wingrove, 2013) The primary health effect of methylmercury is impaired neurological development (EPA). Mammals with toxic levels exhibit abnormal behavior, eating disorders, loss of balance, lack of coordination, and paralysis of legs (Environment Canada 2005). Environment Canada reports that bird eggs downstream of Alberta's oil sands have been found to contain rising traces of mercury, with some samples now above the threshold that could be considered dangerous (Wingrove, 2013).

Methylmercury accumulates in the food chain, which is of particular consequence for members of the First Nations who rely on hunting and fishing for sustenance. Studies have found that all walleye (pickerel), all female whitefish and around 90% of male whitefish, fillets of sucker, goldeye, pike, burbot, and lake trout are considered unsafe to eat under US EPA guidelines (Timoney, 2007).

3.3.3.4. Tailing Ponds

Tailing ponds are a toxic waterway dangerous to animals, particularly birds. Tailing ponds fire off cannon noises to scare off birds from landing due to the fact that the ponds are too sticky for birds to escape from. Syncrude, which operates one of the biggest oilsands sites, was fined \$3-million for the deaths of more than 1,600 ducks when they landed on its tailings pond in 2008. In October 2010, more than 550 birds had to be destroyed when an early winter storm forced the birds to land on the toxic waste ponds belonging to Syncrude and Suncor. These events are among many examples revealing the danger for birds posed by tailing pits (The Globe and Mail, 2014).

4. Results

Our economic system encourages reliance on fossil fuel sources in meeting our energy needs. Government subsidies encourage job creation in these industries, while lowering costs to consumers.

4.1. Lowering Costs to Consumers

Subsidies to the fossil fuel industry lower prices for consumers by having government paying for part of the cost of production. While ethical debates surround the use of subsidizing a profitable industry, the results of lower costs will be discussed below. We will consider the effects lower prices have on consumption.

4.1.1. Lower Prices to Consumers

Subsidies act to distort the market, increasing consumption by lowering prices. Problems with increasing consumption with lower prices are threefold. First, it disincentivizes efficiency. Also, increasing consumption with lower prices creates additional pollution than would be the case with higher prices and less consumption. Lastly, subsidies distort the fossil fuel price, which makes the transition to greener technology more difficult.

Lower prices create less incentive to reduce consumption. Prices signals affect consumption patterns. At lower prices, consumers care far less about conserving resources than would be the case with higher priced goods. This waste of resources is particularly troubling with a finite supply of fossil fuels.

The wasted resources are compounded by the fact that their consumption releases a myriad of chemicals and compounds into the air, water, and soil. The increased harm to life and life systems is a major cost to society by using government revenue for fossil fuel subsidies.

Lower prices of oil cause renewable energy options difficulty in making inroads for providing energy. In order for renewable energy to become feasible, it must become cost competitive with oil. By distorting the prices of oil, renewable energy must duly lower costs accordingly in order to gain market share and for society to realize the benefits of greener energy provision.

4.2. Job Creation

Investment creates need for additional labor to perform the work created from expanding operations. The Oil Sands are misunderstood as providing high-paying and satisfying jobs. Yet the lives of most workers involve long stretches

away from home and family living in work camps. Many turns to drugs and alcohol to handle strains of the job and lifestyle. Temporary foreign workers who fill labor shortages in Alberta often experience exploitation, abuse, racial discrimination, and lack of rights (Mech, 2011). Of importance is not solely the purported number of jobs created, but of paramount significance is what kinds of jobs are created and the effects that created jobs have on the economy as a whole.

4.2.1. Total Jobs Created

If job creation is the goal of government spending, then oil sands is a net job destroyer given the greater job creation opportunities elsewhere with government revenue. The clean energy sector produces more jobs per dollar than the fossil fuel industry because a larger share of clean-energy expenditure goes to manufacturing, installation, and maintenance- far more labor intensive than the extraction and transportation sectors that comprise most fossil fuel jobs (Center for American Progress 2009; Kammen et al., 2004).

Investment in fossil fuel production needs workers. But fossil fuel industries are capital-intensive, and significant portions of expansion costs end up in the form of additional equipment and capital rather than jobs. The 1.3 billion dollars of taxpayer money given by the Federal Government to oil and gas companies every year generates an estimated 2,340-2,860 jobs. Research into this federal government investment to promote job creation however shows that 6-8 times more jobs, totaling between 18,000-20,000 jobs, could be created by investments in renewable energy, energy efficiency, or public transit (More Bang for Our Buck, 2012).

