A Process for Evaluation of Climate Policy Platforms and Greenhouse Gas Reduction Targets

by

Emma Starke

B.Sc. (Hons., Environmental Biology), University of Guelph, 2019

Thesis Submitted in Partial Fulfillment of the
Requirements for the Degree of
Master of Resource Management

in the
School of Resource and Environmental Management
Faculty of Environment

SIMON FRASER UNIVERSITY
Summer 2022

Declaration of Committee

Name:	**Emma Starke**
Degree:	**Master of Resource Management**
Title:	**A Process for Evaluation of Climate Policy Platforms and Greenhouse Gas Reduction Targets**
Committee:	**Chair:** John Welch Professor, Resource and Environmental Management
	Mark Jaccard Supervisor Professor, Resource and Environmental Management
	Bradford Griffin Committee Member University Research Associate, Resource and Environmental Management
	Jotham Peters Committee Member Adjunct Professor, Resource and Environmental Management
	Jamie MacDonald Examiner Director of Policy, Environment and Climate Change Canada Government of Canada

Abstract

Global efforts have failed to address climate change and reduce emissions. In democratic countries, a key reason for continued rise in emissions is the inability for citizens and politicians to estimate the likely effects of proposed climate policy platforms. Through this research I present a climate platform evaluation framework to identify policies that could impact future emissions and economic growth for simulation in an EEE model. I use the gTech CGE model to simulate the climate platforms and promises of two competing political parties in Canada prior to the Fall 2021 election; the NDP and Green Party. Using results from prior analyses of the Liberal and Conservative parties, I compare national emissions and economic impacts in 2030 for all four major parties. The demonstrated process provides a tool that can help voters in all democracies identify viable climate platforms and targets.

Keywords: climate policy; greenhouse gas emissions; evaluation framework; reduction targets; energy economy emissions modelling

Acknowledgements

Thank you first to Dr. Mark Jaccard for always educating with enthusiasm and encouragement, and for supervising this project. Thank you to everyone in the Energy and Materials Research Group who provided invaluable feedback and moral support throughout my research; especially Brad Griffin, who sacrificed hours of time to brainstorming analysis ideas. Thanks to Thomas for talking me through the thesis-writing process with endless patience. Thank you also to Kaitlin for the editing help and encouragement - also provided by Heather, Renate, and Aaron. A big thank you to Jotham Peters, who co-supervised this project, and everyone at Navius who helped me to learn the gTech model; especially Franzi and Brett for dedicating many hours to showing and (re) explaining to me how to model. Special thanks to Vanessa for keeping me on track and handling the administrative side of things. I am so grateful for the good spirits and laughter provided by everyone I met during my time in the REM program. Finally, thank you to my family and friends for always keeping me sane and providing constant support.

Table of Contents

List of Tables

List of Figures

List of Acronyms

BC	British Columbia
CAD	Canadian Dollars
CGE	Computable General Equilibrium
CFS	Clean Fuel Standard
CIMS	Canadian Integrated Modeling System
CON	Conservative Party Plan Scenario / Conservative Party of Canada
EMRG	Energy and Materials Research Group
EEE	Energy Economy Emissions
gCO2e/MJ	Grams Carbon Dioxide Equivalent per Megajoule
GDP	Gross Domestic Product
GHG	Greenhouse Gas Emissions
GREEN	Green Party Plan Scenario / Green Party of Canada
Green 2019	Green Party 2019 *Mission: Possible* climate platform
Green 2020	Green Party 2020 *Vision Green* climate platform document
green60	Green Party 60% Target Scenario
ICE	Internal Combustion Engine
iZEV	Incentives for Zero Emissions Vehicles
LCFS	Low Carbon Fuel Standard
LIB	Liberal Party Plan Scenario / Liberal Party of Canada
LULUCF	Land-use, Land-use change and Forestry
Mt	Megatons (of emissions)
NDP	New Democratic Party Plan Scenario / New Democratic Party
NDP 2019	New Democratic Party's 2019 *Power to Change* climate platform
ndp50	New Democratic Party 50% Target Scenario
OBPS	Output-Based Pricing System
OECD	Organisation for Economic Co-operation and Development
OPEC	Organization of the Petroleum Exporting Countries
QC	Quebec
REF	Reference Scenario
t CO2e	Tonne Carbon Dioxide Equivalent
ZEV	Zero Emission Vehicle
ZEVIP	Zero Emission Vehicle Infrastructure Program

Chapter 1.

Introduction

Canada is not unique as a country that repeatedly fails to achieve its greenhouse gas (GHG) emission reduction targets. Reasons for this failure are likely numerous, including: (1) the common challenges of delivering on aspirational election campaign promises - of any kind - in liberal democracies, (2) the difficulty for one country to take costly unilateral GHG-reducing action when the climate threat may appear temporally and geographically distant and requires global collective action, and (3) the difficulty for voters (and politicians) to estimate the likely GHG-reducing effectiveness of different types of climate policies. Combined, these factors enable less-climate-sincere politicians to set ambitious targets without implementing effective policies. Thus, there is a role for independent researchers to develop, test, and present a framework for identifying climate sincere governments.

In this study, I focus on the third reason for climate policy failure by demonstrating a method to enable citizens to assess the climate-sincerity of competing political parties with more success. Specifically, my aim is to help citizens differentiate in advance of an election viable climate policy platforms from those with negligible or negative effects – on both emissions and economic growth. This type of evaluation framework is increasingly relevant as public concern for the climate increases but effective policies, and substantiative emissions abatement, seem to remain insurmountable at a global scale. The tools presented in this study are therefore relevant to all democratic countries trying to make progress on the climate change challenge.

1.1. Research Objectives

The first objective of this research is to present a climate platform evaluation framework, comprised of three components: (1) a method to assess what policies to allow for evaluation, (2) use of an energy-economy-emissions (EEE) simulation model to estimate likely GHG reductions and gross domestic product (GDP) cost, (3) a process to re-simulate climate platforms with more stringent policies and observe GDP impacts in cases where policies do not achieve targets. Together, the results of this framework can provide climate-concerned individuals with the tools to successfully identify climate sincere politicians.

After presenting my generic climate platform evaluation framework, the second objective of my research is to apply it to a case study. I comparatively analyze the climate platforms of four competing political parties in Canada using an EEE model to project the likely emissions and economic effects of each plan. I achieve this in part by benefitting from analyses done by Navius Research, an independent and reputable consulting firm specializing in energy economy modelling work, who had already modelled the climate platforms/policies of two major Canadian political parties. The contribution I provide through this study is to analyze and model the other two major national parties to enable assessment of all four climate platforms before Canada's 2021 Federal election.

Chapter 2.

Background

2.1. Why global greenhouse gas reduction efforts fail

Climate change has been cited as the “biggest threat modern humans have ever faced,” and one that threatens international peace and security (UN Security Council 2021). A warming climate destabilizes food production, weather patterns, freshwater availability, and, ultimately, socio-economic and political systems. The contribution by humans to this global phenomenon has been scientifically recognized since 1895 (Cass 2012), and in 1979 the World Climate Programme was specifically established to better understand and observe climate change (World Meteorological Organization 2018). Just six years later, the World Climate Programme concluded that warming associated with greenhouse gases was well understood, and "scientists and policy makers should begin an active collaboration to explore the effectiveness of alternative policies and adjustments," (Cass 2012). Thus, both the immense challenge of climate change and the need for rigorously assessed climate policy have been recognized for decades. During these decades, global emissions have continued to rise. So, why hasn’t the world acted?

To start, it is helpful to review how the world, and then Canada specifically, have addressed climate change. The “First Earth Summit” was held in 1972 in Stockholm, Sweden, and officially put the issue of climate change on the international map (Jackson 2007). After the World Climate Programme made its statement to urge further development of climate policy, the Toronto Conference of the Changing Atmosphere was held in 1988 to call for specific policy responses to the threat of climate change, and the Intergovernmental Panel on Climate Change (IPCC) was established to independently research this phenomenon. Also at this conference, a target was set for a 20% reduction in emissions by 2005. This prompted some countries to place climate action high on their list of political priorities, while others such as the United States, the Soviet Union, the OPEC states, and most developing countries continued to lag on climate efforts (Cass 2012). Then, in 1992 at the Earth Summit in Rio de Janeiro, the United Nations Conference on Environment and Development created a framework for international agreements to protect the global environment; from threats that included rising GHG emissions. Also at the Earth Summit, the United Nations Framework Convention on Climate Change was introduced with the goal to, “stabilize atmospheric concentrations of ‘greenhouse gases’ at a level that would prevent dangerous anthropogenic interference with the climate system,” (Jackson 2007). Several years after the Convention’s implementation, the Kyoto Protocol was adopted by signatories in 1997 with the goal to reduce industrialized countries’ emissions 5% below 1990 levels by between 2008 and 2012. This was the first framework to legally bind developed countries to an emissions reduction target (United Nations n.d.). By 2007, the Kyoto Protocol had been officially in force for two years, and the IPCC had released its Fourth Assessment Report; putting climate change into “popular consciousness” (United Nations n.d.). After several years of adjusted targets and revisions to previous agreements and pledges, the 21st Conference of the Parties was held in Paris in 2015 and culminated in the Paris Agreement. This Agreement was signed by 196 Parties with the goal to limit global warming to 2 - or preferably 1.5 - degrees Celsius above pre-industrial levels (United Nations 2021). The primary pillar of the Paris Agreement was the submission by signatories of Nationally Determined Contributions; voluntary emissions reduction commitments which are to be strengthened every five years (United Nations 2021). Since the Paris Agreement, countries have made some progress on strengthening commitments and reducing the growth in emissions, resulting in a lower projected peak temperature this century (Cornwall 2020). However, global emissions are still rising. Global GHGs rose 23% between 2005 and 2018, putting the goal of limiting temperature increases in the next century further out of reach. Within the top ten emitters, China, India, Russia, Brazil, Indonesia, Iran and Canada all saw national emissions continue to rise from 2005 to 2018 (Climate Watch 2022). Policies to prevent further rises in emissions in each of these countries, and numerous others, are desperately needed if humanity is to legitimately address climate change. I now turn to three important reasons for our failure thus far to stifle emissions, before concentrating on Canada’s history of climate policy.

For most of the world’s population, emissions continue to rise because of their need for cheap and easily accessible energy to drive continued development. Fossil fuels are relatively inexpensive, while zero-emission energy systems remain out of reach for many countries – at least until priorities like healthcare, education and food production are addressed. Thus, climate change may not even appear on the political agendas of governments in these countries, who must instead support rapid expansion of fossil-fueled socio-economic development. Wealthier countries *should* provide help to quickly implement zero-emission energy system infrastructure, as abating or preventing further rises in the developing world's emissions will be critical to global climate success (Jaccard 2020). However, the present study focusses on emissions in wealthier democratic nations, another important part of the climate change challenge.

For wealthier - and often democratic - countries, the reasons for continued increase in emissions are different. As mentioned previously, there are three main factors responsible for the developed world's failure to address climate change. The first is the common challenge of delivering on aspirational election campaign promises - of any kind - in liberal democracies. The roots of this challenge are founded in political and sociological theory and will not be thoroughly explored in this study. However, it is worth keeping in mind that enacting strong policy to dramatically alter technology stocks, energy systems, and cause some economic restructuring, all necessary components of deep decarbonization, is extremely difficult no matter the motivation. Jaccard (2020) briefly discusses some of the fundamentals attributes of democratic politics, noting that ideologies and policy preferences come second to group loyalties and cognitive biases towards where "people like me" belong (Jaccard 2020; Kahneman 2013). Thus, working within the landscape of democratic politics - and sociology - is the first challenge to overcome if individual countries and the world are to successfully implement climate policy.

The second challenge is the difficulty for one country to take costly unilateral GHG-reducing action when the climate threat may appear temporally and geographically distant and requires global collective action. This challenge is exacerbated when the issue at hand has international contributors and international impacts. Truly addressing climate change requires action by *all* countries, for all to benefit. But there is an incentive for any one country to let others do more than their fair share, and still reap the benefits. This phenomenon "occurs when a party receives the benefits of a public good without contributing to the costs," where, in this case, the public good is global abatement of GHG emissions (Nordhaus 2015). Historically, politicians have had success in promising to eliminate costly climate policy by justifying free ridership on the efforts of other countries. This was done in Canada under the Harper administration (2006-2015) when

Prime Minister Stephen Harper actively opposed and ultimately withdrew Canada from the Kyoto Protocol. More recently, the Trump administration in the United States (2017-2021) formally backed out of the Paris Agreement in 2020. In both cases, the government cited domestic economic hardship and a lack of effort from other countries as justification for ceasing efforts on the climate challenge. As Jaccard (2020) discusses, this tactic is particularly important for gaining political support from industries whose options for low-emissions production might be expensive, while the risk of production moving to less regulated jurisdictions is high. To counter this trend, Jaccard (2020) describes a strategy where further stagnating of climate change action is disincentivized in individual countries. He and others (e.g., Nordhaus 2015), proffer international "Climate Clubs," where participating members agree to significantly reduce emissions while non-club members face tariffs or other trade penalties. Such an approach reduces the incentive to rely on emissions reduction from others and reduces "spillover effects" – which hurt domestic industry and may cause global emissions to increase – as more members join (Nordhaus 2015). Implementing climate clubs or another strategy to address the public-good characteristics of climate action helps to justify national governments in making serious domestic emissions abatement efforts. However, citizens must be able to tell when their governments are sincerely making efforts that have a high probability of success.

This leads to the third reason for humanity's continued failure to address climate change: the difficulty for voters (and politicians) to estimate the likely GHG-reducing effectiveness of different types of policies, thus enabling less climate-sincere politicians to set ambitious targets without implementing effective policies. Exploring Canada's history of setting targets and implementing ineffective policies provides a good example of this type of failure and introduces the rationale for the present study. Since the 1988 Toronto conference on *Changing the Atmosphere: Implications for Global Security*, Canada has steadily released climate plans and emissions reduction targets, while national emissions have continued to rise. In 1990, the *Green Plan* was released, with its target to reduce emissions to 1990 levels by 2000. This was succeeded by the 1995 *National Action Program on Climate Change*, then the *Action Plan 2000 on Climate Change*, then the 2002 *Climate Change Plan for Canada*, then the 2005 *Project Green* initiative (National Round Table on the Environment and the Economy 2012). All these national strategies were dominated by a similar policy approach: information and subsidy programs to support voluntary reductions in emissions (Jaccard et al. 2006). Emissions targets set along the way became more distant with each passing year. In 1993, the Chretien administration committed to a 20% reduction below 1988 levels by 2006, and in 1997 Canada's Kyoto Protocol commitment became a reduction of 6% below 1990 levels by 2008-2012 (National Round Table on the Environment and the Economy 2012). By 2007, Canada released its *Turning the Corner* climate change plan with new targets to reduce emissions 20% below 2006 levels by 2020 and 60-70% by 2050. This was further altered to a 17% reduction below 2005 levels by 2020 when the *Federal Sustainable Development Strategy* was released three years later. In 2011, the Harper administration withdrew Canada from the Kyoto Protocol entirely (Hrvatin 2016). Then, in the year before the 2015 Paris Agreement, Canada announced a commitment to reduce emissions 30% below 2005 levels by 2030. In part due to a change in government, it took until 2020 for policy details on how the 30% target would be achieved to be released, in the form of the *Healthy Environment and a Healthy Economy* plan (including a rise in carbon pricing to \$170/t CO_2e by 2030) (Environment and Climate Change Canada 2020a). Most recently in early 2021, Canada's Paris Agreement target was strengthened to a 40% reduction in emissions below 2005 levels by 2030, with the *Canadian Net-Zero Emissions Accountability Act* also passed to legally bind Canada to its target of net zero emissions by mid-century (Government of Canada 2021a, 2021b). But will this most recent climate policy plan achieve Canada's Paris Target, or would another federal party's plan come closer, and cost less? These are questions that climate-concerned citizens ask when deciding which political party to support, as before the Fall 2021 election. In this study I present a method for evaluating competing party climate platforms that will enable citizens in Canada and any other liberal democracy to discern climate sincere politicians from those making insincere and/or unachievable promises on climate action.

2.2. Types of climate policy

Before presenting the Climate Platform Evaluation Framework developed through my research, I introduce the types of climate policy tools available to governments, and their strengths and weaknesses. Many types of policies exist that range from highly to less effective in their ability to significantly reduce greenhouse gas emissions. Figure 1 is borrowed from Jaccard 2020 and organizes climate policies first into compulsory and non-compulsory, then regulations and carbon pricing, before showing several types of each compulsory policy option.

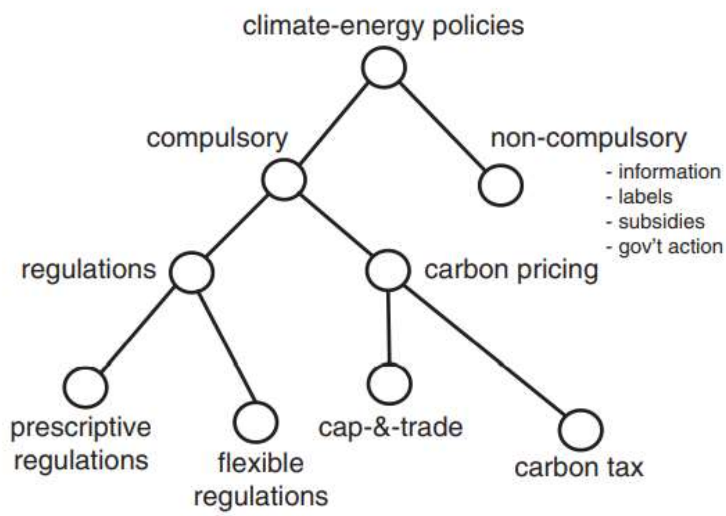

Figure 1: Types of climate policies

Prescriptive regulations are also known as “command-and-control” regulations, specifying exactly what industry or consumers must do, usually in terms of emissions reductions or technology adoption. In contrast, flexible regulations are still compulsory, but they allow regulated entities to trade amongst themselves or to decide how to achieve a wider, over-arching target. British Columbia’s Clean Electricity Standard exemplifies this type of regulation; it requires an increasing percentage of the province’s electricity mix to be “clean” or near zero emissions. “Clean” electricity could mean renewables, but it could also come from fossil fueled generation paired with carbon capture and storage (Government of British Columbia 2021; Jaccard 2020). This flexibility enables electricity producers to choose from multiple options to make clean electricity, or to pay other producers to generate more than their required share - if that’s the least-costly option for a given firm. Overall, flexible regulations aim to mimic carbon pricing in terms of their flexibility and therefore economic efficiency.

