Electrification of Transport as a Driving Factor for a Transition

APSC 401 – W2021

Group 2

Statement of Originality

Our signatures below attest that this submission is our original work.

Following professional engineering practice, we bear the burden of proof for original work. We have read the Policy on Academic Integrity posted on the Faculty of Engineering and Applied Science web site (http://engineering.queensu.ca/policy/Honesty.html) and confirm that this work is in accordance with the Policy.

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Executive Summary

The Bowman Center for Sustainable Energy has requested an analysis of the global trends of a transitioning oil sector including examining existing transition programs and possible recommendations for future transition planning programs. This report seeks to provide a framework for future development of an implementable transition plan for the fossil fuel industry in Canada.

The oil sector in Canada and it's impact to total employment in Canada, tax contribution, global oil trends, and future oil and gas profitability were analyzed. Canadian and international electric vehicle adoption and the potential impact to oil and gas future profitability were investigated as a catalyst for a transition in Canada. The use of extracted bitumen from the oil sands beyond combustion fuels was proposed as a method of limiting release of greenhouse gases. Alternative potential new sectors such as renewable energy, mining, and a range of emerging technology sectors were recommended as a transition location for oil and gas workers.

Existing international transition plans such as in the European Union and the United Kingdom were investigated as part of an inventory of available transition plans. The roles that both federal and provincial governments can have on a successful transition in accordance with Section 91 of the constitution were recommended. High level steps that businesses can take towards taking advantage of the transition rather than seeing it as a hindrance to businesses were recommended as well. Steps that oil and gas extraction businesses must take to utilize existing infrastructure in accordance with the goals of a more sustainable economy were also outlined. General recommendations for the retraining of fossil fuel workers into new sectors were given. Lastly, steps to achieve public support and community involvement in the transition process to ensure an equitable transition were provided.

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1.0 Introduction

The project scope, and objectives of the report are discussed in this section.

1.1 Project Scope

There have been growing concerns from the public regarding global warming and the environment. In 2005, after consultation with international Governments, Canada set a goal to reduce carbon emissions to 30% below 2005 levels (511Mt) by 2030 [1]. The greenhouse gas (GHG) inventories for the oil and gas sector account for 26% of national GHG emissions [2]. Meanwhile, Canadian oil and natural gas provided $110 billion to Canada’s gross domestic product (GDP) in 2019, supported almost 550,000 jobs across the country in 2018, and provided $10 billion in average annual revenue to governments 2017 to 2019 [3], which implies 5.4% of the national GDP coming from the oil and gas sector [3]. A transition from fossil fuel-powered transportation to low carbon electric powered propulsion is underway, unstoppable and underpins the urgent need for transition plans. Despite policies that the Canadian Government has put in place to limit emissions and support renewable energy; an implementable, robust, and detailed transition plan has not been put in place to limit the risk an energy transition will have to our economy. To reduce social and economic upheaval, we need to develop and implement transition plans supported by the majority of Canadians and ideally with all political parties' support or at least supporting the plan's broad objectives.

The purpose of our project is to analyze global and national economies, trends, and current plans to provide our perspectives and some realistic recommendations to the Canadian provincial governments, NGOs, and funding agencies to inspire action and change. This project will also outline some specific short-term and long-term goals for policymakers in the hopes of breaking the current impasses on reaching environmental objectives by the form of a formal report and presentation to our client, the Bowman Centre of Sustainable Energy.

1.2 Project Objectives

Our report will focus on researching and analyzing the global trends of transitioning the traditional oil sector, including existing transition planning programs and possible recommendations for future transition planning programs. The scope of this report will be limited to oil sectors in Canada only. Our goal is to provide recommendations for the Canadian Government to protect those who will, directly and indirectly, impact this inevitable change. Our analysis of global energy and innovation trends will assess a transition plan's urgency and provide recommendations to diversify Canada's economy.

The project's motivation is our eagerness to contribute our perspectives on the inevitable incoming strike to the traditional oil sector. We hope our report could become a 'triggering document' to be shared with the public, government agencies, funding agencies, and NGOs. Three most prominent factors driving this energy transition will be researched and analyzed: economics, technology, and the environment. The deliverables required to meet the objectives outlined by our client, the Bowman Centre for Sustainable Energy (BCSE), are:

- An analysis of the Canadian oil sector.
- An evaluation of the EVs required to impact global oil prices and the timeline for EV adoption
- A detailed transition plan to diversify the Alberta economy

The following topics will be covered:

1. The size of the Canadian oil sector and its GDP contribution to Canada, including the number of direct and indirect employees in that sector.
2. The differences between unconventional Canadian oil and conventional oil and the impact this has on Canadian oil sand's profitability.
3. The impact Electric Vehicle adoption will have on the Canadian Oil Sector.
4. The role bitumen beyond combustion can play in the transition process.
5. Potential new sectors for Canada to diversify the economy.
6. Recommendations for a transition plan.

This report will provide the framework for the development of an implementable transition plan to be incorporated by the Canadian government. This report aims to compile a list of best practices and recommendations for future work on this transition. This report will cover the following topics regarding a transition plan:

1. An inventory/critique of recent transition or renewable energy plans and policies that have been considered or implemented on a national and global level.
2. An inventory/critique of Federal and Provincial jurisdictional issues as defined by Section 91 of our Constitution.
3. Recommendations on how government can create positive change through policy implementation and Industry creation.

4. Suggestions on how prominent private and public oil and gas sector companies can impact the transition towards renewable energy by investing in Canada's future and supporting current employees.
5. Recommendations on adaptations of existing infrastructure to accommodate a changing energy economy.
6. An analysis of possible industries that can help diversify the Canadian economy.
7. Advice on training and supporting current oil sector employees and how to prepare for the impact an energy transition could have on the entire supply chain.
8. Recommendations for achieving public support.
9. Recommendations for ensuring sufficient, supportive involvement of affected stakeholders, including indigenous communities impacted by the energy transition.

2.0 Oil Sector in Canada

Trends in the Canadian oil and gas sector are discussed regarding the impact that a transition would have on the Country.

2.1 Oil Sector Fraction of GDP in Canada

Globally, Canada is the fifth-largest producer of natural gas and sixth-largest producer of oil [4], with the oil sands covering an area of more than 142,000 square kilometres in Alberta and Saskatchewan [4]. Enbridge Inc., Suncor Energy Inc. and Imperial Oil Ltd., lead the list of prominent publicly traded oil and gas companies within Canada. Given the recent average price of bitumen, CAN$50/barrel, the valuation of Canada’s 160 billion barrels of bitumen across Alberta and Saskatchewan values the Canadian Oil Sands at almost ten trillion dollars [5], identifying the oil and gas industry an integral role in Canada’s economy.

2.1.2 Oil Sector Employment

Using the year 2016 as a “slump” year, following the two-year decline of oil prices [6], and data available from Statistics Canada Supply and Use, the following is an account of the Oil and Gas sectors contribution to employment and GDP in Canada. As of 2016, the Canadian oil and gas sector created 220,021 direct jobs and 381,371 indirect jobs, representing 3.3 per cent of all jobs across Canada, this information is relayed in Table 1 [6]. Additionally, over $10.4 billion was paid in the form of wages and salaries to those directly and indirectly associated with the oil and gas sector. The Canadian oil and gas sector also induced jobs in other sectors, including telecommunications (1400 jobs), architectural engineering (29,457 jobs) and others [6].

Table 1: Derived from Statistics Canada Custom Tabulation of the Supply and Use Tables, 2016.

Direct Impact	Indirect Impact	Total Impact	Total Employment	Total Employment (%)
222,021	381,371	603,392	18,436,450	3.3

2.1.2 Contribution from Canada's Oil and Gas Sector

Even with the energy price decrease as of 2016, the broad energy sector's contribution (direct and indirect) amounted to 5.4 per cent to Canada's total GDP [6]. In the same year, the GDP affiliated with the oil and gas sector totalled $101.9 billion, or 5.4 per cent of the total Canadian economy [6].

The value of goods and services produced by the oil and gas sector and its supply chain in 2016 was $209.8 billion, 5.9 percent of Canada's total output [6]. Table 2 shows the contribution from Canadian oil and gas to GDP.

Table 2: Oil and Gas GDP Contribution from Statistics Canada Custom Tabulation of the Supply and Use Tables, 2016.

Direct Impact	Indirect Impact	Total Impact	Total Economy	Share of Total Economy
GDP Impact 2016 ($ Billions)				
56.8	45.1	101.9	1,886.1	5.4%
Output (Purchases of Goods and Services) Impact 2016				
127.1	82.7	209.8	3,564.5	5.9%

2.1.2.1 Tax contributions

Table 3 shows the tax contributions received from the oil and gas sector.

Table 3: Oil and Gas Tax Contribution Derived from Statistics Canada Custom Tabulation of the Supply and Use Tables [7].

Direct Federal Revenues	Indirect federal, provincial, and municipal taxes
$82.7 billion	$14.0 billion

According to the Canadian Energy Sector, The Canadian oil and gas sector's total fiscal contribution to federal, provincial, and municipal government revenue was nearly $493 billion, on an inflation-basis to the 2020 dollar [7]. The five main ways the oil and gas sectors pay revenues to the Canadian Government are indirect taxes, crown lease payments, personal income taxes, corporate income taxes, and rents and royalties [7].

2.1.2.2 Additional Revenues

Table 4 shows additional revenues that the government received from the oil and gas industry.

Table 4: Oil and Gas Additional Revenues Derived from Statistics Canada Custom Tabulation of the Supply and Use Tables [7]

Crown Lease Payments	Personal Income Taxes on Salaries	Corporate Income Taxes	Rents and Royalties
$45.3 billion	$69.1 billion	$59.9 billion	$305.8 billion

Compared to other key sectors, such as real estate and construction, the oil and gas sector contributes significantly higher revenues to the Canadian Government (Real estate contributed $193.4 billion and Construction contributed $275.8 billion between years 2000-2018) [7].

Despite the decline in oil prices between 2014 and 2016, and the resulting negative impacts on the Canadian economy, the oil and gas sector contributed a share of 5.4 percent of Canada's GDP [6], which is still significant. The activities associated with the oil and gas sector are also indirectly responsible for employment and output in many industries within Canada. The oil and gas sector's heavy influence proves the importance of executing a robust transition plan to diversify the Canadian economy.

2.2 Oil Sector Trends

Anticipated trends in the oil sector are investigated and discussed in this section.

2.2.1 Global

Global trends in the oil sector are analyzed in this section.

2.2.1.1 Covid-19's Effect on the Oil Industry

The long-term trends, such as the oil sector's energy transition and digital transformation, have been expedited due to COVID-19 and the oil downturn [8]. Due to this, digitization is taking a prevalent role in 2021 to set emissions targets, drive human-machine collaboration, and regulate reporting to ensure accountability across the sector [8].

2.2.1.2 Oil Demand

In April 2020, global oil demand decreased by 25%. In 2021 oil demand is expected to improve; however, it will remain lower than pre-COVID-19 levels [8]. Additionally, oil prices and energy stocks have underperformed compared to other base metals and the S&P 500 index since July 2020 [8]. Due to the reduction in oil demand, there have been mass layoffs through the sector. In the US alone, oil and gas companies laid off 14% of permanent employees, and around 70% of these jobs will not return by the end of 2021 [8]. This accelerated change in the oil and gas sector could influence the value chain for years to come.

2.2.1.3 Renewable Energy Investments

Due to the low oil prices in 2020, it is anticipated that gulf cooperation council countries – Saudi Arabia, Kuwait, the United Arab Emirates, Qatar, Bahrain and Oman will diversify away from oil and increase investments in renewable energy projects. Nearly 50 GCC countries have started to make renewables practical through auction-based approaches to subsidies [9].

2.2.1.4 Global Energy Trade: LNG Imports and Solar Power

An increase in electricity access in African countries is likely, due to the growth of liquefied natural gas (LNG). LNG extension is projected to help natural gas demand exceed demand for oil and coal through 2040 [10]. Considerable renewable resources remain untapped in Africa, including solar capabilities. The broader energy infrastructure could be enhanced by the continued growth in solar power across Africa. This could create a ripple effect and attract foreign LNG exporters to invest in pipeline construction [10].

2.2.1.5 Decarbonization Efforts and Renewables Focus

Social and environmental pressures on oil and gas companies are growing, raising questions about the role fuels play in a rapidly evolving economy. These companies are being asked to make their operations and business models transparent and show their participation towards lowering Canada's greenhouse gas emissions towards the Paris Agreement's goals.

Oil and gas companies' investment outside core business areas has been less than 1% of total expenditure in Canada, showing little variation in capital spending patterns [11]. The largest investments outside of core business areas by leading oil and gas companies (around 5%) are spent on solar PV and wind [11] . Other areas of concern are electricity distribution, electrical vehicle charging and batteries and research around R&D activities [11]. A further change in overall capital expenditure and allocation is needed to accelerate energy transitions. Figure 1 shows the breakdown of capital expenditures on new projects outside of core business for oil and gas companies.

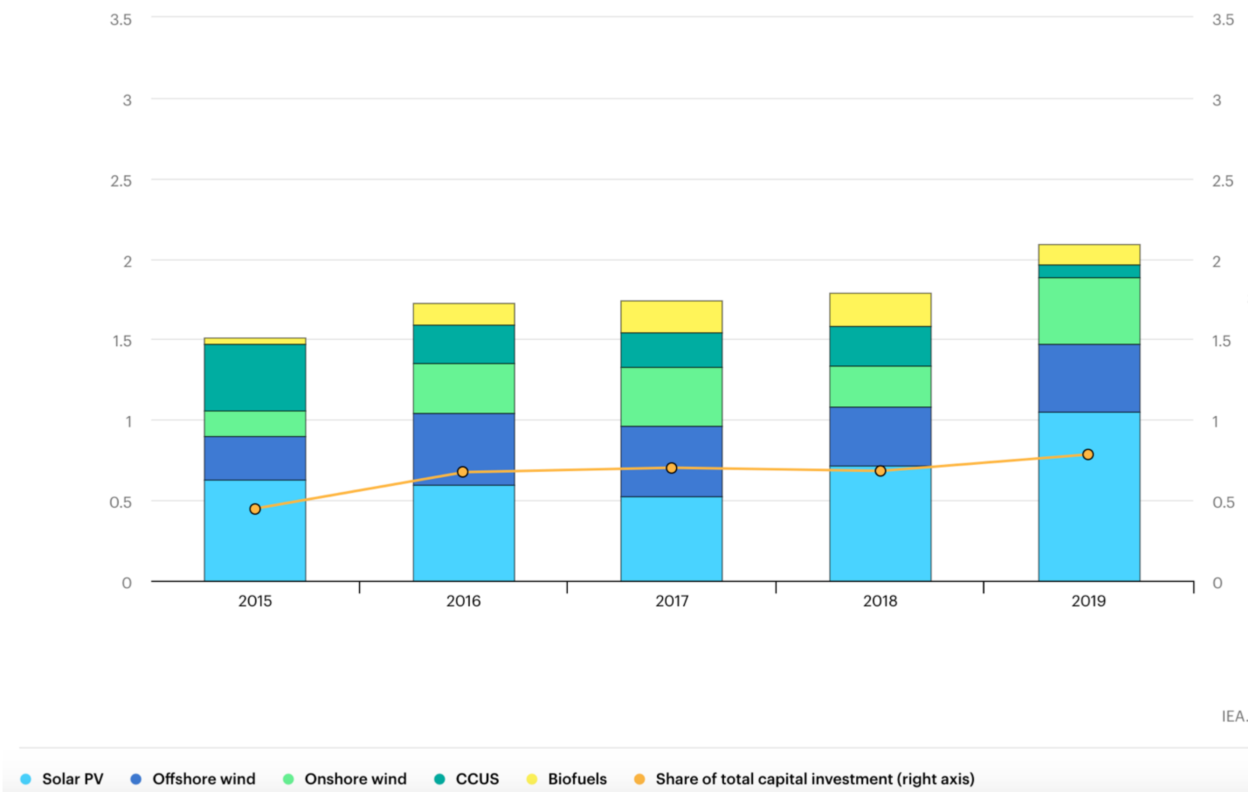

Figure 1: Capital expenditures on new projects outside of core oil and gas supply by large companies, absolute and as share of total capex, 2015-2019 [10].

2.2.1.6 Sustainable Technologies Investments

The oil and gas industry, governments and other stakeholders must create viable business models and invest heavily in carbon capture utilization and storage (CCUS), low-carbon hydrogen, biofuels, and offshore wind technologies to scale them up and bring down their costs. Total world investment in onshore wind, Solar PV, offshore wind, biofuels and CCUS is $300 bn, $530, $75 bn, $20 bn, and <$5 bn, respectively [11]. Figure 2 outlines the share of capital investment into different low carbon technologies.

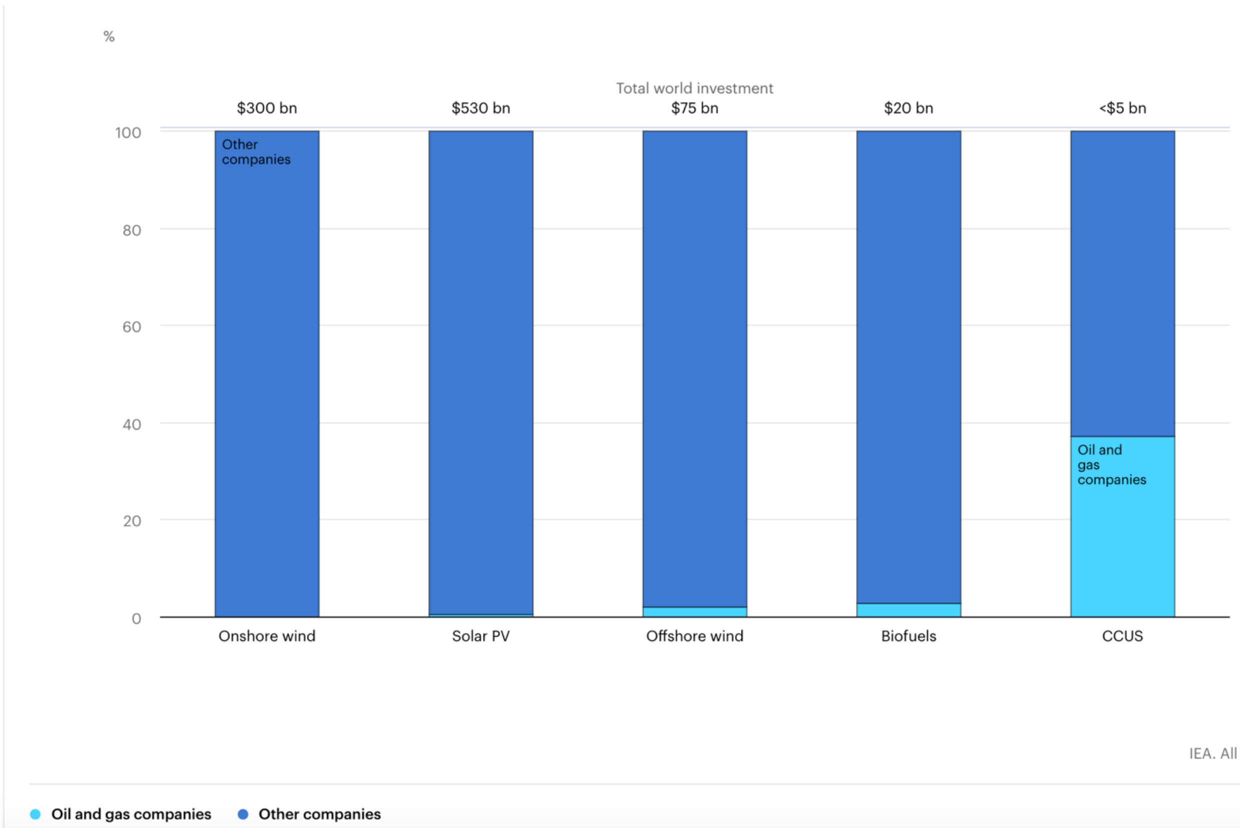

Figure 2: Share of global capital investment in selected low-carbon technologies (2015-2018) [10].

2.2.2 Canada

Trends in the oil sector in Canada are analyzed in this section.

2.2.2.1 Capital Expenditures in the Energy Industry

Figure 3 shows the trend in capital expenditures in the energy industry in Canada.

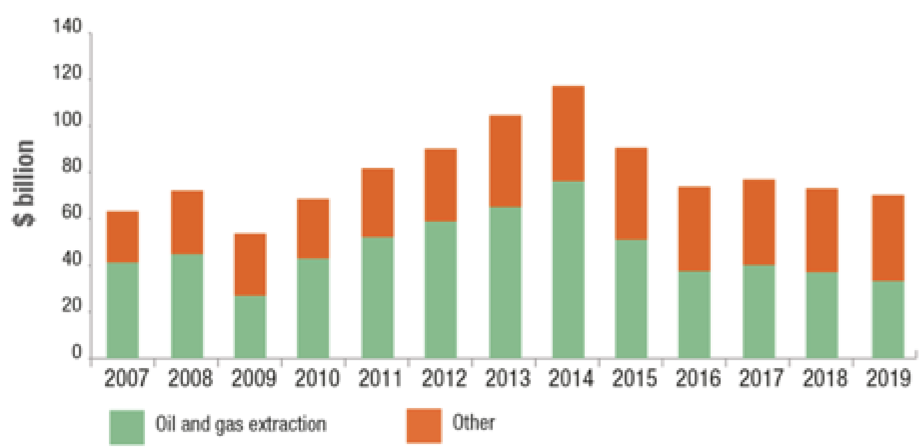

Figure 3: Capital Expenditures in the Energy Industry (Canada) [11].

The majority of Canada's totalled $70 billion of capital expenditures in the energy sector in 2019 were in oil and gas extraction ($33.3 billion) followed by electric power generation ($22.1 billion) [12]. Additionally, the total federal and provincial energy R&D investments in 2018-2019 were $1159M, rising by $360M from 2017-2018 [12]. Driven by energy efficiency-related projects, federal spending increased by 27% in 2018-2019. Energy efficiency increased to $289M in 2018-2019, aligning with Canada's innovation objectives and global renewable energy trends [12]. According to Natural resources Canada, Carbon capture, utilization and storage (CCUS) and other related activities drove P&T spending up by 81% in 2018-2019 ($215M increase), with CCUS investment tripling in 2018 compared to 2017 [12]. Along with all Mission Innovation members, Canada committed to double public investment in clean energy RD&D over the next five years in 2015 [12]. The federal government funded a Clean Technology Data Strategy In 2017 to implement the foundation for regulating the economic, environmental, and social consequences of clean technology in Canada through data advancement [12].

The Canadian government recently affirmed investments of over $56 million to develop small modular reactor (SMR) research and technology in New Brunswick [13]. This investment in Moltex Energy Ltd to produce its 300 MW Stable Salt Reactor-Wasteburner (SSR-W) has many potential economic benefits for Canada. Moltex Energy plans to build a 300 MW Stable Salt Reactor-Wasteburner (SSR-W) and WAste To Stable Salt (WATSS) facility striving for grid connection by the early 2030s. SMR's could be an important opportunity for Canada to attain its goal of net-zero emissions by 2050.

2.2.2.2 Canadian Energy Retail Prices

The energy element of the consumer price index (CPI) has been unstable in recent years. Upstream oil and gas prices and their impression on consumer products such as gasoline have caused this volatility [12]. Between 2002 and 2019, the yearly consumer price index has increased by 36%, this is shown in Figure 4 [12].

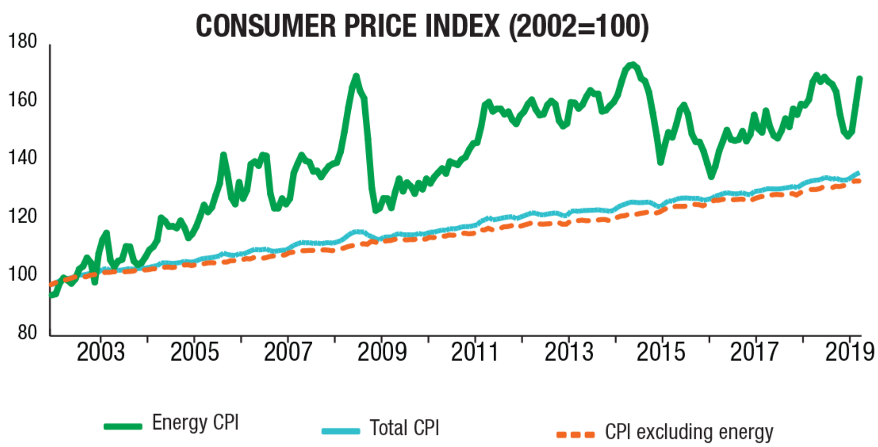

Figure 4: Canada along with all Mission Innovation members committed to double public investment in clean energy R&D over five years in 2015 [11].

2.3 Oil Sands Product vs. International Oil

The production costs of a barrel of oil vary globally, which is shown in Figure 5. As crude oil prices fluctuate due to demand decreases, the profitability of oil production in Canada compared to global competition could be detrimental to the Canadian Economy.

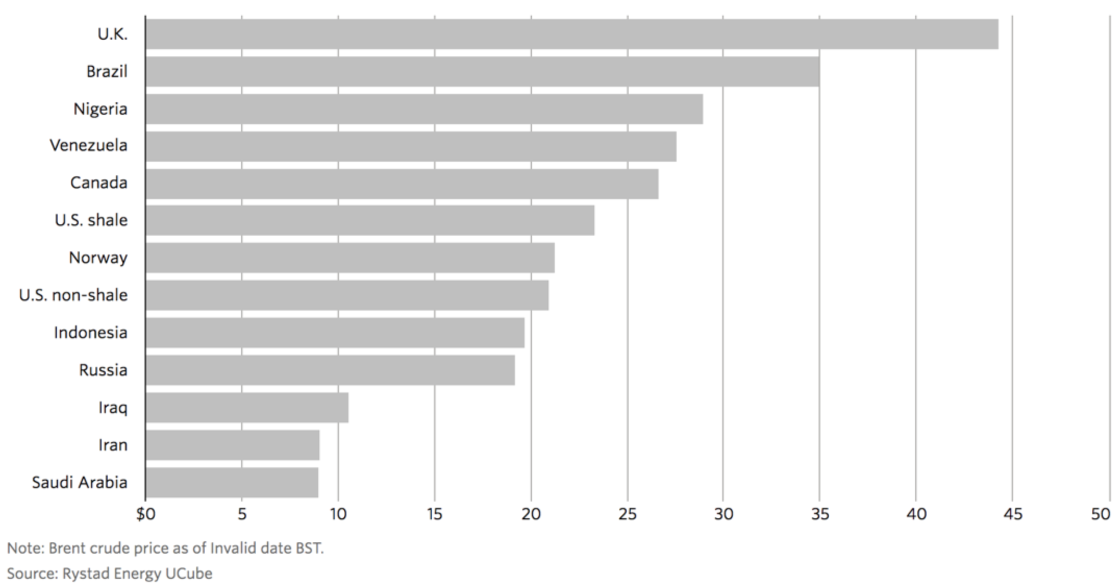

Figure 5: Cost of Producing a Barrel of Oil and Gas by Country, 2016 [12].

