Flipping the Switch: Policy that Supports Alternative Electricity Production in Alberta

by

Stephan Aucoin

B.A., University of British Columbia, 2013

Project Submitted in Partial Fulfillment of the
Requirements for the Degree of
Master of Public Policy

In the
School of Public Policy
Faculty of Arts and Social Sciences

SIMON FRASER UNIVERSITY

Spring 2015

Approval

Name:	**Stephan Aucoin**
Degree:	**Master of Public Policy**
Title:	***Flipping the Switch: Policy that Supports Alternative Electricity Production in Alberta***
Examining Committee:	**Chair:** Doug McArthur Director, School of Public Policy

Jonathan Rhys Kesselman
Senior Supervisor
Professor

Dominique Gross
Supervisor
Professor

John Richards
Internal Examiner
Professor

Date Defended/Approved: March 11th, 2015

Partial Copyright Licence

Ethics Statement

The author, whose name appears on the title page of this work, has obtained, for the research described in this work, either:

a. human research ethics approval from the Simon Fraser University Office of Research Ethics,

or

b. advance approval of the animal care protocol from the University Animal Care Committee of Simon Fraser University;

or has conducted the research

c. as a co-investigator, collaborator or research assistant in a research project approved in advance,

or

d. as a member of a course approved in advance for minimal risk human research, by the Office of Research Ethics.

A copy of the approval letter has been filed at the Theses Office of the University Library at the time of submission of this thesis or project.

The original application for approval and letter of approval are filed with the relevant offices. Inquiries may be directed to those authorities.

Simon Fraser University Library
Burnaby, British Columbia, Canada

update Spring 2010

Abstract

Alberta's electricity sector has traditionally relied on coal and natural gas thermal plants to produce electricity. Alberta's dependence on fossil fuel technology has meant that its electricity sector generates more greenhouse gas emissions than all other provinces in Canada combined. A shift toward clean electricity substitutes is limited by the competitive market structure of electricity in Alberta, which favours low-cost fossil fuels rather than alternatives. Government policy intervention is required if Alberta wishes to increase its clean electricity uptake in the next 10 years. Three case studies from Ontario, California, and British Columbia are undertaken to evaluate their polices to enhance clean energy investment. Expert interviews are conducted to assess the potential applicability of similar policies in the context of Alberta's electricity sector. A Clean Electricity Standard that mandates a minimum proportion of clean electricity production is found to be the best of three policy options.

Keywords: Alberta Electricity Sector; Clean Electricity; Climate Change; Case Study

Dedication

To my parents for a lifetime of love and support

Acknowledgements

There are countless people I would like to thank for providing me the guidance to achieve my academic goals. First, I would like to thank my fiancé, Niki for always being willing to talk about electricity, a rather mundane subject even at the best of times. Your love and encouragement is one thing I can always count on. Second, I would like to thank my parents for always believing in me even when I made seemingly ridiculous decisions. You always provided a loving environment that allowed me to become the best possible version of myself. Third, I would like to thank my supervisor Rhys Kesselman. Your wisdom and insight was greatly appreciated and I apologize for the bad grammar.

Finally, I would like to acknowledge the School of Public Policy. This program was the perfect place for me to develop my critical thinking and analytical capacity. I have learned a great deal about our world in terms of its social, political, and economic systems and hope to apply this knowledge throughout my life. By acknowledging the MPP program I would also like to recognize the faculty, staff, and students who made the experience even more memorable. I have very fond memories of everyone and will not forget this journey any time soon.

Table of Contents

Approval ii
Partial Copyright Licence iii
Ethics Statement iv
Abstract v
Dedication vi
Acknowledgements vii
Table of Contents viii
List of Tables x
List of Figures xi
List of Acronyms xii
Executive Summary xiii

Chapter 1. Introduction 1

Chapter 2. Background 3
2.1. Electricity Generation 3
2.1.1. Physical Properties 3
2.1.2. Coal and Natural Gas Electricity Generation 3
2.1.3. Nuclear Power Generation 4
2.1.4. Renewable Electricity Generation 4
2.1.5. Negative Externalities 5
2.1.6. "Clean" Electricity Generation 6
2.2. Alberta Electricity Market 7
2.2.1. Historical Context 7
2.2.2. Existing Production Capabilities 9
2.2.3. Future Electricity Supply and Demand 12
2.2.4. Interprovincial Electricity Trade 13

Chapter 3. Clean Energy Prospects in Alberta 15
3.1. Literature Review 15
3.2. Policy Mechanisms 18
3.2.1. *Feed-in Tariff* 19
3.2.2. Renewable Portfolio Standard 19
3.2.3. Taxation and Regulation 20

Chapter 4. Methodology 22
4.1. Cross-jurisdictional Review and Expert Analysis 24
Case Studies 24
4.1.1. Ontario 24
4.1.2. California 27
4.1.3. British Columbia 29
4.2. Expert Interviews 31
4.2.1. Government of Alberta Analysts 31

4.2.2. Electricity Production Firms 33

Chapter 5. Policy Objectives, Criteria, and Measures **35**
5.1. Policy Objectives 35
5.2. Criteria and Measures 36

Chapter 6. Policy Options **42**
6.1. Policy Option One: Clean Electricity Feed-in Tariff 42
6.2. Policy Option Two: Clean Electricity Standard 43
6.3. Policy Option Three: Electricity Emissions Tax 44

Chapter 7. Policy Analysis **45**
7.1. Policy Option One: Feed-in Tariff 45
7.2. Policy Option Two: Clean Electricity Standard 47
7.3. Policy Option Three: Emissions Tax 49
7.4. Policy Recommendation 52

Chapter 8. Conclusion **55**

References **56**
Appendix A. Interview Questions 59
Appendix B. Policy Cost Calculations 61

List of Tables

Table 1: Criteria and Measures 37
Table 2: Index of Political Will 39
Table 3: Index for Measuring Administrative Feasibility 40
Table 4: Index for Measuring Public Perception 41
Table 5: Policy Analysis Results Matrix 52

List of Figures

Figure 1. World Carbon Dioxide Emissions and Temperature Trends 1882 - 2010 6
Figure 2: Alberta's Electricity Generation 2013 (Gigawatt Hour) 10
Figure 3: GHG Emissions from Electricity Generation by Province in 2012 11
Figure 4: Expected Generation Capacity Requirements 13
Figure 5: Average Levelized Cost of Electricity Generation Technologies in North America 17

List of Acronyms

CES	Clean Electricity Standard
FiT	Feed-In Tariff
GHG	Greenhouse Gas
RPS	Renewable Portfolio Standard

Executive Summary

Alberta's electricity sector is heavily reliant on fossil fuel resources to generate energy. Ninety percent of all the electricity produced within the province uses coal or natural gas fired thermal plants. Such a reliance of fossil fuels, coupled with energy intensive industries such as the oil sands, makes Alberta the largest producer of greenhouse gas emissions compared to all other provinces in Canada. The Alberta electricity sector produces 44Mt of GHG emissions annually, which is more than all other provinces combined. Scientific consensus has determined that GHG emissions created by human activity are the leading cause of global climate change. In order to avoid catastrophic climate events a global push to reduce GHG emissions is necessary and it should begin in jurisdictions such as Alberta.

This study identified various government policies that can be implemented to enhance clean energy development in Alberta, thus reducing the province's production of GHG emissions. The largest barrier to achieving this result is the existing competitive electricity market system. In the mid-1990's, the Alberta electricity market underwent extensive changes by shifting from publicly owned electricity production services to one supplied by private independent producers. This market structure incentivizes electricity producers to apply technologies that have the lowest production costs, which tend to use fossil fuels. Without public policies to incorporate the external cost of GHG emissions or account for the price difference between clean energy resources and fossil fuel technologies, Alberta's GHG emissions in the electricity sector are unlikely to diminish.

This paper applies two methodologies to identify policy solutions that could help Alberta reduce its emissions in the electricity sector. First, a set of case studies including Ontario, California, and British Columbia are evaluated based on their policies to tackle the same problem as that facing Alberta. Second, interviews were conducted with both the Alberta Ministry of Energy and a major Albertan electricity generating firm, TransAlta, in order to further understand the problem. Both of these methodologies helped to identify available polices and how they could be modified to fit within the existing electricity market in Alberta.

Three policy options—a feed-in tariff, a clean electricity standard, and an emissions tax—were considered as viable alternatives and were assessed based on a host of criteria. The most important factors in weighting of the options were the effectiveness in terms of clean energy uptake and the cost to consumers based on increased electricity prices. After a rigorous assessment, the Alberta Clean Electricity Standard, which sets minimum clean source energy requirements on all electricity firms, was determined to be the most appropriate policy. With the implementation of this policy Alberta could potentially produce 20% of its electricity from clean sources by 2025.

Chapter 1. Introduction

In a modern economy, electricity is one of the most important commodities. Electricity provides energy for light, heating, household operation, communications and industrial processes. Therefore, the efficiency and effectiveness of an electricity market in any jurisdiction is crucial to ensuring that people can receive the services they want when they need it. However, this process is complicated by numerous factors that influence the availability of useful energy. Even more challenging is producing electricity in an environmentally safe and sustainable manner..

In Alberta, electricity has traditionally been produced using coal and natural gas fired thermal plants. This process involves the burning of fossil fuel resources to convert energy into steam, which in turn helps drive turbines and thence generators, thereby producing electricity. Although this industry has been relatively efficient over time, numerous issues are beginning to mount for electricity production services, the most notable of which is increasing greenhouse gas (GHG) emissions. GHG emissions are one of the leading causes of climate change and present an enormous obstacle in maintaining the health of global ecosystems (IPCC, 2014). Evidence dictates that reductions in GHG emissions are crucial to reduce planetary warming and avoid potentially cataclysmic weather events in the future. Unfortunately, burning coal and natural gas to generate electricity is an extremely emissions-intensive process. In order to participate in the global push to reduce emissions, the Alberta electricity sector will have to shift its traditional generation methods toward a more sustainable path.

Currently, reducing Alberta's electricity emissions faces a number of challenges. First, electricity firms are not incentivized to reduce their greenhouse gas emissions because reductions entail higher costs of production and it is unlikely that firms will willingly assume them. Second, renewable forms of electricity generation can be intermittent, non-dispatchable, and face high capital costs, making them expensive relative to fossil-fuel-using technologies. Finally, technological advancements that reduce emissions intensity such as carbon capture and storage also face barriers such as high capital costs. These challenges amount to a need for clear policy that supports alternative ways of generating electricity in Alberta without compromising economic efficiency. To do so, policy must incorporate a multitude of competing demands from government, industry, the general public, and the environment. If properly developed and implemented, policy mechanisms could ensure that Alberta maintains an efficient, reliable, and sustainable electricity system for multiple generations.

This paper assesses the potential of various policy mechanisms to support alternative electricity production technologies in Alberta. I use a variety of methodologies to establish context, develop policy options, and evaluate possible actions. Chapter 2 establishes the background, incorporating information about electricity production; negative externalities; the Alberta electricity market and production capabilities; and future trends. Chapter 3 surveys the literature with regard to clean forms of electricity generation in Alberta and explains potential policy mechanisms that support alternative technologies. Chapter 4 explains the methodology and how the research can impact energy policy in Alberta. Chapter 5 consists of case studies of British Columbia, Ontario, and California that have all adopted policy mechanisms to support alternative electricity generation. This chapter also includes expert interviews with utility analysts who offer their own evaluation of policy mechanisms within the context of the Alberta electricity system. Chapter 6 establishes a set of criteria and measures that are relevant to the electricity generation sector and help evaluate competing policy options. Chapter 7 summarizes four separate policy options. Chapter 8 provides an analysis of the policy options based on the criteria and measures. Chapter 9 concludes with recommendations and suggested implementation strategy.

Chapter 2. Background

2.1. Electricity Generation

2.1.1. Physical Properties

Electricity is a physical charge that exerts force on other objects. This force can be harnessed in such a way to perform work for a variety of functions. What differentiates one electricity producer from another is the process by which they create the mechanical energy to transmit to the generator. Natural mechanical forces that have been used to create electricity include wind energy, gravitational forces from river systems, and tidal fluctuations. Heat is a common form of energy that can be converted to mechanical energy by burning fossil fuels or using geothermal sources deep in the Earth's crust. Solar radiation can produce an electric charge without mechanical energy as it passes through a photovoltaic cell. Given this wide range of electricity generating technologies, firms need to make choices based on competing factors such as costs, technical feasibility, and regulatory constraints.

2.1.2. Coal and Natural Gas Electricity Generation

The burning of coal and natural gas to generate heat for electricity production has traditionally been one of the least costly and most powerful techniques for creating electricity. Coal and natural gas facilities are the primary source of electricity in many countries, particularly in the developing world. Coal and natural gas-fired electricity plants begin by burning a fuel source to generate heat. Heat is transferred into water creating steam, which flows through a turbine to create mechanical energy, which in turn produces electrical energy via a generator. The efficiency of coal and natural gas-fired plants has increased dramatically over time making it an attractive electrical generation type. The dispatchability of fossil fuel resource generation, which is the ability to provide electricity instantly, adds to its value as it allows for people to acquire electricity when and where they want.

The downfall of coal and natural gas electricity generation is its heavy emissions. The amount of carbon dioxide and other greenhouse gas emissions created by burning these resources are substantial and contribute to global climate change and local air quality. The emissions intensities of these technologies have been reduced substantially over time, but they still pollute a tremendous amount. This issue is the focal point of this paper's analysis of alternative electricity production services.

2.1.3. Nuclear Power Generation

Nuclear power is a process of generating electricity by creating a nuclear fission reaction in a confined space. Power is generated through steam turbines which are heated by the fission reaction occurring in the nuclear reactor of the facility. Uranium is the primary fuel source for nuclear fission reactions and can be mined in a number of locations around the world. Nuclear power generation is considered to be a clean form of electricity generation because it does not produce any GHG emissions in order to create energy. Nuclear power is a popular form of power generation in jurisdiction such as France and Japan, but has received worldwide controversy over fears of nuclear proliferation and the damage caused by core meltdowns. A few highly publicized events such as Chernobyl and Three Mile Island have been cited for opposition groups as the potential consequences of increased nuclear use and have been a large reason for a lack of nuclear power generation use in particular regions world.