Carbon pricing is the most economically efficient category of climate policy. Both the carbon tax and a cap-and-trade policy achieve what economists refer to as the equi-marginal principle, meaning that total costs to the economy of abating emissions are minimized. For example, every individual and firm has multiple options to respond to a $50 per tonne carbon dioxide equivalent (CO2e) tax; they can lower energy service demand (e.g., drive less), change fuel type (e.g., use biofuels), change technology (e.g., purchase an electric vehicle), or maintain the status quo and pay the tax. These options mean that each individual and firm will choose their lowest cost response to the policy. For many, this will be to reduce emissions, thereby achieving the goal of the policy at the lowest overall cost to society.

The climate policies presented above can be evaluated using four key criteria: emissions effectiveness, economic efficiency, political acceptability, and administrative feasibility (Jaccard, Hein, and Vass 2016). Compulsory policies perform well in terms of emissions effectiveness because they require specific reduction amounts or technology changes. However, they differ in terms of the remaining three criteria. Carbon pricing policies - cap-and-trade and carbon taxes - are economically efficient because they achieve the equi-marginal principle and therefore minimize total costs to the economy. In contrast, prescriptive regulations are *not* economically efficient because they require everyone to respond to the policy in the same way, regardless of the different costs faced by different economic agents. Flexible regulations fare better in terms of economic efficiency because they mimic the flexibility afforded by carbon pricing. Moving to the third criterion, carbon pricing policies can be highly unfavourable politically due to highly visible costs (Rhodes, Scott, and Jaccard 2021), and a lack of trust in government's ability to effectively implement programs that use tax revenue (Fairbrother 2016). Prescriptive regulations can also be politically unfavourable because they might impose major costs on some firms and individuals, but negligible costs on others. Flexible regulations can be designed to minimize structural changes in the economy, or to protect more trade-exposed sectors. They also tend to be less visible to the individual consumer or firm. Lastly, both prescriptive and flexible regulations require significant administrative capacity to set up, enforce and monitor – lowering their administrative feasibility relative to a simple carbon tax.

With these criteria in mind, one can consider how non-compulsory policies score relative to the compulsory policies discussed above. The level of administrative capacity required by non-compulsory policies varies depending on whether the policy is a one-time investment, a subsidy program, or a disbursement of information. In terms of economic efficiency, they tend to fare poorly. As Jaccard et al. point out, "a government would have to raise other taxes to stratospheric levels if it were to subsidize all major investments and operating expenditures in the economy in order to ensure the dominance of near-zero-emissions options over fossil fuel burning options," (2016). However, these types of policies tend to be politically favourable for several reasons: 1) no one is compelled to do anything, 2) they may involve the government providing funding or subsidies to certain groups, and 3) they sound good on paper to anyone who isn't a climate policy expert – all explaining their prominence in Canada's historical climate plans. Finally, in terms of emissions effectiveness, non-compulsory policies contribute very little to emissions reductions (Axsen, Plötz, and Wolinetz 2020). The following evidence helps to demonstrate how ineffective, although politically favourable, non-compulsory policies are in the context of Canadian and global climate efforts.

Over the last four decades, Canada has implemented numerous examples of non-compulsory climate policies. As early as 1975, the "Canadian Industry Program for Energy Conservation" was established to reduce energy-use and emissions in Canadian industry by encouraging voluntary abatement action (e.g., by firms in mining, manufacturing, electricity generation and oil and gas) (Natural Resources Canada 2020a). The "EnerGuide" program was then introduced in 1978 to provide information to consumers on energy consumption and efficiency of new vehicles, major appliances, heating and cooling equipment, and new houses (Natural Resources Canada 2020b). In Action Plan 2000, the Canadian federal government committed to purchasing 20% of its electricity from low or non-emitting sources; an effort to demonstrate support for emerging low-emissions generation projects. This plan also proposed incentives for new industrial buildings that exceeded the model building code or implemented renewable energy technologies (Government of Canada 2000). In the 2002 Climate Change Plan for Canada, many of the actions listed involved strategic government spending/investments into decarbonization research and development. Additionally, 24 megatons (Mt) of the promised emissions reductions - needed to reach Canada's Kyoto Protocol target - were proposed to be achieved by each Canadian citizen *voluntarily* reducing their emissions by 1 t CO2e annually (Government of Canada 2002). The list goes on. But the important point is that Canada did not meet its Kyoto Agreement target, or any emissions target for that matter.

This myriad of non-compulsory policies and promised actions is not a climate approach unique to Canada. Haug et al. (2010) analyzed hundreds of climate policy evaluations in the European Union and observed a key finding: the prevalence and ineffectiveness of voluntary measures to address climate change. Cass (2012) also discusses at length the United Kingdom's strategy throughout the 1980s and 90s to support further research and set bold targets, while distinctly avoiding compulsory policies. Indeed, anecdotal evidence like this suggests that repetitive reliance on target-setting combined with ineffective non-compulsory policies has dominated the GHG reduction efforts of liberal democracies around the world. To truly combat climate change, evidence suggests that countries should "apply either a rising carbon price or increasingly stringent regulations on technologies and forms of energy," otherwise regarded as *compulsory* policies (Jaccard et al. 2016; EMF Working Group 25 2011) . Thus, ensuring that proposed policies will be effective through independent research is of value. In the next section, I further explain the potential value of a more rigorous climate platform evaluation framework.

2.3. Value of a rigorous climate platform evaluation framework

Missing from the climate change effort is a framework for evaluation of policies and targets that competing political parties promise to implement before an election. The method I propose is thus relevant to Australia, the United States, Canada, and every other democratic country in the world.

For decades, energy-economy-emissions modelers have stressed the importance of improving model capacities to estimate the costs of climate policies and targets so that policymakers can better address the issue of rising emissions (EMF Working Group 25 2011). Before this step, however, policies should be extracted from competing political party platforms using a rigorous and researched approach. First, the analyst uses only exactly what the political party has put on paper and made publicly available well in advance of an election – providing sufficient time and information for modelling to be conducted. From publicly available climate policy platforms, an analyst or researcher can then extract policies proven to have an emissions or economic impact and simulate the effects of these into the future, reporting on projected GHGs, GDP impact, and possibly regional and equity effects. If a party's policy package fails to achieve their stated target, the analyst can then increase carbon pricing – as this is the lowest cost climate policy – until the target is reached, before again reporting on all results. These steps would be repeated for all competing parties, and the results listed in a comparative table to inform climate-concerned voters.

This type of framework holds politicians accountable by showing in advance of an election whether their proposed plans and targets are feasible, and how costly. They are not given the benefit of the doubt when extracting policies from their climate platforms, and all parties receive the same treatment when modelling their proposed policies. Presenting the results of an analysis like this provides voters will the ability to more confidently decide which party to support on climate change.

Chapter 3.

Methodology

In this chapter I describe the research methods I use to develop a climate platform evaluation framework and apply it to the specific case study of Canada's 2021 federal electoral campaign. Three components comprise this framework: (1) a method to assess what policies to allow for evaluation, (2) the use of energy-economy-emissions modeling to estimate the likely GHG reductions and GDP cost of each platform, and (3) a process to re-simulate climate platforms with more stringent policies and observe GDP impacts in cases where stated policies do not achieve targets. I first describe the general criteria that can be used to include or exclude elements of a political party's climate platform before applying these criteria to evaluate four political parties' platforms in Canada. Next, I provide an overview of the energy-economy-emissions model I chose to estimate the likely GHG and GDP impacts of implementing these Canadian climate policy platforms and / or achieving each party's stated emissions target. Lastly, I describe how I implemented the eligible policies in this model to simulate each party's climate platform.

3.1. Extracting key policies from four federal party platforms

In this section, I present the first component of the Climate Platform Evaluation Framework presented in this study. First, the categories of policies to be included in an evaluation of climate platforms are discussed. I then list the types of polices (or non-policies) that should be excluded when comparatively analyzing competing platforms.

3.1.1. Climate platform evaluation criteria

At any time, competing political parties in at least most OECD countries have policy platforms that present how they intend to address specific opportunities and challenges for their jurisdiction. These platforms can contain a range of planned legislation to detailed descriptions of future tax expenditure to promises of vague outcomes. For evaluation of climate platform effectiveness in particular, only certain policies have the potential to change technology stocks, alter energy consumption patterns, and ultimately reduce emissions (Jaccard 2020). These should be compulsory, additional, and specific (Hoyle 2020; Jaccard et al. 2016). *Compulsory* policies require that GHG polluters either reduce emissions, pay a fine/tax on residual emissions, or adjust technology and energy use – ultimately resulting in lowered emissions. In contrast, non-compulsory policies are less likely to cause reductions because, in many industrial and personal contexts, it is financially preferable to continue with the status quo use of emissions-intensive technologies and energy. Further, non-compulsory policies such as subsidies and incentives run the risk of being rendered ineffective by the "free-rider" effect. This occurs when individuals or businesses benefit from receiving an incentive to perform an action they would have undertaken even without the incentive (Rivers and Shiell 2016). For example, a rebate to lower the cost of an efficient dishwasher will in part be received by individuals who were already going to purchase the more efficient dishwasher; thereby *not* creating additional emissions reductions. *Additional* means that the policy causes reductions in emissions beyond those that would otherwise occur due to existing policies or social trends. Lastly, *specific* details must be provided for a policy to be assessed. These include timelines, monetary amounts (i.e., in the case of a tax or subsidy program), stringencies (i.e., in the case of regulations) and coverage (i.e., affected sectors, exemptions). Without specific descriptions of policies, a researcher or modeler must make large assumptions about how a policy might be implemented, reducing the usefulness and accuracy of the analysis. It is important that these assumptions not reward vagueness, as the ongoing failure of climate policies is largely attributed to the mistake of giving insincere politicians the benefit of the doubt when assessing their vague policy claims. Carbon pricing and regulations generally can meet all three criteria. However, if both emissions and economic impacts are to be evaluated, then subsidy programs, incentives or major investments should also be modelled, despite not being *compulsory* or necessarily *additional (*provided that *specific* details are given). This is because a climate plan based on spending policies might not cause changes in emissions but could still have an economic impact due to inefficient use of government funds.

Figure 2 shows the progressive criteria used to extract climate platform policies that could potentially cause emissions reductions and therefore be simulated in an energy-economy-emissions model. Based on these criteria, I created categories of policies to be included in the modelling component of this analysis. Table 1 shows these policy categories and the justification for their inclusion in the modelling phase of the evaluation framework. The next section details which policies and measures to exclude from the modeling component of this framework.

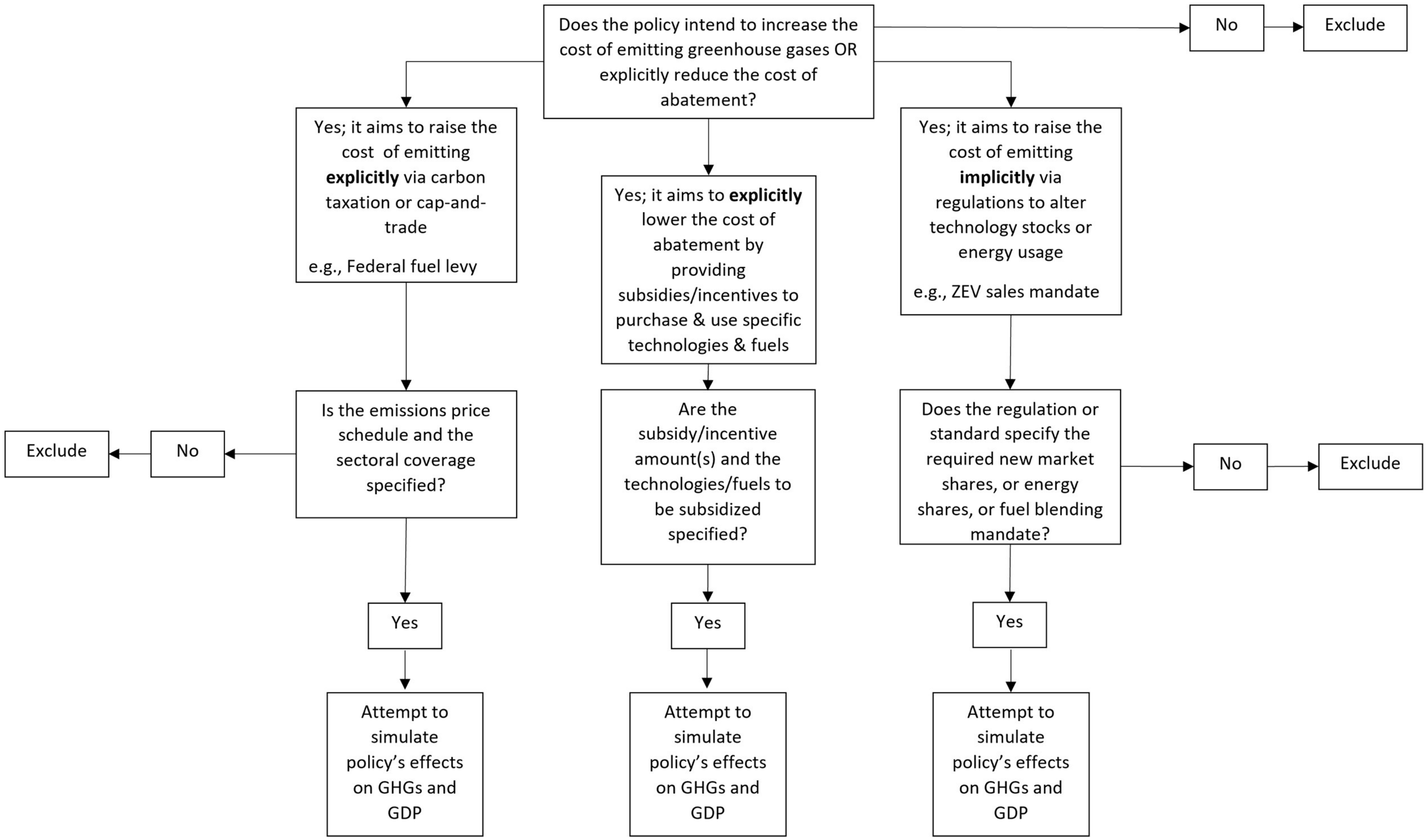

Figure 2: Evaluative criteria for choosing climate policies to include in modelling analysis.

Table 1: Categories of climate policies/measures that can be included in modelling analysis.

Policy Category	Justification	Examples
Carbon Pricing	Carbon pricing policies are compulsory because all applicable emitters must reduce emissions or pay the tax/credit price These policies send a price signal to reduce emissions efficiently in all covered sectors.	Western Climate Initiative in Quebec, Nova Scotia, Washington and California (WCI Inc., 2022). (Western Climate Initiative Inc. 2022)
Flexible Regulations	Flexible regulations are compulsory because all regulated entities must comply – usually through multiple compliance options – or pay a non-compliance fee. These policies target technology and/or energy-use to ultimately reduce emissions in a specific sector or end-use.	Clean Fuel Standard in Canada Zero-Emission Vehicle Regulation in British Columbia (Government of British Columbia 2019) Renewable Portfolio Standard in 29 U.S. states. (Joshi 2021)
Prescriptive Regulations	Prescriptive regulations require a specific change in technology or energy-use by all regulated actors. These compulsory regulations can reduce emissions in specific sectors or end-uses.	Reduction of Carbon Dioxide Emissions from Coal-fired Generation of Electricity Regulations in Canada. (Government of Canada 2018)
Incentives	Incentives are non-compulsory but may impact decisions by firms or consumers to purchase/use technologies/energy. Incentives are unlikely to cause great emissions reductions but can have an economic impact.	iZEV Program in Canada (Transport Canada n.d.)

Government spending	Government spending/investment is unlikely to have a noticeable emissions impact but can have economic impacts if funds are diverted from elsewhere or used inefficiently.	*Healthy Environment Healthy Economy* climate plan in Canada; commits nearly $15 billion to climate measures investments. (Government of Canada 2020)

3.1.2. Climate Platform Exclusions

The general types of proposed policies and actions excluded from the modelling phase of a climate platform evaluation are shown in Table 2, along with the justification for their exclusion. Importantly, all *actions and outcomes* should be excluded from modelling. Actions and outcomes specify something that is promised to happen under a party's platform, but not how this will occur. For example, British Columbia's *Roadmap to 2030* commitments include, "reducing the energy intensity of goods movements by 10% in 2030," but not the policies that would cause this outcome (Government of British Columbia 2021). Thus, actions and outcomes without the policies to back them should be excluded from evaluation of a party's policy platform. See Appendix A for specific examples of excluded policies and actions from the Canadian party platforms.

Table 2: Categories of climate measures (policies and non-policies) to be excluded from modelling analysis.

Exclusion category	***Justification***
Financial support for research & development (R&D), pilot-stage technologies, worker (re)-training or "strategy building"	Primarily informational policies - no guarantee of wider uptake or effectiveness in reducing GHGs
Policies lacking jurisdictional capacity	Federal government cannot enforce policies under sub-national jurisdiction
Non-binding targets or actions	Voluntary targets without legislated policy to ensure attainment
Actions and outcomes lacking policies and/or sufficient details	Actions and desired outcomes without specific policy to ensure their attainment and/or enough detail to reasonably model
Incentives without financial details and/or proof of additionality	Cannot estimate impact of unspecified spending amounts or programs shown to have high free ridership
Financing schemes & spending dependent on partnerships and/or delivered by third-party organizations	Contingent on 3rd-party actions such as investment banks and other levels of government; cannot estimate GHG effects

Measures with highly uncertain/negligible emissions response	Does not guarantee uptake of behaviours or technologies that could reduce emissions
Emissions impact outside Canada	Emissions outside Canada do not contribute to national target

An important metric when assessing which policies/actions to include/exclude in the modelling analysis is *level of detail*. Climate platforms that contain vague statements about financing certain technological trends or implementing GHG reduction strategies, as examples, cannot be viably modelled. This is because the modeler would have to make specific assumptions about the timeline for implementation, the amount of money spent on the policy, where the funds come from, and who is covered by the policy. Additionally, as mentioned, subsidy or offset programs that are not rigorously designed and monitored cannot guarantee additionality of GHGs reductions. Actions / policies listed in climate platforms may also influence behaviour or technological changes that do not guarantee emissions reductions. For example, installing video-conferencing systems in every Canadian community (from Green Party of Canada 2020 platform) does not ensure use of such a facility or a reduction in emissions-intensive travel. These general categories of policies and actions to exclude from the modelling portion of the climate platform evaluation framework are important starting points that can be applied to other case studies (Appendix A describes several additional policies and measures excluded from the Green Party plan that are worth discussing individually as the logic behind their exclusion can be applied to other contexts).

