11 WAYS TO MEASURE CLEAN GROWTH

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CONTENTS

Executive Summary iv

Pursuing a Clean Growth Future 1

Defining Clean Growth 1

Measuring Clean Growth 4

#1 Low-carbon Growth 10

Headline Indicator #1: Decoupling GDP from GHGs 11

Regional Decoupling 12

International Performance 16

Lessons Learned from Historical Decoupling 18

Data Gaps 19

#2 Economic Resilience 20

Headline Indicator #2: Frequency and Cost of Climate-related Natural Disasters 21

Public Costs 21

Private Costs 23

Future Costs 24

Limitations of Natural Disaster Costs as an Indicator 25

Data Gaps 27

 # 3 Technology Development 28

Headline Indicator #3: GDP of Environmental and Clean Technology Products 29

Regional Technology Development 30

Limitations of the Environmental and Clean Technology Products Indicator 31

Data Gaps 34

#4 Technology Adoption 36

Headline Indicator #4: Energy Intensity and Share of Low-carbon Energy 37

Sector-level Low-carbon Technology Adoption 38

Barriers to Technology Adoption 43

Data Gaps 45

#5 Low-carbon and Resilient Trade and Competitiveness 46

Headline Indicator #5: Trade in Low-carbon and Resilient Goods and Services 47

Provincial Trade in Climate-related Goods and Services 48

Global Influence through Climate-related Finance 49

Data Gaps 51

#6 Low-carbon and Resilient Infrastructure Investment 54

Headline Indicator #6: Public & Private Investment in Climate-related Infrastructure 55

Stock of Climate-related Infrastructure 55

Limitations with the Stock and Flow Investment Indicators 58

Data Gaps 60

#7 Low-carbon Jobs ... 62
Headline Indicator #7: Decoupling Jobs and GHGs ... 63
Regional Job Decoupling ... 65
Sector Risks and Opportunities ... 65
Community Risks and Opportunities ... 70
Individual Risks and Opportunities ... 70
Data Gaps ... 73

#8 Affordable Energy ... 74
Headline Indicator #8: Household Energy Expenditures as a Share of Total Expenditures ... 75
Energy Expenditures across Provinces ... 76
Limitations with Using Household Expenditures to Measure Distributional Impacts ... 77
Data Gaps ... 81

#9 Inclusive Resilience ... 82
Headline Indicator #9: Poverty Rates in Canada ... 83
Poverty Rates across Provinces and Cities ... 85
Limitations with Using Poverty Rates as a Proxy for Resilience and Vulnerability ... 86
Data Gaps ... 86

#10 Clean Air ... 90
Headline Indicator #10: Ambient Air Quality across Canadian Cities ... 91
Ambient Air Quality and Canadians' Health ... 93
Climate Change and Air Pollution ... 96
Data Gaps ... 96

#11 Thriving Ecosystems ... 98
Headline Indicator #11: Land Use, Land Use Change and Forestry ... 99
Regional and Sector-level Implications ... 100
Limitations of LULUCF Indicator ... 102
Data Gaps ... 105

Conclusions & Recommendations ... 106
Conclusion #1: Achieving climate, economic, and well-being objectives simultaneously is possible but requires substantial collaborative effort ... 108

Conclusion #2 Policy makers lack much of the data needed to measure clean growth progress ... 109

Conclusion #3: Several aspects of Canada's clean growth progress have been slow or uneven ... 110

Endnotes ... 112

References ... 114

Acknowledgements ... 128

EXECUTIVE SUMMARY

MEASURING PROGRESS TOWARDS **CLEAN GROWTH**

When it comes to the relationship between climate change and economic growth, pessimists and optimists abound. Pessimists tend to see the historical relationship between economic growth and greenhouse gas (GHG) emissions as inextricably linked—believing Canada can either pursue growth or reduce emissions, but not both. In the extreme, some pessimists argue Canada's climate objectives should always come second to the pursuit of growth and jobs, while others see abandoning growth as the only path to achieving Canada's climate objectives.

Optimists, on the other hand, are convinced smart policy and technological change will deliver growth while fighting climate change. To the optimist, clean energy and clean technologies can reduce Canada's emissions while generating new sources of economic growth and jobs.

Where does the truth lie? Do Canadians need to sacrifice economic growth, jobs, and income to address climate change? How can Canadian businesses stay competitive through a low-carbon transition? Can the promise of clean technologies replace lost jobs and income if higher-carbon sectors face declining investment and demand? Who will struggle and who will benefit along the way to a cleaner future?

These questions are at the heart of the Institute's research on **clean growth**—defined as inclusive economic growth that reduces GHG emissions, strengthens resilience to a changing climate, and improves the well-being of Canadians. They are also particularly relevant as governments wrestle with how to make progress on climate change while driving an economic recovery in the wake of the COVID-19 pandemic.

This paper highlights the multiple facets of clean growth by unpacking the connections between economic growth, climate change, and human well-being. We identify 11 data-driven indicators that, together, can guide efforts by governments, businesses, and communities to not only tackle climate change but to do so in a way that achieves sustained growth and the best overall outcomes for people and society as a whole.