2.3.1 Profitability of Oil

Future predicted profitability of oil is analyzed across the globe in this section.

2.3.1.1 Profitability in Canada

Western Canadian Select Crude is composed of bitumen mixed with light condensate so it can flow through pipelines. Synthetic Crude is produced from oil-sands bitumen that is run through an upgrader [14]. Most production comes from oil sand deposits in remote boreal forests in northern Alberta, which have some of the highest capital costs and development timelines globally [14]. The extraction process of bitumen from the Canadian oil sands is labour intensive and expensive. Thus, when oil prices drop below the extraction cost, the process is not economically beneficial [15]. The biggest threat to the oil and gas industry's profitability is the lack of market access. Canadian oil sands companies are dependent on international markets since Canadian demands are not enough to sustain current or future production [15]. On average, in 2019, Canadian Natural's oil sands mining and upgrading costs were $24.17 per barrel, which is an effort of a long process of trying to decrease expenses [16]. In March 2020, heavy oil sold for around $13 U.S. per barrel, making the oilsands production unprofitable. In contrast, West Texas Intermediate, the North American benchmark, averaged about $30 in March [17].

2.3.1.2 Profitability in the United States

Horizontal drilling and fracking technology have led to the emergence of additional light oil in the United States. This has added pressure to the Canadian oilsands investment market due to the more favourable investment cycle, access to markets and potential for better returns [15]. According to the data firm Rystad Energy, in the top two U.S. shale fields, oil and gas companies are profitable when the price per barrel ranges between $30 and $40, making them a dominant marginal producer [18]. Due to low prices and decreased demand, U.S. crude oil production dropped 2 million barrels per day in 2020, which is shown in Figure 6 [19].

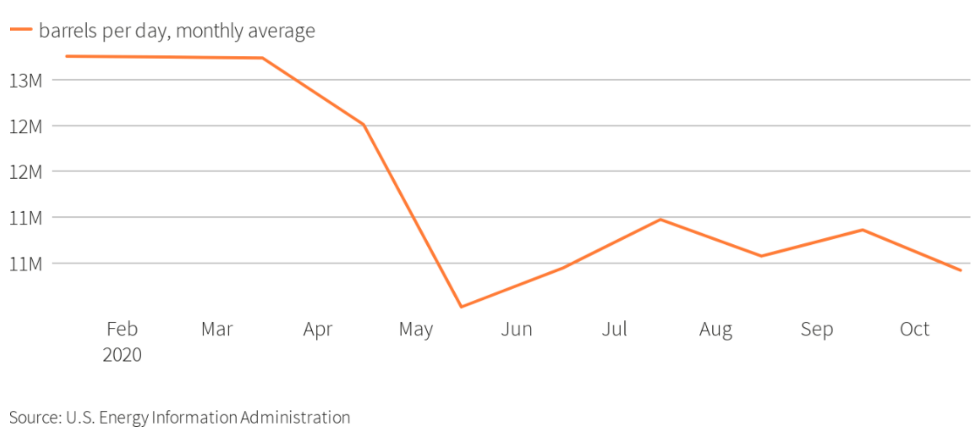

Figure 6: U.S. Crude oil Production decline in 2020.

2.3.1.3 Profitability in Saudi Arabia

According to the U.S. Energy Information Administration (EIA), Saudi Arabia accounted for the most OPEC earnings in 2019, with earnings of $202 billion (over one-third of total OPEC oil revenues) [20].

Over fifty percent of the world's crude oil reserves are in the middle east, with Saudi Arabia being the most prominent producer [18]. Saudi Arabia has vast oil reserves near the desert surface, pooled in large fields, making production much easier and cheaper than in Canada. In 2016, The total production cost (including the capital, production, and administration/transport costs) of oil in Saudi Arabia was the lowest globally, at US$8.98 per barrel [18].

2.3.1.4 Profitability in Russia

The biggest oil companies in Russia are well-positioned to endure low oil prices for the coming years due to their advantages over global competitors. They may be able to turn a profit despite low oil prices of $15 a barrel [21]. These companies are resilient because of the western sanctions that have restrained Russia's access to foreign technology and capital that caused the majority of their expenses and liabilities to be in roubles instead of dollars. As oil prices fall, the rouble usually weakens, improving domestic earnings per exported barrel. Russia also has a tax system that decreases taxes on producers in line with oil prices, and its producers have significant foreign exchange savings. When oil prices are high in Russia, state coffers' benefits outweigh those for the companies and vice versa. Producers are exempt when the price falls below $15 for Urals blend, Russia's local grade trades near $5 a barrel discount to Brent crude. Russian oil companies, Rosneft and privately owned rival Lukoil would make a pre-tax profit with Brent at $15 a barrel [21]. According to Rosneft's company data, the total production cost (to extract and refine oil) was about $5 [21].

2.3.2 Environmental Impact of Canada’s Oil Sands

Unlike conventional oil, unconventional oil cannot be recovered using drilling and pumping methods [22]. Alternatively, oil sand mining and in situ development are used to recover heavier oil in Canada. In geological formations, light-tight oil is extracted through horizontal drilling and hydraulic fracturing [22]. These advanced methods of oil extraction are detrimental to the environment in Canada, which is shown by the comparison of oil extraction lifecycle greenhouse gas emissions in Figure 7.

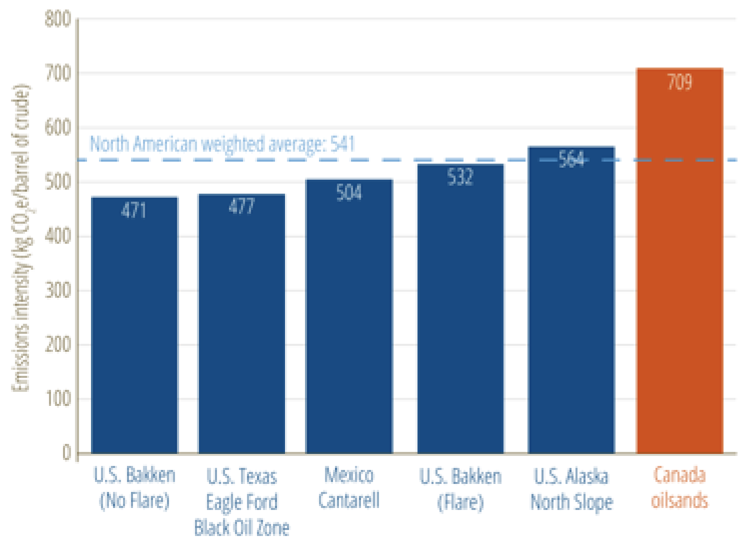

Figure 7: Emissions associated with the full lifecycle of a crude (from extraction to combustion) for a selection of crudes produced in North America [20].

Due to the extensive extraction process in the oilsands (large volumes of natural gas, electricity and diesel involved), average oil sand production is significantly more greenhouse gas intensive than conventional oil [23]. According to the Carnegie Endowment's Oil-Climate Index, oilsands crude is associated with 31 percent more emissions than the average North-American crude throughout its lifecycle [24]. The absolute emissions from the oilsands have also been increasing due to an increase in the number of projects and production. GHG emissions increased from 15.4 MT in 1990 to 72 MT in 2016 [15].

To combat this emissions problem, Alberta's government implemented a climate leadership plan that requires oilsands emissions to be capped at 100 megatonnes (MT) per year [15].

3.0 Electric Vehicles

The role and impact of electric vehicles in a transition of the economy away from fossil fuels is discussed.

3.1 Trends in EV Adoption

In this section, three types of electric vehicles: battery-electric vehicles (BEVs), plug-in hybrid electric vehicles (PHEVs), and hydrogen fuel cell vehicles will be referred to as electric vehicles (EVs).

3.1.1 Global Trends in EV Adoption

There were only 17,000 electric vehicles on the world's roads in the first half of the 2000-2010 [25]. In 2019, 7.2 million electric vehicles are running on the road [25]. Over 20 countries internationally reached electric vehicle market shares above 1% [25]. Figure 8 shows the total number of EVs globally from 2010 to 2019 [25].

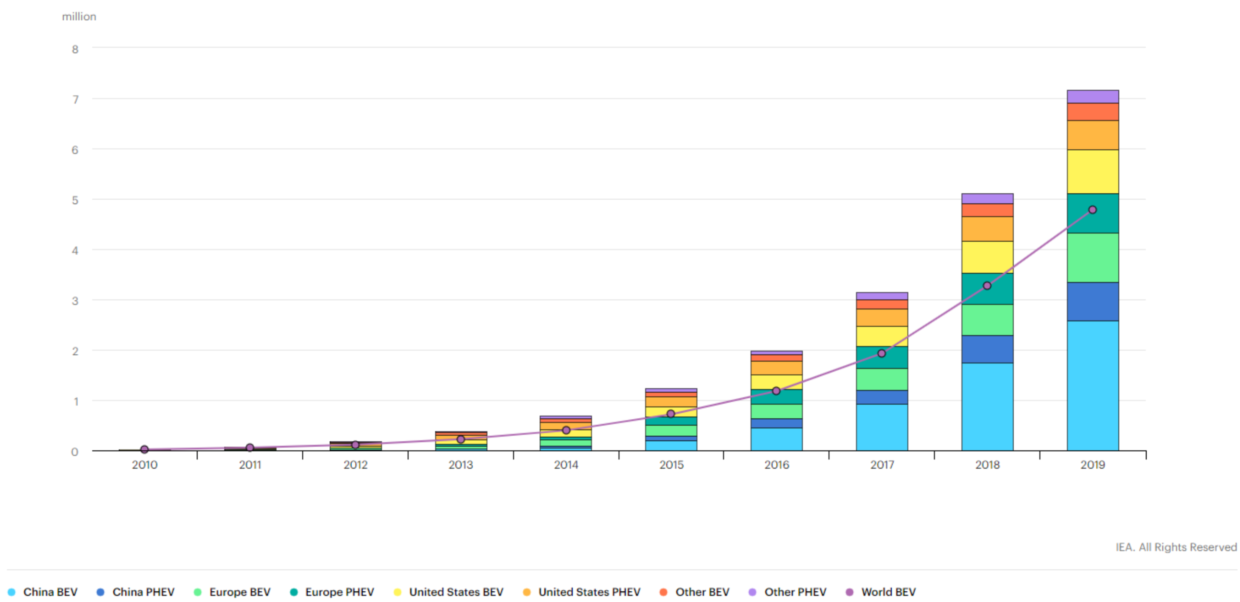

Figure 8: The Total Number of EVs in the Global Trend [25].

In 2020, 3 million electric cars were sold globally [26]. However, 2020 was a contraction in the growth of EVs. Three reasons could explain this trend: car markets contracted, purchase subsidies were reduced in key markets, and consumer expectations of further technology improvements in new models [25]. Figure 9 shows the market share of EVs in key markets annually [27].

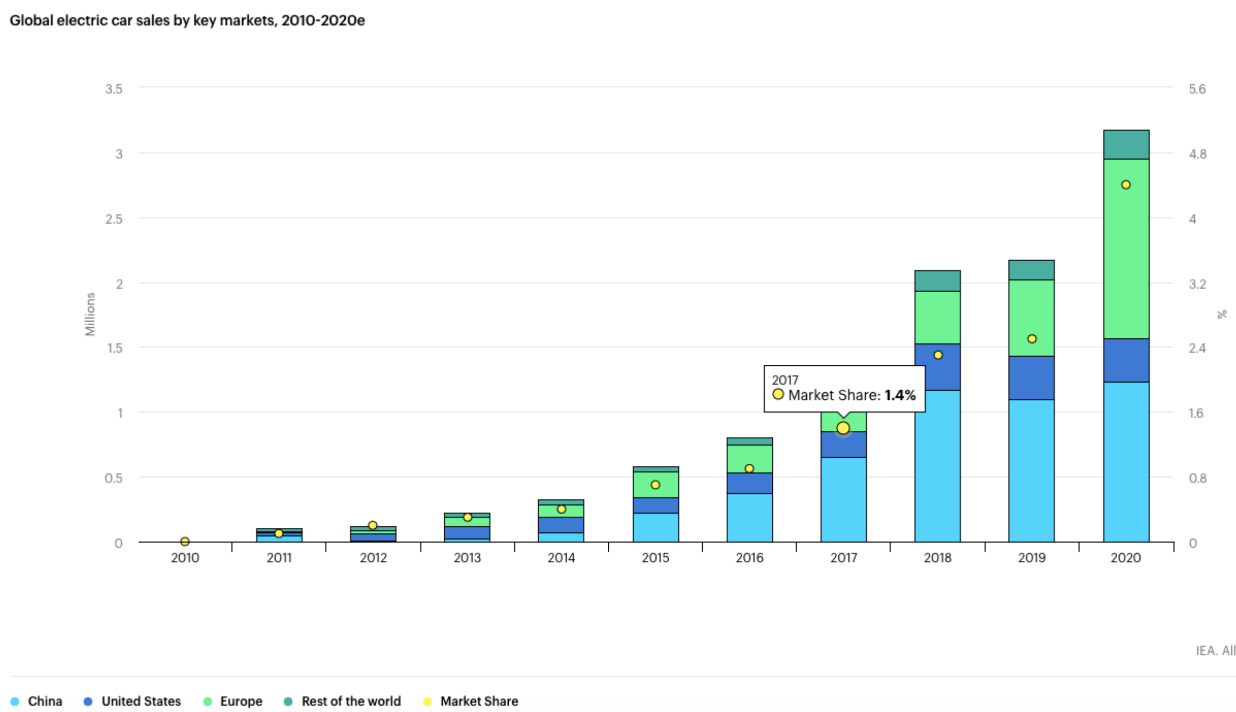

Figure 9: The global EV sales in key markets [17].

One crucial factor that impacts the growth of EVs is the infrastructure for electric vehicle charging stations. In 2019, charging stations for EVs reached 7.3 million chargers worldwide, with 6.5 million of those being private, light-duty vehicle slow chargers in homes, multi-dwelling buildings and workplaces [25]. Table 5 provides an overview of EV charging stations distribution globally in 2019.

Table 5: Overview of EV Charging Stations Distribution in 2019 [27].

Country	Private EV Slow Chargers (6.5 million)	Publicly Accessible EV Slow Chargers (598 thousand)	Publicly Accessible EV Fast Chargers (264 thousand)
China	37%	52%	82%
United States	24%	11%	5%
Germany	5%	3%	1%
France	5%	5%	1%
Norway	5%	1%	2%

Country	Private EV Slow Chargers (6.5 million)	Publicly Accessible EV Slow Chargers (598 thousand)	Publicly Accessible EV Fast Chargers (264 thousand)
Netherlands	4%	8%	<1%
United Kingdom	4%	4%	2%
Japan	3%	4%	3%
Others	13%	12%	5%

3.1.2 Electric Vehicle Trends in Regional Markets

Current and future trends in electric vehicle adoption across different countries are analyzed in this section.

3.1.2.1 Europe

The EU vehicle market has been gradually more and more occupied by BEVs and PHEVs [28]. In 2010, there were only 700 EVs and that number boomed to 550,000 in 2019, which account for 3.5% of new registered passenger vehicles [28]. Figure 10 reports the number of EVs newly registered in Europe [29].

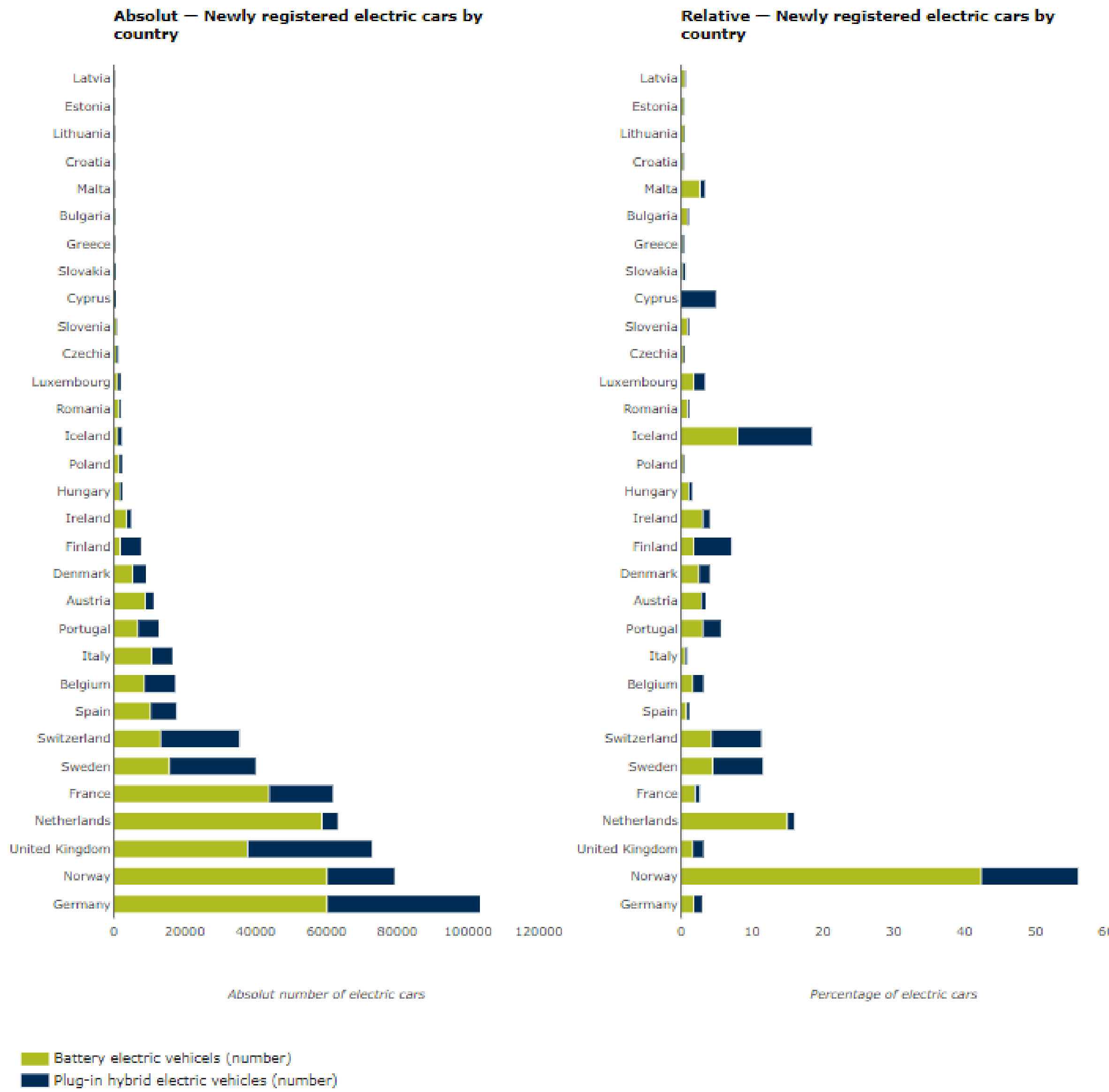

Figure 10: Number of BEV & PHEV in Europe in 2020 [29].

Due to the impact of COVID-19, the demand for new passenger cars contracted by 38.5% in the first quarter of 2020; for April 2020 along (first full month with the pandemic restrictions), the new registry passenger cars declined 76.3% [28].

3.1.2.2 China

For the first half of 2019, China's EV sales growth rate decreased, but the impact of COVID-19 and the impact of the slashed subsidies impact EV sales in the long run. [30]. Meanwhile, China is still encouraging EV charging stations infrastructure and continuously encouraging Chinese manufacturers to produce and market EVs [30]. For the first quarter of 2020, China's EVs sales dropped 57%, due to monetary incentives that were about to expire. The government also prolonged the purchase-tax exemptions of NEVs through 2022 [30].

3.1.2.3 United States

The United States EV market has been dominated by the success of the Tesla Model 3, which alone is responsible for almost half of all EV sales [30]. However, the second half of the year 2020 after the COVID-19, the EV sales dropped dramatically [30]. Car sales in the United States fell dramatically in the first three months of 2020 as the pandemic decreased demand; job losses increased, and large portions of the population were ordered to stay home [30].

3.1.2.4 Remaining Countries

Nations outside of Europe, China, and the United States are lagging in terms of EV sales. This could be explained by various reasons: a lack of government commitment to EVs, insufficient or unsuitable charging infrastructure, unavailability of EVs, and cultural differences regarding mobility models [30]. For example, Japan is a major global car market, but new car sales are dominated by domestically produced vehicles [30]. Less affluent nations have seen resilience to EV adoption due to the comparative higher price that EVs have, such as India which is still dominated by "mass- and low-cost mobility models" [30].

3.1.3 Canadian Trends in EV Adoption

Current and future trends in electric vehicle adoption specific to Canada are analyzed in this section.

3.1.3.1 Canada EV Trend in General

Transportation is the second largest source of greenhouse gas (GHG) emissions in Canada [31]. To reduce the amount of transportation-related GHG emissions, the Canadian government has set incentives and other policies in order to increase the number of ZEVs on the road.

According to Statistics Canada, "electric and plug-in hybrid sales grew from less than 1% of all light-duty sales in 2015 and 2016, to 1% in 2017, 2% in 2018, and 2.7 % in 2019" [32]. Figure 11 shows the trends of electric vehicle sales by type and number of electric vehicle models available by type.

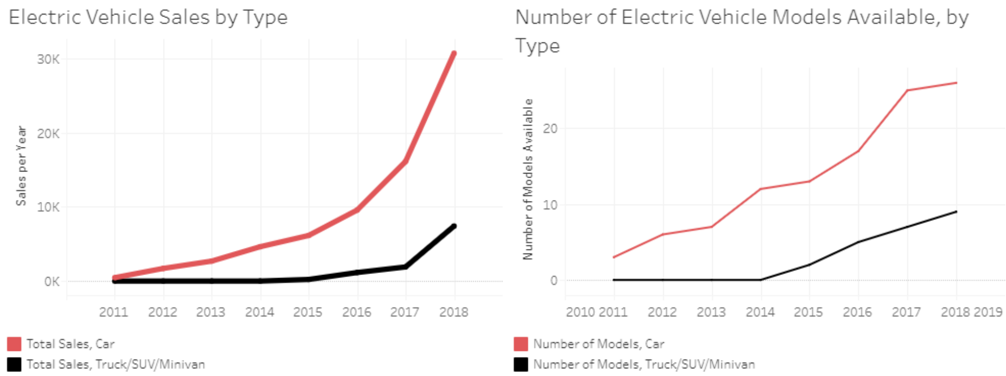

Figure 11: EV Sales by type and Available Models [33].

Transport Canada aims to have "825,000 electric cars registered in 2025, and 2.7 million in 2030 [32]." To have a better view on the growth of EVs in Canada, the following paragraphs explained the idea from the perspective of New ZEVs Registration Analysis provided by Statistics Canada.

3.1.3.2 New ZEVs Registration

Based on the registrations of new zero-emission vehicles provided by Statistics Canada, "ZEVs have grown over 8,300% since 2011, from 518 new vehicles registered in 2011 to 43,655 in 2018" [34]. Among three types of EVs as introduced in the beginning of this section, BEV was the most popular EV type in 2018 [34].

The overwhelming majority of new ZEVs registrations have been concentrated in three provinces that had or currently have rebate programs, Quebec, Ontario and British Columbia, where 97% of new zero-emission vehicles have been registered [35]. Between the year of 2017 and 2018, EV sales growth rate was "119.2% in Quebec, 94.2% in Ontario, and 162.0% in British Columbia" [34]. This dominance could be caused by provincial incentive programs and commitments from governments to EV infrastructure [36]. Figure 12 and Table 6 indicate the breakdown of new EV registration by province.

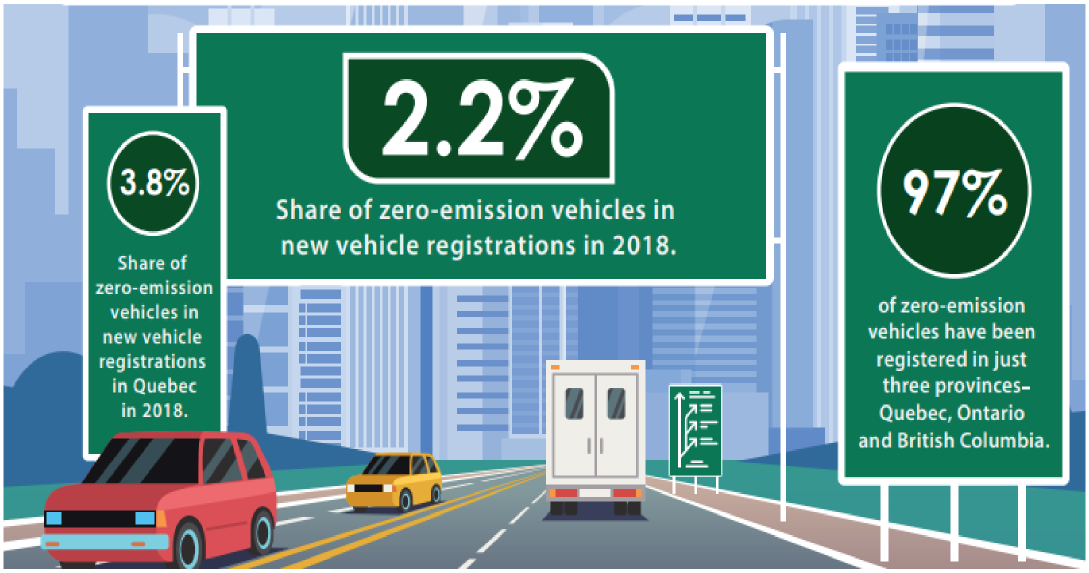

Figure 12: New Motor Vehicle Registration in 2018 Infographic [34]

Table 6: The Amount of EVs in 2017 & 2018, Canada [37]

	Canada(map)		Quebec(map)		Ontario(map)		British Columbia and the Territories(map)	
	Total, vehicle type[1]		Total, vehicle type[1]		Total, vehicle type[1]		Total, vehicle type[1]	
	Number of vehicles		Number of vehicles		Number of vehicles		Number of vehicles	
Fuel Type	2017	2018	2017	2018	2017	2018	2017	2018
	Units							
Battery electric	8,921	22,544	3,313	8,614	3,531	8,192	1,821	5,016
Hybrid electric	22,832	25,355	6,336	6,720	8,123	9,130	5,009	5,971
Plug-in hybrid electric	11,405	21,111	4,779	9,126	4,895	8,173	1,281	3,113

3.1.3.3 Impact of Ontario Rebate Programs

Ontario was one of the first provinces to offer electric vehicles incentives to increase the purchase rate of EVs. In Ontario, "individuals, businesses, and organizations that purchase or lease a new plug-in hybrid electric or battery electric vehicle after July 1, 2010 may be eligible for a rebate between $5,000 and $8,500" [38]. However, in the fall of 2018, the Ontario provincial government opted to cancel the rebate program [39]. This led to a dramatically reduced EV growth rate in Ontario after steadily increased since 2011 and reached a peak in the year of 2018 before the cancellation of Ontario rebate programs, this highlights the impact that rebate programs can have on technology adoption.