3.2. Energy-economy-emissions modelling

The next step in my Climate Platform Evaluation Framework is to estimate how the extracted policies could impact future emissions and economic output. This evaluation involves making assumptions about how proposed policies would be implemented, how the economy might respond – in terms of energy use, technology choices, and level of output – and how global actions might also impact domestic activities. Energy-economy-emissions (EEE) models are well-suited tools for this task because they can simultaneously solve numerous equations using historical datasets and under a multitude of user-defined constraints. These attributes allow modelers to calibrate models to real-world data, impose constraints that represent real or hypothesized conditions, and embed known energy, economic, or emissions relationships into a larger system (i.e., a national or regional economy). Ultimately, models enable researchers to examine different energy, emissions and economic futures based on informed assumptions and real-world experience.

EEE models range in structure and solving method and are thus suited to varying purposes and research questions. “Bottom-up” describes one category of EEE models that are traditionally suited to solving optimization, and specifically decarbonization, problems. For example, those with an objective to find the least-cost way to meet an energy-service demand in a specific region or sector, given technological and policy constraints, but without consideration of the wider economy or behavioural changes. In contrast, “top-down” models attempt to simulate macroeconomic effects of policies on aggregated energy use and production, using microeconomic and general equilibrium theory (Böhringer and Rutherford 2008). The former is technologically explicit, and so well-suited to examine how different technologies and technological developments may affect emissions and energy-use, while the latter can endogenously simulate economy-wide market adjustments to show economic impacts and re-structuring (Böhringer and Rutherford 2008). While both have useful applications, each are limited when attempting to answer questions related to environmental and especially climate change policies. Bottom-up models tend to *only* provide the direct financial costs to firms and households of how specific policy or technological changes could adjust energy use and emissions, ignoring the wider implications for structural change and aggregate economic output. In contrast, top-down models estimate how energy-use and other economic changes may alter output levels but rely on a limited number of historically derived economic parameters that may not fully reflect long-run technological potential and cost effects (Bataille et al. 2006).

More recent development of “hybrid” EEE models aims to address these deficiencies by providing technological explicitness, microeconomic realism and macroeconomic comprehensiveness in one modelling tool; enabling policymakers to discern how technology-specific regulations or economy-wide pollutant pricing policies might affect microeconomic behaviour and yield wider macroeconomic feedbacks (Bataille et al. 2006). Two main approaches have been used to combine top-down and bottom-up model features to develop hybrid models: 1) adding technological explicitness to a top-down, computable general equilibrium model, or 2) adding economic equilibrium feedbacks to a bottom-up model. The following section focusses on the first approach, to provide methodological context for the modelling tool used in the present analysis.

Computable General Equilibrium (CGE) models can assess the effects of economic or policy changes on gross domestic product (GDP), national welfare, industry output, economic distribution, labour markets, and environmental variables (Dixon and Parmenter 1996). Developments in CGE models also now enable researchers to explore multi-regional and multi-time period problems. Dixon and Parmenter (1996) describe several features that, combined, distinguish CGE models from other EEE tools:

- Assumptions about the behaviour of economic actors, i.e., that they optimize in order to maximize utility or minimize costs.
- Descriptions of how supply and demand dynamics affect the prices of commodities and fuels, with the constraint that in all markets total supply must equal total demand.
- Model results that are numerical, or computable. This typically is based in a set of input-output tables, alongside income and price elasticity parameters, that represent how commodities flow between industry, households, and export markets. An important detail of the *numerical* feature of CGE models is that the baseline data and estimation of elasticity parameters are grounded in real-world data.

These attributes enable traditional CGE models to provide insight on how an economy might realistically respond to “shocks”; such as new tax regimes or a change in commodity prices. Bergman (2005) asserts that CGE models, “among many other things, have been used for evaluation of the efficiency of emissions taxes and other environmental policy instruments.” Missing from conventional CGE models is the ability to simulate technology acquisition decisions of individuals, firms and energy supply sectors, which is needed to properly assess technology or energy-focused policies and regulations (Jaccard et al. 2016). A method called “soft-linking” can be used to partly reconcile an economy-wide CGE model with a more technologically explicit bottom-up model. However, better still is to create a comprehensive hybrid model with both the capacity to simulate all economic activity, and importantly, the technological evolution of energy-consuming capital. This is the type of model both described and demonstrated in the present study. I will next characterize this model, before explaining how it was used to simulate climate policies extracted from each Canadian party's climate platform.

3.2.1. The gTech CGE model

I kept the modelling component of my research to a manageable level by benefitting from two climate policy assessments conducted in late 2020 / early 2021 of two Canadian political parties: the governing Liberals and the opposition Conservatives. These assessments were performed by Navius Research Inc. (Navius), using their "gTech" CGE model - the same model I used for the modelling portion of my research. In August 2021, I used a version of gTech to simulate the NDP and Green Party promises and policy platforms, while Navius Research used a slightly different version to perform their own analyses of the Liberal Party and Conservative Party climate platforms in late 2020 / early 2021. I will first describe gTech generally as a model and its suitability for this study, before explaining the modest differences in model versions used for four political party platforms.

As mentioned, gTech is a Computable General Equilibrium model able to represent national economies, including Canada and the United States. In a 2010 study on carbon taxation, Peters et al. noted that CGE models are useful for climate policy analysis because they, "connect all major activities in the economy (production, consumption, savings, investment, trade, public finances) to show how the structure and technological character of the economy changes in response to policies." gTech does this, but also contains technological details and parameters that enable it to simulate technological change and its impact on energy-use and emissions. It derives this latter capacity in part from the model CIMS; an open-source model developed and maintained by the Energy and Materials Research Group at Simon Fraser University. CIMS is designed to simulate how technologies compete to meet energy service demands in key sectors of the economy, with some ability to also account for the resulting macroeconomic performance of these sectors. Much of the technological detail in CIMS was integrated into gTech. A central component of this integration was the modification of CIMS' market-share (i.e., technology competition) equation so that it could operate within a CGE framework. Ultimately, gTech can be considered a hybrid model derived from adding technological explicitness to a macroeconomic CGE model.

Navius Research used a 2-year version of gTech to perform the Liberal Party plan analysis. The model iterates in two-year periods from 2015-2035. This model version disaggregates Canada's economy into 83 sectors and 11 regions (10 provinces plus 1 region to represent the Territories). Each sector can demand energy or non-energy end-use services in each simulation period, such as vehicle-kilometers-travelled, meters-cubed of hot water, exajoules of heat, tonnes of steel, or meters-squared of building space, as examples. Technologies then compete to meet these demands while commodities compete to supply fuels to those technologies requiring energy (e.g., liquid fuel for use in vehicles). Figure 3 illustrates an example of how transportation sectors in gTech demand end-use services, which are met through technologies competing for market share, resulting in demand for competing fuel options. Fuel commodities have an emissions factor allowing energy-use to be aggregated into a sector or region's emissions for a given model period. Also, in each model period, as new and existing technologies compete for market-share to meet end-use service demand, old technologies are retired and must also be replaced. This repeated demand for end-use services or commodity production, and fulfillment by technology competition in each model year, results in the evolution of technologies. Policies can then impose constraints by directly regulating the types of technologies that can be adopted or by changing the economics of technology adoption decisions throughout the economy (e.g., by imposing a tax on emissions). Importantly, because gTech is a general equilibrium model representing all of Canada, it can determine the combined effects of multiple climate policies - at municipal, provincial and national levels - on the economy and on national emissions.

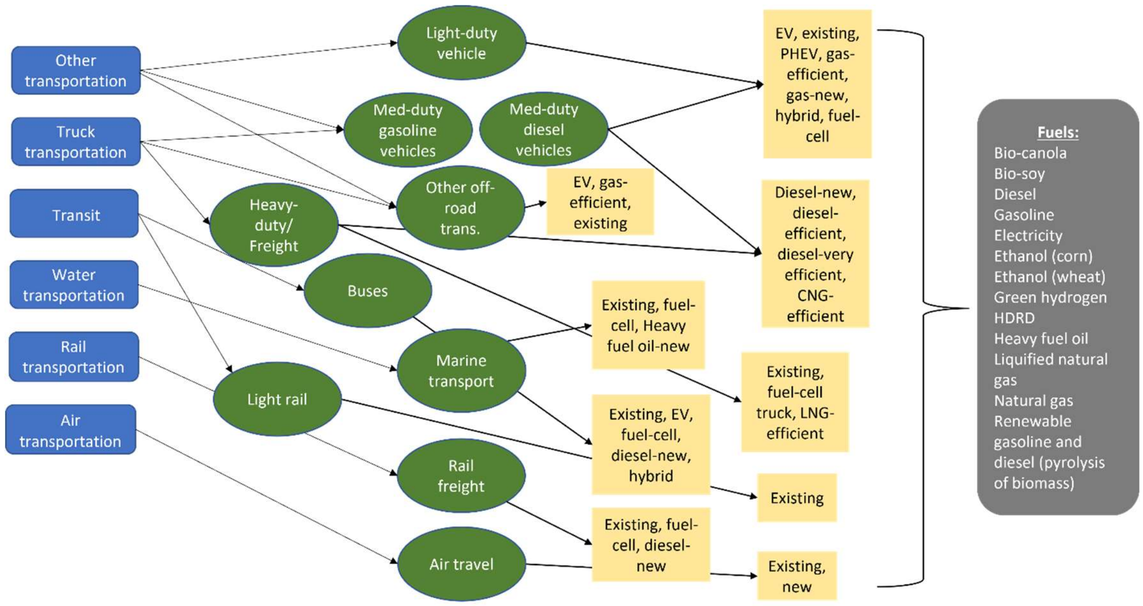

Figure 3: Example of transportation sector (blue), end-use (green), technology (yellow) and fuel (grey) linkages in gTech.

As mentioned, after their Liberal plan analysis, Navius was contracted by the Conservative Party of Canada in the spring of 2021 to explore policy options and simulate a policy platform that would reach that party's GHG commitment to achieve a 30% national GHG reduction (from 2005 levels) by 2030 (Navius Research 2021). The version of gTech that Navius used for this analysis was almost identical to the version used for simulating the Liberal government's policy packages in late 2020. Since Navius provided the policy assumptions, GHG emissions and GDP impacts for both the Liberals and Conservatives, this provided me with the basis for a fair comparison by simulating the NDP and Green stated policies with the same gTech model, using the same policy acceptance criteria, for the same 2030 target date.

For my analyses of NDP and Green targets and policies, I used a 5-year version of gTech with simulation years from 2015-2050. This model version also had 11 Canadian regions, but contained 9 sectors additional to those in the 2-year model version used for the Liberal simulations. These included further disaggregation of agricultural sectors, the addition of CO_2 storage and transport, cellulosic ethanol production, hydrogen transport, and renewable gas and diesel production. Aside from slightly different sectoral disaggregation and simulation periods, the two versions of gTech are functionally equivalent. Important for an analysis of competing climate platforms, both versions can simulate national or provincial tax regimes, revenue recycling, flexible regulations, prescriptive regulations, government investment into specific technologies or sectors, and technology subsidies.

3.3. Scenario implementation

In this section I describe how each scenario was simulated in the gTech model. In total, seven scenarios were modelled to assess possible GDP and GHG impacts. Table 3 briefly describes these scenarios and the sources used to inform them:

Table 3: Names, descriptions and sources used to inform the seven scenarios simulated and evaluated in this analysis.

Scenario code	***Scenario name***	***Description***	***Source***
REF	Reference/base case	Simulates only legislated or nearly legislated climate policies	*Canada Gazette (multiple dates)* (Environment and Climate Change Canada 2020b; Government of Canada 2021c)
LIB	Liberal Party of Canada climate plan	Simulates existing policies + Liberal Party's *Healthy Economy Healthy Environment* climate plan	*Healthy Environment and a Healthy Economy 2020* (Government of Canada 2020)
CON	Conservative Party of Canada climate platform	Simulates Conservative Party's *Secure the Environment* climate platform	*Secure the Environment 2021* (Conservative Party of Canada 2021)
NDP	New Democratic Party climate platform	Simulates NDP's *Power to Change* climate platform	*Power to Change: a new deal for climate action and good jobs 2019* (New Democratic Party 2019)
ndp50	New Democratic Party climate platform + 50% target	Simulates NDP's *Power to Change* climate platform + carbon pricing policy that achieves target of 50% reduction	*Power to Change: a new deal for climate action and good jobs 2019* (New Democratic Party 2019)

		in 2005 emissions by 2030	
GREEN	Green Party of Canada climate platform	Simulates Green Party's *Mission: Possible* & *Vision Green* climate platform documents	*Mission: Possible* (Green Party of Canada 2019), *Vision Green* (Green Party of Canada 2020)
green60	Green Party of Canada climate platform + 60% target	Simulates Green Party's *Mission: Possible* & *Vision Green* climate platform documents + carbon pricing policy that achieves 60% reduction in 2005 emissions by 2030	*Mission: Possible* (Green Party of Canada 2019), *Vision Green* (Green Party of Canada 2020)

As mentioned, the Liberal (*LIB*) and Conservative (*CON*) policy plan assessments were undertaken by Navius using gTech. As part of their *LIB* assessment, Navius also modelled a "base-case" scenario containing only legislated or nearly legislated policies at federal and provincial levels; I use this scenario as my reference case *(REF*) or "business-as-usual" scenario in the present analysis. Using results from Navius for my *REF, LIB* and *CON* scenarios enables me to focus on applying the gTech model to the policy platforms and climate targets of the NDP and Greens (in four distinct scenarios), and to then compare the promises and proposed policies of all four parties as they existed prior to the launch of the federal election in September 2021.

Comparing platforms prior to the launch of an election campaign seems like a relatively fair and tractable approach because: (1) all four parties had two years since the previous election to refine their climate policies and put these in writing for citizens to view, (2) during an election campaign, parties announce new policies at a rate that continuously renders the latest policy modelling comparison out-of-date, leading to claims of unfair treatment. Perhaps comparative evaluations like this will help incentivize political parties to be less vague about their promised GHG reducing policies, between elections and not just during elections.

In all seven scenarios, the simulated federal and provincial policies are limited to those with the potential for an evidence-backed emissions impact on Canadian emissions and GDP. For details on provincial policies present in each scenario, see Appendix A.

Additional scenario details

3.3.1. REF - Reference scenario

The *REF* scenario was modelled by Navius as part of an analysis performed in late 2020 into early 2021 to compare the Liberal Party's newly announced *Healthy Environment Healthy Economy* (hereafter HEHE 2020) plan to an existing policies / reference scenario (Environment and Climate Change Canada 2020a). The federal policies simulated by Navius as part of the reference scenario include: the Clean Fuel Standard, Renewable Fuels Regulations, subsidies for battery electric and plug-in hybrid vehicles, Canada's Passenger Automobile and Light Truck Greenhouse Gas Emission Regulations, and the backstop federal carbon pricing system (legislated to reach $50/t CO2e by 2030). I explain the general model implementation of each below.

The Clean Fuel Standard (CFS) was published in the Canada Gazette in 2020 and final regulations will be released in 2022 (Environment and Climate Change Canada 2022). This policy requires liquid fuel suppliers to decrease the carbon intensity of liquid fuels used in Canada by 13% below 2016 levels by 2030. For years 2022-2030, the carbon intensity requirements in grams CO2e per mega-joule (gCO2e/MJ) are specified and fuel producers can sell or buy credits if they exceed or fail to meet the intensity requirements in each period. In gTech, the CFS is modelled by specifying the reduction in life-cycle carbon intensity of liquid fuels sold (in g CO2e/MJ) from a baseline. This reduction starts at 3.6 g CO2e/MJ in 2023 and reaches 12 g CO2e/MJ by 2030. The maximum price for credits is also specified at $304.69 ($2015 CAD) from 2023-2030. Two other option to generate credits exist in addition to increasing supply of low-carbon fuels: 1) undertaking projects that reduce the life-cycle carbon intensity of liquid fuels, and 2) supporting the switch from use of fossil fuels to less carbon-intensive fuels (e.g., electricity, hydrogen, etc.) (Environment and Climate Change Canada 2022). gTech contains model levers that allow these actions to generate credits in the CFS market, thereby reducing the need for credits to be attained via fuel intensity reduction elsewhere (for example, reductions in the GHG intensity of industrial production of hydrogen and heat qualify for CFS credits).

Canada implemented the *Renewable Fuels Regulations* in 2010 to increase the renewable fuel content of gasoline and diesel (Environment and Climate Change Canada 2020b). The coverage and stringency of these regulations will be maintained once the CFS is fully implemented (Environment and Climate Change Canada 2022). In the reference scenario, the model requires a minimum percentage content for renewable fuel, which is set at 5% for gasoline and 2% for diesel consumed domestically after 2017 until 2030.

In early 2019, the Canadian government implemented the *Incentives for Zero-Emissions Vehicles* (iZEV) program to encourage purchase of battery electric and plug-in hybrid vehicles. As of mid-2021, the program was scheduled to end within the next year and therefore only model years 2019-2021 contain this incentive (note; as of April 2022, additional funding was added to the iZEV program to extend its end-date to 2025 (Transport Canada 2022)). The per-vehicle incentive amounts listed on the Government of Canada website - $2500 for shorter-range plug-in hybrids and $5000 for longer range and battery electric vehicles – are converted into $2015 CAD for input into gTech. These amounts reduce the consumer cost of purchasing a new zero emission vehicle (ZEV).

Canada's *Passenger Automobile and Light Truck Greenhouse Gas Emission Regulations* require light-duty on-road vehicle manufacturers to meet fleet average greenhouse gas emissions standards for a given vehicle model year (Government of Canada 2010). These regulations are aligned with equivalent standards in the United States, where the Environmental Protection Agency implemented greenhouse gas emissions standards for light-duty vehicles, and the National Highway Traffic and Safety Administration established aligned fuel economy regulations (Canada Environmental Protection Act Registry 2018). These light-duty vehicle regulations are represented in the gTech in two places:

1) A model lever that specifies the average grams CO2e per vehicle-kilometer-travelled by light-duty vehicles in each model year. In the *REF* scenario, grams CO2e/vehicle-kilometer-travelled is specified for both Canada and the U.S. for years 2017-2030 at increasing stringencies (to match the emissions intensity component of the U.S. Corporate Average Fuel Economy Standards).

2) A model lever that restricts the share of certain types of new gasoline and diesel vehicles that can be sold in each model year. Less efficient vehicles are essentially phased-out from new vehicle sales after 2017, while efficient diesel vehicles are eventually phased out after 2021 (for heavy-duty) and after 2027 (for medium-duty).

