Environmental Science Undergraduate Thesis: Nova Scotia's Carbon Tax Potential

Honours Professor: Dr. Daniel Rainham

Honours Supervisor: Dr. Melvin Cross

Prepared by: Catherine MacNeil

March 29, 2011

Abstract

This paper explores the potential for a carbon tax in Nova Scotia as a means of meeting the provincial targets for carbon dioxide equivalent reductions of 10% below 1990 levels by 2020. The study first evaluates the current carbon tax policy in place in British Columbia and compares Nova Scotia to British Columbia. Similarities and differences between the coastal provinces are assessed in climate change risks, fossil fuel production and climate policy. Three potential tax progressions were then simulated on Nova Scotia Power Incorporated (NSPI) as a case study. The tax progressions include a tax modeled from the current BC tax, a constant tax rate and an increasing tax rate that were designed to meet the emissions reduction goal. All three carbon tax progressions are theoretically capable of meeting the reduction target while marginally increasing electricity rates. There are however, many environmental and socio-economic benefits and downfalls associated with this climate policy. Due to the limitations of this study more research into this area is needed before conclusive results can be found.

Table of Contents

Chapter 1 - Introduction

The cause of global warming remains controversial due to the complexities of the Earth system and the difficulty in attributing cause to natural and anthropogenic sources of greenhouse gases (Kump, Kasting & Crane, 2010, p. 3). Gases such as carbon dioxide, methane and nitrous oxide are also called greenhouse gases (GHGs). These gases reflect and absorb incoming solar radiation and absorb and emit longer infrared radiation (Intergovernmental Panel on Climate Change, 2007). These greenhouse gases increase the Earth's average temperature to a level that allows life to exist (Kump, Kasting & Crane, 2010, p. 3). Increases in greenhouse gas concentrations change the atmosphere's ability to reflect and absorb radiation. This causes changes in the radiative forcing, the balance between incoming and outgoing radiation, of the climate system. Changes in radiative forcing contribute to increases and decreases in global average temperature (International Panel on Climate Change, 2007).

Carbon dioxide, methane and nitrous oxide are long-lived greenhouse gases. These gases remain in the atmosphere long enough to become evenly distributed through the atmosphere before they can be removed by chemical processes. These gases therefore have a long term effect on the climate (International Panel on Climate Change, 2007). Regardless of the source, the introduction of these greenhouse gases through natural or anthropogenic sources will affect the climate through changes in radiative forcing.

Though the effects of climate change are global, some parts of the globe will be subject to more severe consequences. Reports have shown that those who have contributed least to the accumulation of anthropogenic greenhouse gases in the atmosphere are already feeling the burden of the effects. For example, impoverished women in poor countries are already bearing the disproportionate brunt of climate change (UNFPA & WEDO, 2009). Although developing countries have only contributed one quarter of the total anthropogenic emissions, they will likely be unable to cope with the effects of climate change, such as increase in disease, alterations in precipitation patterns and affects on agriculture among others (UNFPA & WEDO, 2009; McConnel & Abel, 2008, p. 69).

These changes are likely to cause migration from developing countries where resources will become more scarce to developed countries. Furthermore, those who remain in affected areas will not have the resources to accommodate the changing climate. In turn this will increase the potential for violent conflict in areas that are largely affected by the changes (Barnett and Adger, 2007). Climate Change is therefore not only an ecological problem but one the affects the global economy and global security.

As a province with the majority of the population living on the coast, Nova Scotia is at risk of significant effects from Climate Change. Sea level rise and extreme weather events resulting from the changing climate will increase coastal flooding and erosion. Although increases in temperature may result in a longer growing season and higher crop yields, it may also result in increased risk of pests and drought. Increasing ocean temperatures and acidity may negatively affect fish stocks, migration patterns and reproduction. Increasing flooding may result in groundwater contamination and changes in rainfall patterns may affect water levels in watersheds. Increasing temperatures may improve habitat for forest pests and disease as well as habitat for vector-borne disease carriers (Clean Nova Scotia, 2009).

In response to the potential for major ecological, social and political unrest, the United Nations created the United Nations Framework Convention on Climate Change (UNFCCC), an international treaty created to consider the possibilities available to reduce global warming and to create adaptation measures. This treaty was signed by most countries (UNFCCC, 2008). From the UNFCCC came the Kyoto Protocol, adopted the 11 of December 1999 and entered into force on the 16 of February 2005. The Protocol sets binding emission reduction targets for 37 industrialized nations and the European community. This emission reduction strategy sets emission reduction to an average of five percent below 1990 levels over the period from 2008 to 2012. The Protocol recognizes the need for industrialized nations to contribute a greater amount of emission reduction based on their responsibility for the current high level of GHG emissions in the atmosphere resulting from more than 150 years of industrial activity (United Nations, 1998). While the Convention encourages nations to stabilize their emissions, the Protocol commits them to doing so.

Under the Kyoto Protocol, Canada agreed to reduce emissions to 6% below 1990 levels (United Nations, 1998, p. 20). In 2008, Canada's greenhouse gas emissions were 734 megatons or 24.1% above 1990 levels (Environment Canada, 2008). The Canadian government predicts that emissions will continue to rise to 897 megatons by 2020 (Government of Canada, 2005) In 2007 the federal government announced it would not attempt to meet the Kyoto goals (Canada-Kyoto, 2007).

Since not all countries followed their Kyoto Protocol commitments, a plan was set out in Bali Indonesia at COP13 called the Bali Action Plan. It sets out a guide for negotiations with the goal of securing a binding emission reduction strategy by the end of 2009 (UNFCCC, 2008). COP15 was, to many, the last chance to negotiate a binding deal, without which the future of the planet would remain uncertain. As a member of the global north Canada's role was critical in the Copenhagen negotiations. Canada was heavily criticized for their role in the negotiations, coming under fire from negotiators, the media and environmental non-governmental organizations (ENGOs) (Gatehouse, 2009). Canada received the "Colossal Fossil" award for being the country that not only contributed the least to the climate talks but also for actively obstructing progress (Climate Action Network, 2009).

In response to the inaction of the federal government on climate change, provincial governments have been taking the lead in creating climate change policy in Canada (Sierra Club Canada, 2007). In 2009, the Nova Scotia provincial government set out an emission reduction strategy in the Nova Scotia Climate Change Action Plan with the intent of reducing greenhouse gas emissions to at least 10% below 1990 levels by 2020 or approximately 5 megatonnes (Nova Scotia Department of Environment, 2009a). Nova Scotia's electricity production is highly dependent on coal and NSPI has been slow to transition to green energy technologies. According to the Nova

Scotia Action Plan, the electricity industry will account for the largest emissions reduction (Nova Scotia Department of Environment, 2009a).

This project will assess the feasibility of implementing a carbon tax in Nova Scotia as an alternative to the cap currently imposed by the provincial government. A carbon tax has the ability, theoretically, to reduce carbon dioxide emissions while creating government revenue that could be used to mitigate and adapt to climate change. Carbon taxes are also considered by many to be a double dividend. The tax acts not only to increase welfare by reducing pollutants but the revenue collected may also be used to reduce current tax distortions. This results in a smaller deadweight loss in the system (Glomm, Kawaguchi & Sepulveda, 2008). The feasibility will be assessed on the predicted ability of the tax to reduce emissions to the same degree that is planned by the cap. This requires the reduction of 2.5 megatonnes of carbon dioxide equivalents. Hopefully, this research will develop an interest in and provide a base for more research into emissions reductions strategies for Nova Scotia. The continuation of this research may provide an economically feasible and fiscally sustainable measure to reduce greenhouse gas emissions in Nova Scotia.

Chapter 2 provides the theoretical background used in this study. Chapter 3 explains the proposed methods that will be used to meet the goals of the study. Chapter 3 also includes the validity and the limitations and delimitations of the study. Chapter four summarizes the results of the study and will be followed by the discussion in chapter five. The conclusion will be the focus of chapter 6. The works cited and associated appendices are found after the conclusion.

Chapter 2 - Literature Review

2.0 Introduction

This chapter outlines the economic background on which the study is based. The economic theory of monopolies and carbon taxes has been well studied and this paper provides only a brief overview of the theory as needed to understand the basis of the work. A review of the basic economic terms and explanations is followed by an overview of previous research and the most prevalent debates in the field of carbon taxation and climate change policy. The literature review contains material found in academic sources as well as grey literature. Though the theory is well researched, many of the policies currently in place have yet to be analyzed and published academically.

2.1 Economic Background

Theoretically a monopoly is defined as “a market structure in which a single seller of a product with no close substitutes serves the entire market” (Frank & Parker, 2007, p. 433). In some cases the price of producing the good is lower in the case of one firm producing the good than if two or more firms were in the market. This is normally associated with a downward sloping average total cost (LAC) curve. If two or more firms tried to feed the market (each producing a share of the total), the average costs would be higher for each firm. This situation is a natural monopoly (Frank & Parker, 2007). A natural monopoly is not defined by the amount of firms acting in the market, like a common monopoly, but the relationship between cost and quantity (Figure 1). Even in the case of a natural monopoly there may be multiple firms in the market. This leads to inefficiencies in the market or the smaller firms will eventually be outcompeted and leave (Posner, 1969).