September 2020

WHAT IS CLEAN GROWTH?

Clean growth is inclusive economic growth that reduces greenhouse gas emissions, strengthens resilience to a changing climate, and improves the well-being of Canadians.

SKEPTICAL OPTIMISTS

Simultaneously achieving economic growth and significant progress on climate change won't just happen by itself. It's not enough to naively hope that economic growth and jobs will magically fall into place as emissions decline. That's where skeptical optimism comes in—a commitment to pursue clean growth, while systematically rooting out and solving the myriad challenges that could derail progress.

Skeptical optimism is vastly preferable to the pessimist's choice between climate action or economic growth. At its core, skeptical optimism recognizes the importance of contributing to efforts that keep the increase in average global temperatures well below 2 degrees Celsius. Canadian well-being is at stake: without bold global action on climate change, Canadians face rising costs and significant health risks. The best outcomes for Canadians will come from building resilience to the physical effects of climate change while keeping up with the accelerating global low-carbon transition.

At the same time, skeptical optimism recognizes that economic growth can be a catalyst for the future prosperity and well-being of Canadians. Economic growth generates jobs and incomes, while providing governments with the fiscal capacity for high-quality services and supports, such as health care, social programs for disadvantaged groups, public education, roads, and transit.

Clean growth is ultimately about how to achieve these goals simultaneously—addressing climate change, growing economic prosperity, and improving human well-being—without compromising one outcome for another.

CLEAN GROWTH INDICATOR FRAMEWORK

Measuring success on clean growth requires going beyond tracking Canada's GHG emissions. Canada has committed to achieving net-zero GHG emissions by 2050, which could spark major transformations in the country's economy and society. Measuring GHGs is important, but it only tells one part of the larger clean growth story.

Canada needs broader measures that fully capture the depth and complexity of these transformations. It needs measures that can shed light on what is happening with the economy at the national, regional, and local level, and how people are affected by the clean growth transition. It needs measures that illuminate connections between climate change, economic growth, and human well-being, making it possible to identify pressure points and areas where new or amended government policy can achieve better outcomes. Climate policy will be most durable and lasting if it reflects concerns relating to investment, competitiveness, jobs, equity, and affordability. Similarly, economic and social policy will be more successful if it incorporates climate change objectives.

Making progress on each of these elements of clean growth is imperative, yet Canada currently lacks a framework to measure success. For this reason, the Institute's first report on clean growth offers a data-driven assessment of progress to date—and identifies gaps in data that are preventing Canadian policy makers from tracking, analyzing, and understanding progress over time.

Clean growth success cannot be measured by any one data point. The 11 indicators we present capture the complex web of challenges and opportunities, synergies and conflicts that emerge in the pursuit of climate progress, economic growth, and Canadians' health and well-being.

As the figure on the following page illustrates, our framework groups the 11 indicators into three categories: two overarching **goals** of clean growth—low-carbon growth and economic resilience; the **catalysts** of clean growth, which include technology development and adoption, and indicators related to trade and infrastructure; and the **foundations** of clean growth: thriving ecosystems, low-carbon jobs, clean air, inclusive resilience, and affordable energy.

11 CLEAN GROWTH INDICATORS

GOALS

1 LOW-CARBON GROWTH

2 ECONOMIC RESILIENCE

CATALYSTS

3 TECHNOLOGY DEVELOPMENT

4 TECHNOLOGY ADOPTION

5 LOW-CARBON AND RESILIENT TRADE AND COMPETITIVENESS

6 LOW-CARBON AND RESILIENT INFRASTRUCTURE INVESTMENT

FOUNDATIONS

7 LOW-CARBON JOBS

8 AFFORDABLE ENERGY

9 INCLUSIVE RESILIENCE

10 CLEAN AIR

11 THRIVING ECOSYSTEMS

THE GOALS
OF CLEAN GROWTH

The overarching objective of clean growth is to address climate change while growing the economy. Measuring progress requires breaking that goal into two parts, with the first indicator focused on low-carbon growth and the second looking at economic resilience to a changing climate.

Cultivating a clean growth future for Canada will require considering this suite of indicators as a whole and using them to guide priorities and assess progress in the decades ahead.

The **low-carbon growth indicator** tracks the decoupling of GHG emissions from gross domestic product (GDP) over time. We find that all provinces managed to decouple economic growth from greenhouse gas emissions between 2005 and 2018, and six provinces decreased emissions while growing their economies. Evidence also suggests that the territorial economies are decoupling as well (although data limitations prevent us from including the territories in our comparative analysis).

Our analysis finds that progress on low-carbon growth relies on three activities: finding new, low-carbon sources of growth, shifting to lower-carbon sources of growth, and reducing emissions in existing sources of growth. There is significant scope for more detailed research on these three drivers; future research could be supported by enhanced datasets that match economic and GHG data in Canada.