Combined, these model constraints simulate Canada's currently legislated Passenger Automobile and Light Truck Greenhouse Gas Emission Regulations - as well as the U.S. equivalent.

The final major climate policy included in the reference scenario is the federal carbon pricing backstop. In 2016, the Canadian Government released, "The Pan-Canadian Approach to Pricing Carbon Pollution," which set backstop stringency benchmarks for pricing GHG pollution (Government of Canada 2016). This policy allows provinces and territories to either implement their own pricing systems – such as a cap-and-trade regime, as in Quebec, or an explicit carbon-pricing policy, as in British Columbia – or to participate in the Federal carbon levy and output-based-pricing system (OBPS) for large industrial emitters. The federal carbon levy applies to fossil fuels used in a participating region (with some exclusions) and is legislated to increase by $10 annually until reaching $50 in 2022. The OBPS covers large emissions-intensive, trade-exposed facilities that are excluded from the full application of the carbon levy. This component of the federal carbon pricing system is designed to maintain a price signal for these industries to reduce carbon pollution, but to ensure they remain cost-competitive in a global market. To implement Canada's carbon pricing policy in gTech, two model levers exist:

1) A carbon tax can be specified for each model year and region in CAD $2015. Revenues can be recycled to government, households, corporate tax cuts, income tax cuts, or investment streams in specified proportions.
2) The output-based pricing system is modelled as a performance standard in gTech where the price in $2015/t CO_2e and the percentage reduction in emissions intensity from industry baselines can be specified by region and model year. Additionally, free credit allocations for both combustion and process emissions can be specified by region and model year.

Combined, these model levers enable simulation of the federal backstop policy, as well as provincial / territorial versions of carbon pricing (where applicable). In the *REF* scenario, both the price of the carbon levy and the OBPS rise to $50 in 2022 and remain until 2030. For the federal OBPS, emissions intensity must decline 20% below the benchmark set for each industry after 2019. These carbon pricing policies apply to all Canadian regions except British Columbia (BC) and Quebec (QC), where a household and large-final-emitter carbon tax (BC) and a cap-and-trade system (QC) apply instead. For more information on provincial/territorial carbon pricing regimes not regulated by the Federal carbon pricing backstop, see Appendix A.
Additional scenario details. For regions participating in the federal backstop, all revenue collected from both the carbon levy and OBPS is returned to the province / territory where it was collected, with 100% of revenue returned directly to households.

These *REF* scenario policies are both legislated and implemented in Canada as of July 2021, with one exception. The Clean Fuel Standard was not yet in place, but it can be considered part of a reference scenario because of its advanced status in the legislation and implementation process. In the *REF* scenario, Navius assumed 30Mt of CO2e emissions are sequestered by land-use, land-use change and forestry (LULUCF) processes in 2030.

3.3.2. LIB - Liberal Party of Canada climate plan

The *LIB* scenario was also modelled by Navius as part of their analysis to compare the Liberal Party's newly announced *Healthy Environment Healthy Economy* plan to an existing policy scenario. At the time of my analysis, the Liberal Party's emissions target was a 30% reduction in 2030 emissions relative to 2005 levels (this was later increased to a 40% reduction target). The following federal policies were simulated in the *LIB* scenario: the Clean Fuel Standard, Renewable Fuels Regulations, subsidies for battery electric and plug-in hybrid vehicles, Canada's Passenger Automobile and Light Truck Greenhouse Gas Emission Regulations, and the backstop federal carbon pricing schedule announced in fall 2020 which would reach $170/t CO2e by 2030 (Government of Canada 2020, 2021c). The implementation of these federal policies in gTech is largely the same as in the *REF* scenario (explained in the previous section), with a few key differences: Because provincial / territorial response to a new carbon pricing schedule (reaching $170 by 2030) is unknown, all provincial carbon pricing regimes (i.e., British

Columbia's carbon tax and Quebec's cap-and-trade) are removed after 2020 and replaced with the federal carbon pricing system (to ensure the federal price minimum applies to all region in gTech). Additionally, the OBPS is removed across all regions after 2020 and replaced with the national carbon levy. Emissions-intensive and trade-exposed industry are still protected through allocation of free allowances for combustion and process emissions (mimicking the effect of the original OBPS). 100% of carbon pricing revenue is recycled to households within each province / territory. Lastly, emissions assumed to be sequestered via LULUCF reach 30Mt annually by 2030 in the *LIB* scenario.

3.3.3. CON - Conservative Party of Canada climate platform

The Conservative Party climate platform (Conservative Party of Canada 2021) was modelled by Navius Research in April 2021 (Navius Research 2021). The Conservative Party's emissions target was a 30% reduction in 2030 emissions relative to 2005 levels. The following federal policies were simulated that differ from the Liberal climate platform/existing climate policy:

- Replacement of the federal carbon levy with a Low Carbon Savings Account caron pricing policy. As with the federal levy in the *REF* scenario, consumers pay \$50/t CO2e. However, this revenue is directed into a Low Carbon Savings Account, and they can then use this revenue to pay for low carbon technologies and activities.
- The Output Based Pricing System is kept in place and rises to \$170/t CO2e by 2030.
- A Renewable Gas Mandate is implemented, requiring that 15% of gaseous fuel (consumed outside the oil and gas sector) be from renewable sources by 2030.
- A ZEV Mandate is implemented, requiring that zero emission vehicles capture 30% of new market share for light-duty vehicles by 2030.
- A Low Carbon Fuel Standard replaces the Clean Fuel Standard and requires a 20% reduction in the carbon intensity of transport fuels by 2030.
- \$5 billion in federal government investment is put towards carbon capture and storage technologies.

While the specific implementation of these policies in gTech is confidential, all key attributes of gTech base assumptions (initial forecast of GDP and population, world oil price, etc.) were essentially the same for the LIB and CON policy platform simulations conducted by Navius as well as for the simulations I did of the NDP and Green platforms and targets.

3.3.4. NDP - New Democratic Party climate platform

The *NDP* scenario is based on the New Democratic Party's 2019 *Power to Change: A new deal for climate action and good jobs* climate platform document (hereafter NDP 2019) (New Democratic Party 2019). The NDP's emissions target was a 50% reduction in 2030 emissions relative to 2005 levels. The purpose of simulating this scenario is to evaluate how implementation of NDP 2019 might impact both emissions in 2030 relative to the NDP's announced 2030 target, and Canada's GDP in 2030. All policies implemented from NDP 2019 in this scenario are assumed to begin in 2022 and end in 2030. Federal climate policies modelled in this scenario include:

- Maintaining the fuel levy at $50/t CO2e after 2022 and until 2030;
- Removal of the output-based pricing system;
- The Clean Fuel Standard is removed;
- A Zero Emissions Vehicle purchase incentive program increasingly applied to only made-in-Canada vehicles;
- A home-charger purchase incentive;
- Federal tax exclusion on commercial purchases of ZEVs;
- Federal government procurement of EVs, carbon-neutral buildings and renewable energy; and
- Government investments into renewable energy, buildings efficiency, and electrifying transit.

In the *NDP* scenario, the federal carbon tax reaches $50/t CO_2e in 2022 and remains at this level until 2030. Provinces that currently have their own carbon pricing systems (i.e., BC and QC) maintain these systems until 2030 and are not impacted by the following changes. An excerpt from NDP 2019 was used to inform simulation of carbon pricing in the NDP scenario; "…we will continue carbon pricing, including rebates to households that fall under the federal backstop plan, while making it fairer and rolling back the breaks the Liberals have given to big polluters," (New Democratic Party 2019). Based on this, I applied the carbon tax economy-wide by removing any end-use and non-combustion emissions exclusions present in the *REF* and *LIB* scenarios. To ensure that all industry is taxed equally to the rest of the economy, the OBPS was removed after 2020. 100% of revenue from the federal carbon tax was recycled to households after 2020. To be fair to the *LIB* and *CON* carbon pricing policy commitments, which in both cases explicitly and publicly provide their carbon price schedule from 2018 to 2030, I assumed that the NDP price would remain at the initial Liberal price schedule prior to its revision in late 2020. I scanned for an NDP press release or other written policy statement but found nothing indicating an NDP commitment to a carbon price that would rise above $50/t CO2e in 2030. To be consistent with my climate plan evaluation criteria, I could not assume a rising NDP carbon price if the party was unwilling to proclaim this in writing as the other two parties had done, especially given the specific details the NDP provided for some of its GHG policies, such as the ZEV incentive program.

A zero-emissions vehicle purchase incentive policy was simulated based on the following passage from NDP 2019: “To make it easier for families to afford a ZEV right away, a New Democrat government will provide a $5,000 federal purchase incentive […] Over the next few years these incentives will grow in value to $15,000 and be targeted to made-in-Canada vehicles only,” (New Democratic Party 2019). This ZEV purchase incentive program is split into two parts for implementation in gTech. In Part 1, from 2021-2025, $5000 purchase incentives for new light-duty ZEV sales, growing to $15,000 “over the next few years” (New Democratic Party 2019), were assumed to be administered according to the linear trajectory shown in Table 4.

Table 4: ZEV subsidy schedule assumed for NDP scenarios; shown in nominal dollar amounts. *In 2026 and until 2030, only made-in-Canada vehicles are eligible for the ZEV subsidy (see below for details).

Year	2022	2023	2024	2025	2026*
Amount per EV	$5000	$7500	$10,000	$12,500	$15,000*
Amount per PHEV	$3140	$4709	$6279	$7849	$10,313*

From 2022-2025, this per-vehicle ZEV purchase incentive was applied to all ZEV sales made in Canada, regardless of manufacturing origin. Fully electric vehicles receive the full subsidy amount, while the purchase incentive for plug-in hybrid vehicles is scaled back to account for differing plug-in hybrid battery ranges. The proportion of the full ZEV subsidy available for plug-in hybrids is calculated based on the battery ranges of models currently available in Canada (Transport Canada n.d.). The ZEV purchase incentive is modelled differently from years 2026-2030, as follows.

In Part 2, from 2026-2030, the ZEV purchase incentive remains at $15,000 per vehicle but only purchases of "made-in-Canada" ZEVs are assumed to be eligible (NDP 2019) (i.e., those manufactured domestically). Because gTech does not differentiate between sales of domestic or foreign-made light-duty vehicles, the $15,000 could not simply be applied as a per vehicle subsidy. Instead, I modelled it as a lump annual investment into the domestic electronics manufacturing sector - which supplies electric products to the domestic vehicle manufacturing sector. The total annual amount from 2026-2030 invested into electronics manufacturing was determined using a series of calculations shown in Appendix A. displays Table 5 displays the results of these calculations in terms of the number of made-in-Canada EVs and PHEVs predicted to be sold in Canada, and the total subsidy expenditure targeted into gTech's electronic manufacturing sector. A factor of 0.5 was used to temper the amount that actually reaches this sector because not all output is a precursor to ZEV manufacturing.

Table 5: Made-in-Canada electric vehicle (EV) and plug-in hybrid vehicle (PHEV) sales and total subsidy program amounts for years 2026 and 2030 under the NDP ZEV incentive: Part 2.

	2026	***2030***
EV sales (vehicles)	4832	6233
EV subsidy expenditure (CAD millions)	$725	$94
PHEV sales (vehicles)	19328	24934
PHEV subsidy expenditure (CAD millions)	$199	$257

Total (CAD millions):	*$924*	*$351*

A ZEV Tax Exclusion policy was also included in this scenario, based on an excerpt from NDP 2019; "An additional break waiving the federal sales tax for working families on ZEV purchases." I modelled this tax incentive as an annual lump sum investment into ZEVs, dispensed from 2022-2030, using a technology factor of 0.5 to temper the amount that actually reaches the following ZEV technologies: light, medium and heavy-duty electric vehicles, plug-in hybrid vehicles and hydrogen fuel cell vehicles. A factor of 0.5 was used because, in reality, a subsidy helps cover the cost of not only the technology itself, but also additional features, retail margins, etc. Under this policy, the projected future revenue that would be collected by the federal government (from a 5% goods & services tax on vehicles) is modelled instead as a subsidization of ZEVs by the federal government. To calculate future annual amounts of this subsidy, the following was undertaken:

- Using data from Statistics Canada, annual new passenger vehicles sales (in nominal dollars) from 2015 to 2020 were used to find the annual change in sales during this period (Statistics Canada 2021). This average annual change in total sales (-9.6%) was applied forward from the historical 2020-dollar amount to project passenger vehicle sales out to 2030.
- The projected market shares of battery electric vehicles and plug-in hybrids for 2025 and 2030 (used above for the *ZEV Purchase Incentive*) were linearly back casted to the 2020 market shares of these vehicle types to produce projected ZEV market shares for each simulated year (2022-2030).
- Total projected passenger vehicle sales were then multiplied by the projected market share of ZEVs, then by 5% GST, to calculate the annual projected amount "spent" on the ZEV Tax Incentive *(*i.e., foregone federal taxes). All amounts were converted into billions $2015 for input into gTech as a subsidy on ZEV purchases.

A ZEV Home Charger Incentive was also modelled in the *NDP* scenario based on an excerpt from NDP 2019: "We'll also help homeowners cover the cost of installing a plug-in charger, up to $600." Several assumptions were made to simulate this policy in gTech. First, ZEV charger incentives are not likely to be used by every buyer of electric vehicles. This has been the case for Canadian jurisdictions with established rebate programs, such as British Columbia. A 2015 study conducted by the Sustainable Transportation and Research Team at Simon Fraser University on electric vehicles in Canada found that in British Columbia, only 60% of sampled electric vehicle owners made use of home charger rebates (Axsen, Goldberg, and Bailey 2015). This rate of rebate redemption is assumed to stay constant at 60% of new electric vehicle purchases for the simulation period of 2022-2030. The NDP's ZEV Home Charger Incentive was modelled as a lump sum subsidy towards the same ZEV technologies used for the ZEV Tax Exclusion (see above), using a factor of 0.5 to temper the amount of each $600 rebate that would actually reach the final technology (e.g., after installation costs). This lump sum amount was calculated by multiplying the number of projected annual ZEV sales (Canada-made only after 2025; calculated under ZEV Purchase Incentive) by 60%, then $600, then 0.5. As with the above ZEV incentives, this incentive program was assumed to be administered from 2022-2030.

All other spending outlined in NDP 2019 was modelled as lump sum investments into set technology (and/or sector) groups, using technology factors of 0.5 to temper the amount of money actually reaching the final technology (some sectors receive all funds and a factor of 1.0 is used). All spending amounts are assumed to be allocated across years 2022-2030 as NDP 2019 specifies that they aim to "close the [emissions] gap by 2030."

Transit Investment: In NDP 2019, a cycling strategy, expansion of bus routes, VIA rail mandate and a zero-emissions buses mandate comprise their transportation strategy and inform the technology group used for this investment. They promise to spend, "$6.5 billion [on] making transit and transportation cleaner and more affordable." Investment into active transportation (i.e., cycling infrastructure) was not modelled due to its uncertain / incremental emissions impact (Förg, Murphy, and Jaccard 2021). Because part of the NDP's overall transportation strategy is to improve active transport networks, and another portion of this investment would contribute to project administrative, construction and transportation costs, only $3.25 billion of the total 6.5 billion was directed to the following technology group: light rail, electric, hybrid, and fuel cell buses, and EV freight trucks.

Renewable Energy Investment: NDP 2019 commits to spending, "$3.5 billion to spur the transition to renewable energy." Their proposed strategy for renewable energy encompasses both the supply and demand side of renewable electricity, as well as increasing support for renewable gas production. The technology group targeted by this investment contained gTech's renewable electricity and renewable gas sectors. A factor of 1.0 was used to target this investment amount into two gTech sectors.

Clean Communities Investment: A section in NDP 2019 called "improving where we live and work" also commits to spending, "$2.5 billion to create good jobs helping communities adapt to climate change and reduce emissions, including though energy efficient retrofits." The "improving where we live and work" section of NDP 2019 is widely scoped, including plans to finance efficiency upgrades in community, government, and residential buildings, in addition to supporting research and development, public planning and climate change risk management in buildings. Because only efficiency retrofits have a (possibly) tractable emissions impact, $1.25 billion was directed towards the following group of technologies:

- Ground sourced heat pumps for household space heating, commercial space heating, household hot water, and commercial hot water
- Air sourced heat pumps for household furnaces and commercial space heating,
- Near zero office, food, retail, school, warehouse, and other building shells
- Near zero apartment, single family attached, and single family detached home building shells

Federal Leadership Investment: NDP 2019 also commits to spending, "$400 million to drive federal leadership on emissions reductions." This spending is part of their plan to model change by electrifying federal and crown corporation fleets and ensuring that all government buildings use renewable energy and are net carbon neutral. This $400 million was divided equally between the technology funds used for the *ZEV Tax Exclusion* (electrifying fleets), *Communities Climate Leadership* (net-carbon neutral government buildings), and *Renewable Energy Investment* (government buildings use renewable energy) investment policies.

Lastly, I assumed no emissions sink contributions from LULUCF for any of the NDP or Green scenarios. The justification for this decision has two components:

1) Projections of LULUCF contributions in 2025 and 2030 are based on predicted land-use trends that would generally apply in all scenarios (i.e., independent of

federal policy) ((Environment and Climate Change Canada 2017); R4 Annex 2.6), and

2) Future LULUCF emissions reductions estimates are likely optimistic as they assume that forest fire rates will remain consistent with the 1990 to 2017 national average ((Environment and Climate Change Canada 2017); BR4 Annex 2.6; pg. 167).

3.3.5. ndp50 - New Democratic Party climate platform + 50% target

In NDP 2019, the party its states promise to reduce GHG emissions 50% by 2030, relative to 2005 levels (New Democratic Party 2019). However, my simulation of the above NDP policies, based on their written statements, does not achieve the 50% promise. Therefore, in this scenario I adjust the NDP platform to achieve its GHG promise, thus enabling a fair economic impact comparison with the *LIB* and *CON* targets. To minimize the economic impact of an ambitious reduction of 50%, I assume that the NDP would use carbon pricing to reach this target, the most economically efficient policy tool with the smallest possible negative effect on economic output.

The *ndp50* scenario contains all policies implemented in the *NDP* scenario except carbon pricing reaching $50/t CO2e. Instead, a carbon pricing policy is applied to the entire economy (i.e., no OBPS or non-combustion emissions exclusions) at a stringency that achieves a 20% reduction in emissions by 2025 and a 50% reduction in emissions by 2030 (relative to 2005 levels). The carbon pricing policy applied in gTech for this scenario allows the modeler to constrain emissions in each model year, while the resultant carbon price is uncertain. National emissions were capped at 598 Mt (20% reduction) in 2025 and 374 Mt (50% reduction) in 2030. As in the *NDP* scenario, no allowances are given to large final emitters or emissions intensive, trade-exposed industry, maintaining consistency with the NDP's stated intention to provide the same carbon pricing treatment to Canadian industry as to Canadian consumers.