2.1.4. Renewable Electricity Generation

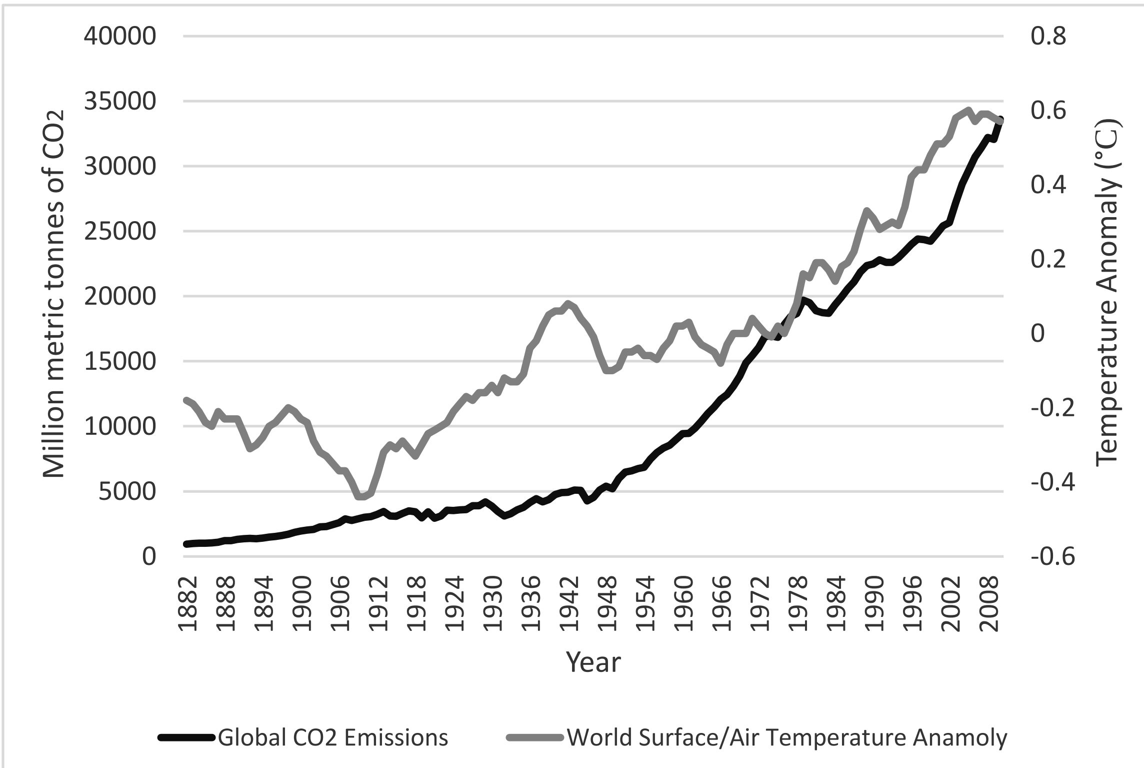
Renewable electricity is created by harnessing the natural energy of Earth systems and producing a usable product for consumers to purchase. The most common forms of renewable electricity generation are wind, solar, and hydro. These technologies transfer kinetic and solar energy into an electrical charge by modifying the Earth's landscape to conform to the technology's requirements. This means covering large areas of land with solar panels, erecting wind towers across prairies or flooding valleys. Although these local impacts are potentially harmful to the environment, renewable energy is considered a sustainable alternative to fossil fuel use because it produces little to no GHG emissions or pollution. For this reason, renewables are a technology that, if fully implemented, could set humans on a more sustainable energy path.

2.1.5. Negative Externalities

Negative externalities are costs generated by an economic activity which are not borne by either the producer or the purchaser of the good or service generated. For example, air pollution generated by operating a motor vehicle is a cost that society bears even though they did not enjoy the benefits of operating that vehicle. If a market is incapable of pricing the full social cost of a negative externality, then that market is said to be inefficient. The agent creating the negative externality has no monetary incentive to constrain their activity to reflect that external cost. Therefore, a pricing mechanism is often developed in order to reflect the true cost of an action within production costs to reduce the action toward an efficient quantity (Tideman and Plassman, 2010). The challenge is actually identifying the social cost of a negative externality and pricing it in the market accordingly.

In the electricity sector, the most relevant and damaging negative externality is greenhouse gas emissions. GHGs are a collection of several gases in the Earth's atmosphere, the most prominent being carbon dioxide. These gases absorb and reflect solar radiation, helping to maintain a stable temperature on Earth. However, when these gases accumulate in greater quantities they affect global temperature and have been known to alter climatic conditions. Since the Industrial Revolution, the amount of carbon dioxide in the atmosphere has risen dramatically due to the burning of fossil fuels. This has contributed to a startling increase in global surface and air temperature as represented in Figure 1. General scientific consensus has determined that in order to avoid massive changes to the Earth's climatic system, we must ensure that global temperatures do not rise more than 2^{o} Celsius above current levels (CCES, 2009). Figure 1 demonstrates that GHG emissions are currently on an upward path and global temperatures are running in conjunction. This analysis indicates that policy around the world is necessary to reduce greenhouse gas emissions and prevent dangerous ecological change.

Figure 1: World Carbon Dioxide Emissions and Temperature Trends 1882 - 2010



Source: The CO_2 emissions data: CDIAC (2014). Temperature: Goddard Institute for Space Studies (2012).

2.1.6. "Clean" Electricity Generation

Electricity generation using fossil fuels or renewables are the two most common forms of production. A given technology is often considered "clean" if it incorporates renewable resources rather than fossil fuels. However, this dichotomy does not consider different technologies or resources that do not add carbon to the global cycle. For example, biomass can be used to fuel electricity generation. It does add carbon to the atmosphere, but is considered "clean" because it takes stored carbon from a plant and adds it to the carbon cycle where it can be absorbed by another plant. Carbon capture and storage, a process where carbon created from burning fossil fuels is injected deep underground, is another form of “clean” energy because it does not add carbon to the global cycle. For the purposes of this paper, nuclear power is considered to be a clean source of electricity generation because it does not produce GHG emissions. These types of technologies are often glossed over in conversations about alternative energy production but could be some of the most cost-effective for electricity generating firms.

This paper analyzes policy mechanisms that promote alternative ways of generating electricity. These alternatives will need to be “clean” in order to reduce or at least maintain the given level of greenhouse gas emissions being produced. For the purpose of this paper, “clean” electricity generation will be considered any technology that does not add greenhouse gas emissions into the atmosphere during the production process. Given this broad definition, any firm that wishes to invest in clean electricity generation will have a number of technologies and options to choose from. Greater selection will improve economic efficiency as firms can determine for themselves the best possible means of reducing their emissions.

2.2. Alberta Electricity Market

2.2.1. Historical Context

Alberta has relied heavily on coal-fired thermal plants to generate electricity for nearly a century. Due to readily available coal resources and relatively cheap cost of constructing coal-fired thermal plants, Alberta has used this technology to its advantage. More recently, thermal generating plants have used natural gas, another fuel source that is readily available in the province. Wind power became a focal point of development in Alberta when federal subsidises supported the industry. Since those federal grants ended in 2011 growth in wind generation has stagnated. Low-cost fossil fuel options have provided a relatively stable market for electricity in Alberta and continue to be the primary source of energy.

In 1996, Alberta implemented regulatory changes in an attempt to improve the efficiency of the electricity market. A key element of this reform was modifying the market from vertically-integrated suppliers to independent private power producers. Prior to deregulation, utilities operated as franchise monopolies who were regulated under a cost-of-service framework and were granted access to consumers in particular geographic regions. Each firm had to demonstrate in legal proceedings why it charged particular rates for electricity or why it required new production facilities to be built. This system was administratively complex and offered no incentives for firms to become efficient in the way they produced or delivered electricity services. With market deregulation, electricity production firms would now compete in a free market for the business of household, commercial, and industrial consumers. Prices would be competitively based on production costs, and consumers could choose the type of electricity they wish to purchase based on availability and their own preferences. All firms that wished to supply electricity to the market were now able to sell their product through the Power Pool, an open access pool of energy, where it would extract profit based on consumers who had established contracts with that company. A competitive market structure was predicted to foster innovation and assure that firms were operating at the lowest cost to benefit consumers. Transmission and distribution lines would remain publicly regulated to avoid any pitfalls of natural monopolies.

The shift to a competitive market structure was a significant change from status quo operation of electricity production services. Traditionally, public utilities have owned and operated large electricity generation sites in order to limit their exposure to risk and cover high capital costs. This would further benefit consumers as economies of scale would eventually lead to lower prices in the long run. However, Alberta is not as well endowed with large resources such as hydroelectric compared to other provinces in Canada. Therefore, a large publicly owned operator may not be as effective in Alberta as it would be in provinces with huge hydroelectric potential such as British Columbia and Quebec. The switch to a competitive market structure was further enabled by the political and economic ideology of the governing Conservative Party which has formed majority governments in Alberta since 1971. Reducing the size of government agencies and applying free market influence continues to be a major factor in Alberta’s social agenda and is unlikely to change in the near future.

The switch to a competitive electricity market structure in Alberta did not eliminate the need for effective regulation to manage the complex sale and purchase of different electricity services. The Alberta Electric System Operator oversees the design and use of the transmission system to ensure fair market rates for consumers and access for all electricity firms. The Alberta Utilities Commission approves the rates that transmission facility owners charge for the provision of distribution service. The Alberta Utilities Commission is also responsible for approving construction, connection, and operation of new transmission facilities in Alberta. No part of the electricity system is owned or operated by the provincial government. Instead the Alberta government establishes the rules and framework that encourages investment, efficiency, and competition in the market. This provision will become useful as policy is implemented to alter the existing market rules for electricity providers.

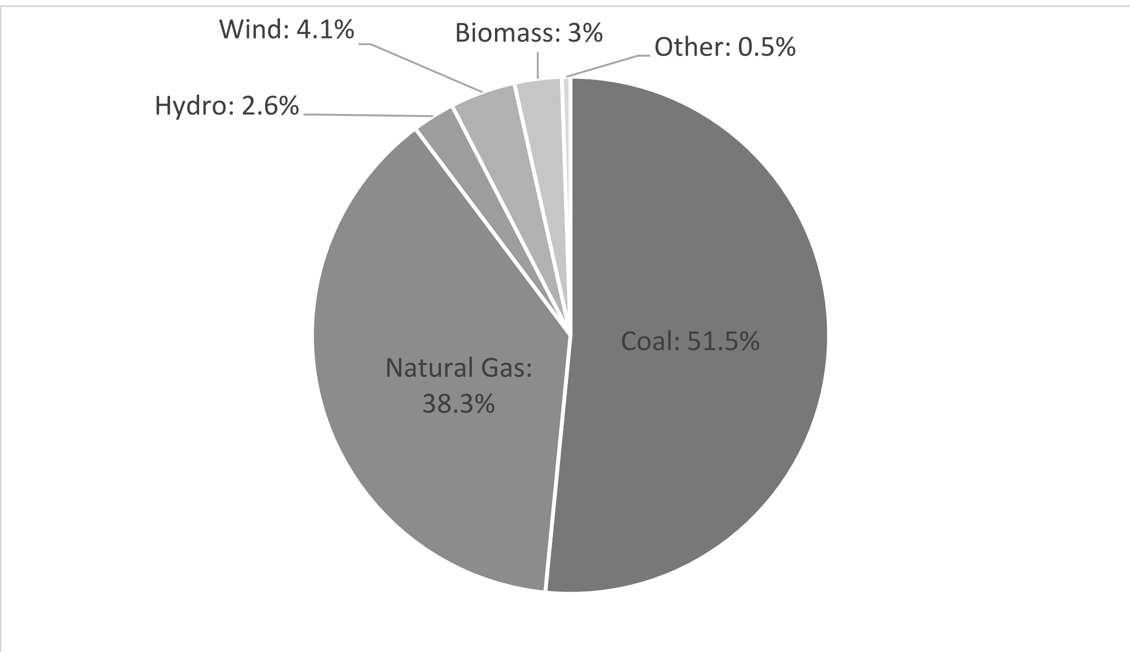
2.2.2. Existing Production Capabilities

Today Alberta's electricity market supplies a wide range of consumers. Two major metropolitan areas, Edmonton and Calgary, are serviced by coal and natural gas generation facilities, respectively (AESO 2014). Large industrial centres such as oil sands production in the northeastern corner of the province are generally serviced by natural gas facilities to ensure stable and efficient supply of electricity (AESO 2014). Agricultural producers are serviced by varied supply technologies such as coal, natural gas, and wind depending on their geographical location. The largest retail firms that generate and supply electricity to the grid are ENMAX, TransAlta, TransCanada, ATCO, and Capital Power. Some of these firms sell electricity to smaller retailers, which handle household distribution such as Direct Energy, Encor, and EPCOR. Other smaller retailers exist, particularly in rural areas, to supply electricity through whichever means has proven to be the most feasible in that given region.

Currently, the vast majority of Alberta's electricity is generated through the use of fossil fuel resources. Figure 2 shows the total production of electricity in 2013 as defined by different fuel sources. Nearly 52% of the electricity generated in 2013 was created through the use of coal, while natural gas use accounted for 38%. The highest production of a renewable resource was wind power at 4% of total production. Other clean electricity technologies included hydroelectric activity and biomass with each representing 3% of total production.

The ability of renewables and other clean electricity sources to infiltrate the grid is often limited by the geophysical characteristics of the region. Alberta is well endowed with wind resources in the south and central-west regions of the province, with average annual wind speeds high enough for strong production (AESO 2014). Hydroelectric potential is most prominent on the Peace and Athabasca river systems, both traversing the north of the province. An untapped renewable resource in Alberta is solar electricity. Currently the province has very little investment is solar energy, but it has one of the highest sunshine rates in all of Canada (Environment Canada 2010). A reason for such high fossil fuel usage could be the ease of building and maintaining a coal or natural gas thermal plant, compared to the geophysical constraints of renewable production facilities.

