TRANSrisk
TRANSITION PATHWAYS AND RISK ANALYSIS FOR CLIMATE CHANGE POLICIES

TRANSITIONS PATHWAYS AND RISK ANALYSIS FOR CLIMATE CHANGE MITIGATION AND ADAPTATION STRATEGIES

D3.2 Context of 15 case studies:

Canada: Oil Sands

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1 COUNTRY CASE STUDIES OF THE HUMAN INNOVATION SYSTEM (HIS): THE ENABLING ENVIRONMENT FOR SUSTAINABILITY

Canada contributes to 1.6 % of global greenhouse gas (GHG) emissions and it is one of the top ten emitters - on both total and per capita - in the world. Fossil fuel production and transportation are the largest contributors to this total, with 27 % and 23 % of contributions respectively.

The province of Alberta contributed to 37.4 % of national emissions in 2014, representing the biggest emitter among all provinces in Canada (Statistics Canada, 2006). Canada has the second largest oil reserves in the world, most of which primarily exist in the form of crude bitumen. The majority of proven reserves are found in oil sands in Western Canada. Unproven reserves, however, are expected to be significantly larger and are likely to reside in Alberta's oil sands. The oil sands production process emits significant GHGs and pollution, and this has led to damaging environmental and health impacts. The industry has been making efforts to address the problem by developing new technologies to cut GHGs, but environmental degradation persists and clear links have not yet made between oil sand production and health impacts.

This case study will explore both the broader environmental impacts of the oil sand production in Alberta as well as the environmental, economic and social impacts, particularly on the Native (First Nations) population who live on land where a significant concentration of oil sands activity is situated in the province. The case study intends to explore the complex issues of First Nations interests, and the vested interests of oil sand developers, by engaging a wide range of stakeholders in the study. The case study aims to gain a better understanding of how Alberta can meet climate change goals by exploring the current fossil fuel energy system and the varied interests of the oil sector and First Nations population, who are significantly and directly impacted by the oil sands development. In doing so it will help identify risks and uncertainties in potential low carbon transitions pathways.

1.1 Research questions for the Canada case study

Overarching research question: How can Alberta use its available energy resources to develop an energy generation sector that is economically, socially and environmentally sustainable?

Sub-questions:

1. What are the short (2020), medium (2030) and long-term (2050) socio-economic implications if Alberta sets a carbon tax for the energy generation sector?
    a. What are the impacts on the economy?
    b. How will the carbon tax impact employment?

2. What technological options are available (in the short med and long term) for reducing carbon emission in the energy generation sector?

   a. E.g. improving the efficiency of processes in value chain, CCS, renewable energy technologies

3. What are the implications of oil sand development impact?
   a. At the local level in Fort McKay
   b. On wider regional environment issues, including water extraction, land use, and melting of glaciers?

4. What are the opportunity costs of leaving oil in the ground?
   a. What are the social benefits of not having adverse impacts from air pollution, accidents etc.?

5. Given its available resources, should Alberta develop low carbon energy generation technologies?
   a. Are there financial, technological, institutional and social lock-ins that prevent the development of low carbon/ renewable technologies?

1.2 Introduction to the general context for the oil sands sector in Alberta, Canada

1.2.1 Policy overview

1.2.1.1 Energy Policies

Canada is home to the 3rd largest crude oil resource in the world. Most of these resources are available in the Athabasca region in the north of the province of Alberta. In this province, the energy sector provides approximately 133,000 jobs and generates $5.2 billion CAD in royalties, about 55 % of the total resource revenue of the province (Alberta, 2016d). In Canada as a whole, the Oil and Gas industry represents 10.8 % of the total GDP, and plays a major role in federal and provincial economy (Canada, 2016e).

In Canada, the main principles of the energy policy comprise of a market orientation, where the private sector outlines the characteristics of the industry based on offer and demand for internal and external markets. Government intervention is focused on regulations, mainly on health, safety and sustainability. More importantly, in the Canadian political system, provinces have the autonomy to set regulations and make decisions on their energy strategy (Canada, 2014). In Alberta, the key energy policies can be divided in two different groups based on their main motivation. Some are driven by business interests such as: developing royalty frameworks, improving market access and shares, diversification of energy resources value chains, and the long term development of natural resources. Other policies are driven by environmental responsibility, such as: the phase out of coal-fired electricity production by 2030, carbon levy and rebate

programs, emissions cap for oil sands production, and reduction of methane emissions (Energy, 2016a).

Considering the current energy scenario in Alberta, all the policy initiatives are based on the assumption of steady growth in oil production within the province and increasing market access based on developing pipeline facilities. There is a difficult challenge for the oil industry in Alberta to tackle the problem of climate change while being a global fossil based energy provider. However, the current government expects to meet the expectations by applying the initiatives previously described.

1.2.1.2 Environmental policies

Due to its geographic location and landscape, Canada faces particular challenges when addressing climate change drivers and consequences. Extreme temperatures, vast landmass, growing population, a diversified growing economy and abundant natural resources are some of the factors impacting GHGs emissions in Canada (Secretariat, 2015). In 2014, fossil fuel production contributed to 27 % of total Canadian GHG emissions; whilst Alberta contributed 37 % of total national GHG emissions.

The Canadian federal government primarily regulates pollution with the Canadian Environmental Protection Act, 1999. However, jurisdiction is not well defined, with most regulatory powers in hands of provincial governments (Field, 2011). In the province of Alberta, the Alberta Energy Regulator (AER) acts as the organisation responsible for outlining the framework for the development of hydrocarbon resources in the province. In their regulatory role, the Alberta Energy Regulator administers coal, natural gas, oil and oil sands, mines and minerals and pipeline activities (Regulator, 2016a).

In addition to the Alberta Energy Regulator administration, the province of Alberta complements its environmental policies and regulations by offering additional programs in three different sub-areas: greenhouse gas emissions, climate change/energy efficiency, and water treatment (Regulator, 2016a). Among the flagship programs being implemented, the *Alberta's Climate Leadership Plan* is the one that has received significant attention, as it intends to significantly decrease the GHGs emissions in the province.

As part of the Paris Agreement, in 2016 Canada agreed to decrease GHGs emission by 30 % below 2005 levels by 2030. The mechanism in place to achieve this goal mainly involve the development of regulatory measures to change the transportation and electricity sectors, control landfill emissions, and promote clean energy technologies. However, such commitment has raised scepticism among some sectors since, historically, Canada's has a poor record on climate change mitigation action. Canada failed to comply with the Kyoto's Protocol conditions, and withdrew from it 2011. In addition, changing political philosophies – e.g. liberal to conservative – among the country and province's leadership seems to directly impact the nature and level of the regulatory framework in place for emissions control. Specifically, for Alberta the energy and environmental regulatory framework to be implemented faces unique challenges. If no significant policies are implemented, emission are expected to grow 20 % by 2030, accounting for 60 % of the total growth of Canadian emission over the timeframe (Leach et al., 2015). On the other hand, Canada's

EcoFiscal commission determined that 18 % of Alberta's economy was emission-intensive and trade-exposed, meaning that an aggressive regulatory framework could cause industry migration to other less-regulated provinces and/or countries, ending in emission leaks and a non-reduction of total global emissions (Beale et al., 2015). Based on these constraints, Alberta envisions developing policies around carbon pricing, emissions capping, electricity generation from renewables, increase efficiency in energy usage, and to decrease emissions growth to maintain similar levels of today. During the proposal of this strategy, the panel of experts did acknowledge that these measures may not be consistent with the global 2°C goal, but are justified to avoid emissions leakage, keep a positive environment in the industry and support the economy for Alberta residents (Leach et al., 2015).

More recently, in October 2016 the Federal government announced a nationwide program for carbon pricing, which expects to substantially reduce carbon emissions, stimulate innovation, and aid the transition to a low-carbon economy (Canada, 2016d). This step, could be useful for the total Canadian contribution to GHG emissions. However, the recent election of Donald Trump in the U.S.– the biggest foreign influence for Canada - could switch the tone in the environmental commitment of the provincial government.

