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The Cost of a Cleaner Future.

Examining the Economic Impacts of Reducing GHG Emissions

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The Cost of a Cleaner Future: Examining the Economic Impacts of Reducing GHG Emissions

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Preface

This report focuses on three themes related to Canada's progress in reducing GHG emissions: the economic impact of carbon pricing, starting from the announced federal program and including a range of Conference Board scenarios; the economic impact of eliminating fossil fuel electricity generation plants in Canada; and the economic impact of the extensive investments in green technology development and implementation that will be required to achieve deep emissions reductions.

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CONTENTS

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EXECUTIVE SUMMARY

The Cost of a Cleaner Future: Examining the Economic Impacts of Reducing GHG Emissions

At a Glance

- This analysis studies three distinct policy measures—the impact of a carbon price and a shift in the electricity generation mix, the impact of substantially decarbonizing our electricity generation sector, and the impact of investments that will allow Canada to reduce its emissions by 60 per cent by 2050.
- Carbon pricing and a shift in our electricity generation mix will have a small negative impact on the economy, but there are distributional impacts that will need to be considered by policy-makers.
- Pricing carbon and decarbonizing our electricity system will need to be accompanied by trillions of dollars in spending on clean energy infrastructure and significant changes to the way we consume energy.
- Changing public behaviour will play a crucial role in the transformation required to reduce emissions. This requires policy-makers to more clearly communicate their plan for reducing greenhouse gas emissions.

Policy action on climate change is set to accelerate quickly over the near term. In December 2015, the Paris Agreement was signed by Canada and 195 other countries. The agreement committed participating countries to implement policies aimed at keeping global temperatures from rising more than two degrees Celsius from pre-industrial levels. As part of its commitment to the Paris Agreement, Canada's federal government announced several initiatives in 2016 aimed at reducing emissions, including a mandatory floor for carbon pricing in all provinces and the elimination of coal-fired electrical power generation plants by 2030. Canada's federal and provincial governments have also negotiated a Pan-Canadian Framework on Climate Change and are working to further define and implement supporting actions.

This report focuses on three themes related to Canada's progress in reducing GHG emissions:

- the economic impact of carbon pricing—starting from the announced federal program and including a range of Conference Board scenarios;
- the economic impact of eliminating fossil fuel-fired electricity generation plants in Canada;
- the economic impact of the extensive investments in green technology development and implementation that will be required to achieve deep emissions reductions.

These economic analyses are informed by a set of technical pathways completed under the guidance of the Canadian Academy of Engineering and published by the Trottier Energy Futures Project (TEFP) in 2016. The technical pathways provided estimates of the required investments, The economy will shrink marginally in response to the carbon tax and the shift to higher-cost electric power generation.

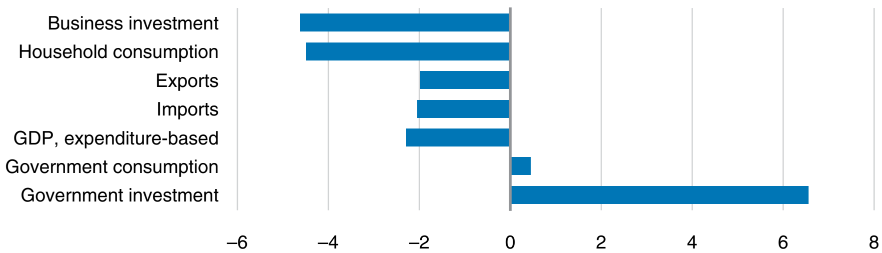
the level of generation capacity that would be replaced in each province, the level of incremental electricity investments, and the implied marginal cost of carbon to achieve each pathway.

Carbon Pricing Impacts

Nationwide carbon pricing will be a reality starting next year, and there will be economic adjustments that will take place in response to pricing carbon. In this research, we assess the economic impacts of three carbon pricing scenarios. In Scenario A, carbon taxes increase from $10 per tonne in 2018 to $80 per tonne by 2025. Scenarios B and C incorporate heavier increases to carbon taxes. By 2025, the tax is at $150 per tonne in Scenario B and $200 per tonne in Scenario C. In addition to carbon pricing, this analysis incorporates changes in the electric power generation sector to reflect a move away from fossil fuels. For each scenario, we assume that carbon tax revenues are reinjected into the economy in the form of corporate and personal income tax cuts and additional public spending (mostly on infrastructure).

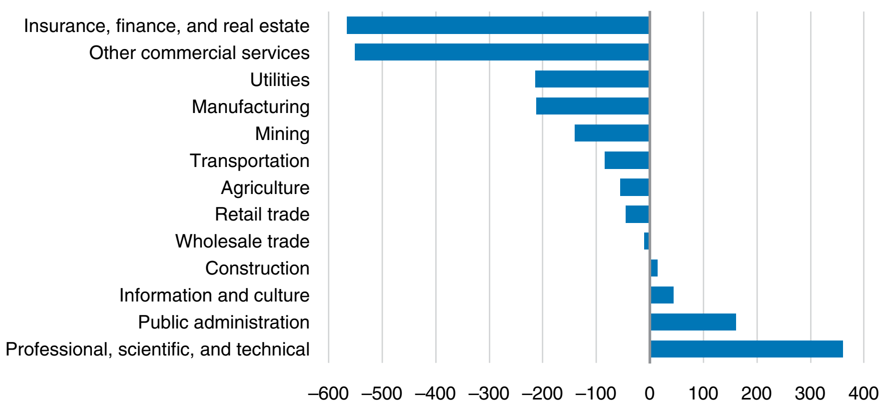
Compared with our status-quo scenario, our analysis suggests the economy will shrink marginally in response to the carbon tax and the shift to higher-cost electric power generation. The negative impact is small due to two main factors—carbon revenue recycling measures and Canada's flexible exchange rate, which (as demonstrated during the commodity price decline from 2014 to 2016) acts as an important automatic stabilizer that cushions negative effects on the economy. But even if the negative impact of the carbon tax on real GDP is minimal, the headline number masks important distributional differences across expenditure categories. Higher prices weaken real household income and spending, and business investment and trade volumes are lower. But public sector spending and infrastructure are bolstered throughout the forecast, partly offsetting those declines. (See Chart 1.) Moreover, the carbon tax leaves some industries worse off, as the increased domestic cost of their production is not fully offset by the depreciation of the loonie. At the same time, other industries with smaller production cost increases benefit from the decline in the loonie and end up better off after carbon pricing is introduced. (See Chart 2.)

Chart 1
Scenario A: Economic Impact by Expenditure Category
(average change versus baseline from 2018 to 2025, 2007 $ billions)



Sources: The Conference Board of Canada; Statistics Canada.

Chart 2
Scenario A: Economic Impact by Industry
(average change versus baseline from 2018 to 2025, 2007 $ millions)



Sources: The Conference Board of Canada; Statistics Canada.

While the flexible exchange rate helps trade-sensitive sectors, industries with a domestic focus that are sensitive to price changes are not as fortunate. The hardest-hit industries in these scenarios were residential construction and the finance, insurance, and real estate sector. Eroded purchasing power also results in households and businesses cutting their spending, and it is therefore no surprise that “other commercial services” (a category that includes services such as accommodation and food services, administrative support, and arts, entertainment, and recreation) also fall significantly.

In 2018, a $10 per tonne carbon tax will generate $5.8 billion.

Output in the utilities sector falls as higher energy costs lead to declines in demand for electricity and natural gas. Transportation output declines as the volume of goods produced in the economy shrinks. Wholesale and retail trade post modest declines due to the drop in consumer outlays. On the other hand, construction output rises marginally as the benefit of higher public sector investment outweighs the decline from reduced residential and business investment. Public administration output is up, based on the assumption that part of the carbon tax revenue will be used to fund a boost in government spending on goods and services. The largest output gain belongs to the professional, scientific, and technical services sector, where demand is boosted by the large increase in government investment in intellectual property products.

Higher production costs hurt the manufacturing sector, which experiences one of the largest declines in output. However, the decline in the Canadian dollar leaves some manufacturing segments better off. The steepest declines are in chemicals, primary metals, wood products, paper, and food manufacturing. These are all energy-intensive industries that see significant increases in their cost of production after the carbon tax is introduced.

The machinery and the motor vehicles and parts industries experience the lowest increases in input prices, and both industries see output gains as the benefit of the depreciating loonie more than offsets the competitive loss from carbon pricing. The computer and electronic product manufacturing industry posts the largest increase, reflecting its low increases in production costs and high sensitivity to the decline in the dollar.

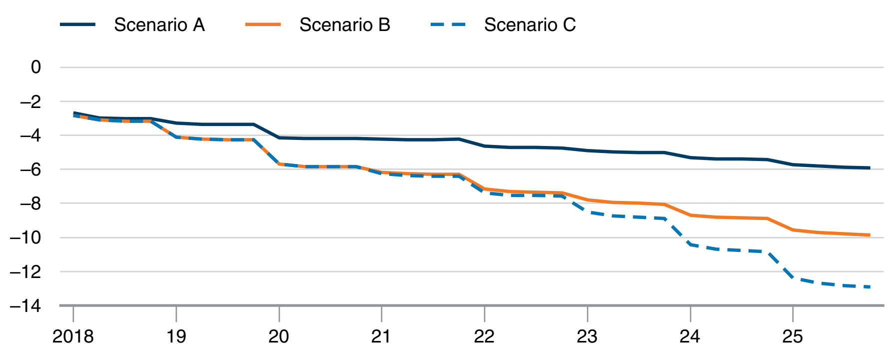
In 2018, a $10 per tonne carbon tax will generate $5.8 billion in fiscal revenues. That works out to just 1.6 per cent of provincial own-source revenues. But, by 2025, a carbon tax of $80 per tonne will generate $48.3 billion, or close to 10 per cent of own-source revenues. Emissions reductions occur across all scenarios, but these reductions are not solely in response to the introduction of a carbon tax. In fact, the lion's share of the drop in emissions in the three scenarios is due to the shift away from using fossil-fuel combustion to generate electricity. This accounts for a decline in GHG emissions of 34.8 megatonnes (Mt) in 2025.

The economic changes in response to pricing carbon (excluding the decline in the electricity sector) have only a small impact on emissions, with reductions by 2025 of 5.8 Mt in Scenario A, 9.7 Mt in Scenario B, and 12.7 Mt in Scenario C. Increasing the carbon tax from $80 to $200 per tonne, therefore, results in only a small reduction in emissions. (See Chart 3.)

Chart 3

CO_2eq GHG Emissions Reductions, Excluding Power Generation

(compared with baseline, Mt)



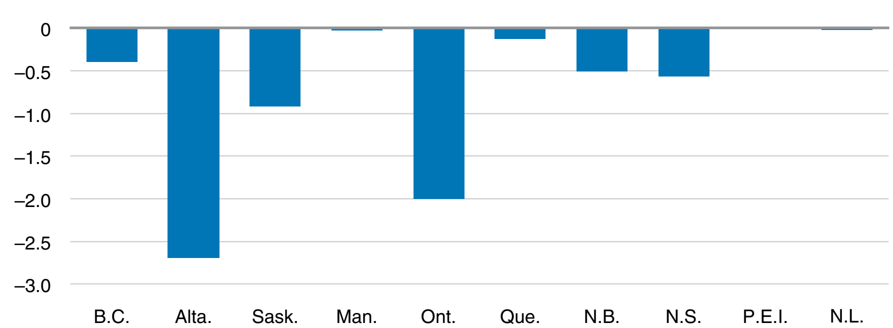
Sources: The Conference Board of Canada; Statistics Canada.

The emissions reductions shown in Chart 3 do not account for carbon leakage. To the extent that trade adjustments include declining exports of carbon-intensive goods without corresponding reductions in consumption of those goods by our trading partners, the emissions reductions in Canada could be fully offset by increases elsewhere. Similarly, an increase in imports, particularly of carbon-intensive goods, will have the effect of exporting our emissions.

Phasing Out Hydrocarbons in Electricity Generation

In addition to carbon pricing, the federal government has committed to eliminating coal-fired electricity generation in Canada by 2030. The Trottier research used for this analysis goes further by suggesting that the lowest-cost option for achieving significant GHG emissions reductions is to decarbonize the electricity system by also eliminating natural gas-fuelled generation capacity, and we have explored these assumptions in our analysis. Prematurely retiring the fossil fuel-powered facilities will have a negative impact on GDP and jobs as productive assets are removed from the economy, and these effects will be felt more in some provinces than in others. Chart 4 shows the provincial impact on GDP from eliminating fossil fuel-fired electricity generation by 2031, as outlined in the TEFP pathways.

Chart 4
Total GDP Impact
(direct and indirect impacts, 2007 $ billions)



Sources: The Conference Board of Canada of Canada; Statistics Canada; Trottier Energy Futures Project.

Across the provinces, the total annual reduction in GDP in 2031 once all the power plants have been retired is $5.0 billion. This represents the direct impact. The indirect effect to workers and suppliers is an additional loss of $2.2 billion per year, bringing the total impact to $7.2 billion per year (in 2007 dollars). For every dollar of GDP lost in electricity generation, the economy loses $1.45 of economic activity.

The Trottier analysis outlines several scenarios or pathways that are capable of achieving 30 and 60 per cent reductions in GHG emissions.

Overall, the economic impact of eliminating most fossil fuels from the power generation mix is significant but not overwhelming. Because electric power generation is capital-intensive, job losses are held to about 20,000. As well, these job losses are exclusive to the plant closures and do not consider the job gains that will come from new generating stations that will be built to replace the retired facilities. In any case, in a good month the economy already adds more than 20,000 new jobs.

Green Investments

In the final part of our analysis, we examine the economic impact of the investments required to achieve 30 and 60 per cent reductions in emissions from 1990 levels by 2050. While the 30 per cent reduction is consistent with Canada's emissions trajectory based on announced policies, a 60 per cent reduction by 2050 would put Canada on a path that closely matches the 2030 emissions reductions required to achieve our commitment under the Paris Accord. The Trottier analysis outlines several scenarios or pathways that are capable of achieving 30 and 60 per cent reductions in GHG emissions based on state-of-the-art energy models that assess the lowest-cost pathway to meet an assumed level of emissions reductions. We chose three of the pathways developed in that report and assessed the economic impact of the required investments.

Based on the Pathway 2 from the TEFP analysis, to achieve just a 30 per cent reduction in emissions below 1990 levels will require some $2 trillion (in 2011 $) in new incremental investments between now and 2050. Of this, $1.7 trillion will need to be invested in national electric power generation, while an additional $360 billion will need to be invested in other sectors, such as biofuels, agriculture, and industrial and commercial operations.

Based on the Pathway 5 from the TEFP analysis, which achieves a 60 per cent reduction in emissions below 1990 levels, a total of $3.4 trillion in new investments is required. About half of this comes from higher investments in transportation—new cars, trucks, subways, and so on. The rest of the additional investment is split almost equally among biofuels production, the commercial sector, and new power plants. Table 1 shows the investment requirements for selected scenarios. The investments are all in addition to the TEFP "Business as Usual" Scenario 1.

Table 1

Investment Requirements Relative to "Business as Usual" Pathway

(difference from Pathway 1, 2011 $ millions)

	Electricity generation	Other	Total	Total annual average	Annual average as a share of current investment**
Pathway 2*—no major technological change	1,679,151	357,886	2,037,037	59,913	29.0
Pathway 4—changes in urban form	1,938,899	223,019	2,161,918	63,586	30.8
Pathway 5—some technological change	1,867,329	1,549,217	3,416,545	100,487	48.7
Pathway 7—no new nuclear	1,946,470	1,274,467	3,220,937	94,733	45.9
Pathway 8—technological, behavioural, and policy changes	1,737,153	–226,243	1,510,910	44,439	21.5

*this pathway achieves only a 30% reduction in emissions, while the other four achieve 60% reductions
**current investment is estimated real non-residential business investment in 2016
Source: Calculations by The Conference Board of Canada based on TEFP investment data.

In addition to pathways 2 and 5, we also looked at several other scenarios that could still achieve the 60 per cent reductions in GHG. Pathway 8 is the most ambitious in its assumptions about technology, behaviour, and policy. Pathway 4, for example, focuses on the changes in urban form outlined in Pathway 8 while ignoring the other technological changes in Pathway 8. Meanwhile, Pathway 7 is similar to Pathway 5 but does not include the construction of new nuclear reactors. These scenarios show how behavioural and policy changes can affect the cost of achieving a 60 per cent reduction in emissions.

The results of this analysis showed that the economic impact of investments can differ substantially, depending on the type of investment being made. In the various scenarios studied in this analysis, the annual average net new investment requirement varied from 22 to 49 per cent of current non-residential business investment. Clearly, no matter which path Canada takes toward reducing emissions, a large portion of its investment spending will need to be redirected toward emission-reducing projects.

Canada is unable to leverage the funds, capital, and labour resources required to generate these investments without diverting funds.

At first blush, a large-scale infrastructure program may seem like an easy win-win solution. Investment spending boosts economic growth, improves our long-term potential, and, in this case, will reduce emissions. But pouring trillions of dollars into emission-reducing efforts is not the long-term answer to slowing economic growth or our dismal productivity performance. The economic reality is that Canada is fast approaching its economic capacity, meaning that capital and labour are fully employed—there is no large pool of labour or capital funds waiting idly to be directed toward these required investments. The simple fact is that Canada is unable to leverage the funds, capital, and labour resources required to generate these investments without diverting funds and productive capacity away from other economic activity.

If we assume that the investments, research, and policy initiatives encompassed in the pathways do not impact productivity (or productive capacity, since a large portion is spent to replace energy that generates emissions with energy that is emissions-free), then much of the investment would come at the expense of other areas of the economy. In other words, a large portion of the money currently invested in everything from productivity-enhancing machinery and upgraded sewer systems to basic transportation infrastructure would need to be redirected toward emission-reducing projects. If, in fact, these investments replace others that enhance our productive capacity but do not generate new capacity themselves, Canada's economy will be smaller than in the business-as-usual scenario.

The Conference Board's forecasting model was used to assess the long-term implications of a sudden increase in investment spending totalling tens of billions of dollars a year. The spending drives us well above our potential output, leading to interest rate increases from the Bank of Canada and a sharp appreciation of the Canadian dollar. Rising demand for labour leads to a spike in wages and prices (as we witnessed in Alberta in the mid-2000s when large investments were occurring in the non-conventional oil industry). The appreciation of the loonie reduces exports and causes businesses to pull back on their investment spending as their international competitiveness position weakens. As demand exceeds our domestic capacity, imports jump. Eventually, the price increases and the effect they have on purchasing power lead to a pullback in household and business spending.

The magnitude of the economic response varies by scenario (30 or 60 per cent emission reductions), given that investment requirements are different. But the narrative remains the same—the Canadian economy is unable to absorb this increase in demand and the investment will be drawn out of other areas of spending in the economy. Households are hit hardest in these scenarios due to rising prices, and it is unlikely that the general population understands the impact that these investments will have on their day-to-day lives.

Policy Implications

To reach Canada's 2030 target, the government's projection indicates that emissions need to fall to 219 Mt below 2016 levels. Environment and Climate Change Canada's projections show emissions in 2030 stabilizing at their current level after including a coal phase-out in Alberta.[1] The results of our analysis show that carbon pricing and decarbonization of electricity generation outside of Alberta will indeed reduce emissions, but those reductions will be far from enough to allow us to reach the 2030 target.

If Canada wants to significantly reduce its emissions, it will require sizable investments in clean energy. Based on different technological and behavioural assumptions, the TEFP has outlined several pathways that result in deep emissions reductions. Given that these investments will mean less spending in other areas of the economy, policy-makers need to undertake a thorough analysis of the different reduction options available. There are potentially significant cost savings that can come from shifting behaviours, and policy-makers need to explore the likeliness of successfully inducing the necessary behavioural changes.

1 The federal government did not announce its national coal phase-out strategy until the end of November. Therefore, the government projections include only province-specific plans to eliminate coal from their electricity generation mix.

At the same time, policy-makers need to be aware of the economic dislocations that will occur during the transition to a low-carbon future and draft solutions that will help minimize and mitigate the negative impacts that will occur.

In addition to the significant new spending needed, achieving deep GHG emissions reductions will require individuals to drastically change the way they live their lives and businesses to fundamentally alter the way they operate (most notably in the way energy is used and produced). Policy-makers will need to clearly articulate to their constituents the scale of the transformation required and what these changes will mean for them in their everyday lives, and ensure that society is willing to embrace these changes. Without broad-based support, the effort to reduce emissions will ultimately fail. Given that the investment requirements are in the trillions of dollars, we cannot afford to neglect the planning and communications required to achieve a successful and substantial reduction in emissions. Motivating broad-based support for the transition is key. Although the cost of action may seem high, the cost of inaction will likely be much higher.

CHAPTER 1

Introduction

Chapter Summary

- As part of its commitment under the Paris Agreement, Canada's federal government announced several initiatives in 2016 aimed at reducing emissions, including a mandatory floor for carbon pricing in all provinces and the elimination of coal-fired electrical power generation plants by 2030.
- Going forward, Canada is set to enter a new era in its fight to combat climate change, one characterized by collaboration and more aggressive policy goals.
- In this research, we quantify the economic impacts associated with the substantive emissions reductions Canada has committed to achieving.

Until recently, Canada's climate change strategy has been characterized by several individual policy initiatives aimed at reducing greenhouse gas (GHG) emissions. Alberta introduced the Specified Gas Emitters Regulation (SGER) in 2007 requiring large emitters in the province to meet emissions-intensity targets, purchase offsets, or pay a penalty. British Columbia introduced North America's first retail carbon tax in 2008. Quebec was the first province to employ a cap-and-trade system. Ontario introduced a cap-and-trade system in 2017. Alberta introduced a carbon tax on fuels in 2017 and is transitioning the SGER to a system that includes output-based allocations, beginning in 2018. The federal government has announced a carbon price that will apply across the country, beginning in 2018. All jurisdictions have developed and updated climate action plans for at least a decade now. The federal and provincial governments have also committed funding to advance clean energy research aimed at reducing emissions.