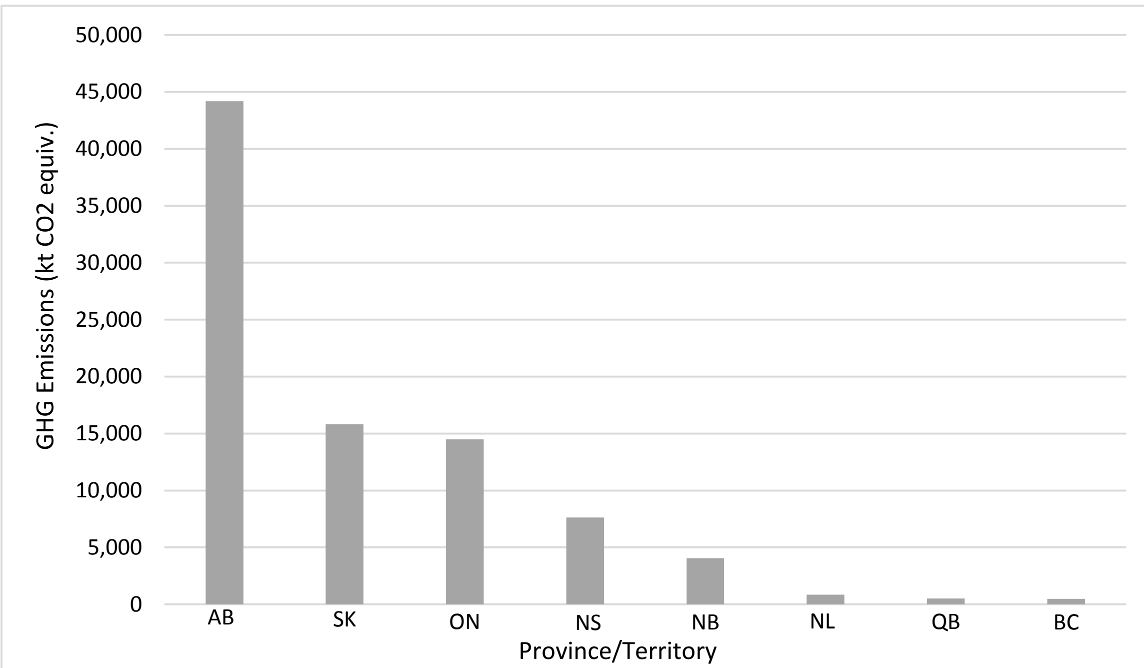
Figure 2: Alberta's Electricity Generation Sources 2013



Source: Government of Alberta (2014).

In 2013, the electricity sector in Canada produced 88Mt of GHG emissions, with Alberta responsible for just over half of the total (National Inventory, 2013). Figure 3 demonstrates these findings graphically. Alberta's electricity sector lags considerably behind other provinces in reducing GHG emissions in the electricity sector. Several other provinces have been endowed with a considerable amount of renewable resources and therefore do not produce as many emissions. Nevertheless, if Alberta hopes to reduce its environmental impact on the planet, it must approach this data with concern and begin to implement clean electricity solutions.

Figure 3: GHG Emissions from Electricity Generation by Province in 2012



Source: National Inventory Report 2013[1].

[1] Does not include provinces or territories with less than 0.5% of total GHG emissions from electricity generation. These included Manitoba, PEI, Yukon, Northwest Territories, and Nunavut.

The greenhouse gas emissions data shown here can be viewed with some optimism as emissions intensity from coal-fired thermal plants in Alberta is likely to decrease in the future. With federal regulations established in 2011 to retire coal electricity generation, most coal-fired thermal plants in Alberta will be no longer operational by 2029 (EDC 2013). Many of these coal fired thermal plants can easily be converted into natural gas plants to avoid losing existing capital investments. This will contribute to a dramatic decline in emissions intensity as natural gas becomes the dominant generation fuel for electricity. However, as demand for electricity increases, GHG emissions are still set to increase by 7% in the next 20 years (EDC 2013). While future growth in Alberta's emissions will be constrained over the next few decades, it is still concerning to see that the province has no plan to actually reduce the total amount of emissions.

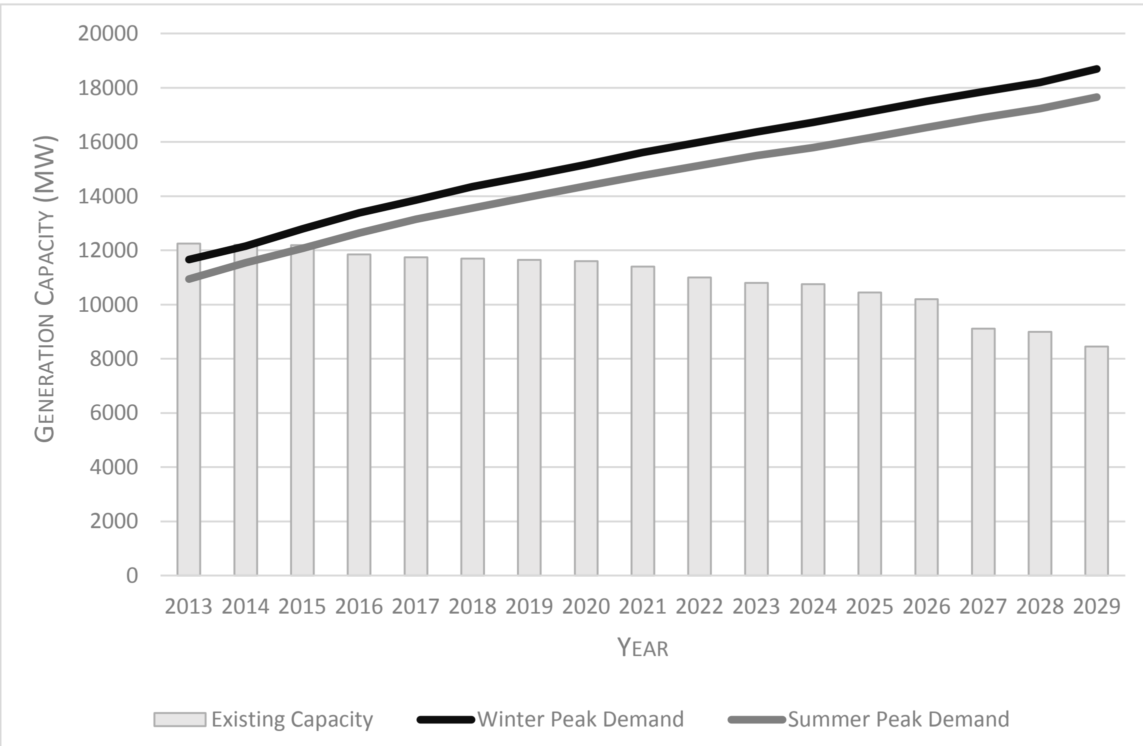
Legislation does exist in Alberta to tax heavy polluters in all industries including the electricity sector. The Specified Gas Emitters regulation requires that facilities that produce more than 100 kt of carbon dioxide emissions choose among four options in order to continue operations based on requirements to reduce the intensity of emissions by 12%. Facilities can either improve efficiency, purchase carbon offsets, purchase credits from facilities that have dramatically increased efficiency (beyond the 12% threshold), or pay a fee of $15/tonne of carbon that exceeds the 12% efficiency threshold. This policy is often cited as Alberta's response to a carbon tax but it suffers from a number of flaws. First, it recognizes only facilities that produce over 100kt of carbon emissions, which would include only the six largest coal plants in Alberta and omits most natural gas facilities (Pembina 2012). Second, the policy includes carbon emissions that exceed the 12% intensity targets, which is just a small portion of the carbon emissions produced by electricity facilities. Therefore, the effect of the Specified Gas Emitters Regulation is debateable and does not behave like a true carbon tax.

2.2.3. Future Electricity Supply and Demand

The future of electricity supply and demand in Alberta is highly dependent on the province's economic conditions. The oil sands industry is a large consumer of electricity and therefore this sector's growth will have a major impact on electricity demand.

Economic growth will also stimulate consumer demand from households, further expanding capacity requirements. Figure 4 shows the expected increase in demand over the next fifteen years based on economic and population growth models. This data is compared with the existing generating capacity, which will decline naturally as facilities are decommissioned. The gap between projected demand and existing capacity will increase over time, providing an opportunity for both new and existing technologies to gain market share. The province stands at a pivotal point where it needs to choose how it will meet existing demand, either through existing market incentives or alternative frameworks that could support clean electricity generation.

Figure 4: Expected Generation Capacity Requirements



Source: AESO (2009)

2.2.4. Interprovincial Electricity Trade

Any discussion of policies to alter the type of electricity production occurring in Alberta requires an examination of interprovincial electricity trade. The natural landscape of Canada is extremely diverse and it is clear that the tools used to generate electricity are very different in each jurisdiction. British Columbia is gifted with an immense supply of rivers in mountainous areas which provides a comparative advantage for hydroelectric resources. Alberta is a relatively flat region with a large supply of coal and natural gas at its disposal. In order to reduce the total amount of GHG emissions, those jurisdictions with clean energy sources at their disposal could trade electricity with jurisdictions that rely more heavily on fossil fuel technologies.

However, this is not currently a practice that provinces have adopted. Instead, Canadian provinces have been more interested in trading electricity with the United States and have very few transmission networks travelling east-west. One of the most prominent reasons for the lack of interprovincial trade is the variety of electricity market systems that exist (Carr 2010). For example, British Columbia has a publicly owned provider of electricity whereas Alberta has a competitive market for electricity supply. Developing transmission networks when one jurisdiction has a single supplier and the other has a multitude of suppliers can be complicated. If British Columbia were to provide clean electricity through its hydro resources to Alberta, which company would have access to this power? How would the government ensure that this electricity was being sold at the cost of production? Interprovincial trade suffers from serious equity issues that must be overcome if new transmission networks are to be produced.

A unique situation has currently arisen in the arena of interprovincial electricity trade. British Columbia plans to build a new hydroelectric dam known as Site C. This dam is a mid-size hydroelectric resource that the province plans to use in support of expansive natural resource development. However, once the dam is built there is likely to be a surplus of energy available that could be exported to Alberta in order to reduce its demand for fossil fuel driven electricity. This arrangement could be mutually beneficial for both the British Columbia and Alberta governments. A great deal of cooperation would be necessary in order to establish transmission networks and supply agreements between the parties. Such arrangements are beyond the scope of this project but should be considered a possible complement to any of the policy options evaluated here.

Chapter 3. Clean Energy Prospects in Alberta

3.1. Literature Review

Analytical research surrounding clean energy production is quite extensive, covering topics such as costs, technological feasibility, and public perceptions. Although clean electricity accounts for only a small proportion of total energy production in the world, it is a constant source of controversy. Some believe current clean technology and future innovations are capable of substantially replacing fossil fuel consumption, while others consider this to be unrealistic. This section will outline the arguments of various leading analysts in order to separate fact from rhetoric in regard to clean electricity generation.

It is clear that Alberta will continue to be supplied by fossil fuel resources in the near future. The challenge is promoting a clean electricity framework that can supply a large portion of future market demand for electricity to reduce the amount of greenhouse gas emissions being produced by the system. Although technically feasible, market forces are making this a difficult reality. Natural gas prices are very low and are not expected to rise any time soon. This is preventing wind power, the most popular renewable in Alberta, from gaining meaningful investment by energy firms. Furthermore, research and development grants, a popular tool for raising the technological capacity of renewable resources have diminished rapidly, making capital investments in wind even more difficult (KPMG 2014). Solar is another clean energy technology that has potentially a bright future in Alberta. Solar power is currently nearing grid parity at certain times of the day in Alberta and could be competitive with conventional sources in as few as five years depending on mass production capabilities (KPMG 2014). Other technologies have equal prospects as wind and solar projects, but with little direction from government and a difficult market, those prospects are likely to fall short.

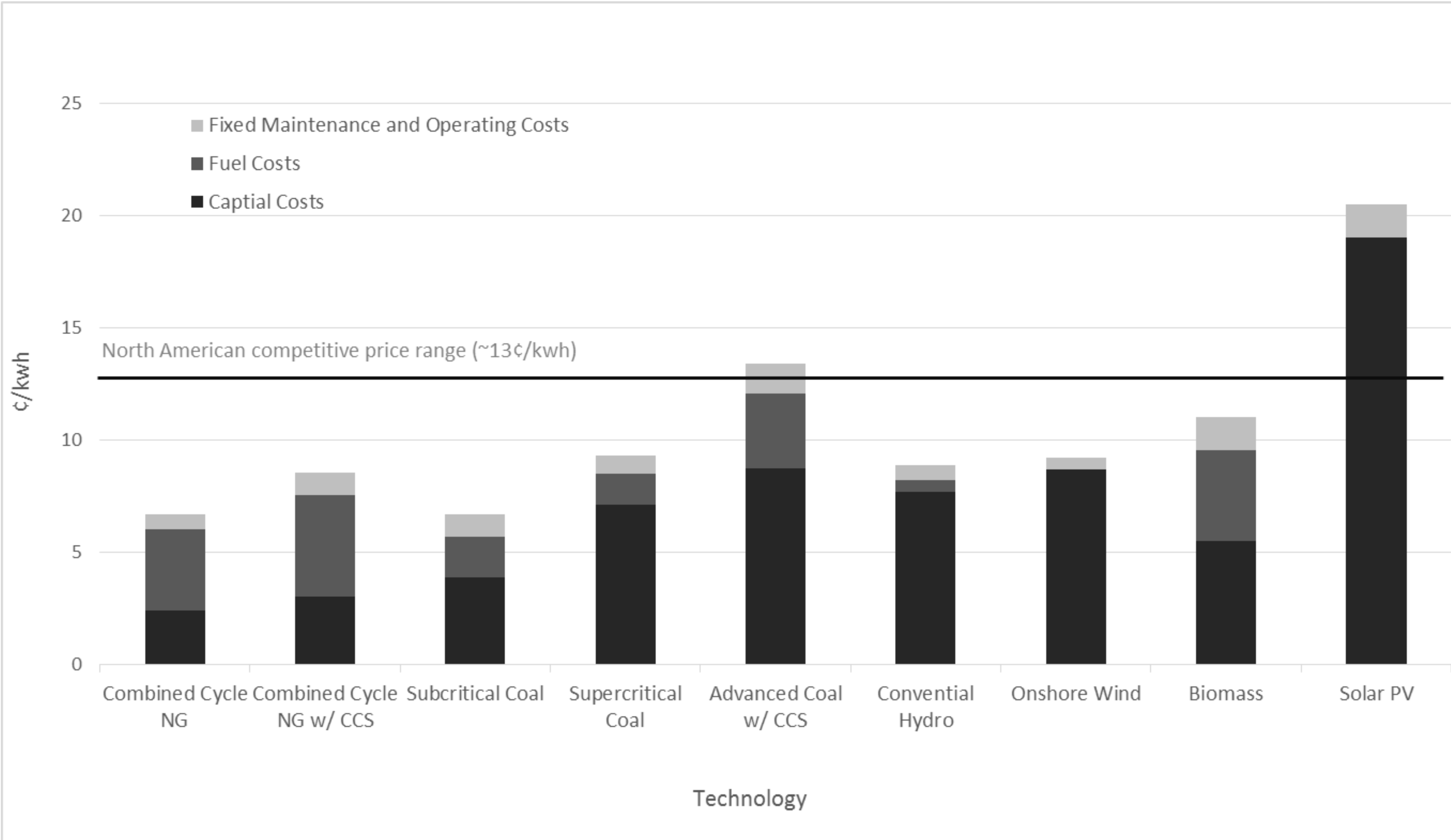
Technological factors contribute to the difficulty of guaranteeing market access of clean energy technologies. First, renewable electricity production must occur at the site of the resource, making electricity transmission from different regions more challenging. Second, the intermittency of renewable resources makes it difficult to have a steady and reliable source of electricity that consumers can use when they need it (NRC, 2010).