4.2.2. Kinds of Jobs Created

Commodity prices are inherently volatile, and oil in particular is characterized by large fluctuations in price (McNally and Levi, 2011). These price variations have a greater effect on tar sands oil production than other oil sources due to its higher production costs. As a result, oil sands projects were among the hardest hit by the recent global recession and resulting oil price crash (Haley, 2011). This undermines the job security associated with these positions due to the variable demand for higher priced oil.

Working conditions are hard. Work is often dangerous, and shifts can be up to three weeks straight and often for 12 hours per day. The polluted environment is unhealthy and there are background sounds of noise cannons throughout the day (National Geographic Magazine, 2009). Many people travel long distances from their homes and families, and addiction to drugs such as cocaine and alcohol is a serious problem for tar sand workers (Dembicki, 2010).

4.3. Effects on the Economy

Tar sand job creation impacts other sectors competing for labor force. Specifically, in remote communities in Alberta, tar sand jobs appear to be drawing workers from virtually all other sectors (Alberta Energy Sector). This not only impacts other industries in facing labor shortage constraints, but also on the quality of life in these communities. Additionally, increased oil production affects jobs in other regions of Canada.

A factor in the Canadian dollar's appreciation has been the commodities boom, led by oil (More Bang for Our Buck, 2012). The resulting higher Canadian dollar has resulted in a loss of competitiveness for manufacturing industries. Cheaper imports depress the domestic price of goods, as well as raises the prices of these same Canadian exports due to the higher Canadian dollar. Many experts view Canada's exchange rate reaching levels where manufactured goods are priced too high to export, which results in the decline or collapse of the manufacturing sector, a condition known as Dutch disease (Bergevin, 2006; Hodgson, 2010; Bimenyimana and Valee 2011; Shakeri, Gray and Leonard, 2012). Recent trends support this finding, with 500,000 manufacturing jobs lost in Canada during the past decade (Mendledon, 2012). An estimated 200,000 jobs in the manufacturing sector were attributed directly to increased oil exports (Beine et al., 2012).

"Regions associated with oil sands development enjoy several economic benefits but these benefits are accompanied by costs to the social well-being of the communities." (National Energy Board, 2006) According to Coldwell Banker's 2009 annual list on housing markets, Fort McMurray is Alberta's most expensive place to live. The large increase in costs of living have had profound effects on community members not working in the higher paying tar sand industry.

5. Discussion

Results above of expanding tar sands' production highlight the need for long-term plans for replacing fossil fuel use with renewable energy. While we continue funding fossil fuels, our funding for renewable energy is falling short of making any concerted effort toward a sustainable future. Fossil fuel subsidies need to be reconsidered. Initiating a carbon tax will not only better reflect their true cost for society but also provide a revenue stream for alternative energy research and address many societal issues concurrently.

5.1. Removal of Subsidies

The removal of these price distortions is a step in the right direction of levelling the playing field for alternative energies. Many countries have pledged to cut or remove fossil fuel subsidies, and it is time for these promises to be acted upon. The removal of these subsidies, estimated to be \$523 billion in 2011 (IEA,2012) provides a significant source of funding, which should be used in promoting useful programs for society rather than encouraging consumption of fossil fuels and thereby increasing pollution and health risks.

Research has estimated that in order to address the climate crisis, an estimated annual budget of \$20 billion would be needed for research, development, and deploying clean energy technologies (Caperton, 2012). The removal of fossil fuel subsidies provides the opportunity to reallocate tax payer money towards a sustainable future rather than continued reliance on fossil fuels.

5.2. Carbon Tax

A carbon tax is a tax on carbon emissions, or more broadly on greenhouse gas emissions, thereby raising the price of economic activities that add carbon to the atmosphere. It aims to incentivize the reduction of carbon emissions, and thereby promoting the development of green technologies. The crux of carbon taxes is that feedback from the taxing of carbon emissions will spur innovative practices, production systems, and lead to more efficient resource use. In addition to the decreased carbon emissions in the environment, carbon taxes can lead to decreased water and air pollution, road congestion by increasing the cost of private vehicle use, and increased efficiency in using earth's resources.

A carbon tax would be administratively simple and straightforward to implement in most industrialized countries, since the tax could incorporate existing methods for fuel-supply monitoring and reporting to the regulatory authority (Aldy and Stavins, 2011). This key advantage allows for maximum revenue to go toward intended uses, as well as the ease of introducing the carbon tax system.