The **economic resilience** indicator focuses on limiting the costs Canada faces from a changing climate. While a dearth of data limits our ability to assess progress on building economic resilience, this indicator highlights some of the key areas where improved tracking of the costs of a changing climate could inform policy and investment decisions.

We use cost estimates of natural disasters as a starting point, which includes costs to households, businesses, and government. Our analysis finds that the costs of floods and wildfires have increased over time, as a result of both climate and non-climate factors; however, we also find that data limitations prevent us from capturing the full scope of these costs. Cost estimates for the 2016 Fort McMurray fire, for example, range between $4 billion and $9 billion depending on which costs are included. Better tracking of a broader range of climate-linked costs over time, combined with improved assessments of future risks, will help support better decision-making by governments, businesses, and homeowners.

CATALYSTS
OF CLEAN GROWTH

The next set of indicators target areas that are catalysts for low-carbon growth and economic resilience: technology development, technology adoption, investment in low-carbon and resilient infrastructure, and low-carbon and resilient trade and competitiveness. These interconnected indicators together form the engine that can accelerate clean growth.

Developing technology that makes it easier and cheaper to reduce emissions and improve resilience can reduce the economic impacts of transition while generating new sources of growth and jobs. To measure technology development, we consider GDP estimates for environmental and clean technology products. While the dataset does not capture all potential sources of economic activity consistent with low-carbon growth and economic resilience goals, it provides a useful starting point. Overall, we find that economic activity associated with environmental and clean technology in Canada has increased over time, but has been uneven across provinces and territories. It is dominated by renewable electricity and clean technology services such as construction; however, real GDP from clean technology manufacturing grew 20 per cent between 2012 and 2018.

One of the biggest barriers to technology development is slow adoption. Data on resilience technologies is limited, so we focus on low-carbon **technology adoption**. Our headline indicator compares Canada's energy intensity and proportion of low-carbon energy to other G7 countries. While we have one of the highest levels of low-carbon energy (25 per cent) due to hydroelectric and nuclear power, our energy use per unit of GDP is significantly greater than other G7 countries. This contrast highlights the magnitude of the technology adoption challenge if Canada is going to significantly reduce emissions without slowing growth. According to a 2017 survey, only 10 per cent of Canadian firms have adopted clean technologies. Accelerating adoption supports low-carbon growth by driving strong domestic markets for new innovations and reducing emissions per unit of output.

Low-carbon and resilient trade and competitiveness is also a catalyst of clean growth. Increased global demand for low-carbon and resilient products and services creates growth opportunities for Canadian businesses, while spurring innovation and economies of scale that drive down the costs of technology adoption over time. We therefore consider exports and imports of environmental and clean technology as a percentage of GDP for this indicator. While it does not include the full range of economic activities that reflect progress, the indicator shows signs that Canada's trade activity in low-carbon goods and services is increasing over time. Fully assessing Canada's competitiveness would require a broader analysis across the economy, including sectors that may be vulnerable to shifts in global markets and investment patterns resulting from a low-carbon transition.

Given the long life of infrastructure, investment patterns can have a significant effect on low-carbon growth and economic resilience. **Infrastructure investments** that are not low-carbon or resilient will increase future costs, while limited investment in low-carbon enabling infrastructure—such as electricity transmission or electric vehicle charging—can slow technology adoption.

According to this indicator, public and private investment in electricity transmission and distribution increased significantly between 2009 and 2019, while investment in wind and solar power declined. In terms of the overall stock of infrastructure, oil and gas infrastructure has increased alongside electricity transmission, electricity distribution, and hydroelectric power generation. While increased investment in low-carbon and resilient infrastructure is generally positive, making choices on where to invest scarce public and private dollars to attain low-carbon growth and economic resilience requires broader data and analysis.

FOUNDATIONS
OF CLEAN GROWTH

The final indicator set considers the foundations of clean growth. While it may be technically possible to make progress on decoupling emissions from growth or reducing the costs of climate change, without progress on these foundational elements the resulting change is less likely to be lasting and durable.

These indicators target five areas where we see the greatest risks and potential to pursue low-carbon growth that improves the well-being of Canadians. Indigenous-led policies and plans are particularly important for making progress on these indicators, given that climate change is expected to disproportionately affect the livelihoods, health, and well-being of Indigenous peoples. At the same time, Indigenous communities are well placed to play a significant role in nature-based and clean energy climate solutions.

The first foundational indicator focuses on **low-carbon jobs.** Maintaining stable and gainful employment is a primary concern as Canada and the world accelerate action to reduce GHG emissions. Transition creates both employment risks and new prospects, which are experienced unevenly across sectors, regions, and individuals. This indicator assesses progress in terms of achieving aggregate growth in jobs as emissions decrease, while minimizing regional and individual job loss and ensuring broad access to new employment opportunities. We look at the decoupling of employment and GHGs over time, and consider risks at the sector, community, and individual level.