3.3.6. GREEN - Green Party of Canada climate platform

The *GREEN* scenario is designed to simulate climate policy statements described in *Mission: Possible* (Green Party of Canada 2019), which are further informed by *Vision Green* (Green Party of Canada 2020). Hereafter, these documents are referred to as

Green 2019 and Green 2020, respectively. The Green Party's emissions target was a 60% reduction in 2030 emissions relative to 2005 levels. All policies implemented from Green 2019 in this scenario are assumed to begin in 2022 and end in 2030 – the year of the climate targets being evaluated. The following federal policies were simulated for this scenario:

- Maintaining the fuel levy at $50/t CO2e after 2022 and until 2030;
- The federal OBPS is kept in place with the price rising to $50/t CO2e by 2022 and remaining until 2030;
- The Clean Fuel Standard is removed;
- Renewable Fuels Regulations are removed;
- New federal vehicle emissions standards for light-duty vehicles (based on California stringencies);
- "Feebate" program: electric and plug-in hybrid vehicle purchase subsidies + revenue recycled from internal combustion engine (ICE) sales to fund ZEV subsidies;
- Ban on new fracking operations;
- Government spending and investments.

Carbon Pricing was applied using a federal carbon tax levy reaching $50/t CO_2e in 2022 and remaining at this nominal amount until 2030 (as in the *NDP* scenario, I assumed that the *GREEN* price would remain at the initial Liberal Party price schedule prior to its revision in late 2020). Provinces that currently have their own carbon pricing systems (BC and QC) maintain these systems until 2030. While Green 2020 describes the intention to impose a cap-and-trade system on industry, no details are given on the timeline, sectoral coverage, administration and stringency of such a policy; therefore, the policy could not be modelled. However, because it is apparent that the Green Party intends to treat industry differently from the rest of the economy, the current OBPS was left in place until 2030 using the same price schedule as their federal carbon tax and requiring a 20% reduction below the benchmarks set for each year (as in the *LIB* scenario).

Vehicle emissions standards in the *GREEN* scenario differ from all other scenarios based on the following excerpt from Green 2020: "Adopt California standards requiring a 30% reduction in GHG emissions from new vehicles sold in Canada by 2020, 50% by

2025, and 90% by 2030." California currently does not have the authority to set its own state emissions standards. However, it has entered into individual bilateral agreements based upon its Framework Agreements on Clean Cars with six auto-manufacturers. The GHG emissions standards set out in these agreements were used to set the grams of CO_2e per kilometer standards used in the *GREEN* scenario (California Air Resources Board 2020).

A Light-Duty Vehicle Feebate Program was simulated based on the Green Party's plan to implement a feebate system which concurrently offers scaled purchase rebates on ZEVs up to $5000 and applies scaled surcharges on inefficient ICE vehicles. No end date was given for this program, so it was assumed to run from 2022-2030. Because many climate policies described in the Green's plan emulate California's climate strategy, it is a assumed that a federal light-duty feebate system would be similar to California's attempted feebate program from 2008 (Ruskin 2007). This program planned to use tax revenue from ICE vehicle sales to fund subsidies for ZEVs to make the feebate system revenue neutral. This transfer of funds between light-duty vehicle sales was modelled in gTech for the years 2021-2025 but not for the period 2026-2030. From 2026-2030, up to $5000 rebates were still offered but the funds were not raised from ICE vehicle sales; by this time there are insufficient new market shares of ICE vehicles to subsidize the - now much larger - new market shares of ZEVs. The subsidy amount for electric vehicles was assumed to be the full $5000/vehicle, while plug-in hybrids received $2500 if they had a battery capacity of less than 15 kilowatt-hours and $5000 if their capacity was greater than 15kWh (Transport Canada n.d.).

The *GREEN* scenario also includes revocation of current federal Renewable Fuels Regulations. As stated in Green 2019, "the Green Party opposes current laws requiring the use of biofuels and will only support standards for biofuel use when supplies of biofuels that are derived from demonstrably sustainable waste sources become available." Based on this statement, I assumed that a Green Party government would revoke the current Renewable Fuels Regulations (which require a minimum of 5% renewable fuels in gasoline and 2% in diesel) because these regulations do not specify that these biofuels come from demonstrably sustainable sources.

A Fracking Ban was implemented based on an excerpt from Green 2020: "Ban fracking. No exceptions. It destroys ecosystems, contaminates ground and surface water, endangers our health and it's a major source of GHGs." To model this policy, no new natural gas or oil wells were allowed after 2020.

Proposed Green Party spending was modelled as lump sum investments into set technology (and/or sector) groups, using technology factors of 0.5 to temper the amount of money actually reaching the final technology (some sectors receive all funds and a factor of 1.0 is used). All spending is assumed to be allocated across years 2022-2030 and falls into two investment programs:

- The Home Retrofit Program supplies $250 million annually for 5 years (2022-2026) to retrofit low-income homes. The technology group targeted by this investment contains: near zero apartment and single-family home building shells, and heat pumps (air and ground sourced) for space and water heating.
- A transit investment of $500 million per year (assuming 2022-2030, 9 years) targets development of urban transit and inter-model connections. In gTech, this investment targets the transit sector, which includes light rail and buses, using a factor of 1.0.

No contribution from LULUCF is assumed in *GREEN*, as in the *NDP* and *ndp50* scenarios.

3.3.7. green60 – Green Party of Canada climate platform + 60% Target

In both Green 2019 and Green 2020, the party states its goal to achieve a 60% reduction in GHG emissions by 2030 (relative to 2005 levels). As with the NDP, my simulation of Green policies did not achieve its 2030 GHG reduction promise. Therefore, as with the NDP, I assumed that the Green Party would use carbon pricing to reach this target; this being the policy tool with the lowest impact on the economy. This scenario also contains no LULUCF assumptions, as in the *NDP* and *ndp50* scenarios.

The *green60* scenario contains all policies implemented in the *GREEN* scenario except carbon pricing that reaches $50/t CO2e. Instead, a carbon pricing policy is applied to the entire economy at a stringency that achieves a 25% reduction in emissions by 2025 and a 60% reduction in emissions by 2030.

To simulate how a carbon tax could be applied *additionally* to the rest of the *GREEN* scenario policies in order to achieve a 60% reduction in emissions by 2030, a national cap on emissions was applied to the entire economy. This carbon pricing policy lever was chosen because it allows the modeler to constrain emissions in each model year, while the resultant carbon price is uncertain. National emissions were capped at 560Mt (a 25% reduction from 2005 levels) in 2025 and 299Mt (a 60% reduction) in 2030. Provincial policies were removed after 2020 and replaced by the federal policy due to the likelihood that these policies would not cause additional reductions beyond the 60% achieved by the very stringent policies required by the very ambitious promise of reducing Canadian emissions so dramatically in just eight years. The federal OBPS for industry is also removed. However, to maintain the pricing signal and trade protection afforded by the OBPS, large-final emissions / emissions-intensive and trade exposed industry were given free allowances for 70% of their emissions in 2025 and 60% in 2030. 100% of all carbon pricing revenue is recycled to households after 2020.

Chapter 4.

Results

4.1. Identifying the clearly stated policies

The primary results of the Climate Platform Evaluation Framework presented in this study are the clearly stated policies I extracted from each party's climate platforms for simulation in an energy-economy-emissions model. Table 6 shows the measures from each party platform that fell into the categories of eligible policies to be simulated in the gTech. The *ndp50* and *green60* scenarios are not shown explicitly in this table because they contain the same policies as the *NDP* and *GREEN* scenarios, albeit with increased carbon prices to meet their 2030 promises.

It is worth noting that because the modelling results used for these seven scenarios are from three different analyses, some discrepancies between assumptions exist. In Navius' analysis of the reference case and the Liberal plan (*REF* and *LIB*), the Clean Fuel Standard was assumed to be present in both scenarios, whereas I removed it in the NDP and Green scenarios. Also, I included major investments and spending commitments contained in the NDP and Green Party climate platforms, if sufficient detail was provided, while Navius did not simulate spending outlined in the Liberal's *Healthy Environment Healthy Economy* plan. For the purposes of this comparison, however, I assumed this discrepancy to be acceptable, given that government spending rarely has a substantial impact on GHG reduction (as history indicates).

The important policies to compare between scenarios are carbon pricing and regulations. Every party takes a different approach to carbon pricing: the Liberal Party uses a carbon levy and OBPS reaching \$170/t CO2e by 2030; the Conservative Party maintains an OBPS reaching \$170/t CO2e but replaces the carbon fuel levy with a Low Carbon Savings account reaching \$50/t CO2e by 2022; the New Democratic Party maintains the carbon levy (assumed to reach \$50/t by 2022) but is assumed to remove the OBPS; and finally, the Green Party maintains both the carbon levy and the OBPS (both assumed to reach \$50/t by 2022). Each party also takes a unique approach to regulations, especially those applying to the transportation sector. The Liberal Party plans to complete implementation of the Clean Fuel Standard while the Conservative party replaces this policy with a Low Carbon Fuel Standard (LCFS). It is assumed that under both the NDP and Green plans the CFS is cancelled, and in the case of the Green Plan, the Renewable Fuels Regulations are also removed. All parties regulate vehicle emissions, and the Green plan increases the stringency to mimic California's standards. The Green plan also adds a new prescriptive regulation: a ban on new fracking wells. In addition to their proposed LCFS, the Conservative plan adds two flexible regulations to generate emissions reductions in the natural gas and passenger vehicle sectors – all three of which emulate current provincial regulations in British Columbia.

Lastly, all parties approach incentive policies differently. The Liberal Party plans to continue the iZEV and ZEVIP program to increase ZEV purchases and increase charging capacity, as well as provide incentives to homeowners to upgrade building shells and appliances. The Conservative plan does not include incentive programs in its climate strategy. The NDP plan proposes a ZEV incentive that grows each year and eventually only applies to made-in-Canada ZEVs. Finally, the Green plan proposes a scaled feebate system where internal combustion engine vehicles are surcharged and ZEVs are subsidized. It also proposed a home retrofit incentive program.

Table 6: Policies from each party platform eligible for model simulation.

Scenario/ Party	***Carbon Pricing***	***Flexible Regulations***	***Prescriptive Regulations***	***Incentives***	***Government spending***
REF-Reference case	Backstop carbon pricing; fuel levy and OBPS rising to $50/t CO2e by 2022 until 2030	Clean Fuel Standard (including Renewable Fuel Regulations)	Vehicle Emissions Standards: in-line with US EPA Tier III emissions standards		
LIB-Liberal Party of Canada	Backstop carbon pricing; fuel levy and OBPS rising to $170/t CO2e by 2030 Carbon levy revenue recycled to households OBPS revenue recycled to clean technology funds	Clean Fuel Standard (including Renewable Fuel Regulations)	Vehicle Emissions Standards: in-line with US EPA Tier III emissions standards	Zero Emission Vehicle incentive (iZEV) program & ZEV infrastructure program (ZEVIP) Home and commercial buildings energy efficiency incentives & spending	
CON-Conservative Part of Canada	Fuel levy is replaced with Low Carbon Savings Account. Consumers pay into fund at $50/t CO2e after 2022 but can use collected revenue for low carbon technologies. OBPS for industry reaches $170/t CO2e by 2030	Renewable Gas Mandate requiring 15% of gaseous content be renewable by 2030 Zero Emissions Vehicle Mandate requiring 30% of new light duty vehicle sales be ZEVs by 2030 Replace CFS with Low Carbon Fuel Standard requiring 20% reduction in	Vehicle Emissions Standards: in-line with US EPA Tier III emissions standards (assumed)		Investments into carbon capture and storage technologies

		carbon intensity of transport fuel by 2030			
NDP-New Democratic Party	Backstop carbon pricing; fuel levy rising to $50/t CO2e by 2022 until 2030 100% of revenue recycled to households No OBPS	Clean Fuel Standard removed Renewable Fuel Regulations in place	Vehicle Emissions Standards: in-line with US EPA Tier III emissions standards	ZEV and home charger purchase incentives, with growing support emphasized on made-in-Canada vehicles ZEV federal tax exclusion	Federal procurement of EVs, carbon-neutral buildings, and renewable energy Investments into renewable energy, buildings efficiency and electrifying transit
GREEN-Green Party of Canada	Backstop carbon pricing; fuel levy and OBPS rising to $50/t CO2e by 2022 until 2030 100% of revenue recycled to households	Clean Fuel Standard removed Renewable Fuel Regulations removed	California-stringency vehicle emissions standards Ban on new fracking wells (natural gas & oil)	Home Retrofit Program Scale-based fee-bate system for vehicles based on efficiency	Investments into public transit

4.2. Environmental effectiveness: emissions in 2030

The results of the modelling component of the Climate Platform Evaluation Framework provide insight on how GHG emissions trajectories might change under different scenarios. In the case study of the period prior to Canada's 2021 election campaign, each competing political party had public emissions reduction targets for 2030. At the time of my analysis, the Liberal's and Conservatives promised to achieve a 30% reduction, the NDP a 50% reduction, and the Green Party a 60% reduction by 2030. Total national emissions in 2030 under each of the seven scenarios are displayed in Figure 4.

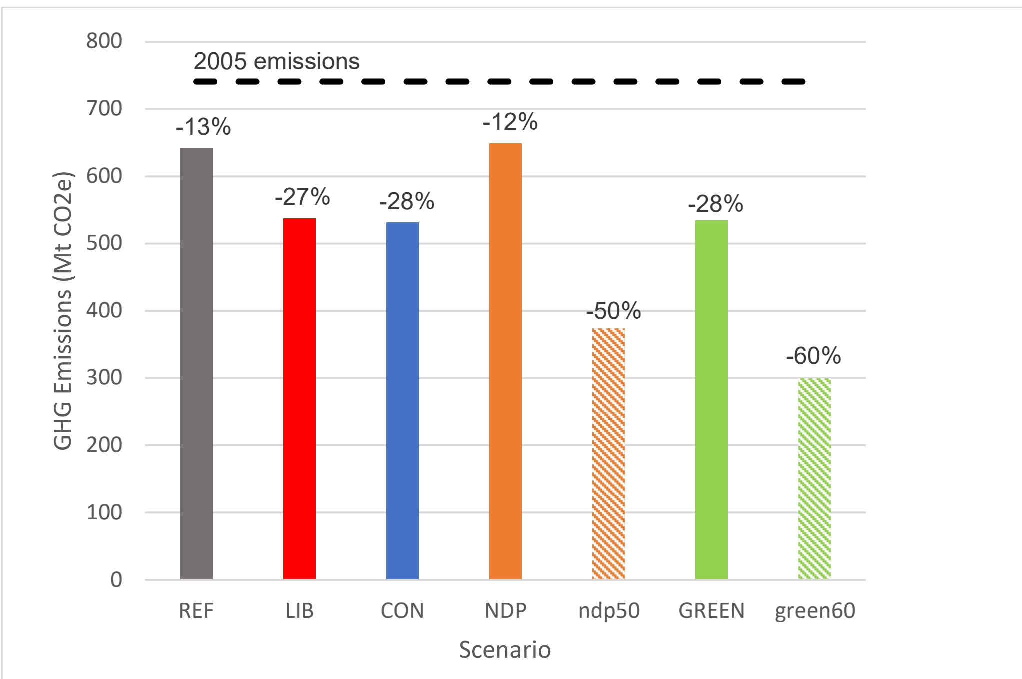

Figure 4: Absolute emissions in 2030 for each scenario and % reduction in emissions relative to 2005 levels (black dashed line).

In 2030, under the reference or business-as-usual (*REF*) scenario, emissions are projected to be 13% lower than 2005 levels; falling short of achieving the 30% by 2030 reductions promised by Canada in the Paris Agreement. Under the Liberal Party's *Healthy Environment Healthy Economy* climate plan, emissions reductions are projected to double, achieving a 27% reduction from 2005 levels and coming within 3 percentage points of the Liberal promise (30% reduction). The Conservative Party plan (CON) is

projected to achieve 6Mt more emissions reduction than the Liberal plan, resulting in a 28% reduction in 2030 and nearly achieving their 30% reduction target. The NDP plan scenario results in higher 2030 emissions than the reference case, achieving only a 12% reduction from 2005 levels and falling significantly short of their 50% reduction by 2030 target (reasons for the *NDP* scenario having higher emissions than the *REF* scenario include its absence of the Clean Fuel Standard and differences in modelling approach used to for the *REF/LIB* and *NDP/GREEN* analyses). The Green Party Plan is projected to reduce emissions by 28% in 2030 relative to 2005 levels, performing comparably with the Liberal and Conservative plans, but falling short of their 60% reduction target. By design, the *ndp50* and *green60* scenarios achieve 50% and 60% reductions in emissions below 2005 levels in 2030. I show the regional and sectoral breakdown of emissions reductions achieved in the *REF, LIB, NDP, ndp50, GREEN* and *green60* scenarios in Appendix B.
Regional and Sectoral Results. Disaggregation of emissions data for the Conservative plan scenario was not available.

4.3. Carbon price

Carbon pricing for the *REF, LIB, CON, NDP* and *GREEN* scenarios is based on implemented policy and written party platforms. But because the NDP and GREEN policy packages failed to achieve these parties' ambitious GHG promises, I ran two additional scenarios (*ndp50* and *green60*) in which the model found the carbon price trajectory to 2030 that would achieve the necessary reductions. For this, I set a constraint in the gTech model for emissions in 2030 such that the 50% reduction promised by the NDP and the 60% reduction promised by the Greens were realized in their respective simulations.

Table ***7*** displays the carbon prices for every simulation. The carbon price needed to achieve the NDP's 50% target reaches \$370/t CO2e in 2030 and reaches \$431/t CO2e to achieve the Green Party's 60% target. Because carbon pricing is considered the most economically efficient climate policy tool, these policy prices can be interpreted as the minimum carbon price necessary to achieve these ambitious GHG reduction targets.

Table 7: Simulated national carbon prices for the REF, LIB, CON, NDP and GREEN scenarios. Where different from the consumer fuel levy, the 2030 OBPS price is shown in brackets beside the national carbon price. *Indicates that the carbon prices for ndp50 and green60 are a result of an emissions cap policy. All prices shown in nominal CAD dollars per t CO2e.