Policy action on climate change is accelerating. In December 2015, the Paris Agreement was signed by Canada and 195 other countries. The Paris Agreement committed participating countries to implement policies aimed at keeping global temperatures from rising more than two degrees Celsius above pre-industrial levels. As part of its commitment under the Paris Agreement, Canada's federal government announced several initiatives in 2016 aimed at reducing emissions, including a mandatory floor for carbon pricing in all provinces and the elimination of coal-fired electrical power generation plants by 2030.

Going forward, Canada is set to enter a new era in its fight to combat climate change, one characterized by collaboration and more aggressive

The Pan-Canadian Framework on Clean Growth and Climate Change includes a multi-pronged approach to reducing emissions.

policy goals. In a historical agreement, most provincial premiers and the prime minister signed the Pan-Canadian Framework on Clean Growth and Climate Change in December.[1] The framework is designed to help Canada meet or exceed its commitment to lower its GHG emissions to 30 per cent below 2005 levels. The government has published details on the agreement, which has "four main pillars: pricing carbon pollution; complementary measures to further reduce emissions across the economy; measures to adapt to the impacts of climate change and build resilience; and actions to accelerate innovation, support clean technology, and create jobs."[2]

The framework includes a multi-pronged approach to reducing emissions, spread over several different policy initiatives. In this research, we quantify the economic impacts associated with the substantive emissions reductions Canada has committed to achieving. There are three distinct elements. The first part of this analysis looks at the economic impact of carbon pricing using tax assumptions made by the Conference Board in combination with a pathway for electricity decarbonization from the Trottier Energy Futures Project (TEFP). Second, we quantify the economic loss associated with prematurely retiring fossil fuel generation capacity from the electricity system. Lastly, this research quantifies the investments required to achieve deep GHG emissions reductions, based on pathways developed in the TEFP. (See "The Trottier Energy Futures Project Scenarios.")

The Trottier Energy Futures Project Scenarios

In April 2016, the Canadian Academy of Engineering (CAE), in partnership with the David Suzuki Foundation, published the Trottier Energy Futures Project, a multi-year research project made possible with funding from the Trottier Family Foundation. The TEFP describes a set of feasible pathways for reducing Canada's GHG emissions. The analysis in the TEFP employed state-of-the-art energy models. An optimization model was used to assess the "least cost" pathway to meet an assumed level of emissions reductions, with "least cost"

1 Government of Canada, *The Pan-Canadian Framework on Clean Growth and Climate Change.*
2 Ibid., 2.

defined as the sum of the producer and consumer surpluses. A process model was used to define the cost and operational characteristics of the energy technologies included in the analysis. The models were iterated using a data bridge to provide consistent solutions between the two approaches.

In addition to the "business as usual" reference scenario, the TEFP project included seven technical pathways, of which three were selected for sensitivity analysis related to the level of hydrocarbons production. For all the main pathways examined, the level of hydrocarbons production and the level of energy services demanded by the economy were held constant. The models solved for the least cost pathway to meet demand, subject to an upper bound on emissions. The TEFP scenarios provide an assessment of the pathways to a low carbon future, as well as the required investments.

The Cost of a Cleaner Future report is a joint project between The Conference Board of Canada and the CAE. The carbon price scenarios modelled in this research are not drawn from the TEFP report. However, the emissions, energy flows, and investment data from the TEFP scenarios are used to assess the impact of stranded capital and the economic and social impacts that would flow from the investments required by the technical pathways. In that sense, this report considers the economic ability to achieve the emissions reductions represented by the TEFP pathways.

Pricing carbon is one of the main pillars of the Pan-Canadian Framework on Clean Growth and Climate Change. Under the framework, the federal government will mandate a minimum carbon price of $10 per tonne beginning in 2018 and rising $10 per tonne a year to reach $50 per tonne in 2022. Provinces will have the option of employing either a direct price on carbon emissions or a cap-and-trade program, and revenues collected from carbon pricing will stay within the jurisdiction where they are collected.

Chapter 2 of this report details the economic impacts of carbon pricing and the higher prices resulting from the change in the generation mix required by the elimination of fossil fuel power. It also explores the sensitivity of higher carbon prices.

The federal government's framework also highlights the need to transform our electricity industry to reduce emissions.[3] In Chapter 3 we examine the current mix of electricity generation across the country and calculate the economic impacts associated with phasing out most fossil fuel generating capacity by 2030.

As the measures explored in chapters 2 and 3 will not be enough to achieve significant GHG reductions, in Chapter 4 we explore the level of investments needed to support the transition to a low-carbon economy. Research from the Trottier Energy Future Project[4] provides different pathways for Canada to make deep reductions in GHG emissions, and the results indicate that a massive amount of new investment will be necessary to make that transition. Chapter 5 summarizes our research findings.

3 Ibid., 10–13.

4 Trottier Energy Futures Project, *Canada's Challenge and Opportunity*.

CHAPTER 2

Potential Economic Impacts of Carbon Pricing

Chapter Summary

- Using an input-output framework, this analysis calculated how carbon pricing will change the prices of goods and services produced in Canada.
- The Conference Board used its macroeconomic model to assess the impact of price changes on consumer spending, investment, and government fiscal balances.
- When all the revenue collected from the carbon tax is put back into the economy through tax cuts, higher government investment, and government spending, much of the negative impact from the carbon tax is offset.
- Still, in all scenarios, the impact on real GDP in 2025 remains negative, as steady increases in the carbon tax leave the economy still adjusting to the price shock at the end of the forecast period.
- Based on our assumptions, in all scenarios, the private sector shrinks while the public sector expands following the introduction of the carbon tax.
- Impacts are not equally distributed across industries. Utilities generation, chemical manufacturing, primary metals, and wood products are hardest hit, with motor vehicles and parts, as well as computers and electronics, showing the largest gains.

In this chapter, we explore the potential economic impacts of carbon pricing—one of the main pillars in the Pan-Canadian Framework on Clean Growth and Climate Change. Under the framework, the federal government will mandate a minimum carbon price of $10 per tonne beginning in 2018, rising $10 per tonne a year to reach $50 per tonne in 2022. Provinces will have the option of employing either a direct price on carbon emissions or a cap-and-trade program, and revenues collected from carbon pricing will stay within the jurisdiction where they are collected.

In addition to carbon pricing, this analysis incorporates changes in the electric power generation sector to reflect a move away from fossil fuels. We assume that carbon will be priced through a direct tax on the combustion of fuels that emit GHGs. We examine the impacts of three different paths for carbon taxes over the 2018–25 time frame, as displayed in Table 2.

Table 2

Carbon Tax

($/tonne CO_2eq)

	2018	2019	2020	2021	2022	2023	2024	2025
Scenario A	10	20	30	40	50	60	70	80
Scenario B	10	30	50	70	90	110	130	150
Scenario C	10	30	50	70	90	120	160	200

Source: The Conference Board of Canada.

Scenario A represents the current path for carbon pricing outlined by the federal government until 2022. In this scenario, it is assumed that the carbon tax will continue to increase by $10 per tonne per year after 2022. The carbon tax in Scenario B assumes a $20 per tonne increase per year. In Scenario C, the increases parallel those in Scenario B until 2022, after which the tax ramps up faster to help move Canada down a path of deeper emissions reductions.

In this chapter, we discuss the methodology and assumptions used in this analysis, followed by the results of our estimates of the economic impacts of the carbon tax for each of the three scenarios.

Carbon Pricing in the TEFP Scenarios

The technical pathways examined by the TEFP do not price carbon directly. Instead, they impose an upper bound on GHG emissions and determine the least-cost mix of technologies needed to meet that upper bound. The cost increase that results from meeting the upper bound represents the implied marginal cost of emissions for each pathway. The results indicate that for any of the technical pathways considered, the marginal cost of emissions in 2025 could be double (or more) the level assumed in our Scenario C.

Methodology and Assumptions

There are several important steps to quantifying the effect of a carbon tax. First, we need to understand how a carbon tax will pass through to all prices in the economy, since a higher tax on emissions will lift prices all along the supply chain. Using detailed supply-chain information available from Statistics Canada, we have developed a detailed model to assess these impacts. The resulting changes in relative prices will encourage households and industry to consume less GHG-intensive energy or goods, or to switch their consumption to less costly substitutes.

These changes in consumer and business behaviour will have the desired effect of reducing GHG emissions, but there is a margin of uncertainty about how much change can be expected. To get at this, we rely on our national model of the Canadian economy, which incorporates estimated historical relations to assess the impacts of changes in relative prices on consumers and businesses. There is a fair bit of uncertainty when estimating these changes. This is especially true

The approach used is likely to represent an upper bound for the economic impacts of the carbon price.

when implementing policies that will increase prices substantially more than typical historical swings. Moreover, if a policy is implemented that provides *certainty* about steady future price increases, as is the case in our scenarios, it may have a greater impact on changing behaviour than that brought about by *uncertain* historical swings in prices.

In the following sections, we consider the three carbon tax scenarios, their impact on prices, and the responses by households and businesses to the higher prices. We also consider the impact on the competitiveness of Canadian businesses if Canada's trading partners do not raise their carbon taxes. Finally, we make assumptions about how governments will spend the resulting revenue from the carbon tax.

The approach used is likely to represent an upper bound for the economic impacts of the carbon price assumptions made for each scenario. There are two primary reasons for this. First, the fixed economic structure of input-output analysis does not consider the impact that would result from the adoption of new technologies that might result from carbon pricing. However, comparing this analysis to the technical pathways examined for the TEFP yields an important insight. The marginal price of carbon identified by their scenarios represents the cheapest mix of existing and new technologies to meet a given level of emissions reductions. Their marginal emissions price for all scenarios is noticeably higher than the carbon prices examined here, suggesting that even our highest scenario—at $200 per tonne—would incentivize only a portion of the new technology adoption included in the TEFP scenarios. Thus, the assumption of a fixed economic structure can be considered reasonable over the period examined. The second factor is that this analysis does not consider permit trading under Ontario's or Quebec's cap-and-trade regimes. Given that some companies subject to the cap will choose to purchase emissions permits from other WCI jurisdictions (such as California), a portion of the carbon revenues measured in these scenarios could transfer to emitters in California rather than governments or companies in Canada. Further, under cap and trade, permit trading in Ontario or Quebec would result in wealth transfers between enterprises rather than tax payments to governments.

Calculating the Price Increase on Commodities Taxed Directly

The first step in this analysis was to calculate the expected direct price increase in energy commodities resulting from a carbon tax.

We assume that the carbon tax is applied at the point of purchase to all fuels that will be combusted within Canada. The tax is based on the GHG emissions that will result from the combustion. Certain exemptions may apply in each jurisdiction, but no exemptions are considered in this analysis. In total, there are nine fuel types that would experience a direct price increase from the carbon tax. (See "End-Use Fuels Subject to a Carbon Tax.") The price increases for eight of these fuels (all except electricity) were calculated using a straightforward methodology. Information about the amount of GHG in the form of carbon dioxide, methane, and nitrous oxide emitted by each of these fuels is available from Canada's *National Inventory Report*.[1] This information allowed us to calculate the emissions for each fuel (excluding electricity). Once we know the emissions, we can calculate the appropriate carbon tax per unit of fuel. For each of the fuels identified here, we produce a baseline forecast out to the year 2025 in which there are no carbon taxes. We then calculate the amount of carbon tax that will be applied to each of the fuels in scenarios A, B, and C. The final price increase is then derived as a function of the carbon tax and the baseline forecast.

End-Use Fuels Subject to a Carbon Tax

- Natural gas
- Natural gas liquids and related products
- Electricity
- Gasoline
- Diesel fuel
- Light fuel oils
- Jet fuel
- Heavy fuel oils
- Coke and other coke oven products

Source: The Conference Board of Canada.

1 Environment and Climate Change Canada, *National Inventory Report 1990–2014*.

Electricity Price Increases

Modelling the change in electricity prices due to a carbon tax presents a unique challenge. Electricity generation is mostly produced with heavy investments in large capital projects that are meant to stay in production for many years, most often decades. As such, it is difficult, if not impossible, to change fuel sources quickly. As part of this research project, we were provided with detailed information from the TEFP on how the electricity generation mix will shift as we transition to a lower carbon future. In TEFP's Scenario 2, coal, heavy and light fuel oils, and almost all natural gas is phased out from the generation mix by 2030. Using the generation mix from TEFP Scenario 2 allows us to model how electricity prices would change based on a shifting carbon content in electricity generation due to the implementation of new carbon taxes, as well as the cost of replacing relatively cheap sources of electricity generation, such as coal, with less GHG-intensive fuels. Because the electricity generation mix varies greatly among the provinces, electricity price increases were produced by province. The national electricity price was then calculated as a weighted average of the provincial prices, with the weights equal to the provincial share of total electricity generation in 2015.

Given that we used shifts in generation technologies to calculate the electricity price increase, we also utilized the emissions data from TEFP's Scenario 2 to calculate the GHGs from the electricity sector in our analysis.[2]

Transmission of a Carbon Tax Through the Economy

We relied on Statistics Canada's industrial framework of Canada's economy to assess the direct impact of carbon taxes on prices. Statistics Canada's input-output (IO) framework provides a detailed analysis of Canada's supply chain, in effect providing a detailed look at the commodities used as inputs into the production process of Canadian industries. This framework can be reworked (see Appendix A) to assess how price increases flow through the supply chain, allowing us to

2 Any of the TEFP scenarios could have been used for this purpose, as fossil fuels are eliminated from electricity generation quickly in all scenarios—even Scenario 2, which represents the lowest emissions-reduction target.

Higher prices due to the carbon tax will cause reallocations and some spending reductions in segments of our economy.

calculate the effect of carbon taxes on 462 different commodities used by Canadian governments, businesses, and households.

The IO price model is based on a fixed structure of Canada's economy at a point in time—it is a static model that can only provide the initial hit of a carbon tax on commodity prices. We need to take the analysis one step further to assess how consumers, businesses, and governments will change their behaviour based on changes in relative prices. To do this, we rely on the Conference Board's national macroeconomic model of Canada's economy—a dynamic model that will capture the second-round impacts of changes in household and business behaviour on a wide range of economic indicators, including second-round impacts on prices. Our national model incorporates a more aggregate price block that includes prices not just at the commodity level, but all the way through the production process—from commodity to industry selling prices to manufacturing prices to final demand prices (such as export and consumption deflators and the consumer price index). Since expenditures in our model respond to price changes, the introduction of higher prices due to the carbon tax will cause reallocations and some spending reductions in segments of our economy.

By feeding the price change assumptions derived from the IO model into our national forecasting model and simulating the model, we determine how carbon taxes impact consumption decisions, industrial output, employment levels, government balances, and trade patterns. While export prices will incorporate the indirect impact of carbon taxes, the treatment of import prices and their effect on domestic prices is more complex.

Assessing the Impact of Import Prices

Given that Canada's most important trading partner—the United States—is unlikely to adopt carbon taxes any time soon, and because carbon emissions are embedded in virtually all goods that are imported, the Canadian government might consider applying tariffs to imported goods so as not to favour those over domestic products that are taxed for their use of GHGs. In the carbon leakage literature, these are referred to as "border adjustments." The intent is to tax imports to a level that matches

The impact on the relative competitiveness of fuel producers would be less affected, because imported fuels would be subject to the carbon tax.

the carbon costs faced by domestic producers. However, accounting for embedded GHG emissions in imported goods would be extremely cumbersome from an administrative viewpoint and could be difficult to implement given our obligations under international trade agreements.

As such, we have assumed that the Canadian government would not place tariffs on goods and services imported into Canada. This has the effect of dampening the effect on overall consumer prices (since the price of imported goods will not increase) and hurting domestic producers facing higher input costs due to the domestic carbon tax. The impact on the relative competitiveness of fuel producers would be less affected, because imported fuels (such as natural gas, gasoline, or other energy products) to be combusted by end-users within our borders would be subject to the carbon tax. Similarly, because we assume that the tax will be levied when fuels are combusted within our borders, energy producers who export their goods will not be subject to the carbon tax, since combustion will occur in another jurisdiction. While we feel that this assumption best reflects the situation with the current U.S. administration, it is possible that over the course of our analysis period (which extends to 2025) the U.S. could reconsider applying carbon taxes. However, the impacts of changes in the relative price of domestic goods versus imports are offset by movements in the Canadian dollar. As such, the uncertainty associated with foreign policy on pricing carbon will be mitigated by Canada's flexible exchange rate policy.

To account for the fact that import prices will not increase (except for the energy commodities directly impacted by the tax), the effect of price increases on final demand prices is scaled by the proportion that is produced domestically. For example, virtually all the potash in Canada comes from domestic supply. Therefore, users of potash will experience higher potash input prices, in line with the increased cost of domestically producing potash. On the other hand, because nearly 30 per cent of veneer and plywood products are imported, the total price increase in this commodity would be only two-thirds of the increase in the cost of domestic production. Margins (trade, transportation, gas and storage, and taxes) are assumed to remain constant and, therefore, the percentage change in final demand (or purchaser) prices is less than the increase in wholesale prices.

Higher prices for GHG-intensive goods will push consumers to change the proportion of spending away from higher priced goods.

Calculating Emissions Reductions From Carbon Pricing

The Conference Board's national economic model incorporates a detailed accounting of GHG emissions, which are modelled as a function of industry output in 61 sectors and household spending on heating, lighting and appliances, and motor fuels and lubricants. As such, model simulations allow us to capture the impact of carbon taxes on government revenues and emissions reductions.

Historical information on GHG emissions by industry are available from Statistics Canada. Using these estimates along with data on GDP by industry, GHG intensities by industry (and from the two household consumption categories) are calculated. Carbon revenues are then simply the product of the emissions from fuel combustion multiplied by the carbon tax.

The baseline (or status quo) scenario is simply the level of emissions associated with economic growth in our most recent economic outlook and assumptions regarding future emissions intensity by industry with no new carbon taxes applied. We then introduced the carbon taxes associated with scenarios A, B, and C. According to the model simulations, higher prices for GHG-intensive goods will push consumers to change the proportion of spending away from higher priced goods such as home heating and gasoline. Firms will also respond to carbon pricing by changing their production to reflect shifts in domestic demand and decreased international competitiveness. (See "Assessing the Competitiveness Impact.") As consumption and production change in the economy, a new path of emissions will be generated by the model, and the difference between the new emission levels and the baseline emission levels represents emission abatement in each of the carbon-pricing scenarios. In this simulation, we have not adjusted emission intensities by industry and consumption category relative to the baseline forecast, so emission reductions reflect solely the change in industry output as a result of the impact of carbon pricing.

The one exception is for electrical power generation. To align with our methodology for calculating the increase in electricity prices as the generation mix shifts, we relied on projections from TEFP to determine emissions in the electricity generation sector. The decline in electric power generation emissions was calculated as the difference between emission profiles in TEFP Scenario 2 and Scenario 1 (their “business as usual” scenario) and the percentage decline was applied to each of our three scenarios.

Assessing the Competitiveness Impact

The extent to which other jurisdictions apply carbon taxes to their production processes and to which other jurisdictions exempt exports from carbon taxes could have important repercussions on the competitiveness of Canadian products for domestic consumption. The phenomenon of carbon leakage is central to analyzing competitiveness. Carbon leakage occurs when consumers of Canadian products choose to substitute products from another nation solely because of the cost increase that results from carbon pricing or other GHG policies. It also occurs when our export customers shift their purchases to other suppliers that do not face carbon pricing. This can happen when the price of our goods, whether in domestic or export markets, rises relative to the price of goods produced in a jurisdiction that does not price carbon. Measuring the actual level of carbon leakage is difficult. As a result, proxy measures are often used to determine the level of exposure, the impact of carbon pricing on competitiveness, and the appropriate remedy to protect against a competitive disadvantage relative to nations that are not taking action to reduce GHGs. Clearly, transferring production from Canada to such jurisdictions reduces emissions in Canada and increases them in those countries. In some cases, global emissions could even rise as a result of carbon leakage.

In cap-and-trade jurisdictions such as the European Union, California, Ontario, and Quebec, protection of carbon-intensive trade exposed (CITE) industries most often takes the form of free emissions permits. Once the CITE industries are identified, producers are given free emissions permits based on historical production levels and some measure of emissions intensity. The emissions intensity is most often based on best performers in the industry. Both the emissions intensity and historical production levels can be reduced through time to provide a transition period for emissions improvements. Alberta is taking a similar approach with its output-based allocations (OBAs), which will come into effect in 2018 for large emitters.

For a jurisdiction that relies specifically on carbon taxes, exports of carbon-intensive products can be exempted from the tax. For example, in British Columbia, hydrocarbon fuels that are purchased within the province for consumption outside of the province are exempt (airline purchases of jet fuel, for example). Similarly, fuels produced in the province but sold in export markets are exempt (natural gas exports, for example). The cement industry also has exemptions to protect it against foreign industries.

Carbon Tax Revenues

As discussed earlier, the federal government's plan is to allow provinces to use a carbon-pricing mechanism of their choice. Alberta has had the SGER since 2007 and is using the resulting revenues to support technology development to reduce GHG emissions. British Columbia has had a tax on carbon since 2008 and its tax is revenue-neutral—in that any revenues from the carbon tax are used to offset other taxes. Quebec has had a cap-and-trade system since 2013 but revenue gains have thus far been modest; once revenues from cap-and-trade accelerate, they are to be used to fund green initiatives.[3] Ontario and Alberta rolled out their carbon-pricing policies in 2017, with Ontario opting for cap-and-trade and Alberta imposing a carbon tax and transitioning the SGER to an OBA-based system. In Ontario, the proceeds from cap-and-trade will fund green projects, while in Alberta the revenue will be funnelled back into the economy through green investments (similar to Ontario), lower taxes on small business, and individual rebates based on income.