Our analysis finds that employment in Quebec is the least tied to GHG emissions, while employment in Saskatchewan is the most tied to emissions. In Newfoundland and Labrador, growth in GHG emissions has been almost the same as growth in employment, whereas most other provinces have decoupled employment and emissions trends since 2005. Smaller communities dependent on one sector are generally more at risk of employment loss, as are individuals with lower levels of education and skills. A higher proportion of Indigenous employment is also in sectors that may be at risk.

The second foundational indicator is **affordable energy.** Households struggling to make ends meet are more vulnerable to rising costs for essential goods and services, such as heat, electricity, and transportation. Tracking and monitoring households' expenditures in these areas can help identify concerns and inform the development of relevant policies as energy systems shift. This indicator therefore looks at energy expenditures as a share of total expenditures by level of income. In general, Canadian households spent less of their income on energy in 2017 than in 2010, but households in the lower-middle to upper-middle income categories—

particularly in Atlantic Canada—continue to spend the largest shares on energy.

The third foundational indicator is **inclusive resilience**, reflecting the concern that those most vulnerable in society will bear the brunt of climate change. Those with financial means and privilege can move, rebuild, adapt, and recover more quickly than those in poverty or those who face challenges due to health, age, discrimination, or disability. Climate change threatens to exacerbate societal inequities; by better understanding who is most vulnerable, governments can develop targeted policies to protect and support them.

We use poverty as an indicator for those that are vulnerable but also identify several other measurement opportunities at the local level. At the national level, the poverty rate fell from 16 per cent of the population in 2006 to nine per cent in 2018 due to policies such as the National Child Benefit and a stronger labour market. The most significant reductions were in major cities such as Toronto, Vancouver, and Montreal.

Despite this progress, however, poverty rates remain high for some groups, such as non-elderly adults living on their own and single mothers under the age of 18, indicating that some Canadians remain highly sensitive to climate impacts and poorly equipped to deal with them. Indigenous communities also face higher risks from climate change. For instance, nearly 22 per cent of residential properties on Indigenous reserve lands in Canada are at risk of a 100-year flood. The physical impacts of climate change will exacerbate pre-existing challenges for Indigenous peoples relating to poverty, housing, health, and lack of infrastructure.

Clean air is the fourth foundational indicator. The enormous opportunity to improve the health of Canadians and limit health risks from a warming climate is often overlooked in efforts to reduce GHG emissions. Air pollutants come from many of the same sources as GHGs, and the evidence is clear that air pollution increases the risk of respiratory, cardiac, and neurological disease, causing over 14,000 premature deaths each year in Canada. Tracking progress on clean air can highlight regions and sources where policies could provide significant air pollution and GHG benefits. In Vancouver in 2017–18, for example, nitrogen dioxide (NO_2) emissions exceeded national air quality standards. Given that transportation is a major source of NO_2 emissions, efforts to encourage greater use of public transport, active transportation, and electric vehicles could generate significant health benefits, while also addressing a major source of GHG emissions.

Thriving ecosystems represent the last foundational indicator. Thinking of ecosystems strictly in the context of nature conservation ignores their essential contribution to achieving objectives relating to economic growth, human well-being, and climate change. Ecosystems provide clean water, clean air, food, natural resources, and wildlife habitat, and they are central to the well-being and self-determination of Indigenous peoples. They also store carbon and support resilience to a changing climate through temperature regulation, soil retention, and reducing flood risk.

As interest grows in carbon offsets, planting trees, and other nature-based climate solutions, a holistic view of the status of Canada's ecosystems and the many benefits they provide can help guide and inform policy development. Unfortunately, however, ecosystem data is very limited. For this indicator, we rely on the land use, land use change, and forestry data provided in Canada's National Greenhouse Gas Emission Inventory, which estimates some of Canada's land-based emission sources and sinks. The data highlight the critical role of Canada's boreal forest as a carbon sink and the magnitude of forest emissions in British Columbia associated with wildfires, insect infestations, and slash burning practices.

FINDINGS AND RECOMMENDATIONS

We draw three big conclusions from the 11 different indicator categories. These conclusions support a series of recommendations for governments and point to several areas for further exploration and analysis.

CONCLUSIONS

1. **Achieving climate, economic, and well-being objectives simultaneously is possible but requires substantial collaborative effort.** With the right policies and actions, reducing GHG emissions, improving resilience, growing the economy, and increasing well-being can be mutually reinforcing. However, policy makers and Canadians should not underestimate the level of effort required. It is easy to say Canada needs to achieve economic growth while significantly reducing GHG emissions but much harder to spell out how to do so. It is also easy to say that no one should be left behind but much more difficult to put mechanisms in place to protect vulnerable Canadians.

2. **Policy makers lack much of the data required to measure progress towards clean growth.** Measuring Canada's progress on clean growth is not a simple exercise. In some cases, the indicators are so multi-dimensional that they are difficult to measure with only a handful of statistics. In others, the data simply are not available to comprehensively assess progress. Data are fundamental to identifying connections and interactions relevant to clean growth. Data allow for governments to measure progress and can inform potential course corrections. Investing in new and better data that connect climate change to economic growth and the well-being of Canadians will lay the foundation for future research and the development of policies that support clean growth success.