1.2.2 Natural resources and environmental priorities

1.2.2.1 Natural resources

Canada has the third largest proven crude oil reserves in the world, and its energy sector contributes to the 10.8 % of the country's gross domestic product (GDP). By 2014, most of the energy produced in Canada was obtained from crude oil. During that year, the primary energy mix was crude oil (43 %), natural gas (33 %), coal (8 %), hydro (7 %), other renewables like wind, solar, biomass, biofuels, and municipal waste (4 %), natural gas liquids (NGLs -3 %) and nuclear (2 %) (Canada, 2016f). However, Canada's energy production varies considerably between provinces due to the vast territory, uneven distribution of population and natural resources availability. Alberta accounts for 62.8 % of the primary energy production of Canada, with the energy production mix shown in Table 1. For Alberta, the energy sector represents 21.7 % of the GDP, which is the highest for all provinces in Canada.

Table 1. Total primary energy supply in Alberta by 2015

Energy commodities	In PJ	In %
Crude Oil	6400	52
Natural Gas	4500	37
NGLs	600	5
Coal	600	5
Other renewables	100	1

Source: (Canada, 2016f)

For electricity generation, the differences are more evident between the Canada scheme and the regional scheme. In 2014, Canada electricity production was dominated by hydro (59.3 %) followed by nuclear (15.9 %), oil and gas (10.2 %), coal (9.5 %) and non-hydro renewables (5.1 %) (Canada, 2016f). By contrast, in 2013 Alberta electricity generation was dominated by coal (43 %) and natural gas (40 %) followed by small contributions from wind (8 %), hydro (6 %) and biomass and others (3 %)(Energy, 2014). With a projected growth in demand as the population in the province increases, Alberta has pledged to reduce power generation from coal while encouraging the development of renewable sources. Generation from coal has progressively decreased from 66 % of the total electricity produced in Alberta in 1996 to 43 % by 2013. Moreover, by 2034 Alberta is aiming to reduce coal electricity generation to only 10 % of the total mix by favouring strategies towards the use of natural gas and renewable sources.

Canada possesses valuable renewable resources with big potential for the production of renewable energy. About 18.9 % of Canada's primary energy supply is covered by renewable sources, mainly through the widespread use of hydro-power. However, other sources such as wind, biomass, solar, geothermal, and ocean energy, could also be exploited. The detail of total renewable energy production by 2014 is presented on Table 2.

Table 2. Total renewable energy in Canada by 2014

Technology	In PJ	As % of all renewable energy production
Hydro	1371.438	65.400
Solid Biomass	559.899	26.700
Wind	80.7345	3.850
Biogasoline	37.3266	1.780
Municipal waste/landfill gas	23.2767	1.110
Solar photovoltaic	9.8559	0.470
Biodiesel	6.291	0.300
Industrial and other waste	6.291	0.300
Solar thermal	1.6776	0.080
Tidal	0.06291	0.003

Source: (Canada, 2016f)

In Alberta in 2014, 55 % of electricity was generated with coal-fired plant and only 14 % was generated with hydro, wind and biomass. Coal-fired electricity produces high levels of greenhouse gases (GHG) emissions and air pollutants, and by 2013 represented 17 % of the total GHG emissions from the province. To decrease the impact of coal-fired generation, Alberta has outlined a strategy to increase natural gas co-generation systems, to increase energy efficiency and develop more renewable energy production, in order to decrease the environmental impact of electricity generation (Leach et al., 2015). Moreover, Alberta is exploring the use of its 20 million tonnes of annual waste as potential feedstock for bioenergy products(Energy, 2016c).

In Canada, more than 70% of secondary energy usage in 2013 was mainly for economic and residential activities (the overall use of energy is presented in Table 3). The industrial sector made up the highest portion of the energy use (40%) but has been declining slightly since 2006, partly due to a reduction in energy intensity (i.e. the ratio of energy use per unit of activity in the pulp and paper industry, metal manufacturing, etc) as well as a decrease in energy use and output in petroleum and coal product manufacturing (2013). Transportation made the next largest share of energy use, comprising around 30%, whilst the residential sectors made up around 17% of energy end use.

Table 3: Canada's Secondary Energy Use by Sector (2006-2013)

	2006	2007	2008	2009	2010	2011	2012	2013
Total Energy Use (PJ)	8,378.8	8,778.0	8,641.3	8,303.8	8,462.2	8,659.2	8,706.8	8,924.0
Residential (PJ)	1,441.9	1,560.7	1,564.8	1,481.0	1,436.0	1,525.0	1,457.3	1,517.5
In %	**17.2%**	**17.8%**	**18.1%**	**17.8%**	**17.0%**	**17.6%**	**16.7%**	**17.0%**
Commercial/Institutional (PJ)	895.1	941.3	955.2	928.2	902.0	947.8	925.6	917.1
In %	**10.7%**	**10.7%**	**11.1%**	**11.2%**	**10.7%**	**10.9%**	**10.6%**	**10.3%**
Industrial (PJ)	3,355.9	3,483.6	3,336.7	3,179.1	3,271.7	3,312.4	3,425.1	3,525.3
In %	**40.1%**	**39.7%**	**38.6%**	**38.3%**	**38.7%**	**38.3%**	**39.3%**	**39.5%**
Total Transportation (PJ)	2,456.9	2,554.5	2,541.9	2,505.0	2,607.7	2,604.4	2,633.6	2,685.5
In %	**29.3%**	**29.1%**	**29.4%**	**30.2%**	**30.8%**	**30.1%**	**30.2%**	**30.1%**
Agriculture (PJ)	229.1	238.0	242.7	210.6	244.9	269.6	265.1	278.6
In %	**2.7%**	**2.7%**	**2.8%**	**2.5%**	**2.9%**	**3.1%**	**3.0%**	**3.1%**

Source: (2015)

Out of the thirteen provinces and territories in Canada, Alberta corresponds to 13 % of the national electricity use (Canada, 2016f). In 2003, Alberta ranked as the biggest energy consumer per capita in Canada, mainly due to a booming oil and gas sector and industrial development increasing faster than population (Canada, 2012). Since then, this trend has continued, but at a slower pace.

Table 4 summarises customer electricity usage estimates from 2010 to 2015 in Alberta (Energy, 2016b). From this historic data, it is possible to see that, over the last 5 years, the industrial sector corresponded to 51 % of the total electricity usage, followed by the commercial sector (27 %), residential (18 %) and agriculture/farming (3 %).

Table 4. Electricity customer usage estimates in Alberta (2010-2015)

Sector	Number of Customers		Usage (GWh)					
	2014	2015	2010	2011	2012	2013	2014	2015
Residential	1,405,894	1,441,858	9,071	9,333	9,412	9,678	9,927	9,892
Farm	83,816	84,094	1,708	1,828	1,800	1,836	1,865	1,909
Commercial	172,609	175,105	13,748	14,207	14,596	14,778	15,155	15,000
Industrial	37,607	37,122	27,076	27,294	27,474	27,838	28,432	27,898
Total*	**1,699,926**	**1,738,179**	**51,603**	**52,662**	**53,283**	**54,131**	**55,379**	**54,877**

**Total may not add due to rounding. Source: (Energy, 2016b)*

By 2014, Canada total GHG emissions ascended to 732 Mt CO_2 equivalent, excluding land use, land-use change and forestry estimates. Canada contributes 1.6 % of global emissions and it is one of the top ten emitters (both total and per capita) in the world (Institute, 2016). Fossil fuel production and transportation corresponded to the biggest contributors to this total, forming 27 % and 23 % accordingly. Of the national total, the province of Alberta contributed to 37.4 % in 2014, representing the biggest emitter among all provinces in Canada (Canada, 2016f). The close relationship of Alberta with the fossil fuel industry sector and power generation, has caused a steady increase in emissions as these sectors develop in the province. Figure 2 shows the predominance of Alberta among other provinces in terms of GHG emissions and the increase of such emission in 53 % from 1990 to 2005 (Boothe and Boudreault, 2016).