Finally, renewables are non-dispatchable, meaning that they cannot generate a certain level of electricity instantly but instead must rely on geophysical conditions. Traditional coal or natural gas-fired thermal plants do not suffer from the same types of difficulties in intermittency or dispatchability. Regardless of these barriers, it is still technically feasible for renewables to penetrate electricity markets and supply a substantial portion of overall energy.

According to America's Energy Future Panel on Electricity from Renewable Resources (2010), there are no technological constraints for wind, solar photovoltaics, geothermal, or biofuels. In fact, the primary barriers are the cost-competiveness of existing technologies relative to other sources of electricity production (NRC, 2010). The cost of producing one unit of electricity from a wind turbine is higher than burning coal or natural gas for that same unit of electricity. This is due to the concentration of energy that is present in fossil fuel resources compared to those in natural systems (NRC, 2010). From an economic standpoint, this makes renewables less competitive relative to fossil fuel generation. Policy is integral in creating cost-competitiveness amongst a wide range of clean electricity technologies.

In order to evaluate the cost-competitiveness of renewables and conventional fossil fuel technologies, analysts often refer to levelized costs of production. A levelized cost is the present value of the cost of installing and maintaining a power station divided by the present value of its expected life-time energy output. Figure 5 shows the levelized costs of various technologies that produce electricity based on North American averages. The levelized cost measure for comparing technologies is deficient in ignoring factors such as intermittency, transmission cost, and cost variability. Nevertheless, it is one of the simplest and most comparable measures and is still useful in discussions of cost differences. It is often thought that fossil fuel technologies have a huge cost advantage over clean electricity sources. However, when assessing the long-run implications of the different fuel types in terms of capital, fuel and maintenance costs, the differences become less stark. Figure 5 shows both hydroelectric and wind electricity costs as competitive within 1-3¢/kWh of natural gas and coal facilities. What needs to be overcome, and is crucial for assessing policy options, are the initial costs of establishing clean energy facilities in order to make them less risky investments.

Figure 5: Average Levelized Cost of Electricity Generation Technologies in North America



Source: Fraser Institute (2013). EDC (2013).

Some think tanks strongly advocate that these types of levelized cost structures should be the only factor determining the choice to invest in particular technologies (Fraser Institute 2013). A rational decision might be based on the premise that both consumers and producers want to incur the least cost when buying and selling goods and services. However, these levelized costs take into account only production costs and fail to account for negative externalities such as GHG emissions. Certainly, clean electricity technologies would be more competitive if we were to internalize carbon emissions in the market, but this is a difficult and controversial practice. Comparing the higher cost of clean electricity technologies with reduced environment damage is not straightforward but instead requires a number of trade-offs (Borenstein 2011). The time, location, and availability of different electricity technologies are all trade-offs that are not taken into account in levelized cost analyses but significantly alter the price of electricity. Therefore, fossil fuels are not better because they are cheaper and renewables are not better because they do not produce emissions. Instead a system that manages different trade-offs in the electricity sector will incorporate both types of technologies to maximize efficiency and economic benefits, while reducing environment harms.

Alberta needs government action in order for the electricity market to modify its choice of technology. Simply relying on market forces to reduce the amount greenhouse gas emissions produced by the electricity sector will not be enough. The status quo relies heavily on cheap fossil fuel energy and will continue to do so well into the future if incentives are not altered. A clear policy direction can change the incentives for particular fuel use and by doing so reduce human impact on the global environment.

3.2. Policy Mechanisms

In order to develop an electricity market that allows clean electricity technologies to penetrate the grid, numerous policy mechanisms have been created by government agencies throughout the world. Although it would be more intuitive to price negative externalities to offer renewables a more competitive platform, governments often elect not to do so. Instead, policies that ensure a given amount of renewables are available to consumers are often chosen for simplicity, effectiveness, and for political reasons. The economic efficiency of these policies are often contentious and therefore, proper design and implementation are crucial for their success. Variations of these policy options will be discussed further in the case study portion of this study.

3.2.1. *Feed-in Tariff*

A feed-in tariff is a policy mechanism used to accelerate investment in clean or renewable electricity by offering long-term contracts to firms that use those technologies. Production of clean electricity is provided guaranteed pricing based on the cost generation firms are faced with in order to shelter the industry from investment risks. Therefore if the true price of electricity is 10¢/kwh but the cost of production for a renewable is 15¢/kwh, the utility regulator will provide the renewable generation entity to difference. Therefore, this mechanism purposefully distorts the market in order to support the industry sector that government prefers. This mechanism can be imposed upon a large portion of the province by allowing households to invest in solar panels on their roofs or farmers to invest in wind farms on agricultural land and sell a portion of their electricity to the grid.

Feed-in tariffs have proven to be one of the most popular techniques for supporting renewable industries across the world. By directly subsidizing the market, the government or consumers are effectively sheltering an industry until it can grow and reap the benefits of economies of scale. Feed-in tariffs can promote private investment in renewables by offering companies assurance of a given price that will recover their investment over a long period of time. A major issue with feed-in tariffs can arise for governments when they commit to major long-term contacts with renewable electricity firms but the cost of electricity remains relatively low (van Kooten 2011). In this situation, the government charges consumers much higher electricity rates and pay cost premiums to industries that have higher costs of production relative to other firms. A regulatory agency has to pick effective technologies that have promising prospects for long-term clean electricity production, a task easier said than done.

3.2.2. Renewable Portfolio Standard

A renewable portfolio standard (RPS) is a regulation applied to electricity producers to increase their overall generation of renewable electricity. The regulation can apply specifically to clean electricity generation or particular types of renewables, depending on the desires and constraints of the governing agency. A renewable portfolio standard generally places an obligation on producers to produce a given percentage of their electricity from renewables. The production of renewable electricity will provide producers with renewable certificates, which they can buy or sell depending on the type of electricity generation they have undertaken. Therefore, a production firm that produces more than their assigned renewable obligation can sell additional electricity certificates to firms that have fallen short of their minimum obligation. Renewable portfolio standards are believed to be more economically efficient than direct subsidies, because they allow transfer the reduction of GHG emissions to those firms that can do so at the lowest real cost.

Renewable portfolio standards have emerged as a relatively popular policy mechanism for a number of different reasons. First, an RPS ensures that renewable producers continuously seek cost reductions. Second, RPS ensures the attainment of specific thresholds. Third, RPS minimizes government involvement (Jaccard 2004). All of these are objectives that any government would like to achieve regardless of whether it was producing alternative electricity. This point is further developed by Barry Rabe, who concludes that establishing an RPS is a natural policy method, for any government concerned about energy security and environmental sustainability (2006). Governments already have established utility regulators but managing the type of electricity produced requires increased personnel, legislative changes, and an enhancement of jurisdictional oversight. The extent of these modifications will ultimately depend upon the existing governing structure and how well it can cope with new responsibilities.

3.2.3. Taxation and Regulation

Any government agency can choose among various means in applying environmental policy to mitigate the generation of negative externalities. Here I will outline the differences between a taxation policy and regulation. Environmental taxation is a means of internalizing the negative externality by forcing firms to pay the true social cost of their activity. This type of policy is economically efficient because it can directly charge polluting industries for the hypothetical environmental damage occurring as a result of their actions. A regulation is a more complex type of environmental policy that aims at reducing the environmental damage caused by a particular activity by invoking quotas or efficiency standards. Generally, regulations do not create price signals for firms but instead force them to undertake a particular action. The key difference between these two policies is that a tax allows for equal marginal abatement costs across all polluters, whereas a non-tradable quota regulation does not (Bovenberg and Goulder 2001). This means that a pollution tax can signal to a firm the marginal cost of reducing their unit of pollution (exactly equal to the tax rate) but a quota, depending on how it is distributed, will make some firms relatively worse off depending on their abatement costs. A modification of standard environmental regulations is to incorporate tradable permits, which allow firms to determine more accurately their abatement costs based on the availability of permits. This is a hybrid model of quantity and price regulations that establishes more flexibility for firms.

Chapter 4. Methodology

In order to contribute to the research regarding renewable electricity generation this paper incorporates two separate methodologies. First, I examine the policies enacted by three other jurisdictions: British Columbia, Ontario, and California. All three have enacted legislation to create a renewable energy portfolio in their electricity markets, some successful, others not. An evaluation of outside jurisdictions will help determine potential policy options and implementation strategies to ensure that new policy in Alberta can avoid various pitfalls. Second, I conduct interviews with experts in the realm of electricity policy in Alberta to gauge their feelings with regards to policies that promote renewable electricity. These interviews help gather information to both establish policy options and evaluate their likelihood of effectiveness in the context of Alberta. The findings from these two methodologies help to motivate the findings in the rest of this paper.

The use of case studies as a research methodology has both strengths and weaknesses. Case studies are a tool a researcher can use to identify the underlying principles of a policy problem and critically analyze the means by which certain policies were put in place. In the context of the Alberta electricity market, case studies can be an effective means of determining how other jurisdictions managed to get renewable portfolios into the realm of policy. More specifically, these case studies can help to outline the attitudes, institutions, and market structures necessary to support a renewable electricity generating system. However, it will be important not to prescribe too heavily solely on the basis of the case study findings. Numerous factors influence policy choices, and inferring causation in one jurisdiction does not mean that those same polices will prove effective in another. Therefore, insights from expert interviews from policy makers in Alberta are essential for avoiding those types of missteps.

The case studies in this paper were selected in order to gather the most relevant idea of renewable electricity policy to Alberta. Many countries have made great strides toward investment in renewable energy, but it is important to choose jurisdictions with similar institutions and economic constraints. Ontario is the only province in Canada that has supported policy mechanisms favouring renewable electricity production. Like Alberta, this province also went through market restructuring to incorporate a greater presence of competition among generation firms. Although Ontario does not have the same economic reliance on natural resource production, it is a jurisdiction with similar institutions and will be an important case study for this paper.

One jurisdiction that has experienced massive changes to its level of renewable electricity production is California. California has also invested in policy mechanisms to increase the renewable portfolio, but its policies are much different than those enacted in Ontario. Finally, British Columbia has maintained a steady supply of renewable electricity production throughout its lifetime and had some success with a clean electricity standard. Although British Columbia is well endowed with large hydroelectric resources, the polices they have enacted independent of the crown corporation, BC Hydro, could be relevant to Alberta's future development. To gather information from these jurisdictions, I conducted a survey of both academic work and government reports. Public opinion data also assists in understanding public sentiments toward new policies.

The expert interviews conducted for this report complement the data collected in the case studies. The interviews are used as a means to relate the policies of other jurisdictions to the context of the Alberta electricity market. They further serve to ensure that all the data collected regarding the electricity system in Alberta is accurate. The interviews in this report include two with analysts at Alberta's Ministry of Energy and one with an analyst at TransAlta, a major electricity firm. All analysts interviewed worked in renewable energy divisions of their respective departments but were capable of candidly discussing other issues related to Alberta's electricity system. Contact was made with firms that distribute renewable energy, but nobody within these organizations was available for comment before the final draft of this report. In order to contact all participants, emails were sent to select individuals within the various organizations who appeared to have the qualifications necessary to discuss the issue of clean electricity production in Alberta. Individuals chosen to participate in the final interview process were those who responded and demonstrated interest in participating. All participants gave consent to reproduce their responses to various questions. The names and contacts of the interview participants have not been shared in this report in accordance with their consent. All interview questions can be found in Appendix A.

The methodology of contacting individuals solely based on their ability to respond to my emails and telephone calls may have run the risk of restricting the potential for some to participate. However, it was the only methodology available under tight time constraints. The interviews and their recruitment were conducted between January 5th and February 13th 2015. During this time the global price of oil had dropped significantly, leading to a relative decline in the demand for electricity. The recent decline in demand for energy may have led some interviewees to conclude that investing in clean energy projects would not be profitable in the short-run.

4.1. Cross-jurisdictional Review and Expert Analysis

To uncover and evaluate potential policy options that can enhance clean electricity production in Alberta, I conducted a cross-jurisdictional review and expert interviews. The results of those exercises are presented here.

Case Studies

4.1.1. Ontario

Ontario has gone through a series of changes in its electricity production technologies over the past decades. Historically, the province relied heavily on hydroelectric power as the primary source of electricity. In the 1970's and 1980's, nuclear power rose to prominence and filled the increased energy demand. As demand continued to rise, coal- and natural-gas-fired thermal plants became more popular and assisted during peak hours. In 2013, the electricity mix in Ontario was supplied by 58% nuclear power, 24% hydroelectric power, 11% natural gas, and nearly 6% alternative electricity resources. Coal-fired power plants, which had been popular in the 1990's, were all decommissioned in 2014 as the province has moved steadfastly toward less environmentally impactful production services.

The organization of electricity production and distribution services in Ontario has experienced similarly sharp changes as production technology types in recent history. The late 1990's and early 2000's was the most tumultuous time period for the Ontario electricity sector as rising debt, low capacity, and political pressure forced the operating monopoly, Ontario Hydro, to give up its power over electricity planning. Instead, the government proposed measures to introduce a competitive electricity market, similar to Alberta, as a viable alternative. The competitive market experiment faced significant setbacks as supply constraints raised electricity rates by twice the rate experienced before the competitive market was implemented. Government responded by setting a rate cap for consumers that was well below the market equilibrium rate, leading to a decline in new electricity investment. The competitive market is set by independent agencies selling electricity to the government-run electricity operator, which then sets prices that are often lower than the real costs of production for firms. This means that the government operator could potentially run at a perpetual loss and will have to cover these costs through general government expenditure. This type of hybrid planning is still in effect in Ontario.