Scenario	*2020*	*2025*	*2030*
REF	$30	$50	$50
LIB	$30	$95	$170
CON	$30	$50 ($95)	$50 ($170)
NDP	$30	$50	$50
ndp50	$30	$130*	$370*
GREEN	$30	$50	$50
green60	$30	$174*	$431*

These carbon price trajectories need to be considered in the light of carbon pricing in Canada and elsewhere. As recently as 2019-2021, the governments of Ontario and Alberta retracted carbon pricing in their climate policy platforms, the government of France faced weeks of riots when it tried to increase its carbon tax by $10/t CO2e, and the United States Congress again rejected all carbon pricing policy proposals.

Despite these political challenges to carbon pricing as a policy, the Canadian Liberal government promised in advance of an election, in late 2020, that it would increase Canada's carbon price by $15 per year to reach $170 by 2030. Even with many regulatory policies and substantial subsidies included in its policy platform, the Liberal government of Canada decided to take this political risk, given the necessity of a rising carbon price to achieve its GHG promise.

In this study, I have applied the same logic to the NDP and Green platforms, thus providing a comparison of the carbon price implications of their ambitious GHG promises. As the results show, in 2030 the NDP carbon price would need to hit $370 while the Green carbon price must hit $430. This means that under the NDP the price of gasoline would need to increase about 9 cents/litre per year while under the Greens it would need to increase about 11 cents/litre per year.

In both cases, there is a significant gap between the ambitious targets of these political parties and their written policy platforms that should have contained sufficient policy detail to help Canadians overcome the longstanding climate failure caused by politicians making GHG policies they fail to achieve.

4.4. Economic impact to 2030

National gross domestic product in 2030 is compared with the *REF* scenario to determine the projected loss of economic growth under each scenario. Loss of economic growth refers to the projected difference between a “business as usual” scenario, where policies and other current conditions remain constant into the future, and an alternative scenario where policies and assumptions are changed. Thus, the percentage difference between projected economic output (GDP) captures any losses or gains caused by differences in policies or other assumptions. However, it is important to note that this captures only domestic GDP effects when a single-country analysis is performed, as in this study. Avoided GDP losses from climate change damages – due to reduced temperature increase due to stronger climate policy – are not included, because that requires modeling the global effort. It should therefore be kept in mind that any GDP loss projected for a scenario with stronger climate policy in one country occurs alongside avoided GDP losses from climate change damages, dependent on if the rest of the world also acts.

As shown in **Error! Reference source not found.**, The initial *NDP* scenario has the least impact on GDP and results in only a 0.4% loss relative to REF, but this is to be expected given that this scenario has similar GHG results. The *GREEN* scenario is projected to cause a loss of GDP growth 1.3 percentage points more than in the *LIB* scenario, despite both scenarios reducing emissions by the same amount. Finally, the Conservative plan (CON) is projected to cause a 0.9% loss of GDP growth while achieving the greatest emissions reductions in 2030 out of the four party plan scenarios (*LIB, CON, NDP, GREEN).* The *ndp50* and *green60* scenarios cause the greatest loss of GDP in 2030 relative to the *REF* scenario: 5.8% and 6.7%, respectively. Regional and sectoral GDP impacts are discussed in Appendix B. To put these figures into perspective, note that a GDP loss of 1.6% - as in the case of the *LIB* scenario - is equivalent to perhaps a loss of half a year's economic growth. Thus, for example, between 2020 and 2030 the GDP might grow by 25% with no change in current climate policy but by 23.4% with the intensified climate policies proposed in the *LIB* scenario, a reduction of 1.6% of GDP.

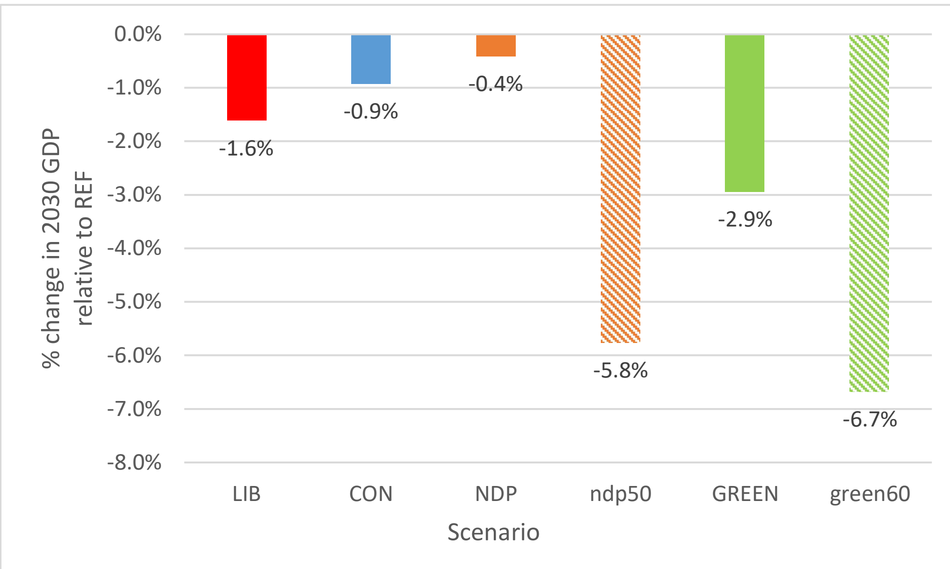

Figure 5: By scenario, total change in Canada's national GDP in 2030 relative to the REF (business-as-usual) scenario.

Another useful way to examine each party's climate platform is to compare the average cost of each megaton of emissions reduced – or the average abatement cost. Figure 6 shows the average percentage reduction in Canada's GDP, relative to the *REF* scenario, of each megaton of emissions reductions achieved in each scenario, relative to 2005 levels. The *CON* and *NDP* scenarios are equally as costly per megaton of emissions reduced in 2030, while achieving different emissions levels in 2030 (-28% and -12%, relative to 2005, respectively). Also, while the Liberal and Conservative plans induce similar reductions in emissions, the *CON* scenario is half as costly on average. These cost comparison results are due to the Conservative's economically efficient use of use of carbon pricing revenue. The Conservative plan is projected to generate more economic activity than the Liberal's because they return a portion to small businesses, while only households are returned revenue under the Liberal plan (Navius Research 2021). This efficient use of carbon pricing revenue offsets the Conservative's less efficient reliance on regulations to achieve emissions reductions in certain parts of the economy, and results in a very low average cost of abatement given the significant emissions reductions achieved. The Liberal scenario still performs reasonably well in terms of average cost of abatement because of their use of a stringent carbon pricing policy to achieve economy-wide emissions reductions.

The *NDP* scenario appears to perform well in terms of average abatement costs, but this is due to the low emissions reductions achieved by 2030. Because the lowest cost abatement actions are undertaken first, higher cost options are not ever implemented at the low level of reductions achieved under the NDP plan, thus the average cost of abatement remains low. In the *ndp50* scenario, when a carbon pricing policy is used in addition to the NDP plan to achieve their promised reductions of 50% by 2030, the average cost of abatement increases dramatically: from a 0.004% GDP reduction per tonne abated to -0.015%.

The *GREEN* scenario results indicate that the Green plan would have nearly as high an average abatement cost as the two deep decarbonization (*ndp50* and *green60*) scenarios, despite cumulatively achieving much less in total reductions (see Figure 4). The Green plan's use of a high-impact prescriptive regulation (ban on new fracking wells) contributes to its higher cost of average abatement because it requires emissions reductions with a high economic cost to occur, rather than less costly abatement options. Thus, while the *GREEN* scenario results in less than half the emissions reductions as the *green60* scenario, the average abatement costs are nearly identical (-0.014% and -0.015%, respectively). Importantly, the *GREEN, LIB* and *CON* scenarios all achieve 27-28% reductions in 2030 emissions, but range in average abatement costs by a factor of 2-3.

The *ndp50* and *green60* create the highest average abatement costs due to the deep reductions achieved by 2030 in these scenarios – where more costly abatement options are required to reach the 50% and 60% reduction targets. I discuss the regional and sectoral impacts on GDP growth and economic output of each scenario in Appendix B.

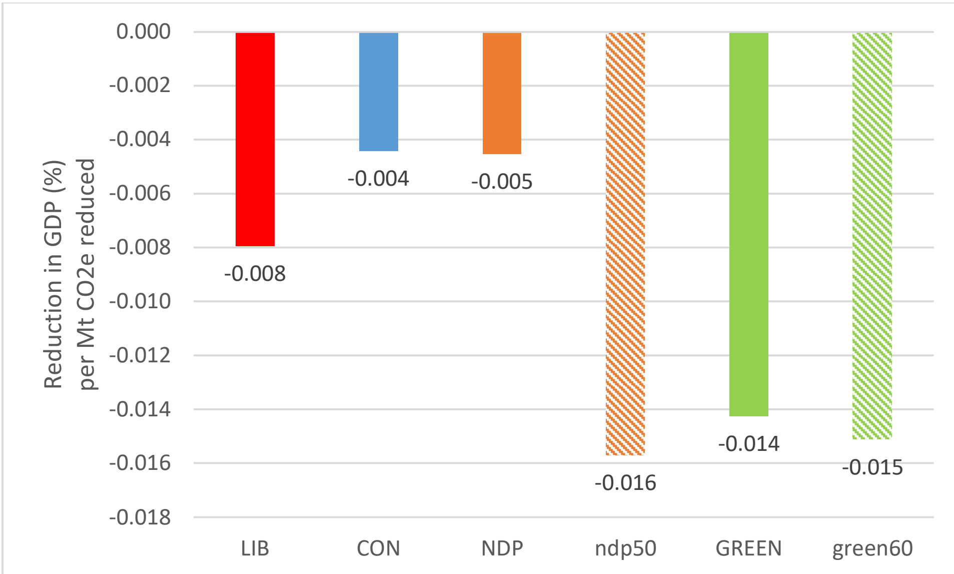

Figure 6: By scenario, cost of emissions reductions: % reduction in 2030 GDP from REF scenario per Mt CO2e reduced from 2005 levels.

Chapter 5.

Discussion & Conclusion

This research combines three modelling analyses, all using the same model, to exemplify a comparative evaluation framework to assess competing climate platforms. Ideally, future applications would model all scenarios as part of the same analysis, ensuring that all assumptions on policy implementation are identical. In this case, I can be confident that major input assumptions are essentially equivalent; however, it is worth noting this possible limitation for the sake of future analyses. Future research could extend the climate platform framework I present by putting economic and emission model results in the context of past political experiences and regional political preferences to better frame how each climate platform might realistically be implemented (or rejected). Also, future studies might model scenarios of domestic policy platforms - as in this study - in combination with a global model capable of determining the costs or avoided costs of climate damages. This would enable citizens and politicians to better understand the potential net costs or net benefits of their proposed climate strategies. Lastly, measures of equity should be further analyzed in any future applications this framework.

In this study, I provide a generic framework for evaluation of competing political party climate platforms. After presenting a climate platform evaluation framework that can be applied to any liberal democracy, I demonstrate its use by assessing four major competing party platforms prior to Canada's 2021 federal election: those of the Liberal, Conservative, New Democratic and Green parties. This framework enables citizens, and politicians, to know in advance of an election which climate platforms are likely to influence emissions and how costly they will be on the economy.

The first component of this evaluation framework is identification of policies from the climate platforms put forth by each competing party. Importantly, this step does not allow for any party to receive the benefit of the doubt when interpreting their platforms; only clearly stated policies with proven impacts on emissions (or the economy) are extracted. These include carbon pricing regimes, flexible and prescriptive regulations, and some spending or subsidy programs – all with delineated timelines and stringencies provided. In the next step, the effects of these policies are simulated using an energy-economy-emissions model capable of modelling both microeconomic decisions and macroeconomic effects. The projected emissions under each platform can then be compared to promised targets, and the effect on economic output compared to the level of abatement achieved. Where a party's promised emissions target is not reached, scenarios are re-simulated with a higher carbon price to show what stringency would be needed to achieve their targets, and the economic impact of doing so. This comparison enables voters to know whether a climate platform will work and holds politicians accountable for putting forth viable climate platforms that are both effective in terms of emissions and economically efficient. Otherwise, some voters might be misled into voting based on only one side of the ledger – the promised GHG target – without knowing its likelihood of being achieved and its likely cost to their economy and the services provided by their government.

To illustrate my framework, I first extract climate policies from competing political platforms in Canada prior to the Fall 2021 election. I then model a reference (or "business as usual") scenario using only current Canadian policies, and compare this to the Liberal, Conservative, NDP and Green Party climate plans. I also re-run the NDP and Green climate plan scenarios using a carbon price that achieves their stated emissions targets, as their climate plans do not come close to achieving the promised reductions. I then compare results in terms of emissions reductions relative to each party's stated target, the federal carbon price, and economic impact relative to the reference scenario.

The Liberal's approach to climate policy is a steadily rising carbon tax, in combination with several key flexible regulations and some spending and incentives. The Conservatives introduce a Low Carbon Savings Account carbon pricing policy, and several flexible regulations to target key domestic sectors. The NDP's primary approach is public spending, as well as removing carbon tax breaks for large emitters. Lastly, the Green Party introduces prescriptive regulations and implements two incentive programs. These differing approaches to climate policy have contrasting projected impacts on emissions reductions and national GDP growth out to 2030.

The Conservative and Liberal plans both essentially achieve their promises in early 2020 to reduce national emissions 30% by 2030. The small differences in my estimates are within the margin of error of this type of modelling. The Liberals, however, have an average cost of abatement double that of the Conservative plan. This difference in abatement cost results in only a marginally higher economic output under the Conservative plan versus the Liberal plan – possibly a loss of 3-4 months of economic growth over an 8-year period (2022-2030). The NDP plan results in the smallest loss of economic output because of its negligible emissions reductions. Once carbon pricing is implemented to achieve the NDP's promised target, however, GDP loss increases to much more significant levels. The Green plan also falls short of achieving its promised target of a 60% reduction, and under both the Green plan and the scenario where carbon pricing is used to reached its promised target, average cost of abatement is substantial. Economic loss with the 60% emissions reduction is the most significant out of all scenarios. Sectoral and regional impacts also differ between scenarios, and these results are important for political considerations – to know who will be most affected by certain policy mixes and to what extent. However, the main goal of my research is to present and apply a framework for assessing climate plans and promises, so in this case study I discuss results only at the national level.

Several notable differences in policy approaches help to explain the range of emissions and GDP results from the seven scenarios in this analysis. The NDP plan is projected to have the least impact on emissions, essentially keeping Canada on a business-as-usual trajectory, because much of the NDP platform contains only vague descriptions of future outcomes without policy to induce them, and no clearly stated additional policies beyond those already in place. The Conservative plan has a lower carbon price than the Liberal's, and therefore uses more regulations to make up the difference in reductions. Regulations are generally considered less economically efficient than a stringent carbon tax, but the Conservative's more efficient use of tax revenue more than offsets their reduced reliance on carbon pricing. Thus, they achieve a slightly greater reduction in 2030 emissions than the Liberals and at a lower cost to the economy. Reductions under the Green plan are generally very economically inefficient due to its reliance on lowering emissions through reduced oil and gas production, and its removal of transportation fuel regulations (which target a domestic sector that can be more cheaply decarbonized than oil and gas). Lastly, both the NDP and Green scenarios with additional carbon pricing should be considered optimistic estimates of the cost to achieve their stated targets, as carbon pricing is widely accepted as the least costly climate policy.

These policy extraction and modelling results are intended to provide a helpful service to the climate-concerned citizen. They provide a generic, researched framework that can be applied to any democratic jurisdiction to help ensure that viable climate platforms are supported by voters. If a democratic country wants to make real effort to address climate change, applying a climate evaluation framework may be essential. Methodically extracting and simulating the future impacts of proposed climate platforms holds politicians accountable for putting forth policy platforms that have a high likelihood of reducing emissions, with minimal impact on economic growth. Enabling climate-concerned citizens to vote for feasible climate platforms could help break the common cycle of setting distant targets while acting minimally in the present to reduce GHG emissions. Ideally, once more of the world's population is on a path to lowered emissions, further efforts can be made to abate emissions globally and truly address the climate change challenge.

References

Axsen, Jonn, Suzanne Goldberg, and Joseph Bailey. 2015. “Electrifying Vehicles: Insights from the Canadian Plug-in Electric Vehicle Study.” *Simon Fraser University* (July):201.

Axsen, Jonn, Patrick Plötz, and Michael Wolinetz. 2020. “Crafting Strong, Integrated Policy Mixes for Deep CO2 Mitigation in Road Transport.” *Nature Climate Change* 10(9):809–18. doi: 10.1038/s41558-020-0877-y.

Axsen, Jonn, and Michael Wolinetz. 2018. “Reaching 30% Plug-in Vehicle Sales by 2030: Modeling Incentive and Sales Mandate Strategies in Canada.” *Transportation Research Part D: Transport and Environment* 65(October):596–617. doi: 10.1016/j.trd.2018.09.012.

Bataille, Chris, Mark Jaccard, John Nyboer, and Nic Rivers. 2006. “Towards General Equilibrium in a Technology-Rich Model with Empirically Estimated Behavioral Parameters Author (s): Chris Bataille , Mark Jaccard , John Nyboer and Nic Rivers Source : The Energy Journal , Vol . 27 , Special Issue : Hybrid Modeling of En.” 27:93–112.

Bergman, Lars. 2005. “CGE Modeling of Environmental Policy and Resource Management.” Pp. 1273–1306 in *Handbook of Environmental Economics*. Vol. 3.

Böhringer, Christoph, and Thomas F. Rutherford. 2008. “Combining Bottom-up and Top-Down.” *Energy Economics* 30(2):574–96. doi: 10.1016/j.eneco.2007.03.004.

California Air Resources Board. 2020. *Framework Agreement on Clean Cars*. Sacremento, CA.

Canada Environmental Protection Act Registry. 2018. “Passenger Automobile and Light Truck Greenhouse Gas Emission Regulations: Discussion Paper.” Retrieved August 10, 2021 (https://www.canada.ca/en/environment-climate-change/services/canadian-environmental-protection-act-registry/publications/automobile-truck-emission-regulations-discussion.html#toc1).

Canadian Vehicle Manufacturers’ Association. 2021. “Automotive Industry Statistics.”

Retrieved July 27, 2021 (https://www.cvma.ca/industry/stats/).

Cass, Loren R. 2012. *The Failures of American and European Climate Policy: International Norms, Domestic Politics, and Unachievable Commitments*.

Climate Watch. 2022. "Data Explorer." Retrieved July 1, 2022 (https://www.climatewatchdata.org/data-explorer/historical-emissions?historical-emissions-data-sources=cait&historical-emissions-gases=all-ghg&historical-emissions-regions=All Selected&historical-emissions-sectors=total-including-lucf&page=1#data).