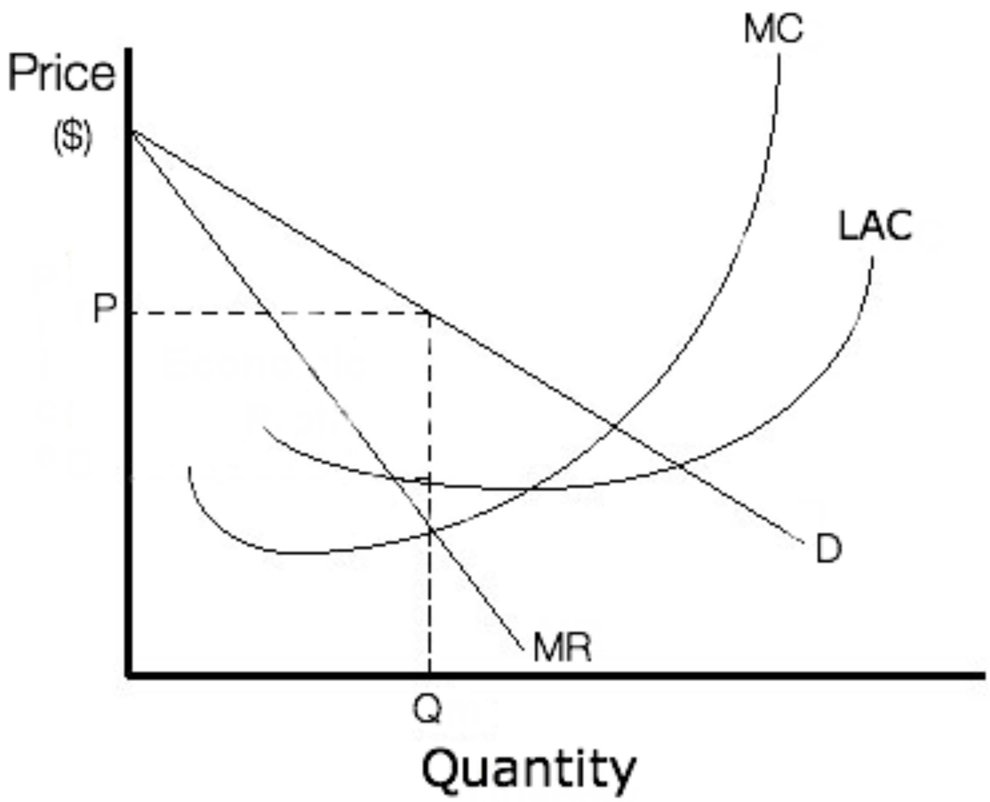

Figure 1. Graph showing natural monopoly demand, marginal revenue and marginal cost curves. The intersection of the marginal cost and marginal revenue represents the quantity produced and price per unit in this market. When two firms try to produce the market quantity in the same market, the marginal cost and therefore the price, is higher. In the case of a natural monopoly it is more efficient to have one firm instead of multiple (adapted from AnalystNotes, 2011).

As previously mentioned, NSPI has a monopoly on electricity production in Nova Scotia. Though the company is mandated by the NS government to provide electricity, NSPI also maintains a natural monopoly on electricity. It is common for governments to provide protection for firms who are providing public goods in markets considered to be natural monopolies, such as electricity. However, because competition is not an effective regulation, governments must provide regulation to control rates. NSPI is not able to set its own rates outright but must have all rate hikes approved by the NSURB (Posner, 1969).

In economics, an externality arises when a third party is affected by the production or consumption of a good but no compensation is paid or received to that third party (Callen & Thomas, 2007; Mankiw, 2008). If an externality confers positive effects it is called a positive externality and vice versa (Mankiw, 2008). Of particular interest in environmental economics are environmental externalities. These externalities have an effect on the natural environment but also humans living within this environment (Callen & Thomas, 2007). Because producers and consumers do not take into account the economic costs of externalities, they are said to cause a market failure (Mankiw, 2008). There is no incentive to consider anything other than personal gain in the free market thus producers and consumers do not experience the full opportunity cost of their decisions (Callen & Thomas, 2007).

A Pigouvian tax is used in economics as a means to reduce the production and consumption of goods that incur negative environmental impacts. By adding a tax to a product and effectively increasing the price of a good, the producer and in turn the consumer, are forced to take into account the impacts they are having on third parties and the environment (Mankiw, 2008). A carbon tax is a form of Pigouvian tax created with the intent of increasing the price of carbon-intensive goods compared to non-carbon-intensive goods (Choi, Bakshi, & Haab).

Regardless of the tax rate, there are two methods of implementation that can be used. The preferred method among economists and policy makers is to increase the tax rate over time. This would involve the introduction of a relatively low tax that would increase by a pre-determined amount at defined intervals. The second method involves introducing the tax with no exemptions or provision for transition (Metcalf & Weisbach, 2009).

2.2 Previous Research

A large portion of the research in the area of carbon tax has been into the calculations of the social cost of carbon, the dollar value that would be attributed to carbon should a tax market materialize. The social cost of carbon is calculated based on the predicted environmental and social damages that would arise should that carbon dioxide accumulate in the atmosphere (Pearce, 2003).

Regardless of approach, most calculation methods have been created for a global scale or at the country level. The studies cover large areas. Countries, such as Canada (i.e.. Hamilton and Cameron, 1994), country groups like the European Union (EU) (i.e.. Zografakis, Georgakopoulos, Capros, Proost & Van Regemorter,1996) or the entire world economic system (i.e.. Nordhaus, 2001) are the focus of this area of research. There are few studies that focus on smaller geographic areas like provinces, though they exist. Though there are estimates for the social cost of carbon, there are no studies available that focuses specifically on potential Nova Scotia policy. This is important because the ability of a tax to reduce emissions is based on the current level of emissions and the reduction targets that are trying to be met. These variables differ in all locations.

The other area of research covers the downfalls or barriers to implementing a carbon tax. These are discussed below with an insight into how they will be dealt with in this study.

2.3 Debates

One of the most debated concepts surrounding climate policy is discounting. Discounting is often used in economic costs-benefit analyses and accounting exercises to refer to the value of goods through time. In the case of carbon policy we are dealing with the notion of valuing the welfare of households through generations. A positive time discount rate means the welfare of future generations is less valued than the present and vice versa (Nordhaus, 2007). Discounting is an issue because if future costs and benefits of climate are discounted at a positive rate, then the present value of actions that pay off in the very distant future will be small (Perrings, 2003). This issue is beyond the scope of the paper as the calculations for the carbon tax were not completed.

Implementing a carbon tax can also lead to 'carbon leakage.' It is believed by some that without a global agreement on climate policy, in a global market, those who implement a climate policy will be at a disadvantage. Carbon leakage is the "increase in emissions in non-signatories as a fraction of the reduction by a subset of nations" (Perroni & Rutherford, 1993, p. 273). This would suggest that due to the emission standard that is implemented, NSPI would benefit from relocating and continuing their poor environmental practices. Though this is unlikely due to the large capital investment currently in place by NSPI, industries reliant on NSPIs low rates could move if prices were to increase.

Carbon taxes have also been criticized for the distributional effects of taxing goods that affect all consumers. Hamilton and Cameron (1994) found that in their carbon tax simulation, the decrease in consumable income in the lowest quintile were 1.1 to 1.2 percent larger than for those in the highest quintile and that low income married couples where the most affected (p. 394). These effects were felt only in the short term, as energy efficiency and substitution for low carbon fuels increase, consumption patterns change among the affected groups. This being said, the negative effects incurred by low income households due to the implementation of a carbon tax can be negated with good tax policy on the governmental level through financial transfers to those most affected (Hamilton and Cameron, 1994). Tax redistribution is a common method of mitigating distributional effects.

Chapter 3 - Methods

3.0 Introduction

This section will introduce the methods that will be used to achieve the objectives of the proposed research. A case study was used to aid in calculating the potential effects of tax options. The calculations used are provided with an explanation of how the tax options were developed. The validity and reliability of the study will be assessed.

3.1 Methods

A comparison was made between British Columbia and Nova Scotia. The two provinces was compared in their energy policies and current greenhouse gas emission levels. The make-up of the two province greenhouse gas emitters was also compared. This information will help to understand the similarities and differences in the barriers to emission reduction in each situation. The emission reduction strategy of British Columbia was compared to the strategy of the Nova Scotian government from the Climate Change Action Plan and the Energy Strategy.

The BC energy tax will be studied to ensure a complete understanding of the policy in place in the province. The overview of the tax will offer a general description as well as the logistics of the tax including implementation and collection. The projected government revenue and household effects was used as a baseline of expected results for a potential tax in Nova Scotia.

The social cost of carbon being used in BC was then applied to NS to assess the possibility of this type of tax. NSPI will be used as a case study to assess the effects in terms of emissions reductions and government revenue that would arise from the implementation of this type of carbon tax. Calculations were made to assess whether or not this price of carbon would be successful in attaining Nova Scotia's emissions reductions goal. Based on these predictions two other scenarios (differing prices of carbon) were used to find a cost that when implemented as a tax would be successful in meeting the goals of reduction required by NSPI.

To make predictions about the effectiveness of a carbon tax in Nova Scotia calculations were used based on information available on the province's share of emissions and various assumptions. The calculations were based on distinctions made between residential, commercial and industrial consumers of electricity.

The total emissions and total electricity consumption (minus that created by clean energy) were converted into the emissions released per energy consumed (tonnes CO_2eq/KWh). This was multiplied by the chosen tax ($/tonne CO_2eq) to find the increase in electricity rates. The percent change in the price of electricity per KWh was calculated and multiplied by the PEDE to find the percent change in quantity. This was then converted to total change using the current consumption levels. The associated change in emissions was calculated using the value for the amount of emissions per energy consumed and the change in consumption levels. The revenue was calculated by multiplying the emission level by the tax rate. This process was repeated for every year until 2050 and totaled.

The following equation for the price elasticity of demand:

$$\eta = \frac{(\Delta Q/Q)}{(\Delta P/P)}$$

(where η is the price elasticity of demand for electricity, Q is the quantity of electricity demanded, P is the price, and Δ refers to a change) was re-arranged to solve for the change in quantity demanded:

$$(\Delta Q/Q) = \eta * (\Delta P/P)$$

By changing the price variable (social cost of carbon), the decrease in quantity demanded and the associated decrease in emissions can be calculated allowing various emission paths to be considered. The government revenue from each scenario was calculated by multiplying the emissions that continue to be emitted by the tax for all proposed paths. Calculations were completed starting with the current year, 2011, and continuing to 2050 to assess the possibilities of Nova Scotia reaching its short term goal in 2020 and the long term goal in 2050.

The price elasticity of demand is ‘the percentage change in the quantity of a good demanded that results from a 1 percent change in its price” (Frank & Parker, 2007, p. 685). In other terms, it is an economic measure that attempts to predict the change in quantity demanded with a known change in price or vice versa. Calculations for the price elasticity of demand for electricity (PEDE) vary based on multiple variables. The numbers used in the calculations above are based on an amalgamation of estimates put together by The Electric Power Research Institute (EPRI) (2008). A range of calculations were completed using the minimums, maximums and means of the price elasticity of demand provided by the study. Modification to the duration of the short and long-run also creates variation in the calculations. This produced an array of results based on many variables.

The information used in the calculations were based on 2009 emission levels and electricity use. These were the data available from government websites and the NSPI website. The range of calculations is based on the variables mentioned above of PEDE, the short and long-run, and the sector of electricity use. The tenant of *ceteris paribus* (Ekelund & Hébert, 1997) was used for all other variables that affect the use of electricity in the province. Under this tenant, population, income, climate, and all other variables are held equal over the timeframe of the simulation. The short and long-run were varied because there is no definite length of time that defines them. For example, residential consumers would be likely to make changes to energy efficient appliances before a large industry has the ability to change all of their equipment. This demonstrates two potentially different short-run lengths that need to be considered.