In 2009, the Liberal government of Ontario adopted the Green Energy Act. The Act was a significant shift from the existing polices surrounding electricity production and implemented a number of policies such as enhanced renewable electricity production, energy efficiency, and conservation measures. Of primary importance for policy makers in Ontario was to promote renewable electricity sources as viable options for increasing electricity capacity and reducing the environmental impact of electricity production in the province. In order to do so, the Green Energy Act established a Feed-In Tariff (FiT) that would offer guaranteed long term contracts for renewable electricity producers such as solar, wind, and biomass. Ontario offered cost of production prices for renewable producers while setting price caps for the amount that consumers would have to pay for a unit of electricity delivered from these technologies. This means that the provincial government is effectively subsidizing renewable forms of electricity production.

Since its implementation, the Feed-In Tariff has dramatically increased the number of renewable energy projects in Ontario. Within its first two years, the Feed-In Tariff created 2,000 renewable energy contracts totalling 4,600MW of power capacity (Ontario Ministry of Energy 2012). This meant that the supply of renewable energy doubled in 2010 and once again in 2011 (Stokes 2013). For comparison, Ontario created two times more renewable capacity in two years than all of Alberta's existing renewable electricity production today. If the growth in renewable projects continues as projected, the provincial government expects to have 20,000MW of installed renewable capacity by 2025 (Ontario Ministry of Energy 2013). Without the Feed-In Tariff to support the long-term cost structures of these renewable energy projects, it is unlikely that this level of growth in the renewables sector would have occurred (Stokes 2013). Much of the expected growth in renewables is expected to come in the form of wind, solar, and biomass projects all of which are guaranteed different prices from the provincial government based on their levelized costs.

Although the increase in renewable electricity generation in Ontario can be seen as positive signal of the Feed-In Tariff's success, it has also led to higher prices for consumers. After the Feed-In Tariff's implementation, wind power prices rose an additional 2.5¢/kWh, while solar prices nearly doubled depending on the type technology used (Stokes 2013). These price increases were meant to account for production costs in various industries but had consumers upset over the obvious subsidy that was being afforded to renewable technologies. According to economist Donald Dewees, consumer concerns over the increase in energy prices are valid, particularly when governments attempt to pick "winners" in the energy system. Dewees notes that any renewable technology that can displace coal or natural gas justifies prices between 9.5 and 13¢/kWh, based on a carbon price of $25 and $100 per tonne, respectively (2013). Currently the only renewable technology that can produce electricity within this price range in Ontario is wind power, whose use justifies prices between 6 and 9.5¢/kWh, well below the 11.5¢/kWh currently being charged in Ontario's Feed-In Tariff program (Dewees 2013). Therefore, the Feed-In Tariff clearly benefits particular technologies and effectively supports industries, like solar power, that are not competitive with natural gas-fired thermal plants, even when the price of carbon is accounted for. Establishing an economically efficient feed-in tariff policy would require an evaluation of which technologies are the most effective at minimizing cost while simultaneously charging consumers the true cost of production.

Other criticism of the Ontario Feed-In Tariff surrounds the implementation of the policy. After FiT was established, there ensued a mad dash to construct wind turbines and solar panels across the province with little regard for the preferences of residents. This led to a fracturing of the relationship between government and rural residents over the aesthetic appeal and noise created by wind turbines. Eventually, the Wind Concerns Ontario organization formed as a protest group that sought to undermine the proliferation of wind turbines. They managed to create a great deal of debate surrounding support for renewable energy (Stokes 2013). An increase in the amount of renewables will likely require greater land use, directly impacting rural communities. The concerns of these types of communities will need to be better managed if jurisdictions like Alberta are interested in increasing their production of renewable energy.

4.1.2. California

After Alberta, California was one of the first jurisdictions in North America to transition from a state-owned utility toward a competitive market structure for electricity supply. It did so in the mid-1990s, as electricity prices in the state were 50% higher than the US average, in hopes that the competitive market would lead to efficiency gains and lower prices for consumers (Jaccard 2002). By 1998, California had firmly entrenched the competitive electricity market in place with multiple firms that had direct access to residential, commercial, and industrial consumers in the state. During its first few years, the competitive structure appeared to be functioning quite well until the summer of 2000 when the price of electricity experienced dramatic peak increases. This situation soon became a crisis as the price of electricity failed to stabilize into the winter months. Finally the government intervened by setting rate caps for consumers, a policy that led to enormous financial loses for the State. Eventually prices stabilized in 2001 with the assistance of coordination from multiple federal departments. The California electricity crisis has been diagnosed with multiple different causes including price gouging from large firms such as Enron, system capacity constraints, and extreme weather events (Jaccard 2002). The California electricity market restructuring has been an important case study for other jurisdictions interested in market reforms. Furthermore, the existing competitive market structure and the past experience of electricity system crisis play an important role in shaping clean electricity policy in the state.

The existing production capacity in California is similar to Alberta in the sense that its primary fuel source is a fossil fuel, but the state has taken recent steps to increase renewable investment. The state currently produces nearly two-thirds of its electricity from natural-gas-fired thermal plants, while renewables such as solar, wind, geothermal, and small hydro represent 20% of total electricity production, nuclear facilities represent 9% of production, and large hydroelectric projects make up the final 5% (EIA 2014). The system is also relies on a high level of electricity imports, mainly from hydroelectric projects in Washington, Oregon, and British Columbia.

California is widely considered to be one of the most progressive jurisdictions in North America in terms of its clean electricity production and has become a model that many other regions have begun to emulate. This reputation stems primarily from policy enacted in 2002 to incorporate a Renewable Portfolio Standard (RPS) for all retailers of electricity in the State. The RPS establishes a minimum level of renewable electricity that must be produced by firms in order to sell electricity on the open market. So far, the RPS has remained on target and has increased in-state renewables generation capacity from 7,000MW in 2002 to nearly 19,000MW in 2014 (California Energy Commission 2014). Much of this increase can be traced to the program's acceleration that occurred in 2008, which now requires 33% of total electricity to be produced from renewable fuel sources by 2020 (Office of the Governor 2008). This standard will establish California as the largest producer of non-hydro renewable electricity in North America.

One of the often-cited issues with a portfolio standard for electricity production is the increased costs of energy that result after its implementation. A study conducted by Energy and Environmental Economics Inc. (E3) found that electricity prices in California are predicted to increase from 14¢/kWh in 2012 to 21¢/kWh in 2030 (2014). However, the study also notes that the increase in electricity price has much more to do with aging infrastructure and system constraints rather than the RPS policy. In fact they estimate that over the 18-year period from 2012 to 2030, utility rates are likely to increase 6-8% as a direct result of the implementation of the RPS policy (E3 Inc. 2014). The E3 report further analyzes more extreme standards for electricity production, stating that a 40% RPS policy could increase consumer prices an additional 3% beyond the base-case scenario. A 50% RPS could increase prices 23% beyond the base-case scenario. This data suggests that creating minimum standards for clean electricity production does increase the price of electricity, but the effect is much more pronounced as the standard is increased to significantly high levels.

It is important to note that the California state government established the RPS program with a significant level of leadership. The governor of California at the time the RPS was established, Arnold Schwarzenegger, firmly stood behind the principles of renewable electricity investment. This level of government support has remained consistent throughout the policy's lifetime and has likely contributed to its overall success. Avid support from government likely contributed to lower levels of public outcry and general support from industry. Much like the success of any policy, leadership will be a prerequisite in the Alberta context.

4.1.3. British Columbia

British Columbia's electricity system is much different from its counterparts in Alberta, Ontario, and California. Instead of a competitive market for electricity where individual firms produce and sell electricity to consumers based on market prices, the Government of British Columbia's crown corporation, BC Hydro, generates and distributes electricity for the majority of the province. BC Hydro is regulated by the British Columbia Utilities Commission in the prices it charges consumers, to ensure that cost of production is accurately reflected in the unit price of electricity. A major impetus for the establishment of a crown corporation in charge of electricity generation was the creation of major hydroelectric projects in the 1960's that carried huge capital costs. Since that time, BC Hydro has established itself as the main planning and operating organization for the electricity system in British Columbia and owns both hydroelectric dams and natural gas thermal plants. Independent power producers are firms not under the umbrella of BC Hydro yet sell electricity to the grid at the cost of production. These firms assist BC Hydro meet peak demand during supply shortages through the use of small hydro, thermal plants, biomass, and wind projects. Independent power producers are important partners in electricity system planning and help to create a more diversified energy portfolio in British Columbia.

The electricity system in British Columbia is not generally known for government policies that incentivize investment in clean electricity beyond hydroelectric power. However, the province has actually instituted some of the most aggressive climate policies in North America, of which one major policy directly affects electricity production. British Columbia's Clean Electricity Standard is similar to the Renewable Portfolio Standard established in California as it dictates the exact proportion of "clean" electricity that must be produced by independent power producers. The difference between the policies lies in the broader prescription for zero-emitting technologies, such as biomass and carbon capture and storage, rather than simply a renewable supply. The most popular choice of clean technology in the province includes biomass, representing 10% of electricity production, and wind energy, representing just over 1% (Government of B.C. 2012). While the actual standard has evolved over the past number of years, the actual proportion of clean electricity that comes from independent power producers must be 93 percent as of 2010 (Government of B.C. 2010). BC Hydro supplies nearly 90 percent of the province's electricity demand through mega hydroelectric projects with multiple dams along the Peace and Columbia River systems. Combining the electricity production from BC Hydro and the independent power producers that are subject to the Clean Electricity Standard, British Columbia produces nearly 100 percent of its electricity from clean technologies.

The Clean Electricity Standard was not the only policy the government of British Columbia chose to bolster its commitment to GHG emission reductions. In 2008, the same year the Clean Electricity Standard was established, British Columbia created the BC Carbon Tax, a per unit tax applied to all industries that generate GHG emissions. Although the BC Carbon Tax does not relate significantly to the electricity system due to its existing low emissions technologies, it is an example of a similar type of policy that Alberta could apply to its own electricity sector to enhance clean technology investment. The BC Carbon Tax charges \$30/tonne CO_2, which equates to an additional cost in the production of thermal generated electricity. This forces independent power producers in British Columbia to take into account their carbon emissions as new costs and could lead to a shift in the type of technology used to generate electricity. Government leadership was a major part of the adoption of the Clean Electricity Standard and the BC Carbon Tax. The 2007 BC Energy Plan outlined the focus of the government to commit to reducing GHG emissions and improving the clean energy sector through these policy mechanisms.

Without a strong commitment from government to improve the existing environmental standards, it is unlikely that policies in other jurisdictions will achieve the same salience as they did in British Columbia.

The effectiveness of the Clean Electricity Standard and the BC Carbon Tax as measured in terms of reduced GHG emissions can be uncovered through an analysis of potential electricity generation had the policies not been established. If the Clean Electricity Standard had not come into effect, British Columbia would have likely moved toward an expansion of low-cost thermal plants, in order to supply larger metropolitan regions on Vancouver Island and the Lower Mainland. According to researchers Rhodes and Jaccard, the Clean Electricity Standard created a reduction of 10.8 to 16.6 Mt of carbon dioxide emissions per year, based on projections into 2020 (2013). Compare this with projections by Rivers and Schaufele, that the BC Carbon Tax reduced carbon emissions by 3.04 Mt in its first four years of implementation (2013). Using this data, its apparent that the Clean Electricity Standard has the ability to reduce carbon dioxide emissions four to six times more than the BC Carbon Tax, based on the existing parameters of the policy. However, it is crucial to note that the existence of the Clean Electricity Standard poses a much higher economic cost in comparison to the BC Carbon Tax. In fact, the Clean Electricity Standard has a cost of \$90 - \$210/tonne CO_2 reduced, while the Carbon Tax imposes a cost of \$30/tonne CO_2 (Rhodes and Jaccard 2013). Therefore, a trade-off exists between the potential effectiveness and the economic costs of a given policy. Rhodes and Jaccard indicated that a Clean Electricity Standard may be the best course of action for political actors as public perception surrounding this policy tool is much less adverse compared to the Carbon Tax (2013). While public perception is not the only criterion by which we evaluate electricity policies, it will undoubted play a major role in the analysis of policy options for the Alberta market.

4.2. Expert Interviews

4.2.1. Government of Alberta Analysts

Analysts with Alberta's Ministry of Energy confirmed the importance of a market-based approach to electricity generation. For these analysts, establishing a reliable and efficient electricity market is a top priority. These demands make it difficult for clean electricity projects to gain significant investment as they tend not to have as high financial returns. Clean electricity investment is further hindered by technical constraints present in intermittent fuel sources without any form of storage technology available. The analysts did mention that they expect to see moderate growth in wind power, as the production costs of this technology continues to fall. Pilot projects for energy storage have been funded but they have received limited uptake from industry at this time.

Currently the Ministry of Energy has limited methods for enhancing the level of investment in clean electricity technologies. Carbon offsets, generated through the heavy emitters tax in Alberta helps to fund renewable projects in Alberta. A climate change initiative fund allows projects to draw funds if they meet certain standards for clean electricity. Finally, building permits for renewable energy projects can be streamlined in order to avoid some planning costs. These methods are mediocre at best and likely contribute to minimal advances in clean electricity investment. Due to the supremacy of market forces and minimal interventionist techniques available to government agencies, clean technologies are subject to the whims of electricity prices. Unless the price of natural gas or coal rises dramatically, large-scale investment in renewables or alternative sources of electricity remains unlikely.

When asked about various policy options for enhancing clean energy investment, the analysts were moderately optimistic about particular polices. The analysts seemed to prefer an emissions tax strategy that would charge electricity companies a given price for each ton of carbon produced. The tax would be easy to implement and monitor, with the funds going toward further investment in clean energy technologies. They did have concerns about whether the tax would actually change behaviour or if it would be simply another fee that could stifle economic activity in the electricity sector. The Renewable Portfolio Standard was also met with tentative approval. According to their views, the RPS can be a type of market-based approach that will increase clean electricity investment but it requires active consultation with firms in order to ensure that the targets are manageable. The Feed-in Tariff was not a popular policy, particularly if it used taxpayer dollars to be funded. While the analysts could see the potential for the increased development of renewables, it comes at the expense of economic efficiency and government expenditure.

The potential for a large increase in the price of electricity was most prominent in the Feed-In Tariff policy, while the other options would create more moderate increases in the consumer price. With any policy, the consensus was that proper planning and implementation were prerequisites to success.