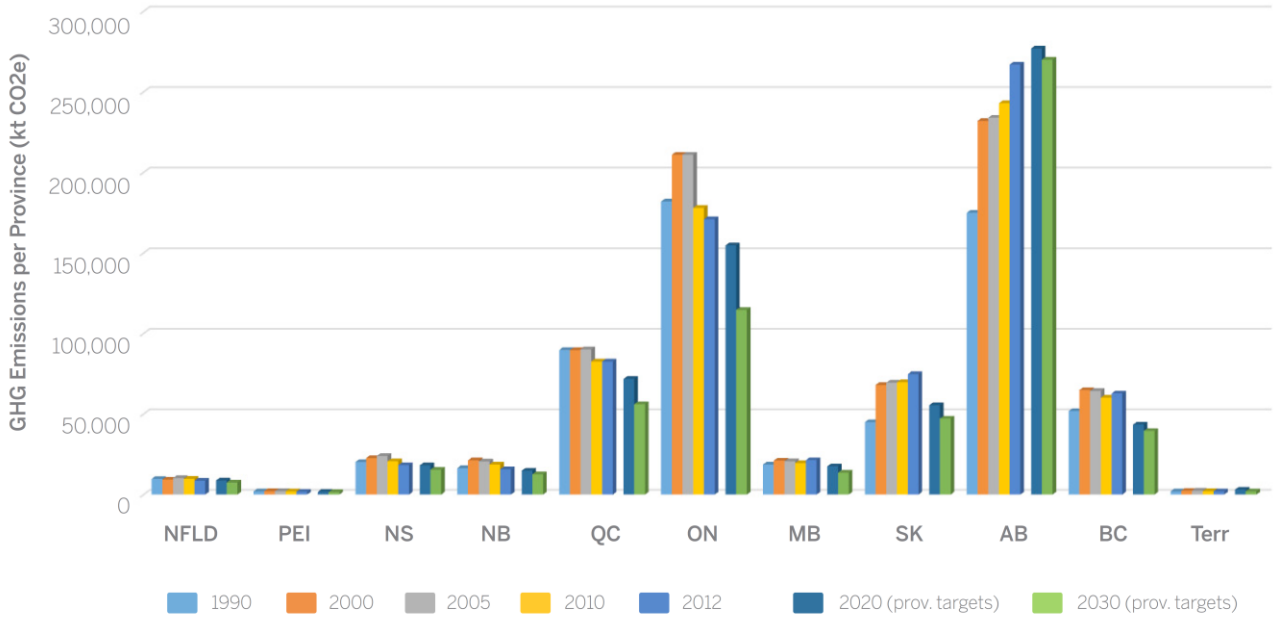

Figure 1. GHG emissions per province, for 1990-2013 and projected levels for 2020 and 2030 targets. Reproduced from (Boothe and Boudreault, 2016)

By 2013, emissions in Alberta rose to 66.6 t/per capita, and are expected to increase further if no measures are taken. To dampen this rise, the government of Alberta released in 2015 the Alberta's Climate Leadership Plan, targeting emissions of 277 Mt CO_2 equivalent (60.1 t/per capita) for 2020 and 270 Mt CO_2 equivalent (49.2 t/per capita) (Leach et al., 2015).

1.2.2.2 Environmental priorities

The environmental priorities of Alberta are reflected in the main goals of the Alberta's Climate Leadership Plan (Leach et al., 2015) and the Environment and Parks Ministry priorities (Parks, 2016). As described in previous sections, the province maintains three main priorities: (i) *ending coal pollution* by phasing out all coal-fired power plants, (ii) *decrease GHG Emissions* by capping and taxation programs, and (iii) e*nsure environmental protection, conservation and ecosystem integrity* by providing a clearer legal framework for industries operating in the area. These will be discussed further in section 1.2.5.

1.2.3 Economic priorities

Canada's Gross Domestic Product (GDP) was 1550.54 billion US dollar in 2015 (2085.9 billion CAD). The GDP value of Canada represents 2.5 % of the world economy, corresponding to the 12th largest economy worldwide (Economics, 2016). Canada takes part in a number of international trade, financial and economic organisations, stressing the influence of world markets on its economy. Among the most relevant accords, the World Bank, the World Trade Organization, the International Monetary Fund, the Organisation for Economic Co-operation and Development, the Financial Action Task Force and the Financial Stability Board, can be named. Canada also takes part in the G8 and the G20 (Canada, 2016b).

The Canadian GDP annual growth rate averaged 3.19 % from 1962 to 2016, reaching a record high of 8.80 % in 1962 and a record low of -4.10 % in 1982. In 2015, Canada´s GDP grow rate was 1 %, behind the 2.2 % and 2.5 % registered for 2013 and 2014 respectively, mainly due to a decline in world oil prices and a wildfire in the Municipality of Wood Buffalo, an oil production area, that affected crude oil output (US, 2016). Real GPD is expected to grow by 1.4 % in 2016, and about 2.2 % in 2017 and 2018, based on rising energy prices and low interest rates providing a confidence boost for investors (Canada, 2016a). In the case of Alberta, the province contributed to 16.3 % of Canadian GDP in 2015. Alberta's GDP growth rate between 2012 and 2014 fluctuated around 4 % until the economic contraction suffered in 2015 (low oil prices and Wood Buffalo wildfire) that decreased the province's GPD by 3.5 %, with a further fall of 2.7 % predicted by the end of 2016. There is modest GDP growth of 2.4 % forecasted for 2017 as oil production returns to previous levels (2015), oil prices improves and public investment in infrastructure materialises in the province (Alberta, 2016a).

Under these scenarios the federal government has developed a plan focused on strengthening the middle class through: financial benefits, decreases in taxes, affordable post-secondary education, employment insurance, green infrastructure investments; and promoting the prosperity of vulnerable minorities, such as veterans, seniors and indigenous peoples. In addition, the federal government plans to develop an innovative clean economy by dedicating funds to research, development and implementation of green technologies. It also plans to create a Low Carbon Economy Fund, intended to support provinces and territories actions to reduce GHG emissions (Canada, 2016c). On the other hand, Alberta has outlined a plan targeting a diversification of the economy by increasing by 40 % funds dedicated to technology incubators and start-up companies, attracting foreign investment for local industries, and also to fund a comprehensive research and development framework (Alberta, 2016b). For the energy sector, the government of Alberta is aiming to modify the royalty framework, guarantee the responsible use of natural resources,

enhance environmental regulations, and decrease GHG emission by improving energy infrastructure and technology (Alberta, 2016c).

1.2.4 Societal priorities perspective on climate change:

The population in Canada is estimated to be 36 million, corresponding to 0.5 % of the world's population. Due to its vast territory, with an area of 9.9 million km^2, Canada is the second largest country by area in the world (behind only Russia) and has a low population density of 4 people per km^2 (US, 2016). Alberta' population is 4.3 million people, equivalent to ~11 % of Canada's total population. It also has the fastest-growing population in the country, with a 0.4 % growth in only in the first trimester of 2016, accounted for by a large intake of immigrants and natural growth (babies) (Canada, 2016h). In Alberta, less than 20 % of the population correspond to visible ethnic minorities, and only 7.5 % identifies themselves with aboriginal origins. Today, Canada faces a demographic shift with a median age of 42 years. Currently there are more seniors over the age of 65 than there are children under the age of 15, indicating that there will be less working age Canadians to support the overall population, restricting growth (Canada, 2016c).

In Canada, ~82 % of the population is located in urban areas with almost 100 % access to clean drinking water, and 88 % access to internet and telecommunications (US, 2016). Canada provides free education between the ages of 4 and 16, and has a high literacy levels (97 %). There is no federal education system, as each province defines their own education standards. The GDP per capita in Canada is $45,600 (CAD), with a median total income of $32,790. Alberta median total income is $41,570, locating itself above the national median (Canada, 2016g). Income inequality places at 0.322 (Gini coefficient), above Scandinavian countries but below Spain, UK and United States (OECD, 2016a). Poverty rates, calculated as the ratio of citizens with an income below half the median household income of the total population, correspond to 0.126, with housing, nutrition and precarious employment being the main issues (OECD, 2016b). Among the vulnerable population, indigenous peoples are vastly affected by poverty. In Alberta, 42% of food bank users identified themselves as First Nations in 2014, and Canada-wide half of all indigenous children live in poverty (Macdonald and Wilson, 2013).