3.1.3.4 Impact of Infrastructure

In 2016, the province of Ontario introduced a five-year plan to fight climate change, to reduce greenhouse gas pollution, and transition to a low-carbon economy [40]. The government planned to install 500 electric charging stations in 250 locations, enabling EVs to be able to travel from Windsor to Ottawa and from Toronto to North Bay [41]. Figure 13 shows the timeline for full implementation of accessibility standards.

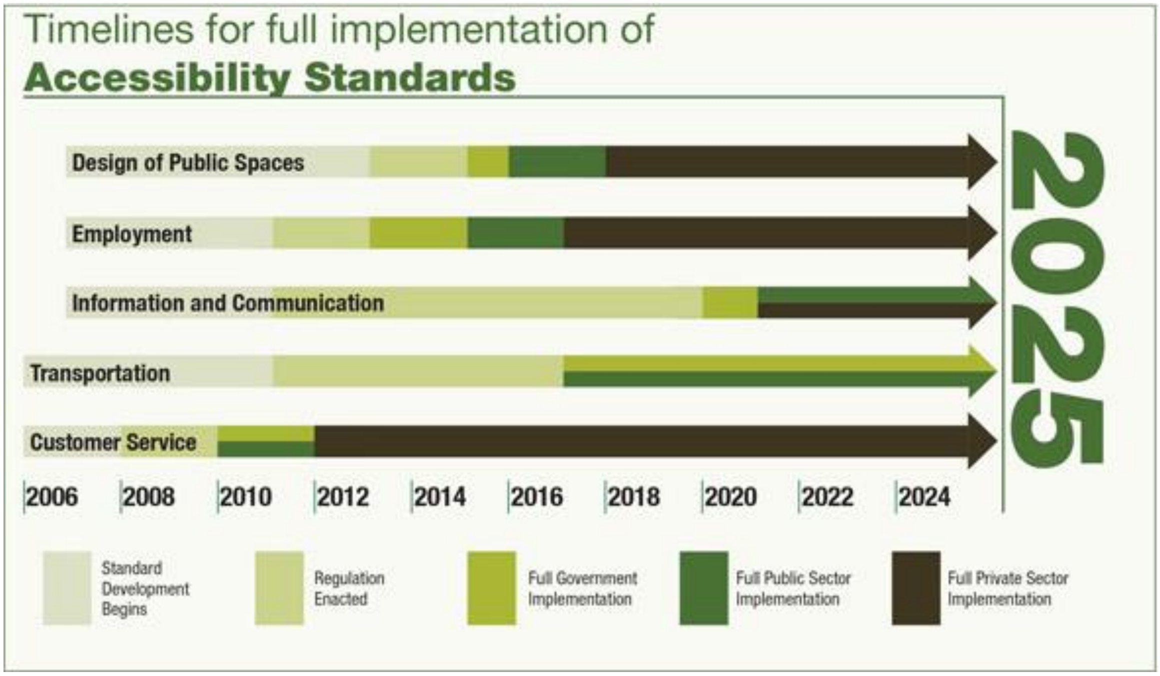

Figure 13: Timelines for Full Implementation of Accessibility Standards [41].

To achieve this goal, the Ontario government opted to install a corridor of both fast (DCFC) and level 2 (240 volts) charging stations between Quebec and Ontario [42].

For example, Toronto mandates that level 2 charging plugs be installed on all new residential and commercial buildings [43]. This commitment ensured a charging infrastructure exists for EV drivers, which is one of the major factors explained the high EV adoption in Toronto.

According to NRCAN, Canada hosts approximately 5000 EV charging stations with approximately 900, or 18% of charging stations across Canada, being found in the Ottawa-Gatineau and Toronto alone [44]. Figure 14 shows the placement of charging stations across Ontario.

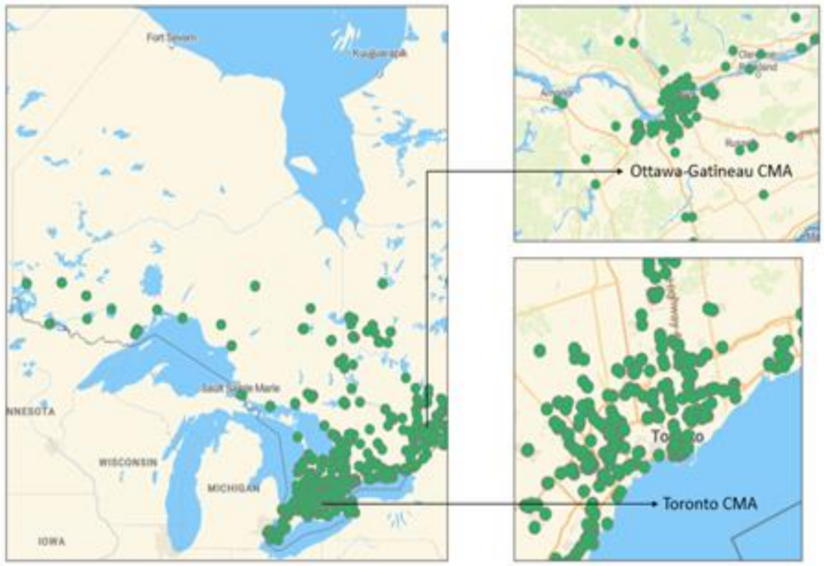

Figure 14: EV Charging Stations Distribution in Two Major CMA of Ontario, Canada [44].

3.1.3.5 Future EV Trends in Canada

In the early 2010s, the selection of EVs was much more limited than today, which could be another potential booming EV adoption rate factor, the availability of EV models over time may increase the speed of EV adoptions as the technology develops.

The main factors that are stopping the customers adopt EV could be concluded as battery range anxiety, limited EV model selection, and lack of EV infrastructure. However, driven by the competitive market, today's auto industries race to build more powerful EV models which could store ever-larger amounts of energy, cost-effective, and continuously record growing grid-scale systems [45]. Given the increased choices on EV models, extended battery life, upgraded EV fast charging stations, in the survey of 2,000 Canadians done by the global research firm, 62% of Canadians looking to buy an EV in the next five years [46].

It is reasonable to believe the future EV adoption rate in Canada will not show any sign of decrease, or even increase more aggressively due to the eliminating range anxiety by increased battery range, huge expansion in the number of models available, more complete of charging station infrastructure, and the ever-growing awareness and concerns over climate change.

3.2 Impact of EVs on Oil Prices

According to a new analysis of the electric-vehicle market by Bloomberg New Energy Finance, "by 2040, long-range electric cars will cost less than $22,000 (in today's dollars), according to the projections. Thirty-five percent of new cars worldwide will have a plug" [47].

Different organizations contradict the predictions of the impact of EVs on oil price. OPEC holds the opinion that "EVs will make up just 1 percent of cars in 2040" [47]. However, we do know that automakers and tech companies are investing billions in new models. Given how much EV batteries have been upgraded in the past few years, it is reasonable to assume that the cost of making one EV will decrease, and it perform better. Figure 15 shows a prediction on BEV/PHEV share of new vehicle sales.

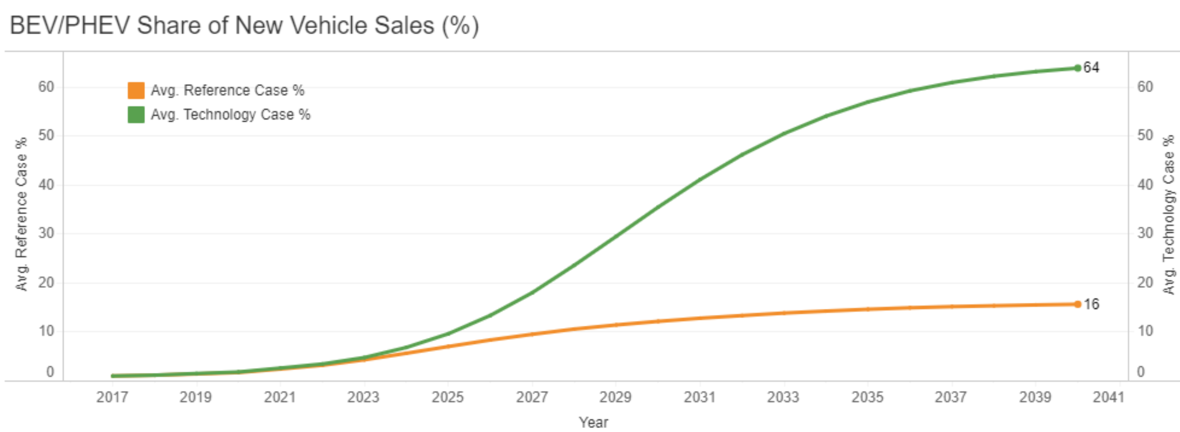

Figure 15: BEV/PHEV Share of New Vehicle Sales in Percentage [47].

According to Bloomberg's new animated series *Sooner Than You Think*, "the effect of continued 60 percent growth and found that electric vehicles could displace oil demand of 2 million barrels a day as early as 2023" [48]. Using Bloomberg New Energy Finance model, it indicated that in 2028, we will "cross the oil-crash benchmark of 2 million barrel" [49]. Figure 16 gives a prediction on changes of percentage composition for the transportation fuel.

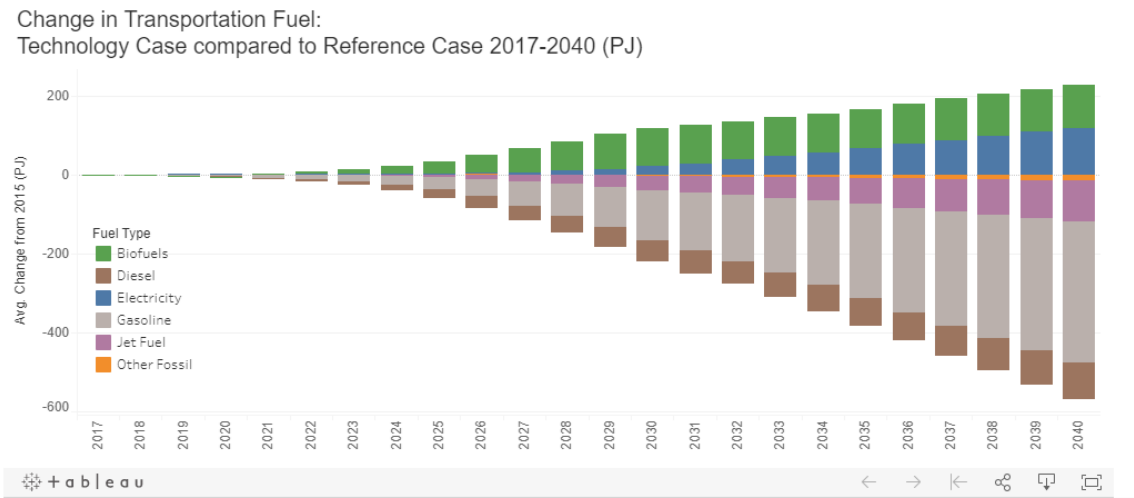

Figure 16: Change in Transportation Fuel: Technology Case Compared to Reference Case [49].

3.3 EV Timeline and its Impact to the Oil Industry

The International Energy Agency joined the predicts that "overall energy demand is set to increase by 1% per year until 2040, but that demand for crude oil will plateau in 2030, ten years earlier than it had predicted, due to a rise in the use of EVs" [50].

By the year of 2040, there is expected to be over 330 million EVs running on the world from today's 5 million EVs [50]. The EV displacement could be reached "around 4 million barrels per day (BPD) of oil consumption" [50]. However, this prediction underestimates how aggressive the EVs could expand; the IEA 2020 report indicated more than 10 million EVs reached in 2020 [11]. Figure 17 shows EV market size prediction up to 2040.

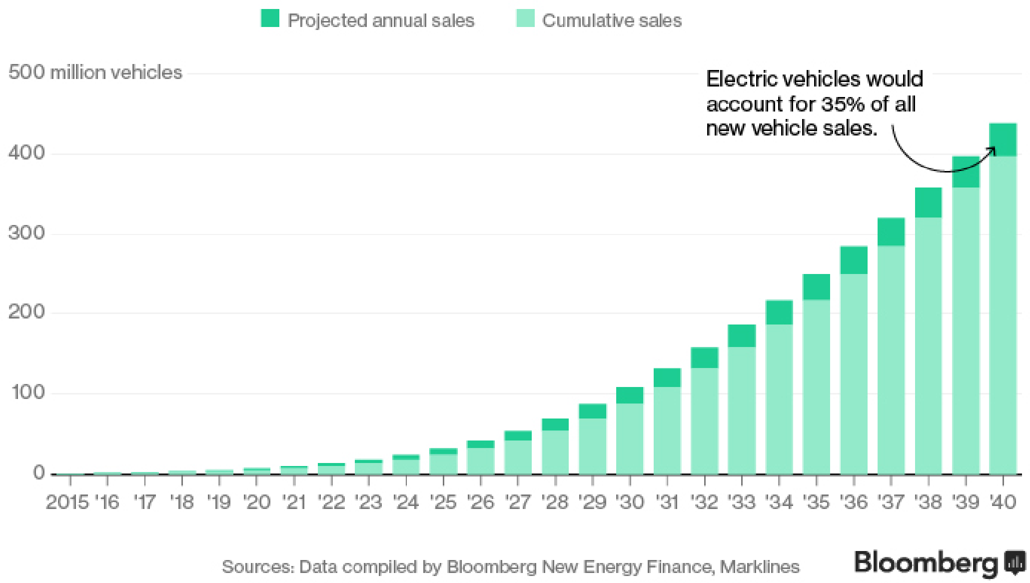

Figure 17: The rise of electric cars trend [50]

With the concern of incomplete infrastructure for EVs, countries as key markets' cuttings of subsidies, unavoidable travelling range anxiety, and unpredictable of technology improvement; it is still too hard to have an exact date to say when EVs will be the largest margin of vehicles sold per year. However, it is unnecessary to have a full transition to electrified transport to damage the oil extraction industry, a partial transition of 40 million EVs globally will begin to affect the oil prices. As mentioned before, 10 million EVs globally has already been reached in 2020, as the total EVs numbers are growing exponential exponentially, 40 million EVs running on the roads is foreseeable future is not a far stretch. Another advantage of EVs have is the energy efficiency, "EVs convert over 77% of the electrical energy from the grid to power at the wheels while conventional gasoline vehicles only convert about 12%-30% of the energy stored in gasoline to power at the wheels" [51]. An electric motor is about 3.4 times more energy efficient than an ICE engine and transmission system, so it takes far less new electrical energy to replace oil. In summary, it is important to notice that the oil industry could be hit heavily within a few years as early as 2030, only 9 years away from today.

4.0 Bitumen Beyond Combustion

The role that bitumen extracted from the Alberta oil sands can have in a post transition sustainable economy is discussed.

4.1 Oil Sands Composition

With crude oil extraction infrastructure already in place for Alberta's Athabasca oil sands, alternative end uses for the product other than as a hydrocarbon fuel is an increasingly more prevalent topic. Canada is home to the world's third largest proved reserve of crude oil, with 97% or 169 billion barrels located in the oil sands [52]. The oil sands are comprised of sand, water, clay, and bitumen [52]. The composition of oil sands deposits is approximately 4-18 wt% bitumen, 55-80 wt% inorganic materials such as clay, and 2-15% saline solution [53].

Bitumen is the heaviest classification of petroleum materials, and requires the most processing, called upgrading, before refineries purchase the product and turn it into products such as fuel. Bitumen is also the most difficult petroleum material to extract because of its high viscosity. Its high viscosity requires bitumen to be significantly heated before it can be prompted to flow and pumped up from in-situ techniques. The relationship between viscosity and density for standard petroleum products is shown in Figure 18.

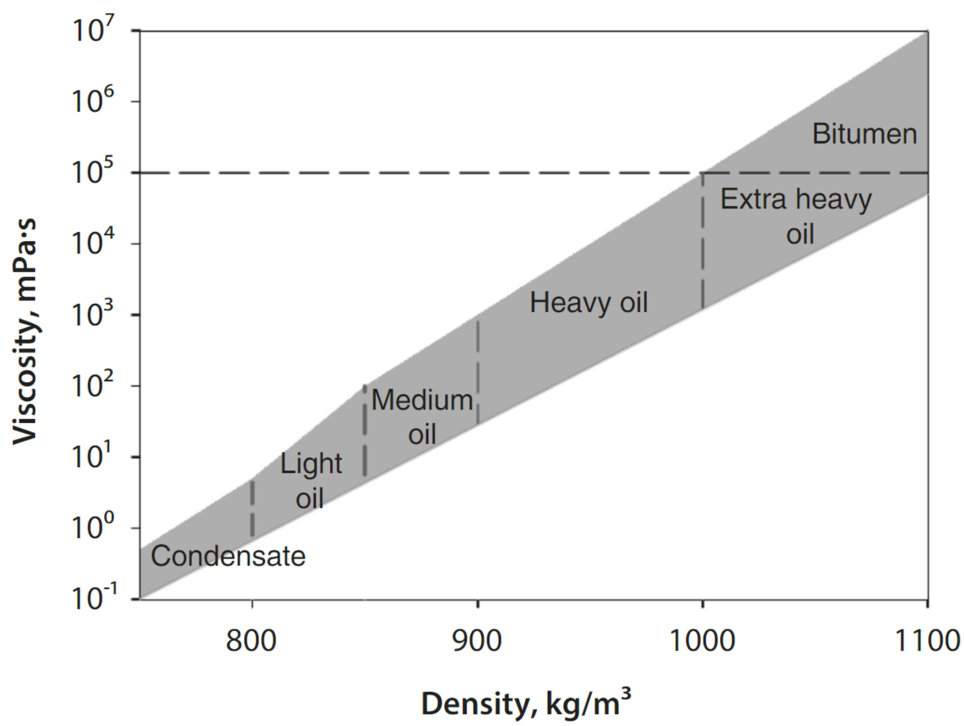

Figure 18: Viscosity and density of crude oils and bitumen [54].

Commercially available energy reserves in Alberta are summarized in Table 7.

Table 7: Commercially available energy reserves in Alberta as of 2008 [54].

Energy Reserve Type	Amount
Conventional Oil Reserves	$241x10^6$ m^3
Total Crude Bitumen	$27,448x10^6$ m^3
Surface Minable Bitumen	$4,960x10^6$ m^3
In situ Bitumen Reserves	$22,490x10^6$ m^3
Natural Gas	$1.09x10^{12}$ m^3
Coal	$34x10^9$ tonnes

From Table 7 above it can be seen that on a volume basis, there is in the order of 10^2 more bitumen in Alberta than conventional oil reserves. For this reason, for the purposes of this section, only alternative uses for bitumen will be investigated, and not for conventional oil reserves as well.

Bitumen is inherently a low-quality, low-value heavy feed material, and requires significant upgrading before it can be processed by refineries into final products such as fuels, lubricants, and petrochemicals [54]. Bitumen contains many more impurities such as nitrogen, sulphur, and heavy metals when compared to lighter petroleum materials. Bitumen upgrading is the processes of coking or hydro processing. Alternatively, bitumen can be diluted with light naphtha to reduce viscosity to enable pipeline transport [54].

A summary of the chemical composition of Athabasca bitumen is shown in Table 8 below.

Table 8: Properties and fractionation results from Athabasca bitumen [55].

Characteristic	Athabasca ASTM2007
Saturates (wt%)	16.9
Aromatics (wt%)	18.3
Resin (wt%)	44.8

Characteristic	Athabasca ASTM2007
Asphaltine (wt%)	17.18
Carbon (wt%)	83.34
Hydrogen (wt%)	10.26
Sulfur (wt%)	4.64
Oxygen (wt%)	1.08
Nitrogen (wt%)	0.53
Residue (wt%)	0.15

Saturates, Aromatics, Resin, and Asphaltine (SARA) analysis is the most widely used method to describe petroleum fractions. Each fraction classifies oils based on their polarity. A SARA analysis can be used as a method to classify compounds by their similar properties and allow for insight into which separation and processing techniques to utilize.

4.2 Platform Chemicals and Alternative Products

Currently, 90% of Canada's bitumen is processed into an array of combustion fuels such as gasoline, diesel, heating oil, and aviation fuels, and a much smaller percentage gets converted to asphalts and petrochemicals [56]. Gaseous carbon in the form of carbon dioxide (CO_2), methane (CH_4), and other volatile compounds has been at the forefront of environmental research in playing the largest role in the man-made acceleration of global climate concerns. However, carbon in the form of hydrocarbons is the building block of plastics, adhesives, lubricants, and many other petrochemicals used in everyday life. By placing a larger emphasis on utilizing bitumen as a feedstock of petrochemicals instead of as a combustion fuel, less carbon ends up in the atmosphere.

Upgrading and separation of bitumen components is a well-studied industry and can provide a long-term job prospect for industry workers already skilled and trained in the oil and gas industry [54]. Fractionation of bitumen into its constituents through methods such as use of paraffinic solvents, gel permeation chromatography, and precipitation are all viable methods for separation of bitumen. Bitumen contains a large array of molecular weight polymers, and bitumen can be separated into compounds with similar properties that can be further processed into petrochemicals.

A platform chemical is defined as a chemical that can be used as a substrate in the production of other higher value-added products. Figure 19 indicates a potential petrochemical products flow chart.

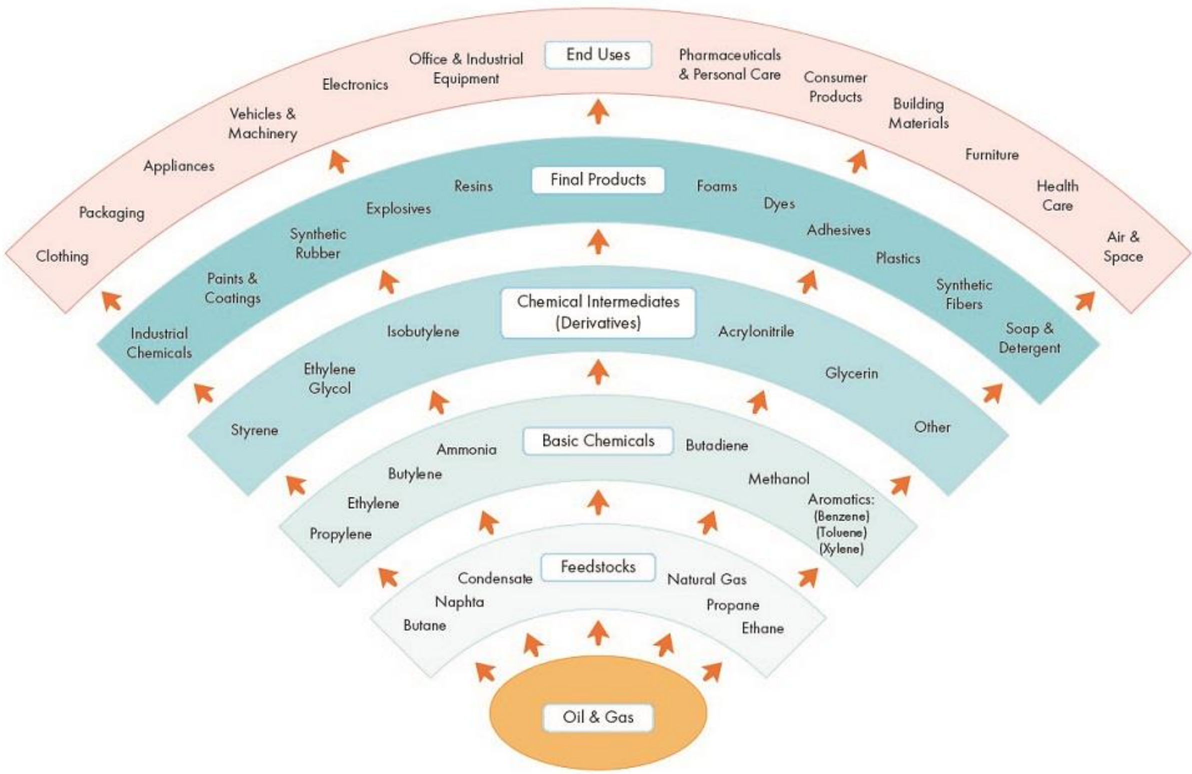

Figure 19: Petroleum products flow chart for oil and gas derived compounds [57].

Bitumen-based petrochemicals provides a revenue stream for existing petrochemical companies that is mostly untapped. Products such as styrene which is a compound obtained from the dehydrogenation of ethylbenzene [58]. The substrates required to make ethylbenzene would be part of the 18.3 wt% of Athabasca bitumen that contains aromatics, as shown in Table 8.

Petrochemicals derived from bitumen such as styrene, of which 46% is used as polystyrene which is used in injection molding, has a continuingly growing demand. This opens opportunity for western Canada to be a larger player in this industry if a larger percentage of bitumen is sent for processing into petrochemicals, and less is used for combustion fuels [59].