3. **Canada's progress on clean growth has been slow or uneven in several areas.** Our analysis highlights areas where Canada could accelerate progress, including: decoupling GHGs from GDP in regions of the country that are lagging; developing and adopting low-carbon and resilient technology; addressing the sectors, communities, and individuals that risk losing jobs as Canada transitions to a lower-carbon future; and halting loss and degradation of ecosystems. The analysis also identified opportunities that are not being fully captured with current approaches, including investing in low-carbon and resilient infrastructure and acheiving health benefits by reducing air pollution.

RECOMMENDATIONS FOR GOVERNMENTS

- **Establish explicit cross-mandate accountabilities within government,** by providing clear direction (e.g., in Ministers' mandate letters) to consider integrated climate change, economic, and well-being objectives and by establishing formalized horizontal governance structures (such as a low-carbon growth committee).
- **Better connect GHG data to economic data.** Clean growth research and policy development requires easily accessible GHG data that matches GDP, employment, trade, and other data.
- **Improve GHG data for Canada's territories.** Researchers need better data to include territories in comparative analyses with provinces.
- **Collect more and better data on the costs of extreme weather events.** The consistency and comprehensiveness of the Canadian Disaster Database should be improved.
- **Broaden cleantech data to include more climate-relevant technologies.** This should include economic activities that may not be purely "clean" but are consistent with low-carbon growth pathways. It should also include technologies that support adaptation and resilience to a changing climate.
- **Tag public infrastructure investments for better tracking.** We propose slotting climate-related infrastructure investments into four categories: 1) low- or no-carbon, 2) low-carbon enabling, 3) resilient, and 4) natural.
- **Develop more complete metrics of society's vulnerability to a changing climate.** Vulnerability to a changing climate depends on multiple factors, including pre-existing sensitivities (such as poverty or underlying health conditions), exposure to climate impacts, and ability to adapt before and after climate events occur. Right now, few metrics fully capture all components.
- **Improve data and reporting on ecosystem trends and related climate implications.** Canada needs an organization with capacity comparable to the Canadian Forest Service for ecosystems such as wetlands and coastal and estuarine areas to coordinate improved measurement of carbon sinks and sources and undertake analysis on climate resilience benefits. The federal government should also work towards reporting more comprehensive GHG data on natural disturbances, such as wildfires and permafrost thaw, on unmanaged lands.
- **Use near-term investments to support a long-term clean growth transition.** Governments can play a key role in overcoming barriers to private investment, particularly at a time when economies are struggling and capital is limited. Policies and investments made today can plant seeds that grow into long-term low-carbon and resilient economic growth.

In addition to the 11 indicators analyzed, this report highlights important data gaps, research questions, and policy questions that need to be answered to support Canada's journey towards clean growth. We identify several areas below that would benefit from greater research and analysis.

PROSPECTIVE AREAS FOR FURTHER EXPLORATION BY GOVERNMENTS AND RESEARCHERS

- **Undertaking strategic clean growth assessments.** Several governments in Canada require policy proposals to include a strategic environmental assessment. The federal government has also developed a climate lens for major public investments in infrastructure. It is worth exploring an expansion of these tools to explicitly incorporate a broader set of criteria linked to clean growth objectives. For example, while an infrastructure project would naturally consider general economic objectives, it might not consider low-carbon growth objectives. A low-carbon growth lens could lead to a greater emphasis on "enabling" infrastructure investments that support low-carbon technology development and adoption.
- **Connecting technology development with technology adoption.** Since a lack of domestic technology adoption is a significant barrier to growth for clean technology companies, policy tools that aim to accelerate adoption rates could also consider areas where Canadian companies are showing signs of success but struggling to find domestic buyers. This could help grow strong domestic markets that better position Canadian companies for international success.
- **Linking economic development and skills policies with climate-related employment risks and opportunities.** Some communities and regions may be more vulnerable than others because they have a concentration of employment in an at-risk sector. Individuals with lower levels of skills or education may also be at greater risk. Strengthening the connection between forward-looking climate change transition scenarios and economic development and skills policies could help reduce vulnerability and connect people with low-carbon growth opportunities.
- **Targeting urban transportation.** Our indicators show multiple reasons to consider a greater emphasis on urban transportation—such as slower levels of technology adoption in transport, rising GHG levels, and increased evidence of a link between urban air pollution and adverse health outcomes.
- **Slowing the loss of climate-related ecosystem services.** Slash burning practices used by logging companies, draining of wetlands for agriculture or development, deforestation for industrial activities, and many other actions are decreasing the benefits nature provides to people today and will provide to people in the future. Climate change will further exacerbate many of these pressures on ecosystems.
- **Supporting Indigenous-led opportunities that accelerate clean growth.** Indigenous-led initiatives can achieve multiple economic, social, environmental, and climate benefits simultaneously. Additional support for Indigenous protected areas, land management, renewable energy projects, resilient housing, fire management, and other opportunities linked to climate change objectives could help accelerate clean growth progress in Canada.