Regarding environmental perception, in 2014 65 % of Canadians claimed to be familiar with the discussion around the use of fossil fuels and their impact on climate change, and 62 % agreed that protecting the environment was more important than the price of energy, indicating a preference for government measures to implement taxes on main polluters (Research, 2014). A similar proportion of public opinion was identified in the prairies region where Alberta is located. In the same year, another survey revealed that ~43 % of the population was completely or partially in favour of oil sands projects in Alberta, mainly due to their economic and employment benefits. However, a growing 35 % indicated that their impression of the oil sands projects has worsened over the past five years. In 2015, a survey performed by a major broadcasting company (CTV) indicated that over seven in ten Canadians (72 %) believed that the science of climate change is irrefutable. In addition, 63 % of Canadians were willing to pay more for certain products in order to help the country to meet its environmental commitments, despite the fact that 66 % (45.5 % in the Alberta region) acknowledged they were aware that meeting the new target may involve a significant job loss in the Canadian oil sector (Research, 2015). Considering the public's opinion, the government carried out a national consultation to define the budget for 2016, receiving significant feedback regarding the use of green technologies and the growth of the green energy sector. This feedback helped the government to outline a comprehensive strategy for the sector.

In 2016, a survey revealed the views of the Canadian public on climate change initiatives. In this survey, more than three out of four Canadians supported a national plan that guaranteed meeting international targets for emissions reduction, supported independent action from the federal government to meet the targets and had a positive perspective on establishing a minimum carbon pricing scheme across Canada (Research, 2016).

1.2.5 Politics of energy development priorities

As described in previous sections, the most impactful policies on the reduction of the environmental impact of the oil sands sector come from provincial government, more specifically those outlined by the Ministry of Environment and Parks in the Climate Leadership Plan. These were launched in August 2016 and cover three main areas:

- *Ending coal pollution* by phasing out all coal-fired power plants by 2030, and replacing two thirds of the plant with renewable energy and one third with natural gas.
- *Decrease GHG Emissions* using three different approaches: (a) implementing a carbon levy in the price of fuels including diesel, gasoline, natural gas and propane, in order to raise funds for investments in renewable energy technology, green infrastructure and energy efficiency programs; (b) capping oil sands emissions to a maximum of 100 Mt per year and assigning a carbon price of $30/tonne with the expectation of full compliance by 2030; and (c) reduce methane emissions by 45 % by 2025 by applying new emission standards for new and existing oil production facilities, and improving monitoring and reporting; and
- *Ensure environmental protection, conservation and ecosystem integrity* by providing clarity for land users and land-use decision-makers for proper planning of land use making provisions for new or expanded conservation and recreation areas, enforcing protection of surface water quality, and elimination of surface residue water reservoirs (known as tailings ponds).

Some of these provincial policies are in agreement with other plans presented by the federal government. In October 2016, the federal government approved the *Pan-Canadian Approach to Pricing Carbon Pollution*. All provinces are encouraged to implement a minimum carbon price of $10/tonne by 2018, increasing by $10 per year up to $50/tonne, in order to reach an emission reduction target equal or greater than 30% by 2030, depending on the pricing structure selected by each province. This carbon price is initially below the $30/tonne proposed by Alberta earlier; however, no further increments were proposed. Therefore, by the time of release of the Federal plan, Alberta's leadership declared it would not support the federal plan until plans for developing energy infrastructure blocked by environmental groups - e.g. building new pipelines – would be approved.

1.2.6 Conflicts and synergies of priorities

Canada faces several issues around increasing costs of living, decreasing average incomes and rising inequality. Moreover, new generations are increasingly concerned about being able to achieve the standard of living previous generations enjoyed. Today, the leadership of Canada believes that supporting the development of the middle class may boost economic growth and provider a better future.

Among the priorities previously discussed, a strong synergy is observed between the public's desire for tackling climate change and governmental initiatives to decrease GHG emissions. Canadians are aware of the impacts of climate change and are willing to change, to some extent, their lifestyles in order to aid the global goals for cutting carbon emissions (Research, 2015).

However, in a local provincial context, there may be conflicting goals with the federal ambition to reduce carbon emissions. Alberta's economy mainly depends on the oil and gas sector as the main source of jobs and income for the province. Therefore, it is clear that Alberta intends to improve its carbon footprint but without committing to major changes in its energy sector structure. The province of Alberta expects the proposed policies of the Climate Leadership Plan to be implemented alongside a developing oil and gas sector. The current leadership in Alberta believes this changes would allow the province to tackle climate change while maintaining its position as an energy provider. This represents a risk of double standard, since the panel that suggested the Climate Leadership Plan acknowledged that such measures would probably not be enough to meet the emission reduction goals of the Paris agreement. Detractors of these new measures stress the fact that more drastic changes are needed in order to achieve the global objectives.

1.3 The Human Innovation System Narrative

1.3.1 Overview of the development of the case study focus

Knowledge of oil sands has been part of the Frist Nation cultural heritage for centuries, not as an energy source but as an isolation material for canoes. The first historical documents mentioning them date to the 18th century when European explorers and crown emissaries, brought to the region by fur trading economic interests, observed and described the abundance of bitumen near the Athabasca River as a natural substance emanating from the ground ((CAPP), 2016). Hundreds of years later, the first government-sponsored geological study on the oil sands was performed along with additional expeditions, unveiling a significant economic potential for the use of the resource. During this time, natural gas and conventional oil were discovered, developed and used as primary energy sources for the communities in the province (Tourism, 2016). However, commercial development of the oil sands did not begin until the early 1920s, with some failed attempts to extract the oil using drilling wells between 1906 and 1917 (Program, 2016). After this, technologies for oil separation from the sand using hot water were developed using the same principle as the First Nations people had used in the past. This technology was mainly applied at a pilot scale, and supported by governmental institutions such as the federal Department of Mines and the Alberta Research Council.

The main focused of oil sands exploitation by that time was roofing and road surfacing applications (Energy, 2016d). It was not until 1962 when the large-scale oil sands development began. That year, the government of Alberta developed a specific oils sands policy to supplement the conventional crude oil policy already in place. The inaugural project was the Great Canadian Oil

Sands (GCOS) Project, later transformed into the current Suncor Energy, who brought the first oil sands operation "on stream" in 1967. Along with the GCOS, the Syncrude consortium was formed and shipped its first barrel of oil in 1978, becoming the second major oil sands producer in Canada (Innovation, 2016). Today, the oil sands attract local and foreign investment. The oil sands region in Alberta is divided in three major deposits - Athabasca, Cold Lake and Peace River oil sands - which together form the world's third-largest proven oil reserves (see Figure 3) (Board, 2010). Two main methods are used to recover the oil sands deposits: surface mining and in-situ recovery. Technological development efforts are mainly directed at decreasing the production costs and environmental impacts of oil sands production, whilst keeping a competitive price for exports to the international markets.

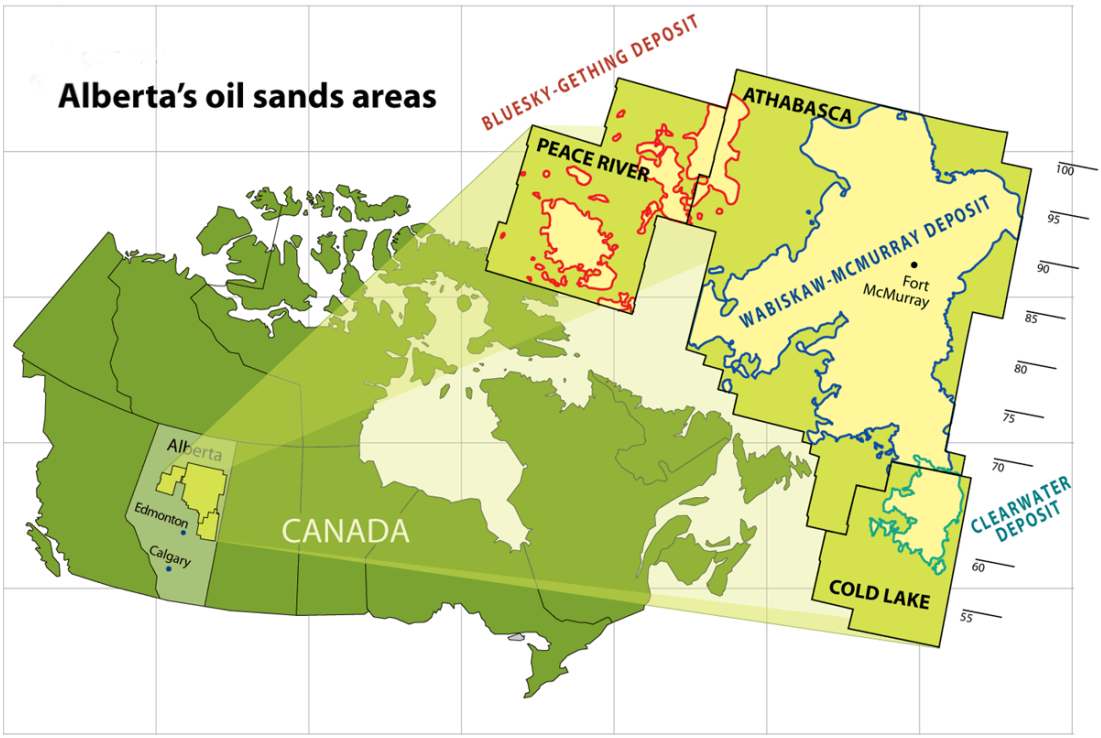

Figure 2. Location of the Alberta's oil sands areas and selected deposits. Reproduced from: (Board, 2010)