4.2.2. Electricity Production Firms

The views of electricity firms tends to be quite clear with regards to clean electricity production in Alberta. A TransAlta representative felt that the existing regulatory environment for the electricity system is working and imposing government regulation on the type of fuels used to generate electricity could lead to challenges in the future. Currently, firms invest in renewable electricity production because it makes financial sense to do so. An analyst with a major electricity company in Alberta cited existing and projected market prices for electricity as being the key indicator of renewable investment in the province. As the price for electricity rises, due to increases demand or scarcity of cheap fuel sources, it becomes more viable to invest in clean energy projects. This has led many companies to diversify their energy portfolio, particularly as coal-fired thermal plants are decommissioned in the near future. However, the TransAlta representative expressed an industry view that government regulation, particularly with regard to the types of renewables that must be used to generate electricity, will lead to unnecessary increases in the price of energy. Of particular importance for electricity generating firms is the maintenance of a competitive electricity market structure in Alberta with as little government intervention as possible.

When talking about the technical feasibility of increasing the number of clean electricity production facilities in the province, the TransAlta representative seemed optimistic about the future. He felt it would be possible to increase the amount of clean electricity technologies in Alberta without compromising the ability to satisfy demand. Experts did note the technical difficulty with expanding intermittent technologies, especially when they are located a significant distance away from large metropolitan regions. Increasing the level of renewable electricity production is therefore limited by the geophysical conditions of the province and the demand for electricity. However, one expert noted that an increasing reliance on a fuel whose price tends to be relatively volatile such as natural gas for the production of electricity could lead to issues of energy security. Therefore careful planning and management of different fuel sources for energy will be crucial for the development of clean electricity technologies.

When asked about specific policies that could be implemented by the government of Alberta to enhance renewable electricity production, the representative from TransAlta seemed unsure of the best choice. One expert noted the potential harm of a renewable portfolio standard that forces large generation companies to produce a given level of renewables while seeing profits going toward smaller firms that produce only renewable electricity. The potential for a feed-in tariff seemed promising for energy companies but experts did recognize that these types of policies are economically inefficient as the government is willing to pay for renewables that more expensive, regardless of their future potential. A carbon tax seemed to be the most palatable policy for electricity firms, but they did note that a carbon tax will likely lead to a significant increase in energy prices for consumers. One expert noted that the natural tendency will be to invest in clean electricity in the long-term as environmental regulations become more rigorous. Therefore, the sentiment appeared to be that the electricity market, with some environmental regulations will tend to sort itself out and lead to the optimal mixture of electricity technologies.

Chapter 5. Policy Objectives, Criteria, and Measures

This chapter identifies and discusses the policy objectives, criteria and measures used to evaluate the policy options.

5.1. Policy Objectives

The development of a clean electricity portfolio in Alberta combines a number of policy objectives. The main focus of this assessment is to introduce a policy that will reduce greenhouse gas emissions while limiting the costs to the economy of Alberta. In the process, the policy must address political concerns in Alberta by curbing budgetary and administrative impacts. Finally, stakeholder and public perception of the policy are major components that will determine the success of the policy instrument. Incorporating all of these objectives into the framework of the policy analysis is crucial for developing a comprehensive assessment of the policy options.

The objectives of a clean electricity portfolio will have both short-term and long-term dimensions. The short-term is defined as the first ten years after the policy has been implemented. During this timeframe, the policy objective is to firmly establish clean electricity production as a major supplier to the provincial grid. Ten years is considered to be enough time to initiate investment in clean electricity and provide firms the opportunity to determine how they would like to proceed with their clean electricity supply. In the long run, the policy objective is to maintain growth in clean electricity production as a proportion of total supply for multiple decades. It is difficult to lay out policy objectives for the long term due to a lack of knowledge regarding the future of the Alberta economy, clean electricity technology, and the political climate. Therefore, the criteria in this analysis will focus solely on the short-run impacts of the policy options.

5.2. Criteria and Measures

The policy alternatives developed to enhance the clean electricity portfolio in Alberta will be compared on the basis of the following criteria: effectiveness; economic efficiency; government impacts; stakeholder acceptability; administrative feasibility; and public perceptions. Each criterion has a particular measure and will be scored on the basis of a particular benchmark that corresponds to a value of high (3), medium (2), or low (1). The total scores for each policy option are added together and the highest total value is considered the preferred option. Table 1 describes each criterion, their measurements, and the benchmark used for their scoring. Each criterion plays an important role in addressing the policy problem and has major implications for short- and long-run implementation. In order to account for the significance of effectiveness and economic efficiency, these criteria are weighted double. For criteria with multiple measures, an average score will be taken in order to establish equality between other criteria of equal importance.

Table 1: Criteria and Measures

Criteria	Definition	Measurement	Benchmark	Value
Effectiveness (Weight x2)	The amount of clean electricity being produce as a portion of total electricity produced in the province.	The percentage of clean electricity in the provincial grid by 2025	< 10% 10 – 20 % >20%	Low (1) Medium (2) High (3)
Economic Cost (Weight x2)	The additional cost of a unit of electricity after the policy is implemented.	The per kWh amount of price increase.	>4¢/kWh 2-4¢/kWh <2¢/kWh	Low (1) Medium (2) High (3)
Government Impacts	The degree to which government would be willing to undertake such a policy.	Political alignment	Major shift Moderate shift Minor shift	Low (1) Medium (2) High (3)
Administrative Feasibility	The increase or decrease in regulations that the utility regulator will have to manage.	The complexity of regulations / legislation before and after the policy	Major increase Moderate increase Minor increase	Low (1) Medium (2) High (3)
Stakeholder Acceptability	The reaction of stakeholders to a policy that will affect their expectations and cost structure	Qualitative assessment of feelings towards particular policies	Minor support Moderate support Major support	Low (1) Medium (2) High (3)
Public Perception	The amount of public backlash that will occur as a result of the policy change.	The potential for protest, civil disobedience, or loss of trust in government	Major backlash Moderate backlash Minor Backlash	Low (1) Medium (2) High (3)

Effectiveness: The effectiveness of the policy is measured by the proportion of clean electricity that is produced in the provincial grid after implementation. A policy is deemed to be effective if it can stimulate clean electricity production beyond a particular point. The benchmarks of <10%, 10 – 20%, and >20% as low, medium, and high values respectively, were chosen as they relate to the current production capabilities of Alberta's electricity market. The status quo will likely see minor growth in renewable electricity generation and carbon capture and storage in the next ten years, meaning <10% clean electricity production across the entire provincial grid. The other two benchmarks can be achieved based on the impact of the policy, where >20% clean electricity production would meet current generation capacity in progressive jurisdictions such as California.

Economic Cost: Economic cost measures the impact any policy will have on the consumer price of electricity in Alberta by 2025. Any policy that attempts to reduce the amount of carbon emissions being produced by shifting the focus toward particular technologies, will likely lead to increased costs for producers and in turn for consumers. Different polices will impose different types of costs on producers, but they could also create incentives to minimize the total costs of switching to less carbon-based fuel sources. It is crucial that the type of policies chosen to enhance the role of clean energy have the lowest possible cost to society while still achieving effectiveness benchmarks. The unit price of electricity (¢/kWh) charged to consumers is chosen as the measure of economic efficiency because it reflects the actual production costs borne by electricity producers with different policies. The thresholds <2¢/kWh, 2-4¢/kWh, and >4¢/kWh were chosen as they relate to data gathered in the case studies regarding the increase in electricity prices after certain policies were established. Often we consider investments in clean energy and economic growth to be trade-offs. Here, the policies will attempt to limit the effect of this trade-off by increasing the effectiveness of the policy while limiting its effects on Alberta's economy.

Government Impacts: This criterion identifies the ways in which policy will affect the existing government and whether they would be likely to enact the policy. This criterion has two separate measures. First, some polices will require government funding and will impact the budget. Any outlays needed by government to influence clean electricity production would hurt the policy's potential success, particularly in a market that has traditionally been unencumbered by government influence. Second, any policy changes to enhance clean energy investment will likely require strong leadership on the part of government, especially if there are negative government impacts. The degree to which a given policy aligns with the political will of the government will be an important factor for successful implementation. The desired outcomes in Table 2 help to determine the difference between a major and minor shift in the political will of government. A policy that satisfies one or less of the desired outcomes is a major shift in political will; two or three desired outcomes is a moderate shift; and all four desired outcomes is a minor shift.

Table 2: Index of Political Will

Category	Desired Outcome
Ideology	1) The policy remains within the political and economic ideology of the governing party (right-wing conservative)
Policy	2) Government has shown support for similar policies
	3) The governing party perceives no risk to their status as a result of the policy's implementation
Leadership	4) The governing party has the ability to firmly support the principles of the policy

Administrative Feasibility: This criterion measures how easily the policy can be implemented under the existing framework of utility regulators. A policy that requires major regulatory change is considered to be less feasible than a policy that requires a minimal regulatory changes. Legislative changes would be even more difficult to enact as they require elected officials rather than an autonomous regulatory agency. Due to the complexity of the electricity sector market, the ability for utility regulators to manage new policies is vital for the success of a given policy. The desired outcomes in Table 3 help to determine the difference between a major increase in regulatory complexity versus a minor increase. A policy that satisfies two or less desired outcomes is a major increase in complexity; three or four desired outcomes is a moderate increase; and five or more desired outcomes is a minor increase.

Table 3: Index for Measuring Administrative Feasibility

Category	Desired Outcome
Utility Regulators	1) Limited number of new regulations (1-3)
	2) Does not increase funding
	3) Data readily available
	4) Easily enforceable
	5) Comparable information from one electricity producer to another
Legislation	6) Does not require new legislation

Stakeholder Acceptability: Stakeholder acceptability is the reaction of existing electricity firms to new policies that alter their expectations and cost structure. If the policy creates significant costs for existing electricity firms, it will not be well received by those stakeholders. It is a priority to ensure that the costs borne by industry are as small as possible for a given level of clean electricity investment. This criterion will be measured by a qualitative assessment of expert interviews with electricity generating firms. The interviews will probe participant reactions to particular policies and will determine whether particular policies are deemed to be favourable. Interviews with firms that currently produce a large proportion of electricity in Alberta will be assigned higher weight than with firms that supply a small percentage of total electricity. The opinions of new entrants to the electricity market as a result of the policy are not considered, as they are not as influential for determining new policies. Any policy that is viewed quite favourably will receive a score of 3 or high; if viewed with reasonable support the policy will receive a score of 2 or moderate; and if viewed with a complete lack of support the policy will receive a score of 1 or low.

Public Perception: This criterion assesses the reaction from the general public as a result of the policy being enacted. How the policy is viewed by the general public will be a major factor in altering the electricity market structure in Alberta. Negative public sentiment will likely lead to government mistrust, but it could go as far as civil protest and disobedience depending on the severity of their concerns. The desired outcomes in Table 4 help to determine the difference between major and minor public backlash. A policy that satisfies one or less desired outcomes has the potential for major backlash; two or three desired outcomes may have moderate backlash; and all four desired outcomes should have minor backlash from the public.

Table 4: Index for Measuring Public Perception

Category	Desired Outcome
Public Life	1) Policy does not impact the daily lives of the majority of citizens
	2) Policy is transparent and easily understood
	3) Policy aligns with the general political and economic views of the citizenry (right-wing conservative)
Media	4) Policy does not receive negative media attention for an extended period (>1 month)

Chapter 6. Policy Options

This chapter outlines the policy options developed to increase the proportion of clean electricity being produced in Alberta.

6.1. Policy Option One: Clean Electricity Feed-in Tariff

The Alberta Clean Electricity Feed-in Tariff would be a cost-based compensation for clean energy producers, providing price certainty using long-term contracts that help to finance clean electricity investments. Here, certified clean electricity producers can sell their electricity to the Alberta Power Pool for a higher price then what would be available on the open market. Long-term contracts between energy companies and utility regulators will extend for ten years. This time frame grants clean electricity producers certainty about prices and will help them determine whether new projects can be profitable. The Alberta Utilities Commission in conjunction with the Ministry of Energy will be tasked with managing long-term contracts with clean electricity producers and providing additional funds to these firms when their costs of production exceed market price. The Alberta Utilities Commission can recover these funds with higher costs for end-users of electricity. However, if the production cost of a clean energy technology exceeds 5¢/kWh, a threshold established to protect consumers from price spikes, a fund will pay for additional top-ups. The funds to pay for the price gaps that exceed 5¢/kWh will come from a new Clean Electricity Fund that firms operating coal- and natural-gas-fired thermal plants will have to pay into. The amount private firms pay will be an annual flat rate based on projected power generation in a given year. Price caps will be established to set a limit on how much the Clean Electricity Fund will be able to top up electricity prices to clean electricity firms. This will ensure that only technologies that are relatively close to standard market prices will be provided long-term contracts.

The designation of “clean” electricity means that any production technology that creates no net increase in the level of greenhouse gas emissions can qualify for the Feed-in Tariff. If a coal or natural gas plant chooses to add a carbon capture and storage facility, then it could qualify for the Feed-in Tariff. This type of flexibility allows firms the choice of determining what mix of technologies would be most profitable when faced with the potential for an economic benefit from the utility regulator. Rather than being punished for a poor performance in terms of their emissions levels, a firm has the opportunity to be rewarded if they subscribe to certain production techniques.

6.2. Policy Option Two: Clean Electricity Standard

The Alberta Clean Electricity Standard would ensure that all suppliers of electricity are forced to attain a minimum standard of clean electricity production. By investing in clean electricity, firms will be given credits that can then be bought and sold in a tradable market with other electricity firms. A firm has the choice to invest in new clean energy capital that will allow their existing capacity to fall within the minimum standard, or they can choose to purchase credits from another electricity vendor. If a firm fails to reach the minimum standard of clean electricity generation and does not purchase credits from other producers, it will face stiff financial penalties. This is a market-based approach in the sense that firms are faced with a multitude of ways to enhance their minimum clean electricity production and must bear the costs of those choices. Once again, the designation of "clean" electricity means that firms can invest in any technology deemed to be carbon neutral. Over time the Clean Electricity Standard will increase in order to effectively establish the desired level of clean electricity investment. The exact proportion of clean electricity that firms would have to achieve will be determined after a review of the technical constraints of the electricity system and a discussion with energy firms.

In order to monitor and enforce the Clean Electricity Standard, the Alberta Utilities Commission will need to expand its capacity. Evaluating which firms have or have not complied with the minimum standard will be a large burden and will likely require heavy administrative changes. These changes include greater emphasis on data collection from energy firms, the design and maintenance of a credit market, and increased inspections to ensure that firms are indeed using clean energy technologies. The extent of these changes will have to be determined after an examination of the policy within the Alberta Utilities Commission.