Revenue could be collected upstream, when the fossil fuel is first sold following production, or downstream at the consumer level of sales. Upstream would involve fewer companies, and therefore be administratively cheaper. The Congressional Research Service estimates a carbon tax could cover 80% of U.S. greenhouse gas emissions by levying the carbon tax on fewer than 2,300 business entities upstream (Ramseur et al., 2012).

Carbon taxes have succeeded in raising revenue, curbed carbon emissions, and even helped economic growth. However, current efforts at regulating carbon emissions have limited effects on world carbon emissions. Gains from carbon regulations have been further undermined through emission leakage to areas without such incentives to reduce carbon emissions. Emission leakage results from firms relocating to areas without carbon tax enforcement and thereby simply increasing carbon emissions in other areas. Carbon taxes reduce demand for carbon intensive fuels globally, which causes the world price of these fuels to decrease. This results in increased use of these fuels in areas without carbon taxes, resulting in further offsetting gains of carbon taxes (Aldy and Stavins, 2011).

5.2.1. Current Carbon Taxes

Carbon taxes have been introduced in Finland, the Netherlands, Norway, Sweden, Denmark, Costa Rica, the United Kingdom, Switzerland, and Ireland, as well as regionally within the United States and Canada. These taxes vary in breadth of emissions covered across countries, the price of the tax, and enforcement across industry sectors. Overall, these programs have yielded lower carbon emissions, raised significant government revenue, and funded various social programs.

5.2.2. Revenue Stream

Carbon taxes provide government with revenue that could be put toward a variety of uses. Importantly, this revenue is not subject to political whims, and provides a stable source of funding programs to help alleviate some of the adverse effects which result in using carbon taxes. For example, carbon tax revenues could allow for reductions in existing taxes on labor and capital, thereby stimulating economic activity and offsetting some of the policy's social costs (Goulder, 1995; Goulder and Parry, 2008).

Low income households spend a greater portion of income on energy resources, while less in total, than higher income earners. As such, the brunt of negative effects from carbon taxes would be borne by lower income classes. Similar to the efforts of redistributing income to particular industries negatively affected by trade agreements, so too must lower income earners be assisted as affected members of carbon tax policy.

A number of approaches have garnered recent research (See Metcalf, 2009; Shultz and Becker, 2013). Two such options include a lump-sum carbon tax rebate, as well as a specific carbon tax rebate offered to Social Security recipients. These efforts would assist in alleviating the regressive effects of the carbon tax, increase the after-tax income of lower income classes, and could make the carbon tax overall progressive depending on the amounts of the chosen program (Ramseur et al., 2012).

5.2.3. Border Adjustments

While long-term gains in research and development provide economic security and prospects for cleaner energy at lower prices, any country initiating a carbon tax faces higher short-term production cost. In order to ensure a level economic playing field, carbon taxing countries can utilize border adjustments, which are import fees levied on manufactured goods from non-carbon taxing countries. This enables for a country to successfully employ a carbon tax while not losing competitiveness in their domestic market. Border adjustments would encourage carbon reduction both at home and abroad, and result in reducing the incentives causing carbon leakage.

Border adjustments represent another revenue stream for use in supporting valuable projects or assisting disadvantaged segments of society, as well as acting to reduce carbon leakage through removal of incentives to relocate to non-carbon taxing areas.

6. Conclusion

Energy plays a pivotal role in both economic systems as well as life systems. The effects of further development of Alberta's oil sands are profound in both economics and ecology.

This study reviews the literature surrounding the economic and environmental impacts of the oil sand development projects. With the increased reliance on this energy source, it is crucial for effective management of oil sand projects for sustainable environmental health and economic growth.

This study provides guidance to policy makers and stakeholders in Alberta's oil sand development projects. It is hoped that greater balance between environmental protection and economic growth be realized.

There are limitations to this study. First, most of the literature concerning oil sand development projects has been published by private organizations. Hopefully in the future, more research will be conducted by governmental agencies to remove possible bias. In addition, there is a lack of adequate monitoring of environmental impacts. Given the fact that the scope of tar sand activities involves complex interrelated factors, improved monitoring of the impacts of tar sand operations is required. Lastly, the economic impacts of tar sand developments need to include qualitative measures rather than solely quantitative considerations. If Canada is to continue to expand its oil sand operations, realizing the full economic impacts is paramount to creating a healthy and prosperous society.

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