Energy production in Alberta is the province's biggest source of GHGs, with 46% of the total corresponding to oil and gas production (Leach et al., 2015). Historically, developing the oil sands and protecting the environment have been a challenge for policy makers and industry representatives(Chastko, 2000). After World War II, the oil and gas sector became the dominant economic industry in the province, and by the 1970s this industry accounted for 40 % of the province's income. The rapid growth of the sector in the 21st century has also influenced politics, since actions towards the regulation of the industry could be perceived as detrimental to the economic progress of the province (Finkel, 2000). Despite this, the government of Alberta and the oil companies have made the efforts to cooperate in order to decrease emissions from the sector. Since 1992, Canada committed to reduce its GHGs emissions at the United Nations Conference on Environment and Development in Rio de Janeiro, but it was not until the 2000s where more funds

were allocated to institutions and program focused on lowering carbon emissions and developing green energy (Energy, 2016d).

In 2007, Alberta developed the first regulatory framework for emissions intensity in North America, known as the Specified Gas Emitters Regulation (SGER). Although innovative by the time of implementation, the regulation fails to reduce emissions when the emitters increase their overall production (Read, 2014). Despite this, the government claim to have achieved a 30 % emissions reduction between 1990 and 2013. Environmental groups such as the Pembina Institute have acknowledged this progress, but wars about an increase in emissions of 25 % between 2004 and 2014, suggesting a negative trend for emission reduction goals (Israel, 2016). Today, Alberta is expecting to meet its emissions reduction targets with the implementation of the Climate Leadership plan; however, it is still to be seen if such a target can be reached with the existing regulatory framework and infrastructure. Overall, Canada has communicated its national intention to decrease the GHGs emissions. However, efforts presented in its Intended National Determined Contributions submission to the UNFCCC (see Figure 4) may be consider inadequate to reach the 2 °C goal if major carbon credits are traded between land change, forestry and oil and gas industries (Secretariat, 2015).

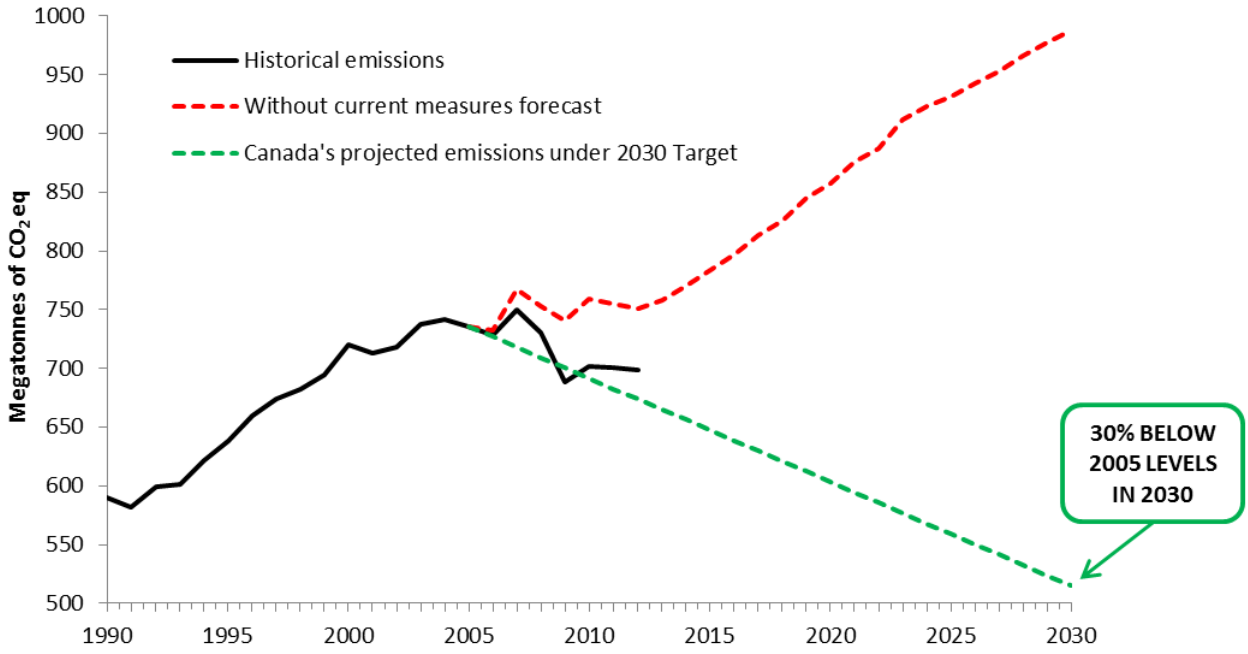

Figure 3. Canadian Emissions under 2030 Target. Reproduced from:(Secretariat, 2015).

This case study explores the broader impact of the oil sands development in Alberta and the wider environmental and social impacts at the provincial and at the community level. We focus our stakeholder engagement in this case study on First Nations communities located around the oil sand production areas, as the communities are among the stakeholders most significantly impacted by oil sands development. We place particular emphasis on the community of Fort McKay, which is located on the Regional Municipality (R.M.) of Wood Buffalo, Alberta, Canada, approximately 54 km north of the City of Fort McMurray. It lies within the limits of the Athabasca Oil Sands Area, according to the Alberta Energy Regulator (AER) designated areas (Regulator,

2016b). The region is the only Surface Minable area approved in Athabasca region and is surrounded by several oil sands projects and upgrading facilities (Regulator, 2016c). This particular situation presents various challenges to the community, mainly confronted by the Fort McKay First Nation, where sustainable growth is necessary to guarantee the preservation of the rich environment and cultural heritage.

1.3.2 TIS life cycle value chain: a cradle to grave analysis

The technological innovation system life cycle of the oil sands is described below.

a) **Energy resource extraction:** oils sands in Alberta are exploited using two main technologies: (i) Mining: superficial extraction of oils sands, or (b) Drilling: using steam stimulation to extract oil from deeper reservoirs. Both methods provide crude bitumen to be processed.
b) **Power plant generators (energy conversion technology systems):** crude bitumen can be processed by: (i) upgrading, a refining process where contaminants, such as sulphur, and heavier fraction like petroleum coke removed in order to produce a crude oil suitable for posterior refining to produce commodity fuels like gasoline and diesel; (ii) Gasification, where steam is utilised to gasify bitumen in order to produce syngas ($CO+H_2$) as a useful gas mixture essential for methanol, ammonia, hydrogen and other specialty products.
c) **Processing transportation:** the main products from oil sands are transported using three different means: (a) liquid pipelines, to transport diluted bitumen to refinery sites, (b) rail using tanks, and (c) marine transportation to supply US and Asian markets.
d) **Storage:** most of the oil that cannot be sent to other provinces (British Columbia, Ontario, Quebec) or overseas (USA) is stored in crude oil storage tanks, with capacity of 49 million barrels concentrated in Edmonton and Hardisty, all managed by private companies.
e) **Distribution to end-users:** distribution to end users is provided by ground transportation in the case of fuels for vehicle refuelling stations, and gas pipelines that transport natural gas from production sites to households and distribution centres.
f) **End users:** By 2015 the split for end users was 76 % transportation/mobility (gasoline, diesel, jet fuel),16 % consumer products (propane, asphalt, petrochemical feedstocks), 8 % to other industries (heavy fuel oil, light fuel oil) (Canada, 2016f).
g) **Decommissioning:** once production from an oil well ceases, companies are required to cement down the wellbore and remove all wellhead equipment. This process is known as "Abandonment"
h) **Reclaiming land and waste handling:** after the wells have been appropriately abandoned, the company must return the land to its original state. Without a reclamation certificate provided by the Alberta Energy regulator, that proves compliance with all conditions, the company will not be allowed to leave the well site.
i) **Facilitating services & infrastructure:** there are organisations/support systems/infrastructure that are outside the product and service supply chain (external to the TIS system) but are fundamental to facilitating the TIS system. These institutions and their corresponding organisations are listed below:
    a. **Industry institutions:** Suncor, Canadian Natural Resources Limited (CNRL), Imperial Oil, Shell, Syncrude, Husky.