6.3. Policy Option Three: Electricity Emissions Tax

The Alberta Electricity Emissions Tax is a per unit tax on carbon emissions specifically tied to the electricity sector. The Emissions Tax will be an expansion of the existing Specified Gas Emitters Regulation that charges $15/tonne of CO_2 if emission intensities exceed a particular baseline. Often the Specified Gas Emitters Regulation is criticized for having a high baseline target resulting in the average cost per unit of carbon produced to be quite minimal. Instead of charging firms the tax only when they exceed a baseline, the new Emissions Tax will charge a firm a given price for each unit of emissions, similar to the BC Carbon Tax. The Emissions Tax is a market tool that can be used to incentivize firms to reduce their consumption of fossil fuels while simultaneously increasing the financial liability of clean energy investment by increasing the cost of using carbon-based inputs. The funds generated from the Emissions Tax can be used in any number of ways including investment in research and development for clean technologies, general funds for government expenditure, or redistribution to citizens through income tax reductions. The final decision for the deployment of these funds will be determined by the Alberta's governing party.

In order for this policy to effectively shift demand from fossil fuel technologies toward clean energy, it is crucial that we understand the marginal abatement costs experienced by firms. If we are unaware of the cost function of these firms then the Emissions Tax may become an additional fee for electricity firms without witnessing an increase in the proportion of clean electricity used. This challenge will likely require the Emissions Tax to grow steadily over time in order to find the optimal level of clean electricity production. Initially this tax will be applied only to the electricity sector with potential expansion into other industries as time progresses. The reason for this is to ensure that the problem of carbon emissions in the electricity sector is tackled first, without implicating the entire economy. Furthermore, applying the tax only to the electricity sector offers a better means of evaluating each policy option individually without implicating spill-overs into other energy sectors that are beyond the scope of this analysis. As the policy progresses and implementation issues are managed, there will be opportunities to expand the policy further.

Chapter 7. Policy Analysis

This chapter evaluates the policy options based on the criteria and measures outlined in chapter 6. The results of this analysis are summarized in Table 5 and a recommendation follows.

7.1. Policy Option One: Feed-in Tariff

Effectiveness: Based on existing literature, data gathered from the Ontario experience, and expert interviews, a Feed-in Tariff is a very effective means of increasing clean electricity investment. By decreasing the costs of production through a “top-up” on electricity prices and reducing the risk of investing in clean energy projects in the long-run, it is very likely that the electricity system in Alberta will enhance its clean electricity investment. Based on the experience in Ontario, investment could easily exceed 20% of system-wide production in the next 10 years. For effectiveness, this policy option receives a score of 3 or high.

Economic Cost: This policy tends to be economically inefficient because industries that are not as competitive in the existing electricity market are able to gain greater access to market share. A Feed-in Tariff essentially chooses which technologies to support even if their long-run cost effectiveness is questionable. While the type of Feed-in Tariff established here limits access to clean technologies, allowing only those that are relatively close to existing market prices to be granted the subsidy, the market price of electricity will rise. Market prices will increase because every firm is forced to pay into the Clean Electricity Fund, thereby increasing their costs of production. In the case of Ontario, the price of electricity rose dramatically, exceeding the 4¢/kWh threshold for a number of different technologies. Not only will the initial price of electricity increase, but the long-term price of electricity may remain high as firms that invest in clean electricity have limited incentives to invest in efficiency gains. For economic efficiency, this policy receives a score of 1 or low.

Government Impact: Subsidizing inefficient technologies, regardless of their potential benefits is not the type of policy that is often considered within the Alberta government. The reason the Province wanted to establish a competitive electricity structure was to reap the rewards of efficiency gains. A Feed-in Tariff does not align with those objectives. The Feed-in Tariff fails four of the benchmarks for government impacts, but it could be firmly supported by the governing party if they focused on the benefits of reducing GHG emissions and that the policy will not be funded by government expenditure. For government impacts this policy receives a score of 1 or low

Administrative Feasibility: The Feed-in Tariff may be administratively difficult in terms of the requirements to manage new clean electricity projects and "top-up" the price of electricity for certain producers. Managing the Clean Electricity Fund may also prove to be a challenge and will likely require an increase in funding and staff. However, the Feed-in Tariff requires no enforcement, has easily accessible data in terms of clean electricity providers, and is comparable across all electricity providers. The Feed-in Tariff manages to accomplish three of the six benchmarks in terms of its administrative feasibility and therefore receives a score of 2 or moderate.

Stakeholder Acceptability: Existing electricity firms will have a complicated relationship with the Feed-in Tariff policy. On one hand, the policy requires all firms that use fossil fuels to generate electricity to pay into a Clean Electricity Fund, which will negatively impact their level of profits. However, electricity firms that diversify and invest in clean electricity production may be able to benefit from the policy. Information gathered from the interviews suggests that existing electricity firms enjoy the competitive market structure in Alberta and believe that government intervention tends to limit profit maximization. Existing firms are unlikely to support this policy as it forces them to support the production costs of competing firms because they have to pay into the Clean Electricity Fund. Firms that solely produce clean electricity support the policy to a much greater extent but their existing production is so small that we cannot base stakeholder acceptability on their opinions. For stakeholder acceptability this policy receives a score of 1 or low.

Public Perception: The general public will likely perceive the Feed-in Tariff as a poor choice in the Alberta context. The idea of subsidizing non-cost competitive industries will not align well with the political and economic sentiments of most citizens and will likely be further attacked by the media in Alberta. The Feed-in Tariff satisfies less than three of the benchmarks for public perception and receives a score of 1 or low.

7.2. Policy Option Two: Clean Electricity Standard

Effectiveness: The Alberta Clean Electricity Standard will be very effective at achieving higher system-wide clean electricity production. It does so by mandating the exact proportion of clean electricity that each firm must produce, thereby achieving any level of clean electricity that the Government of Alberta wishes to achieve. The utility regulators will likely see fit to gradually increase the necessary proportion of clean electricity production over time as firms adjust to the new policy. Achieving a 20% clean electricity threshold will be quite easy with the Clean Electricity Standard and therefore this policy receives a score of 3 or high for effectiveness.

Economic Cost: Forcing electricity firms to invest in clean electricity projects will undoubtedly impose new costs on the economy and will likely lead to an increase in the price of electricity for consumers. According to data gathered from the Renewable Portfolio Standard in California, a 1.2¢/kWh increase in the price of electricity could be directly correlated to the policy's implementation. Superimposing this data in the Alberta context is possible, however, California is a jurisdiction with a greater potential for clean electricity production with much more cost-effective solar and geothermal projects. This means that minimum requirements for clean electricity in California is likely a much cheaper option than in Alberta. It is reasonable to assume that Alberta could experience a higher increase in the price of electricity compared California, but it would be very unlikely to exceed a 4¢/kWh price increase based on the discussion with interview participants. With tradable certificates, this mechanism does incentivize production firms to improve the efficiency of their clean electricity production in the long run and could lead to small price reductions. Although a tradable quota system can be as economically efficient as taxation, the initial allocation of the minimum standards will result in some market difficulties that could lead to higher prices. For economic efficiency, this policy scores a 2 or moderate.

Government Impact: The Clean Electricity Standard falls reasonably within the bounds of acceptable policy for the Government of Alberta. This policy is market-based, does not veer too far from existing provincial policy, and poses little threat to the reputation of the government. Furthermore, the government should have the capacity to firmly stand behind the principles of the Clean Electricity Standard as it sets to reduce GHG emissions without imposing undue hardships on consumers. For government impact, the Clean Electricity standard satisfies all four benchmarks and receives a score of 3 or high.

Administrative Feasibility: Management of the Alberta Clean Electricity Standard will prove to be one of its most challenging aspects. This policy will require a large extension of the powers afforded to the Alberta Utilities Commission in order to track and manage clean electricity certificate trading and monitor individual clean energy facilities to ensure they are producing at necessary levels. These components will require new legislation, regulations, funding, and data. Further increasing the administrative burden, the AUC will be in charge of enforcing penalties on firms that do not comply with the policy and managing their complaints as they arise. For administrative feasibility this policy fails all six benchmarks and receives a score of 1 or low.

Stakeholder Acceptability: During the course of the expert interviews, the Clean Electricity Standard was somewhat well received by participants. Existing firms that produce electricity through the use of fossil fuels are not pleased with the idea that a portion of their profits will end up in the hands of their competitors that produce primarily clean electricity. However, these firms have the ability to invest their own capital into clean energy alternatives in order to increase their own proportion of clean electricity production if they see fit. Putting money into the hands of competitors is a choice that firms will have to make like any decision when faced with new regulations. Undoubtedly, firms will initially be upset with new clean energy requirements but the flexibility that this policy option provides gives firms choice, something that is crucial in a competitive market. For stakeholder acceptability, this policy receives a score of 2 or moderate.

Public Perception: The Clean Electricity Standard is a policy that will not impact the general public on a daily basis. The policy targets electricity firms rather than demand-side consumers, meaning that a Clean Electricity Standard could remain unknown to many citizens. Where it could impact citizen's lives is in regions where there is high uptake of clean energy projects that interfere with rural communities. Furthermore the policy could receive some negative media attention based on the government interfering with the competitive electricity structure that already exists. Therefore this policy fails two of the four benchmarks for public perception and receives a score of 2 or moderate.

7.3. Policy Option Three: Emissions Tax

Effectiveness: The Alberta Electricity Emissions Tax is an effective means of reducing the gap between the production costs of fossil fuel thermal plants and clean electricity projects. However, this policy lacks crucial information that makes it difficult to measure the level of success it will have in terms of a shift towards clean electricity technologies, namely, the marginal abatement cost of every electricity firm. Without a precise evaluation of every firm's marginal abatement cost we will not be able to set an emissions tax rate that would lead to an exact emissions reduction floor. By setting a price of carbon we are assuming that firms will reduce their emissions but we cannot accurately know by what degree clean electricity production will increase. Without this information it is impossible to firmly state that clean electricity production in the province will exceed 20%. However, we can adequately assume that even a minimal tax on the price of carbon will lead to higher than normal investment in clean electricity that will exceed 10%. For effectiveness, this policy receives a score of 2 or moderate.

Economic Efficiency: The Alberta Emissions Tax is an economically efficient way of internalizing the external costs of carbon pollution into the price charged for electricity. Based on my own calculations (See Appendix B), a \$15/tonne CO_2 emissions tax would lead to a price increase of nearly 1.5¢/kWh for coal-fired thermal plants. The same emissions tax would lead to a price increase of 0.9¢/kWh for natural-gas-fired thermal plants. These numbers indicate that a modest carbon tax would have minimal implications for the price of electricity being charged to consumers. If the tax was doubled to \$30/tonne CO_2, the level it is currently set in British Columbia, it would lead to a 3¢/kWh price increase for firms using coal-fired thermal plants and 1.8¢/kWh for those using natural gas. While these numbers suggest that the Emissions Tax could lead to prices that exceed the 2¢/kWh threshold, it is important to consider that the existing Specified Gas Emitters

Regulation has not been considered meaning that the increase in the unit price of electricity may even smaller than the calculations provided because some carbon emissions are already being priced. Furthermore, as firms manage their new cost structures with the new Emissions Tax, they are incentivized to find ways to reduce costs and limit the effect of these charges, leading to lower costs for consumers in the long run. Finally, Alberta is naturally shifting away from coal-fired thermal plants towards natural gas, a fuel source that is less emissions-intensive and therefore less negatively affected by the Emissions Tax. For economic efficiency, the Emissions Tax receives a score of 3 or high if the tax rate remains under \$30/tonne CO_2 until 2025.

Government Impact: New forms of taxation are generally not the preferred method of policy-making in Alberta, especially in the energy sector. Increasing the level of taxation clashes with the political views of governing Conservative Party in Alberta; however, in terms of free-market economics, its principles remain intact. There could be some risk to the reputation of the Conservative Party by putting forth this type of policy, based on their historical tendency to reduce the amount of tax charged to citizens and industry. Strong leadership surrounding this policy option is possible if the governing party continually supports the region's commitment to GHG emissions reductions and a market-oriented method of doing so. For government impacts, this policy receives a score of 2 or moderate.

Administrative Feasibility: This policy mechanism is very simple to implement and encounters few administrative hurdles because emissions in the electricity sector are already calculated through the Specified Gas Emitters Regulation. Applying the Emissions Tax will be a simple formula initiated by the Alberta Utilities Commission but will not increase the need for funding or new regulations. The only benchmark this policy fails is the requirement for new regulation. For administratively feasibility, the Emissions Tax receives a score of 3 or high.

Stakeholder Acceptability: During the course of the expert interviews, this policy appeared as the most-favoured choice for existing electricity firms. Firms like the idea that a tax can be applied to carbon emissions with little involvement on the part of government. This way firms are allowed the flexibility to choose how they would like to respond to the new costs of producing GHG emissions. The issue with this policy arises when we consider the inequality that exists between charging electricity firms for their carbon emissions while failing to charge other types of industries for the same types of emissions. This will leave electricity firms asking why their services must be taxed while others are not. Built into this policy option is the assumption that the provincial government will eventually establish a province-wide tax after further discussions with other industries, but in the short run it will leave electricity firms unsatisfied with government policy. For stakeholder acceptability this policy option receives a score of 2 or moderate.

Public Perception: The Emissions Tax will likely be seen in a negative light by the larger public in Alberta. Negative media attention is a certainly a major concern for this policy option, particularly because it clashes with the political sentiments of the general population. The Emissions Tax may also be perceived as having a negative impact on the daily lives of citizens if they believe the tax is likely to extend beyond the confines of the electricity sector. The only benchmark that it does accomplish is transparency as it is quite obvious what is being taxed and how. For public perception this policy option receives a score of 1 or low.

Table 5: Policy Analysis Results Matrix

Criteria	Feed-in Tariff	Clean Electricity Standard	Emissions Tax
Effectiveness (x2)	**3 (6)**	**3 (6)**	**2 (4)**
Economic Cost (x2)	**1 (2)**	**2 (4)**	**3 (6)**
Government Impact	**1**	**3**	**2**
Administrative Feasibility	**2**	**1**	**3**
Stakeholder Acceptance	**1**	**2**	**2**
Public Perception	**2**	**2**	**1**
Total	**14**	**18**	**18**

7.4. Policy Recommendation

After a careful analysis of three distinct policy options, it is unclear which policy should be chosen. Two policies, the Alberta Clean Electricity Standard and the Alberta Electricity Emissions tax scored the highest, but neither is a dominant policy. The Clean Electricity Feed-in Tariff scored far lower than the other two options, mainly because of its incompatibility with a competitive market for electricity. Inherent in the concept of a Feed-in Tariff is supporting industries that are not economically advantageous in order to accomplish some other goal. This creates inefficiencies in the market, resulting in a negative stance on the part of Alberta's government and existing stakeholders. A Feed-in Tariff may be the best policy option for other jurisdictions, but it is not appropriate for the Alberta electricity sector and can be excluded from the potential recommendations.