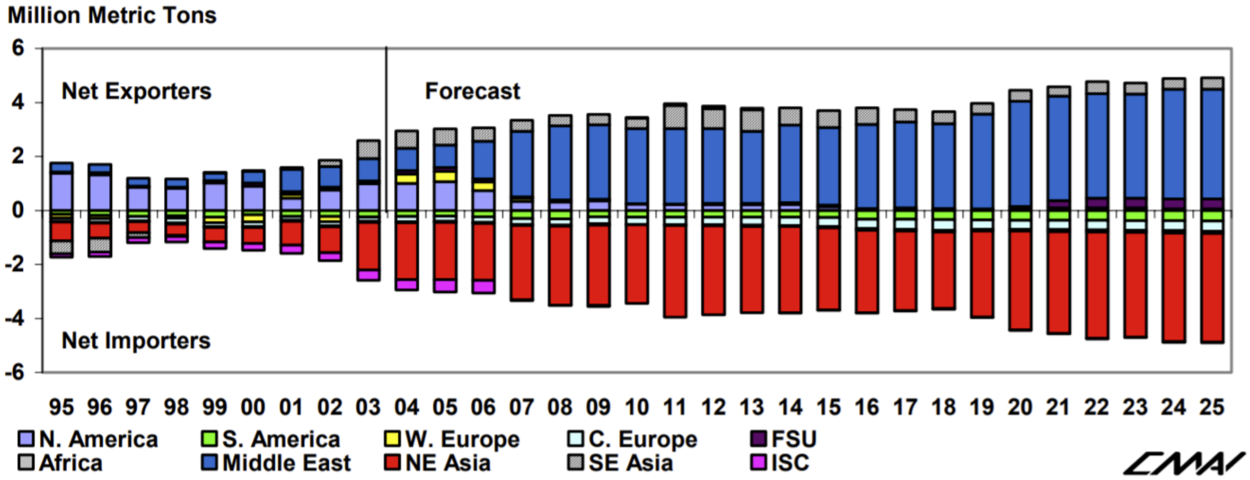

Figure 20: Export and import forecasts for styrene by region [59].

From Figure 20 it can be seen that the trend for these plastics products are projected to steadily increase over time, meaning that there needs to be an increase in production somewhere. Besides styrene, bitumen can be upgraded and processed into a large array of petrochemicals. A short list of potential end products for bitumen beyond just combustion fuels is summarized in Table 9.

Table 9: Short list of bitumen end products other than combustion fuels [59].

Product	Use
Ethylene	-Plastics and films -Detergents -Lubricants -Styrene
Propylene	-Used as the base monomer in polypropylene -Plastic polymers to be used in products from carpets to industrial foam
Butadiene	-Synthetic rubbers

Product	Use
Aromatics (benzene, toluene, xylene)	-Nylon fibres -Clothing -Packaging

4.3 Carbon Fibre

Carbon fibre is used in industries including automotive, construction, polymers, and many more. Traditional carbon fibre is produced from polyacrylonitrile polymer, which is produced through the refining of crude oil to separate naphtha which undergoes a series of processing techniques before polyacrylonitrile is available as a feedstock [60]. This is an expensive process which can be replaced with the production of a pitch equivalent from oil sands feedstock [60]. The high carbon percentage asphaltene in bitumen can be extracted through C-5 precipitation de-asphalting, and then used as a feedstock to the same carbon fibre production process as polyacrylonitrile [60]. Table 10 below outlines the estimated price comparison between carbon fiber production costs for different feedstocks.

Table 10: Comparison of carbon fibre production cost based on feedstock [60].

Feedstock	Price
Polyacrylonitrile	US$3-4/lb (US$6,700-8,800/ton)
Asphaltene	US$0.02/lb (US$44/ton)
Bitumen	US$0.15/lb (US$331/ton)

As seen in the table, utilization of bitumen to produce carbon fibre can result in significant cost saving. However, carbon fibre produced from pitch-based feedstock compared to polyacrylonitrile feed has slightly different product properties, including a lower ultimate tensile strength, and higher Young's modulus [60]. These differences in product properties can position pitch-based carbon fibre to offer different customer solutions as the properties of traditional carbon fibre may not always be suitable. These considerations warrant thorough investigation into the commercial viability of carbon fibre production from Alberta feedstocks as an alternative product to replace combustion fuels. The global carbon fibre production as of 2015 was 80,000 tonnes per year representing an estimated market size of

US$77 billion by 2030, showing the potential for a significant serviceable attainable market for Alberta producers [60].

4.4 Flipping the Barrel Upside Down

Traditionally when bitumen is not upgraded to synthetic crude oil, 85% of bitumen is utilized as a binder in asphalt for the construction of roads [61]. The upgrading of bitumen to synthetic crude oil is energy intensive and therefore oil refineries net a reduced price per gallon of bitumen due to the increased costs they will have to incur to get a final product when compared to light fuels from other oil producing countries. Traditionally the value of oil is inversely proportional to the length of carbon chains and consequently density and boiling point of the crude product. Figure 21 indicates the traditional breakdown of crude distillation and its product, with lighter fuels at the top being valued higher than heavier hydrocarbons like bitumen.

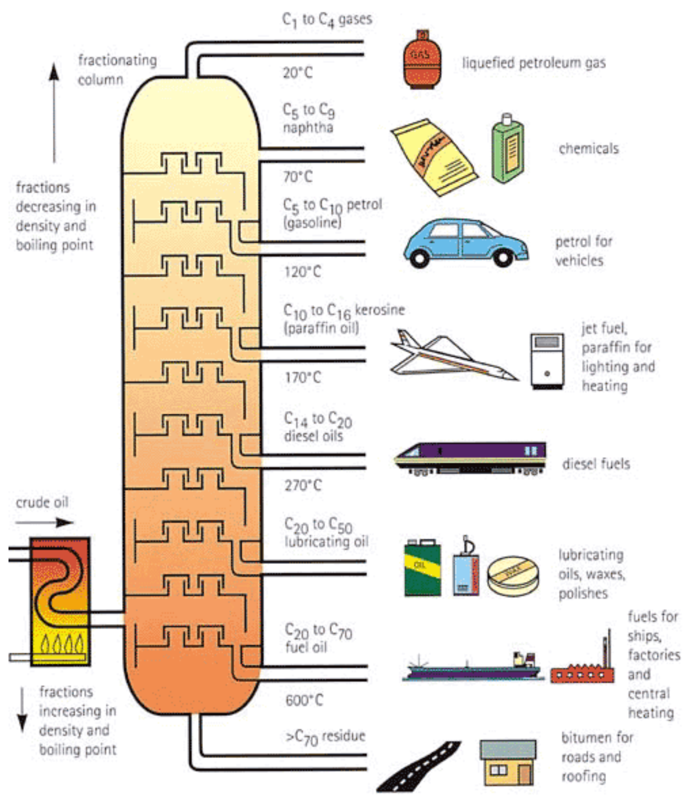

Figure 21: Crude oil fractional distillation product summary [62].

As the demand for combustion fuels begins to decrease, and therefore prices begin to decrease, new crude oil production projects will begin to slow, and eventually crude oil production facilities will begin to close. As the production of crude oil is decreased because light fuel oil demand is decreased, the overall production of bitumen will also decrease. Combustion fuel demand is projected to decrease, however, bitumen for use in asphalt for roads will continue to be a value item. International oil producers which have a much lower proportion of bitumen will see a decrease in demand for majority of their barrel, the fuel component, and the drilling costs will likely surpass the value they can derive from the bitumen proportion of the barrel. This trend will most likely cause oil producers to close and the overall production of bitumen decreasing as well. Basic economics dictates that as the supply of bitumen decreases but the demand stays the same due to its inherent stable requirement in the economy, the price of bitumen will increase. This shift of crude component value could flip the barrel upside down in terms of component price. The Alberta oil sands could see an increased for bitumen reliance not as an upgraded synthetic crude oil combustion fuel, but as bitumen for roads.

5.0 Potential New Sectors

New sectors that the fossil fuel industry in Canada can transition to are discussed and recommended in this section.

5.1 Renewable Energy

Looking at the energy breakdown of the three major energy consuming sectors of electricity, heating and cooling, and transportation, electricity provides the largest potential for change because it allows the other sectors to also change. Sectors such as transport, manufacturing, and other industries can rely more heavily on grid power as a method of reducing carbon footprint when the grid electricity is clean. Figure 22 shows the breakdown of CO_2 emissions by sector, highlighting that electricity and heat producers have a lot of room to improve, and that by shifting to lower emission electricity it becomes also more realistic to lower transport and industry emissions.

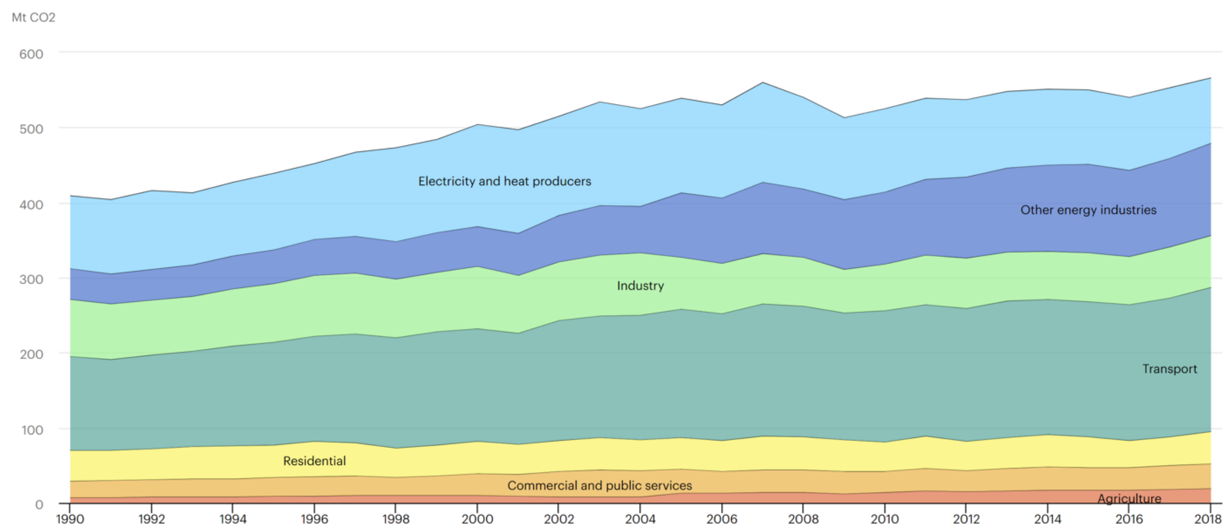

Figure 22: Carbon dioxide emissions by sector in Canada between 1990 and 2018 [63].

The step towards a green economy with electric vehicles, and more sustainable industry practices begins with having an electricity grid that is has low to no greenhouse gas emissions. The breakdown of Canadian electricity generation as of 2018 is shown in Figure 23.

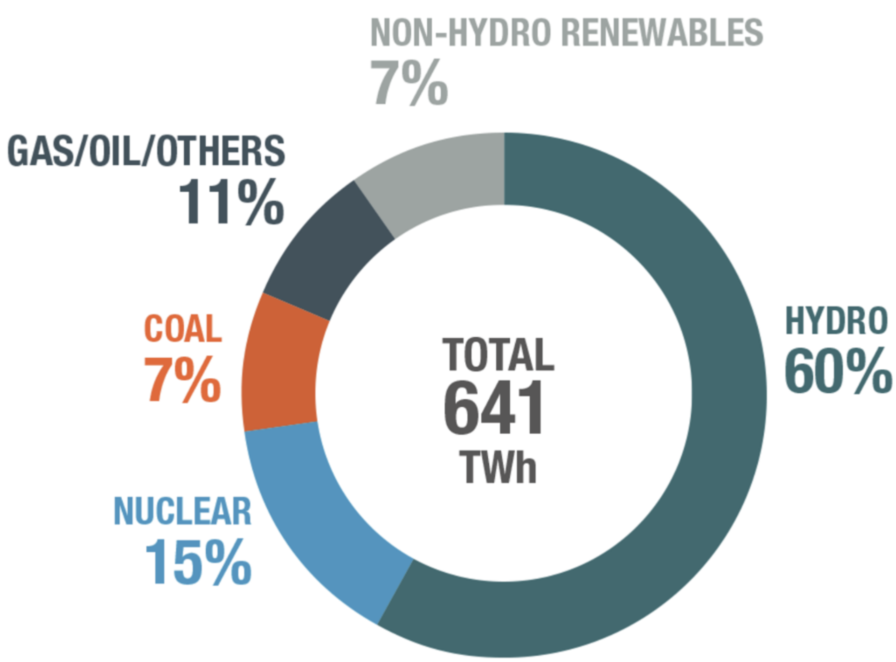

Figure 23: Summary of electricity generation by source in Canada in 2018 [64].

Figure 23 shows that a very small percentage of Canadian electricity is derived from combustion hydrocarbons. This observation indicates that it will require limited infrastructure change to fill the last 18% of Canadian electricity with renewable or low-carbon emission energy sources.

Currently, Alberta's electricity grid has the highest greenhouse gas intensity in Canada with a value of 790 gCO_2/kW-h, which is almost 20 times the greenhouse gas intensity as Ontario, and over 650 times more greenhouse gas intense than Quebec, this is shown in Figure 24 [65]. As of 2016 Alberta generates 47.4% of its electricity from coal, 40.3% from natural gas, and 12.3% from renewables, further highlighting the opportunity for improvement [65].

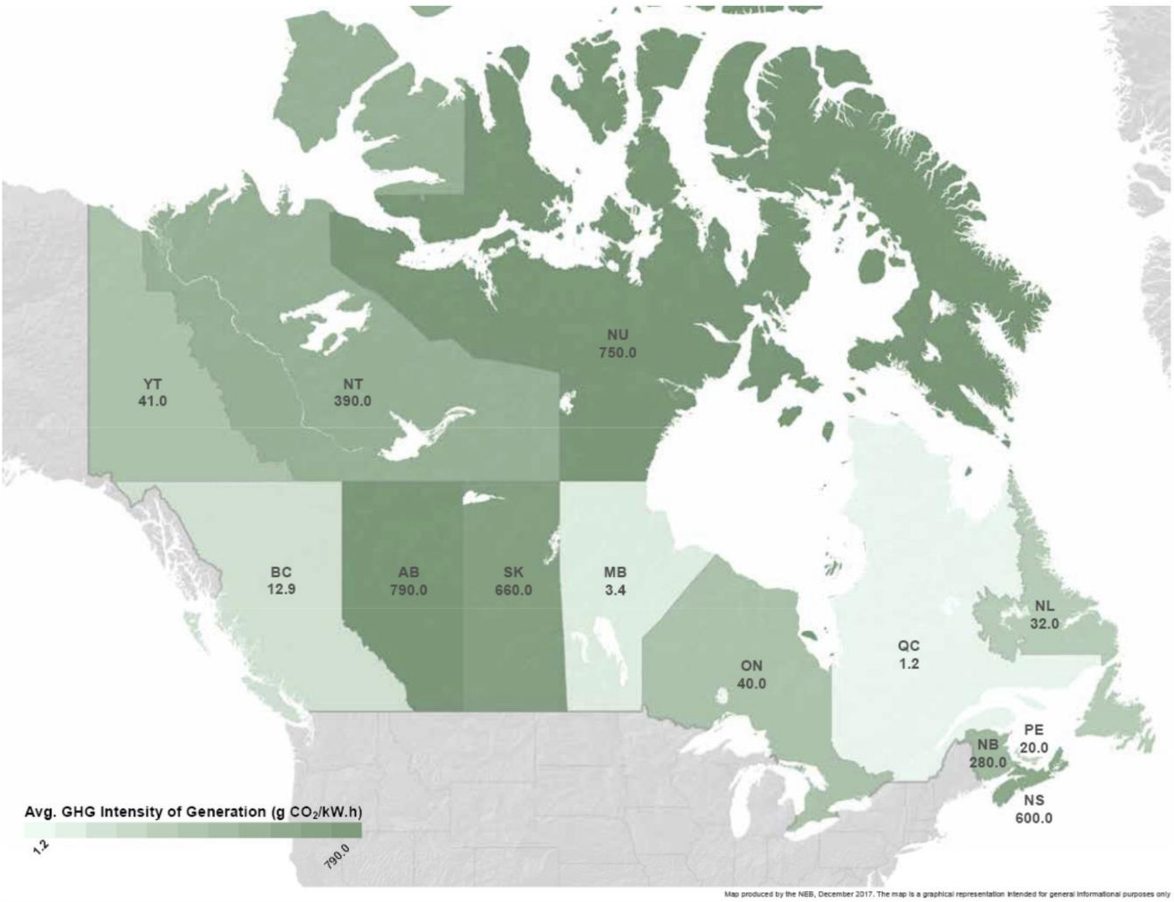

Figure 24: Greenhouse gas intensity by province and territory in Canada as of 2017 [65].

A full lifecycle analysis of different electricity generation methods' greenhouse gas intensity is summarized in Figure 25. Figure 25 indicates the difference that shifting away from coal, oil, and natural gas could have on energy intensity on Canadian electricity.

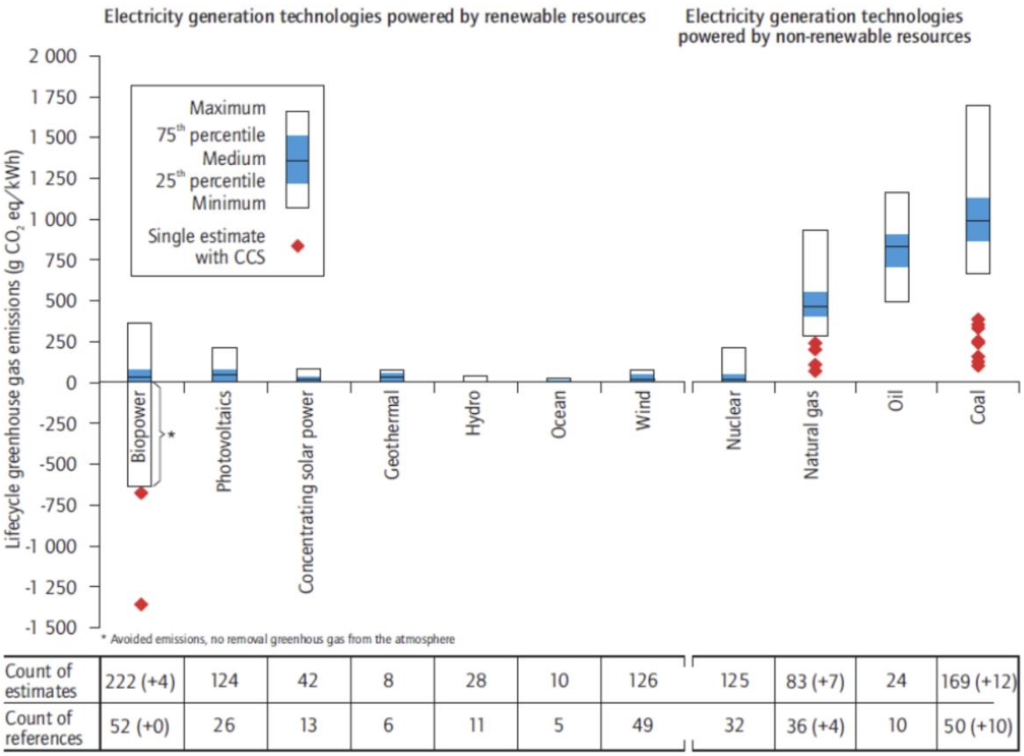

Figure 25: Lifecycle estimates of greenhouse gas emission intensity [66].

5.1.1 Geothermal

Heat production in Canada is largely serviced by natural gas, which is an energy source with a high greenhouse gas intensity [67]. Geothermal energy available in Alberta can be used to reduce the dependency on natural gas. Geothermal energy in Northern Alberta is characterized as low thermal gradient and geothermal energy unsuitable for electricity production, however, the bitumen extraction process requires significant water heating to 50-60°C which can be accomplished by geothermal energy in Alberta [67]. Currently in Alberta the large volumes of heated water required for bitumen extraction is done so with the combustion of natural gas [67].

Geothermal energy for electricity production requires temperatures of >150°C [67]. These high geothermal temperatures can be found in the Athabasca region and is suitable for engineered geothermal systems (EGS) [67]. An EGS produces heat by drilling at the depth of several kilometers and then circulating fluids to create artificial porosity zones [67]. The opportunity for EGSs in Alberta is there but is deemed economically unfeasible with current technology and therefore low-grade geothermal heat for the purpose of heating will remain the main recommendation of this report for geothermal.

For heating, geothermal energy in Alberta can be achieved at a similar cost to natural gas at $3-6/GJ [67]. Considering potential future carbon taxes and subsequent increase in natural gas price, long term economics of utilizing geothermal heat can prove advantageous.

5.1.2 Wind Power

Wind power generation is a reliable source of power in the long term, however it inherently can be unpredictable in the short term. This unpredictability leaves wind to not be viewed as a base load-supplier but, still can alleviate much of the electricity reliance on coal in Alberta [68]. Wind resources are concentrated in southern Alberta, and wind farms such as in Pincher Creek obtain a capacity factor of 46.7% [67]. This capacity factor indicates that on average wind turbines in Pincher Creek produce 47% of the maximum possible power output for the turbine. Considering the average capacity factor of wind turbine projects built between 2014 and 2017 in the US is 41.9%, wind power in Alberta is a viable venture for power generation [69].

Current estimates and anticipated changes to the Alberta electricity generation system place wind energy increasing to 6445 MW by 2032, which will be roughly 25% of Alberta's energy generation [70]. Table 11 summarizes the anticipated power generating capacity from 2017 projecting forward to 2037.

Table 11: Current and expected generating capacity in Alberta (MW) [70].

Year	Coal	Cogen	CC Gas	GT	Coal-to-Gas	Hydro	Wind	Solar	Other	Total
2017	6,299	4,934	1,746	916	0	894	1,445	0	479	16,713
2022	3,849	5,024	1,746	1,059	1,581	894	3,045	200	479	17,877
2027	2,904	5,114	2,656	1,249	2,371	894	5,045	400	479	21,112
2032	0	5,204	5,386	1,486	2,371	1,244	6,445	700	479	23,315
2037	0	5,339	6,751	2,769	790	1,244	6,445	1,000	479	24,817

Table 11 shows that wind power is expected to be the largest growth for power in Alberta over the next 15 years. With available subsidies, wind power projects received a price of $37 per MWh in Alberta which is the lowest in Canada [70].

5.1.3 Hydropower

Hydropower in Canada constitutes 60% of the total electricity production, however, hydropower in Alberta is a severely underdeveloped [66]. From the Canadian Hydropower Association, Alberta is ranked fourth for underdeveloped hydroelectric potential in Canada [66]. Currently Alberta is only utilizing 4% of Alberta's total 6050 MW of potential hydroelectric power [66]. Alberta has 36 sites that are viable for hydroelectric power ranging from 4.6 MW to 828 MW per site [66]. There are 17 potential sites on the Athabasca river, 18 sites on Peace River, and one site on Slave River [66]. Hydroelectric power is also economically advantageous when compared to other renewable and non-renewable energy sources. Table 12 outlines the prices of power generation in Alberta as of 2013, showing that hydroelectric power can be beneficial for reducing greenhouse gas emissions, and reducing long term costs.

Table 12: Minimum and maximum levelized cost of electricity for electricity generating technologies [66].

Technology	Min Cost (USD/MWh)	Max Cost (USD/MWh)
Bioenergy	80	250
Bioenergy co-firing	80	140
Geothermal	35	200
Solar PV	155	350
Hydro	20	230
Wind Onshore	50	140
Wind Offshore	140	300
New Coal	40	90
New Gas	40	120
Micro Hydro	35	230
Small-Scale Solar PV	185	600

Technology	Min Cost (USD/MWh)	Max Cost (USD/MWh)
Small-Scale Biogas	110	155

Hydroelectric power in Alberta can provide reliable and sustainable energy in Alberta to alleviate the reliance on coal and natural gas. However, significant Indigenous consultation as well as environmental assessments must be done before implementation. Long-term returns on investment are generally expected for hydroelectric power and requires significant capital cost to construct, making short term outlooks on hydropower less desirable than other forms of electricity, but long-term outlooks highlight the benefits.

5.1.4 Solar Power

Alberta is compatible with intermittent solar power but mostly at a small, residential scale, and not at a grid powering scale [71]. Among Canadian municipalities, Calgary ranks among the top in terms of photovoltaic scale, this comparison can be seen in Table 13.

Table 13: Summary of Canadian municipalities and their photovoltaic potential [72].

Municipality in Canada	Yearly Photovoltaic Potential (kWh/kW)
Regina	1361
Calgary	1292
Winnipeg	1277
Edmonton	1245
Ottawa	1198
Montreal	1185
Toronto	1145
Yellowknife	1094
Vancouver	1009

Under international standards, Alberta's solar potential is still significant, solar panels use light to generate power, not heat. Calgary and Edmonton both have higher photovoltaic potential than Germany, which is one of the global leaders in integrating solar technology. Table 14 compares photovoltaic potential between cities across the globe.

Table 14: Summary of cities and their photovoltaic potential [72].

City	Yearly Photovoltaic Potential (kWh/kW)
Cairo, Egypt	1635
Capetown, South Africa	1538
New Dehli, India	1523
Los Angeles, USA	1485
Regina, Canada	1361
Sydney, Australia	1343
Beijing, China	1148
Berlin, Germany	848

Due to lack of large-scale power storage, solar photovoltaic power still remains a mostly untapped resource in the Canadian power grid. The inherent intermittency of makes it impossible to use reliably in the grid, however, solar power on a residential scale can prove extremely beneficial as a means of reducing grid dependency for households across Alberta.

5.2 Mining

As the world shifts to green alternatives for existing technologies, the demand for precious metals and other minerals used in the manufacturing of these technologies increases. Distinctly the demand for metals required in the manufacturing of batteries for EVs opens new opportunities in Alberta. Compared to other provinces and territories in Canada, the availability of mineral resources in Alberta is not as extensive. However, there is strong evidence that Alberta has potential for significant mining projects with uranium, potash, lithium, diamonds, and magnetite [73]. Figure 26 shows the supply and demand projections for lithium, indicating the strong shift coming as demand for lithium-ion batteries grow due to being lighter and less expensive than nickel-ion batteries [74].