3.2 Validity

NSPI is being used as a case study to estimate the potential for a carbon tax in Nova Scotia. Electricity production accounts for 46% of greenhouse gas emissions in Nova Scotia. The Province also states that electricity will account for the largest emission reduction to meet the 2020 target (Nova Scotia Department of Environment, 2009a). NSPI has a monopoly on electricity production in Nova Scotia, producing and distributing 95% of electricity within the province, and accounts for a large percentage of the province’s total emissions (Nova Scotia Power Incorporated, 2010).

Chapter 4 - Results

4.0 Introduction

This chapter will show the results that were achieved using the above mentioned methods. Section 4.1 is a comparison of British Columbia and Nova Scotia on issues relating to their climate policy. 4.2 gives a brief outline of the carbon tax currently in place in British Columbia. This overview will offer an example of what a carbon tax may look like once implemented. The third section, 4.3, analyses three tax progressions when applied to Nova Scotia Power Incorporated (NSPI).

4.1 British Columbia and Nova Scotia Compared

British Columbia and Nova Scotia share many similarities but also differ in important ways. Both are coastal provinces which will potentially be significantly affected by climate change. As stated in both the BC and NS Climate Action Plans, the large coastal area of both provinces will leave them vulnerable to rising sea level, increased storm surges and flooding. Both provinces will also likely be affected by increasing temperatures causing drought and heat waves (Nova Scotia Department of Environment, 2009a; Government of British Columbia, 2008). It can be argued that the issues are more real and identifiable currently in BC. With the effect of the Northern Pine Beetle affecting BC forests and the commencement of glacial melting, BC is already immersed in the effects of climate change (Government of British Columbia, 2008). Because of these effects, both have a vested interest in trying to mitigate the effects.

Perhaps more important to the issue in question, both BC and NS receive large economic value from their fossil fuel industries. In the Nova Scotia energy strategy, published in conjunction with the CAP, the Nova Scotian government laid out the plan for increased fossil fuels in the province. The government plans on increasing offshore and onshore oil production as well as natural gas exploration. There are plans to increase the amount of renewable energy in the province; wind, solar, tidal, biomass etc., however, these will likely prove far less lucrative in the short run than the fossil fuel industry. A government news release states that the natural gas industry contributes about 3% of the provincial GDP and creates about 3,200 jobs contributing $115 million a year (Government of Nova Scotia, 2010).

In 2006, oil and gas sales in BC reached $7 billion dollars. Oil and natural gas are a large export resource for BC and are also used domestically. In 2006 BC oil production was 2358 10^3m^3 and natural gas production was 32.8 10^9m^3. In total, the fossil fuel industry generated approximately $2.1 billion per year in revenue for the government (British Columbia Ministry of Energy, Mines and Petroleum Resources, n.d.). This being said, profits from natural gas have decreased in the past years, falling approximately to $4.1 billion in 2009 (British Columbia Ministry of Finance, 2010) This large fossil fuel sector makes the implementation of the CAPs much more difficult.

The provinces vary in their contribution to the overall national greenhouse gas emissions levels. NS contributes only 2.8% of the national GHG inventory while BC contributes 8.9%. Though NS emitted far less total GHGs (20,889 kt CO_2eq) compared to BC (65,061 kt CO_2eq) in 2008, the difference in population puts the difference in context. The population of BC is much larger than that of Nova Scotia and the emissions per capita in NS is approximately 22 tonnes per person compared to only 15 in BC (Environment Canada, 2010). This can partially be explained in the source of the greenhouse gas emissions in each province. Where Nova Scotia emits most of its GHGs due to a coal dependent electricity industry (79% of electricity in 2009), BC receives most of its electricity from BC hydro (more than 60%), a renewable resource (Nova Scotia Department of Environment, 2009a; Government of British Columbia, 2008). The majority of the emissions in BC are created through transport. This explains the difference in emphasis in both CAPs. The difference in emission sources also creates variances in the requirements for emission reduction. In terms of electricity production, coal is seen as a low hanging fruit. Switching to any other electricity source would reduce emissions. As previously mentioned BCs electricity comes mostly from BC hydro and therefore there is less room for emission reduction in that sector. That is a large sector that cannot be tapped into and therefore they must work to achieve reductions in other sectors.

BC and NS have both set out specific emission reduction targets in their CAPs. The BC goals were established into law in 2007 (Government of British Columbia, 2008) while Nova Scotia's plans were not established until the release of the CAP in 2009. Nova Scotia plans on reducing GHG emissions by 2.5 million tonnes (2.5 megatonnes) from 2009 levels by 2015. This will put the province halfway to the 2020 goal (Nova Scotia Department of Environment, 2009a). By 2010 the BC government aims to have the public service carbon neutral as a means to set an example for the citizens of the province (Government of British Columbia, 2008). The 2020 goal in NS is to reduce emissions to 10% below 1990 levels (about a 5 megatonne reduction) and in BC the plan is to decrease emissions by 33% from 2007 levels (about a 21 megatonne reduction). Both long term goals aim to reduce emissions by 80%, in NS from 2009 levels and in BC from 2007 levels (Nova Scotia Department of Environment, 2009a; Government of British Columbia, 2008).

As previously mentioned, Nova Scotia plans on meeting these goals in large part with the use of caps on electricity production. The caps are grouped into compliance periods and though NSPI has the flexibility to pollute above the cap on an annual basis, it is required to meet the reduction goal at the end of each period. If the corporation fails to meet these goals they can be fined un to $500,000 per day of non-compliance. Any charges resulting in fine under this act will go to the Nova Scotia Environmental Trust Fund. Should NSPI choose, they are able to exceed the emissions cap by 3% in exchange for an investment into the provincial electricity grid that would increase the capacity to handle electricity created by renewable sources (Nova Scotia Department of Environment, 2009b). The emissions caps, compliance periods and investment requirements are shown in the table below.

Table 1. The CO_2eq emission caps placed on NSPI to meet the emission reduction strategy. The table shows the annual caps, compliance period cumulative caps, and transmission investment requirements needed to offset emission reduction (adapted from Nova Scotia Department of Environment, 2009b).

Calendar Year	Annual Cap (million tonnes CO_2eq)	Compliance Period (million tonnes CO_2eq)	Transmission incentive per tonne	Maximum Transmission incentive (million tonnes CO_2eq)
2010	9.7	19.22	$15	0.58
2011	9.52			
2012	9.34	18.5	$25	0.56
2013	9.16			
2014	8.98	26.32	$40	0.79
2015	8.8			
2016	8.54			
2017	8.28	24.06	$60	0.72
2018	8.02			
2019	7.76			
2020	7.5	7.5	-	-

4.2 BC Carbon Tax Overview

The BC tax is included on all fossil fuels. Implemented in 2008, the tax rate was $10/Tonne CO_2eq and increases by $5 /Tonne CO_2eq per year until 2012. The tax is collected at the point of wholesale except for marketable natural gas and propane which is collected at the retail level with the sales tax (Government of British Columbia, 2008; 15).

Predictions for the government revenue generated through the tax scheme have been laid out in the BC Budget Fiscal Plan (2010). The BC government expects to raise a total of $1,849 million dollars by the end of 2011 in tax revenues (British Columbia Ministry of Finance, 2008). The BC carbon tax is a revenue neutral carbon tax. This means that all of the revenue generated by the tax must, by law, be returned to citizens through tax breaks. A low income tax credit and a 2% rate decrease for the two lowest income brackets was increased to 5% in 2009. Businesses also benefited. Reductions in the general corporate rate reached 10% in 2011 and the reduction in the small business corporate rate was 2.5% in 2011(British Columbia Ministry of Finance, 2008).

It is difficult to assess the success of the tax to date as little data is available about the emissions levels in 2009 and 2010. The most recent greenhouse gas inventory provided by the BC government covered only 2008 emissions (British Columbia Ministry of Environment, 2010). Furthermore, it is likely that greater decreases will happen closer to the 2020 date as the transition from the short-run to the long-run occurs. It has been argued that despite the implementation of the carbon tax in BC, emissions levels continue to rise and are predicted to continue rising (Davies, 2010).

4.3.1 Three Possible Tax Progressions for NS

All three tax progressions were assessed using the calculations in the methods section. The maximums, minimums and averages for the short-run and long-run price elasticity of demand for electricity were used and a range was created based on the results. The full results can be found in the Appendix in table form. What is provided in the results section is the possible range of results based on calculations done with varying inputs based on a range of data.

1) The first tax progression used was the same as the tax implemented by the British Colombian government, starting with a $10/tonne CO_2 eq tax and increasing by $5/tonne CO_2 eq until the tax reaches $30/tonne CO_2 eq. This tax progression was used as a baseline to assess whether Nova Scotia would be able to adapt to a carbon tax similarly to British Columbia. Sensitivity analysis was performed to show the changes in consumption, emissions and revenue for variances in the duration of the short and long run. Shown below is the change in consumption associated with the tax progression mentioned above using the average PEDE (all other variations can be seen in Appendix A). The graphs show the change in consumption as a function of the length of the short-run. As the length of the short run increases there is a smaller decrease in consumption. This decrease in consumption is associated with decreases in emissions and revenue collected.

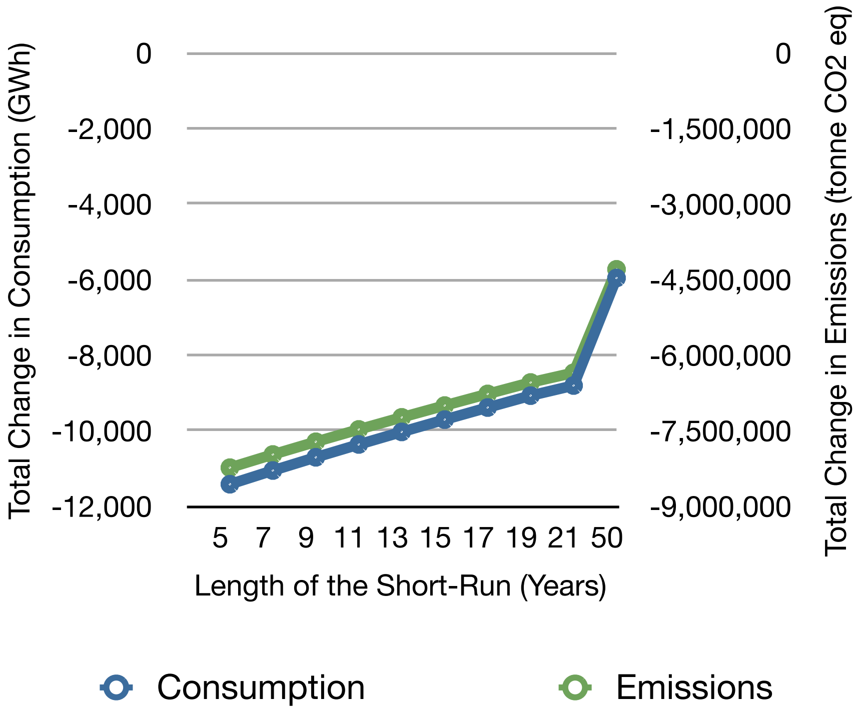

Figure 2. Graph displaying the consumption and emissions decrease from NSPI under a tax progression equal to that imposed in British Columbia projected over 50 years. The x-axis demonstrates changes in total abatement with changing short-run lengths.