The current provincial carbon-pricing policies show that there is no provincial consensus on the preferred carbon-pricing mechanism or how the resulting revenues should be spent. The goal of this research is to determine how Canadian industries will be impacted by carbon pricing; it is not to assess the merits of the different provincial plans or how these plans might influence actual emissions reductions in each province. Thus, for this analysis, the carbon-pricing mechanism and resulting revenues are assumed to be the same across provinces. As discussed, the cap-and-trade framework adopted by Ontario and Quebec will result

3 Woods, "Quebec's Cap-and-Trade System."

We assume that 50 per cent of emissions revenues will be given back in the form of provincial personal and corporate income tax cuts.

in permit sales and purchases between companies, including companies outside of Canada, and is likely to generate less government revenue than the carbon price considered here. Carbon will be priced using a carbon tax and the resulting revenues are assumed to be reinvested into the economy. We assume that 50 per cent of emissions revenues will be given back in the form of provincial personal and corporate income tax cuts, 40 per cent will go to additional public investment spending, and 10 per cent will go to lifting public sector spending to cover higher administration costs.

Estimating the Impacts Across Provinces

Because of data limitation at the provincial level, especially with respect to prices, we relied on our more detailed national model to provide the aggregate economic impacts of carbon pricing. We estimated the national model results on the provincial economies by using the impact by industry at the national level and applying it to each province by keeping the share of output by industry by province constant over time. For example, our national model simulation results suggest that carbon taxes will result in a $10-million loss in agricultural output. Because Ontario has 15 per cent of national output in that industry, a decline of $1.5 million would be attributed to Ontario. Employment changes by industry in each province were calculated based on the change in total output divided by average productivity in that industry.

Sharing out the national results to the provinces is an imprecise estimate—especially considering the stark differences in the mix of fuels used for electric power generation across provinces and the implications that this would have on electricity price increases by province. Given the data limitations, we feel that the estimates presented are the best approximations we can make.

Results

This section provides a generalized discussion of how the three main agents in the economy (households, businesses, and government) respond when the carbon tax is introduced. It then presents the detailed modelling results from our three scenarios. Unless otherwise indicated, results are presented as the change relative to a baseline forecast that does not include carbon pricing.

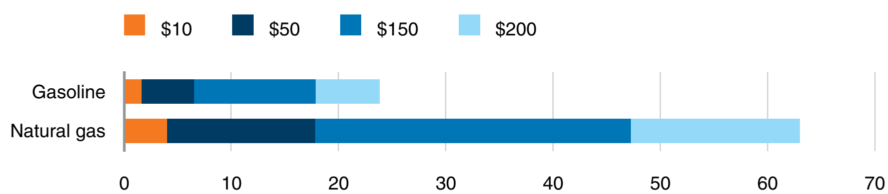
Economic Changes From Pricing Carbon

The carbon tax will affect the economy in many ways. We first estimate the direct impact on prices—as the cost for fuels increases, consumers will pay more for gasoline, electricity, natural gas for home heating, and propane. At $50 per tonne, the final consumer natural gas prices will increase by almost 20 per cent and at $200 per tonne, natural gas prices will rise by over 60 per cent.[4] (See Chart 5.)

Chart 5

Impact on Select Energy Commodities

(percentage change associated with different carbon taxes)



Note: The $10 and $50 tax rates are from Scenario A in 2018 and 2022, $150 is the level of the carbon tax in Scenario B in 2025, and $200 is the value in 2025 in Scenario C.
Source: The Conference Board of Canada.

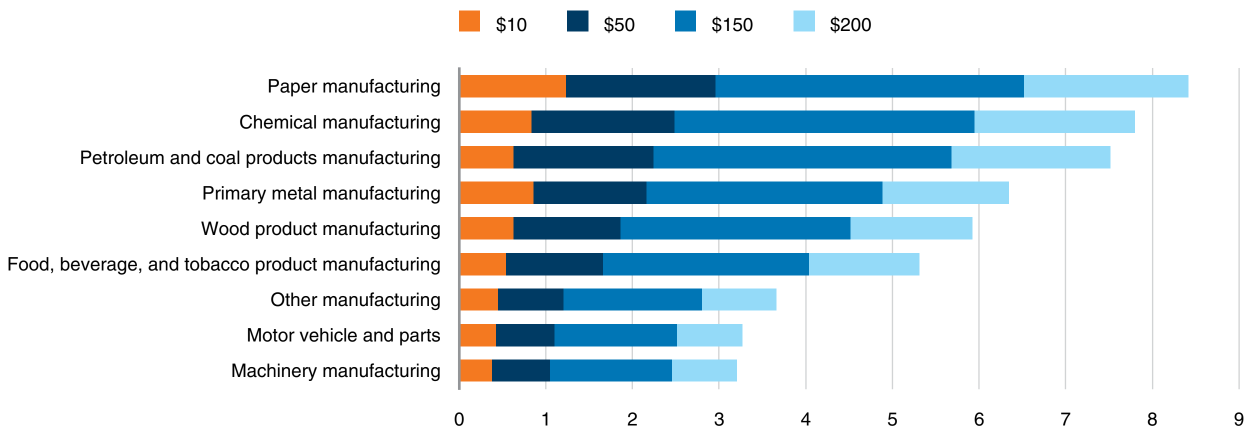
Businesses will face higher input costs as higher energy prices ripple throughout the economy and push up the cost of goods and services in the economy. Assuming linear impacts and no import substitution, industry product prices are set to rise only modestly when carbon is priced at $10 per tonne but more substantially when the carbon price increases to $200 per tonne. (See Chart 6.)

4 While gasoline is more carbon-intensive than natural gas, the increase in prices is calculated on the final selling price and thus includes distribution and storage margins, as well as other taxes. Since many taxes are already included in gasoline prices, the percentage increase in final prices from adding a carbon tax is smaller on gasoline than on natural gas.

Chart 6

Impact on Select Industry Product Prices

(percentage change associated with different carbon taxes)



Note: The $10 and $50 tax rates are from Scenario A in 2018 and 2022, $150 is the level of the carbon tax in Scenario B in 2025, and $200 is the value in 2025 in Scenario C.
Source: The Conference Board of Canada.

If we first consider the impacts of a carbon tax without reinjecting those tax revenues in the economy, there is a significantly negative impact on the economy. Higher prices reduce household purchasing power, resulting in a drop in real consumer expenditures. However, the impact on consumers is not isolated to just the impact from higher prices on goods. When the government increases its share of taxation revenue, there will be an offsetting reduction in incomes going to businesses or consumers. In a previous report conducted by the Conference Board, our review of the literature and internal modelling showed that when businesses face higher tax costs, over the long term they will pass these costs on to their workers in the form of lower wages.[5] As a result, corporations adjust their salary costs down to mitigate the effect of higher input costs and the drop in profitability. The implication is that household spending is lowered significantly in response to both higher prices and lower wages, resulting in a negative impact on real GDP.

5 The Conference Board of Canada, *A Cost-Benefit Analysis*.

An important consideration when evaluating the impact of carbon pricing is the issue of revenue recycling.

Higher prices will affect not only the purchasing power of consumers; businesses and governments will also face reduced purchasing power. Thus, without measures to recycle the carbon tax revenue into the economy, real government spending and business investment spending will decline. The impacts on the various components of investment spending differ widely, as price increases are driven by the increased costs that feed into the different expenditure categories. For example, residential investment spending will see a notable increase as the costs of wood products and other inputs rise.

Even after passing on the higher costs to their workers, exporters will still be at a competitive disadvantage, as they will not be able to pass on any of those higher costs to foreign buyers. Higher domestic prices will put downward pressure on the Canadian dollar, which does provide an important offset to the impact of higher domestic production costs. However, the depreciation in the loonie will not be enough to completely offset the impact of higher production costs on the prices that Canadian exporters sell internationally. As such, exports are also negatively affected by higher carbon taxes. Moreover, because import prices are unaffected, import prices become more favourable when compared with the price of many domestic goods. The overall result is a significant deterioration in the real trade balance.

However, carbon tax revenues add significantly to the coffers of governments. As such, an important consideration when evaluating the impact of carbon pricing is the issue of revenue recycling. Since the provincial governments collect the revenue from the carbon tax, it is unlikely that revenue recycling policies will be standardized across the country. Given the information we have from provinces that are already pricing carbon, our revenue recycling assumptions include public investment in infrastructure and green technology, administrative spending, and tax relief. When revenue recycling is introduced into the model—that is, all the revenue collected from the carbon tax is put back into the economy through higher public investment and government spending, as well as tax cuts—much of the negative impact from the carbon tax is offset. In the sections that follow, we present the results of the model simulations for each of our three carbon tax scenarios, with each including revenue recycling measures.

Scenario A

At $10 per tonne in 2018, it is estimated that the provincial governments will collect $5.8 billion in carbon taxes. That works out to just 1.6 per cent of own-source revenues and is far less than the expected $15.9 billion collected in gasoline and motive fuel taxes or the $96 billion in general sales tax collected that year. By 2025—when the carbon tax reaches $80 per tonne—carbon revenues will reach $48.3 billion. Including corporate and personal income tax cuts, simulation results suggest that by 2025, carbon taxes will account for 9.8 per cent of provincial government own-source revenues. (See Table 3.)

Table 3

Scenario A: Carbon Tax Revenues and Emissions

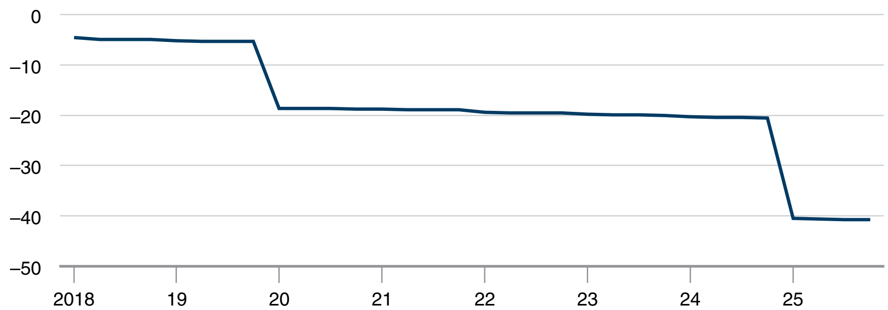
(change compared to baseline scenario)

Carbon tax ($/tonne CO_2eq)	10	20	30	40	50	60	70	80
Total emissions (kilotonnes, CO_2eq)	–4.9	–5.3	–18.7	–18.9	–19.5	–19.9	–20.4	–40.6
Industry emissions	–3.0	–3.2	–16	–16.1	–16.4	–16.7	–16.9	–36.8
Household emissions	–1.9	–2.1	–2.7	–2.8	–3.1	–3.3	–3.6	–3.8
Carbon tax revenue ($ billions)	5.8	11.8	17.6	23.8	30.0	36.4	42.8	48.3

Source: The Conference Board of Canada.

In response to the carbon tax, GHG emissions are projected to fall by 40 megatonnes (Mt) relative to the baseline projection. (See Chart 7.) There are notable reductions in GHG emissions at the beginning of 2020 and 2025 when fossil fuel-based electricity generation facilities are removed from service. In 2025, the emission reductions from the electricity sector accounts for 34.8 Mt of the reduction, with an additional 5.8 Mt in reductions resulting from households reducing consumption and businesses reducing output in higher cost sectors.

Chart 7
CO_2eq GHG Emissions Reductions
(Scenario A compared with baseline, Mt)



Sources: The Conference Board of Canada; Statistics Canada.

Turning to the impact on the real economy, our analysis suggests the economy will shrink marginally in response to the carbon tax. The initial hit to GDP is $3 billion in 2018. The negative effect on growth moves the economy away from its potential and this results in a mild depreciation of the Canadian dollar. (See Table 4.) The exchange rate acts as an automatic stabilizer and its depreciation cushions the blow to the export sector. There is little monetary response in this scenario, as it is assumed that the Bank of Canada does not lift interest rates in response to the higher domestic prices attributable to the carbon tax. While taxing carbon lifts inflation, the impact is temporary; when setting interest rates, the Bank focuses on demand-driven price increases, as opposed to temporary boosts from factors such as tax changes. In fact, the impact on interest rates is slightly negative, as the dip in real GDP moves the economy away from its potential and this leads to excess supply in the economy, which softens demand-driven price growth.

Table 4
Scenario A: Key Economic Indicators
(change versus baseline)

	2018	2019	2020	2021	2022	2023	2024	2025
GDP at market prices (2007 $ billions)	–3.0	–2.7	–3.3	–2.5	–2.0	–1.7	–1.4	–1.8
GDP at market prices ($ billions)	3.9	7.6	10.4	14.3	18.8	23.2	27.1	30.5
GDP deflator (percentage change)	0.3	0.5	0.6	0.7	0.8	1.0	1.1	1.2

(continued …)

Table 4 (cont'd)

Scenario A: Key Economic Indicators

(change versus baseline)

	2018	2019	2020	2021	2022	2023	2024	2025
Consumer price index (percentage change)	0.2	0.5	0.6	0.8	1.0	1.2	1.3	1.4
Average weekly wage (percentage change)	0.0	–0.2	–0.3	–0.4	–0.5	–0.6	–0.7	–0.8
Employment (000s)	–28.3	–26.1	–31.3	–22.7	–17.7	–12.2	–9.0	–11.1
Unemployment rate (per cent)	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.1
Household primary income ($ billions)	–2.0	–3.4	–5.1	–6.0	–7.0	–8.3	–9.7	–11.7
Gross operating surplus ($ billions)	0.1	–1.2	–2.8	–4.6	–5.9	–7.2	–8.9	–9.5
Exchange rate (US¢)	0.0	–1.0	–1.0	–2.0	–2.0	–2.0	–2.0	–3.0
90-day T-bill rate (basis points)	–2.0	–4.0	–5.0	–6.0	–6.0	–7.0	–7.0	–7.0
Current account balance ($ billions)	0.4	–1.1	–2.0	–3.5	–4.7	–5.7	–6.7	–7.2
Personal income taxes ($ billions)	–2.6	–5.3	–8.1	–11.1	–14.2	–17.6	–21.2	–24.6
Corporate income taxes ($ billions)	–0.7	–1.8	–2.9	–4.3	–5.5	–6.8	–8.2	–9.3
Taxes on products ($ billions)	5.9	12.1	18.0	24.4	30.8	37.4	44.1	49.7
Federal government balance* ($ billions)	–0.6	–0.9	–1.5	–1.8	–2.2	–2.5	–2.8	–3.2
Collective provincial government balance* ($ billions)	–0.4	–0.8	–1.5	–2.2	–3.2	–4.3	–5.7	–7.3
Federal government debt ($ billions)	0.4	1.1	2.4	4.2	6.3	8.7	11.4	14.5
Provincial government debt ($ billions)	0.2	0.8	2.0	4.0	6.8	10.6	15.8	22.5

*Government balances are measured as cash balances.
Source: The Conference Board of Canada.

Taxes on products rise sharply due to the carbon tax, while personal and corporate income tax payments fall due to the assumed revenue recycling measures. The decline in wages and profits in this simulation further reduces provincial tax revenues, negatively impacting the provincial government balance, which is down by $7.3 billion in 2025.[6] By the end of the forecast, provincial debt is up by $22.5 billion, reflecting higher investment and the deterioration in its balance. Similar results are also observed federally, with federal debt up $14.5 billion at the end of the forecast due to a larger accumulated deficit.

While the total negative impact of the carbon tax on real GDP is mitigated over time, the headline number masks important distributional differences across the expenditure categories. As shown in Chart 8, lower household

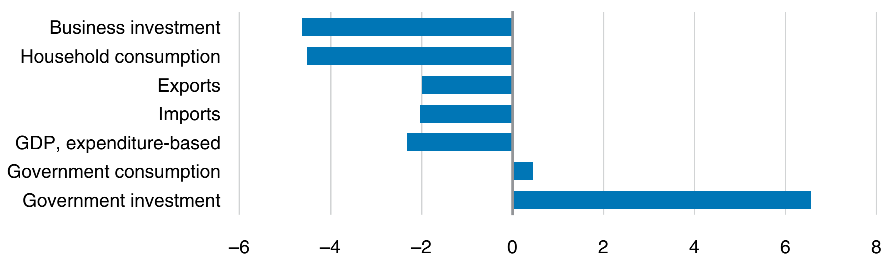
6 Government balances in this analysis refer to the cash balance, referred to as "gross net lending" in the System of National Accounts.

income results in a reduction in real household consumption.[7] Business investment and trade volumes are also lower throughout the forecast period. The only aggregate spending categories to post gains are government consumption and investment. In summary, the private sector shrinks while the public sector expands following the introduction of the carbon tax.

Chart 8

Scenario A: Economic Impact by Expenditure Category

(average change versus baseline from 2018 to 2025, 2007 $ billions)



Sources: The Conference Board of Canada; Statistics Canada.

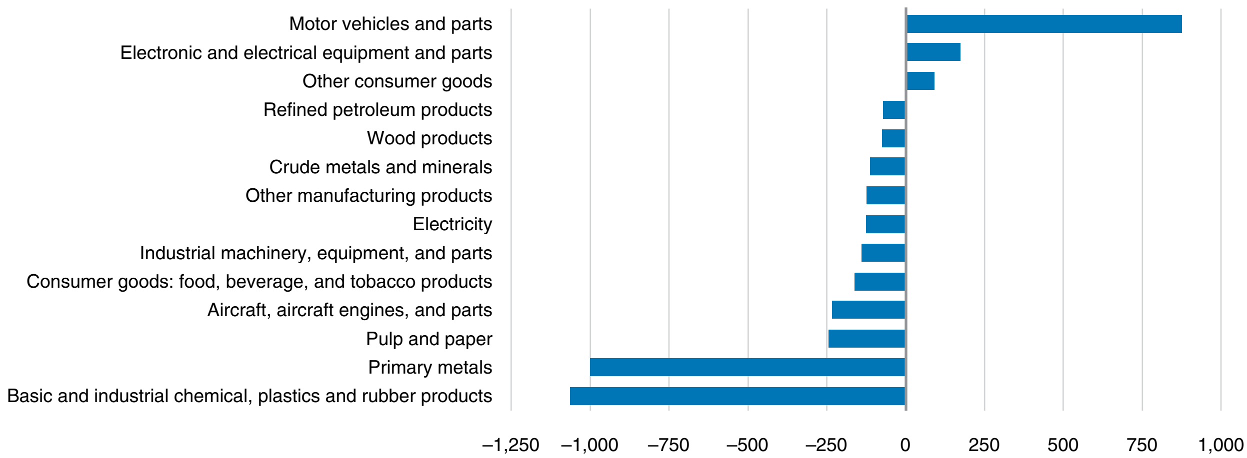
The exchange rate plays an important role in the economy by acting as an automatic stabilizer. The decline in demand for export products that results from higher prices linked to the carbon tax are partially mitigated by the depreciation of the Canadian dollar, which somewhat improves the competitiveness of Canadian exports. (See Chart 9.) In this scenario, merchandise exports are $3.2 billion lower in 2025 than in the baseline scenario. The impact on imports is reversed—the lower Canadian dollar makes imports more expensive, leading to higher import prices (and thus higher domestic prices), thereby dampening the demand for imported products.

7 Full modelling results are shown in Appendix B.

Chart 9

Scenario A: Economic Impact by Export Category

(average change versus baseline from 2018 to 2025, 2007 $ millions)



Sources: The Conference Board of Canada; Statistics Canada.

Scenario B

In Scenario B, the carbon tax starts at $10 per tonne (as in Scenario A) but then ratchets up by $20 per year to reach $150 in 2025. In this scenario, carbon tax revenues increase from $5.8 billion in 2018 to $90.2 billion in 2025. (See Table 5.)

Table 5

Scenario B: Carbon Tax Revenues and Emissions

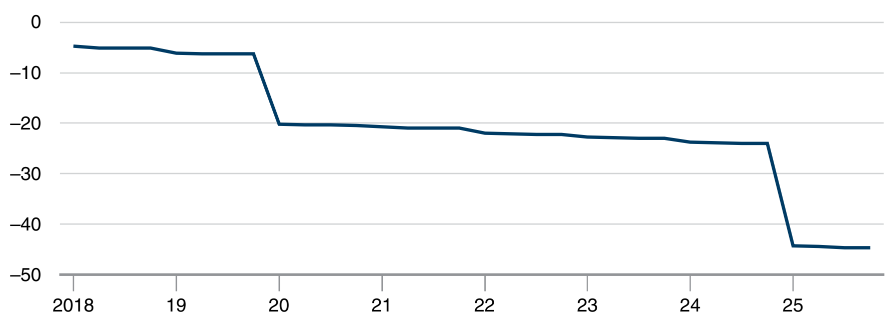
(change versus baseline)

	2018	2019	2020	2021	2022	2023	2024	2025
Carbon tax ($/tonne CO_2eq)	10	30	50	70	90	110	130	150
Total emissions (kilotonnes, CO_2eq)	–5.0	–6.2	–20.3	–20.9	–22.1	–22.9	–23.9	–44.5
Industry emissions	–3.1	–3.5	–16.5	–16.8	–17.3	–17.7	–18.1	–38.2
Household emissions	–1.9	–2.7	–3.8	–4.1	–4.8	–5.2	–5.8	–6.3
Carbon tax revenue ($ billions)	5.8	17.7	29.3	41.5	53.8	66.4	79.2	90.2

Source: The Conference Board of Canada.

In Scenario B, emissions fall by 44.5 Mt, compared with the baseline scenario. (See Chart 10.) All scenarios have the same assumption for emissions reductions in the electricity sector. As a result, reductions from the electrical power generation industry account for 34.8 Mt of the decline in 2025. Emissions drop significantly in 2025 as more fossil fuel-powered electricity plants are retired and the decline in emissions leads to slower growth in carbon revenues. Compared with Scenario A, there is a larger reduction in household emissions, with consumers reducing their emissions by 6.3 Mt in response to higher prices, accounting for nearly two-thirds of the emissions reductions outside of the power generation sector.

Chart 10
CO_2eq GHG Emissions Reductions
(Scenario B compared with baseline, Mt)



Sources: The Conference Board of Canada; Statistics Canada.