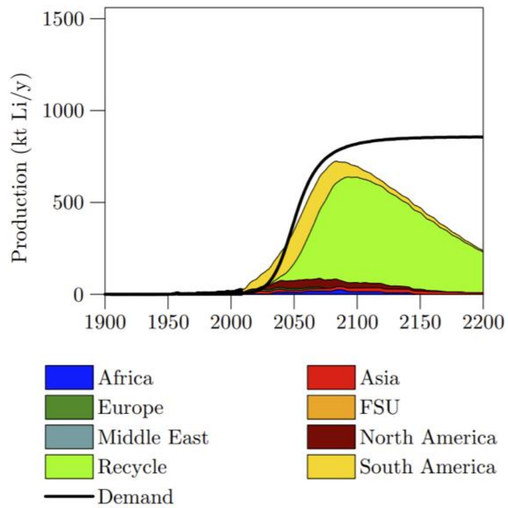

Figure 26: Projected lithium supply and demand by continent [74].

The introduction of more mining projects into the Alberta economy presents opportunity for diversification as it shifts the heavy reliance on oil price, and spreads that over a wide range of metals and minerals. From 2011 drilling reports it was determined that Alberta contains 557 million mt of iron (33%) and vanadium (0.20%) [73]. It was also determined that Alberta has the potential to produce economically viable potash between 15% and 25% K_2O [73].

Mining operations in Canada present the unique opportunity to provide necessary metals and minerals required in the global shift towards green technologies, while keeping these mining operations under the strict environmental guidelines present in Canada that might not be in place in other countries. Mining operations in Canada also have the benefit of although the operations are extremely energy intensive, operations in Canada have the benefit of pulling electricity from a mostly clean grid, compared to high energy emission intense grids of other traditionally mining based economies such as South Africa or Australia. Projects such as Raglan nickel mine in northern Quebec or Sudbury Integrated Nickel Operation (INO) can be used as models for mining operations run with sustainability in mind and using the low carbon intensity of the Canadian provincial grids to product these metals and minerals at the cost of much lower greenhouse gas emissions than other countries are capable of. Raglan mine in northern Quebec on average produces 10% of its total energy consumption from two on-site wind turbines [75]. Sudbury INO boasts a fully electrified mine fleet, saving millions of litres of diesel a year. These two projects highlight innovations in the mining industry that allow Canadian operations to produce products required in the transition to a more sustainable economy, but at the net global benefit of lower overall emissions. Another example to further highlight this point is that aluminum production, which is extremely energy intensive due to the high temperatures required, in Canada is fuelled almost entirely by hydroelectric power [76]. China is responsible for 50% of the worlds aluminum production but their processes are powered by 90% coal-fired power and consequently the carbon footprint of China's aluminum is seven times larger than aluminum from Canadian smelters [76].

5.3 Emerging Industries

Many emerging industries in the field of technology and digitization are becoming a focus for the Alberta government as an avenue to transition educated and skilled workers in the oil and gas sector. Roles such as software developers, data scientists, full stack developers, cybersecurity analysts and other are essential to the rapid automation and expansion of many other sectors. Digital sectors are not only a key pillar of a diversified economy, but these sectors have low to no carbon emissions with the help of clean grid electricity and carbon credits.

With an aging population in Canada, the healthcare sector in Alberta is expected to see significant growth [77]. Although transition of oil and gas workers to healthcare practitioners is not a realistic solution, technology is becoming a larger part of healthcare with increasing usage of robotic surgery, wearables, and health data analytics [77]. The healthcare sector also requires an increasing demand for lab technicians, biostaticians, researchers, and technologists. The healthcare sector in Alberta is expected to see a compound annual growth rate of 2.6% which is double the growth rate of the entire economy. Figure 27 shows the historical and projected employment numbers for the healthcare sector in Alberta, and Figure 28 identifies digital jobs in the healthcare sector and what percentage of healthcare employers indicating them as in demand jobs.

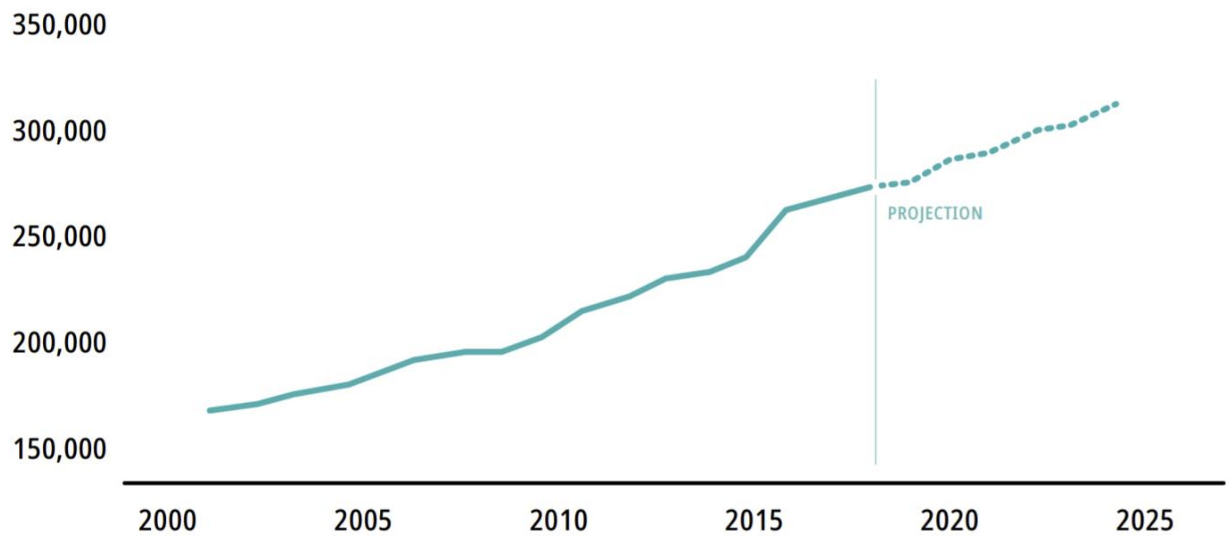

Figure 27: Historical and projected Alberta healthcare employment [77].

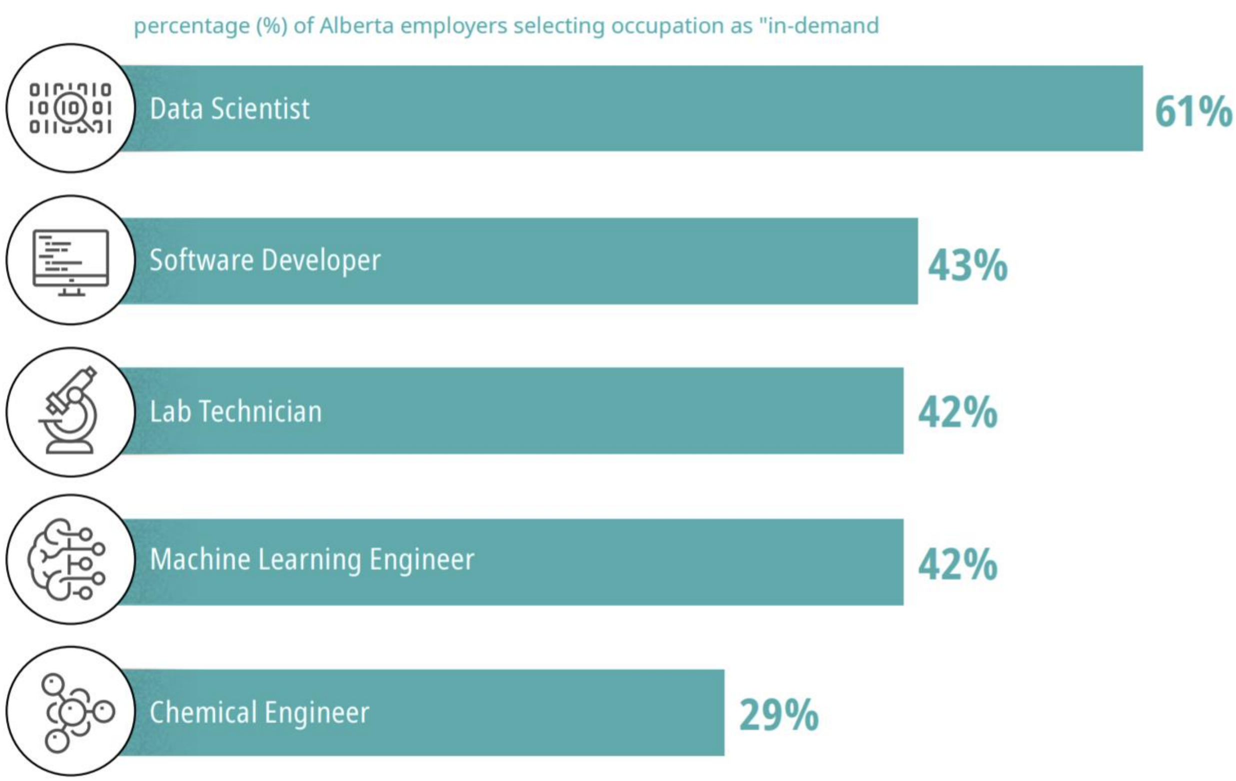

Figure 28: Summary of top in-demand digital and technical jobs in the Alberta healthcare sector [77].

Advanced manufacturing is the use of technologies such as machine learning, 3D printing, and advanced robotics in the manufacturing sector. Traditional manufacturing employs 130,000 people as of 2019 traditionally manufacturing products such as heavy machinery, petrochemicals, and food and beverage products [77]. Advanced manufacturing in Alberta is a growing industry with current operations producing micro-optical devices, nano materials, and many others [77]. Advanced manufacturing is expected to experience a 5.5% compound annual growth rate until 2025 [77]. Figure 29 shows the historical and projected employment numbers for the advanced manufacturing sector in Alberta, and Figure 30 identifies digital jobs in the advanced manufacturing sector and what percentage of advanced manufacturing employers indicating them as in demand jobs.

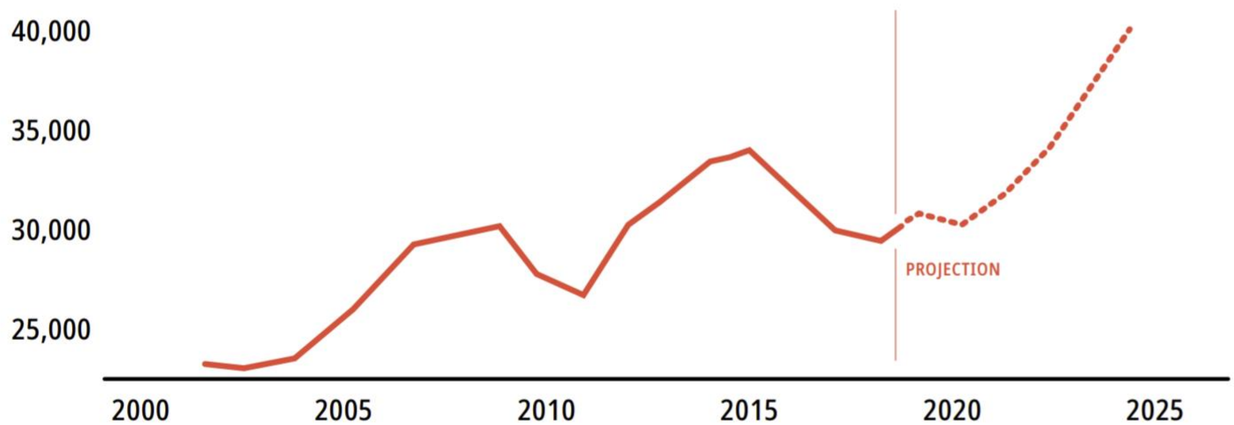

Figure 29:Historical and projected Alberta advanced manufacturing employment [77].

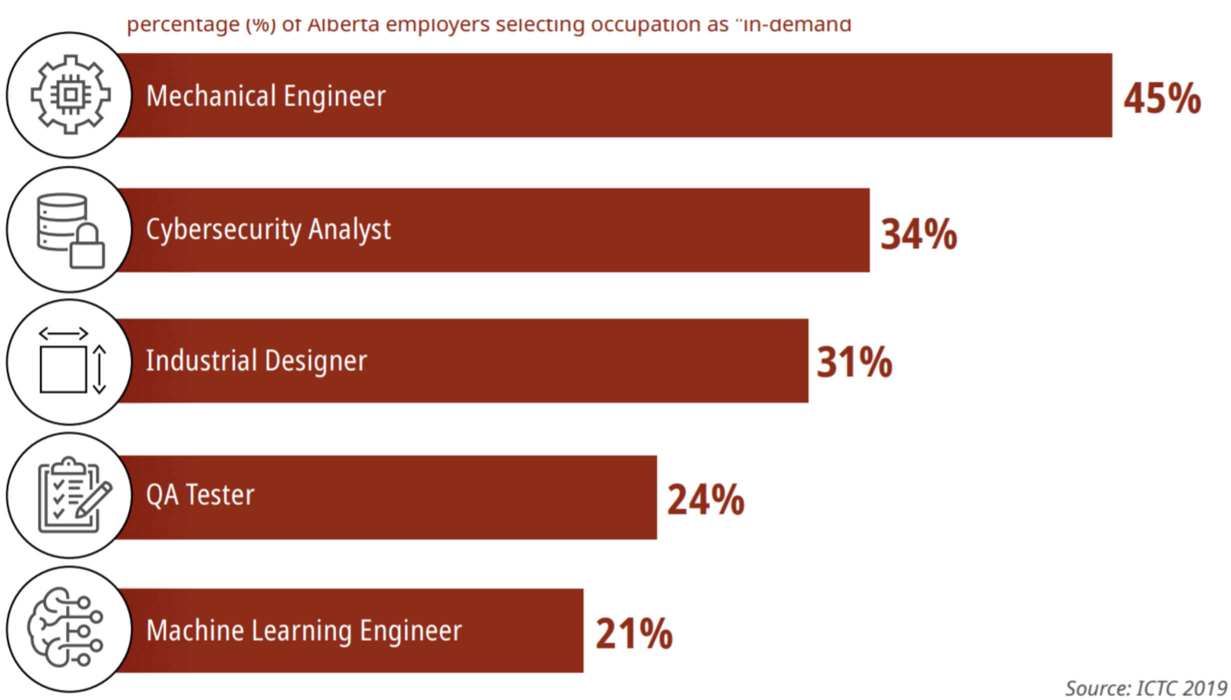

Figure 30: Summary of top in-demand digital and technical jobs in the Alberta the advanced manufacturing sector [77].

In the transition to a cleaner economy, the growing cleantech sector in Alberta will be an important part of this shift. The cleantech sector is comprised of companies working in renewable power generation, advanced chemical processes, energy storage, smart grid development and others [77]. Through consultations with cleantech employers in Alberta, 40% indicated that funding is the biggest barrier to growth [77]. This barrier to growth provides an opportunity for traditional oil and gas companies to diversify through funding of these firms, as well as giving resources such as employees or research and development facilities. Figure 31 shows the historical and projected employment numbers for the advanced manufacturing sector in Alberta, and Figure 32 identifies digital jobs in the cleantech sector and what percentage of cleantech employers indicating them as in demand jobs.

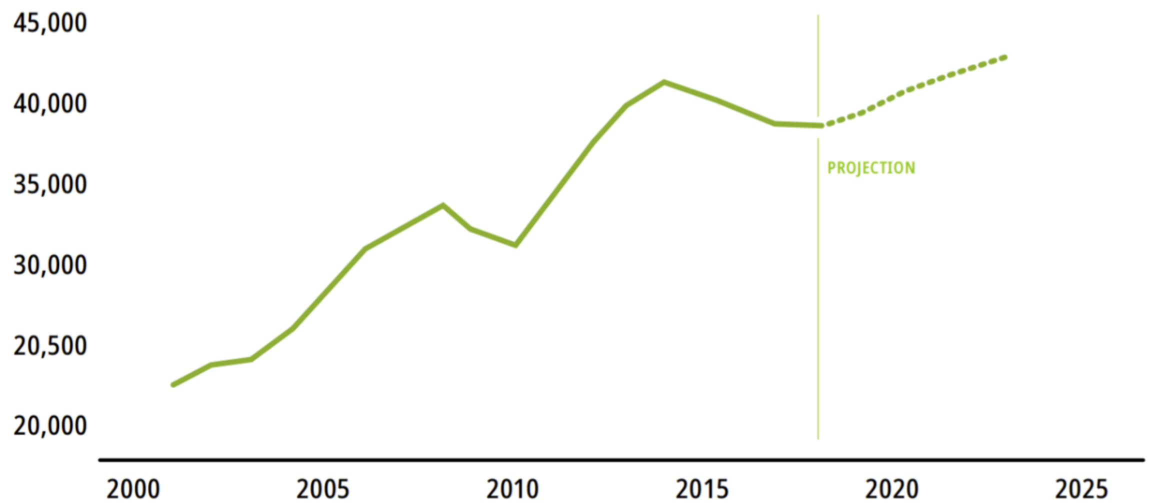

Figure 31: Historical and projected Alberta cleantech employment [77].

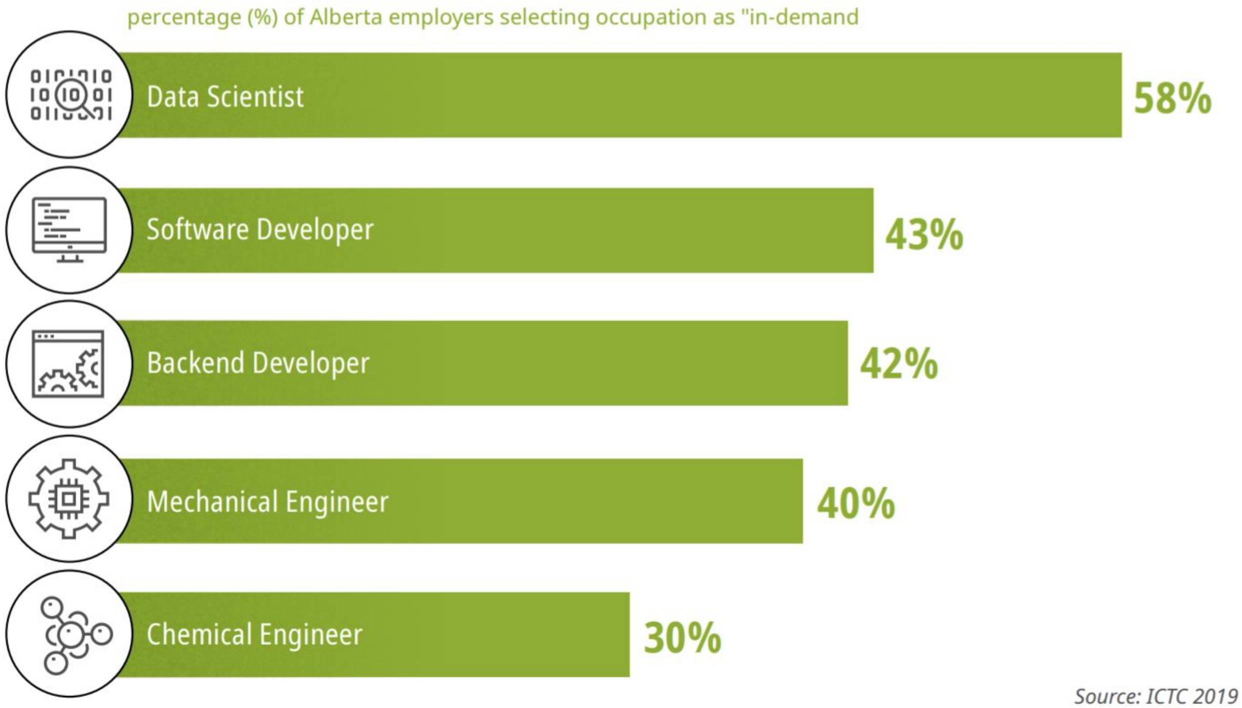

Figure 32: Summary of top in-demand digital and technical jobs in the Alberta the cleantech sector [77].

6.0 Transition Plan

Transition plan strategies are analyzed, and key recommendations are made to ensure a just transition for the Canadian fossil fuel sector.

6.1 Transition Plan Inventory

As a whole, the degree of climate action is insufficient to meet the climate targets set by the Paris agreement [78]. According to the Energy Translation Index (ETI), which analyzes a country's readiness to adopt clean energy using the criteria of access and security, environmental sustainability and economic development and growth, 94 of 115 countries have improved their combined score since 2015 [78]. Progress is being made in several areas, such as the retirement of coal-fired powerplants and carbon pricing initiatives; however, countries must ensure delivery on their energy transition and climate change promises to create real, quantifiable change.

6.1.1 Global Energy Transitions

Analyzing countries that have been successful in their climate and energy initiatives and plans can give insight and offer lessons to Canada to drive progress and accelerate their energy transition.

6.1.1.1 The European Energy Transition

The EU has made significant progress on their climate and energy package targets enacted in 2009 (the 20-20-20 objectives) [79]. In the EU, renewable investments are substantial, and offshore wind and solar power costs are dropping. Various valuable tools have helped support the European Unions' energy transition, including the European Investment Bank and the Emission Trading System (ETS), which has pushed up carbon prices and other infrastructure and innovation investments [79]. The EU energy transition process also includes further steps, such as establishing a European Energy Union through the European Commission to encourage integrated energy markets and policies.

The majority of EU governments have introduced plans to phase out coal from power generation, which is expected to reduce installed capacity to 70GW from 140GW by 2030 [79]. Distinctly, Germany has set a model for a coal generation transition in the EU, with their coal generation (37%) to be expected to be phased out by 2038 [80].

Between 2016 and 2018, the Clean Energy Package for All Europeans, a comprehensive tool, was finalized [79]. This package committed the EU to increase renewables' share to 32% of final energy production and improve energy efficiency by at least 32.5% by 2030. It also took the initiative towards enhancing the electricity market integration and security to accelerate the decarbonization of the transport sector [79].

The EU has also made institutional changes by creating a Vice President for the Energy Union and adopting a regulation on governance, which requires member states to adopt planning tools [79]. This change has given the EU Commission a 220% increase in energy efficiency, a 20% reduction of CO2 since 1990, and 20% renewables in final consumption by 2020 [79]. The EU has confirmed that it is permanently committed to its energy transition through its increasing policy implementation involvement [79].

6.1.1.2 The EU Emissions Trading System

The EU's most important instrument for reducing GHG emissions is the EU Emissions Trading System (EU ETS) [81]. This system has gradually expanded to cover more sectors since it began in 2005, limiting emissions to a lowered ceiling each year [81]. About half of the EU's emissions rights are distributed for free, and half are auctioned off; however, there is no free allocation for emissions from electricity production. The EU ETS includes carbon dioxide emissions from energy-intensive sectors, including oil refineries and combustion installations. Between 2021-2030, the EU plans to reduce emissions from the EU ETS by 34% [81].

6.1.1.2 Energy Transition Index

The Energy Transition Index (ETI) facilitated by the World Economic Forum outlines the top-performing countries by their adoption of actions that support an energy transition towards a secure and sustainable future energy system [78]. These country's best practices can be used as a roadmap for Canada.

Sweden has been a consistent global leader in energy transitions. Among IEA member countries, Sweden currently has the lowest share of fossil fuels in its primary energy supply and is also the second-lowest carbon-intensive economy [82]. The 2016 Energy Agreement and the 2017 Climate Framework outline ambitious goals to reach net-zero emissions by 2045 [82]. Sweden is also the only country in the world to set a target to achieve zero-carbon electricity production by 2040 [83].

Sweden has achieved this success through market-based policies and alternative energy investments, showing that energy transition policies can coincide with economic growth. The integration of biofuels and hydroelectric power into the Swedish energy system have made the most significant renewable contribution [81]. Emissions pricing has been the basis of Swedish climate policy, including the carbon tax (with the exemption of biofuels) and the EU Emissions Trading System [81]. These instruments and supplemental, specific instruments in different sectors have combined to create an effective climate governance strategy. Additionally, Sweden has focused on energy efficiency and renewable energy to drive decarbonization across various sectors [81].

6.1.2 Policy Instruments

The effectiveness of different policy instruments in their ability to reduce country wide emissions is analyzed in this section.

6.1.2.1 The Climate Act

The Climate Act makes it difficult for the Swedish government to counteract climate goals or pursue an insufficient policy [81]. This act is effective because it obligates current and future governments to prioritize climate goals and report to parliament on their policy efforts and results regularly. The government must present a climate report which makes it easier to monitor climate effects in all areas, describe necessary decisions, and evaluate the need for further measures [81]. Additionally, Sweden has a cross-sector Climate Policy Council that assists the government by independently assessing their policies to ensure they are compatible with climate targets [81]. This Council consists of members with high scientific expertise in climate change, climate policy, economics, and political and behavioural science [81]. The Climate Act and Climate Policy Council's purpose is to keep the Swedish government accountable to their national and international climate targets.

6.1.2.2 Energy and Carbon Tax

Sweden's energy taxation system includes a carbon tax, an energy tax on fuel, and an energy tax on electricity. The purpose of the energy tax in Sweden has been to realign energy consumption towards energy efficiency and renewables. The carbon tax in Sweden has increased from SEK 0.25 per kg carbon dioxide in 1991 to SEK 1.20 per kg in 2020 [81]. Tax rates increase annually on an index-linked basis under previously determined statutory mandates. The energy tax on fuel differs depending on its use (motor fuel or heating). Additionally, the tax rate for heating fuels changes based on whether it is used for households, industries, and the energy supply sector. Energy taxes have efficiently and effectively curbed carbon emissions in Sweden.

6.1.2.3 District Heating Network

Sweden has seen emission reductions by expanding the district heating network and increasing their use of biofuels and waste fuels in district heating production. By substituting fossil fuels with biofuel and waste in electricity and district heating production, Sweden's electricity emissions fell by 24% between 1990 and 2018 [81]. Renewable energy currently accounts for the most significant proportion of energy production in Sweden. Only a small percentage of energy production comes from fossil fuels and the rest from nuclear power, shown in Figure 33. Wind power is also expanding and is expected to be a meaningful contributor to the future electricity system, shown in Figure 34.