Between these two top-scoring policy options, the Alberta Clean Electricity Standard and the Alberta Electricity Emissions Tax, there exist clear trade-offs. The Clean Electricity Standard scored higher in terms of effectiveness as it mandates the exact quantity of clean electricity that needs to be produced, while the Emissions Tax cannot guarantee a particular reduction in emissions through increased clean electricity investment. However, the Emissions Tax will tend to impose fewer costs on the price of electricity compared to the Clean Electricity Standard as it avoids mandating changes to the types of technologies used to produce electricity. Such mandates inherently drive the economic costs of the policy upward whereas charging firms the social cost of producing GHG limits inefficiencies that mandated technologies can create. This assumption is based both on the economic principles outlined previously and the findings of the case studies. The biggest barrier for the Clean Electricity Standard is the administrative feasibility involved in managing a complex system of regulations and certificate trading. For the Emissions Tax, the biggest challenge is to meet the approval of the general public and achieve support for the tax through strong government leadership. Basing the decision of which policy should be implemented solely on the basis of the chosen policy objectives appears to be a fruitless endeavour as each of these two policies has its strengths and weaknesses. A consideration of other factors may be necessary.

Distinguishing between these two policies will require a discussion of the impacts of each option and how well the Government of Alberta can mitigate risks. By implementing the Clean Electricity Standard, the greatest threat to an efficient electricity sector is the administrative burden of dealing with existing electricity firms and ensuring that the minimum standard of clean electricity is produced. Although this option may present a daunting challenge it is manageable. Utility regulators in Alberta can adjust to changing market conditions and solve any inadequacies internally without involving other agents such as the governing political party or the general public. Implementing the Emissions Tax has the opposite effect. By directly taxing a market externality, it presents the opportunity for political and social parties to voice their concerns, particularly if they feel that the emissions tax will extend beyond the electricity sector. Establishing an emissions tax opens a massive debate surrounding the entire energy sector in Alberta, particularly in regard to its impact on the overall economy. The debate over emissions taxation could take years to complete and in the meantime little will be accomplished in supporting clean electricity production.

After including the potential risks of each policy option, it is recommended that the Alberta Clean Electricity Standard be implemented. This policy option is a creative means of increasing the proportion of clean electricity in the province while minimizing economic inefficiency. Furthermore, the Clean Electricity Standard can be implemented immediately, in order to firmly establish Alberta's commitment to reducing GHG emissions in both the short and long run. The debate surrounding whether to implement an emissions tax on the energy sector can continue, but in the interim it is important to make strides toward clean energy investment. The Clean Electricity Standard has a few minor issues that need to be sorted out, particularly in regard to consumer electricity pricing, administrative feasibility, and support from existing electricity firms. Managing these concerns will be the responsibility of the Government of Alberta whose commitment to reducing GHG emissions will require strong leadership and courage.

The intricacies of the Clean Electricity Standard still need to be established in an active conversation among government, utility regulators and individual firms. These conversations will include minimum clean electricity requirements, the issuing of clean energy certificates, and how the trading scheme will function. System planning will play a major role as an increase in clean electricity production will create capacity constraints as non-dispatchable technologies replace those that are dispatchable. A discussion of these variables has not been conducted in the analysis in order to evaluate the principles of each policy option rather than unique variables. For future research it may be beneficial to apply regression-type models to determine what the exact impact of a given minimum requirement for clean electricity or a given emissions tax would be on electricity prices. The research presented here will be a beginning tool for the ongoing conversation regarding the best way to reduce emissions in Alberta's electricity sector.

Chapter 8. Conclusion

Alberta is one of the largest emitters of greenhouse gas emissions in Canada. If the province wants to improve its pollution record, a good place to start is to develop policy aimed at converting its electricity generation from thermal plants toward non-emitting technologies. Unfortunately, the competitive electricity market structure will continue to support fossil fuel industries as long as they have a cost advantage over alternatives. This presents a policy problem. Without government policy intervention, alternative methods of electricity generation such as wind, small hydro, geothermal, solar, and thermal plants with carbon capture and storage will not expand production at a rate that will significantly cut carbon emissions.

In this paper I have presented and assessed three potential policy options that could be used to enhance the proportion of clean electricity produced in Alberta. These options were evaluated based on six criteria to incorporate important factors such as the level of clean electricity production, consumer costs, political willingness, and public scrutiny, among others. After a careful analysis it was determined that the Clean Electricity Standard would be the most appropriate option in the context of the Alberta electricity market. This option is a market-based instrument that forces firms to produce a given level of clean electricity while simultaneously incentivizing them to efficiently use clean electricity resources to their advantage. The policy suffers from some downfalls such as increasing the price of electricity and being difficult to administer. With careful planning and coordination between electricity producers and consumers, it is possible to reduce the blow of many problems inherent in a Clean Electricity Standard.

If our planet is to avoid catastrophic environmental damage due to climate change, action is required across the globe to reduce GHG emissions. Emissions from Alberta represent only a small fraction of what is necessary to dramatically improve the well-being of our world’s ecosystems, but it is our ethical responsibility to act. Establishing a Clean Electricity Standard in Alberta is one small step toward a global push to fight climate change in order to ensure a viable future for generations to come.

References

Alberta Electric System Operator. (2009). “Future Demand and Energy Outlook (2009 - 2029)”

Alberta Electric System Operator. (2012). “2012 Long-Term Outlook”

Alberta Department of Energy. (2005). “Alberta’s Electric Policy Framework: Competitive, Reliable, Sustainable”.

Alberta Ministry of Energy. (2012). “Power for the People”.

America’s Energy Future Panel on Electricity from Renewable Resources (NRC). (2010). “Electricity from Renewable Resources: Status, Prospects, and Impediments”. National Academies Press. Washington, DC.

Angevine, Gerry; Murillo, Carlos; Pencheva, Nevena. (2012). “A Sensible Strategy for Renewable Electrical Energy in North America”. Fraser Institute.

Boden, T.A., G. Marland, and R.J. Andres. 2010. Global, Regional, and National Fossil-Fuel CO2 Emissions. Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy

Borenstein, Severin. (2012). “The Private and Public Economics of Renewable Electricity Generation”. Journal of Economic Perspectives, 26 (1), pp. 67-92.

Bovenberg, A. Lans and Goulder, Lawrence. (2001). “Environmental Taxation and Regulation”. National Bureau of Economic Research.

California Energy Commission. (2003). “Integrated Energy Policy Report”.

California Energy Commission. (2014). “Tracking Progress – Renewables”.

Carr, Jan. (2010). “Power Sharing: Developing Inter-Provincial Electricity Trade”. C.D. Howe Commentary: Economic Growth and Innovation, No. 306.

Center for Climate and Energy Solutions. (2009). “Copenhagen Climate Summit: Summary”

Congressional Budget Office (Congress of the United States). (2001). “Causes and Lessons of the California Electricity Crisis”.

Dewees, Donald. (2013). “The Economics of Renewable Electricity Policy in Ontario”. University of Toronto.

EDC Associates. (2013). “Trends in GHG Emissions in the Alberta Electricity Market”

Energy and Environmental Economics, Inc. (2014) “Investigating a Higher Renewable Portfolio Standard in California”

Energy Information Administration (2014). “California Net Electricity Generation by Source”

Environment Canada. (2012). “National Inventory Report 1990 – 2012:Greenhouse Gas Sources and Sinks in Canada.

Fraser Institute “A Sensible Strategy for Renewable Electrical Energy in North America”, 2012.

Goddard Institute for Space Studies. (2012). “GISS Surface Temperature Analysis”

Government of Alberta. (2013). “Electricity Statistics”

Government of British Columbia. (2010). “Clean Electricity Act”

Government of British Columbia. (2012). “Electric Generation and Supply”. Ministry of Energy and Mines. Web: http://www.empr.gov.bc.ca/EPD/ELECTRICITY/SUPPLY/Pages/default.aspx

Government of British Columbia. (2007). “The BC Energy Plan: A Vision for Clean Energy Leadership.

Jaccard, Mark. (2004). “Renewable Portfolio Standard”. Encyclopedia of Energy, Volume 5.

Jaccard, Mark; Rhodes, Ekaterina. (2013). “A Tale of Two Climate Policies: Political Economy of British Columbia’s Carbon Tax and Clean Electricity Standard” Canadian Public Policy. 30 (2).

KPMG. (2014). “Alberta’s Future Energy Mix: Exploring the Potential for Renewables”.

Mendoca, Miguel; Jacobs, David; Sovacool, Benjamin. (2010). *Powering the Green Economy: The Feed-in tariff Handbook.* Earthscan. Sterling, VA.

OnPoint Consulting Inc. (2010). “Realizing British Columbia’s Second Renewable Electricity Revolution”.

Ontario Ministry of Energy. (2012). “Ontario’s Feed-In Tariff Program: Two Year Review Report”.

Ontario Ministry of Energy. (2013). “Achieving Balance: Ontario’s Long-Term Energy Plan”.

Pembina Institute. (2012). “The High Cost of Cheap Power: Pollution from Coal-fired Electricity in Canada”.

Rabe, Barry. (2007). “Race to the Top: The Expanding Role of U.S. State Renewable Portfolio Standards”. Sustainable Energy, Volume 7(3).

Rivers, Nic; Bohringer, Chris; Rutherford, Tom; Wigle, Randy. (2012). “Economic and Employment Impacts of Ontario’s Feed-in tariff Program”. Ontario Network for Sustainable Energy Policy.

Rivers, N., and B. Schaufele. (2013). “Carbon Tax Salience and Gasoline Demand.” Working Paper. Ottawa, ON: Graduate School of Public and International Affairs and Institute of the Environment, University of Ottawa

Stokes, Leah. (2013). “The Politics of Renewable Energy Policies: The case of feed-in tariffs in Ontario, Canada. *Energy Policy*. Volume 56. pp. 490-500

Tideman, T.N. and Plassman, F. (2010). “Pricing externalities”, European Journal of Political Economy, 26 (2), pp.176-184.

Tides Canada. (2013). “Power to Change: How Alberta can Green its Grid and Embrace Clean Energy”.

United States Energy Information Administration. (2014). “Carbon Dioxide Emissions Factors for Coal and Natural Gas”.

Van Kooten, G.C. (2011). “Economic Analysis of Feed-in tariffs for generating Electricity from Renewable Energy Sources” University of Victoria.

Wiser, Ryan; Pickle, Steven; Goldman, Charles. (1998). “Renewable Energy Policy and Restructuring: A California Case Study”.

Zareipour, Hamidreza; Canizares, Claudio; Bhattacharya, Kankar. (2007). “The Operation of Ontario’s Competitive Electricity Market: Overview, Experiences, and Lessons”. Institute of Electrical and Electronics Engineers.

Appendix A.

Interview Questions

The following is a list of all interview questions I may have posed during the course of the expert interviews:

What are the most important renewable resources that exist in the province?

Are their possibilities to enhance the output of unused technologies? Ex. solar and geothermal?

Are renewables considered to be a top priority in existing electricity system planning in Alberta?

Do you feel as though an increase in the amount electricity produced by renewables would be technically feasible in Alberta?

What do your feel are the largest barriers to entry for clean electricity production technologies in Alberta?

Is the cost of renewable production significantly higher than conventional sources such as coal or natural gas fired thermal plants?

In a competitive market for electricity, what capacity does your agency have to enhance the output of renewable resources?

Do you feel as though consumers would be willing to purchase renewable energy even if it had an associated premium?

Without policy to incentivize firms to invest in renewable electricity, do you feel as though there will be any growth in clean electricity in the next 10 years?

Does your agency feel as though a carbon tax would be an effective means of increasing renewable production?

Does your agency feel as though a renewable portfolio standard would be an effective means of increasing renewable production?

Does your agency feel as though long-term contracts and/or and feed-in tariff would be an effective means of increasing renewable production?

Would your agency be more interesting in pursuing renewable energy production if the government offered some type of subsidy?

Administratively, would it be difficult to implement the above polices in Alberta?

Why has TransAlta chosen to invest in renewable forms of electricity generation?

Are renewable energy production sources a part of your agency's future electricity framework?

Do you feel as though the cost of investing in renewable electricity generation is higher than coal or natural gas fired thermal plants (per unit of electricity)?

Do you feel as though the cost per unit of electricity would increase for consumers if TransAlta invested more heavily in renewable electricity generation?

Does you think industry would be responsive to including renewable quotas to their electricity production?

How would a provincial carbon tax effect the types of electricity generation that firms invest in?

Would your company be more interesting in pursuing renewable energy production if the government offered some type of subsidy?

Do you feel as though increased renewables would be technically feasible in Alberta?

Why do you think has solar power not had the same grid penetration compared to hydro and wind power?

Does your agency ever consider greenhouse gas emissions to be a major problem in the electricity sector in Alberta?

Do you feel as though the prospects for carbon capture and storage are legitimate? Could we see carbon capture and storage become a major component of Alberta's electricity sector in the near future?

Without policy to incentivize firms to invest in renewable electricity, do you feel as though there will be any growth in clean electricity in the next 10 years?

Do you feel as though consumer electricity rates would significantly increase if renewables were provided grid parity rates and long-term contracts?

Appendix B.

Policy Cost Calculations

Tonnes of CO_2 emitted per kWh generated (U.S EIA 2014):

- Coal: .0094
- Natural gas: .00058

kWh produced for each fuel type:

- Coal: 39,186,000,000
- Natural gas: 29,028,000,000

Tonnes of CO_2 generated in each industry:

- Coal: 407,534
- Natural gas: 176,917

With a hypothetical carbon tax of $30/tonne CO_2 (similar to B.C.)

- Coal: $30/tonne x .0094 = 2.8¢/kWh
- Natural Gas: $30/tonne x .00058 = 1.7¢/kWh

Average price increase is 2.3¢/kWh, without including the existing effect of the Specified Gas Emitters Regulation. Furthermore the transition towards natural gas will likely involve a much smaller price increase than presented here.