In this scenario, real GDP is $3.2 billion lower in 2018 and falls further below the baseline in 2020 as the retirement of some electricity generation plants slows growth in carbon revenues, which, in turn, results in a deceleration in the growth of funds available for revenue recycling. (See Table 6.) The impact on GDP shrinks between 2020 and 2024 before increasing again in 2025 when additional high-emitting generation stations are retired.

Wages are down by 1.6 per cent, the consumer price index (CPI) is up by 2.4 per cent, and the Canadian dollar falls by four cents U.S. in this scenario by 2025. Private sector incomes decline as the government takes a larger share of income gains in taxes. The corporate gross operating surplus declines by $18.7 billion and household primary income is $23.8 billion lower.

Table 6

Scenario B: Key Economic Indicators

(change versus baseline)

	2018	2019	2020	2021	2022	2023	2024	2025
GDP at market prices (2007 $ billions)	–3.2	–3.0	–4.0	–3.2	–2.8	–2.6	–2.3	–3.0
GDP at market prices ($ billions)	4.1	10.9	16.4	23.6	31.7	39.9	47.5	53.8
GDP deflator (percentage change)	0.4	0.6	0.9	1.1	1.4	1.6	1.9	2.1
Consumer price index (percentage change)	0.2	0.7	1.0	1.4	1.7	2.0	2.2	2.4
Average weekly wage (percentage change)	0.0	–0.3	–0.5	–0.7	–1.0	–1.2	–1.4	–1.6
Employment (000s)	–29.6	–28.8	–38.6	–28.5	–23.6	–16.2	–11.8	–16.2
Unemployment rate (per cent)	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.1
Household primary income ($ billions)	–1.9	–4.8	–8.2	–10.6	–13.4	–16.3	–19.6	–23.8
Gross operating surplus ($ billions)	0.2	–2.5	–5.7	–9.2	–11.7	–14.3	–17.4	–18.7
Exchange rate (US¢)	–0.4	–1.1	–1.8	–2.4	–2.9	–3.5	–4.0	–4.4
90-day T-bill rate (basis points)	–1.7	–4.0	–5.1	–6.9	–8.1	–9.9	–12.4	–14.1
Current account balance ($ billions)	0.4	–1.6	–2.9	–5.3	–7.5	–9.5	–11.6	–12.9
Personal income taxes ($ billions)	–2.6	–7.9	–13.4	–19.2	–25.4	–32.0	–39.0	–45.7
Corporate income taxes ($ billions)	–0.7	–2.6	–4.8	–7.2	–9.6	–12.0	–14.7	–17.0
Taxes on products ($ billions)	5.9	18.1	29.9	42.4	55.1	68.1	81.3	92.5
Federal government balance* ($ billions)	–0.6	–1.3	–2.4	–3.2	–4.0	–4.6	–5.4	–6.2
Collective provincial government balance* ($ billions)	–0.4	–1.1	–2.3	–3.6	–5.3	–7.3	–9.8	–12.8
Federal government debt ($ billions)	0.3	1.4	3.4	6.4	10.1	14.6	19.8	25.8
Provincial government debt ($ billions)	0.2	1.0	2.8	5.9	10.6	17.1	26.0	37.6

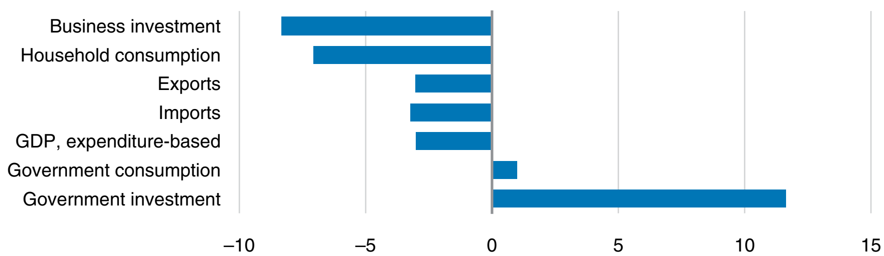
*Government balances are measured as cash balances.
Source: The Conference Board of Canada.

The change in the composition of expenditures in the economy follows the same pattern as in the first scenario, although the magnitude of the shift is different in Scenario B. (See Chart 11.) By 2025, household consumer expenditures are $9.9 billion lower and business investment falls by $14.6 billion. Real government spending on goods and services increases by $2 billion and public sector investment expands by $20.8 billion.

Chart 11

Scenario B: Economic Impact by Expenditure Category

(average change versus baseline from 2018 to 2025, 2007 $ billions)



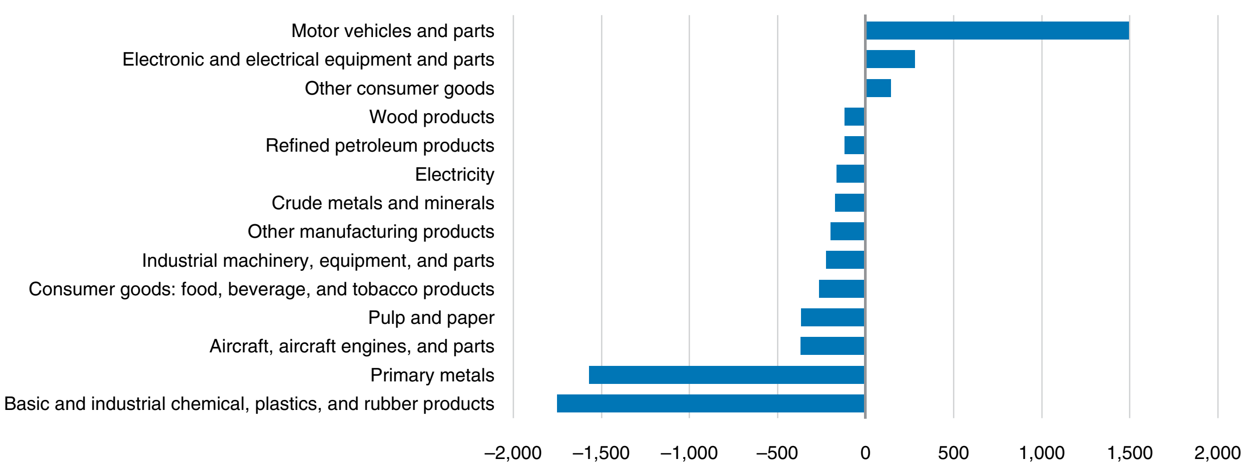
Sources: The Conference Board of Canada; Statistics Canada.

Looking at the impact on different export sectors, once again the pattern is similar to what we see in Scenario A but with a greater magnitude, given that the shock examined in this scenario is larger. Steady increases in producer prices hurt many of the country's export sectors, with those producing primary metals, chemicals, pulp and paper, and aircraft and aircraft parts hit particularly hard. (See Chart 12.) These declines are

Chart 12

Scenario B: Economic Impact by Export Category

(average change versus baseline from 2018 to 2025, 2007 $ millions)



Sources: The Conference Board of Canada; Statistics Canada.

partly offset by growth in industries that benefit from the falling exchange rate, such as motor vehicles and parts and electronic and electrical component manufacturing.

Scenario C

Scenario C begins with the same annual $20 per tonne increase in the carbon tax in Scenario B until 2022, after which the tax increases more aggressively to achieve larger emissions reductions. In this scenario, provincial governments collect $5.8 billion in carbon revenues in 2018 but that number then jumps to $120 billion in 2025 when the carbon tax hits $200 per tonne. (See Table 7.)

Table 7

Scenario C: Carbon Tax Revenues and Emissions

(change versus baseline)

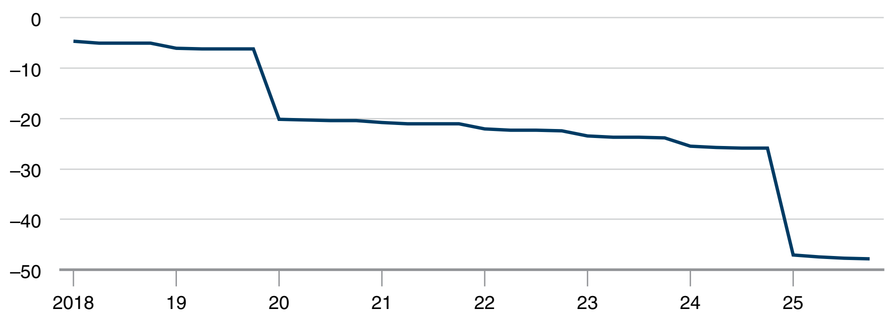
	2018	2019	2020	2021	2022	2023	2024	2025
Carbon tax ($/tonne CO_2eq)	10	30	50	70	90	120	160	200
Total emissions (megatonnes, CO_2eq)	–5.0	–6.2	–20.3	–21.0	–22.3	–23.7	–25.7	–47.5
Industry emissions	–3.1	–3.5	–16.5	–16.8	–17.4	–18.0	–18.9	–39.5
Household emissions	–1.9	–2.7	–3.8	–4.2	–4.9	–5.6	–6.9	–8.0
Carbon tax revenue ($ billions)	5.8	17.7	29.3	41.5	53.8	72.4	97.3	119.8

Source: The Conference Board of Canada.

Greenhouse gas emissions fall by 47.5 Mt in this scenario. (See Chart 13.) As in the other scenarios, 34.8 Mt of this decline is due to retirements of fossil fuel-burning electricity generation stations. As expected, household emissions and industry emissions outside of the power generation sector fall by a larger amount given the higher price on carbon that incentivizes consumption away from high-emitting products. Household emissions are down by 8 Mt in 2025, while industry emissions (other than power generating) fall by 4.7 Mt.

With the same assumption for carbon pricing and electricity price growth between 2018 and 2020, the impact on real GDP in Scenario C is identical to that in Scenario B during the first three years. However, higher carbon prices (which also lead to higher electricity prices) in the later years of this forecast result in real GDP declining to $4.2 billion

Chart 13
CO_2eq GHG Emissions Reductions
(Scenario C compared with baseline, Mt)



Sources: The Conference Board of Canada; Statistics Canada.

below the baseline in 2025—the largest hit to GDP among the three scenarios. (See Table 8.) In 2025, this scenario also has the largest increase in the CPI (up 3.1 per cent) and the greatest decline in wages (down 2.2 per cent) and the loonie (down five cents U.S.). The more pronounced downturn in household and business income results in federal government debt rising $28.4 billion above the baseline. Provincial governments see their debt levels increase by $39.4 billion as they ramp up infrastructure spending in response to substantial carbon tax revenues.

Table 8
Scenario C: Key Economic Indicators
(change versus baseline)

	2018	2019	2020	2021	2022	2023	2024	2025
GDP at market prices (2007 $ billions)	–3.2	–3.0	–4.0	–3.4	–3.1	–2.9	–2.7	–4.2
GDP at market prices ($ billions)	4.1	10.9	16.4	23.7	32.0	43.8	58.5	71.1
GDP deflator (percentage change)	0.4	0.6	0.9	1.1	1.4	1.8	2.3	2.7
Consumer price index (percentage change)	0.2	0.7	1.0	1.4	1.7	2.1	2.7	3.1
Average weekly wage (percentage change)	0.0	–0.3	–0.5	–0.7	–1.0	–1.3	–1.7	–2.2
Employment (000s)	–29.6	–28.8	–38.6	–29.7	–26.2	–18.9	–14.5	–23.3
Unemployment rate (per cent)	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.1
Household primary income ($ billions)	–1.9	–4.8	–8.2	–10.7	–13.5	–17.7	–23.7	–31.4
Gross operating surplus ($ billions)	0.2	–2.5	–5.7	–9.0	–11.4	–15.2	–21.0	–24.8
Exchange rate (US¢)	–0.4	–1.1	–1.8	–2.4	–2.9	–3.7	–4.6	–5.3

(continued …)

Table 8 (cont'd)

Scenario C: Key Economic Indicators

(change versus baseline)

	2018	2019	2020	2021	2022	2023	2024	2025
90-day T-bill rate (basis points)	–1.7	–4.0	–5.1	–7.0	–8.4	–10.3	–12.4	–14.7
Current account balance ($ billions)	0.4	–1.6	–2.9	–5.3	–7.5	–10.0	–13.2	–15.7
Personal income taxes ($ billions)	–2.6	–7.9	–13.4	–19.2	–25.4	–34.6	–47.0	–59.1
Corporate income taxes ($ billions)	–0.7	–2.6	–4.8	–7.2	–9.5	–12.8	–17.3	–21.4
Taxes on products ($ billions)	5.9	18.1	29.9	42.4	55.1	74.2	99.8	122.8
Federal government balance* ($ billions)	–0.6	–1.3	–2.4	–3.2	–4.0	–5.0	–6.4	–8.1
Collective provincial government balance* ($ billions)	–0.4	–1.1	–2.3	–3.6	–5.3	–7.5	–10.6	–14.3
Federal government debt ($ billions)	0.3	1.4	3.4	6.4	10.1	14.8	20.8	28.4
Provincial government debt ($ billions)	0.2	1.0	2.8	5.9	10.6	17.2	26.5	39.4

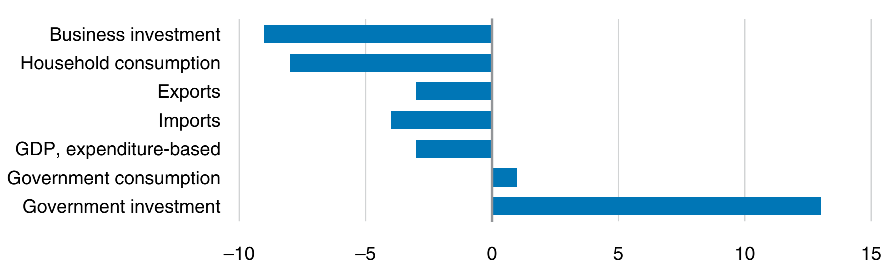
*Government balances are measured as cash balances.
Source: The Conference Board of Canada.

Given the larger decline in household and business income in this scenario, it is not surprising that consumption and investment also record the most significant declines in Scenario C. (See Chart 14.) Real household consumption is down by $13 billion in 2025, while business investment falls by $19.5 billion. Despite the higher cost of domestic production, imports fall in response to the depreciation in the dollar and weaker domestic demand, making the impact on net trade positive over the first few years of this simulation. However, in the final three years—when the carbon tax increases more aggressively and causes larger increases in industry product prices—exports are hurt, resulting in the trade sector subtracting from growth.

Chart 14

Scenario C: Economic Impact by Expenditure Category

(average change versus baseline from 2018 to 2025, 2007 $ billions)



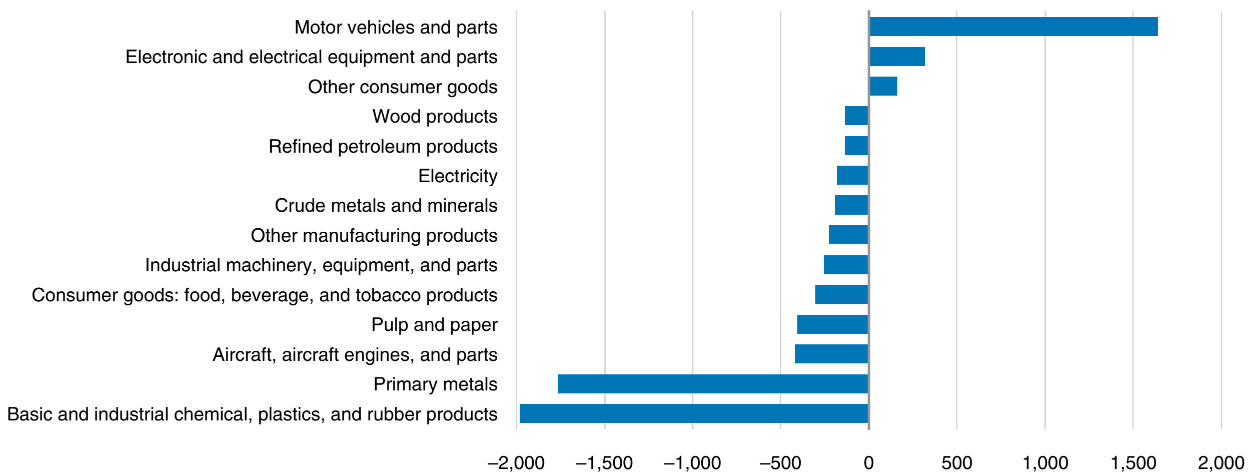
Sources: The Conference Board of Canada; Statistics Canada.

The more rapid increase in carbon prices hurts the export sector. In 2025, the export sector is $7.7 billion smaller even though some industries post gains driven by the currency depreciation. (See Chart 15.) The largest declines are in chemical and plastics manufacturing, down $4.1 billion, and in primary metals, which falls by $3.5 billion relative to the baseline.

Chart 15

Scenario C: Economic Impact by Export Category

(average change versus baseline from 2018 to 2025, 2007 $ millions)



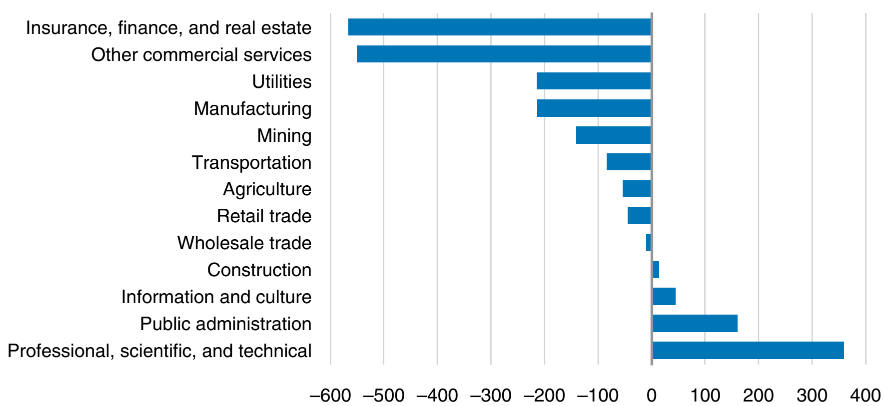
Sources: The Conference Board of Canada; Statistics Canada.

Impact by Industry

The carbon tax leaves some industries worse off, as the increased domestic cost of production is not fully offset by the depreciating loonie. However, other industries, where the production cost increases are not as large, benefit from the decline in the loonie and end up better off after the carbon price is introduced. Running Scenario A again, but this time holding the exchange rate fixed (i.e., we do not allow it to depreciate in response to weaker demand conditions) results in merchandise exports declining by $9.8 billion in 2025, compared with the baseline. The $6.6-billion difference between the impact on exports when the dollar depreciates versus when it remains static illustrates just how important exchange rate adjustments are in mitigating the economic impact from carbon pricing.

While the flexible exchange rate helps trade-sensitive sectors, industries with a domestic focus that are sensitive to price changes are not as fortunate. One of the expenditure categories that suffered the largest hit in our three scenarios was residential investment, and, when looking at the impact on industries, the insurance, finance, and real estate sector experiences the largest decline in output. (See Chart 16.) Consumers and businesses cut their real spending as their purchasing power is eroded and, therefore, it is no surprise that "other commercial services" (which includes services such accommodation and food services, administrative support, and arts, entertainment, and recreation) also falls significantly.

Chart 16
Scenario A: Economic Impact by Industry
(average change versus baseline from 2018 to 2025, 2007 $ millions)



Sources: The Conference Board of Canada; Statistics Canada.

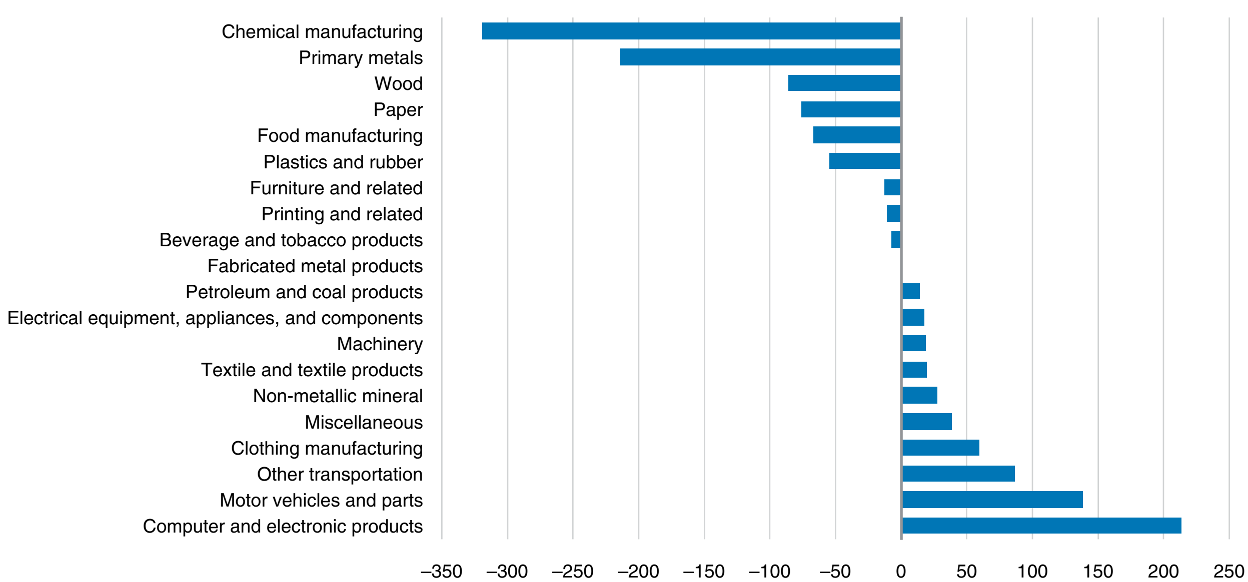
Responding to higher energy costs, output in the utilities industry falls as demand for electricity and natural gas declines. Transportation output declines as the volume of goods produced in the economy shrinks. Wholesale and retail trade experiences modest declines due to the drop in consumer outlays. On the other hand, construction output experiences a marginal gain as the increase in public sector investment outweighs the decline in private sector investment. Public administration output is up (based on the assumption that part of the carbon tax revenue will be used to fund a boost in government spending on goods and services). The largest output gain accrues to the professional, scientific, and technical industry, where demand is boosted by the large increase in government investment in intellectual property products.