b. **Policy institutions:** Alberta Energy Regulator, Environment and Climate Change Canada, Government of Alberta, Canadian Environmental Assessment Agency,
c. **Political institutions:** Political Parties (NDP, PC, Liberals), Industrial Associations:
    - Canadian Association of Petroleum Producers (CAPP)
    - Canadian Energy Pipeline Association (CEPA)
    - Canada's Oil Sands Innovation Alliance (COSIA)
    - Canadian Heavy Oil Association (CHOA)
    - Climate Change and Emissions Management Corporation (CCEMC)
    - Oil Sands Community Alliance (OSCA)
d. **Financial institutions:** banking, investment banks
e. **Education institutions:** postgraduate education institutions, polytechnic institutes, professional training programs
f. **Media institutions:** independent media, industry founded media, websites and social media
g. **Legal institutions:** Regional Municipality of Wood Buffalo, Provincial Court of Alberta
h. **Other informal institution**: Indigenous council/community (Fort McKay), PEMBINA Institute, Alberta Energy Efficiency Alliance
i. **Infrastructure that supports the TIS system:** EPC Companies, Manufacturing and transportation

1.3.3 Enabling environment: policy mixes in the socio-economic system

Table 5 presents Canadian policy instruments that influence the oil and sand sector. The main instruments are divided by themes such as energy, environment and infrastructure support of the TIS system. The presented policies and regulations, have a direct impact on the development of oil sands projects in Canada. They can be divided in two main groups: (i) sector-specific instruments, such as those regarding natural resources development, energy usage, exploitation rights, and operational safety regimes; and (ii) impacted areas, such as land management, air, water and biodiversity protection, and transportation.

Table 5: Canada policy instruments that directly or indirectly impact the oil sand sector

Policy themes	Canada Federal and Provincial Policy Instruments		
Energy	Mines and Minerals Act	Oil Sands Tenure, Royalty and Conservation Regulations	Alberta Energy Regulator (AER) Directives on project development
Climate	Canadian Environmental Protection Act, 1999	Environmental Regulations for the Energy and Transportation Sectors	Alberta Climate Leadership Plan
Agriculture	Public Lands Act	Alberta Land Stewardship Act	
Air	Environmental Protection and Enhancement Act	AER Flaring and Venting Directives	

Waste/ resource use	Alberta Waste Control Regulation	Oil and Gas Conservation Act and the Oil and Gas Conservation Regulations	AER Waste Management Directives	Suspension, Abandonment, Decontamination, and Surface Land Reclamation of Upstream Oil and Gas Facilities (AER)
Water	Alberta Water Act Codes of Practice			
Biodiversity	Wildlife Land Use Guidelines (AER)			
Transportation	Rail Transportation of Dangerous Goods Regulation	Transport Canada, Marine Safety Regulations	Alberta Energy Regulator Pipeline and Regulation	Pipeline Safety Regimes in Canada

1.3.4 Enabling environment: government institutions

The energy sector in Canada is a shared responsibility, however, most of the responsibility over management and regulatory frameworks lies in the provincial jurisdiction. For example, the federal government is, in general, responsible for international and interprovincial energy trade and infrastructure, as well as policies of national interest (environment, economic, security and technology). On the other hand, the ownership, management, royalty framework, electricity, land use, and regulations on development of natural resources are responsibilities of the provinces. The most relevant shared responsibilities between the federal and provincial government comprise environmental regulations and energy efficiency, since provinces may have a significant effect beyond their boundaries (Canada and Canada, 2016). Figures 4 and 5 provide a summary chart of the major institutions influencing the Canadian Oil and Gas sector.

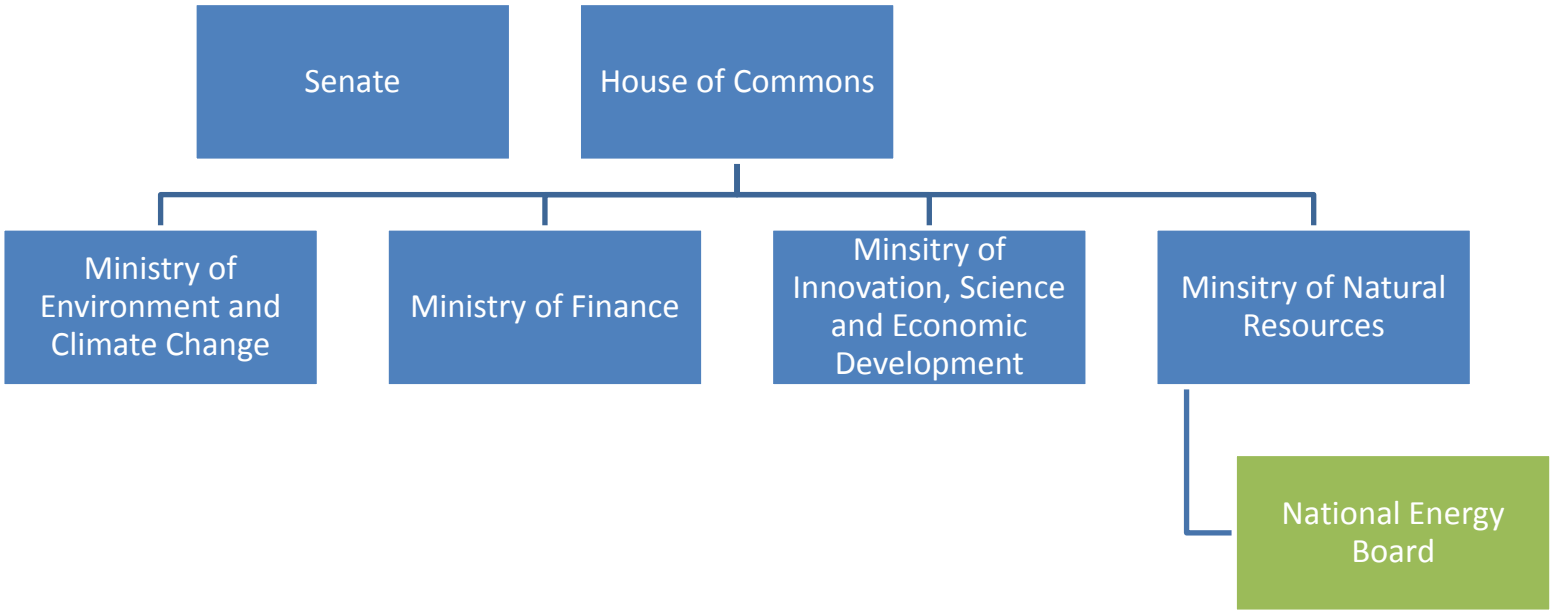

Figure 4: Major institutions in the energy framework in Canada, Federal Government. Regulatory agencies are highlighted in green