Conservative Party of Canada. 2021. *Secure the Environment: The Conservative Plan to Combat Climate Change*.

Cornwall, Warren. 2020. "The Paris Climate Pact Is 5 Years Old. Is It Working?"

Dixon, Peter B., and B. R. Parmenter. 1996. "Computable General Equilibrium Modelling for Policy Analysis and Forecasting." Pp. 3–85 in *Handbook of Computational Economics*. Vol. 1.

EMF Working Group 25. 2011. *Energy Efficiency and Climate Change Mitigation*. Vol. I. Stanford, California.

Environment and Climate Change Canada. 2017. *Fourth Biennial Report*.

Environment and Climate Change Canada. 2020a. *A Healthy Environment and a Healthy Economy*.

Environment and Climate Change Canada. 2020b. "Renewable Fuels Regulations: Frequently Asked Questions." Retrieved (https://www.canada.ca/en/environment-climate-change/services/canadian-environmental-protection-act-registry/renewable-fuels-regulations-frequently-asked-questions.html).

Environment and Climate Change Canada. 2022. "Clean Fuel Regulations." Retrieved (https://www.canada.ca/en/environment-climate-change/services/managing-pollution/energy-production/fuel-regulations/clean-fuel-regulations.html).

Fairbrother, Malcolm. 2016. "Trust and Public Support for Environmental Protection in

Diverse National Contexts.” *Sociological Science* 3:359–82. doi: 10.15195/v3.a17.

Förg, Franziska, Rose Murphy, and Mark Jaccard. 2021. *Clearing the Air Transportation, Land Use and Carbon Emissions in Metro Vancouver*. Vancouver.

Government of British Columbia. 2019. *Zero-Emission Vehicles Act*. Canada.

Government of British Columbia. 2021. *Clean BC: Roadmap to 2030*.

Government of Canada. 2000. *Government of Canada Action Plan 2000 on Climate Change*.

Government of Canada. 2002. *Climate Change Plan for Canada*.

Government of Canada. 2010. *Passenger Automobile and Light Truck Greenhouse Gas Emission Regulations*. Canada.

Government of Canada. 2016. *Pan-Canadian Framework on Clean Growth and Climate Change : Canada’s Plan to Address Climate Change and Grow the Economy.*

Government of Canada. 2018. *Regulations Amending the Reduction of Carbon Dioxide Emissions from Coal-Fired Generation of Electricity Regulations: SOR/2018-263*.

Government of Canada. 2020. *A Healthy Environment and a Healthy Economy*.

Government of Canada. 2021a. *Canadian Net-Zero Emissions Accountability Act*.

Government of Canada. 2021b. “Net-Zero Emissions by 2050.” Retrieved December 5, 2021 (https://www.canada.ca/en/services/environment/weather/climatechange/climate-plan/net-zero-emissions-2050.html).

Government of Canada. 2021c. “Update to the Pan-Canadian Approach to Carbon Pollution Pricing 2023-2030.” Retrieved June 16, 2022 (https://www.canada.ca/en/environment-climate-change/services/climate-change/pricing-pollution-how-it-will-work/carbon-pollution-pricing-federal-benchmark-information/federal-benchmark-2023-2030.html).

Green Party of Canada. 2019. “Mission : Possible.” Retrieved (https://www.greenparty.ca/en/mission-possible).

Green Party of Canada. 2020. *Vision Green*.

Haug, Constanze, Tim Rayner, Andrew Jordan, Roger Hildingsson, Johannes Stripple, Suvi Monni, Dave Huitema, Eric Massey, Harro van Asselt, and Frans Berkhout. 2010. "Navigating the Dilemmas of Climate Policy in Europe: Evidence from Policy Evaluation Studies." *Climatic Change* 101(3):427–45. doi: 10.1007/s10584-009-9682-3.

Hoyle, Aaron J. 2020. "Modelling the Effect of Canada's Clean Fuel Standard on Greenhouse Gas Emissions." Simon Fraser Univeristy.

Hrvatin, Vanessa. 2016. "A Brief History of Canada's Climate Change Agreements." *Canadian Geographic*, May.

Jaccard, Mark. 2020. *The Citizen's Guide to Climate Success*. 1st ed. Cambridge, UK: University Printing House.

Jaccard, Mark, Christopher Bataille, Rose Murphy, John Nyboer, and Bryn Sadownik. 2006. "Burning Our Money to Warm the Planet." *C.D. Howe Institute Commentary*.

Jaccard, Mark, Mikela Hein, and Tiffany Vass. 2016. "Is Win-Win Possible ? Can C Anada ' s Government Achieve Its Paris Commi Tment." *School of Resource and Environmental Management, Simon Fraser University* 1–31.

Jackson, Peter. 2007. "From Stockholm to Kyoto: A Brief History of Climate Change." *Green Our World*. Retrieved (https://www.un.org/en/chronicle/article/stockholm-kyoto-brief-history-climate-change).

Joshi, Janak. 2021. "Do Renewable Portfolio Standards Increase Renewable Energy Capacity? Evidence from the United States." *Journal of Environmental Management* 1(287). doi: 10.1016/j.jenvman.2021.112261.

Kahneman, Daniel. 2013. *Thinking, Fast and Slow*. New York: Farrar, Straus and Giroux.

Miele, Amy, Jonn Axsen, Michael Wolinetz, Elicia Maine, and Zoe Long. 2020. "The Role of Charging and Refuelling Infrastructure in Supporting Zero-Emission Vehicle Sales.” *Transportation Research Part D: Transport and Environment* 81(March):102275. doi: 10.1016/j.trd.2020.102275.

National Round Table on the Environment and the Economy. 2012. “Reality Check: The State of Climate Progress in Canada.” Retrieved (http://nrt-trn.ca/chapter-2-canadas-emissions-story).

Natural Resources Canada. 2020a. “Canadian Industry Partnership for Energy Conservation.” Retrieved (https://www.nrcan.gc.ca/energy-efficiency/energy-efficiency-for-industry/canadian-industry-program-energy-conservation-cipec/20341).

Natural Resources Canada. 2020b. “EnerGuide in Canada.” Retrieved July 15, 2022 (https://www.nrcan.gc.ca/energy-efficiency/energuide/12523).

Navius Research. 2021. *Assessing the Greenhouse Gas and Economic Impacts of the Conservative Plan to Combat Climate Change Prepared for the Conservative Party of Canada About Us*. Vancouver.

New Democratic Party. 2019. *Power to Change: A New Deal for Climate Action and Good Jobs*.

Nordhaus, By William. 2015. “Climate Clubs : Overcoming Free-Riding In.” 105(4):1339–70.

Peters, Jotham, Chris Bataille, Nic Rivers, and Mark Jaccard. 2010. “Taxing Emissions, Not Income: How to Moderate the Regional Impact of Federal Environment Policy.” *C.D. Howe Institute Commentary* (314).

Rhodes, Ekaterina, Willam A. Scott, and Mark Jaccard. 2021. “Designing Flexible Regulations to Mitigate Climate Change: A Cross-Country Comparative Policy Analysis.” *Energy Policy* 156(112419). doi: https://doi.org/10.1016/j.enpol.2021.112419.

Rivers, Nicolas, and Leslie Shiell. 2016. “Free Riding on Energy Efficiency Subsidies: The Case of Natural Gas Furnaces in Canada.” *The Energy Journal* 37(4):239–66.

Ruskin, Assembly Member. 2007. *Article 3. Clean Vehicle Incentive Program*.

Statistics Canada. 2021. “New Motor Vehicle Sales.” Retrieved July 27, 2021 (https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=2010000101&pickMembers%5B0%5D=1.1&pickMembers%5B1%5D=2.2&pickMembers%5B2%5D=3.1&pickMembers%5B3%5D=5.1&cubeTimeFrame.startMonth=01&cubeTimeFrame.startYear=2011&cubeTimeFrame.endMonth=01&cubeTimeFrame.e).

Transport Canada. 2022. “Light-Duty Zero-Emissions Vehicles.” Retrieved July 2, 2022 (https://tc.canada.ca/en/road-transportation/innovative-technologies/zero-emission-vehicles/light-duty-zero-emission-vehicles).

Transport Canada. n.d. “List of Eligible Vehicles under the IZEV Program.” Retrieved August 3, 2021 (https://tc.canada.ca/en/road-transportation/innovative-technologies/zero-emission-vehicles/list-eligible-vehicles-under-izev-program).

UN Security Council. 2021. “Climate Change ‘Biggest Threat Modern Humans Have Ever Faced’, World-Renowned Naturalist Tells Security Council, Calls for Greater Global Cooperation.” Retrieved (https://press.un.org/en/2021/sc14445.doc.htm).

United Nations. 2021. “Paris Agreement - Status of Ratification.” *United Nations Framework Convention on Climate Change*. Retrieved (https://unfccc.int/process/the-paris-agreement/status-of-ratification).

United Nations. n.d. “Climate Negotiations Timeline.” Retrieved June 30, 2022 (https://www.un.org/sustainabledevelopment/climate-negotiations-timeline/).

Western Climate Initiative Inc. 2022. “Greenhouse Gas Emissions Trading: A Cost-Effective Solution to Climate Change.” Retrieved June 28, 2022 (https://wci-inc.org/).

World Meteorological Organization. 2018. "World Climate Programme (WCP)". Retreived July 19, 2022 (https://library.wmo.int/index.php?lvl=notice_display&id=5900#.YwvJ_S295-U).

Appendix A.
Additional scenario details

A.1. NDP Policy Calculations

The following section details how Part Two of the *NDP* scenario ZEV Purchase Incentive was calculated in four steps.

1) *Determine ZEV new market share projections out to 2030 (under a policy landscape akin to the NDP scenario)*

Axsen & Wolinetz (2018) use the REspondent-based Preference and Constraints (REPAC) model to project future market shares of electric vehicles (plug-in hybrid and battery electric) under different policy and scenario assumptions. REPAC employs real-world survey data on consumer preference, travel patterns, prices, and purchase constraints to simulate market uptake of different vehicle types (Axsen and Wolinetz 2018). All policy scenarios in this study assume a carbon tax reaching $50 in 2022 and remaining until 2030, as well as provincial purchase incentives in place up to 2018. Under their "Scenario #2: Incentive-Focused Policy: Version 2C", national electric vehicle purchase incentives of $6000/vehicle are in place from 2018-2030; applying equally to PHEVs and pure BEVs. Additionally, this scenario assumes "aggressive charging infrastructure rollout" from 2015-2030, which emulates the NDP Scenario's $600 *Home charger incentive* (see below). Axsen & Wolinetz's "Scenario #2C" therefore closely mirrors Part 1 of the NDP's *ZEV purchase incentive* and their resultant projections (Table SA1) are assumed to be an appropriate estimation of future electric vehicle sales under the NDP Scenario.

Table SA1: Electric vehicle market share (%) under Scenario #2C ($6000 subsidy on electric vehicles from 2018-2030, increased charger access, carbon tax at $50) of the 2018 study by Axsen & Wolinetz. Lower and upper market share limits represent the range of uncertainty introduced by electric vehicle familiarity, availability, and gasoline and purchase prices.

Year	*2025*	*2030*	*% Increase 2025-2030*

Lower limit (%)	9	14	5
Upper Limit (%)	34	42	8

While Axsen & Wolinetz (2018) provide a range of projected total electric vehicle (EVs and PHEVs only) new market share, a 2020 study by Miele *et al.* projects new ZEV sales by type (i.e., battery electric, plug-in hybrid and hydrogen fuel cell vehicles) using the same REPAC model to simulate different policy scenarios, focusing on charging/refuelling availability (Miele et al. 2020). Table SA2 displays the ZEV market share projections under a business-as-usual and an extensive ZEV policy scenario (where "Reference" simply indicates modest increases in charging infrastructure access).

Table SA2: ZEV market share (%) under the BAU-Reference (no national ZEV subsidy, modest increases in charging access, carbon tax remains at $50) and ZEV-Reference (federal ZEV subsidy of $8000 until 2025 then $2000 until 2030, ZEV mandate of 15% by 2025, modest increases in charger access, carbon tax reaches $100 by 2027) scenarios of the Miele et al. 2020 study.

Year	**2025**	**2030**	***Increase 2025-2030***
BAU-Reference (%)	5	9	*4*
ZEV-Reference (%)	18	30	*12*

Neither study modelled a scenario that perfectly aligns with parts 1 & 2 of the NDP Scenario *ZEV Purchase Incentive.* However, results from each were combined as follows to inform the ZEV new market share assumptions for Part 2 of the NDP's *ZEV Purchase Incentive:*

- The $6000 purchase incentive on electric vehicles in the 2018 study and the $50 carbon tax more appropriately mimics the NDP Scenario policy landscape (as their subsidies reach $15,000 gradually and are assumed to be scaled back for PHEVs). It is assumed that the point estimates within their uncertainty range are appropriate projections of future PHEV sales.

- In the 2020 study under the ZEV-Reference scenario, ZEVs sales proportions are projected to be 80% PHEVs and 20% BEVs in 2030 (no hydrogen fuel cell uptake)
- Combining these, it is assumed that under the NDP Scenario, PHEV and BEV sales reach 15.2% and 3.8% by 2025, respectively, and 25.6% and 6.4% by 2030, respectively. This amounts to total ZEV light duty market shares of 19% in 2025 and 32% in 2030.

2) *Find national light duty vehicle sales projections out to 2030*

According to Statistics Canada, total passenger vehicle sales (i.e., all drive train & fuel types) have decreased 52% from 2011 to 2020 (Statistics Canada 2021). Annually, passenger vehicle sales have decreased by an average of 3.4% in this time period. It is assumed that this downward trend in demand for light-duty vehicles is maintained out to 2030, considering the increasing focus on mode shifting and expanding transit networks. Using this logic, total passenger vehicle sales are assumed to be 269,273 vehicles in 2025 and 226,505 in 2030.

3) *Determine national Canadian-made light duty vehicle sales*

Statistics provided by the Canadian Vehicle Manufacturer's Association indicate that so far in 2021, sales of Canadian-made light duty vehicles have comprised 43% of total light-duty sales in Canada (Canadian Vehicle Manufacturers' Association 2021). This market share breakdown of Canadian vs. foreign-made light duty vehicles has stayed approximately constant since 2009, and Canadian-made light-duty vehicle sales are therefore assumed to remain at 43% of total sales out to 2030.

4) *Determine national ZEV sales in 2025 and 2030 & associated subsidy expenditure*

Using the projected total passenger vehicle sales (specifically Canadian-made after 2026) and projected market shares of BEVs and PHEVs, the Table SA3 displays the assumed number of new light-duty ZEV sales in 2025 and 2030. Assuming $15,000 BEV purchase subsidies from 2026-2030 (subsidies are assumed to be half this amount for PHEVs with battery sizes less than 15kWh (Transport Canada n.d.), Table SA3 also shows the total lump sum amount of government expenditure on ZEV subsidies in these years. These are the amounts targeted towards a technology fund containing:

- light and medium-duty electric vehicles
- light and medium-duty plug-in hybrid vehicles

- light and medium-duty hydrogen fuel cell vehicles

Table SA3: ZEV sales and total subsidy program amounts for years 2026 and 2030 under the NDP ZEV incentive: Part 2.

	2026	*2030*
EV sales (vehicles)	4832	6233
EV subsidy expenditure (millions)	$725	$94
PHEV sales (vehicles)	19328	24934
PHEV Subsidy Expenditure (millions)	$199	$257
Total (millions):	$924	$351

A.2.Green Party Policy Exclusions

The following section details specific Green Party plan policies that were mentioned in either Green 2019 or Green 2020 but were excluded from the modelling component of this analysis, and provides justification for these decisions.

A two-cent/kWh subsidy for renewable energy in any province/territory adopting ART+ was excluded because no jurisdictions currently participate in/deliver Advanced Renewable Tariff programs. Future implementation of such programs is beyond federal ability to predict or enforce.

The redirection of funding destined for the trans-mountain pipeline into East-West grid expansions & renewable energy requires delineation of the funding that federal government is 1) specifically targeting to the TMP and 2) is free to be re-directed into other projects. Both financial uncertainties of this action *and* of the emissions impact makes this action unfeasible to model.

A Cap-and-Trade system for industry is mentioned several times throughout Green 2020 and a large emphasis placed on directing all carbon pricing revenue to households. No details on timelines, stringency or sectoral coverage of a cap-and-trade policy are specified, nor its interaction with the current output-based pricing system. Because it is clear that the Green's intend to specially treat emissions from industry, the OBPS is maintained in its current form, rather than revoked entirely.

Both Green climate policy documents purport their intention to end all federal subsidies to oil, coal, gas and coalbed methane industries. However, 1) no details on which subsidies are given, 2) the NDP and current government also claim they will do this, and 3) it is impossible to estimate what this means for government finances or changes in demand for fossil fuels from removing the so-called subsidies. For these reasons, elimination of fossil fuel subsidies is not simulated in all three scenarios.

Landfill Regulation: Management of waste is primarily under provincial/territorial jurisdiction. While Green 2020 emphasizes that they will advocate for a tax on landfill methane emissions and a requirement for methane capture after 2025, no details are given on how this could be implemented considering Canada's co-operative federal system.

Halocarbon phase-out: No details are given on what kind of regulation could cause the phase out of halocarbons by 2025.

Aviation Tax: No specifications of exact tax rates or timelines were given. Additionally, no details were given on how an additional tax on aviation fuel would apply to domestic vs. international air travel, and in Green 2020 it is acknowledged that emissions from international aviation and shipping are currently outside of the Paris Agreement.

Provincial Policies

Provincial policies modelled in the NDP and Green party scenarios are shown in Table SA4. ALL indicates that the *NDP, ndp50, GREEN* and *green60* scenarios all contain the policy measure.