INTRODUCTION

PURSUING A CLEAN GROWTH FUTURE

When measuring progress on climate change, governments, analysts, and advocates too often benchmark success according to a single metric: greenhouse gas (GHG) emissions. Yet to succeed in the long term with such a major adjustment to our economy and society, climate policies must position Canada to succeed in economic and social terms as well.

Conversely, as governments implement policies to drive and support economic growth, they should not measure success only in terms of Gross Domestic Product (GDP) growth. In the long term, failure to address climate change will undermine economic growth and the well-being of Canadians.

Clean growth connects climate change to Canada's economic and societal ambitions such as GDP growth, job creation, affordable living, and good health. It moves away from a focus on all-or-nothing trade-offs between different objectives towards identifying and supporting integrated solutions that address multiple goals simultaneously. Clean growth offers a vision for how Canada can prosper and thrive while addressing climate change. Furthermore, it recognizes that those goals can be mutually supportive—if they are managed carefully.

In the context of climate change, clean growth is inclusive economic growth that reduces GHG emissions, strengthens resilience to a changing climate, and improves the well-being of Canadians.

To provide a more tangible illustration of clean growth, and to start the process of measuring progress, this report proposes and analyzes 11 key statistical indicators. Together, they provide a sketch of the elements needed to achieve clean growth success. Measured over time, the indicators can provide insights on where progress has been made, where progress is lagging, and where there are critical information gaps. In many cases, they also help identify policy opportunities and challenges, while underscoring the need for new and different approaches to how governments and businesses collect and analyze data.

DEFINING CLEAN GROWTH

While clean growth encompasses a range of environmental issues, we focus on climate change for two reasons: 1) climate change represents the most significant clean growth challenge for Canada in the coming decades and 2) our Institute mandate is to provide research and analysis that informs climate change policy decisions. For our purposes, clean growth focuses on the intersection of climate change goals, economic growth, and well-being.

While we focus specifically on climate change, our approach is in many respects broader than traditional interpretations of clean growth or green growth (Box A). We maintain a focus on economic growth and GHG emissions as core elements, but

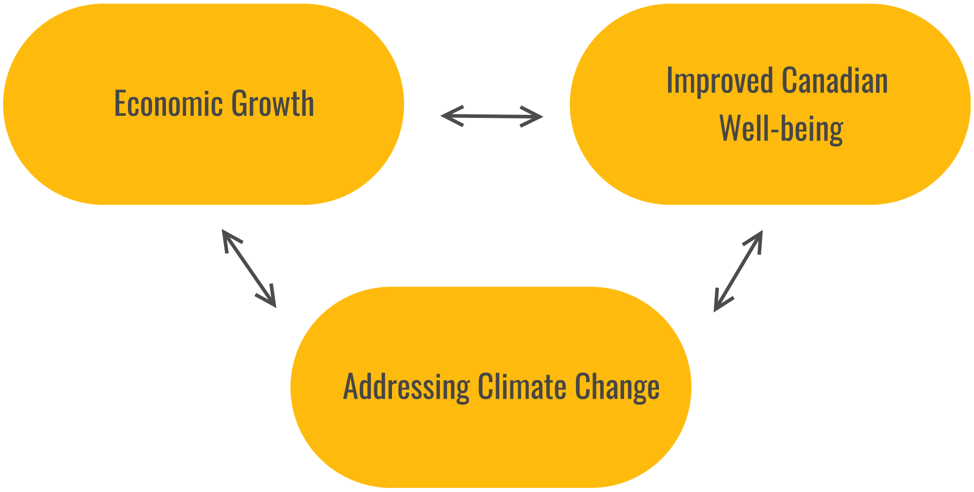


FIGURE A:

Three Interconnected Elements of Clean Growth

we also integrate aspects of well-being and resilience to a changing climate.