2) The second tax option is to use a constant tax rate instead of starting low and increasing the tax on an annual basis. The result is a constant tax of $15/tonne CO_2 eq. This tax progression was used to show the differences between a constant rate and an increasing rate when applied to NSPI with the goal of meeting NS emissions reduction strategy. The variation of the results based on PEDE can be found in Appendix B.

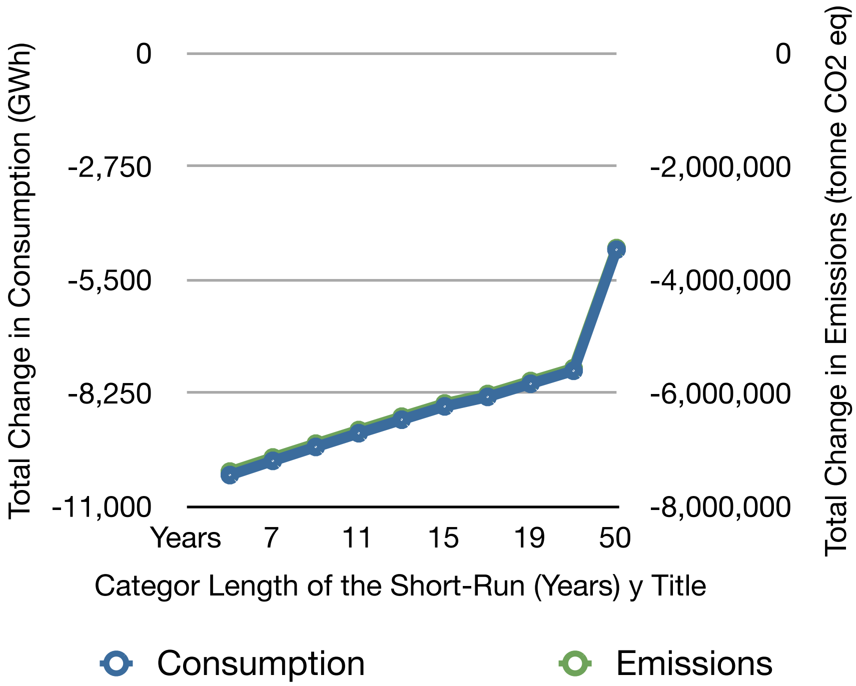

Figure 3. Graph displaying the consumption and emissions decrease from NSPI under a tax progression under a constant $15/tonne CO_2 eq tax progression projected over 50 years. The x-axis demonstrates changes in total abatement with changing short-run lengths.

3) The third proposed tax progression option also requires the phasing in of the tax but the original and subsequent increases in the tax rate increase were based on meeting the Nova Scotia emissions reduction goals. The tax was introduced at $5 /tonne CO_2 eq and increased at $5/year until it reached $15/tonne CO_2 eq. The tax remained at this rate for the duration of the simulation. The tax progression used was calculated based on the ability of the tax to theoretically meet the emissions reduction goals using the average PEDE. The variation of the results based on PEDE can be found in Appendix C.

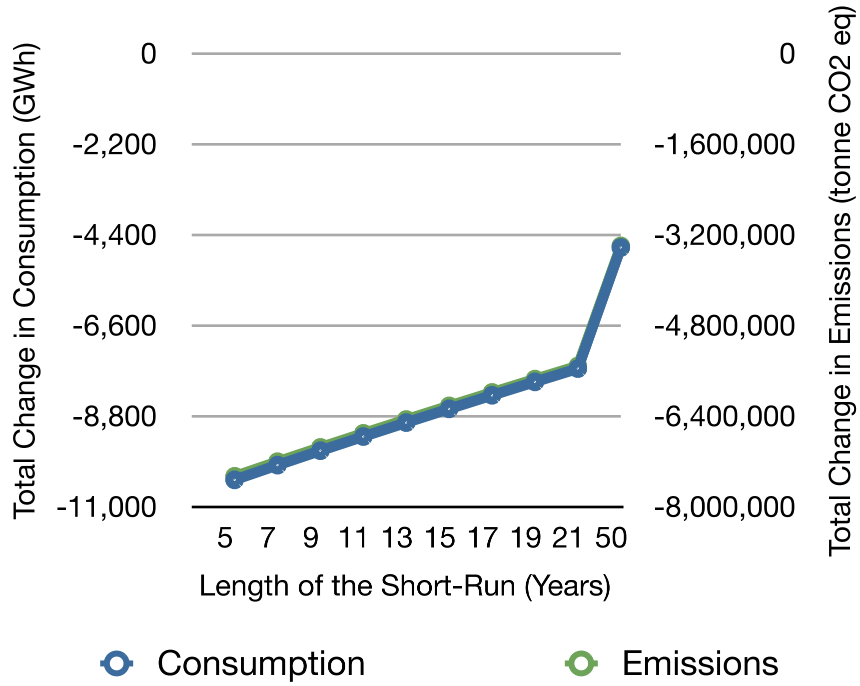

Figure 4. Graph displaying the consumption and emissions decrease from NSPI under a tax progression under a an increasing tax progression from \$5/tonne CO_2 eq to \$15/tonne CO_2 eq tax progression projected over 50 years. The x-axis demonstrates changes in total abatement with changing short-run lengths.

Table 2. Range of consumption decrease, emissions abatement and revenue collected based on minimum and maximum estimates for the PEDE for all three tax progressions projected to 2020.

	2020		
	Consumption (GWh)	Emissions (tonnes)	Revenue ($CDN)
Tax Option 1 (BC)	-3,748 to -7,120	-2,559,000 to -4,867,687	1,912,973,930 - 1,700,523,171
Tax Option 2	-2,656 to -5,132	-1,775,165 to -3,909,094	1,301,538,037 - 1,131,281,049
Tax Option 3	-2,638 to -5,280	-1,902,365 to -3,807,771	1,143,956,009 - 1,036,191,252

Table 3. Range of consumption decrease, emissions abatement and revenue collected based on minimum and maximum estimates for the PEDE for all three tax progressions projected to 2050.

	2050		
	Consumption	Emissions	Revenue
Tax Option 1 (BC)	-8,010 to -11,181	-5,777,291 to -8,063,901	6,779,485,898 - 4,093,108,063
Tax Option 2	-6,869 to -10,174	-4,954,169 to -7,337,967	4,009,738,186 - 2,770,571,907
Tax Option 3	-6,945 to -10,203	-5,008,526 to -7,358,781	3,873,977,294 - 2,683,751,046

4.3.2 Analysis

All three graphs show the same visible trend with regard to the short and long run. All else held equal, the longer we assume the short-run to be, the smaller the reduction in consumption and associated greenhouse gas emissions. This is logical as more significant changes would occur when capital is not fixed. In the long-run the commercial and industrial sectors would be able to create large changes in inputs in terms of machinery and equipment. In the residential sector the long run equates to the ability to make changes in appliances and complete home renovations. Therefore, the longer the simulation is held in the short-run, fewer significant changes are able to happen. These differences are linked inherently to the differences in the short-run and long-run PEDEs. Along the same line, variations in the PEDE (minimum, average and maximum) changed the results of the simulation. The lower the PEDE, the smaller the change in consumption and associated emissions. Under the maximum estimate of the PEDE the simulation showed the most significant change in consumption behaviour.

As seen in the table above there is little difference in the results of the second and third tax progressions. Both were created to meet the same target so this was a predictable result. However, the results show that second option (constant tax) has slightly better results than the third option for the 2020 goal. This changes in the long-run as the third options gives greater results in consumption decrease and emissions reductions. This being said, both progressions offer very similar results and overlap in some areas. The first tax progression appears to be too strict for the Nova Scotia electricity sector. The tax applied in British Columbia, if applied to Nova Scotia would result in decreases in consumption and emissions beyond what had been proposed by the provincial government. If this strategy were to be adopted there is the potential for Nova Scotia to meet and exceed their 2020 goal.

None of the proposed tax progressions meet the Nova Scotia 2050 goal of reducing emissions by up to 80% from current levels. This is due to the low level of tax maintained throughout the entire simulation. If the tax were increased over time it does have the potential to decrease consumption and emissions to a much greater extent than shown above. Furthermore, the long term effects of an increasing tax would likely be significant as many changes are possible before 2050 including the creation of technology that currently does not exist.

Chapter 5 - Discussion

5.0 Introduction

The discussion will offer insight into the results of the research and the drawbacks to the methods used. This is followed by discussion of the potential environmental and socio-economic benefits and downfalls of implementing a carbon tax in Nova Scotia. The final section will discuss the political issues and barriers to implementing this type of policy and suggestions for how these can be mitigated.

5.1 Limitations

There are a number of limitations that restrict the validity and scope of this research. Each of these factors were considered and discussed in the sections below. These include the constraints of time, uncertainty in data, the need to consult the UARB and the use of *ceteris paribus*. These factors lead to the inability to calculate values that represent holistically the potential success or failure of a Nova Scotia carbon tax.

5.1.1 Time

This study was limited most significantly in time which affected the scope of the research. Because of the relatively short timeframe, this study focused only on several scenarios created based on the BC energy tax. Furthermore, only the case study NSPI was assessed and not the effect of a carbon tax on all Nova Scotia industries. A lack of time also limited the number of variables that could be considered in the calculations which is elaborated on below.

5.1.2 Problems estimating the PEDE and assessing the short and long-run

There are many barriers to the calculation of the PEDE. All of the estimates in the literature were calculated based on a number of variables such as the climate and income among others which can have an effect on the calculation for the PEDE. Though these factors are considered it remains that predicting consumer behaviour is still a difficult feat and cannot be guaranteed.

The variation in the short and long-run price elasticities of demand for electricity were difficult to assess. The use of the short and long run on economics is very conceptual and can be debated at length for every situation. Because the distinction between the short and long-run is very grey, using the different variables in the calculations became problematic. The majority of the academic research that used short and long-run PEDEs involved far more complicated models than are within the scope of this study (see Kahn, Sathaye & Robbins, 1986).