Scenario	*Province*	*Policy*	*Simulation years*

ALL	British Columbia	Low Carbon Fuel Standard	2015-2030
ALL	Ontario	Greener gas and diesel regulations	2015-2030
ALL	British Columbia Quebec	ZEV mandate	2015-2030
ALL	British Columbia Alberta Saskatchewan Manitoba	Renewable gas and diesel regulations	2020-2030
ALL	British Columbia Ontario Quebec	ZEV purchase incentives	2020
ALL	British Columbia Quebec	Renewable Natural Gas Mandate	2020-2030
ALL	Ontario	Renewable electricity requirements	2020-2030
ALL	British Columbia Alberta Manitoba Quebec New Brunswick Nova Scotia	Renewable Portfolio Standard	2020-2030
NDP ***GREEN***	British Columbia	Carbon pricing system	2020-2030
NDP ***GREEN***	Quebec	Cap-and-Trade	2020-2030

ndp50 green60	British Columbia	Carbon pricing system	2020
ndp50 green60	Quebec	Cap-and-Trade	2020

Appendix B.
Regional and Sectoral Results

B.1. Regional emissions

Regional emissions were analysed for the *NDP, ndp50, GREEN,* and *green60* scenarios only, due to data availability. Total national emissions reductions from 2020-2030 in each scenario are: 81 Mt in *NDP,* 196 Mt in *GREEN,* 357 Mt in *ndp50,* and 431 Mt in *green60.* Regional emissions can be discussed in terms of how much each province/territory reduces their own emissions over time, or by how much each region contributes to overall national emissions. Figure SB1 shows the percentage change in each province/territory's emissions from 2020-2030, while Figure SB2 shows the share of total reductions – from 2020-2030 - contributed by each region. In the less stringent scenarios of *NDP*, the Maritime provinces reduce their own emissions the most out of all regions. This is a result of decreased emissions intensity of electricity generation and decreased output from oil and gas. In the *GREEN* scenario, Alberta and Saskatchewan reduce their emissions the most relative to their 2020 levels due to the Fracking Ban policy in place. In the *NDP* and *ndp50* scenarios, provinces with heavy industry or high-emitting sectors (Maritime provinces, Alberta, Saskatchewan) decrease their emissions by greater proportions relative to others due to decreased output from carbon-intensive industry under the full carbon tax. Under the *green60* scenario all provinces reduce their emissions by at least 38%. Those that reduce emissions the most are provinces with prominent oil and gas sectors and emissions intensive electricity generation: Alberta, New Brunswick, Nova Scotia, and Saskatchewan.

Under the *NDP* plan scenario, total national emissions are projected to be 81Mt lower in 2030 relative to 2020, and Alberta, Saskatchewan, and Ontario contribute the largest share of these emissions reductions. Relative to 2020 levels, the Maritime provinces decrease their own emissions most. Reductions in these provinces under the *NDP* plan are due to improvements in household efficiency, uptake of lower emitting vehicles, decarbonization of electricity generation, and reduced production of oil and gas. In the *ndp50* scenario, a 50% reduction by 2030 in national emissions is achieved (by design), resulting in 357Mt fewer GHGs in 2030 than 2020. An even greater share of these total emissions reductions is achieved by Alberta (40%), and relative to its own

2020 levels, Alberta reduces its own emissions by 51%. Ontario and Saskatchewan are the next highest contributors to emissions reductions in the *ndp50* scenario, while New Brunswick and Nova Scotia reduce their own emissions by the greatest proportion. Under the *GREEN* plan scenario, national emissions in 2030 are projected to be 196Mt lower than 2020 levels. Alberta reduces its own emissions by 45% in this period and contributes 64% of the total national emissions reductions in this scenario – largely from reductions in output from the manufacturing and oil and gas sectors. British Columbia and Saskatchewan are both the next two highest contributors to national reductions and reduce their own emissions by the next highest proportions (-35% and -38%, respectively). Emissions reductions are primarily due to decreased output from the oil and gas sector in BC, and from decarbonization of electricity generation in SK. All provinces reduce emissions due to increased efficiencies in household appliances and transportation. Lastly, under the *green60* scenario, a 60% reduction in national emissions is achieved by 2030 (by design); equivalent to a 431Mt absolute reduction from 2020. Again, Alberta contributes the highest share of total reductions, with Ontario, Saskatchewan, and Quebec, as the next highest contributors. Alberta, New Brunswick, Nova Scotia, and Saskatchewan reduce their own emissions by the greatest proportion relative to 2020: achieving -66%, -63%, -63% and -67% reductions, respectively. In this scenario, emissions become net-zero or net-negative in some regions and sectors; specifically, Saskatchewan uses bioenergy with carbon capture and storage for electricity generation and can offset emissions elsewhere from this sector becoming emissions negative. In other regions, emissions in industrial sectors approach net-zero under the *green60* due to increased adoption of carbon-capture and storage technologies.

A few notable trends help to summarize regional emissions results. In all scenarios, a significant portion of reductions from both Alberta, Saskatchewan, and the Maritime provinces are due to reductions in emissions intensity of electricity generation. The Maritime provinces also achieve emissions reductions due to reduced output from oil and gas in all scenarios. Across all regions and scenarios, emissions reductions are achieved through reduced emissions intensity of electricity production, increased household and commercial appliance efficiency, and increased adoption of low or zero emission vehicles. In the *ndp50, GREEN,* and *green60* scenarios, emissions decline due to decreased output from large-emitting sectors (manufacturing, mining, oil and gas). In

Ontario, emissions from electricity generation in the *NDP* and *GREEN* scenarios increase significantly (210-266%) due to increased demand for electricity being met by rapid expansion of natural gas-fired generation but are offset by reductions in household emissions. Lastly, in most scenarios and regions, emissions in agriculture and forestry increase or stagnate by 2030.

Figure SB1: Regional emissions shown as a percentage change from 2020 to 2030. From top left to bottom right: NDP, ndp50, GREEN, green60.

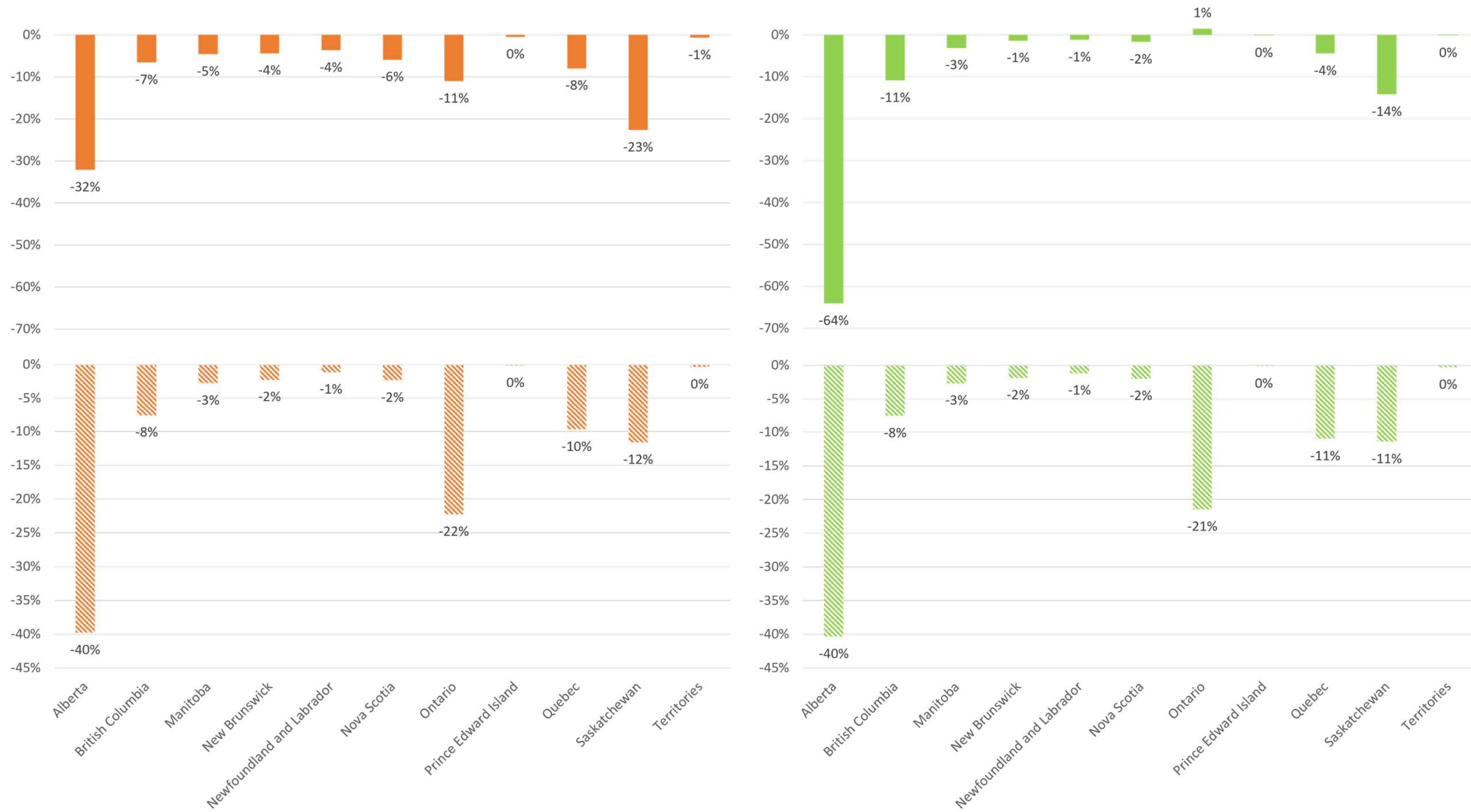

Figure SB2: Regional emissions shown as % contributed by each region to total national reductions achieved from 2020 to 2030. From top left to bottom right: NDP, ndp50, GREEN, green60.

B.2. Sectoral emissions

Sectoral emissions can also be discussed in terms of how much each sector reduces their own emissions over time, or by how much each sector contributes to overall national emissions. Figure SB3 shows the percentage change in each sector's emissions from 2020-2030, while Figure SB4 shows the share of total reductions contributed by each sector. In all scenarios, emissions from electricity generation decrease by 32-99%. This is due to provinces eliminating coal-fired generation, switching to more efficient forms of natural-gas fired generation, or increasing renewable generation. Households reduce emissions 24-57% by using more efficient appliances and low-emitting personal vehicles.

Under the NDP plan (*NDP*), projected emissions reductions come primarily from increased appliance and light-duty vehicle efficiency, capture of landfill methane, and reduced emissions intensity of electricity. Under the NDP plan oil and gas emissions decrease and mining and manufacturing emissions increase only slightly, due to these sectors' full exposure to the carbon tax. In the *ndp50* scenario, where a 50% reduction by 2030 is achieved (by design), most reductions come from the oil and gas, manufacturing, and utilities, and these sectors reduce emissions by 56%, 605 and 95%, respectively. This is a result of decreased output from the oil and gas, manufacturing and natural gas distribution (part of utilities) sectors. In the Green plan scenario (*GREEN*), most reductions come from oil and gas as a result of a 17% reduction in output from this sector – due to the Green Party's Fracking Ban policy. Other reductions under this scenario come from decarbonized electricity production and increased adoption of low emissions light-duty vehicles. In *green60*, all sectors contribute to the significant emissions reductions required in this scenario, with oil and gas and construction both reducing emissions by 64%, manufacturing by 70%, and utilities by 99%. Reductions in oil and gas are largely due to decreased output, while decreased emissions in manufacturing result from increased technological efficiency

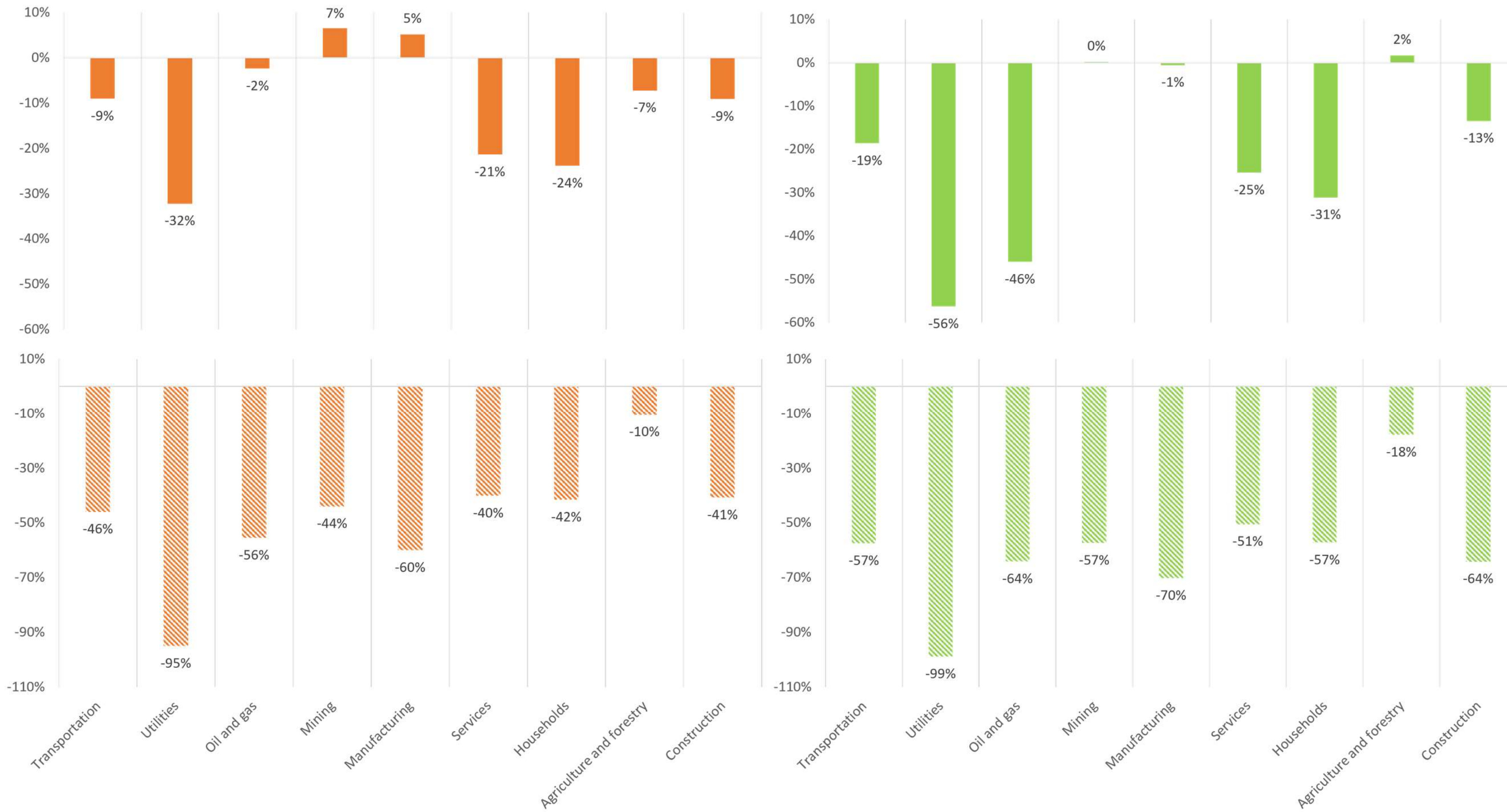

Figure SB3: Sectoral emissions shown as % reduction from 2020 to 2030. From top left to bottom right: NDP, ndp50, GREEN, green60.

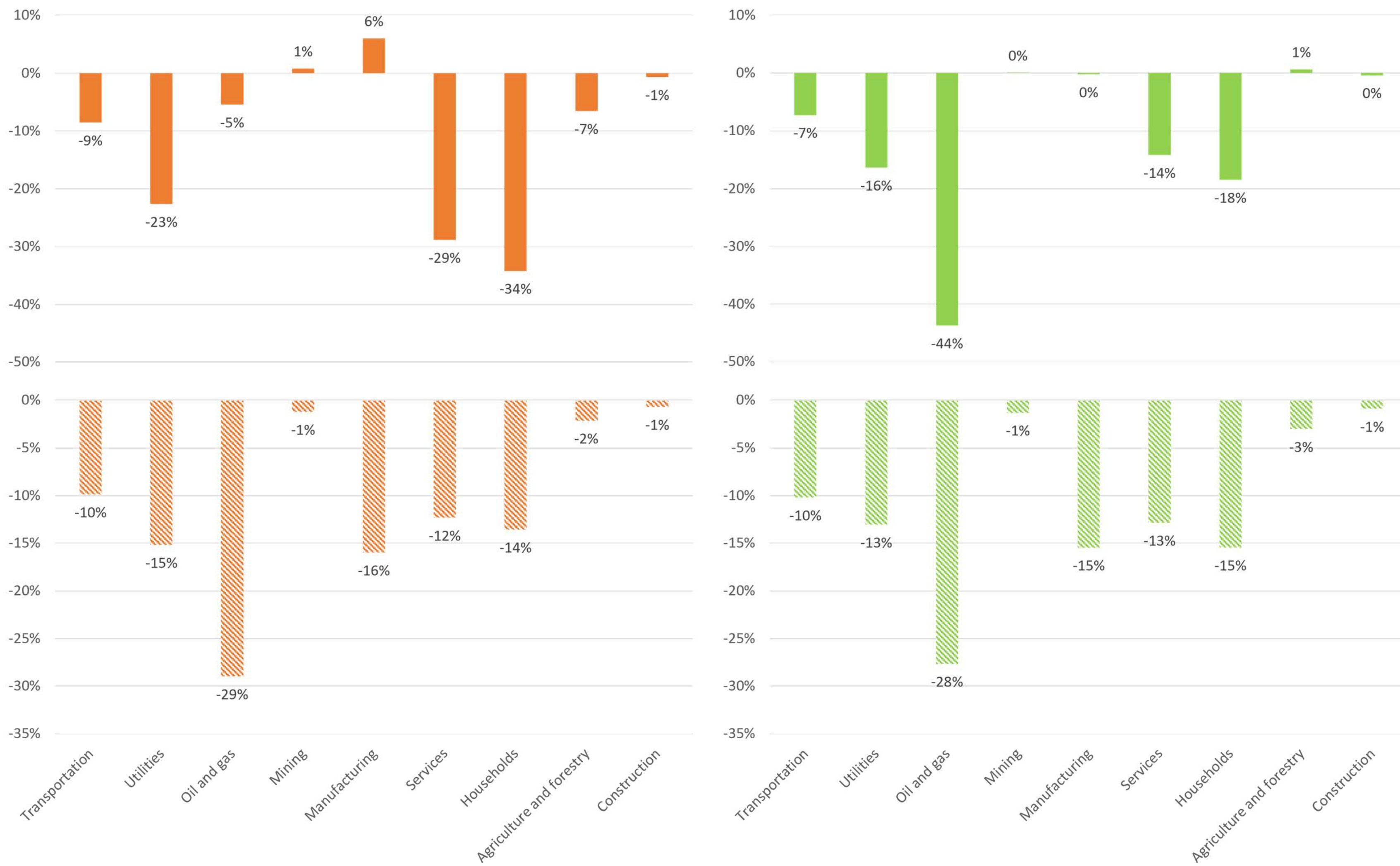

Figure SB4: Sectoral emissions shown as % contributed by each sector to total national reductions achieved from 2020 to 2030. From top left to bottom right: NDP, ndp50, GREEN, green60.