Higher production costs are not good for the manufacturing sector, which experiences one of the largest declines in output. However, the decline in the exchange rate does leave some segments of the manufacturing sector better off. (See Chart 17.) Mirroring the results in the export sector, the largest declines in the manufacturing sector occur in the chemical and primary metal manufacturing sector. Large declines also occur in the wood product, paper, and food manufacturing industries—all of which experienced increases in their cost of production after the carbon tax was introduced.

Chart 17

Scenario A: Economic Impact on Manufacturing Industries

(average change versus baseline from 2018 to 2025, millions 2007 $)



Sources: The Conference Board of Canada; Statistics Canada.

The magnitude of the relative decline in real GDP increases as the carbon tax ramps up.

The lowest increases in producer prices caused by the carbon tax were in the machinery and the motor vehicles and parts industries, and both experience output gains as the benefit of the depreciating dollar more than offsets the competitive loss they experience from carbon pricing. The computer and electronic product manufacturing industry posts the largest gain, reflecting the low increases in its production costs and its high sensitivity to the decline in the dollar.

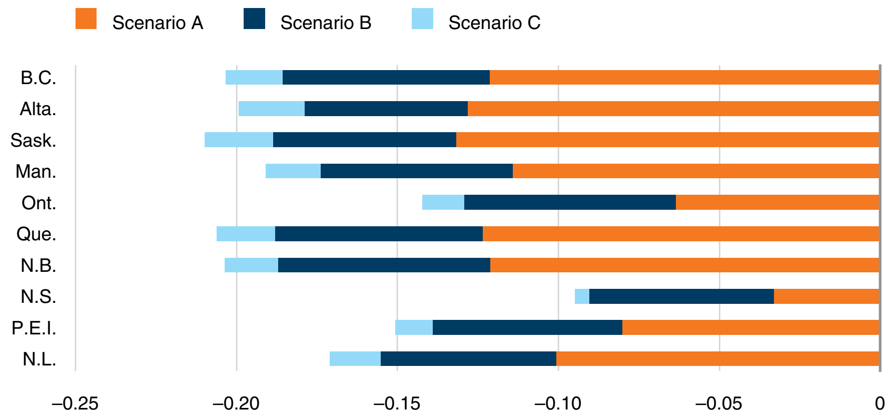
In each scenario, carbon taxes increase every year through to the simulation horizon. As such, the magnitude of the shock to the economy intensifies over the forecast period and the economy must continuously adjust to the rising carbon price. Since it takes time for the economy to adjust after experiencing any type of shock, these results do not show the impact after the adjustment is complete. However, we would expect the dollar to continue to depreciate modestly until the economy is once again operating at capacity.

Impacts by Province

As noted in the methodology section, the provincial impacts are assessed using the national results shared out to the provincial economies based on their respective weights in industry output. This approach provides a rough assessment of the impact, but one of the major limitations in these estimates is that electricity price increases are assumed to be constant across provinces. This means that impacts will be overstated for provinces where electricity price changes are expected to be below average (such as Quebec and Manitoba) and understated in regions with above-average electricity price increases (such as Alberta and Saskatchewan).

The provincial declines are driven in large part by population (since consumer spending and residential investment account for a large part of the expenditure decline) and by the composition of each province's manufacturing and export sector (given that the impacts vary significantly across different industrial sectors). As expected, the magnitude of the relative decline in real GDP increases in scenarios B and C as the carbon tax ramps up. (See Chart 18.)

Chart 18
GDP Impact by Province Across Scenarios
(average change from 2018 to 2025 versus baseline as a share of total GDP, per cent)



Sources: The Conference Board of Canada; Statistics Canada.

Alberta's manufacturing sector is hit hard by the decline in chemical manufacturing, while Quebec's manufacturing industry experiences notable declines in primary metal, chemical, wood, and pulp and paper manufacturing. Ontario also sees negative impacts in these areas, but the declines are partially offset by stronger growth in motor vehicles and parts and computer and electronic component manufacturing. Still, Ontario experiences a decline in real GDP due to the decline in consumer and business purchasing power. In British Columbia, the wood products, chemical, and primary metal manufacturing industries suffer the largest declines.

Results Summary

In all scenarios, the impact on real GDP remains negative in 2025 (see Table 9), as steady increases in the carbon tax mean that the economy is still adjusting to the price shock at the end of the simulation period. Consumers are negatively impacted by the introduction of the carbon tax, not just through reduced purchasing power, but also through lower wages as businesses respond to higher input costs in the supply chain by reducing their wage bills. Even after cutting wages, business gross operating surplus is lower than in the baseline. In response to weaker incomes, households and businesses need to reduce their purchases, and this leaves real private sector spending lower compared with the baseline. It is important to note that while the overall economic impact is small, the distribution is not equal across sectors, with some industries bearing notable costs.

Table 9
Comparing Impacts Across Scenarios
(impacts in 2025, change versus baseline)

	Scenario A	Scenario B	Scenario C
Carbon tax (\$/tonne CO_2e)	80	150	200
Carbon tax revenue (\$ billions)	48	90	120
Total emissions (megatonnes, CO_2e)	–41	–45	–47
GDP at market prices (2007 \$ billions)	–2	–3	–4
Consumer price index (percentage change)	1.42	2.43	3.06
Average weekly wage (percentage change)	–0.79	–1.62	–2.16
Exchange rate (US¢)	–3.0	–4.4	–5.3
Private domestic sector* (2007 \$ billions)	–14	–26	–34
Public sector (2007 \$ billions)	12	23	30
Federal government debt (\$ billions)	15	26	28
Provincial government debt (\$ billions)	23	38	39

*non-government consumption and investment
Source: The Conference Board of Canada.

Lower private sector spending is partially offset by higher government spending. Revenue recycling measures play an important part in offsetting the negative economic impact resulting from pricing carbon. However, provincial investments in infrastructure (funded with carbon revenues) drive up provincial government debt by $22 billion in Scenario A and by $39 billion in Scenario C. The increases in federal debt do not, however, reflect higher investment levels. Instead, in all the scenarios, the federal deficit rises due to the decline in personal and corporate income tax revenues. This implies that the federal debt grows because of a deterioration in the federal government balance over the forecast period.

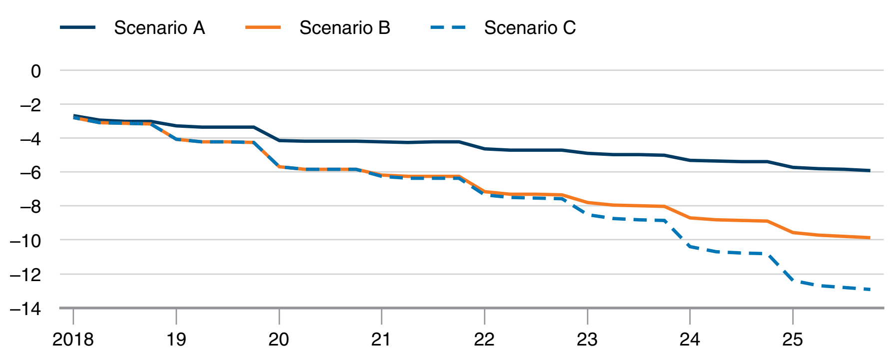
The exchange rate acts as an automatic stabilizer in the economy and the different declines in the value of the Canadian dollar among the three scenarios reflect the degree of adjustment necessary to help bring the economy back to its potential. In Scenario A, the loonie drops by 2.6 cents U.S.; in Scenario B, by 4.4 cents; and in Scenario C, by 5.3 cents.

Emissions decline under all the scenarios, but these reductions are not all in response to the introduction of a carbon tax. Most of the drop in emissions is attributable to the shift away from fossil fuel combustion to generate electricity. This accounts for a decline of 34.8 Mt in 2025. The economic changes in response to pricing carbon (excluding the decline in the electricity sector) have only a small impact on emissions, with reductions in 2025 of 5.8 Mt in Scenario A, 9.7 Mt in Scenario B, and 12.7 Mt in Scenario C. Increasing the carbon tax from $80 to $200 per tonne therefore results in only a small additional reduction in emissions. (See Chart 19.)

Chart 19

CO_2eq GHG Emissions Reductions, Excluding Power Generation

(compared with baseline, Mt)



Sources: The Conference Board of Canada; Statistics Canada.

In total, the decline in emissions is 40.6 Mt in Scenario A, 44.5 Mt in Scenario B, and 47.5 Mt in Scenario C in 2025. In the Pan-Canadian Framework, the government sets a reduction target of 219 Mt from 2016 levels by 2030. This analysis, however, goes only until 2025, and additional economic adjustments will occur between then and 2030 that will further reduce demand for high carbon products. Coal generation is not completely phased out in 2025. Therefore, there will be further

These results do not consider the mitigating factors that are part of Canada's strategy to reduce emissions.

emissions reductions in the electricity generation sector in the second half of that decade. Furthermore, our analysis assumed no change in industry emission intensity relative to the baseline forecast, while the government plans to invest heavily in new technologies that are likely to reduce emission intensities. Nevertheless, our analysis shows that carbon pricing and decarbonization of our electricity system will be grossly insufficient to meet the government's 2030 target on their own.

There are also several factors not considered in this research that could change the results presented here. An upside risk comes from the fact that these results do not consider the mitigating factors that are part of Canada's strategy to reduce emissions. For example, the wood products industry is identified in this analysis as vulnerable after the introduction of a carbon tax. However, part of the Pan-Canadian Framework includes a commitment from governments to encourage the use of more wood products in construction through initiatives such as revised building codes.[8] This type of initiative could reduce the negative impact on the wood products industry. Another component of the strategy in the Pan-Canadian Framework is to invest in the development of new technological solutions to reduce emissions. If these new technologies can be commercialized, it is possible that new sectors will emerge focused on products and services that promote clean energy and emissions reductions. These new sectors, not considered in this analysis, could help mitigate the negative effects of carbon pricing on the economy.

On the downside, this analysis reveals a large accumulation in federal and provincial government debt but no response to higher debt levels by governments in Canada. With both levels of government facing challenging fiscal prospects over the medium and long terms, significant debt accumulation and the accompanying increase in debt-servicing costs will further strain government finances. Governments would likely respond by increasing tax revenues or reducing spending to try to get their budget deficits under control. This, in turn, would have a further negative impact on the economy.

8 Government of Canada, *The Pan-Canadian Framework*, 22.

Furthermore, it looks increasingly likely that Canada's largest trading partner—the U.S.—will not adopt carbon pricing at any point before 2021, and there is a risk that our model underestimates the economic impact of higher electricity prices and the carbon tax providing an incentive for companies to move their Canadian operations to the United States. This is a particular concern for industries such as petrochemical plants, chemical producers, and cement plants that have access to feedstock across the border and are harder hit by carbon pricing. This potential not only creates downside economic risk, but also means that domestic policies that are designed to reduce emissions could simply result in those emissions occurring in another jurisdiction. So, while emission intensities would be lower in Canada, the policy would actually increase global emissions.

CHAPTER 3

Assessing the Impact of Restructuring Canada's Infrastructure

Chapter Summary

- In this chapter, we calculate the economic value of lost production from fossil fuel-burning facilities that will be shut down.
- Virtually all facilities that combust fossil fuels to produce electricity are closed in this scenario. The impacts, therefore, reflect the impact of moving away from heavy fuel oils, coal, and natural gas for generating electricity.
- There is a large variance across the provinces in their use of fossil fuels for electricity generation, and the impacts from retiring these stations vary significantly between provinces.
- The largest GDP declines occur in Alberta, Ontario, and Saskatchewan.
- Overall, the total impact on GDP across the country is $7.2 billion, comparable to the output of a relatively small Canadian industry.

While carbon pricing will play an important role in Canada's pathway to lower emissions, using carbon pricing alone would require a prohibitively high carbon price to meet our emissions targets. Instead, a multi-faceted approach, which includes targeted investments in infrastructure and new technologies, can deliver results at a lower cost. The Organisation for Economic Co-operation and Development estimates that this approach could reduce the economic costs of climate change mitigation by up to 50 per cent.[1]

Canada's existing policy actions on emissions reflect this approach. In addition to carbon pricing, the federal government has made a commitment to eliminate coal-fired electricity generation in Canada by 2030. Alberta has also put plans in place to phase out coal-fired generation by 2030, is working with generators to determine the best replacement technologies, and has announced plans to support additional renewable energy generation capacity. Alberta and Ontario have made reinvesting carbon tax revenues in green technologies a key part of their climate action policies. Other provinces are likely to follow.

Moving toward a low-carbon future will entail economic costs, and in the rest of this report, we seek to quantify some of these costs. Our analysis is based on the pathways developed in the TEFP to achieve deep greenhouse gas emissions reductions. These pathways outline the behavioural and technological changes that would enable Canada to meet specific emissions targets. Our analysis of the economic impacts associated with the TEFP pathways are divided into two separate chapters. In this chapter, we focus on the economic impacts of retiring obsolete capital in the power generation sector that would result from retiring coal and natural gas stations before their end of life. In Chapter 4, we focus on the economic impacts of new investments.

1 Organisation for Economic Co-operation and Development, *Taxation, Innovation, and the Environment, 2010*, 23.

The carbon-pricing scenarios include the impact on electricity prices of closing hydrocarbon-fuelled power plants. However, it was implicitly assumed that any retired hydrocarbon facilities would be replaced by new generation capacity to maintain electricity supply. Therefore, only the impact of higher electricity prices on the economy was measured in those scenarios, with no consideration paid to the lost capacity or job losses associated with the power plant closures. Prematurely retiring obsolete capital will have a negative impact on GDP and jobs as productive assets are removed from the economy. In this chapter, we carefully assess the assets that would be retired prematurely and isolate the negative impacts on the economy of those lost assets.

Economic Impact of Obsolete Capital: Background and Methodology

The TEFP outlines numerous pathways for achieving deep emissions reductions, but they all share one element in common—they require the elimination of most fossil fuel-fired electricity generation by 2030. Every province has at least one fossil fuel-burning power plant in the electricity grid, and these must be mothballed as part of the emissions reductions foreseen in the TEFP.

Across the country, thermal power plants burning coal, natural gas, diesel, or heavy fuel oil account for approximately 25 per cent of Canada's total installed electricity generating capacity.[2] Based on the TEFP estimates, a total of 22 gigawatts of fossil fuel-generating capacity must be retired over the next 15 years.

Manitoba has only one small coal-fired generating station and provincial legislation states that it can be used only in emergencies.[3] The province also has a small natural gas-fired generating station, which is used primarily to backstop baseload sources in times of high demand.[4] Thus, Manitoba's adjustment would be small. Similarly, Prince Edward Island imports most of its electricity and has only a few small fossil

2 Statistics Canada, *Installed Generating Capacity, by Class of Electricity Producer*.

3 Government of Manitoba, *The Climate Change and Emissions Reduction Act*.

4 Manitoba Hydro, *Role of the Selkirk Generating Station*.

Manitoba, Prince Edward Island, Quebec, and Newfoundland and Labrador are on track to meet TEFP requirements without additional initiatives.

fuel generators. Quebec has effectively idled its only fossil fuel-fired natural gas generating station. Newfoundland and Labrador rely on a major fuel oil-fired generating station, but this is aging and is scheduled to be closed when the province's Muskrat Falls hydroelectric facility comes online in the next few years. So, these four provinces—Manitoba, Prince Edward Island, Quebec, and Newfoundland and Labrador—are on track to meet TEFP requirements without any additional initiatives.

On the opposite end of the spectrum, despite some installed capacity in wind and hydroelectric power generation, Nova Scotia, Alberta, and Saskatchewan rely predominantly on coal and natural gas to generate electricity. In order to eliminate fossil fuel combustion from its utility grid, Alberta will have to retire capacity equal to 78 per cent of its electricity power generation GDP. For Nova Scotia, that figure is 85 per cent; for Saskatchewan, 70 per cent. These provinces will have to make extensive changes over the coming years to eliminate fossil fuels from their generation mix.

In between these two extremes are the rest of the provinces. British Columbia generates nearly all its electricity from hydropower and has a policy that new generation must be renewable (except for liquefied natural gas plants), but it does have one operating natural gas generating station and several small natural gas-fired cogeneration plants. The province must retire capacity equivalent to 10 per cent of electricity power generation GDP to meet TEFP emissions targets. Ontario closed all its coal-fired generating stations between 2010 and 2014, replacing generating capacity with more expensive alternative sources. This has contributed to higher electricity prices for consumers and businesses in that province. Retiring most of the province's remaining natural gas and diesel-fired generation will remove about 16 per cent from electricity power generation GDP. New Brunswick has a diversified energy system, with hydro, wind, and nuclear power all accounting for significant shares of electricity generation. However, most of the installed capacity is still in fossil fuels, and some of the largest facilities burn coal and heavy fuel oil. To meet TEFP targets, New Brunswick would have to retire facilities that currently account for about 43 per cent of its GDP in electric power generation.

Much of the generation capacity that needs to be retired is base load capacity, and this has important implications for the size of the GDP impact resulting from these retirements and the investment requirements to replace them. (See “Basic Requirements for the Electricity Grid.”)

Basic Requirements for the Electricity Grid

The retirement of fossil fuel-fired facilities and the subsequent replacement with non-emitting alternatives must be done in a manner that does not compromise the operation and reliability of the electrical systems. Reliable operation of an electrical grid requires that the supply of power generated on the system equals the demand. This balance is maintained continually and requires that the aggregate output of generation sources on the grid be adjusted in response to the changing demands of users on the system. Adjustments to power generation are made in real time to maintain this balance, and larger adjustments can be made by starting up or shutting down units on a scheduled basis. This requirement to maintain a balance between generation and load is always a key operational consideration that is managed by the system operator. The addition of wind, solar, and other variable sources of energy generation increases the complexity of balancing generation to market in real time.

Electricity grid operators must match energy generated and energy demanded to ensure reliable operation at the lowest cost to system customers, and different generation sources assume different roles on the grid. A typical electrical grid will have three types of power sources: base load, load following, and peak load. As the name suggests, base load sources meet the grid’s minimum demands. These generating stations generally take a long time—several hours or days—to start up or shut down, and in normal operating situations they run continuously and provide a consistent output of power. Load-following sources, on the other hand, help meet electricity demand when it exceeds the base load. Load-following generating stations are similar in design to base load stations, but they vary their output throughout the course of the day, producing at maximum capacity during times of high power demand and running at low output or shutting down during times of low demand. Peak sources are generally operated only during the periods of highest demand. A peaking power plant will be idle for most of the day and will be started up only when the grid’s requirements exceed the capacity of the base-load and load-following sources.

The system operator's role depends in part on whether there is an open market for power. Where competitive markets exist, the system operator uses a bidding process to meet market demands at the lowest cost. A typical grid also includes a role for generators that stand ready to provide power at very short notice to meet unexpected demand or to maintain key operating characteristics.

Different fossil fuels play different roles in the electric power system. For example, coal-fired power plants are generally slow to start up and shut down and can't be used as a peaking source. On the other hand, natural gas-turbine generating stations can be started up quickly but have lower efficiency and so are more often used as load-following or peaking sources.

For our purposes, retiring a megawatt of base load capacity is not the same as retiring a megawatt of peaking capacity. A megawatt of installed base load capacity is responsible for many more megawatt hours of generated power than a peaking source simply because it is running more often. That means that the practical and, therefore, economic impact of losing a megawatt of base-load capacity will be larger than that of losing a megawatt of peaking capacity. We account for this in the economic impact analysis in this section.

The TEFP calculated the electrical generating capacity that would need to be retired in each province for coal, natural gas, diesel, and fuel oil. We combined the megawatts retired with the capacity factor to estimate the actual generated electricity in megawatt hours (MWh) that is being lost. Finally, we calculated the value-added GDP per megawatt hour of electricity produced in each province. The product of the GDP per MWh and the total MWh lost gives us an estimate of the decline in real GDP resulting from the retirement of the various power plants. We then used Statistics Canada's interprovincial input-output model to calculate the indirect effects of the loss of these power plants.

Results

Retiring fossil fuel plants will have a significant direct impact on real GDP in some provinces. The loss in generation capacity in Nova Scotia is equal to 85 per cent of its electric power sector output. (See Table 10.)

Large losses in utilities output also occur in Alberta, Saskatchewan, and New Brunswick while the other provinces will experience smaller losses.

Table 10

Impact on Electricity Production Associated With Retired Fossil Fuel Facilities

	B.C.	Alta.	Sask.	Man.	Ont.	Que.	N.B.	N.S.	P.E.I.	N.L.
Lost production (millions $ 2007)	231	1,901	688	–	1,351	21	386	422	1	4
Share of electric power industry GDP (per cent)	9.5	78.0	69.7	0.0	16.5	0.2	42.7	84.7	0.7	0.8

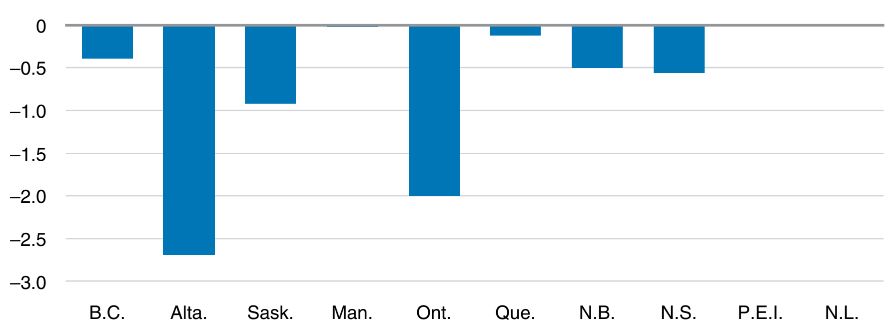
Sources: The Conference Board of Canada of Canada; Statistics Canada; Trottier Energy Futures Project.