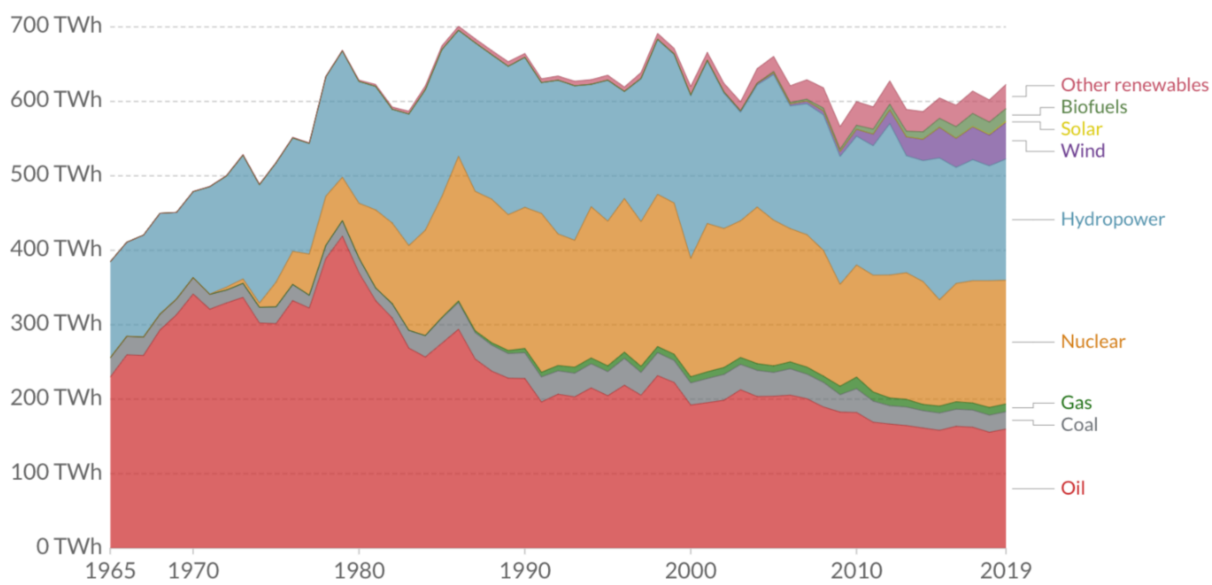

Figure 33: Energy Consumption in Sweden [84]

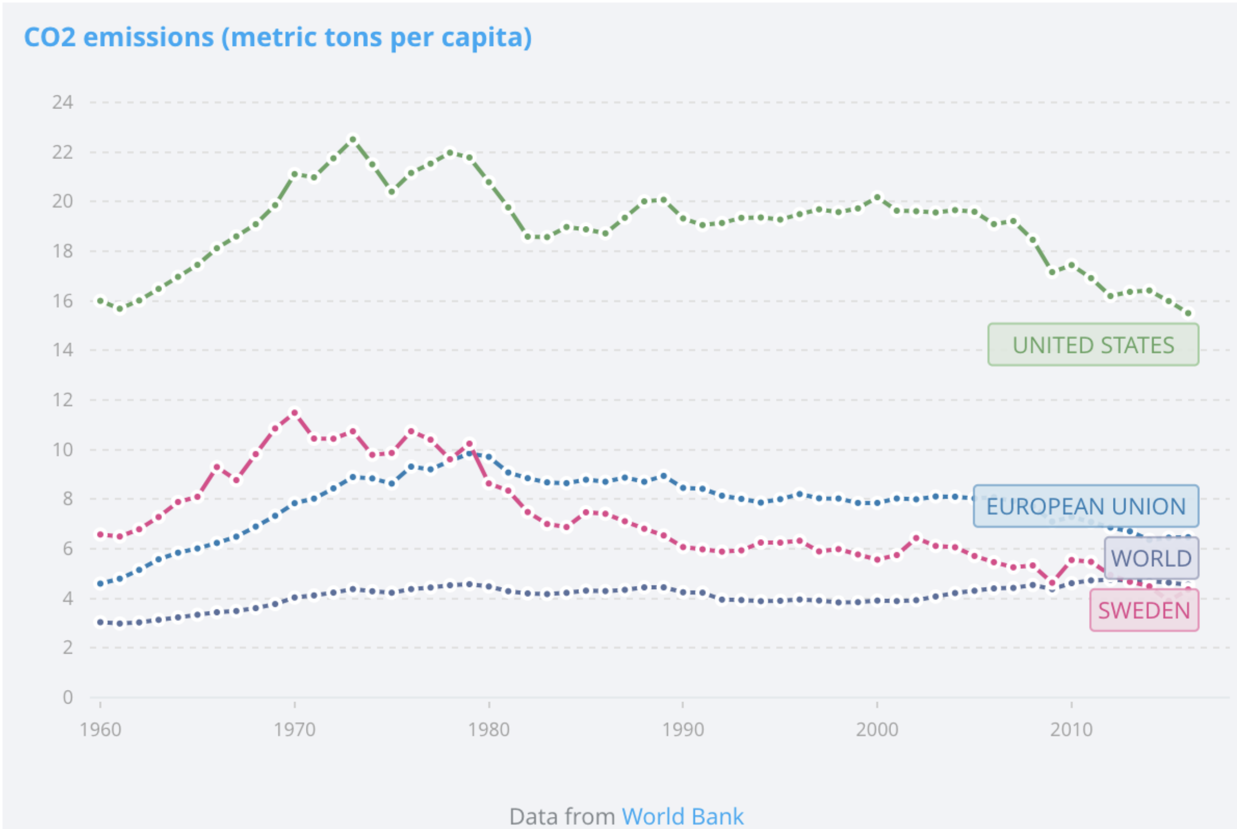

Figure 34: CO2 Emissions (metric tons per capita) [85]

6.1.3 United Kingdom's Energy Transition

The UK's Clean Growth Strategy focuses on energy technology and innovation to achieve decarbonization. Specifically, the UK's offshore expertise provides a solid basis for innovative technologies, including energy efficiency, hydrogen, and carbon capture, utilization and storage (CCUS) [82]. The lowest energy-related CO2 emissions levels since 1888 in the UK were reached in 2017. This reduction was made possible by significant renewable investments follow the United Kingdom's Electricity Market Reform (EMR). The UK has forecasted that by 2030, its share of renewables will pass 50% [82].

Security of supply has never been an issue for the UK; however, with the new, higher share of wind and solar to the power system, market rules will need to accommodate interconnections, storage, and demand response to maintain this electricity security [86].

Other energy security policies include the Maximising Economic Recovery Strategy, led by the new Oil and Gas Authority, which stabilized oil and gas production in the North Sea [86]. The UK will be more dependent on imports of electricity and natural gas as domestic production declines, especially combined with the slow progress in adding nuclear capacity and retirement of other coal and nuclear plants [86].

6.1.3.1 UK's Future Transition Plans

There is a new UK emissions trading scheme to replace the EU ETS [87]. The emissions cap will be 5% lower than that of the EU ETS, and the UK government will consult on gradual reductions to achieve net-zero [87]. This open allowance market could give a greater incentive to reduce emissions as it provides more flexibility in allowance purchasing. Trading schemes are also less likely to be altered compared to a tax-based strategy [87].

After transport, buildings are the second-largest source of emissions in the UK [88]. The UK government plans for emissions from all buildings to be eliminated by 2050 [88]. This will be done through an emphasis on improving the energy efficiency of buildings. The Energy Saving Opportunity Scheme is meant to encourage energy audits from businesses to achieve energy and carbon and energy savings.

The UK Governments Heat and Buildings Strategy outlines plans to decarbonize heating through the testing and trial of hydrogen on the gas networks. The implementation of district heating across domestic and non-domestic buildings and electric heating pumps will be encouraged by funding a Heat Network Transformation Programme. The heating sector is a vital area for the UK to address in their energy transition due to its current misalignment with their net-zero targets; however, the technology proposed (hydrogen and electric heat pumps) are largely untested, and there are possible risks of delay in their roll-out process [88].

The UK is supporting industries through measures to improve energy performance and reduce emissions. These measures include exemptions from non-commodity costs, funds like the Clean Steel Fund and Industrial Energy Transformation Fund, and revenue mechanisms to support investment in emerging technologies (like CCUS) [88]. The government has also committed to delivering "low carbon clusters" where multiple industrial users can share clean energy infrastructure and are investing £1billion by 2024 to facilitate these infrastructures in four clusters by 2030 [88]. The UK Government also plans to bring back one large-scale nuclear plant to retain nuclear energy in their energy mix [88].

The UK has addressed the need for more intelligent systems to install thermal power, batteries and the creation of an energy marketplace to support their ambitious renewable energy targets and achieve net-zero [88]. Power and gas networks will have to be adjusted to support new technologies and fuels used and plan for the change in supply and demand relationships in the future.

6.1.4 China’s Energy Revolution

China's economy was deemed unsustainable and unstable, inspiring the creation of their 12th Five Year Plan (FYP) to change their course of action [89]. This plan includes China's industrial upgrade plan and "energy revolution" priorities, which were released in a paper outlining their overall strategies for China's energy sector through 2030 [89]. This energy revolution includes demand-side management for consumption and consumer habits, energy production efficiency measures, and an effort to develop energy technologies to reduce emissions [89]. These industrial programmes have been proven to drive change since China has a solid ability to incentivize industrial outcomes. The 13th FYP emphasizes clean technology investments [89].

China is now a global leader in renewables. By 2017, China's wind and solar power capacity had increased to 168.5 GW and 130.06 GW, and renewables generated 5.3% of China's electricity supply, significantly improving from 2012 [89]. China could become both a climate leader and a villain, depending on its clean energy exports and internal energy transition [89]. China has invested over US$100 billion a year since 2015 in domestic renewable energy projects, driving global renewables consumption growth by installing capacity at home and exporting solar panels and wind turbines [89]. China's energy security is also supported by increasing renewables' share within their energy mix and reducing import dependency, limiting the risk of geopolitical conflict or price volatility on energy supply.

6.1.5 Canada's Current Initiatives

Canada's climate targets are weakest globally, and current policies to reduce emissions are inadequate. These ineffective policies are undermined by government efforts to support the fossil fuel sector through direct and indirect subsidies. Canada's current pace of action contradicts its desire for a clean energy transition.

One of Canada's most notable transitions towards clean energy is its transition away from coal power in power generation. There is an influential effort to phase out coal use, with all power plants' goal to stop burning coal by the end of 2029. This is a necessary initiative towards Canada's climate policy goals [90]. The expected total benefits of the coal transition in Canada are $4.9 billion, which includes $3.6 billion in avoided climate change damage and $1.3 billion in health and environmental benefits caused by better air quality [91].

The Alberta provincial government and the Canadian federal government are implementing policies to support communities and coal workers negatively impacted by the phase-out of coal power. They have promised a just transition managed by the state that is fair for workers in Canada. This approach to a shift away from coal is reasonable and likely to succeed [90].

6.1.5.1 Community Impact

Despite the limited impact a phase-out of coal has on Canada's economy as a whole, the Stakes are high for the communities where coal facilities are at risk since substantial portions of employment and investment into these regions will be taken away. In Alberta, for example, twenty municipalities and first nations are impacted by the coal phase-out, mostly rural communities [92].

6.1.5.2 Policies

Transitioning from a coal-burning, private market towards a heavily regulated, cleaner electricity grid requires various plans and policies. Some of these plans include Alberta's climate leadership plan, which has a carbon levy on transportation and heating fuels, an annual oil sands emissions cap of 100 megatons of CO2, a directive to increase renewable energy from 9 percent of total power generation in 2015 to 30% in 2030, the creation of Energy Efficiency Alberta to promote public fund towards energy efficiency and the phase-out of coal-fired electricity generation by 2030 [93]. Several policies relate to financial commitments by the government. When the energy market went from a lightly regulated, private market to one that includes bot an energy and capacity market, producers were required to compete for payments to provide electricity capacity on-demand to sell power [92]. This encourages new capital investments from electricity firms. The NDP government also implemented an electricity price cap of 6.8 cents per KW hour to protect families and businesses from potential price volatility as the energy market transitioned [92].

In 2016, the Off-Coal Agreements ensured that Alberta's government compensated ATCO, TransAlta, and Capital Power $1.36 billion over 14 years with funds from Alberta's carbon tax for large industrial emitters [92]. In return, companies agreed to continue investments into the provinces' energy grid, keep employees in Alberta, and convert their coal units to gas by the mandated deadline. The use of rules and timelines allowed companies to plan and invest in the necessary infrastructure. At least 13 of Alberta's 18 coal units are likely to be converted to gas by 2029 [92].

Transition programmes for communities were also implemented in addition to Workforce Adjustment Committees, which involve companies, labour unions, government representatives and other stakeholders to help support workers' transition to another job, retraining, or retirement as needed [92].

The Alberta government established an advisory panel to consult with coal workers and communities to examine the phase-out's potential impacts and identify ways to support workers. A $40 million fund was initiated to support several transition programmes for the province's coal workers. The Alberta Federation of Labour-led Coal Transition Coalition, an advocate for coal workers, identified best practices to guide the government's programmes [92].

The government transition programmes consisted of six components [92]:

1. The bridge to re-employment relief grant: provides up to 75% of worker's previous week's earnings.
2. The bridge to retirement relief grant: financial support for workers close to retirement but not yet eligible for their employer pension.
3. Up to a $5000 grant for Coal workers that are laid off and move 40 KM or more to begin a new job.
4. A grant of up to $12,000 if coal worker's wish to return to school within five years of being laid off.
5. Career consultants and employment service providers are made available to work directly with coal workers to share information, make plans and provide short-term skill development courses.
6. A list of qualified facilitators was provided to unions to assist employees when setting up a workforce adjustment committee to create tailored transition plans for individual worksites.

In addition to implementing this program, in late 2017, the Alberta government created a $5 million Coal Community Transition Fund. Approximately 20 municipalities and First Nations communities impacted by the coal transition were eligible to apply [94]. This fund was exhausted by various projects that included strategic planning, feasibility studies, tourism development, and economic hubs, including agribusiness, transportation, and technology industries in 17 coal communities [94]. Next, a fund of $30 million was created through the Community and Regional Economic Support and available to rural communities across the province [94]. An additional fund of $200 million was announced to be invested towards renewable energy by the Alberta government in 2018 [94]. These three funds are helping to create a path towards economic stability and environmental sustainability in rural communities.

Although this collaborative approach between the state and labour organizations is an effective and just energy transition model that can be used to mitigate harm from environmental policies, it is not robust enough to address the comprehensive and transformational transition towards clean energy.

6.1.5.3 Canada's Nationally Determined Contribution

Canada's 2017 nationally determined contribution (NDC) submission to the united nations framework convention on climate change includes a commitment to reducing greenhouse gas emissions by 30% below 2005 levels by 2030 [95]. Canada has also set a target of achieving net-zero emissions by 2050 [95]. Canada is required to submit its successive NDC by 2025.

6.1.5.4 Pan-Canadian Framework on Clean Growth and Climate Change

The Pan-Canadian Framework on Clean Growth and Climate Change (PCF) is Canada's plan to reduce emissions and grow the economy. Canada's first ministers adopted this framework in December 2016 [96]. The PCF includes four pillars: pricing carbon pollution, complementary actions to reduce emissions across the economy, adaptation and climate resilience and clean technology innovation and jobs [96]. The PCF also has more than 50 actions that impact all Canadian economy industries [96]. If followed, the PCF will enable Canada to meet its Paris Agreement greenhouse gas emissions reduction targets; however, it does not outline specific goals towards a complete energy transition [96].

To support the various measures discussed in the PCF, the Canadian government announced significant investments, including [95]:

1. A $2 billion Low Carbon Economy Fund to fund new provincial and territorial actions to reduce emissions by 2030.
2. $21.9 billion to support green infrastructure, including renewables, electric vehicle charging and natural gas and hydrogen refuelling stations, new building codes, disaster mitigation strategies, and reduced reliance on diesel in remote communities.
3. $20.1 billion to support urban public transit; and,
4. Over $3 billion has been invested between 2016 and 2019 to support research, development, and clean energy adoption.

6.2 Role of Government

Governments and private sector resources must mobilize and maintain momentum to support energy transition priorities and mitigate the effects of climate change. As discussed in this report previously, Covid-19 has deeply affected the energy sector, making it integral that government policies regarding an energy transition are robust and resilient to mitigate the risk of future disruptions.

6.2.1 Section 91 of our Constitution

The environment was not identified as a relevant subject matter requiring government protection when the British North American Act (now the *Constitution Act, 1867)* was enacted [97]. Since environmental issues have surfaced, this original constitutional framework that distributes legislative powers to parliament and the provincial legislatures have assigned these issues to one or both levels of government [97]. The federal and provincial governments have collaborated to organize environmental regulations since the distribution of legislative powers can be complex and overlap [97].

One complicated issue is shared jurisdiction. When both levels of government have decision-making power over matters, and there is a conflict, then the provincial law is declared invalid to the extent it conflicts with the federal law ("doctrine of paramountcy") [97].

6.2.2 Greenhouse Gas Emissions

Provinces and territories have broad jurisdiction to regulate greenhouse gas emissions. They may impose provincial carbon tax under the provincial taxation power and control emissions from various industries under their jurisdiction. Provinces can also create emissions trading schemes due to their power to regulate property and civil rights [97]. Alternatively, the federal government can regulate greenhouse gas emissions based on its authority under the constitution. The federal government can impose carbon taxes, regulate emissions from industries, and regulate emissions of specific gases listed as toxic substances regardless of the source [97]. Also, the federal government can regulate emissions standards for vehicles and engines.

Canada's main issue is that no government levels are putting enough effort into creating effective climate policies; since both groups are responsible, no one is being kept accountable. The Canadian Council of Ministers of the Environment sets out guidelines around which government level will do what and harmonizes environmental laws between jurisdictions [97]. However, there is still work to be done to enable all governments to place policies aligned with emissions reduction goals and play a role in environmental protection.

6.2.3 Recommendations for Canadian Policy Implementation

A comprehensive energy transition plan for Canada requires federal and provincial government involvement, similar to the actions made when transitioning away from coal power; however, the social and economic costs are much greater. For the Canadian government to have latitude when persuading a complete fossil-fuel phase-out, it is vital to dismantle structural inequalities and place the interests of workers, communities, and our environment over those of corporations.

A challenge Canada faces is maintaining energy security while meeting emissions reduction targets. All energy options must be assessed by availability, scalability, cost, environmental impacts, and alternatives to ensure a viable transition plan is in place. The following section outlines potential policy initiatives Canada and provincial governments can pursue to create an environment better prepared for an energy transition.

These policies address various factors affecting Canada's energy transition and emissions reduction goals, including:

- Achieving a net-zero emissions economy by 2050.
- Increased investments in resilient infrastructure.
- Climate solutions that leverage zero-carbon industries.
- Long-term, market-wide policy tools.

6.2.3.1 Energy markets

Establishing a competitive and international energy market in Canada will create an incentive for investments that bring economic flexibility and energy efficiency. Political governance, including a carbon tax, sulphur tax and nitrogen monoxide emissions charges, can broadly impact price signals in energy markets, reducing the use of fossil fuels [98]. Voluntary measures, including investments in energy efficiency meant to produce cost savings and reduce emissions, have failed to alter emissions trends upwards, making it necessary for the Canadian federal government to place higher carbon costs.

6.2.3.2 Phasing-out Subsidies

To provide incentives for reducing consumption and transition towards renewables, the Canadian government should eliminate fossil fuel subsidies. A significantly higher carbon tax than what is currently implemented would more accurately address the cost of environmental damage caused by fossil fuel burning. According to the International Monetary Fund, in 2015, fossil fuel subsidies amounted to $US1,283 per person in Canada, primarily due to the costs of climate change and air pollution [99]. Without a transition away from fossil fuels, total subsidies would amount to $US1.151 trillion from 2016 to 2040 [99].

6.2.3.3 Reducing Consumption

The federal government should implement energy conservation and efficiency regulations and incentives. These should be enforced to the greatest extent possible and can include but are not limited to massive infrastructure improvements, building retrofits, efficient mass transit and enhanced building codes. To achieve energy security, and maximize the benefits of investments in renewable energy, reducing consumption on a large scale is imperative. Reducing consumption will also reduce expenditure on a new energy supply, and as a result, the environmental and economic costs of developing it. Specifically, the federal government could establish a demand-side management program that reduces energy needs. For example, Nova Scotia has offered a 30% tax credit for investments that reduce greenhouse gas emissions.

6.2.3.4 Renewable Energy Incentives

Although there are limitations with the complete adoption of renewable energy at the current consumption level, including wind, solar and geothermal energy, it is essential to encourage investment into renewable technology. Limitations include the intermittency of solar and wind power and backup requirements. There are also environmental consequences of hydro dams. A scaling up of clean energy technology investment and electrification, stimulated by fiscal policies, in all sectors is required. Also, to support electrification in the long-term, streamlining regulation in electricity wholesale and retail markets is necessary to ensure competitive markets. Other initiatives the government could execute include mandating increased reliance on renewable energy within the Canadian electricity portfolio [100].

6.2.3.5 Infrastructure and Energy Systems

Implementing better energy codes for buildings, considering retrofits for buildings and electrifying space and water heating with heat pumps can encourage Canada's energy savings. Another way to promote energy savings is to have tax measures that eliminate the PST or GST on purchasing energy-efficient equipment and government procurement programs for high-efficiency products.

6.2.3.6 Smart Systems

Networks will need to expand to account for the significant new demand for power from the electrification of transport [101]. Heavily investing in innovative grid programs that enable research and technological advancements can help remove energy storage barriers and support more competent, flexible energy consumption [102].

6.2.3.7 Transportation

Various initiatives can effectively reduce emissions from the transportation sector in Canada, including improving mandates for fuel-efficiency standards in cars and trucks and implementing fuel taxes to provide incentives for cleaner transportation options [100].

6.2.3.8 Additional Recommendations

The above recommendations are not a comprehensive list of what needs to be done to ensure Canada prepares its economy for the inevitable global energy transition. The Canadian government must realize that although oil and gas will be required to maintain current consumption levels for some time, failing to prepare for a shift towards renewable energy is a misguided decision and will lead to energy insecurity in the long-term. Also, realizing the limitations to Canada's current plans is essential, including addressed that the increase of hydropower and upscaling of nuclear energy generation is not likely to happen for environmental and economic reasons. Although other well-performing countries globally can act as a transition plan model, there is no one-size-fits-all solution. Canada will need a precise, action-based plan to achieve both its climate and economic goals. For example, although biofuels' introduction as a replacement for fossil fuels has been effective in Sweden, there are low net-energy gains of this technology, making it an insignificant substitute since the initial emissions of biomass burning are equivalent to burning coal. Canada should be concerned about being uncompetitive in emerging renewable industries rather than worrying about continuing a damaging, traditional energy industry reliant on fossil fuels.

6.4 Transition of Businesses

"For companies, a just transition is an enterprise-wide process to plan and implement companies' emissions reductions efforts, based on social dialogue between workers and employers. This includes a company's supply chains. The goal is to reduce emissions and increase resource productivity in a way that retains and improves employment, maximizes positive effects for workers and communities, and allows the company to grasp the commercial opportunities of the low-carbon transition" [103].

6.4.1 Why Should Companies Implement a Transition Plan?

Whether businesses agree with it or not, governments and citizens are pushing for sustainable development goals which will change the way that many industries currently operate. Implementing a transition plan will allow companies to plan for, manage, and optimize the reputational and operational effects that cutting emissions will have.

Social responsibility aside, climate risk, and opportunities including risks of transition, are among the information that investors are increasingly requiring that businesses disclose [104]. An example of this is in 2019 when the Church of England Pension Board, Church Commissioners of England, and Sweden's Public Pension Funds which represents an assets under management over $3.8 trillion USD called for safety and environmental audits to tailings of 727 publicly listed extractive companies (including Oil and Gas companies) [105]. This audit required the companies to disclose the tailings environmental and safety information publicly to be eligible for future investment [105]. In 2016, 68% of investors identified that non-financial information was important to their financial decisions due to the verifiable link between good management of these issues and company returns [104].

Just transition planning allows companies to address climate impact and potential future workforce issues at the same time. Employee retention is directly linked to better labour practices and companies that engage in a social dialogue of how to utilize their existing workforce in a changing industrial landscape will inevitably lead to higher returns [104]. Brand reputation in regard to sustainability is becoming a large part of how customers spend, with 70% of millennials reporting that they would spend more money with brands that support causes they care about [104].

Siemens is a good example of the reputational benefits of being a company that is a frontrunner in not only in environmentally conscious work, but also being committed to transitioning workers into a new and sustainable sector. Siemens invested £160M into wind turbine production and installation facilities in the UK which built an infrastructure for 1,000 new jobs [104]. Siemens created a two-year training program to train young graduates into a career path in renewable energy and due to this initiative, they received considerable positive political and media attention [104]. Companies should see transitions as opportunities to innovate, grow, and create a new brand for themselves, rather than as restrictions placed by governments.

6.4.2 Engage, Plan, Enact

Business transition strategic planning is business sector and region specific and therefore general best practices are discussed in this section [104].

6.4.2.1 Engage

A key component of any business implementing a transition plan is to engage and consult with workers, their unions, and other stakeholders. Through ensuring open social dialogue, regionally specific transition plans can be built. The required support for a remote region such as Wood Buffalo, Alberta where 31.2%

of the workers are employed by the fossil fuel industry is a lot different than the over 50% of all oil and gas workers that are employed in cities will require [106]. Best practices for topics to include when consulting with stakeholders include the following:

- Gathering information to improve processes and develop new technologies or innovations capable of reducing emissions and waste or promoting resource efficiency.
- Analyzing and agreeing on different alternatives for climate action by the business or in the sector.
- Forecasting and identifying pathways to maximize the positive influence of company-wide climate action for its workers and communities, as well as outlining how to minimize its negative influence.
- Forecasting skills required and employment prospects and designing appropriate training services.
- Developing and advocating for government policies to support a transition, specifically for workers in high carbon sectors that are vulnerable, and to push for job creation and development.

6.4.2.2 Plan

Once stakeholder insights and concerns have been collected, businesses need to collaborate to create a specific, time-bound, plan for a just transition. Companies must identify ways that they can reduce emissions in the short, medium, and long term, and evaluate the consequences of implementing them. Emission reduction strategies often incur high capital costs or have a high opportunity cost it might require phasing out a business area. However, redeploying workers in new areas, or hiring additional workers from high-emission areas to clean businesses sectors can provide long term benefits. An example of this is AGL energy in Australia which reduced its carbon footprint by 18% by switching from being a primarily coal fired electricity generator to including natural gas, wind, and solar electricity. This switch consequently also lowered their generating costs from $106/MWh to $83/MWh [104]. The following key considerations should be included to ensure a business transition plan is well structured:

- Include short- and long-term targets to produce reductions in emissions company-wide in accordance with emissions reduction targets for net-zero emissions.
- Consider vulnerable workers and communities and the risks that they might face with regards to a just transition. Include risk managing steps for these groups.
- Aim to create sustainable and transition-proof jobs within the company and its supply chains.

- Provide infrastructure to reskill and redeploy existing workers in the company's transition.
- Push for investment in community diversification of affected groups.