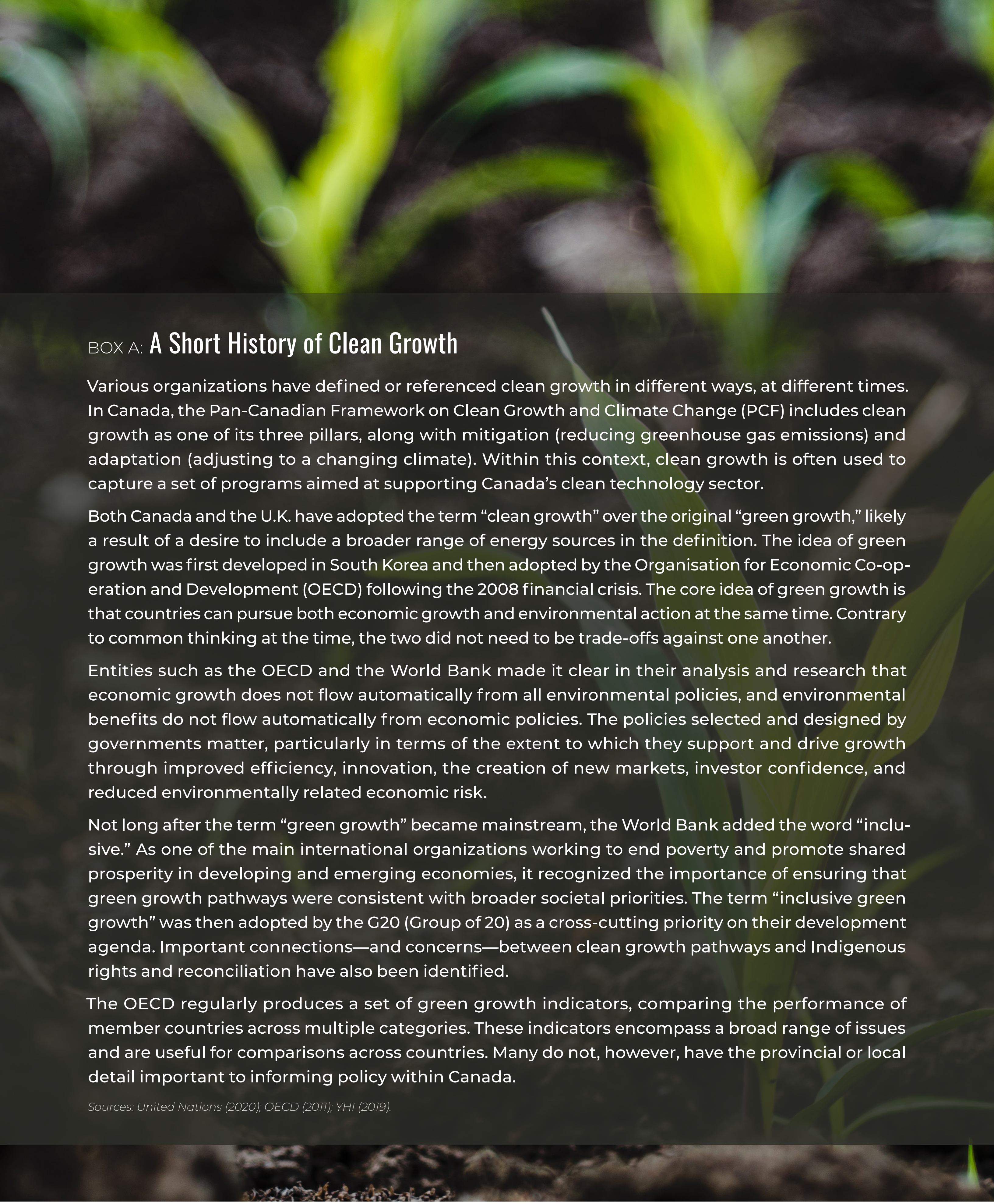
This leaves us with three core elements of clean growth: economic growth; improved Canadian well-being; and addressing climate change (Figure A). Each is important in its own right. Canada has committed to address climate change by significantly reducing GHG emissions, through both its 2030 target and a goal of achieving net-zero emissions by 2050. It has also committed to ensuring that Canadian communities are resilient to a changing climate under the Pan-Canadian Framework on Clean Growth and Climate Change, implying that businesses, governments, and individuals will be able to manage and bounce back from the physical impacts of climate change.

At the same time, economic growth underpins the prosperity of Canadians, driving the jobs and income that make Canadians increasingly better off and the fiscal capacity for high-quality government services and supports. Improving well-being is even broader in scope and is about ensuring that all Canadians—across all backgrounds and circumstances—are prosperous and healthy and have a clean and safe environment. This is particularly relevant to Indigenous peoples, who are expected to keenly feel the impacts of climate change on their livelihoods, health, and well-being and are well placed to play a significant role in nature-based and clean energy climate solutions (YHI, 2019; Townsend et al., 2020).

Achieving climate change, economic growth, and well-being objectives simultaneously is the challenge that lies at the heart of clean growth. Indeed, some environmental activists,academics, and journalists have questioned whether these objectives are at odds and pull in different directions (Cassidy, 2020). Economic growth has historically been linked to GHG emissions, leading to concerns about whether economic growth and emission reductions are inherently incompatible. On the other side, there are concerns that addressing climate change means sacrificing economic growth and the prosperity of current generations.

Yet clean growth is both possible and desirable (see Box B). Clean growth can retain the positive aspects of growth—such as higher incomes, innovation, and jobs—while implementing policies to address undesirable side effects, such as GHG emissions and social inequities.

In fact, achieving success on one objective requires success on the others.



BOX A: A Short History of Clean Growth

Various organizations have defined or referenced clean growth in different ways, at different times. In Canada, the Pan-Canadian Framework on Clean Growth and Climate Change (PCF) includes clean growth as one of its three pillars, along with mitigation (reducing greenhouse gas emissions) and adaptation (adjusting to a changing climate). Within this context, clean growth is often used to capture a set of programs aimed at supporting Canada's clean technology sector.