Across the provinces, the total annual reduction in GDP in 2031 once all the power plants have been retired is $5.0 billion. This represents the direct impact. The indirect effect to workers and suppliers adds up to an additional loss of $2.2 billion per year, bringing the total impact to $7.2 billion per year (in 2007 dollars). That is roughly equivalent to what the paper manufacturing industry contributed to GDP in Canada last year. Overall, for every dollar of GDP lost in electricity generation, the economy loses $1.45 in economic activity. As expected, the provinces hit the hardest by plant closures suffer the worst of the economic impact. (See Chart 20.) Alberta loses $2.7 billion in GDP, with Ontario close behind at $2.0 billion. Saskatchewan's GDP is reduced by $900 million.

Chart 20

Total GDP Impact

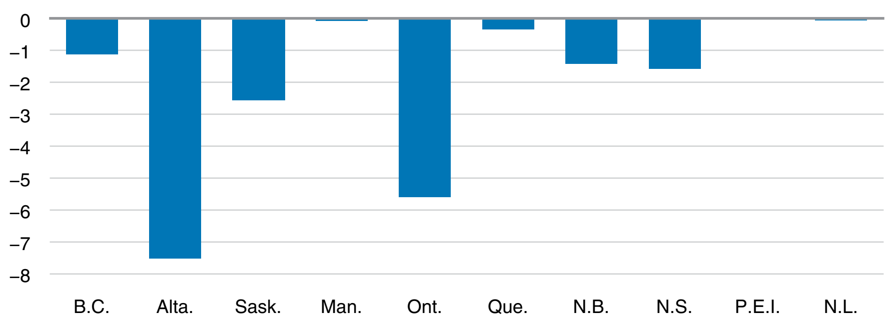
(direct and indirect impacts, 2007 $ billions)



Sources: The Conference Board of Canada of Canada; Statistics Canada; Trottier Energy Futures Project.

The number of direct job losses associated with the closures is 13,000, and an additional 7,000 jobs are eliminated among suppliers. (See Chart 21.) Once again, the provinces with the largest reduction in capacity are the hardest hit, with Alberta losing 7,500 jobs and Ontario losing 5,500.

Chart 21
Total Jobs Impact
(jobs, direct and indirect impacts, 000s)



Sources: The Conference Board of Canada of Canada; Statistics Canada.

Feasibility of Full Decarbonization

The analysis in this section is based on the premise that every province will phase out all their coal-, natural gas-, fuel oil-, and diesel-fired generating capacity by the end of 2030. But that is not in line with current policy. So far, the major progress toward this goal has come in the form of announcements by the federal and Alberta governments that coal-fired generation will be phased out by 2030. But this phase-out plan is not entirely watertight. Some provinces, such as Nova Scotia, will receive waivers to continue generating coal-fired power if they agree to transition the rest of their grids directly to clean energy without stopping at natural gas power along the way. And, although some provinces already have relatively clean grids, it is not government policy anywhere in the country to phase out natural gas-, oil-, or diesel-fired power plants by 2030. In fact, Alberta is seeking to replace some of its current coal generation capacity with natural gas-fired generation, suggesting that

The elimination of coal power and the increase in renewables is only partly responsible for Ontario's price increases.

full decarbonization is unlikely before 2030. Furthermore, Ontario's recent experience with significant electricity price increases may make some politicians and consumers leery about fully shifting their generation mix to non-emitting sources. (See "Are Ontario Electricity Price Increases a Warning to Other Provinces?")

In light of this, it is reasonable to ask whether the assumptions embedded in this scenario are realistic. From our point of view, we use the assumption of a complete fossil fuel phase-out by 2030 because it is part of the lowest-cost solution to meeting our emissions targets in that year.

Are Ontario Electricity Price Increases a Warning to Other Provinces?

Discussions about eliminating fossil fuel power generation in Canada almost always involve Ontario's recent experience in phasing out coal power. Between 2003 and 2014, coal power went from producing 25 per cent of the province's power to zero per cent. Over the same period, electricity prices for residential and small-business consumers rose by 70 per cent. On the face of it, this looks like a stark warning for any province that is thinking about following in Ontario's footsteps. What government would want to increase voters' electricity rates by 70 per cent? However, the elimination of coal power and the increase in renewables is only partly responsible for Ontario's price increases.

In Ontario, the price paid by consumers and small businesses for electricity in Ontario is broken up into two separate charges: the hourly Ontario energy price (HOEP), and the global adjustment. The HOEP represents the market-clearing price on the spot market for electricity in the province and can be thought of as the operating cost of generating the last kilowatt of electricity demanded at any given time. Everything else, including building and maintaining power plants and the electricity grid, is funded through the global adjustment. While the HOEP has declined since 2008 thanks to more renewables and lower fuel costs, the global adjustment has risen from 0.61 cents per kWh to an average of 9.66 cents a kWh in 2016, accounting for 85 per cent of the total electricity price last year.

The increase in the global adjustment includes the cost of phasing out coal-fired power and replacing it with new renewable and natural gas generation. It also includes the cost of fixed rate guarantees (higher than the HOEP) for each kilowatt hour of power contracted providers generate, usually for a period of 20 or 25 years. One of the largest renewable power deals saw the government paying 13.5 cents per kilowatt hour of wind power and 44.3 cents per kilowatt hour of solar power. By comparison, nuclear plants in Ontario are currently paid around 6 or 7 cents per kilowatt hour. About 45 per cent of the global adjustment in 2016 is for payments to solar, wind, and natural gas providers.

However, the increases in the global adjustment may be inflated compared with what other provinces can expect to see happen to their electricity prices. Some of the rates for wind and solar were generous even at the time the contracts were signed, and the tumbling price of renewables since suggests new contracts would be less expensive. In addition, the province planned its new capacity based on historical increases in demand. But electricity demand in Ontario has flatlined since the financial crisis. As a result, the province has ended up with far more generation capacity than it needs. Compounding the issue, many of the new electricity contracts included a clause called "guaranteed dispatch"—a promise that the power generated would be purchased. This was supposed to help entice electricity providers to build the required capacity, since it assured them that the power they generated would actually be purchased. But, combined with the excess capacity problem, guaranteed dispatch now means the government is forced to purchase excess electricity even when the province is not using it. This excess electricity is usually sold to neighbouring jurisdictions at a loss, and that loss must be absorbed by Ontario ratepayers.

There is no doubt that changes in the generation mix have contributed to Ontario's electricity price increases. But given that other provinces will be able to learn from Ontario's experience, there is no guarantee that they will also face these problems when they make their own transitions. Furthermore, some other important contributors to electricity price increases in Ontario—notably, the increased maintenance costs required for Ontario's aging transmission and distribution infrastructure and the costs associated with nuclear refurbishment—are unique to that province. Still, as other provinces transition away from coal, they will have to bear the costs associated with building new, greener electricity generation capacity, and some have much further to go in this respect than Ontario ever did. But the story of electricity prices in Ontario is more complex than just the phasing out of coal, and care must be taken when using the Ontario experience as a guide for what will happen elsewhere.

The economic impact of eliminating most fossil fuels from the power generation mix is significant but not overwhelming.

To eliminate fossil fuels from the grid, over 20 gigawatts of installed generating capacity will need to be replaced, with the majority in the Maritime provinces and Alberta. Four major hydroelectric developments are currently in development, including Site C in British Columbia (1,050 megawatts), Keeyask in Manitoba (695 megawatts), La Romaine in Quebec (1,500 megawatts), and Muskrat Falls in Newfoundland and Labrador (824 megawatts). Newfoundland and Labrador's Gull Island (2,250 megawatts) has also been released from environmental assessment, but no other large hydroelectric or pumped storage projects are currently in the environmental assessment process, leaving us well short of new capacity to replace all fossil fuel plants. Given the development timelines for large-scale developments, actions are required now to start planning activities to achieve in-service dates by 2030 if this goal is to be achieved.

Summary

Overall, the economic impact of eliminating most fossil fuels from the power generation mix is significant—but not overwhelming. The total impact on GDP, at $7.2 billion, is comparable to the output of a relatively small Canadian industry. Because electric power generation is capital-intensive, job losses are held to about 20,000. But these job losses come exclusively for the plant closures and would be offset at least somewhat by jobs created at the new generating stations that will be built to replace the retired facilities. Moreover, the economy frequently adds more than 20,000 new jobs in a good month. The impacts discussed here highlight those provinces that face the largest adjustments. The variances in required regional adjustments are necessary to understand, since generation capacity lost in one province will not necessarily be replaced within that province.

In the next section, we continue to explore the economic impacts related to the TEFP pathways and turn our focus to the investments that will be necessary to replace the fossil fuel plants, as well as the other necessary investments to achieve the GHG emissions reductions outlined in the TEFP.

CHAPTER 4

Investment Requirements for Pathways to Deep Emissions Reductions

Chapter Summary

- The carbon-pricing scenarios as covered in Chapter 2 and the decarbonization of the electricity system are insufficient on their own to achieve Canada's Paris Accord commitments.
- Achieving the deep GHG emissions reduction targets requires a significant rethinking of how Canadians produce and use energy.
- In the "30 per cent below 1990 levels" emissions-reduction scenario, $2 trillion in new investment is required between now and 2050.
- Achieving a 60 per cent reduction in emissions could cost an additional $1.4 trillion, although changes in policies and behaviours could lower that cost.
- Given capacity constraints, these investments will require that a large portion of current investment levels be redirected toward projects aimed at reducing emissions.

Pricing carbon and transitioning away from fossil fuels for electricity generation are important steps toward reducing GHG emissions in Canada. However, the measures described in the preceding chapters are insufficient on their own to result in deep GHG emissions. Indeed, in the foreword to *The Pan-Canadian Framework*, the government says that achieving a low-carbon future will require transforming how we produce and use energy:

> This means using clean energy to power our homes, workplaces, vehicles, and industries, and using energy more efficiently. It means convenient transportation systems that run on cleaner fuels, that move more people by public transit and zero-emission vehicles, and that have streamlined trade corridors. It means healthier and more comfortable homes that can generate as much power as they use. It means more resilient infrastructure and ecosystems that can better withstand climatic change. It means land use and conservation measures that sequester carbon and foster adaptation to climate change.[1]

The federal government acknowledges that these types of transformative changes will require significant funding and is committed to initiating the transition by making investments in infrastructure, the Low-Carbon Economy Fund, and clean technology funding.[2]

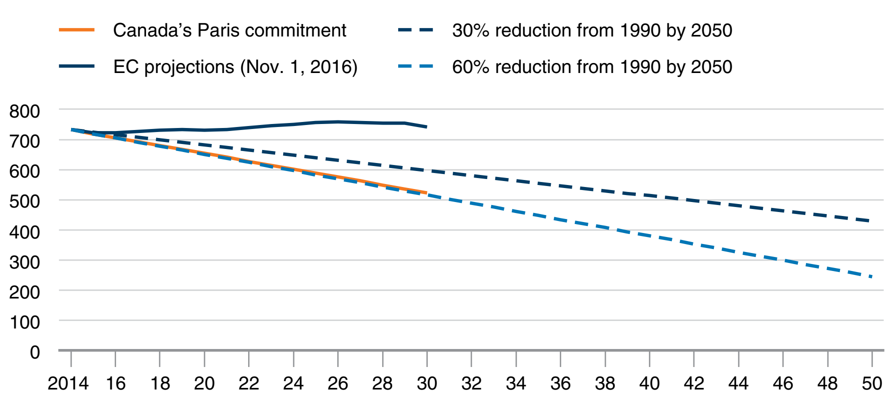
While the federal government has outlined some of the initiatives it plans to fund over the next few years, the transition to a low-carbon economy is not something that can be achieved in the near term. Revamping the way that we live and work is a multi-decade process, and it remains unclear which pathway Canada will take as it transforms itself into

1 Government of Canada, *The Pan-Canadian Framework*.
2 Ibid., 47.

a low-carbon society. There are many different pathways that Canada can take to achieve deep emissions reductions, as illustrated in the TEFP analysis. In this final chapter, we explore some of the pathways outlined in the TEFP and calculate the direct and indirect economic impacts of these investments.

The investment pathways discussed in this section include one that achieves a 30 per cent reduction in emissions from 1990 levels by 2050 and a number of pathways that achieve a 60 per cent reduction by 2050. A 60 per cent reduction would put Canada on a path that closely matches what we need to achieve the 2030 emissions-reductions targets in our commitment under the Paris Accord. Chart 22 displays these paths, including Environment Canada's projection of Canada's current emissions path, which incorporates policy actions announced up to November 1, 2016, This is essentially a status quo scenario, with emissions stabilizing because of policy initiatives in Ontario, Quebec, and Alberta (including phasing out coal and putting a 100 Mt cap on oil sand emissions), new federal efficiency standards announced in Budget 2016, and lower estimates for growth in GDP and energy production.[3]

Chart 22
Comparing Emission Paths
(CO_2 eq, MT)



Sources: The Conference Board of Canada of Canada; Statistics Canada.

3 Environment and Climate Change Canada, *Canada's 2016 Greenhouse Gas Emissions Reference Case.*

The other lines are linear interpolations of the emissions paths required to hit specific end targets—Canada's Paris Accord commitment (30 per cent below 2005 levels by 2030) and two emissions reduction targets developed by the TEFP. While emissions trends in the real world cannot be perfectly linear, this graph provides a comparison of the ambitiousness of targets that use different end dates and reference years.

Pathway to Achieving 30 Per Cent Emissions Reductions

The first scenario produced by TEFP is Pathway 1, and in this scenario, there is no policy action to reduce GHG emissions, which soar to over 1,100 Mt by 2050. While it might seem counterintuitive to begin an analysis of deep emissions reductions by modelling a pathway with large emissions increases, this scenario is essential for evaluating the move toward deep emissions reductions, as it provides a reference point for calculating how much change is necessary to realize the targeted emissions reductions.

The next pathway outlined in TEFP is Pathway 2, which was modelled as "no additional policy changes, technological changes, or restraints." Pathway 2 essentially mirrored Pathway 1, but a constraint was added that emissions must be reduced. New nuclear facilities are included, but it is assumed that new high voltage interconnection infrastructure is not built. The results in this scenario show the minimum cost solutions, under the above assumptions, that would allow Canada to reduce its emissions to 30 per cent below 1990 levels by 2050.[4] In this scenario, emissions in 2050 are reduced by 455 Mt relative to TEFP's Scenario 1.[5]

There are several changes that occur in Pathway 2:

- In the transportation sector, there is improved efficiency in internal combustion engines, electrification of passenger vehicles, and electrification of light and medium-sized freight vehicles.

4 In the TEFP report, Scenario 2 also examined the pathway for achieving a 60 per cent emissions reduction. In this report, we discuss only the requirements to achieve a 30 per cent reduction for that scenario.

5 Trottier Energy Futures Project, *Canada's Challenge and Opportunity*.

- In the energy sector, there is electrification of the supply chain, including extraction, collection, upgrading, refining, transport, and distribution.
- There is increased electrification in industry and agricultural production.
- In the commercial and residential sector, there is increased conservation and increased electrification, especially for space heating and hot water and steam production.
- The electricity supply is switched from thermal-based generation to renewables (hydro and wind) and nuclear.[6]

The changes outlined above will require significant investments in most sectors of the economy—most notably in power generation as the economy transitions away from using fossil fuels to generate electricity. (See Table 11.) In total, $1.7 trillion (all numbers in 2011 dollars) over and above the investments assumed in Pathway 1 will need to be invested in national electric power generation, with the largest investment occurring in Alberta.[7] An additional $360 billion will need to be invested in other sectors, such as biofuels, agriculture, and industrial and commercial operations. Excluding residential investment, a total of $2 trillion will need to be invested to reduce GHG emissions to 30 per cent below 1990 levels given the assumptions used in Pathway 2. The $2 trillion in investment is spread out over 2017 to 2050 and averages $60 billion per year—equivalent to 29 per cent of current Canadian non-residential business investment. The largest relative investment would need to occur in Alberta, with almost half of all current business investment being redirected toward this spending.

As noted, part of the emissions reductions in Pathway 2 comes from energy conservation and fuel switching in the residential sector. However, despite these changes, national investment in the residential sector is lower than in Pathway 1. Regional variations exist in the requirements for investment in the residential sector but, overall, total residential investment is $2.1 billion lower in this scenario. While this

6 Ibid., 166.

7 Unless otherwise stated, the numbers discussed in this section are relative to Scenario 1 to isolate the requirements to achieve emissions reductions.

was not addressed explicitly in the TEFP analysis, a potential reason for the lower residential investment is that higher prices for electricity and fuels lower household purchasing power, resulting in a reduction in real spending relative to Pathway 1.

Table 11

Investments by Province Through 2050

(difference between Pathway 2 and Pathway 1, 2011 $ millions)

	Electricity generation	Other	Total	Total annual average	Annual average as a share of current investment*
N.L.	21,221	2,337	23,558	693	6.9
P.E.I.	170	2,736	2,906	85	20.3
N.S.	11,130	295	11,425	336	10.6
N.B.	20,445	6,220	26,665	784	34.5
Que.	230,870	41,152	272,022	8,001	27.6
Ont.	252,449	180,877	433,326	12,745	20.4
Man.	27,633	290	27,923	821	9.6
Sask.	68,635	90,968	159,602	4,694	37.7
Alta.	870,452	20,573	891,025	26,207	47.5
B.C.	176,148	12,438	188,586	5,547	24.0
Canada	**1,679,151**	**357,886**	**2,037,037**	**59,913**	**29.0**

*current investment is estimated real non-residential business investment in 2016.

Source: Calculations by The Conference Board of Canada based on TEFP investment data.

In total, investment spending (residential and non-residential) will need to increase by about $2 trillion relative to the TEFP's Pathway 1. The investments required to reduce GHG emissions outlined in Pathway 2 are a significant outlay and will have a large economic impact. We have compiled the investment spending in the TEFP pathway and examined the direct and supply-chain impacts associated with those investments. (See Table 12.)

Table 12

GDP Impacts by Province

(difference between Pathway 2 and Pathway 1, 2011 $ millions)

	Direct	Direct and indirect	Total annual average	Share of 2016 GDP (per cent)
N.L.	10,844	13,602	400	1.3
P.E.I.	529.16	1000.98	29	0.6
N.S.	3,972	7,518	221	0.6
N.B.	8,853	14,892	438	1.5
Que.	115,620	186,487	5,485	1.6
Ont.	150,215	319,983	9,411	1.4
Man.	8,816	15,927	468	0.8
Sask.	44,146	66,697	1,962	2.6
Alta.	401,100	560,987	16,500	5.3
B.C.	66,665	105,323	3,098	1.4
Canada	**810,758**	**1,292,416**	**38,012**	**2.1**

Source: Calculations by The Conference Board of Canada based on TEFP investment data.

In total, these investments will have a direct impact on GDP of $811 billion. Add in the supply-chain impacts and these investments will generate GDP of $1.3 trillion, or about $62 billion per year. Annually, this is equal to 2.1 per cent of last year's GDP, and while that number might sound small, it represents almost a third of business non-residential investment spending. Looking at the results regionally, the smallest impacts occur in Prince Edward Island and Nova Scotia, while the largest occur in Alberta and Saskatchewan. However, the Canadian economy is fast approaching full productive capacity and, therefore, is unable to accommodate a large multi-decade infrastructure spending program without creating economic dislocations.

Pathways to Achieving 60 Per Cent Emissions Reductions

The TEFP study provides various pathways that involve different combinations of the technological, behavioural, and policy changes required to put Canada on a path to achieving the deeper 60 per cent reduction in emissions from 1990 levels by 2050.[8] In this section,

8 Unless otherwise noted, the discussion in this section is framed relative to Pathway 2 to demonstrate how deeper emissions reductions and changes in assumptions shape the path to meeting the emissions reduction targets.

TEFP's Pathway 5 incorporates the greatest range of investments and embedded techno-logical changes.

we discuss the unique assumptions underlying each pathway before presenting the investments and economic impacts of various pathways. The TEFP's Pathway 5 provides a good starting point for our analysis, as it incorporates the greatest range of investments and embedded technological changes. Pathway 8, which is the main focus of the TEFP report, incorporates all of the technological changes in Pathway 5 but adds the role that major behavioural and policy changes can play in meeting emissions targets. In effect, Pathway 8 suggests that behavioural change can help us meet the same emissions targets but with less investment. We also include a discussion of two alternative pathways—4 and 7—to illustrate the sensitivity of results to changes in the underlying assumptions.

Pathway 5

Pathway 5 makes two major assumptions that differentiate it from Pathway 2. First, it assumes what TEFP refers to as "national electricity self-sufficiency." The assumption of *national* electricity self-sufficiency removes the need for each province to be self-sufficient in electricity generation and results in the construction of additional interconnections between the electricity grids of provinces and territories. This means that provinces can seek out lower-cost electricity from their neighbours or build sufficient capacity in their own province, whichever is most cost-effective.

Second, this pathway makes assumptions about the availability of new technologies that were not included in Pathway 2. It adds several new technologies that are currently under development and show promise, including carbon capture and underground storage (CCUS) for coal-burning electricity generation, second-generation ethanol fuel production from lignocellulose, and second-generation biodiesel. These options are assumed to become commercially viable between 2015 and 2020. This contrasts with the other scenarios (except Pathway 8), which limit options for emissions reductions to technologies that are already technically and commercially viable. Pathway 5 can thus be considered as a relatively middle-of-the-road pathway since it makes some assumptions about technological progress while avoiding some of the stronger assumptions made in the other scenarios.