The majority of the literature that defined the short and long-run with regard to the PEDE, based the distinction on residential changes (such as Barnes, Gillingham & Hagemann, 1981 or Reiss & White, 2005). In these articles the short run was defined by the ability for households to change basic habits and the long run by the ability to finance and purchase energy saving appliances and perform minor or major renovations. Though the distinction for residential PEDE could be estimated, there were little data on the short and long-run on the PEDEs for commercial and industrial aspects. It is much more difficult therefore to estimate when the PEDE will transition from the short term estimate to the long term estimate when considering commercial and industrial enterprises.

The use of the short and long run estimates in this case therefore limits the exactness of the calculations. A range of estimates was calculated using multiple scenarios where the short and long run PEDEs change. This provided a range of potential estimates of the consumption and emission changes. The difference in the short and long run estimates of the PEDE creates significant differences in the final calculations. Calculations were performed using a minimum, average and maximum estimate for the PEDE to evaluate the range. The results are available in the appendices.

5.1.3 Uncertainty with the decision made by the UARB

NSPI, faced with a carbon tax, would likely request a rate increase that would cover the increased marginal costs incurred. Though this research assumes that the rate increase needed to counteract the effect of the tax on the marginal cost of the producer, NSPI, this would not necessarily be the case. There are two main issues that need to be considered with regard to the Utilities and Review Board (UARB). The first is the need for the board to regulate the monopoly price. Persuant to the Public Utilities Act, the UARB is responsible for overseeing the operation of all electrical utilities in the province. Rate increases fall into this jurisdiction. The UARB must ensure that the cost of electricity is maintained at a level attainable to the general public and does not increase beyond reason (NSUARB, 2008). This conflicts with the need for the UARB to recognize the requirement for the price increase to meet the needs of the province to reduce emissions. There maintains a need to correct for the external cost of electricity generation.

5.1.4 “All else held equal”

The calculations in this research are based on the tenant of *ceteris paribus* (all else held equal) to allow the variations in the desired variables to be shown. Though this aids greatly in simplifying the calculations, it fails to consider some factors that may indeed have a significant impact on the use of electricity and the associated emissions. Population is considered to be unchanging for the extent of the simulation. Though the population of Nova Scotia decreased by only 0.1% between the years of 1996 and 2001 it may see significant changes in the future (Service Canada, 2003). One major factor not considered is the innovation of new technologies in the electricity and renewable energy sectors. It is likely that much development will happen in the near future in the growing sector of renewables.

5.2 Environmental Benefits and Downfalls

The environmental effects of climate change have been outlined in the introduction to this paper. Decreasing consumption of electricity in Nova Scotia, which is highly dependent on coal, will decrease the CO_2 equivalent emissions as shown in the results section. This decrease is associated with the CO_2 and nitrous oxides (NO_x) that would be saved in combustion of coal. However, the environmental benefits are further reaching than solely GHG emissions. A reduction in the use of coal in Nova Scotia would also be associated with a marked decrease in toxic emissions including sulfur oxides (SO_x), toxic heavy metals, nitrous oxides (NO_x) and particulate matter (McConnell and Abel, 2008).

Emissions from coal fired power plants like those in use in Nova Scotia are associated with the creation of industrial and photochemical smog. Though air quality standards have improved since the introduction of large scale electricity production using coal, NSPI still emitted over 100,000 tonnes of sulfur dioxide and over 20,000 tonnes of NO_x in 2008 (NSPI, 2011). SO_x along with soot and other particulates from coal combustion contribute heavily to industrial fog. When emitted, SO_x reacts with oxygen to form SO_2, sulfuric acid and ammonium sulfate. These chemicals are the main components of local smog. NO_x when released also reacts with oxygen forming NO_2 and other chemicals which form photochemical smog, which is capable of traveling large distances with the weather creating a regional issue (Brennan & Withgott, 2005). Smog can have serious health effects and can negatively effect wildlife, livestock, vegetation and buildings (Draper & Reed, 2005).

Releases of SO_x and NO_x into the atmosphere react to create sulfuric and nitric acid which are transported and deposited. This acidic deposition can be in the form of wet deposition (rain, hail, snow, etc.) or dry deposition (acid gas or dust) (Draper & Reed, 2005). The environmental impacts of acidic deposition are wide ranging and include negative biological effects on animals and vegetation which include direct vegetation injury and decline or damage to fish populations (Freedman, 1995). Aquatic ecosystems are very negatively affected by increases in acidity which can break down the food chain. When acidity is high, waters may be free of fish and no longer capable of supporting animals dependent on aquatic organisms for food. Increases in acidity also increases the leaching of heavy metals into the environment which can effect all ecosystems and human health (Draper & Reed, 2005).

This being said there are environmental concerns associated with the imposition of a carbon tax or any climate policy in Nova Scotia. The potential for NSPI to switch to a lesser emitting fossil fuel (oil or natural gas) is a possibility. Though this would indeed improve the province's emissions standard it is not the ideal situation. The power company would likely be successful in greatly decreasing their GHG emissions by simply switching from coal to oil or gas. If this were to happen, many of the negative environmental impacts such as smog and acidic deposition would be decreased but would not necessarily be eliminated (McConnell and Abel, 2008).

The use of biomass has also been suggested but has environmental implications in Nova Scotia. The use of biomass for energy production is only renewable when the rate of regeneration is equal to or greater than the rate of harvest. It must be ensured that smart land practices are used to prevent soil erosion, water pollution, flooding and habitat loss if the use of biomass is going to be a sustainable energy source (Draper & Reed, 2005). In Nova Scotia, the use of clear-cut remnants from forest and mill activities has been planned for bioenergy (Government of Nova Scotia, 2009). The bioenergy plan has been highly criticized due to the potential for forest decline and inefficiency in energy production among other complaints. Many organizations including the Ecology Action Centre, the Woodlot Owners and Operators Association and the Sierra Club Atlantic among many others, have spoken out against the use of biomass energy as it is seen as an unsustainable resource in the province (Ecology Action Center Forestry Program, 2009).

Regardless of the change, there would be environmental benefits incurred by switching away from the use of coal for electricity production. As the "dirtiest" type of fossil fuel, there are many improvements that could be made. It is environmentally preferable to switch a renewable or "green" energy source as it will benefit far further into the future. The risk of switching to a lower emitting fossil fuel is that the costs would be such that the power plants would have to be in production for a long time. It is likely that in the future regulations will become much more stringent and energy sources would have to be changed once again. Hence, it would be better to switch to a zero emission energy source that would be useful far into the future, regardless of increases in taxes or emission caps. If there is interests in switching energy sources it is necessary to review the options and choose the method that is the most sustainable in this area.

5.3 Socio-Economic Benefits and Downfalls

The use of a carbon tax as a means to decrease GHG emissions also has socio-economic benefits and downfalls. The first downside to a carbon tax is that it is inherently regressive. Because the tax is constant per Tonne of carbon, those in the lower income brackets are required to use a larger portion of their income to compensate for the increase in the cost of electricity. It is also less likely that those in the lowest or lower income brackets will be able to finance the necessary purchases and or renovations in the longer term that would result in a decrease in electricity use and financial gains in the long run. In Nova Scotia this issue must be reviewed in depth prior to any tax being implemented because of the high level of unemployment, 10.1% in 2011 (Statistics Canada, 2011). Electricity prices under the cap system would also increase. The government of Nova Scotia states that there are many factors affecting the price and it is not possible to estimate future electricity rates with the cap in place (Nova Scotia Department of Environment, 2009b). Electricity price increases due to the proposed taxes were found to be minimal. The most intensive tax progression, the BC tax, incurs a maximum rate increase of ¢2.16/KWh. In the most extreme case this may result in a 33%, a 21% and an 18% increase for industrial, commercial and residential consumers respectively.

Because of this, the burden of ensuring low income households are not negatively effected by the tax lies in the hands of the government imposing it. If the wish is that the tax be either progressive or at least equal, a portion of the revenue must be returned to low income households to mitigate the negative effects. This requires a certain amount of effort on the part of the government to create policy that meets these needs without drawing on too many resources. In BC this issue was mitigated using a revenue neutral tax (Government of British Columbia, 2008). The downfall of the revenue neutral tax is that all tax revenue must be returned to residents and businesses and cannot therefore be used to subsidize or fund new sources of electricity production which would have positive long term results. It also prevents the ability of the government to invest in research and design.

The addition of the tax will result in a decrease in electricity use by consumers, the switch to greener energy production or a combination of both. In the case of reduction, it is possible that substantial demand decrease will result in plant closure and loss of employment. This industry change can also lead to potential expertise export as people travel to find work suited to their skill set unless other work becomes available locally. On the other hand, if NSPI were to diversify their energy portfolio by increasing renewable energy, some studies suggest that there is the potential for employment increase and economic growth (see Demerse & Bramley, 2008 or Bataille, Wolinetz, Peters, Benett & Rivers, 2009).

In BC, the implementation of the tax has been well thought out. It has been found that when a carbon tax is implemented at a low rate and increases steadily that the consumer has a greater ability to change behaviours and mitigate prior to being taxed harshly. This helps sell the tax to the public as a good idea. It also allows the population to plan and budget accordingly. When coupled with government programs to subsidize residential and commercial consumers, this method deflects much of the negative impacts on the public. The BC carbon tax has all been been set up with the intent of minimizing administrative costs and burden (Government of British Columbia, 2008). This is a benefit to the taxation system currently in place in the west.

The major disadvantage to using a tax incentive to decrease emissions is uncertainty. Though the decreases in emissions can be predicted using economic models, there is no certainty that the firms or individuals will act as expected. There is the potential to over or under tax such that the public is dissatisfied that the target is not met. With a cap there is certainty that firms will emit below the allowed level or will be fined. It is a more direct method and blame can easily be made when the goals are not met. This is not possible with a tax incentive (Pearce, 1991).

There has also been attention drawn to the fairness of the BC tax. Though a revenue neutral tax has the ability to negate distributional effects it does not necessarily mean that is has been done so. The Center for Policy Alternatives has researched into the effects of the BC carbon tax on low income households. Researchers found that the tax remains regressive even with the tax cuts and a grant system in place (Lee & Sanger, 2008: Rehnby, 2008). Consideration must be taken to ensure that the measures put in place to mitigate distributional effects are appropriate and continually monitored to ensure they are providing the effects wanted.

5.4 Political issues

Climate policy is a highly politicized issue. The implementation of a carbon tax can create tension among citizens if there is not enough education on the function of the tax or the rebates that would be made available. The implementation of a cap will almost certainly be accompanied by a price increase to help stifle demand but the connection is much less visible to consumers. Overall, regardless of the policy, it is highly contentious to ask consumers to pay more for a service while simultaneously asking them to decrease their use.