6.4.2.3 Enact

Enacting the transition plan devised goes further than executing the steps outlined. Transitions will often never be able to predict all market changes and variables and therefore companies should continuously monitor, report, and engage in social dialogues to iterate and improve the plan. Companies are encouraged to provide continuous training and support to their workers such that their skills remain in demand in a transitioning market. The following key considerations should be made when enacting a just transition plan:

- Include continuous training and learning opportunities in green business practices.
- Include training and learning opportunities in occupational health and safety.
- Include reskilling and upskilling in sustainable and environmentally friendly innovations.
- Ensure that the company includes training that results in certification.

6.4.3 Oil Sector Case Approach

What does the layout of Section 6.4.2 mean for oil companies in Alberta, what does a transition like this look like for these companies? It is clear that oil and gas companies will have to shift their focus to becoming energy companies, among other things. The phasing out of oil will be met with utilization of naturel gas as an intermediate stepping stone to lowering grid energy intensity, but that shift will only serve as a temporary band-aid if Canada is aiming for carbon neutrality by 2050.

The landscape of sectors that will fill the GDP gap that a shrinking oil sector will vary greatly, and companies need to consult with communities to see which opportunities fit best for each community. Although the transition of oil jobs into renewable energy jobs seems like a good fit as oil companies can transition many of the skills their workers already have, into being diversified energy companies, the transition does not have to include moving everyone to green energy.

The oil sector experiences an average annual employee turnover rate of 10% [107]. This means that on average 10% of the employees in the oil sector change into different industries every year. The actual impact to employment will in reality be smaller than what is expected if new jobs into the oil sector are limited, and the 10% employee bleed continues until the number of employees in the oil sector are significantly reduced. If new oil projects are limited and existing projects are continued until the end of the project lifetime, the natural employee reduction will decrease the number of employees that are left at risk of unemployment.

6.4.3.1 Green Energy

As discussed in Section 5.1, Alberta has an already scheduled large shift to green energy as the mandated shut down of coal energy by 2030 takes place. However, there is still lots of rooms for companies to innovate and be extremely profitable in this space past what the government has already planned. The 6050 MW of hydropower potential in Alberta remains an unclaimed resource, as well as the non-existent usage of solar power in Alberta.

The United States have set very tight emissions targets and their projected green energy production schedule will most likely not meet these targets [107]. This opens the possibility to sell green energy to America with an excess of green energy in Canada. Canada could fill the GDP gap that oil will leave with an export industry for green energy [107]. It is likely that green energy prices will demand a premium as countries start reaching emissions target dates and they have not yet developed the infrastructure to reach those targets.

Oil companies can leverage their existing expertise in the energy sector and become industry leaders in green energy. For the 44% of oil and gas jobs that are working in the fields, this transition can look like working on the planning, manufacturing, maintenance, and management of green energy infrastructure such as windmills, hydroelectric dams, solar photovoltaic farms, and geothermal wells. For the 56% of oil and gas jobs that are in cities, this transition can look like working in research and development, engineering design, green financing, and other office related administrative work related to the energy sector.

6.4.3.2 Other Industries

Oil and gas companies have the expertise, and personnel that with training can make successful transition into industries outside of the energy sector. Mining of metals and minerals required in a transition to a green economy such as lithium required in lithium-ion batteries, and many other emerging industries such as the booming tech industry in Calgary make good candidates for oil and gas workers to make a transition to.

The 44% of oil and gas workers that work in the field, many of which operate heavy machinery would transition into mining work quite easily. The 56% of oil and gas jobs in cities can transition the engineering design work and the infrastructure surrounding it to tech jobs, plastics and polymers, healthcare, any many more growing fields.

With the immense expertise and access to resources, it is up to oil and gas companies to evaluate the landscape of their employees, and to assess which sectors will allow them to thrive during and post transition. This assessment will require consultation and evaluation of many different options and many oil and gas companies will most likely see themselves involved in many different industries depending on their personnel. Effective use of government subsidies, as well as effective use and retraining of existing employees will separate oil and gas companies that will thrive post transition, and companies that will try and just survive as long as they can.

6.5 Utilization of Existing Infrastructure

Existing oil and gas infrastructure still can play a role in a green society. Oil extraction is still a necessary input for polymer production, with polymers being an essential ingredient to many green technologies. With adaptation of existing oil extraction infrastructure to upgrade bitumen extracted in the oil sands to synthetic crude oil which can then be refined to different chemical feedstocks, the oil extraction industry in Alberta does not have to be completely removed. The end product will need to shift beyond combustion fuels and focus more on chemical feedstocks, carbon fiber, and tar for roads, but with the correct provisions in place, there can still be room for limited oil extraction in Canada.

In the transition to a more sustainable society, oil companies need to incorporate the following provisions to ensure compatibility with the goals of society:

- Ensure proper closure and regulation of closed wells to reduce methane leakage.
- Reduce life-cycle greenhouse gas emissions for oil and gas extraction lower than competing global markets.
- Implement carbon capture and sequestration technologies.
- Integrate renewable energy as the sole supplier of energy for extraction, includes eliminating natural gas burning to produce steam for SAGD extraction.
- Report consistent regulatory updates by third party assessment to evaluate environmental impact.
- Ensure diversified product mix away from combustible fuels.

Furthermore, the oil and gas refining and transportation infrastructure and expertise can be repurposed for other refining and separation uses such as for biofuels. Biofuels such as ethanol and biodiesel require many of the same chemical separation and pipelining technologies that crude oil requires. As part of a product mix diversification strategy, oil refining companies can look to repurpose some of the existing infrastructure for use with biofuels. These adaptations are specific to each company as feedstock, production, and transportation requirements vary greatly, but companies are encouraged to consider biofuel production as part of a post-transition economy.

6.6 Training and Transitioning Workers to New Sectors

Worker transition is community specific and consultation with community members, workers, unions, and government at all levels is required to ensure the needs of the economy and the communities are met. Furthermore, once jobs in clean industries are made available through investment by governments, or companies such as energy companies, the natural 10% annual turnover rate will gradually decrease the size of the oil sector, barring that new projects and jobs are not added, and old projects reach retirement age. However, there will still be concern for those that do not transition naturally, and need assistance in the from of training, relocation, or both.

Transitioning of workers from the oil and gas industry begins with identifying job specificity to the oil and gas industry, jobs can be categorized into no training required, some training required, and complete retraining required. Jobs such as administrative staff, roadworks construction, marketing, and many others would require little to no retraining in a new industry as the industry practices are widely applicable. Other positions such as chemical engineers working on bitumen upgrading would have all the required education and skills to work in many other industries but would require some training due to lack of experience in other sectors. Lastly, jobs such as extraction labour workers who has been involved in oil extraction drilling their whole life and their skillset is unique to oil and gas work would require complete retraining.

Once equivalent jobs in new sectors are identified, the time and cost required for retraining can be estimated based on trade schools, licenses, certifications, or college and university training required. A United States Bureau of Labor Statistics report found that only 30-35% of coal industry jobs were specific to the coal industry [108]. Although a different sector than oil and gas, coal workers in Canada will need transitioning as well, furthermore, it is assumed that this figure would be similar for oil and gas jobs. In a 2016 US study on the transition of coal workers to photovoltaic solar power jobs, it was estimated that the average cost to fully retrain an employee would be $4295 USD [108]. With 220,000 direct oil and gas jobs in Canada, that would constitute an estimated cost of $330,715,000 USD to fully retrain all oil and gas workers whose skills are not transferable to other industries. This cost does not have to be realized in one year, this cost would be spread across the 30+ years that oil and gas projects will still be running. However, it is important that this process begins immediately as retraining of workers can take months to years, and as green energy and other post transition sectors begin to grow, newly trained workers will be required to meet that growth. The funding of this retraining will also be spread across multiple sources such as self funded, employer funded, and government funded. Although the retraining cost might seem like a significant burden to taxpayers, in comparison to tax subsidies that the oil and gas sector receives, there should be no issue in funding the retraining of oil and gas workers. A 2020 study by the International Institute for Sustainable Development found that the lack of transparency of Canadian tax subsidies for the fossil fuel industry is problematic [109]. There were 128 subsidies in place for the fossil fuel sector, of which only 50% were quantifiable [109]. Of the quantifiable subsidies, these tax subsidies accounted for an estimated $3.2B CAD in annual revenue forgone [109]. A simple reduction of subsidies for the fossil fuel sector would be enough money to train all fossil fuel workers 10 times over.

However, retraining the existing oil and gas industry is unfortunately not the only component to consider. Past a certain age, retraining an individual makes less sense than hiring a new, young employee. Governments and companies should be prepared to include early retirement packages for employees that will be negatively impacted by a transition and are not able to switch careers. Furthermore, governments should encourage, and potentially subsidize, colleges and universities to create specific programs to retrain workers in the fossil fuel industry. Universities could create four-month programs that do not necessarily require oil and gas engineers relearn engineering principals, but fill in the gaps in knowledge to make them employable in a sustainable industry of their choosing. Colleges could create programs that teach labour workers from oil drilling how to repurpose their skills to be useful in wind turbine manufacturing and installing for example. Lastly, governments, and oil and gas companies need to be cognisant of communities that will be more heavily impacted by these transitions. Some communities rely almost entirely on the work provided by the oil and gas industry, and these regions need to be involved in the planning and retraining design process to identify where these communities fit in a post transition world. This topic is covered more in depth in Section 6.8.

6.7 Achieving Public Support

“Public support is crucial, because it lends credibility to your efforts, helps you gain further support, provides strength for action or political pressure, and creates community ownership of and responsibility for measures to deal with the issue. To build that public support, you need support first from key individuals and groups in the community - trusted figures from various walks of life to whom people listen, or whose credibility is high because of their involvement in the issue" [110].

6.7.1 Public Attitudes to a Transition

Given that Alberta's economy is dependent heavily on the oil and gas industries, the public opinions of Albertans are diverse. There are very few academic studies giving perspectives from audiences in various demographic on climate change and energy, especially for the association between the Albertan's demographics and people's attitudes towards a transition plan. The layout of 6.7.1 is structured as a summary of attitudes held by different groups of Albertans from the Alberta Narratives Project II [111].

"The Alberta Narratives Project is a community-based initiative convened by the Alberta Eco trust Foundation and Pembina Institute to seek ways of talking about climate and energy that reflect the shared values and identities of Albertans and to provide a more open and constructive basis for conversation" [111].

6.7.1.1 Oil Sands Workers & Energy Professionals

As oil and gas workers who are working for the single largest sector in the Alberta economy, many of them are proud of their daily work and hold strong share identity towards both the community and Canadian. Hence with the raising attention to transitions that required to move into a renewable energy field, many are supportive which contradicts what many others think, but many also feel their own livelihood are undervalued or under attack. Many participants who were in the Alberta Narratives Project do not feel the government are focusing on the real issues, overpopulation, and pollution; instead of being supportive, the feeling of misunderstanding pushes the requirements on an effective communication channel to give out their voices. In general, the attitudes towards the future of oil and gas industry tended to be optimistic and caring more on environmental pollution rather than the climate change.

6.7.1.2 Conservatives

Essential values that conservative leaning people generally hold is the gratitude to Alberta and having strong sense on taking responsibilities. With great concern on increasing social polarisation by social media, many participants shared sense of being gazed in a negative tendency and a great concern on losing civil discourses. Similarly, as oil sands workers and energy professionals, "they supported renewables as a new source but not as a replacement for fossil fuels" [111]. With a tendency of being sceptical towards climate change topics, a wide range of opinions from deep concern to outright dismissal, mixed views on degrees of taking personal responsibility for climate change were expressed.

6.7.1.3 Environmentalists

Majority of environmentalists are younger, and generally are university educated, with core passions regarding the environment. Generally, environmentalists have strong beliefs in compassion, empathy, integrity, responsibility and making contributions. With the strong agreement across all groups that the climate is changing, environmentalists expressed concerns over the declining respect for science and hopelessness over the possibility of change. Participants in this group held a general appreciation for the oil and gas industry and considered the goal of abandoning oil and gas altogether as unrealistic. They see the transition as an opportunity for change and supporting the energy diversification. Similar to other groups, the environmentalists also expressed the feeling on needing more respectful and informed conversations as to not “feel attacked from all sides”.

6.7.1.4 Rural Albertans

Rural Albertans referred to rural and small communities, which “tend to have older populations, vote conservatively, have fewer university graduates, and have far fewer new Canadians” [111]. They see themselves as knowledge keepers and stewards of the land, with pride of Alberta and the foundational role of agriculture, they had wide-ranging concerns about societal changes related to overconsumption, overpopulation and increasing urbanisation.

Besides feeling frustrated by people mis-seeing their opinions, they tend to hold more homogeneous attitudes towards climate changing and sees the recent shifts in weather patterns as a sign of general climate change. With the general appreciation for the energy industry, the participants criticized the slowness on government actions to head innovation. With the perspective on welcoming the new opportunities on diversified energy and economy and looking forward to possible generational employment. Like other groups, the rural Albertans mentioned the importance on having informed, respectful, and intelligent discussions.

6.7.1.5 Business Leaders

As a group of people holding positions in senior management, they are essential in politics and economic decision-making even though only make up a few percent of the total labour market. The participants saw Alberta as a place of “unlimited opportunity” [111] and pride for the natural beauty of Alberta. With the fearing on both political polarisations, fuelled by social medias, and the society is moving away from their values of being honest, they expressed concerns on lacking balance in public debates. “They felt under attack from progressives, especially environmentalists” [111], and “feared a loss of their public standing” [111]. Almost all of the participants worked closely with the energy sector. Regarding the energy transition, they held mixed views on both seeing new opportunities and worrying “the changes could be too abrupt and destroy their legacy” [111]. Like other groups, they expressed the feeling on being realistic and showed the needing on discussions about energy future and what the transition will look like.

6.7.1.6 Youth

Statistics Canada classified those ages of 16-28 as youth and those under the age of 16 as children [111]. With the personal values about “acceptance of others, friends and family, and qualities related to change and personal growth, youth valued Alberta’s nature and landscapes” [111]. This group showed that concerns about unemployment and economic stress tend to trump their concern with climate change. “Like the environmentalist group, children and youth expressed fear of the future, citing environmental destruction, ecosystem failure, species endangerment, animal extinction and world politics as particular concerns” [111]. This group talked about feeling powerless or disempowered. Youth tend to think the transition would not happen in the next few years. Like all other groups, the youth highlighted the importance of having open discussions.

6.7.2 Obstructions to Supporting People

Albertan’s diverse perspectives towards a transition plan are categorized more by beliefs of demographics rather than data supported.

Supportive factors are caring about the climate change, worried the nature disaster, being social conservative. On the other side, the opposing factors are more “realistic”, such as being economic conservative, not enough scientific research showing the future of oil and gas industries is in shadow, people who need the job and economic support to raise their families, pension issues that may cause by the transitions, the fear and not knowing the future on the transition. One interesting factor here, is that many people are both supportive to the expansion of oil and gas, and excited for new opportunities provided by the renewable industries. Disregard the information gap among the groups and opposite opinions on a transition, three attitudes are in common, looking forward in renewable energy industries, concerns regarding polarisation on social media, and the desire to have respectful and intelligent conversation and expressing their feelings.

The obstructions could be concluded as:

- Being extremely optimistic on the future of oil and gas industries.
- The existing infrastructure, job opportunities, trainings, economic support are not sufficient for transiting to renewable industries.

- Lacking the peaceful communication opportunities for groups who are holding different opinions.
- Being proud of the oil and gas industries, opposing the idea moving away from oil sectors entirely, seeing renewable industries like new opportunities rather than a replacement.
- Being anxious on the heavily dependency on the oil sands, without clear guidelines from the governments on the restructuring of the economy.

6.7.3 How to Achieve Public Support

With the raising urgencies on having a transition plan, it is important for local governments and relating parties to take actions in a timely manner This includes building a communication channel for relating parties, preparing for new job opportunities along with required trainings, and giving a clear perspective involving research for the future forecasting of the oil and gas industry. The following are some recommendations and ideas:

Investment: The provincial governments should propose incentive programs supporting the development of renewable industries in Alberta. Including the funding for companies on researching reducing pollution from existing oil and gas industries; supporting government owned renewable companies in green energy; extra financial support to workers who moved from traditional oil sectors to renewable industries.

Communication: The provincial government should lead on creating a communication channels for all relating parties to have a chance to express their concerns and opinions. For example, providing workshops for oil sand workers, open discussion forum and topics on discussion websites and social media such as Twitter, Reddit, and Facebook.

Opportunity: Creating job opportunities and provide training for existing oil sand workers; hosting workshops providing clear instruction on transitioning; building network opportunities for current workers to reduce the risk on transitioning between jobs.

Advertisement: Explaining the importance and benefits of reducing dependence on traditional oil sectors and expanding the green energy. Including providing scientific reports such as how raising electric vehicles will impact the oil price in short term, advertising on television, newspaper, radio, and other ways to widespread the knowledge. Mainly, having clear transition instructions and solutions for the public concerns is an essential step.

6.8 Community Involvement

Strategies and considerations for engaging communities in transition planning are discussed in this section.

6.8.1 Indigenous Community

The importance of Indigenous people on a transition plan has certainly been devalued, as the group of people who are impacted the most from the climate change and greatly depend on fossil fuels in their daily life, it is important to realize getting indigenous people involved and being respect to their opinions is one essential step in a transition plan. First nations, Inuit and Métis people are involved in, or own, over 150 large-scale clean energy projects in Canada [112]. “Many are developing renewable energy programs to break free of colonial ties, move towards energy autonomy, establish more reliable energy systems and secure long-term financial benefits” [112].

Indigenous communities are facing issues more than energy transition, such as discrimination, colonization burden, and high rates of mental health issues, it is essential to realize the importance of respect towards the leadership that indigenous community could take on green energy industries.

To help the engagement for indigenous people in part of the energy transition, the following are proposed by the report “Canada's Energy Transition: Getting to Our Future, Together”:

- Building mutually beneficial and respectful relationships requires political will, joint leadership, trust, accountability, and transparency. This requires substantial commitment by all parties involved [113].
- Recognizing the knowledge and perspectives of Indigenous elders and keepers of Traditional Knowledge regarding community ethics, concepts, and practices can serve as a guide for the use of Traditional Knowledge in Canada’s energy transition [113].
- Engaging Indigenous peoples in the energy transition in a collaborative and solutions-oriented manner will lead to better economic, social and environmental outcomes [113].

These recommendations could be included as improving awareness indigenous community with existing opportunities, providing funding on green energy projects with indigenous community involvement, and preparing technical training and workshops to operate green energy projects.

6.8.2 Achieving Sufficient Community Involvement

It is essential to acknowledge that the government needs to take the leadership role and be the bridge to ensure numerous communities affected by transitions from the oil and gas sector can achieve sufficient involvement. Furthermore, provincial governments, and the federal government should collaborate on building a green Canadian energy system. The role of the government is to facilitate "providing the foundation to ensure that policy-makers, industry, investors, the financial community, academia, consumers and the public have the information they need to make informed decisions" [114].

Two reports published by natural resources Canada, "Building Canada's Energy Future Together" [114] and "Canada's Energy Transition: Getting to Our Future, Together" [113], has provided helpful suggestions on how to lead the energy transition, how to support evidence-based decision making, and how to build the public trust in resource development.

- Building a government-owned platform, hosting workshops, or establishing an institute that assisting communities to have a clear understanding of standards and instructions on the energy transition.
- Providing scientific analysis and accurate, timely data as the base evidence on communities' decision-making process.
- Constructing a transparent communication channel ensures there is no information gap between governments, affected communities, and interested parties.

These strategies could boost collaboration between provincial governments, territorial governments, industry associations, businesses, scientific agencies, and other stakeholders. Moreover, it would help to develop a more structured system to forcing a transition plan moving forward. With the public and related parties' involvement, the chance to move quickly with executing an energy transition plan for the possible incoming crisis could be supervised by the public.

7.0 Conclusions

In 2016, Canadian oil and gas sector was responsible for 3.3% of all jobs across Canada [6]. Even with the energy price decrease as of 2016, the broad energy sector's contribution amounted to 5.4 percent of Canada's total GDP [6]. For the future of the oil sectors globally, 2021 oil demand is expected to be greater than 2020 oil demand; however, it is expected that it will remain lower than pre-COVID-19 levels. After Canada submitted the greenhouse gas emissions goals towards the Paris Agreement, companies are being asked to make their operations and business models transparent and show their participation.

The EV adoption rate is increasing every year both globally and in Canada. Even with the impact from COVID-19, as the total vehicle market contracted, the EV adoption rate still showed a promising future. It is reasonable to believe that within 5 to 10 years, the oil price and the development of oil sectors could be negatively impacted by the expanding EVs.

Bitumen, the heaviest classification of petroleum materials and the most challenging petroleum material to extract because of its high viscosity is the main component of the Alberta oil sands composition. To limit greenhouse gases, one method that was proposed is to use the extracted bitumen from oil sands beyond combustion fuels. Bitumen can be converted to platform chemicals and alternative products such as carbon fibre. Basic economics dictates that as the supply of bitumen decreases due the reduction in global oil production for combustion fuels, the demand stays the same due to its inherent stable economy requirement. Hence it is possible to see an increase in bitumen price.

To embrace the future of decreasing the oil sector's use and seeing the development of green and renewable energy, it is essential to plan substitute sectors. Choices for the oil sands such as geothermal, wind power, and hydropower are all viable options for energy generation in Alberta. Mining projects and other emerging technology sectors are recommended for diversification of the Albertan economy. For example, there is strong evidence that Alberta can potentially have significant mining projects with uranium, potash, lithium, diamonds, and magnetite.

Recommendations for a successful transition plan are broken down into eight sections: a summary of existing international transition plans, the federal and provincial governments' roles and how to collaborate to work on a successful transition, recommendations for successful business transition, how to utilize the existing infrastructure, retraining of existing fossil fuel workers into new sectors, achieving public support, and lastly, how to ensure the sufficient community involvement, especially how to include the indigenous community into energy transition plan from the beginning.

8.0 Final Recommendations

Policymakers and private-sector entities, civil society groups, and consumers play a critical role in the energy transition process, making multi-stakeholder collaboration at the national and provincial level imperative for Canada.

In summary, to create the correct fundamentals for a just energy transition in Canada towards a sustainable, inclusive future energy system, we recommend the following actions:

1. Establish competitive and international energy markets in Canada to create an incentive for investments in energy efficient and renewable technologies.
    a. Implement larger carbon tax, sulphur tax, and nitrogen oxide emissions charges to impact price signals.
2. Phase out fossil fuel subsidies to reduce consumption.

3. Implement energy conservation and efficiency regulations and incentives.
    a. Improve infrastructure, include building retrofits, develop efficient mass transits systems and enhanced building codes.
4. Encourage investment into renewable technology through fiscal policies.
    a. Invest in developing technology that addresses current renewable energy limitations including the intermittency of solar and wind power and backup requirements.
    b. Invest in innovative grid systems to support new power demand from the electrification of transport.
    c. Improve mandates for fuel-efficiency standards in cars and trucks and implementing fuel taxes to provide incentives for cleaner transportation options.
5. Engage and consult with workers, their unions, and other stakeholders.
    a. Ensure open social dialogue so regionally specific transition plans can be built.
    b. Gather information to improve processes and develop new technologies or innovations capable of reducing emissions and waste or promoting resource efficiency.
    c. Analyze and agree on different alternatives for climate action by the business or in the sector.
    d. Forecast and identify pathways to maximize the positive influence of company-wide climate action for its workers and communities.
    e. Forecast skills required and employment prospects and design appropriate training services.
    f. Develop and advocate for government policies to support a transition, specifically for workers in high carbon sectors that are vulnerable, and push for job creation and development.
6. Collaborate with various businesses to create a specific, time-bound, plan for a just transition.
    a. Identify ways that they can reduce emissions in the short, medium, and long term, and evaluate the consequences of implementing them.
    b. Redeploy workers in new areas or hire additional workers from high-emission areas to clean businesses sectors.
    c. Include short and long-term targets to produce reductions in emissions company-wide in accordance with emissions reduction targets for net-zero emissions.
    d. Consider vulnerable workers and communities and the risks that they might face with regards to a just transition and include risk managing steps for these groups.

    e. Aim to create sustainable and transition-proof jobs within the company and its supply chains.
    f. Provide infrastructure to reskill and redeploy existing workers in the company's transition.
    g. Push for investment in community diversification of affected groups.
7. Continuously monitor, report, and engage in social dialogues to iterate and improve the enacted transition plan.
    a. Companies should provide continuous training and support to their workers such that their skills remain in demand in a transitioning market.
        i. Include continuous training and learning opportunities in green business practices.
        ii. Include training and learning opportunities in occupational health and safety.
        iii. Include reskilling and upskilling in sustainable and environmentally friendly innovations.
        iv. Ensure that the company includes training that results in certification.
8. Utilize Existing Infrastructure
    a. Adapt existing oil extraction infrastructure to upgrade bitumen extracted in the oil sands to synthetic crude oil which can then be refined to different chemical feedstocks.
    b. Ensure proper closure and regulation of closed wells to reduce methane leakage.
    c. Reduce life-cycle greenhouse gas emissions for oil and gas extraction lower than competing global markets.
    d. Implement carbon capture and sequestration technologies.
    e. Integrate renewable energy as the sole supplier of energy for extraction, includes eliminating natural gas burning to produce steam for SAGD extraction.
    f. Report consistent regulatory updates by third party assessment to evaluate environmental impact.
    g. Ensure diversified product mix away from combustible fuels.
9. Train and Transition Workers to New Sectors
    a. Consult with community members, workers, unions, and government at all levels to ensure the needs of the economy and the communities are met.
    b. identify job specificity to the oil and gas industry, jobs can be categorized into no training required, some training required, and complete retraining required.

c. Once equivalent jobs in new sectors are identified, estimate the time and cost required for retraining based on trade schools, licenses, certifications, or college and university training required.
d. Include early retirement packages for employees that will be negatively impacted by a transition and are not able to switch careers.
e. Encourage, and potentially subsidize, colleges and universities to create specific programs to retrain workers in the fossil fuel industry.
f. Be cognisant of communities that will be more heavily impacted by these transitions.

10. Achieve Public Support
    a. Collaborate between various level of government to build a Canadian energy system.
    b. Build a government-owned platform, host workshops, or establish an institute that assisting communities to have a clear understanding of standards and instructions on the energy transition.
    c. Provide scientific analysis and accurate, timely data as the base evidence on communities' decision-making process.
    d. Construct a transparent communication channel ensures there is no information gap between governments, affected communities, and interested parties.