Investments in Pathway 5

Reaching a more ambitious emissions target without major behavioural changes requires major investments in new infrastructure. Compared with Pathway 2, Pathway 5 requires an additional $1.4 trillion in investment between 2017 and 2050. (See Table 13.) On an annual basis, that is equivalent to an additional $41 billion per year, or about 20 per cent of Canada's current non-residential business investment. Since Pathway 2 required investments totalling 29 per cent of non-residential investment, this would bring the total investment requirements for achieving a 60 per cent emissions reduction to about 50 per cent of current business investment levels. As in Pathway 2 (and all the other pathways), the investment is spread across various sectors: agriculture, biofuels production, the commercial sector, households, transportation, electricity generation, and the industrial sector.

Of the $1.4 trillion in additional investment required over and above the Pathway 2 investments, about half goes to higher investment in transportation—new cars, trucks, subways, and so on. The rest is split almost equally between biofuels production, the commercial sector, and new power plants.

Table 13

Investments by Province Through 2050

(difference between Pathway 5 and Pathway 2, 2011 $ millions)

	Electricity generation	Other	Total	Total annual average	Annual average as a share of current investment*
N.L.	34,994	8,381	43,375	1,276	12.6
P.E.I.	–70	993	923	27	6.4
N.S.	–3,848	10,136	6,288	185	5.8
N.B.	3,606	13,965	17,571	517	22.7
Que.	8,044	110,715	118,759	3,493	12.0
Ont.	–22,604	167,135	144,531	4,251	6.8
Man.	13,043	31,558	44,601	1,312	15.4
Sask.	2,202	27,557	29,759	875	7.0
Alta.	75,782	97,183	172,965	5,087	9.2
B.C.	77,029	723,708	800,737	23,551	102.0
Canada	**188,177**	**1,191,331**	**1,379,508**	**40,574**	**19.7**

*current investment is estimated real non-residential business investment in 2016.
Source: Calculations by The Conference Board of Canada based on TEFP investment data.

Manitoba and Alberta have higher investment levels, driven by new biofuels production and electricity generation investments.

A large portion of the investment in this scenario occurs in British Columbia. The major drivers of B.C.'s investment increases are electricity generation and transportation. The electricity generation investments are in new hydrothermal, nuclear, pumped storage, and onshore wind turbine facilities. The B.C. government's existing ban on new large-scale hydro developments remains in place in this scenario, so new hydroelectric investments are not a large contributor to B.C.'s investment total. In the transportation sector, this pathway foresees higher spending in nearly every category, but the high investment totals are driven by spending on cars and trucks. Investments in trucks alone account for about $300 billion of B.C.'s investment total. Part of the reason why investment in trucks is so high is because the TEFP requires heavy-duty trucks to transition to biofuel use and, after 2040, to hydrogen fuel cells, which are expensive.

An important caveat is that in other large provincial economies the *total* investments in light- and heavy-duty trucks are similar to B.C.'s. Total raw investment in trucks in Pathway 5 is $549 billion in B.C., $692 billion in Ontario, and $426 billion in Alberta. However, Pathway 2, which is used as a comparative reference, expects significantly higher ongoing investments in trucks in other provinces than in B.C., and, thus, the totals for B.C. are larger, compared with in Pathway 2.

Outside of B.C., Pathway 5 still represents a large ramping up in investment, compared with Pathway 2. There are significantly higher investments in biofuels production and in the commercial sector, and households are expected to spend more on replacing their home appliances. Once again, Newfoundland and Labrador has an outsized investment total due to investments in new hydroelectric capacity. Manitoba and Alberta also have higher investment levels, driven by new biofuels production and electricity generation investments. Interestingly, Ontario's investment totals are relatively low due to a $23-billion decline in electricity generation investment in the province in this pathway. That investment comes out of new nuclear generation and new pumped storage, both of which have higher investment in Pathway 2. The addition of new interconnects and the removal of self-sufficiency requirements allow Ontario to import power at lower cost from Quebec instead.

Impact of Investments on GDP

The additional $1.4 trillion in new investment spending is expected to result in direct and indirect economic impacts of $411 billion from 2017 to 2050.[9] (See Table 14.) That translates into a total annual GDP increase of just over $12 billion, or 0.7 per cent of current GDP. Due to its high investment spending, B.C. sees a larger GDP impact than the other provinces, equivalent to nearly 2 per cent of its current GDP. The other province with a relatively large GDP impact in this pathway is Newfoundland and Labrador, which has a GDP impact equal to about 2 per cent of its current GDP. Apart from B.C. and Newfoundland and Labrador, most provinces see a relatively modest GDP impact in this pathway. Alberta's and Manitoba's above-average investment levels are associated with multipliers that are close but not equal to Newfoundland and Labrador's. They both see GDP impacts equivalent to about 0.8 per cent of current GDP. In the other provinces, the impact on GDP is between 0.1 and 0.5 per cent.

Table 14

GDP Impacts by Province

(difference between Pathway 5 and Pathway 2, 2011 $ millions)

	Direct	Direct and indirect	Total annual average	Share of 2016 GDP (per cent)
N.L.	15,985	19,621	577	1.8
P.E.I.	87	183	5	0.1
N.S.	654	1,567	46	0.1
N.B.	3,225	4,779	141	0.5
Que.	30,993	51,750	1,522	0.4
Ont.	40,005	74,728	2,198	0.3
Man.	10,378	15,999	471	0.8
Sask.	4,444	7,900	232	0.3
Alta.	49,938	82,851	2,437	0.8
B.C.	103,469	151,341	4,451	1.9
Canada	**259,179**	**410,719**	**12,080**	**0.7**

Source: Calculations by The Conference Board of Canada based on TEFP investment data.

9 All dollar amounts in this chapter are in constant 2011 dollars.

Pathway 8

Among the scenarios, Pathway 8 is the most ambitious in its assumptions about technology, behaviour, and policy. It builds on the base of Pathway 5 and adds several new assumptions. It adopts the same technological assumptions from Pathway 5 but also adds biojet fuel to the list of technologies that will become commercially viable in the near future. It allows for thermal electricity generation using biomass, combined with carbon capture and storage, which is part of the Intergovernmental Panel on Climate Change's recommendation to pursue net-negative-GHG sources to help offset difficult-to-eliminate emissions sources. On the policy side, Pathway 8 removes the existing ban on new large-scale hydro projects in British Columbia, opening up 30 gigawatts (GW) of new B.C. hydropower capacity in the lowest-cost solution. And it assumes that we can radically rethink the way our cities are designed, making them more walkable and greatly reducing our reliance on automobiles in our daily lives. The TEFP specifically highlights the following changes:

- urban densification;
- fully integrated urban communities;
- reductions in personal travel by personal transport within urban regions;
- greatly increased use of public transportation;
- development of fully integrated local energy systems, including distributed energy, district energy, waste to energy, rooftop solar systems, and battery and thermal energy storage;
- increased physical activity and improved public health;
- enhanced environmental space;
- reductions in the production of waste materials.

In the TEFP report, Pathway 8 was included in part to help measure what type of changes would be necessary to hit the emissions target under the most favourable conditions. In our case, we include Pathway 8 in the analysis as a "what if" scenario. Rather than focusing on meeting emissions targets through investments, Pathway 8 asks this key question: What would be required if, instead, we could make significant changes to our behaviour, technology, and public policy? The results, therefore, offer hope that reducing our impact on the climate may not require investments as large as those discussed in the other sections of this report.

Investments in Pathway 8

Despite meeting a substantially more ambitious emissions target, Pathway 8 foresees *lower* overall investment than Pathway 2. The more generous assumptions result in lower investment totals in almost every province. (See Table 15.) Almost all the "savings" come from the residential and transportation sectors. In this pathway, households spend $64 billion less on upgrading major appliances and almost $600 billion less is spent on transportation. The relative decline in transportation investment comes almost entirely from lower spending on light- and heavy-duty trucks and vehicles.

Table 15

Investments by Province Through 2050

(difference between Pathway 8 and Pathway 2, 2011 $ millions)

	Electricity generation	Other	Total	Total annual average	Annual average as a share of current investment*
N.L.	35,099	–7,934	27,165	799	7.9
P.E.I.	–629	–5,702	–6,332	–186	–44.1
N.S.	–14,331	–11,076	–25,407	–747	–23.6
N.B.	–4,069	–7,626	–11,694	–344	–15.1
Que.	–7,799	–134,187	–141,987	–4,176	–14.4
Ont.	–75,489	–308,193	–383,682	–11,285	–18.1
Man.	9,831	–4,204	5,627	166	1.9
Sask.	–15,255	–25,851	–41,106	–1,209	–9.7
Alta.	–5,793	–60,518	–66,311	–1,950	–3.5
B.C.	136,437	–18,837	117,600	3,459	15.0
Canada	**58,002**	**–584,129**	**–526,127**	**–15,474**	**–7.5**

*current investment is estimated real non-residential business investment in 2016.
Source: Calculations by The Conference Board of Canada based on TEFP investment data.

Nationally, total investments are $526 billion lower than in Pathway 2. The overall investment totals do hide some important differences, though, and there are still areas in which investments are higher in Pathway 8 than in Pathway 2. Most significant are an additional $73-billion investment in biofuels production and $58 billion in electricity generation. The electricity generation investments are shared unevenly across the country, as Newfoundland and Labrador, Manitoba, and British Columbia invest more in hydropower. In B.C., the lifting of the ban on new large-scale hydro projects results in $136 billion of additional investment in electricity generation compared with Pathway 2.

Impact of Investments on GDP

Interestingly, despite forgoing a significant amount of investment in this pathway (compared with Pathway 2), the impact on GDP is relatively small. Nationwide, the GDP impact is $34 billion lower than in Pathway 2. This is an average annual difference of $1 billion—or just 0.1 per cent of current GDP. (See Table 16.) As expected, Newfoundland and Labrador, Manitoba, and B.C.'s positive investment totals in this pathway mean they are the only provinces with a positive GDP impact. As a share of current GDP, the impact is just 0.2 per cent in Manitoba, while B.C. has a larger impact of 0.8 per cent of current GDP and Newfoundland and Labrador has an impact equal to 1.6 per cent of its current GDP. Elsewhere, the negative GDP impacts are not large, ranging from approximately zero per cent of GDP in Alberta to 0.6 per cent in Nova Scotia.

The fact that the GDP hit is so small relative to the lost investment in this pathway provides an interesting insight. It suggests that the investments being given up in this pathway were contributing relatively little to GDP in Canada, as most of the forgone investment would have been spent on imported goods and services.

Table 16

GDP Impacts by Province

(difference between Pathway 8 and Pathway 2, 2011 $ millions)

	Direct	Direct and indirect	Total annual average	Share of 2016 GDP (per cent)
N.L.	14,695	16,788	494	1.6
P.E.I.	–515	–590	–17	–0.3
N.S.	–5,474	–6,863	–202	–0.6
N.B.	–1,805	–2,085	–61	–0.2
Que.	–15,960	–19,384	–570	–0.2
Ont.	–46,815	–75,096	–2,209	–0.3
Man.	3,105	4,096	120	0.2
Sask.	–6,711	–7,852	–231	–0.3
Alta.	–5,333	–3,304	–97	0.0
B.C.	42,668	59,990	1,764	0.8
Canada	**–22,144**	**–34,299**	**–1,009**	**–0.1**

Source: Calculations by The Conference Board of Canada based on TEFP investment data.

Alternative Pathways

The pathways examined above clearly showed that the assumptions regarding technological and behavioural changes can have a sizable impact on the scale of change required to achieve emissions reductions. Pathways 5 and 8 are just two of the scenarios developed by the TEFP, with its other pathways examining implications of behavioural changes.

Pathway 4, for example, focuses on the changes in urban form outlined in Pathway 8, while ignoring the other technological changes in Pathway 8. As such, Pathway 4 isolates the impact of making major changes to the way our cities work. In particular, Pathway 4 results in the following changes:

- Overall residential energy demand declines by 14 per cent.
- Passenger cars and ligh-duty vehicles see a 47 per cent reduction in passenger-kilometres.
- Subways see an eightfold increase in passenger-kilometres.
- Bus travel sees a tripling in passenger-kilometres.
- Intercity rail transport sees a fourteenfold increase in passenger-kilometres.
- Domestic air travel sees a 54 per cent reduction in passenger-kilometres.

Pathway 7, on the other hand, is similar to Pathway 5 but does not include the construction of new nuclear reactors. Nuclear energy plays a substantial role in the lowest-cost solution in the other pathways, and Pathway 7 examines the additional costs associated with meeting the growth in electricity demand if nuclear is not a considered option. We briefly explore how the changes in assumptions in pathways 4 and 7 impact the level of investment required to achieve the target of a 60 per cent reduction in emissions. Spending in these pathways is framed relative to the investment requirements in Pathway 5 to isolate the impact that the change in assumptions has on investment requirements while still maintaining the same emissions reduction target.

Investments in Pathways 4 and 7

Compared with Pathway 5, Pathway 4 allows for a savings of $1.3 trillion (all numbers in 2011 dollars) by 2050. That is equivalent to an annual average of approximately $37 billion, which equals 18 per cent of current investment. (See Table 17.) Improvements in urban design allow city dwellers to greatly reduce their daily reliance on automobiles. Consequently, investment in automobiles falls. In many cases, the decline in auto demand is enough to offset the increase in investment in other sectors.

Table 17

Investments in Blue Sky Pathways Through 2050

(difference from Pathway 5, 2011 $ millions)

	Electricity generation	Other	Total	Total annual average	Annual average as a share of current investment*
Pathway 4	71,570	–1,326,197	–1,254,627	–36,901	–17.9
Pathway 7	79,141	–274,750	–195,609	–5,753	–2.8

*current investment is estimated real non-residential business investment in 2016.
Source: Calculations by The Conference Board of Canada based on TEFP investment data.

Pathway 4 demonstrates that there are large savings to be made by changing the way we interact with our cities. Moreover, making cities more livable while reducing transportation and energy demand could actually improve the way that cities work for humans. It could, There are large savings to be made by changing the way we interact with our cities.

for instance, allow people to spend less time commuting, giving them more free time. However, the changes foreseen in this pathway are not minor. Rather, they would represent a wholesale change in the way Canadians live and work in their urban areas. Given the savings that can be achieved, it is worth having a discussion about changes to our cities. We must keep in mind, though, that making these types of changes will require a great deal of effort and disruption in the lives of all Canadians living in cities.

Compared with Pathway 5, Pathway 7 allows for a savings of $196 billion by 2050. That is equivalent to an annual average of approximately $5.8 billion, equivalent to just under 3 per cent of current investment. This is a surprising result. In the minimum-cost scenarios, nuclear generation is heavily used in Alberta, British Columbia, Saskatchewan, and Ontario, so restricting further use of this lowest-cost generation capacity should lead to higher investment costs as these provinces look for other, more expensive, solutions to generate power. The TEFP calculations found that, when excluding nuclear power from the mix, the lowest-cost option in most cases is wind generation combined with pumped storage. And because replacing nuclear power with wind involves eliminating a reliable baseload source with an intermittent one, the total installed capacity increases from 560 to 800 GW. Investments in electricity generation are higher in Pathway 7 than in any of the other pathways, but the difference is relatively small—$79 billion more over the forecast than in Pathway 5.

There are some differences in the provincial impacts of Pathway 4. Most of the eastern half of the country experiences a decline in investment, whereas investments rise in Manitoba, Alberta, and Saskatchewan. In these three provinces, the improvements in urban form are not enough to offset the other investments required to lower emissions in the commercial and electrical generation sectors.

In Pathway 7, most of the investments are relatively consistent across the country. However, the restriction on additional nuclear capacity does have noticeably different effects in other provinces. Provinces where nuclear power isn’t part of the lowest-cost generation mix are

Meeting an emissions target of 60 per cent below 1990 levels by 2050 will require major investments.

relatively unaffected by the restriction on nuclear power. The effect of the restriction is therefore concentrated in the handful of provinces in which nuclear power is a key part of the electricity grid in Pathway 5. This includes British Columbia, Alberta, Saskatchewan, and Ontario. Alberta relies heavily on nuclear power to meet its electricity generation needs in the other pathways, but it lacks the natural features conducive to affordably replace that capacity in this pathway with, for example, large-scale hydro development. Total electricity generation capacity in the province rises in Pathway 7 due to a large amount of new wind-turbine-and-pumped-storage capacity. But the restriction on nuclear power causes a significant amount of investment in electricity generation to leave Alberta for other jurisdictions where power can be produced at a lower cost and then transmitted back to Alberta. For British Columbia, Saskatchewan, and Ontario, the restriction on nuclear power has the effect of increasing investment as nuclear power is replaced with new wind turbines and pumped storage.

Investment Summary

Having looked at the specific details of each pathway, we can make some broad observations. Pathway 2 resulted in the smallest emissions reductions but was relatively expensive, as it did not consider technological or behavioural changes. Pathway 5 made some reasonable technological and policy assumptions and then asked what additional investments would be required to meet a more ambitious emissions target. Pathway 8 built on Pathway 5 with more ambitious policy, behavioural, and technology assumptions. Pathways 4 and 7 were included as a sensitivity analysis and to examine the effects of assumptions on urban form and nuclear power.

Based on the analysis above, meeting an emissions target of 60 per cent below 1990 levels by 2050 will require major investments. For instance, in Pathway 5, about $3.4 trillion in new investments are required between now and 2050 relative to the business-as-usual reference case. (See Table 18.)

Table 18

Investment Requirements Relative to "Business as Usual" Pathway

(difference from Pathway 1, 2011 $ millions)

	Electricity generation	Other	Total	Total annual average	Annual average as a share of current investment**
Pathway 2*—no major technological changes	1,679,151	357,886	2,037,037	59,913	29.0
Pathway 4—changes in urban form	1,938,899	223,019	2,161,918	63,586	30.8
Pathway 5—some technological changes	1,867,329	1,549,217	3,416,545	100,487	48.7
Pathway 7—no new nuclear	1,946,470	1,274,467	3,220,937	94,733	45.9
Pathway 8—technological, behavioural, and policy changes	1,737,153	–226,243	1,510,910	44,439	21.5

*this pathway achieves only a 30 per cent reduction in emissions, while the other four achieve 60 per cent reductions.
**current investment is estimated real non-residential business investment in 2016.
Source: Calculations by The Conference Board of Canada based on TEFP investment data.

However, if we broaden the scope beyond just looking at the required investments and assess how behavioural and policy changes can impact the results, it is evident that deep emissions reductions are possible at a much smaller cost. Pathway 4 assumes that the design of our cities changes to rely less on vehicles and, in this pathway, investment requirements fall substantially to $2.2 trillion. Pathway 8 takes the analysis a step further and makes optimistic assumptions about policy changes and disruptive new technologies. As a result, total investments required are $1.5 trillion. That is *lower* than the Pathway 2 investments, which only achieved a 30 per cent reduction in emissions. Pathway 7 produced the surprising finding that banning nuclear power results in a relatively small impact on the total investment spending required, relative to Pathway 5.

The results of this analysis showed that the economic impact of investments can differ substantially, depending on the sectors receiving the funding. Pathways that depend heavily on new residential and transportation investment, as pathways 5 and 7 do, have lower economic impacts because new investments in cars, trucks, buses, and air conditioners have high import content, resulting in a portion of the economic impacts accruing outside the country. On the other hand, the pathways in which investment is biased toward large-scale, fixed projects (such as biofuels production and electricity generation) tend to have

While it is technically feasible to transition Canada to a low-carbon society, what that will mean to the lives of Canadians is not well understood.

bigger economic impacts as a proportion of the investment. As a result, Pathway 8 results in a GDP impact roughly in line with Pathway 2, despite much lower spending on new investment.

When looking at the economic benefits by province, several trends emerge. Newfoundland and Labrador sees significant new investments in hydropower, with the result that the province sees the biggest economic impact as a proportion of GDP in almost every pathway. The lone exception is Pathway 5, where Newfoundland and Labrador falls just behind British Columbia. The GDP impacts in the rest of the country are generally about half as large as those in Newfoundland and Labrador and British Columbia. Alberta has some uneven results, with strong GDP gains in some pathways but weak results in the pathways in which investments occur in lower-cost provinces. The smallest GDP impacts are in Nova Scotia, where the gains attributable to additional investment spending are the smallest in the country.

Reality Check: Are the Investment Pathways Economically and Politically Feasible?

With the signing of the Pan-Canadian Framework, the federal and most provincial governments agreed to steer Canada down a path to a low-carbon future. The work done in the TEFP has shown us that it is technically feasible to transition Canada to a low-carbon society. However, what a low-carbon future will mean to the everyday lives of Canadians is not well understood. Canadians know that a nationwide price on carbon will begin in 2018 and that by 2030, most coal-fired electricity generation will be eliminated. But in Chapter 2 of this report, we demonstrated that pricing carbon and decarbonizing our electricity system will not be nearly enough to achieve the emissions reduction targets agreed to in Paris. That means that the investments underpinning the TEFP scenarios will result in the largest portion of our GHG emissions reductions.

In this chapter, we examined the investments that would be required to achieve those deep emissions reductions. We noted that the requirements are in the trillions of dollars, and we focused on the economic impacts of that spending but did not address just how transformative the changes underpinning those investment decisions would be for our economy and society. In this final section, we deviate from the quantitative assessments that have dominated the report thus far and look at the economic and political challenges associated with moving toward a low-carbon future.

The Economic Realities of Making Deep Reductions in GHG Emissions

At first blush, a large-scale infrastructure program may seem like an easy win-win solution. Investment spending boosts economic growth, improves our long-term potential, and, in this case, reduces emissions. But pouring trillions of dollars into emissions-reducing investments is not the long-term answer to slowing economic growth or our dismal productivity performance. The economic reality is that Canada is fast approaching its economic capacity, meaning that capital and labour are fully employed and there is no large pool of labour or capital funds waiting idly to be directed toward these required investments. The simple fact is that Canada is unable to leverage the funds, capital, and labour resources required to generate these investments without drawing funds and productive capacity away from other economic activity.