Further to these issues, there may be a sense among the population that Nova Scotia alone cannot have a significant effect on meeting national or global targets as we emit such a low percentage of the total. Climate change is a big problem and comparatively, Nova Scotia contributes a small amount of greenhouse gases compared to other developed areas as mentioned above. Currently, business in Canada have not been investing in climate credits and projects. The current state has been perpetuated by slow government reaction in Ottawa (Page, 2010). This lack of interest and action from private and public institutions perpetuates waning concern among the public.

Chapter 6 - Conclusions

The simulations that were used in this research provide an idea of what type of a carbon tax would be needed to help Nova Scotia reach its emission reduction goals. Using the average PEDE, all three tax progressions created a range that included or surpassed the 2020 reduction goal. The two tax progressions created with the intent of meeting the goals are much lower than the tax used currently in BC. The two tax progressions do not exceed $15/tonne CO_2 eq where the BC tax is intended to reach $45 tonne CO_2 eq. To meet the NC 2050 reduction goal, an increase in the tax rate would be necessary over the period between 2020 and 2050.

There are many environmental and socio-economic implications in implementing a carbon tax. For this reason the issue will continue to be highly politicized. Many of these issues overlap with other climate policies, particularly carbon emission caps. This being said, there are also important differences between the policies that need to be considered when considering a climate policy. When implemented, a carbon tax would have a much more widespread effect than would the caps proposed only on Nova Scotia Power Incorporated.

The British Columbia carbon tax may provide important insight into environmental and socio-economic issues associated with this climate policy. However, there has been little time to assess the impacts of the tax as it was only instated in 2007. More information needs to become available with regard to the emissions changes that have been seen since the tax has been implemented and how the tax has affected the economy and the public. Once this information is made public, the ability to assess impacts due to carbon taxes on a small scale will be possible.

This research has been limited by many factors. Time and uncertainty in data and calculations restricts the ability to make recommendations on climate policy in Nova Scotia. This being said, the research provides important insight into the potential for carbon taxes to be used in Nova Scotia. More research is needed to confirm the results and look further into the economic, social and environmental impacts that would be incurred. I feel that this is an important policy issue that deserves greater attention and further discussion.

Bibliography

AnalystNotes. (2011). *LOS b. Explain the relation between price, marginal revenue, and elasticity for monopoly and determine a monopoly's profit-maximizing price and quantity*. Retrieved from http://www.analystnotes.com/notes/los_detail.php?id=1109.

Barnes, R., Gillingham, R & Hagemann, R. (1981). The short-run residential demand for electricity. *The Review of Economics and Statistics, 63* (4), 541-552.

Barnett, J. & Adger, N. (2007). Climate change, human security and violent conflict. *Political Geography, 26,* 639-655.

Brennan, S. & Withgott, J. (2005). *Environment: The Science Behind the Stories*. Toronto: Pearson.

British Columbia Ministry of Energy, Mines and Petroleum Resources. (n.d.). *Oil and Gas Activity in British Columbia: Statistics and resource Potential 1996-2006* [Brochure]. Canada: Province of British Columbia.

British Columbia Ministry of Environment. (2010). *British Columbia Greenhouse Gas Inventory Report 2008*. Canada: Province of British Columbia.

British Columbia Ministry of Finance. (2008). *Budget and Fiscal Plan 2008/09-2010/11.* Canada: Province of British Columbia.

British Columbia Ministry of Finance. (2010). *2010 British Columbia Financial and Economic Review* (70th ed). Canada: Province of British Columbia.

Callan, S. J., & Thomas, J. M. (2007). Environmental Economics and Management: Theory, Policy, and Applications (4th ed.). Ohio: Thomson South Western.

Canada-Kyoto Timeline. (2007, February 14). CBC News. Retrieved from http://www.cbc.ca/news/background/kyoto/ timeline.html.

Davies, J. (2010, April 22). B.C. emitting more greenhouse gases. *CBC News.* Retrieved from http://www.cbc.ca/news/canada/british-columbia/story/2010/04/22/bc-greenhouse-gas-emission-increase.html.

Demerse, C. & Bramley, M. (2008). *Choosing greenhouse gas emission reduction policies in Canada*. Alberta: The Pembina Institute.

Choi, J.K., Bakshi, B.R., & Haab, T. (2010). Effects of a carbon price in the U.S. on economic sectors, resource use, and emissions: An input-output approach. *Energy Policies*, 38, 3527-3536.

Clean Nova Scotia. (2009). Climate Change Impacts. Retrieved from http://www.clean.ns.ca/content/Content_Impacts.

Climate Action Network. (2009). Climate Shame as Canada Named Colossal Fossil. Retrieved from http://www.fossiloftheday.com/.

Draper, D, & Reed, M.G. (2005). *Our Environment: A Canadian Perspective* (3rd ed). Toronto: Thomson.

Ecology Action Center Forestry Program. (2009). *Is forest biomass the answer to Nova Scotia s renewable electricity targets?* Retrieved from http://www.novascotiaforests.ca/biomass-answer.

Ekelund, R. B. & Hébert, R. F. (1997). *A History of Economic Theory and Method* (4th ed.). Toronto: McGraw-Hill

Environment Canada. (2008). Canada's 2008 Greenhouse Gas Inventory: A Summary of Trends: 1990-2008. Government of Canada.

Environment Canada. (2010). *Greenhouse gas emissions data.* Retrieved from http://www.ec.gc.ca/indicateurs-indicators/default.asp?lang=en&n=BFB1B398-1#ghg1_en.

Frank, R. H., & Parker, I.C. (2007). Microeconomics & Behaviour (3rd ed.). Toronto: McGraw-Hill Ryerson Ltd.

Gatehouse, J. (2009). Suddenly the World Hates Canada: How did a country with two per cent of the world's emissions turn global villain? MacLean's Magazine. Retrieved from http://www2.macleans.ca/2009/12/15/suddenly-the- world-hates-canada/2/.

Glomm, G., Kawaguchi, D. & Sepulveda, F. (2008). Green taxes and double dividends in a dynamic economy. *Journal of Policy Modeling, 30*, 19-32.

Government of British Columbia. (2008). Climate Action Plan. Canada: Province of British Columbia.

Government of Canada. (2005). *Canada's Report on Demonstrable Progress under the Kyoto Protocol*. Retrieved from http://unfccc.int/resource/docs/dpr/can1e.pdf.

Government of Nova Scotia. (2009). *Nova Scotia renewables current activity in bioenergy*. Retrieved from http://www.gov.ns.ca/energy/renewables/current-activity/bioenergy.asp.

Government of Nova Scotia. (2010). *Report Shows Natural Gas Industry Creates Jobs, Grows Economy* [Press Release]. Retrieved from: http://www.gov.ns.ca/news/details.asp?id=20100430005

Hamilton, K., & Cameron, G. (1994). Simulating the distributional effects of a Canadian carbon tax. *Canadian Public Policy*, *20*(4), p. 385-399.

Intergovernmental Panel on Climate Change. (2007). Climate Change 2007: Working Group I: The Physical Science Basis. Retrieved from http://www.ipcc.ch/publications_and_data/ar4/wg1/en/tssts-2.html

Kahn, E., Sathaye, J. & Robbins, D. (1986). An engineering-economic approach to estimating the price elasticity of residential electricity demand. *Energy Economics, 8* (2), 118-126.

Kump, L., Kasting, J., & Crane, R. (2010). The Earth System (3rd ed.). New Jersey: Pearson Education Incorporated.

Lee, M. & Sanger, T. (2008). *Is BC's carbon tax fair? An impact analysis for different income levels.* British Columbia: Canadian Centre for Policy Alternatives.

Mankiw, N.G. (2008). *Principles of Economics* (5h ed.). Ohio: South-Western Cengage Learning.

McConnell, R. & Abel, D. (2008). *Environmental Issues: An Introduction to Sustainability* (3rd ed.). New Jersey: Pearson Education Incorporated.

Metcalf, G. E., & Weisbach, D. (2009). The Design of a Carbon Tax. *Harvard Environmental Law Review, 33* (2), 499-556.

Bataille, C., Wolinetz, M., Peters, J., Benett, M. & Rivers, N. (2009). *Exploration of two Canadian greenhouse gas emissions targets: 25% below 1990 and 20% below 2006 levels by 2020*. British Columbia: M. K. Jaccard and Associates Inc.

Nova Scotia Department of Environment. (2009a). *Toward a Greener Future: Nova Scotia's Climate Change Action Plan*. Canada: Province of Nova Scotia.

Nova Scotia Department of Environment. (2009b). *An Approach to Regulating Electricity Sector Greenhouse Gas and Air Pollutant Emissions in Nova Scotia: A Discussion Paper.* Canada: Province of Nova Scotia.

Nova Scotia Power Incorporated (NSPI). (2011). *Archived Emissions Levels*. Retrieved from http://www.nspower.ca/en/home/environment/emissions/archivedemissionslevels/default.aspx.

Nova Scotia Utility and Review Board (NSUARB). (2008). *Electricity*. Retrieved from http://www.nsuarb.ca/index.php?option=com_content&task=view&id=19&Itemid=15.

Nordhous, W. D. (2001). Global Warming Economics. *Science, 294 (5545), 1283-1284.*

Nordhaus, W. D. (2007). A review of the of the Stern Review on the economics of climate change. *Journal of Economic Literature, 45*, 686-702.

Page, R. (2010). *Canada: Climate Apathy Slows Carbon Markets.* In A. Kramer (Ed.), Greenhouse Gas Market Report 2010: Post Copenhagen and Climate Policy: Where Global Emissions Trading Goes from Here. International Emissions Trading Association: Switzerland.

Pearce, D. (1991). The role of carbon taxes in adjusting to global warming. *The Economic Journal, 101*, 938-948.

Pearce, D. (2003). The social cost of carbon and its policy implications. *Oxford Review of Economic Policy, 19* (3), 362-384.

Perrings, C. (2003). The economics of abrupt climate change. *Philosophical Transactions: Mathematical, Physical and Engineering Sciences, 362* (1810), 2043-2059.

Perroni, C., & Rutherfor, T. F. (1993). International trade in carbon emission rights and basic materials: General equilibrium calculations for 2020. *Scandinavian Journal of Economics, 95* (3), 257-278.

Posner, R.A. (1969). Natural monopoly and its regulation. *Stanford Law Review, 21*(3), 548-643.

Rhenby, N. (Ed). (2008). *Searching for the good life in a carbon neutral BC: Meeting BC's greenhouse gas reduction targets with fairness and equity.* British Columbia: Canadian Centre for Policy Alternatives.

Reiss, P. C. & White, M .W. (2005). Household electricity demand, revisited. *The Review of Economic Studies, 72* (3), 853-883.