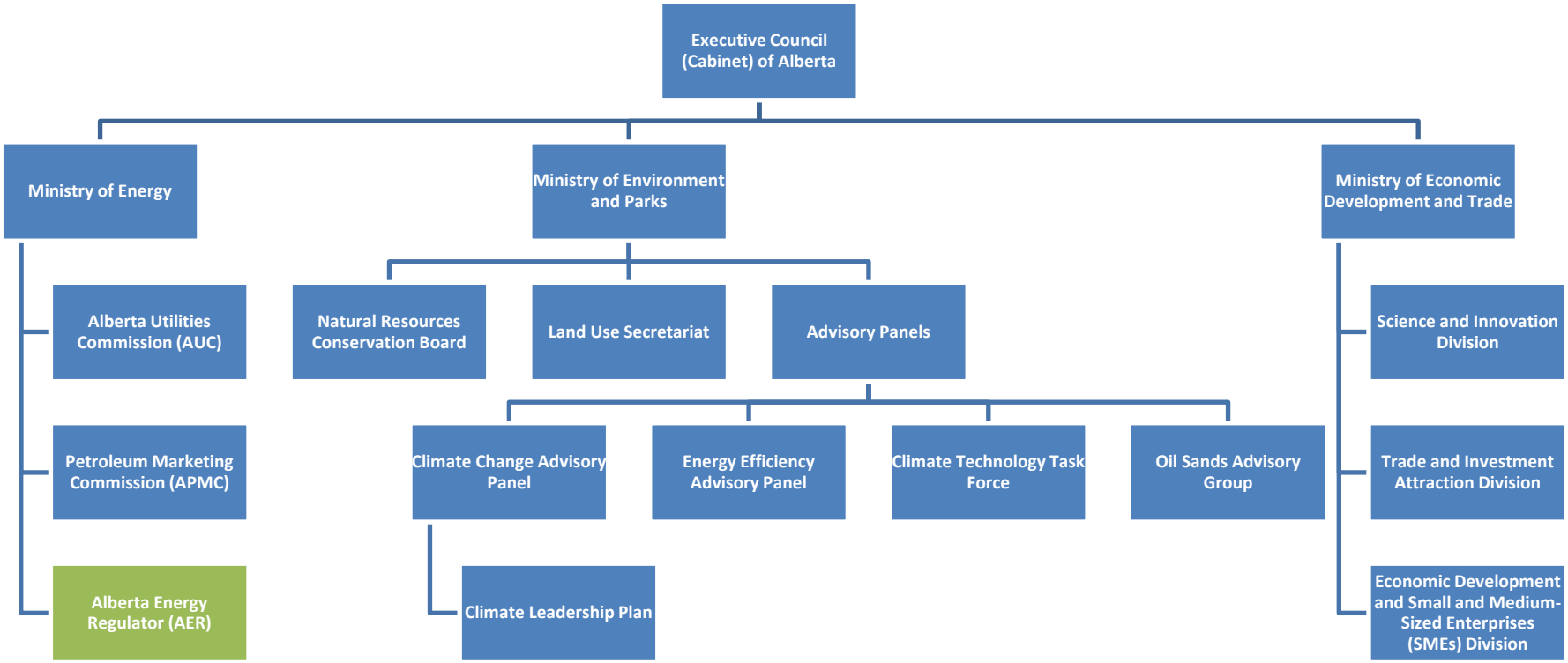

Figure 5 Major institutions in the energy framework in Canada, Provincial Government. Regulatory agencies are highlighted in green

1.4 The Innovation System map

The system map (see Figure 5) is an initial draft that of the oil sands development sector in Alberta, and identifies some of the key elements that impact the sector's development. The map was developed based on secondary research and will be revised over time as we gain more insights from our research and stakeholder consultations.

On the left hand side of the map, the 'Technological Innovation System (TIS) Life Cycle' (i.e. the oil sands development supply chain) is identified and categorised as upstream, midstream and downstream sectors. The case study will primarily focus on aspects of the supply chain that are located in Alberta including the upstream and midstream sectors and some parts of the downstream, including the end users. We will not focus on refining in the downstream sector, as a large percentage of the bitumen produced is processed in the United States.

Below the TIS lifecycle box, the 'Local Context' box identifies two aspects: 1) key stakeholders that are impacted by the oils sands, including the indigenous communities surrounding the oil sands development sites; and 2) the social, economic and environment impacts from the sector. There are several arrows flowing between the indigenous communities (located in the Local Context box) to 'Government Policy Institutions', 'Facilitating Services and Infrastructure' and 'Political Parties'. The flow of arrows indicates that there are some important interactions, but we have not yet categorised the nature of these interactions (i.e. whether they are barriers or enablers to a low carbon development pathway); thus these areas need further exploration. We will also include other key interactions as we carry engage with more stakeholders thorough our research.

On the top right hand side of the system map, the 'Policy Mix' box highlights the key policies influencing the development of the sector while the 'Government Policy Institutions' 'Industry Institutions' and 'Political Parties' boxes represent the key institutions with power, influence and interests in developing the oil sands. The 'Facilitating Services and Infrastructure' box represents other institutions that may not be directly linked to the oil or energy sector, but have an important direct or indirect link to the sector.

There are also several other key stakeholders not yet included in the system map, including civil society. We aim to include civil society in the next version of the system map as we engage with more stakeholders from civil society.

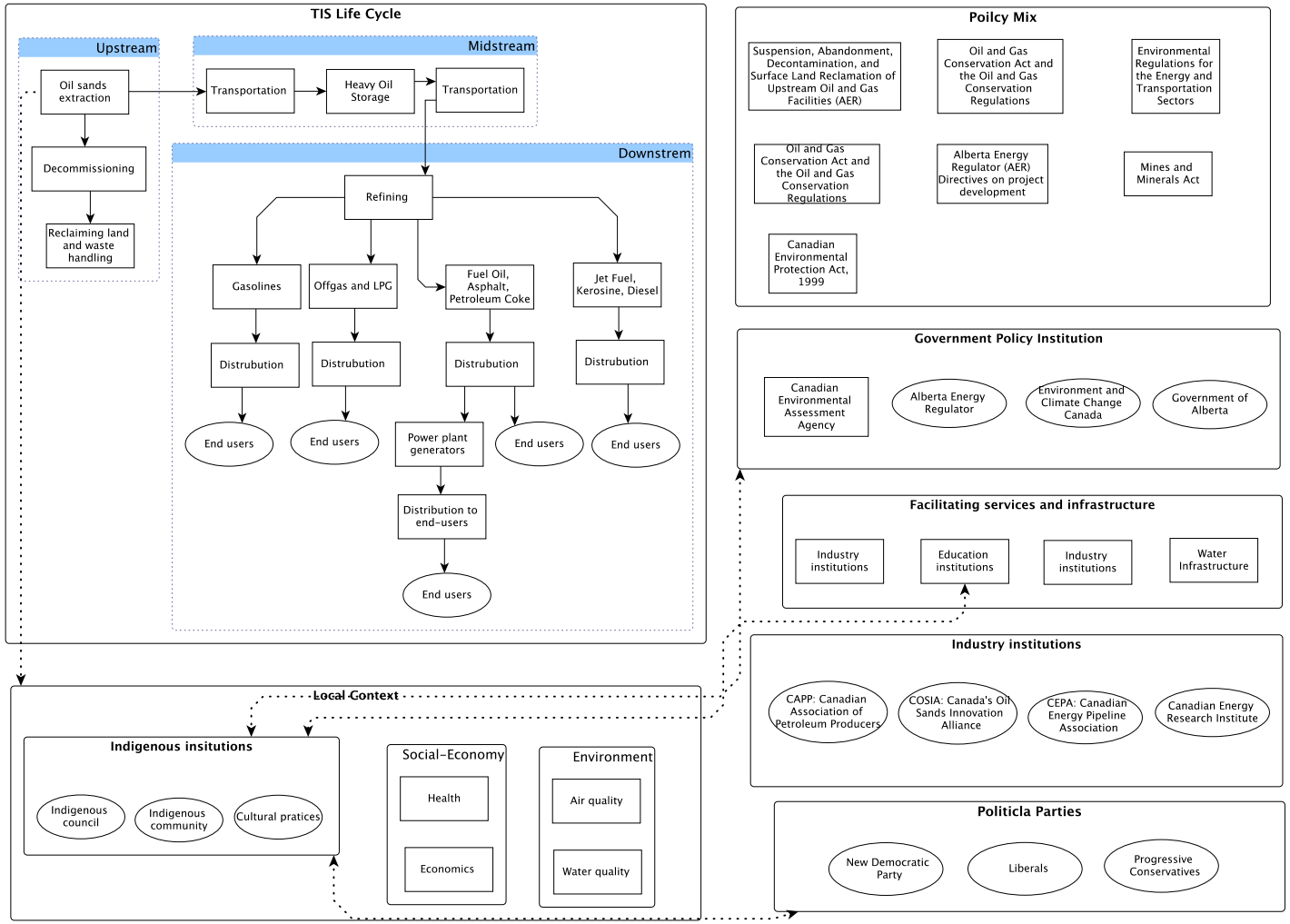

Figure 6: System map of the oil sands development in Alberta

Source: Author's own work

1.5 Stakeholder engagement

For the development of the general context for the case study, three preliminary interviews were performed with individuals involved in the oil and gas sector. These individuals, or generalists, provided an overview of their perspectives on the challenges and opportunities of the sector, along with some views about the possible future of the oil and gas in Canada, considering the current political environment. A brief description of the interviewees is presented below on Table 6.