If we assume, for instance, that the investments, research, and policy initiatives encompassed in the pathways do not impact productivity (or productive capacity, since a large portion is spent to replace energy that generates emissions with energy that is emissions-free), then much of the investment would be diverted from other areas of the economy. In other words, a large portion of the money currently invested in the Canadian economy on everything from productivity-enhancing machinery and upgraded sewer systems to basic transportation infrastructure would need to be redirected toward emissions-reducing projects. And if these new investments do not themselves generate new capacity, Canada's economy will be smaller than in the business-as-usual scenario.

To get a sense of how the economy would react to a sudden increase in investment spending, the Conference Board ran some long-term simulations through our national forecasting model. Boosting investment by tens of billions of dollars a year leads to a number of predictable

Achieving deep GHG reduction targets requires the progressive decarbonization of the residential, commercial, and agricultural sectors by 2050.

economic consequences. The spending drives us well above our potential output, leading to interest rate increases from the Bank of Canada and a sharp appreciation of the Canadian dollar. In Pathway 2, the average annual employment gain from the investment is 286,600—equal to almost a quarter of the number of current construction workers. The soaring demand for labour leads to a spike in wages and prices, just as we witnessed in Alberta in the middle of the 2000s when large investments were occurring in the non-conventional oil industry. The appreciation of the loonie sends export volumes plummeting, and businesses pull back on their investment spending as their international competitiveness position weakens. Given that demand exceeds our domestic capacity, imports jump. Eventually, the price increases weaken purchasing power, leading to a pullback in household and business spending.

The magnitude of the economic response varies across the scenarios (i.e., 30 or 60 per cent emissions reductions) given that investment requirements are different, but the narrative remains the same—the Canadian economy is able to absorb this increase in demand but the investment crowds out other areas of spending in the economy. Households are hit the hardest in these scenarios due to rising prices, and it is unlikely that Canadians in general understand the impact that these investments will have on their day-to-day lives.

Policy Implications of Pathways

All the pathways share common themes and implications for policy-makers. The role of electricity in the Canadian economy is dramatically increased and fossil fuel use decreases substantially no matter which of the pathways Canada takes to a lower-carbon economy. Each of the TEFP pathways requires that the use of fossil fuel be progressively reduced and replaced by renewable electricity and biomass. Achieving deep GHG reduction targets requires the progressive decarbonization of the residential, commercial, and agricultural sectors by 2050, with some fossil fuel combustion remaining in transportation, industry, and fossil fuel supply and delivery. Specifically, there would be about a threefold increase in the use of electricity, a fourfold increase in biomass, and a two-thirds reduction in fossil fuel use within a period of 33 years.

The transition to a low-carbon future will require a complete transformation of how we use and produce energy.

What these changes mean for Canadian households and businesses is not well understood, and that presents a major potential hurdle when drafting policies that will lead to a low-carbon future. Factors critical to successfully achieving this goal include:

- **End-user acceptance:** It is impossible to overstate how important this element is to achieving a low-carbon future. The transition will require a complete transformation of how we use and produce energy. If Canadians do not understand and embrace this change, the policy is doomed to fail. The progressive substitution of fossil fuel (particularly natural gas, which is efficient and relatively inexpensive) with electricity will require significant investments by end-users in both systems and energy supply. For example, households will need to agree to stop using fossil fuels for home heating and many will need to switch to zero-emitting vehicles. It is imperative that policy-makers clearly communicate what is needed from households and businesses to achieve large emissions reductions and that society is ready to make those commitments. History has taught us that long-term change cannot be successfully imposed by governments; rather, it must be desired by the citizens.
- **Acceptance of large-scale projects:** Substantial investment in large-scale hydro, nuclear, wind, and transmission projects will be required in all parts of the country. Large-scale projects typically attract their share of controversy, and acceptance of these projects among environmentalists, Indigenous groups, and the public is necessary.
- **An efficient environmental assessment process for large projects:** The environmental assessment process for nuclear and large-scale hydro projects is intensive, requiring substantial planning, environmental studies, and a cumulative effects analysis. The development life cycle for a large project can easily extend over a decade, including planning, environmental assessment, and construction.
- **Regulatory acceptance of the need for investment and cost-recovery:** A multitude of capital-intensive and long-lived investments are required throughout the country, and developers will require assurances that their investments can be recovered.

Research Summary

The Pan-Canadian Framework on Clean Growth and Climate Change was signed by the federal government and most provinces in December 2016 and is designed to meet or exceed the goal of lowering Canada's GHG emissions to 30 per cent below 2005 levels by 2030. The framework includes a multi-pronged approach to reducing emissions spread over several different policy initiatives. In this research, we aim to quantify the economic impacts associated with some of these initiatives. Specifically, this research quantified the economic impact of pricing carbon and of decarbonizing our electricity supply. Furthermore, based on the work in the TEFP, the value of the lost output from decarbonizing the electricity sector and the investments required to achieve significant GHG emissions reductions were quantified.

Our analysis suggests that the change in prices resulting from pricing carbon and moving toward the decarbonization of our electricity system has only a modestly negative effect on the economy as a whole. However, the negative impacts are not distributed evenly, and the consequences for some industries are significant. Furthermore, higher prices do little to change behaviour on their own. Even when carbon is taxed at $200 per tonne, emissions outside of the electricity sector fall by only 12.7 Mt by 2025. Adding in the move away from fossil fuels in the electricity generation sector removes another 34.8 Mt of emissions but still leaves Canada far from meeting its Paris Accord commitment. Environment and Climate Change Canada's own projections show emissions basically stabilizing at their current level after the phasing out of coal in Alberta. And the results of our analysis show that adding in carbon pricing and the decarbonization of electricity outside of Alberta would still not be enough to reach the 2030 target. To achieve that target, the government's projection indicates that emissions need to fall 219 Mt below 2016 levels.

In our analysis, the electricity sector is yet to be fully decarbonized in 2025, economic adjustments to the carbon price remain incomplete, and our calculation of emissions reductions incorporates no technological change, efficiency improvements, or behavioural shifts (aside from the response to higher prices). It is these last three factors—technological

Changes in behaviour can drastically reduce the investments required to cut emissions.

change, efficiency improvements, and behavioural shifts—that are expected to have a substantial impact on our emissions trajectory. Based on different technological and behavioural assumptions, the TEFP has outlined several pathways that result in deep emissions reductions. These pathways require major new investments and would have important economic consequences, depending on the pathways chosen. The fact is that Canada would be unable to find the additional funds, capital, and labour resources required to generate these investments without drawing them away from other economic activities. Our model simulations show that spending in other areas of the economy would eventually fall in response to higher prices and capacity pressures, with consumers bearing the brunt of the impact and private businesses also seeing reduced investment.

The results of our analysis of the TEFP scenarios show that changes in behaviour can drastically reduce the investments required to cut emissions. Policy-makers need to be aware of the significant cost savings that can come from shifting behaviours and explore the practical likeliness of inducing the required behavioural shifts. At the same time, policy-makers need to be aware of the economic dislocations that will occur during the transition to a low-carbon future and craft solutions to help minimize and mitigate the negative impacts that will occur.

One of the most important takeaways from this research is that simply pricing carbon and moving away from fossil fuel-fired electricity generation are far from enough of what is needed to achieve deep GHG emissions reductions. Achieving these reductions requires significant new spending, a drastic change in the way Canadians live their lives, and for businesses to fundamentally alter the way they operate. Policy-makers will need to clearly articulate to their constituents the scale of the transformation required and what it will mean for their everyday lives, and they will have to convince society to embrace these changes. Without broad-based support, the effort to reduce emissions will ultimately fail.

Given that the investment requirements are in the trillions of dollars, we as a country cannot afford to make such a costly mistake as neglecting to plan and communicate the path forward for emissions reductions.

APPENDIX A

Input-Output Price Model

The input-output price model is built using the supply-use (formally referred to as input-output) tables produced by Statistics Canada, which show how commodities are produced and used in our economy. The total supply (output) in our economy is equal to domestic production and international imports, and the total use (input) in our economy is equal to intermediate inputs plus final expenditures (including consumption, investment, inventories, and exports).

We are interested in the relationship between commodities used as intermediate inputs (i.e., the total value produced of a commodity as a function of all its intermediate inputs and its value-added) in order to use the supply-use tables to estimate price impacts. The quantities in the supply-use tables are in dollar values, but implicit in those values are a price component and a quantity component.

Following the methodology used in U.S. economist Kevin Perese's *Input-Output Model Analysis: Pricing Carbon Dioxide Emissions*,[1] we created the commodity-by-industry direct requirements (matrix B) by dividing the intermediate inputs in the use table by total output by industry. Matrix B shows the share of each commodity and value-added category that go into producing a unit of output in that industry. Next, we create the market-share matrix D by dividing the transpose of the supply table by total output by commodity. The D matrix shows the proportion of each commodity produced by each industry. Lastly, we convert the value-added vector (the sum of all the value-added components) by total output by industry and multiply by the D matrix to derive the

1 Perese, *Input-Output Model Analysis*.

scaled value-added coefficient vector v. We then derive a symmetrical commodity-by-commodity matrix A that describes the proportion of commodity inputs into the production of commodities as:

Equation 1: $A = BD$

Recalling that the figures in the supply-use tables represent prices and quantities of production, the price of one unit of production is a function of the price of intermediate inputs multiplied by the share of that input in the production process plus the value-added from producing that unit. Expressed algebraically,

Equation 2: $A'p + v = p$

In **equation 2**, the proportion of each commodity in the production function multiplied by the price of that commodity plus its value-added equals the price of producing one unit of a commodity. Our analysis utilized the D-level supply-use tables. Therefore, our matrix A is a 462 by 462 element matrix and **equation 2** thus represents 462 equations that represent the production process for each commodity produced in our economy.

Solving **equation 2** for p, we derive:

Equation 3: $p = (I - A')^{-1}v$

where I is an identity matrix. Solving **equation 3** produces a price vector of ones and provides a baseline for evaluating relative price changes in the economy.

The next step of the analysis is to create a tax matrix—T. The T matrix is a commodity-by-industry matrix and contains zeros on all elements except for the commodities that will be subject to the carbon tax. The values of the carbon tax on each of these commodities was calculated as explained in Chapter 2.

In order to incorporate the tax matrix T into our price calculation, we convert it into a coefficient tax vector t:

Equation 4: $t = (\{U \otimes T\}\, \hat{g}^{-1} D)' i$

where U is the intermediate input portion of the use table, $\hat{g}$ is the g vector (total output by industry) expressed as a diagonal matrix (square matrix with the vector values on the diagonal and zeros everywhere else) and i is a column vector of ones.

Incorporating the tax vector t into our estimate of prices in **equation 3** simply requires adding the tax vector to the value-added vector:

Equation 5: $p = (I - A')^{-1}(v+t)$

The new price p reflects the impact of the higher energy prices throughout the supply chain. Price increases in gasoline, for example, will increase the cost of extracting logs, which will lead to higher prices for manufactured wood products.

As in the analysis done by Perese, the derived price impacts are built on the assumption that the price increases are fully passed on to consumers and the production functions are fixed and, therefore, there is no substitution response to higher input costs. As noted by Perese, the assumption of fixed production functions means “the results from these models can only be interpreted as the short-run, first-order effects of a carbon-pricing policy. Firms will, however, respond to the carbon policy and will seek lower-priced alternative inputs to their production processes. To the extent that production substitution is able to lower the initial costs of the policy, the estimated effects presented here are likely to be upper bounds beyond the short term.”[2]

Even though the results presented here are upper-bound, short-term impacts, they provide important information on the sectors that benefit from or are harmed by carbon pricing.

2 Ibid.

APPENDIX B

Detailed Modelling Results

Table 1

Scenario A: Real GDP by Expenditures

(change versus baseline, 2007 $ billions)

	2018	2019	2020	2021	2022	2023	2024	2025
Total consumption	–3.2	–3.2	–4.6	–4.6	–4.6	–4.6	–4.7	–5.2
Household consumption	–3.0	–3.2	–4.6	–4.7	–4.9	–4.9	–5.1	–5.6
Non-profit consumption	–0.1	–0.2	–0.3	–0.4	–0.5	–0.6	–0.7	–0.7
Government consumption	–0.1	0.1	0.2	0.4	0.5	0.7	0.8	0.9
Investment	–0.3	0.2	0.9	1.9	2.7	3.2	3.6	3.7
Business investment	–1.7	–2.8	–3.6	–4.1	–4.8	–5.7	–6.7	–7.6
Business residential investment	–0.7	–1.5	–2.0	–2.4	–2.9	–3.6	–4.3	–5.0
Business non-residential structures investment	–0.4	–0.4	–0.5	–0.5	–0.6	–0.7	–0.8	–0.8
Business non-residential M&E investment	–0.6	–0.8	–0.9	–0.9	–0.9	–1.0	–1.1	–1.2
Business non-residential intellectual property investment	–0.1	–0.1	–0.2	–0.2	–0.2	–0.2	–0.2	–0.3
Government investment	1.4	3.0	4.5	6.0	7.4	8.8	10.2	11.2
Final domestic demand	–3.4	–3.0	–3.7	–2.6	–1.9	–1.3	–0.9	–1.3
Inventories	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Exports	–0.8	–1.0	–1.5	–1.8	–2.2	–2.6	–2.8	–3.2
Imports	–1.2	–1.4	–1.9	–2.0	–2.2	–2.3	–2.5	–2.8
Net exports	0.4	0.4	0.5	0.2	0.0	–0.3	–0.4	–0.4
GDP, expenditure-based	–3.0	–2.7	–3.3	–2.5	–2.0	–1.7	–1.4	–1.8

Source: The Conference Board of Canada.

Table 2
Scenario A: Impact on Select Export Industries
(change versus baseline, 2007 $ millions)

	2018	2019	2020	2021	2022	2023	2024	2025
Merchandise exports	–777	–1,014	–1,466	–1,768	–2,183	–2,579	–2,856	–3,207
Refined petroleum products	–23	–39	–53	–65	–79	–92	–103	–112
Electricity	–83	–100	–117	–125	–132	–142	–150	–154
Crude metals and minerals	–51	–67	–88	–104	–124	–142	–156	–174
Primary metals	–378	–565	–754	–913	–1,092	–1,265	–1,433	–1,592
Basic and industrial chemical, plastics, and rubber products	–331	–547	–758	–948	–1,167	–1,383	–1,593	–1,786
Wood products	–34	–45	–60	–71	–84	–94	–99	–108
Pulp and paper	–85	–149	–197	–234	–271	–307	–338	–369
Industrial machinery, equipment, and parts	–41	–60	–95	–122	–157	–189	–215	–245
Electronic and electrical equipment and parts	70	108	136	160	186	215	246	271
Motor vehicles and parts	225	512	659	833	973	1,105	1,295	1,408
Aircraft, aircraft engines, and parts	–82	–124	–170	–209	–255	–299	–341	–382
Other manufacturing products	–39	–61	–89	–111	–137	–162	–185	–209
Consumer goods: food, beverage, and tobacco products	–50	–79	–117	–147	–182	–212	–236	–261
Other consumer goods	50	66	75	83	94	106	119	130

Source: The Conference Board of Canada.

Table 3
Scenario B: Real GDP by Expenditures
(change versus baseline, 2007 $ billions)

	2018	2019	2020	2021	2022	2023	2024	2025
Total consumption	–3.2	–4.2	–6.6	–7.0	–7.4	–7.5	–7.8	–8.8
Household consumption	–3.0	–4.2	–6.9	–7.5	–8.0	–8.3	–8.8	–9.9
Non-profit consumption	–0.1	–0.3	–0.5	–0.7	–0.9	–1.0	–1.2	–1.3
Government consumption	–0.1	0.2	0.5	0.9	1.2	1.5	1.8	2.0
Investment	–0.4	0.5	1.5	3.0	4.2	5.2	6.1	6.5
Business investment	–1.8	–4.0	–6.0	–7.5	–9.2	–10.9	–12.8	–14.6
Business residential investment	–0.7	–2.0	–3.4	–4.6	–5.8	–7.1	–8.4	–9.8
Business non-residential structures investment	–0.4	–0.6	–0.9	–0.9	–1.1	–1.3	–1.4	–1.5
Business non-residential M&E investment	–0.6	–1.2	–1.4	–1.6	–1.7	–1.8	–2.1	–2.3
Business non-residential intellectual property investment	–0.1	–0.2	–0.2	–0.3	–0.3	–0.4	–0.4	–0.5
Government investment	1.4	4.6	7.5	10.5	13.3	16.1	18.8	20.8
Final domestic demand	–3.6	–3.6	–5.0	–3.9	–3.0	–2.0	–1.4	–2.0
Inventories	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Exports	–0.8	–1.1	–1.8	–2.4	–3.3	–4.2	–4.9	–5.7
Imports	–1.2	–1.8	–2.9	–3.2	–3.6	–3.9	–4.3	–4.9
Net exports	0.4	0.7	1.1	0.8	0.3	–0.3	–0.6	–0.7
GDP, expenditure-based	–3.2	–3.0	–4.0	–3.2	–2.8	–2.6	–2.3	–3.0

Source: The Conference Board of Canada.

Table 4

Scenario B: Impact on Select Export Industries

(change versus baseline, 2007 $ millions)

	2018	2019	2020	2021	2022	2023	2024	2025
Merchandise exports	–856	–1,108	–1,807	–2,435	–3,317	–4,204	–4,910	–5,665
Refined petroleum products	–24	–55	–84	–110	–138	–165	–188	–207
Electricity	–89	–117	–142	–160	–176	–197	–214	–223
Crude metals and minerals	–55	–80	–116	–148	–189	–227	–260	–296
Primary metals	–399	–735	–1,073	–1,386	–1,737	–2,078	–2,410	–2,725
Basic and industrial chemical, plastics, and rubber products	–345	–745	–1,139	–1,517	–1,945	–2,371	–2,786	–3,168
Wood products	–36	–57	–84	–108	–137	–162	–180	–200
Pulp and paper	–91	–179	–262	–336	–412	–486	–553	–615
Industrial machinery, equipment, and parts	–46	–68	–124	–177	–248	–315	–375	–435
Electronic and electrical equipment and parts	73	146	202	253	306	360	418	472
Motor vehicles and parts	212	822	1,165	1,491	1,730	1,930	2,217	2,411
Aircraft, aircraft engines, and parts	–87	–159	–241	–318	–410	–500	–586	–669
Other manufacturing products	–42	–77	–124	–167	–220	–270	–318	–365
Consumer goods: food, beverage, and tobacco products	–54	–102	–170	–230	–303	–369	–424	–479
Other consumer goods	51	92	112	131	154	178	202	224

Source: The Conference Board of Canada.

Table 5

Scenario C: Real GDP by Expenditures

(change versus baseline, 2007 $ billions)

	2018	2019	2020	2021	2022	2023	2024	2025
Total consumption	–3.2	–4.2	–6.6	–7.1	–7.5	–8.1	–9.2	–11.3
Household consumption	–3.0	–4.2	–6.9	–7.5	–8.1	–9.0	–10.5	–13.0
Non-profit consumption	–0.1	–0.3	–0.5	–0.7	–0.9	–1.1	–1.4	–1.7
Government consumption	–0.1	0.2	0.5	0.9	1.1	1.6	2.2	2.7
Investment	–0.4	0.5	1.5	3.0	4.2	5.6	7.3	8.4
Business investment	–1.8	–4.0	–6.0	–7.5	–9.2	–12.0	–15.9	–19.5
Business residential investment	–0.7	–2.0	–3.4	–4.6	–5.8	–7.6	–10.1	–12.7
Business non-residential structures investment	–0.4	–0.6	–0.9	–0.9	–1.1	–1.5	–1.8	–2.1
Business non-residential M&E investment	–0.6	–1.2	–1.4	–1.6	–1.7	–2.2	–3.0	–3.5
Business non-residential intellectual property investment	–0.1	–0.2	–0.2	–0.3	–0.3	–0.4	–0.6	–0.7
Government investment	1.4	4.6	7.5	10.4	13.3	17.5	23.0	27.6
Final domestic demand	–3.6	–3.6	–5.0	–4.0	–3.2	–2.3	–1.6	–2.6
Inventories	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Exports	–0.8	–1.1	–1.8	–2.5	–3.4	–4.6	–6.0	–7.7
Imports	–1.2	–1.8	–2.9	–3.2	–3.7	–4.3	–5.3	–6.5
Net exports	0.4	0.7	1.1	0.8	0.2	–0.3	–0.7	–1.2
GDP, expenditure-based	–3.2	–3.0	–4.0	–3.4	–3.1	–2.9	–2.7	–4.2

Source: The Conference Board of Canada.

Table 6

Scenario C: Impact on Select Export Industries

(change versus baseline, 2007 $ millions)

	2018	2019	2020	2021	2022	2023	2024	2025
Merchandise exports	–856	–1,108	–1,807	–2,500	–3,447	–4,610	–6,009	–7,672
Refined petroleum products	–24	–55	–84	–110	–139	–180	–232	–277
Electricity	–89	–117	–142	–165	–185	–217	–251	–275
Crude metals and minerals	–55	–80	–116	–151	–195	–248	–314	–389
Primary metals	–399	–735	–1,073	–1,404	–1,774	–2,278	–2,919	–3,538
Basic and industrial chemical, plastics, and rubber products	–345	–745	–1,139	–1,529	–1,970	–2,593	–3,391	–4,148
Wood products	–36	–57	–84	–110	–141	–178	–223	–274
Pulp and paper	–91	–179	–262	–340	–423	–523	–649	–781
Industrial machinery, equipment, and parts	–46	–68	–124	–181	–255	–347	–460	–585
Electronic and electrical equipment and parts	73	146	202	255	311	400	515	615
Motor vehicles and parts	212	822	1,165	1,480	1,709	2,101	2,654	2,969
Aircraft, aircraft engines, and parts	–87	–159	–241	–323	–418	–546	–708	–873
Other manufacturing products	–42	–77	–124	–170	–225	–296	–386	–481
Consumer goods: food, beverage, and tobacco products	–54	–102	–170	–233	–309	–405	–523	–646
Other consumer goods	51	92	112	133	156	195	246	293

Source: The Conference Board of Canada.

APPENDIX C

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