Service Canada. (2003). *Nova Scotia Population*. Retrieved from http://www.servicecanada.gc.ca/eng/ns/lmi/statistics/population.shtml.

Sierra Club Canada. (2007). Kyoto Report Card 2007. Retrieved from http://www.sierraclub.ca/national/kyoto/executive- summary-2008.html.

Statistics Canada. (2011). *Labour force characteristics, unadjusted, by economic region (3 month moving average)*. Retrieved from http://www40.statcan.gc.ca/l01/cst01/lfss05b-eng.htm.

The Electric Power Research Institute. (2008). Price elasticity of demand for electricity: A primer and synthesis. California: EPRI.

United Nations. (1998). Kyoto Protocol to the United Nations Framework Convention on Climate Change.

UNFCCC. (2008). Report of the Conference of Parties on its thirteenth session, held Bali from 3 to 15 December 2007. Retrieved from http://unfccc.int/resource/docs/2007/cop13/eng/06a01.pdf.

UNFPA & WEDO (2009). Climate change connections: A resource kit on climate, population and gender. Retrieved from http://unfpa.org/public/site/global/lang/en/pid/4028

Zografakis, S., Georgakopoulos, P., Capros, B., Proost, S. & Van Regemorter, D. (1996). *Co-ordinated versus uncoordinated European carbon tax solutions analyzed with GEM-E3 linking the EU-12 countries*. In S. Proost (Ed.), Economic Aspects of Environmental Policy. Kluwer Academic Publishers.

Appendices

Appendix A.

Calculated consumption, emissions and revenue for the British Columbia tax. Each sector (residential, commercial and industrial) is broken into the minimum, average and maximum price elasticities of demand from the EPRI study.

a) Residential

Length of the short run (years)	Minimum PEDE (short-run = -0.2, long-run = -0.7)			Average PEDE (short-run = -0.3, long-run = -0.9)			Maximum PEDE (short-run = -0.6, long-run = -1.4)		
	Delta Q (GWh)	Delta E (tonnes CO_2 eq)	Revenue ($CDN)	Delta Q (GWh)	Delta E (tonnes CO_2 eq)	Revenue ($CDN)	Delta Q (GWh)	Delta E (tonnes CO_2 eq)	Revenue ($CDN)
5	-3,288.76	-2.37E+06	1.90E+09	-3,703.42	-2.67E+06	1.57E+09	-4,252.48	-3.07E+06	1.00E+09
7	-3,137.08	-2.26E+06	2.07E+09	-3,577.50	-2.58E+06	1.74E+09	-4,188.80	-3.02E+06	1.14E+09
9	-3,000.15	-2.16E+06	2.21E+09	-3,461.63	-2.50E+06	1.87E+09	-4,127.82	-2.98E+06	1.24E+09
11	-2,874.37	-2.07E+06	2.33E+09	-3,353.45	-2.42E+06	1.99E+09	-4,068.98	-2.93E+06	1.32E+09
13	-2,757.38	-1.99E+06	2.43E+09	-3,251.44	-2.35E+06	2.08E+09	-4,011.88	-2.89E+06	1.39E+09
15	-2,647.58	-1.91E+06	2.51E+09	-3,154.51	-2.28E+06	2.16E+09	-3,956.26	-2.85E+06	1.45E+09
17	-2,543.77	-1.83E+06	2.58E+09	-3,061.88	-2.21E+06	2.23E+09	-3,901.92	-2.81E+06	1.50E+09
19	-2,445.07	-1.76E+06	2.64E+09	-2,972.94	-2.14E+06	2.28E+09	-3,848.70	-2.78E+06	1.54E+09
21	-2,350.80	-1.70E+06	2.69E+09	-2,929.70	-2.11E+06	2.31E+09	-3,796.46	-2.74E+06	1.58E+09
50	-1,601.88	-1.16E+06	2.86E+09	-2,182.44	-1.57E+06	2.50E+09	-3,335.55	-2.41E+06	1.70E+09

b) Commercial

Length of the short run (years)	Minimum PEDE (short-run = -0.2, long-run = -0.7)			Average PEDE (short-run = -0.3, long-run = -1.1)			Maximum PEDE (short-run = -0.7, long-run = -1.3)		
	Delta Q (GWh)	Delta E (tonnes CO_2 eq)	Revenue ($CDN)	Delta Q (GWh)	Delta E (tonnes CO_2 eq)	Revenue ($CDN)	Delta Q (GWh)	Delta E (tonnes CO_2 eq)	Revenue ($CDN)
5	-1,829.43	-1.32E+06	9.89E+08	-2,179.4	-1.57E+06	7.03E+08	-2,312.65	-1.67E+06	5.08E+08
7	-1,745.16	-1.26E+06	1.09E+09	-2,113.57	-1.52E+06	8.10E+08	-2,285.5	-1.65E+06	5.61E+08
9	-1,669.71	-1.20E+06	1.17E+09	-2,050.66	-1.48E+06	8.98E+08	-2,260.78	-1.63E+06	6.01E+08
11	-1,600.77	-1.15E+06	1.23E+09	-1,990.03	-1.44E+06	9.71E+08	-2,237.87	-1.61E+06	6.32E+08
13	-1,536.91	-1.11E+06	1.28E+09	-1,931.26	-1.39E+06	1.03E+09	-2,216.38	-1.60E+06	6.58E+08
15	-1,477.14	-1.07E+06	1.33E+09	-1,874.06	-1.35E+06	1.08E+09	-2,196.05	-1.58E+06	6.78E+08
17	-1,420.77	-1.02E+06	1.37E+09	-1,818.2	-1.31E+06	1.13E+09	-2,176.67	-1.57E+06	6.95E+08
19	-1,367.28	-986,112	1.40E+09	-1,763.51	-1.27E+06	1.17E+09	-2,158.11	-1.56E+06	7.09E+08
21	-1,316.27	-949,320	1.43E+09	-1,709.86	-1.23E+06	1.20E+09	-2,140.26	-1.54E+06	7.20E+08
50	-912.8596	-658,373	1.52E+09	-1,236.99	-892,146	1.31E+09	-1,994.35	-1.44E+06	7.59E+08

b) Industrial

Length of the short run (years)	Minimum PEDE (short-run = -0.1, long-run = -0.9)			Average PEDE (short-run = -0.2, long-run = -1.2)			Maximum PEDE (short-run = -0.3, long-run = -1.4)		
	Delta Q (GWh)	Delta E (tonnes CO_2 eq)	Revenue ($CDN)	Delta Q (GWh)	Delta E (tonnes CO_2 eq)	Revenue ($CDN)	Delta Q (GWh)	Delta E (tonnes CO_2 eq)	Revenue ($CDN)
5	-5,074.39	-3.66E+06	1.91E+09	-5,536.77	-3.99E+06	1.42E+09	-5,715.0	-4.12E+06	1.17E+09
7	-4,813.93	-3.47E+06	2.29E+09	-5,365.55	-3.87E+06	1.76E+09	-5,596.9	-4.04E+06	1.45E+09
9	-4,567.36	-3.29E+06	2.60E+09	-5,194.33	-3.75E+06	2.03E+09	-5,475.3	-3.95E+06	1.69E+09
11	-4,331.15	-3.12E+06	2.86E+09	-5,023.10	-3.62E+06	2.27E+09	-5,351.0	-3.86E+06	1.88E+09
13	-4,103.13	-2.96E+06	3.08E+09	-4,851.88	-3.50E+06	2.46E+09	-5,224.5	-3.77E+06	2.05E+09
15	-3,881.86	-2.80E+06	3.27E+09	-4,680.66	-3.38E+06	2.63E+09	-5,095.9	-3.68E+06	2.20E+09
17	-3,666.27	-2.64E+06	3.43E+09	-4,509.44	-3.25E+06	2.78E+09	-4,965.7	-3.58E+06	2.32E+09
19	-3,455.60	-2.49E+06	3.56E+09	-4,338.22	-3.13E+06	2.91E+09	-4,833.9	-3.49E+06	2.42E+09
21	-3,249.24	-2.34E+06	3.68E+09	-4,167.00	-3.01E+06	3.01E+09	-4,700.7	-3.39E+06	2.51E+09
50	-1,438.26	-1.04E+06	4.11E+09	-2,540.41	-1.83E+06	3.42E+09	-3,382.7	-2.44E+06	2.85E+09

Appendix B.

Calculated consumption, emissions and revenue for the Option 2 tax, a constant tax at $15/tonne CO_2 eq. Each sector (residential, commercial and industrial) is broken into the minimum, average and maximum price elasticities of demand from the EPRI study.

a) Residential

Length of the short run (years)	Minimum PEDE (short-run = -0.2, long-run = -0.7)			Average PEDE (short-run = -0.3, long-run = -0.9)			Maximum PEDE (short-run = -0.6, long-run = -1.4)		
	Delta Q (GWh)	Delta E (tonnes CO_2 eq)	Revenue ($CDN)	Delta Q (GWh)	Delta E (tonnes CO_2 eq)	Revenue ($CDN)	Delta Q (GWh)	Delta E (tonnes CO_2 eq)	Revenue ($CDN)
5	2,736.69	1.97E+06	1.24E+09	3,185.71	2.30E+06	1.09E+09	3,900.31	2.81E+06	7.87E+08
7	2,619.28	1.89E+06	1.30E+09	3,077.97	2.22E+06	1.15E+09	3,829.11	2.76E+06	8.42E+08
9	2,508.61	1.81E+06	1.35E+09	2,975.25	2.15E+06	1.20E+09	3,759.62	2.71E+06	8.90E+08
11	2,403.63	1.73E+06	1.40E+09	2,876.82	2.07E+06	1.25E+09	3,691.64	2.66E+06	9.30E+08
13	2,303.55	1.66E+06	1.44E+09	2,782.10	2.01E+06	1.29E+09	3,624.97	2.61E+06	9.65E+08
15	2,207.75	1.59E+06	1.47E+09	2,690.65	1.94E+06	1.32E+09	3,559.49	2.57E+06	9.95E+08
17	2,115.71	1.53E+06	1.50E+09	2,690.65	1.94E+06	1.32E+09	3,495.07	2.52E+06	1.02E+09
19	2,027.02	1.46E+06	1.53E+09	2,602.11	1.88E+06	1.35E+09	3,431.62	2.47E+06	1.04E+09
21	1,941.35	1.40E+06	1.55E+09	2,516.17	1.81E+06	1.38E+09	3,369.06	2.43E+06	1.06E+09
50	1,236.14	8.92E+05	1.63E+09	1,725.19	1.24E+06	1.48E+09	2,808.67	2.03E+06	1.13E+09