9.0 References

[1] "Progress towards Canada's greenhouse gas emissions reduction target," 03 03 2021. [Online]. Available: https://www.canada.ca/en/environment-climate-change/services/environmental-indicators/progress-towards-canada-greenhouse-gas-emissions-reduction-target.html. [Accessed 08 03 2021].

[2] "Greenhouse gas sources and sinks: executive summary 2020," 19 01 2021. [Online]. Available: https://www.canada.ca/en/environment-climate-change/services/climate-change/greenhouse-gas-emissions/sources-sinks-executive-summary-2020.html. [Accessed 08 03 2021].

[3] "Canadian Economic Contribution, CAPP," [Online]. Available: https://www.capp.ca/economy/canadian-economic-contribution/#:~:text=Canadian%20oil%20and%20natural%20gas,for%20roads%2C%20school%20and%20hospitals.. [Accessed 08 03 2021].

[4] C. O. a. N. G. Producers, "CAPP," 2020. [Online]. Available: https://www.capp.ca/economy/canadian-economic-contribution/#:~:text=Canadian%20oil%20and%20natural%20gas,for%20roads%2C%20school%20and%20hospitals. [Accessed 15 February 2021].

[5] M. K. P. S. Ed Brost, "Electric Vehicle Impact on the Oil Sands," The Bowman Centre for Sustainable Energy, Sarnia, 2020.

[6] C. E. Centre, "Jobs and GDP: The oil and gas sector's contribution to Canada's economy in a "slump" year," September 2020. [Online]. Available: https://www.canadianenergycentre.ca/wp-content/uploads/2020/09/CEC-FS-18-Jobs-and-GDP-FINAL.pdf. [Accessed 15 February 2021].

[7] M. M. Lennie Kaplan, "Canadian Energy Centre," 8 November 2020. [Online]. Available: https://www.canadianenergycentre.ca/672-billion-the-energy-sectors-revenues-to-canadian-governments-2000-2018/#:~:text=Between%202000%20and%202018%2C%20the%20oil%20and%20gas%20sector%20paid,in%20provincial%20corporate%20income%20taxes.. [Accessed 15 February 2021].

[8] D. Dickson, "2021 Oil and Gas Industry Outlook," Deloitte, 2020.

[9] C. Dewhurst, "THE NEAR FUTURE OF OIL & GAS IN 2020: BDO'S GLOBAL ENERGY VISION," BDO Global, Brussels, 2017.

[10] W. Roelf, "Gas Processing & LNG," Gulf Publishing Holdings LLC, 2019.

[11] IEA, "Capital expenditures on new projects outside of core oil and gas supply by large companies, absolute and as share of total capex, 2015-2019," IEA, Paris, 2020.

[12] G. o. Canada, "Energy and the Economy," Government of Canada, Ottawa, 2020.

[13] W. N. News, "Canadian government invests in SMR project," 18 March 2021. [Online]. Available: https://world-nuclear-news.org/Articles/Canadian-government-invests-in-SMR-project. [Accessed 1 April 2021].

[14] W. N. Graphics, "The Wall Street Journal," Down Jones and Company Inc. , 15 April 2016. [Online]. Available: http://graphics.wsj.com/oil-barrel-breakdown/. [Accessed 19 February 2021].

[15] N. Ihejirika, "The Canadian Oilsands and Strategic Approaches to Profitability," The Oxford Institute for Energy Studies, Oxford, 2019.

[16] G. Morgan, "Financial Post," 6 August 2019. [Online]. Available: https://financialpost.com/commodities/energy/unloved-despite-oilsands-relentless-cost-cutting-investors-still-wary-of-jumping-back-in#:~:text=Canadian%20Natural's%20oilsands%20mining%20and,effort%20to%20rein%20in%20expenses.. [Accessed 20 February 2020].

[17] GLJ, "Price Charts," GLJ, 2020.

[18] CNNMoney, "HBJ Hartfort Business," 24 November 2015. [Online]. Available: https://www.hartfordbusiness.com/article/what-it-costs-to-produce-a-barrel-of-oil. [Accessed 21 February 2021].

[19] J. Hiller, "Reuters," 10 January 2021. [Online]. Available: https://www.reuters.com/article/us-global-oil-shale-idUSKBN29F06N. [Accessed 24 February 2021].

[20] U. E. I. Administration, "EIA," 14th January 2021. [Online]. Available: https://www.eia.gov/international/analysis/special-topics/OPEC_Revenues_Fact_Sheet. [Accessed 24 February 2021].

[21] H. Foy, "Why Russian oil groups are well positioned for a price crash," 29 03 2020. [Online]. Available: https://www.ft.com/content/87196fa8-6289-4f9c-9353-cdf18d5fabc8. [Accessed 01 04 2021].

[22] C. A. o. P. Producers, "CAPP," CAPP, 2021. [Online]. Available: https://www.capp.ca/oil/extraction/. [Accessed 24 February 2021].

[23] B. Israel, "Pembina Institute," 4 October 2017. [Online]. Available: https://www.pembina.org/blog/real-ghg-trend-oilsands. [Accessed 15 February 2021].

[24] "Oil Climate Index," Carnegie Endowment for International Peace, 2015. [Online]. Available: http://oci.carnegieendowment.org/#total-emissions. [Accessed 15 February 2021].

[25] "Global EV Outlook 2020," 2021. [Online]. Available: https://www.iea.org/reports/global-ev-outlook-2020.

[26] "electric-vehicles-global-sales-jump-39-percent-in-2020-3-million-units-sold," [Online]. Available: [https://www.businesstoday.in/sectors/auto/electric-vehicles-global-sales-jump-39-percent-in-2020-3-million-units-sold/story/430707.html.

[27] "how-global-electric-car-sales-defied-covid-19-in-2020," [Online]. Available: https://www.iea.org/commentaries/how-global-electric-car-sales-defied-covid-19-in-2020.

[28] "New registrations of electric vehicles in Europe," EEA Web Team, [Online]. Available: https://www.eea.europa.eu/data-and-maps/indicators/proportion-of-vehicle-fleet-meeting-5/assessment. [Accessed 27 02 2020].

[29] E. W. Team, "Newly registered electric cars by country," EEA Web Team, 18 08 2020. [Online]. Available: https://www.eea.europa.eu/data-and-maps/daviz/new-electric-vehicles-by-country-3#tab-dashboard-01. [Accessed 27 02 2021].

[30] "McKinsey Electric Vehicle Index: Europe cushions a global plunge in EV sales," 17 07 2020. [Online]. Available: https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/mckinsey-electric-vehicle-index-europe-cushions-a-global-plunge-in-ev-sales#.

[31] Z.-e. vehicles, "Zero-emission vehicles," 31 1 2020. [Online]. Available: https://tc.canada.ca/en/road-transportation/innovative-technologies/zero-emission-vehicles.

[32] "Global News," 07 11 2020. [Online]. Available: https://globalnews.ca/news/7448683/canada-electric-car-target/#:~:text=The%20group%20said%20there%20are,and%202.7%20million%20in%202030.

[33] "Market Snapshot: EVs in Canada – The hidden potential of the electric truck market," 02 01 2019. [Online]. Available: https://www.cer-rec.gc.ca/en/data-analysis/energy-markets/market-snapshots/2019/market-snapshot-evs-in-canada-hidden-potential-electric-truck-market.html.

[34] "New motor vehicle registrations, 2011 to 2018," 18 11 2019. [Online]. Available: https://www150.statcan.gc.ca/n1/daily-quotidien/191118/dq191118c-eng.htm.

[35] 27 02 2021. [Online]. Available: https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=2010002101.

[36] "New Motor Vehicle Registrations Data Visualization Tool," 18 11 2019. [Online]. Available: https://www150.statcan.gc.ca/n1/pub/71-607-x/71-607-x2019028-eng.htm.

[37] "The road ahead is electric: New zero-emission vehicle registrations in Canada," 27 02 2021. [Online]. Available: https://www150.statcan.gc.ca/n1/en/catalogue/11-627-M2019081.

[38] "ontario-paves-the-way-for-electric-vehicles," [Online]. Available: https://news.ontario.ca/en/release/12732/ontario-paves-the-way-for-electric-vehicles.

[39] "/green-ontario-fund-ottawa," [Online]. Available: https://www.cbc.ca/news/canada/ottawa/green-ontario-fund-ottawa-1.4713637.

[40] "Archived - Climate Change Action Plan," 27 03 2019. [Online]. Available: https://www.ontario.ca/page/climate-change-action-plan.

[41] "EV Charging Station info in Ontario, Toronto," [Online]. Available: https://chargehub.com/en/countries/canada/ontario/toronto.html#:~:text=In%202016%2C%20the%20province%20of,from%20Toronto%20to%20North%20Bay.

[42] "chargehub.com/en/countries/canada/ontario/ottawa," [Online]. Available: https://chargehub.com/en/countries/canada/ontario/ottawa.html.

[43] "chargehub.com/en/countries/canada/ontario/toronto," [Online]. Available: https://chargehub.com/en/countries/canada/ontario/toronto.html.

[44] "Electric Charging and Alternative Fuelling Stations Locator," 04 09 2018. [Online]. Available: https://www.nrcan.gc.ca/energy-efficiency/energy-efficiency-transportation-and-alternative-fuels/electric-charging-alternative-fuelling-stationslocator-map/20487.

[45] "renewable-power-the-worlds-largest-battery," [Online]. Available: https://www.bbc.com/future/article/20201217-renewable-power-the-worlds-largest-battery.

[46] "/strategyonline.ca," [Online]. Available: https://strategyonline.ca/2021/02/25/seven-in-10-canadians-plan-to-buy-an-ev-within-the-decade/#:~:text=The%20global%20research%20firm's%20survey,in%20the%20next%20five%20years.

[47] T. Randall*, "Here's How Electric Cars Will Cause the Next Oil Crisis," [Online]. Available: https://www.iene.eu/heres-how-electric-cars-will-cause-the-next-oil-crisis-p3240.html.

[48] "electric-vehicle-outlook-table-of-contents," [Online]. Available: https://about.bnef.com/electric-vehicle-outlook-table-of-contents/.

[49] "Electric vehicle projection shows changes in electricity and fuel demand," 2 01 2021. [Online]. Available: https://www.cer-rec.gc.ca/en/data-analysis/energy-markets/market-snapshots/2019/market-snapshot-electric-vehicle-projection-shows-changes-in-electricity-fuel-demand.html?=undefined&wbdisable=true.

[50] "Are Electric Vehicles Really About To Plateau Oil Demand?," 25 11 2019. [Online]. Available: https://www.forbes.com/sites/gauravsharma/2019/11/25/are-electric-vehicles-really-about-to-plateau-oil-demand/?sh=3efd007c3b13.

[51] "fueleconomy.gov," [Online]. Available: https://www.fueleconomy.gov/feg/evtech.shtml.

[52] G. Stringham, "Chapter 2 - Energy Developments in Canada's Oil Sands," *Environmental Science,* vol. 11, pp. 19-34, 2012.

[53] Q. L. D. I. T. E. M. Geramian, "Influence of Oil Sands Composition on Bitumen Quality During Non-Aqueous Bitumen Extraction from the Athabasca Deposit," *The Canadian Journal of Chemical Engineering*, vol. 97, no. 1, pp. 268-280, 2018.

[54] M. Gray, Upgrading Oilsands Bitumen and Heavy Oil, Pica Pica Press, 2015.

[55] T. G. P. Rahimi, The Chemistry of Bitumen and Heavy Oil Processing, Calgary: CDX Canada, 2007.

[56] Alberta Innovates, "Looking beyond current bitumen uses," 12 December 2017. [Online]. Available: https://albertainnovates.ca/impact/newsroom/looking-beyond-current-bitumen-uses/. [Accessed 4 April 2021].

[57] "Market Snapshot: Petrochemical products in everyday life," Canada Energy Regulator, 29 Janurary 2021. [Online]. Available: https://www.cer-rec.gc.ca/en/data-analysis/energy-markets/market-snapshots/2018/market-snapshot-petrochemical-products-in-everyday-life.html. [Accessed 13 February 2021].

[58] K. Rogers, "Styrene," Encyclopedia Britannica, [Online]. Available: https://www.britannica.com/science/styrene. [Accessed 13 Februrary 2021].

[59] R. M. G. H. J. W. O. M. G. Crandall, "Phase II - Refined Products and Petrochemicals from Bitumen," Government of Alberta, Calgary, 2005.

[60] Stantec Ltd., "Bitumen Beyond Combustion - Phase 2 Report," Alberta Innovates, 2018.

[61] B. Afework, J. Hanania, J. Jenden, S. K. and J. Donev, "Bitumen," 25 June 2018. [Online]. Available: https://energyeducation.ca/encyclopedia/Bitumen. [Accessed 27 February 2021].

[62] University of Alaska Fairbanks, "Fractional Distillation," [Online]. Available: http://ffden-2.phys.uaf.edu/212_spring2011.web.dir/kristine_odom/temp/10956/ftddrops/Downstream.html. [Accessed 27 Februrary 2021].

[63] International Energy Agency, "Canada Data Browser," [Online]. Available: https://www.iea.org/countries/canada. [Accessed 20 February 2021].

[64] National Resources Canada, "Electricity Facts," Government of Canada, 6 October 2020. [Online]. Available: https://www.nrcan.gc.ca/science-data/data-analysis/energy-data-analysis/energy-facts/electricity-facts/20068. [Accessed 20 February 2021].

[65] Canada Energy Regulator, "Canada's Renewable Power Landscape 2017," Government of Canada, 29 September 2020. [Online]. Available: https://www.cer-rec.gc.ca/en/data-analysis/energy-commodities/electricity/report/2017-canadian-renewable-power/canadas-renewable-power-landscape-2017-energy-market-analysis-ghg-emission.html. [Accessed 20 February 2021].

[66] Legislative Assembly & Standing Committee on Resource Stewardship, Review of the potential for expanded hydroelectric energy production in Northern Alberta: Twenty-Eight Legislature, First Session, Calgary: Alberta Legslative Assembly, 2013.

[67] M. Elsholkami, A. Elkamel and F. Vargas, "Optimized integration of renewable energy technologies into Alberta's oil sands industry," *Computers and Chemical Engineering,* vol. 90, no. 12, pp. 1-22, 2016.

[68] B. Livingston, "The Alberta Electrical Grid: What to Expect in the Next Few Years in Alberta," *The School of Public Policy Publications,* vol. 11, no. 1, 2018.

[69] Center for Sustainable Systems, "Wind Energy Fact Sheet," University of Michigan, 2020. [Online]. Available: http://css.umich.edu/factsheets/wind-energy-factsheet#:~:text=The%20capacity%20factor%20of%20a,by%20its%20maximum%20power%20capability.&text=On%20land%2C%20capacity%20factors%20range%20from%200.26%20to%200.52.&text=The%20average%202018%20capacity%20factor. [Accessed 20 February 2021].

[70] J. Duan, A. McKenna, G. Van Kooten and S. Liu, "Renewable Electricity Grids, Battery Storage and MIssing Money: An Alberta Case Study," in *Agricultural Economists*, Vancouver, 2018.

[71] M. Elsholkami, A. Elkamel and F. Vargas, "Optimized integration of renewable energy technologies into Alberta's oil sands industry," *Computers & Chemical Engineering,* vol. 90, no. 12, pp. 1-22, 2016.

[72] J. V. Krivitsky, Solar rights and renewable energy in Alberta, Canadian Institute of Resources Law, 2010.

[73] Lithium Mining Group, "Alberta's mineral wealth: Potential and passion," *Engineering and Mining Journal,* vol. 213, no. 4, pp. 65-67, 2012.

[74] S. Mohr, G. Mudd and D. Giurco, "Lithium Resources and Production: Critical Assessment and," *Minerals,* vol. 2, no. 1, pp. 65-84, 2012.

[75] Hatch Ltd., "Raglan Mine Integrated Wind-Storage-Diesel Energy," [Online]. Available: https://www.hatch.com/en/Projects/Energy/Raglan-Mine-Integrated-Wind-Storage-Diesel-Energy-Project. [Accessed 21 Februrary 2021].

[76] R. Galvez and M. MacDonald, Decarbonizing Heavy Industry: The Low-Carbon Transition of Canada's Emission-Intensive and Trade-Exposed Industries, Ottawa: Senate Canada, 2018.

[77] A. Cutean and R. McLaughlin, "A Digital Future for Alberta," The Information and Communications Technology Council, Ottawa, 2019.

[78] W. E. Forum, "Fostering Effective Energy Transition," World Economic Forum, Cologny/Geneva, 2019.

[79] C. o. t. E. Union, "Climate change: what the EU is doing," 22 March 2021. [Online]. Available: https://www.consilium.europa.eu/en/policies/climate-change/. [Accessed April 2021].

[80] H. H. P. H. O. H. B. L. C. S. Pao-Yu Oei, "Coal phase-out in Germany – Implications and policies for affected regions," *Energy,* vol. 196, no. 117004, pp. 360-5442, 2020.

[81] S. M. o. Environment, "Sweden's long-term strategy for reducing greenhouse gas emissions," Government Offices of Sweden, 2020.

[82] IEA, "Sweden is a leader in the energy transition, according to latest IEA country review," IEA, 2019.

[83] C. Council, "11 COUNTRIES LEADING THE CHARGE ON RENEWABLE ENERGY," 13 01 2019. [Online]. Available: https://www.climatecouncil.org.au/11-countries-leading-the-charge-on-renewable-energy/. [Accessed April 2021].

[84] H. R. a. M. Roser, "Sweden: Energy Country Profile," 2020. [Online]. Available: https://ourworldindata.org/energy/country/sweden. [Accessed April 2021].

[85] S. Sverige, "Energy Use In Sweden," [Online]. Available: https://sweden.se/nature/energy-use-in-sweden/#:~:text=Sweden%20has%20a%20rich%20supply,production%20and%20bioenergy%20for%20heating.. [Accessed April 2021].

[86] IEA, " The United Kingdom has made major progress in reducing emissions, according to the IEA’s latest country review," IEA, 2019.

[87] I. Energy, "ENERGY WHITE PAPER: WHAT’S IN IT FOR YOU?," 15 December 2020. [Online]. Available: https://inspiredenergy.co.uk/energy-white-paper/. [Accessed April 2021].

[88] E. a. I. S. Secretary of State for Business, "Powering our Net Zero Future," HM Government, 2020.

[89] M. Hafner, The Geopolitics of the Global Energy Transition, Milan: Springer Nature Switzerland AG, 2020.

[90] G. o. Canada, "Coal phase-out: the Powering Past Coal Alliance," 18 09 2020. [Online]. Available: https://www.canada.ca/en/services/environment/weather/climatechange/canada-international-action/coal-phase-out.html. [Accessed April 2021].

[91] G. o. Canada, "Canada Gazette, Part I, Volume 152, Number 7: Regulations Amending the Reduction of Carbon Dioxide Emissions from Coal-fired Generation of Electricity Regulations," 17 February 2018. [Online]. Available: https://canadagazette.gc.ca/rp-pr/p1/2018/2018-02-17/html/reg3-eng.html. [Accessed April 2021].

[92] H. Mertins-Kirkwood and I. Hussey, "A top-down transition: A critical account of Canada’s governmentled phase-out of the coal sector," in *Just Transitions: Social Justice in the Shift Towards a Low-Carbon World*, London, Pluto Press, 2020, pp. 172-197.

[93] G. o. Alberta, *Alberta's Climate Leadership Plan: Progressive climate policy,* Government of Alberta, 2018.

[94] G. o. Alberta, "Coal Community Transition Fund," [Online]. Available: https://www.alberta.ca/coal-community-transition-fund.aspx. [Accessed April 2021].

[95] G. o. Canada, "CANADA'S 2017 NATIONALLY DETERMINED CONTRIBUTION SUBMISSION TO THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE," UNFCCC, 2017.

[96] G. o. Canada, "Complete text for Pan-Canadian Framework on Clean Growth and Climate Change second annual report," [Online]. Available: https://www.canada.ca/en/environment-climate-change/services/climate-change/pan-canadian-framework-reports/complete-text-for-second-annual-report.html#toc0. [Accessed April 2021].

[97] P. Becklumb, " Federal and Provincial Jurisdiction to Regulate Environmental Issues," 24 09 2013. [Online]. Available: https://lop.parl.ca/sites/PublicWebsite/default/en_CA/ResearchPublications/201386E. [Accessed April 2021].

[98] C. E. Regulator, "Canada's Energy Future: Chapter 2. Key Assumptions," [Online]. Available: https://www.cer-rec.gc.ca/en/data-analysis/canada-energy-future/2017/chapter-2-key-assumptions.html#:~:text=Pricing%20carbon%20raises%20the%20price,the%20use%20of%20those%20fuels.&text=Creating%20an%20economic%20incentive%20for,that%20help%20reduce%20GHG%. [Accessed April 2021].

[99] CCPA, "CANADA'S ENERGY OUTLOOK Current realities and implications for a carbon-constrained future," 2017. [Online]. Available: https://energyoutlook.ca/conclusions/. [Accessed April 2021].

[100] D. Marshall, Making Kyoto work: a transition strategy for Canadian energy workers, Canadian Centre for Policy Alternatives, 2002.

[101] J. Strapp, "Electrification of transportation will change the utility business," [Online]. Available: https://www.pwc.com/ca/en/industries/power-utilities/publications/electrification-of-transportation.html. [Accessed April 2021].

[102] G. o. Canada, "Smart Grid Program," 09 11 2020. [Online]. Available: https://www.nrcan.gc.ca/climate-change/green-infrastructure-programs/smart-grids/19793. [Accessed April 2021].

[103] N. Moussu, Just Transitions: Social Justice in The Shift Towards a Low-Carbon World, London: JSTOR, 2020.

[104] The B Team, "Just Transition: A Business Guide," Just Transiton Centre, 2018.

[105] The Church of England, "Investor Mining and Tailings Safety Initiative," 31 March 2020. [Online]. Available: https://www.churchofengland.org/about/leadership-and-governance/church-england-pensions-board/old-pensions-board-investments-0. [Accessed 10 March 2021].

[106] H. Mertins-Kirkwood, "Making Decarbonization Work for Workers," Canadian Centre for Policy Alternatives, Ottawa, 2018.

[107] H. Mertins-Kirkwood, Interviewee, *CCPA Interview*. [Interview]. 12 February 2021.

[108] E. Louie and J. Pearce, "Retraining investment for U.S. transition from coal to solar photovoltaic employment," *Energy Economics,* vol. 57, pp. 295-302, 2016.

[109] T. Laan and V. Corkal, "Best Practices: Estimating tax subsidies for fossil fuels in Canada," International Institute for Sustainable Development, Winnipeg, 2020.

[110] "gain-public-support," [Online]. Available: https://ctb.ku.edu/en/table-of-contents/assessment/getting-issues-on-the-public-agenda/gain-public-support/main.

[111] "/albertanarrativesproject," [Online]. Available: http://albertanarrativesproject.ca/wp-content/uploads/2019/02/ANP-Report-II-final-online.pdf.

[112] "/indigenous-led-clean-energy-projects-could-power-reconciliation," [Online]. Available: https://www.queensu.ca/gazette/stories/indigenous-led-clean-energy-projects-could-power-reconciliation.

[113] "energy/CoucilReport," [Online]. Available: https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/energy/CoucilReport_june27_English_Web.pdf.

[114] "BuildingCanadas_EnergyFutureTogether," [Online]. Available: https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/emmc/pdf/2018/en/BuildingCanadas_EnergyFutureTogether_en.pdf.

[115] M. Lukacs, "The Guardian," 26 October 2017. [Online]. Available: https://www.theguardian.com/environment/true-north/2017/oct/26/revealed-oil-giants-pay-billions-less-tax-in-canada-than-abroad. [Accessed 17 February 2021].

[116] R. R. M. o. Alberta, "RMA: Rural Municipalities of Alberta," 20 January 2020. [Online]. Available: https://rmalberta.com/news/unpaid-taxes-owed-from-oil-and-gas-companies-to-rural-municipalities-continue-to-increase/. [Accessed 17 February 2021].

[117] "IEA, Global electric car sales by key markets," 2010-2020. [Online]. Available: https://www.iea.org/data-and-statistics/charts/global-electric-car-sales-by-key-markets-2015-2020.

[118] G. o. Canada, "Government of Canada," 19 01 2020. [Online]. Available: https://www.canada.ca/en/environment-climate-change/services/environmental-

indicators/progress-towards-canada-greenhouse-gas-emissions-reduction-target.html. [Accessed 20 February 2021].

[119] "Electric vehicles setting a course for 2030," 28 07 2020. [Online]. Available: https://www2.deloitte.com/us/en/insights/focus/future-of-mobility/electric-vehicle-trends-2030.html.

[120] "Zero Emission Vehichle in Canada 2020 first 2 quarters infographics," [Online]. Available: https://www150.statcan.gc.ca/n1/en/pub/11-627-m/11-627-m2020077-eng.pdf?st=yT9PKS_E.

[121] "Automotive statistics," 12 02 2021. [Online]. Available: https://www.statcan.gc.ca/eng/topics-start/automotive.

[122] "Ontario Paves The Way For Electric Vehicles," 18 06 2010. [Online]. Available: https://news.ontario.ca/en/release/12732/ontario-paves-the-way-for-electric-vehicles.

[123] "Electric Vehicle and Alternative Fuel Infrastructure Deployment Initiative - News and FAQs," 24 02 2021. [Online]. Available: https://www.nrcan.gc.ca/energy-efficiency/energy-efficiency-transportation-alternative-fuels/electric-and-alternative-fuel-infrastructure/electric-vehicle-alternative-fuels-infrastructure-deployment-initiative/news-faqs.

[124] "/market-snapshot-evs-in-canada-hidden-potential-electric-truck-market," [Online]. Available: https://www.cer-rec.gc.ca/en/data-analysis/energy-markets/market-snapshots/2019/market-snapshot-evs-in-canada-hidden-potential-electric-truck-market.html.

[125] "2016-ev-oil-crisis," [Online]. Available: https://www.bloomberg.com/features/2016-ev-oil-crisis/.

[126] "-what-albertans-really-think-about-the-energy-transition-interview-with-prof," [Online]. Available: https://energi.media/news/you-may-be-surprised-what-albertans-really-think-about-the-energy-transition-interview-with-prof-melanee-thomas/.

[127] "/www.un.org/development/desa/indigenouspeoples/climate-change," [Online]. Available: https://www.un.org/development/desa/indigenouspeoples/climate-change.html.