Table 6: Stakeholder Engagement

Type of stakeholder		Position in the organisation*	Economic sector**	Type of engagement***	Month and year contacted
1.	Consultancy	Technical Consultant	Energy, Environment	Interview	November 2016
2.	Business/Research	Manager Process Development	Energy, Industry	Interview	November 2016
3.	Business	Process Engineering Specialist	Energy, Industry	Interview	November 2016

* Government (national / subnational), research / consultancy, business, other (specify)
** Energy, Industry, transport, environment, agriculture / forest, financial / trader, other (specify)
*** Interview, focus group, workshop, survey etc.

For the next milestones of the case study further interviews will be performed to engage stakeholders and assess potential pathways. Stakeholder input will be used to develop these pathways, i.e. asking individuals directly affected by changes in the sector what they would like to consider in terms of low-carbon technologies and GHGs emissions reduction.

A preliminary stake holder screening list is presented in the Appendix section, Table 7.

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Appendix A: Stakeholder Screening List

In Table 7, a summary of the preliminary stakeholder screening is presented. These stakeholders are expected to be interviewed between 2016 and 2017, to define the low carbon pathways to be included as scenarios in the case study.

Table 7 Preliminary stakeholder screening. Canada Case Study

No.	Name	Organisation	Position within organisation
	GENERALISTS		
1	James K. Gray	Brookfield Asset Management Inc.	Chairman
2	Dr. Andrew Leach	University of Alberta	Associate professor Alberta School of Business - Chair of Climate Change Leadership Alberta
3	Dr. Shawn Marshall	University of Calgary	ProfessorTier II CRC/Clim Change
4	Reegan McCullough	Oil Sands Community Aliance (OSCA)	Executive Director
5	Dan Wicklum	Canada's Oil Sands Innovation Alliance (COSIA)	Chief Executive – Environment Canada
6	Bill Whitelaw	Canadian Heavy Oil Association (CHOA)	Director – JUNEWARREN-NICKLE'S ENERGY GROUP
7	Reegan McCullough	Oil Sands Community Aliance (OSCA)	Executive Director
8	Peter Tertzakian	ARC Financial Corp	Chief Energy Economist and Managing Director
	STAKE HOLDERS		
11	Shannon Phillips	Government of Alberta	Minister of Enviroment and Parks
12	Bill Werry	Government of Alberta	Deputy Minister Alberta Climate Change Office (ACCO)
13	Margaret McCuaig-Boyd	Government of Alberta	Minister of Energy
14	Melissa Blake	Wood Buffalo County	Mayor
15	Julia Cardinal	Wood Buffalo County	Councillor - Ward 2
16	Claris Voyageur	Wood Buffalo County	Councillor - Ward 2
17	Allan Glenn Vinni	Wood Buffalo County	Councillor - Ward 3
18	Jim Boucher	Fort MacKay	Chief
19	Raymond Powder	Fort MacKay	Councillor
20	Mark Little	Suncor	Fort Hills EVP upstream
21	Fiona Jones	Suncor	Environment/Sustainability manager
22	Réal J.H. Doucet	CNRL	Senior Vice-President, Horizon Projects

23	Philip A. Keele	CNRL	Vice-President, Mining
24	William R. Clapperton	CNRL	Vice-President, Regulatory, Stakeholder and Environmental Affairs
25	J.M. Mintz	Imperial Oil	President's Fellow.
26	Mick Elliott	Imperial Oil	Stakeholder Relations Advisor
27	Sandy Campbell	Imperial Oil	Regulatory and Environmental Lead
28	Mike Daley	Syncrude	Vice President, Safety, Security, Health & Environment
29	Greg Fuhr	Syncrude	Vice President, Production, Mining and Extraction
30	Steve Yatauro	Syncrude	Vice President, Production, Upgrading
31	Ron Lewko	Syncrude	Team Leader, Environmental Research
32	John Myer	Husky	Senior Vice President, Oil Sands
33	Stanley T.L. Kwok	Husky	Health, Safety and Environment Committee
34	John Rossall	Canadian Association of Petroleum Producers (CAPP)	Chair - Senior Vice President, Canada Talisman Energy Inc.
35	J. Michael Gatens	Canadian Association of Petroleum Producers (CAPP)	Vice Chair - Chief Executive Officer UGR Blair Creek Ltd
36	Terrance Kutryk	Canadian Energy Pipeline Association (CEPA)	Chair - President & CEO, Alliance Pipeline Ltd.
37	Alex Pourbaix	Canadian Energy Pipeline Association (CEPA)	Past Chair - President, Energy and Oil Pipelines, TransCanada PipeLines Limited
38	Leon Zupan	Canadian Energy Pipeline Association (CEPA)	Vice/Incoming Chair - Chief Operating Officer, Liquid Pipelines, Enbridge Pipelines Inc.
39	Dan Wicklum	Canada's Oil Sands Innovation Alliance (COSIA)	Chief Executive – Environment Canada
40	John Brogly	Canada's Oil Sands Innovation Alliance (COSIA)	Director, Water EPA – CNRL
41	Jenna Dunlop	Canada's Oil Sands Innovation Alliance (COSIA)	Director, Land EPA – CAPP
42	Wayne Hillier	Canada's Oil Sands Innovation Alliance (COSIA)	Director, Greenhouse Gases EPA – Suncor
43	Jonathan Matthews	Canada's Oil Sands Innovation Alliance (COSIA)	Director, Tailings EPA – Syncrude
44	Kelly Munkittrick	Canada's Oil Sands Innovation Alliance (COSIA)	Director, Monitoring – Environment Canada
45	Stephen Arseniuk	Canadian Heavy Oil Association (CHOA)	President - LARICINA ENERGY LTD.
46	Kym Fawcett	Canadian Heavy Oil Association (CHOA)	Director - ENERPLUS CORPORATION
47	Simon Davies	Canadian Heavy Oil Association (CHOA)	Director - CANADIAN NATURAL RESOURCES INC.
48	Bill Whitelaw	Canadian Heavy Oil Association (CHOA)	Director – JUNEWARREN-NICKLE'S ENERGY GROUP

49	Rodger Bernar	Canadian Heavy Oil Association (CHOA)	Director - HUSKY ENERGY
50	Heather Scott	Canadian Heavy Oil Association (CHOA)	Director - BRION ENERGY
51	Tim Hazlett	Canadian Heavy Oil Association (CHOA)	Director - GOVERNMENT OF CANADA
52	Don Greaves	Canadian Heavy Oil Association (CHOA)	Director - IBM CANADA
53	Kathleen Sendall	Climate Change and Emissions Management Corporation (CCEMC)	Chair – CGG and Enmax
54	Reegan McCullough	Oil Sands Community Aliance (OSCA)	Executive Director
55	Chris Severson-Baker	PEMBINA Institute	Regional Director, Alberta
56	Simon Dyer	PEMBINA Institute	Associate Regional Director, Alberta
57	Charlie Fischer	PEMBINA Institute	Advisor - former CEO of Nexen Inc. and head of clean energy working group within the US-Canada Clean Energy Dialogue (industry expertise)
58	Fred Gallagher	PEMBINA Institute	Advisor - Principal, Innovitas Inc. (renewable and electrical energy expertise)
59	David McLaughlin	PEMBINA Institute	Advisor - President and CEO, National Roundtable on the Environment and the Economy (policy expertise)
60	Jason Switzer	PEMBINA Institute	Senior Advisor to the Executive Director
61	Tom Jackman	Alberta Energy Efficiency Alliance	Chair - SAIT
62	David Conn	Alberta Energy Efficiency Alliance	Vice Chair - ATCO Gas
63	Ken Hogg	Alberta Energy Efficiency Alliance	Officer - Renewable Energy Solutions
64	Ben van Beurden	Shell	Chief Executive Officer (CEO)
65	Melina Laboucan-Massimo	Green Peace	