b) Commercial

Length of the short run (years)	Minimum PEDE (short-run = -0.2, long-run = -0.7)			Average PEDE (short-run = -0.3, long-run = -1.1)			Maximum PEDE (short-run = -0.7, long-run = -1.3)		
	Delta Q (GWh)	Delta E (tonnes CO_2 eq)	Revenue ($CDN)	Delta Q (GWh)	Delta E (tonnes CO_2 eq)	Revenue ($CDN)	Delta Q (GWh)	Delta E (tonnes CO_2 eq)	Revenue ($CDN)
5	1,542.50	1.11E+06	6.52E+08	1,943.28	1.40E+06	5.13E+08	2,133.79	1.54E+06	4.01E+08
7	1,476.34	1.06E+06	6.87E+08	1,880.75	1.36E+06	5.55E+08	2,103.61	1.52E+06	4.24E+08
9	1,414.32	1.02E+06	7.16E+08	1,819.83	1.31E+06	5.91E+08	2,075.01	1.50E+06	4.43E+08
11	1,355.74	9.78E+05	7.42E+08	1,760.31	1.27E+06	6.22E+08	2,047.73	1.48E+06	4.59E+08
13	1,300.09	9.38E+05	7.63E+08	1,702.01	1.23E+06	6.49E+08	2,021.58	1.46E+06	4.72E+08
15	1,246.97	8.99E+05	7.82E+08	1,644.80	1.19E+06	6.73E+08	1,996.40	1.44E+06	4.84E+08
17	1,196.06	8.63E+05	7.98E+08	1,588.56	1.15E+06	6.94E+08	1,972.09	1.42E+06	4.93E+08
19	1,147.11	8.27E+05	8.12E+08	1,533.21	1.11E+06	7.11E+08	1,948.54	1.41E+06	5.01E+08
21	1,099.91	7.93E+05	8.24E+08	1,478.66	1.07E+06	7.27E+08	1,948.54	1.41E+06	5.01E+08
50	713.64	5.15E+05	8.68E+08	991.01	7.15E+05	7.84E+08	1,733.43	1.25E+06	5.32E+08

b) Industrial

Length of the short run (years)	Minimum PEDE (short-run = -0.1, long-run = -0.9)			Average PEDE (short-run = -0.2, long-run = -1.2)			Maximum PEDE (short-run = -0.3, long-run = -1.4)		
	Delta Q (GWh)	Delta E (tonnes CO_2 eq)	Revenue ($CDN)	Delta Q (GWh)	Delta E (tonnes CO_2 eq)	Revenue ($CDN)	Delta Q (GWh)	Delta E (tonnes CO_2 eq)	Revenue ($CDN)
5	4,517.48	3.26E+06	1.33E+09	5,116.83	3.69E+06	1.07E+09	5,388.71	3.89E+06	9.18E+08
7	4,289.85	3.09E+06	1.47E+09	4,942.24	3.56E+06	1.20E+09	5,253.81	3.79E+06	1.04E+09
9	4,069.66	2.94E+06	1.60E+09	4,767.65	3.44E+06	1.32E+09	5,116.58	3.69E+06	1.15E+09
11	3,855.65	2.78E+06	1.70E+09	4,593.06	3.31E+06	1.43E+09	4,977.33	3.59E+06	1.24E+09
13	3,646.90	2.63E+06	1.80E+09	4,418.47	3.19E+06	1.52E+09	4,836.30	3.49E+06	1.32E+09
15	3,442.73	2.48E+06	1.88E+09	4,243.88	3.06E+06	1.60E+09	4,693.67	3.39E+06	1.39E+09
17	3,242.58	2.34E+06	1.95E+09	4,069.29	2.93E+06	1.67E+09	4,549.59	3.28E+06	1.46E+09
19	3,046.04	2.20E+06	2.01E+09	3,894.71	2.81E+06	1.73E+09	4,404.17	3.18E+06	1.51E+09
21	2,852.73	2.06E+06	2.06E+09	3,720.12	2.68E+06	1.78E+09	4,257.52	3.07E+06	1.56E+09
50	1,135.42	8.19E+05	2.26E+09	2,061.52	1.49E+06	1.98E+09	2,815.75	2.03E+06	1.73E+09

Appendix C.

Calculated consumption, emissions and revenue for the Option 3 tax, an increasing tax to $15/ tonne CO_2 eq. Each sector (residential, commercial and industrial) is broken into the minimum, average and maximum price elasticities of demand from the EPRI study.

a) Residential

Length of the short run (years)	Minimum PEDE (short-run = -0.2, long-run = -0.7)			Average PEDE (short-run = -0.3, long-run = -0.9)			Maximum PEDE (short-run = -0.6, long-run = -1.4)		
	Delta Q (GWh)	Delta E (tonnes CO_2 eq)	Revenue ($CDN)	Delta Q (GWh)	Delta E (tonnes CO_2 eq)	Revenue ($CDN)	Delta Q (GWh)	Delta E (tonnes CO_2 eq)	Revenue ($CDN)
5	2,772.64	2.00E+06	1.19E+09	3,216.76	2.32E+06	1.04E+09	3,917.77	2.83E+06	7.49E+08
7	2,649.58	1.91E+06	1.25E+09	3,104.05	2.24E+06	1.10E+09	3,843.39	2.77E+06	8.09E+08
9	2,534.02	1.83E+06	1.31E+09	2,996.92	2.16E+06	1.16E+09	3,770.92	2.72E+06	8.60E+08
11	2,424.72	1.75E+06	1.35E+09	2,894.50	2.09E+06	1.21E+09	3,700.09	2.67E+06	9.03E+08
13	2,320.78	1.67E+06	1.40E+09	2,796.14	2.02E+06	1.25E+09	3,630.72	2.62E+06	9.40E+08
15	2,221.47	1.60E+06	1.43E+09	2,701.33	1.95E+06	1.29E+09	3,562.63	2.57E+06	9.71E+08
17	2,126.23	1.53E+06	1.46E+09	2,609.66	1.88E+06	1.32E+09	3,495.69	2.52E+06	9.98E+08
19	2,034.59	1.47E+06	1.49E+09	2,520.79	1.82E+06	1.34E+09	3,429.81	2.47E+06	1.02E+09
21	1,946.17	1.40E+06	1.51E+09	2,434.44	1.76E+06	1.37E+09	3,364.87	2.43E+06	1.04E+09
50	1,221.33	8.81E+05	1.59E+09	1,706.04	1.23E+06	1.45E+09	2,784.23	2.01E+06	1.11E+09

b) Commercial

Length of the short run (years)	Minimum PEDE (short-run = -0.2, long-run = -0.7)			Average PEDE (short-run = -0.3, long-run = -1.1)			Maximum PEDE (short-run = -0.7, long-run = -1.3)		
	Delta Q (GWh)	Delta E (tonnes CO_2 eq)	Revenue ($CDN)	Delta Q (GWh)	Delta E (tonnes CO_2 eq)	Revenue ($CDN)	Delta Q (GWh)	Delta E (tonnes CO_2 eq)	Revenue ($CDN)
5	1,563.81	1.13E+06	6.23E+08	1,963.28	1.42E+06	4.84E+08	2,139.73	1.54E+06	3.85E+08
7	1,494.20	1.08E+06	6.60E+08	1,898.29	1.37E+06	5.29E+08	2,107.69	1.52E+06	4.10E+08
9	1,429.23	1.03E+06	6.91E+08	1,835.10	1.32E+06	5.67E+08	2,077.44	1.50E+06	4.31E+08
11	1,368.09	9.87E+05	7.18E+08	1,773.45	1.28E+06	6.00E+08	2,048.67	1.48E+06	4.48E+08
13	1,310.16	9.45E+05	7.41E+08	1,713.13	1.24E+06	6.28E+08	2,021.15	1.46E+06	4.62E+08
15	1,254.99	9.05E+05	7.60E+08	1,653.99	1.19E+06	6.53E+08	1,994.71	1.44E+06	4.74E+08
17	1,202.22	8.67E+05	7.77E+08	1,595.91	1.15E+06	6.75E+08	1,969.22	1.42E+06	4.84E+08
19	1,151.56	8.31E+05	7.92E+08	1,538.78	1.11E+06	6.93E+08	1,944.57	1.40E+06	4.93E+08
21	1,102.77	7.95E+05	8.04E+08	1,482.51	1.07E+06	7.09E+08	1,944.57	1.40E+06	4.93E+08
50	705.34	5.09E+05	8.49E+08	980.37	7.07E+05	7.69E+08	1,720.34	1.24E+06	5.25E+08

b) Industrial

Length of the short run (years)	Minimum PEDE (short-run = -0.1, long-run = -0.9)			Average PEDE (short-run = -0.2, long-run = -1.2)			Maximum PEDE (short-run = -0.3, long-run = -1.4)		
	Delta Q (GWh)	Delta E (tonnes CO_2 eq)	Revenue ($CDN)	Delta Q (GWh)	Delta E (tonnes CO_2 eq)	Revenue ($CDN)	Delta Q (GWh)	Delta E (tonnes CO_2 eq)	Revenue ($CDN)
5	4,606.35	3.32E+06	1.23E+09	5,181.79	3.74E+06	9.83E+08	5,437.08	3.92E+06	8.43E+08
7	4,369.49	3.15E+06	1.39E+09	5,002.17	3.61E+06	1.13E+09	5,298.89	3.82E+06	9.76E+08
9	4,141.06	2.99E+06	1.52E+09	4,822.55	3.48E+06	1.26E+09	5,158.09	3.72E+06	1.09E+09
11	3,919.53	2.83E+06	1.63E+09	4,642.94	3.35E+06	1.36E+09	5,015.05	3.62E+06	1.19E+09
13	3,703.81	2.67E+06	1.73E+09	4,463.32	3.22E+06	1.46E+09	4,870.06	3.51E+06	1.27E+09
15	3,493.09	2.52E+06	1.81E+09	4,283.71	3.09E+06	1.54E+09	4,723.32	3.41E+06	1.35E+09
17	3,286.74	2.37E+06	1.88E+09	4,104.09	2.96E+06	1.61E+09	4,575.01	3.30E+06	1.41E+09
19	3,084.28	2.22E+06	1.95E+09	3,924.47	2.83E+06	1.68E+09	4,425.26	3.19E+06	1.47E+09
21	2,885.30	2.08E+06	2.00E+09	3,744.86	2.70E+06	1.73E+09	4,274.18	3.08E+06	1.52E+09
50	1,121.56	8.09E+05	2.21E+09	2,038.51	1.47E+06	1.94E+09	2,787.12	2.01E+06	1.70E+09