Both Canada and the U.K. have adopted the term "clean growth" over the original "green growth," likely a result of a desire to include a broader range of energy sources in the definition. The idea of green growth was first developed in South Korea and then adopted by the Organisation for Economic Co-operation and Development (OECD) following the 2008 financial crisis. The core idea of green growth is that countries can pursue both economic growth and environmental action at the same time. Contrary to common thinking at the time, the two did not need to be trade-offs against one another.

Entities such as the OECD and the World Bank made it clear in their analysis and research that economic growth does not flow automatically from all environmental policies, and environmental benefits do not flow automatically from economic policies. The policies selected and designed by governments matter, particularly in terms of the extent to which they support and drive growth through improved efficiency, innovation, the creation of new markets, investor confidence, and reduced environmentally related economic risk.

Not long after the term "green growth" became mainstream, the World Bank added the word "inclusive." As one of the main international organizations working to end poverty and promote shared prosperity in developing and emerging economies, it recognized the importance of ensuring that green growth pathways were consistent with broader societal priorities. The term "inclusive green growth" was then adopted by the G20 (Group of 20) as a cross-cutting priority on their development agenda. Important connections—and concerns—between clean growth pathways and Indigenous rights and reconciliation have also been identified.

The OECD regularly produces a set of green growth indicators, comparing the performance of member countries across multiple categories. These indicators encompass a broad range of issues and are useful for comparisons across countries. Many do not, however, have the provincial or local detail important to informing policy within Canada.

Sources: United Nations (2020); OECD (2011); YHI (2019).

For example, global markets and investor preferences are shifting in response to government policies to rapidly reduce GHG emissions. These shifts create both risks and opportunities for economic growth in Canada. Reducing emissions in at-risk sectors, shifting resources towards lower-carbon sources of economic activity, and developing new low-carbon sources of growth will help support Canada's economy through global transition.[1]

Sustained economic growth will also be challenged if the economy is not resilient to a changing climate that poses significant risks, including damaged infrastructure and built structures, lost worker productivity, and disruption of business operations and supply chains. As a result, finding ways to improve Canada's ability to manage and recover from these risks supports economic growth objectives.

Technology, investment, and trade will play an integral role. Simultaneously achieving economic growth and addressing climate change depends significantly on the extent to which we develop and adopt low-carbon and resilient technologies in Canada.[2] Public and private investments in low-carbon and resilient infrastructure are fundamental to enabling these technologies and changing behaviour. And international trade and investment provide a way to grow both domestic and global markets for low-carbon and resilient technologies while generating economic opportunities for Canadian exporters.

Ultimately, economic growth is a means to an end—making Canadians better off. However, an approach that focuses only on a narrow, GDP-centred definition of clean growth misses other factors that are essential to the well-being of Canadians.

For example, aggregate economic indicators can mask stark differences across regions or populations. The transition to a low-carbon and resilient economy cannot be successful if it increases regional unemployment, exacerbates existing inequalities, or lets the most vulnerable suffer the brunt of climate change impacts. Understanding and addressing these impacts where they occur is fundamental to achieving clean growth.

The transition is not just about protecting people from risk, however. We also need to seize opportunities to improve well-being. For example, reducing GHG emissions offers enormous potential to improve the health of Canadians. Harmful air pollutants that increase our risk of disease and premature death are often co-emitted with GHGs. There are also opportunities to connect people to new sources of jobs and income.

Finally, nature lies at the foundation of the economy, human well-being, and climate change. Thriving ecosystems can sequester and store carbon, protect against floods, cool urban areas, improve water and air quality, provide food and natural resources, support wildlife, and generate many other benefits. Maximizing these benefits requires a deep comprehension of the linkages between nature and economic and human activity. Indigenous people play a critical role and need to be included in the development of policies and plans. Indigenous people have a unique relationship with nature, given inextricable linkages to their livelihoods and well-being and as stewards and protectors of many important ecosystems.

MEASURING CLEAN GROWTH

To make clean growth measurable, we developed a series of statistical indicators based on a review of domestic and international approaches and consultations with internal and external experts (Box C). Together, these indicators provide a starting point for tracking progress on clean growth and identifying priorities for action. We targeted indicators that fall at the intersection of climate, economic, and societal objectives.

The statistics selected do not perfectly measure every aspect of clean growth. In many cases, data are not available or are incomplete. However, the

BOX B: Why Advocate for Clean Growth?

By Dr. Richard Lipsey, Clean Growth Expert Panelist and Professor Emeritus at Simon Fraser University

The Canadian Institute for Climate Choices is dedicated to studying policies for clean growth—policies that encourage the advantages of economic growth while mitigating its undesirable side effects. This implies that we believe that simultaneously cleaning and growing the economy is both possible and desirable.

There are those that will disagree with us. Some disagree on whether clean growth is possible, while others disagree on whether it is desirable. Those who deny the possibility argue there is a trade-off in which you can have more of one but only at the cost of less of the other. A more extreme position is held by those who deny the desirability of maintaining a growing economy, arguing that modern growth has been harmful on balance, so that if it is slowed or stopped as a consequence of greening the economy, so much the better.

We reject both these views. On balance, growth has benefited all societies. We also observe that countries such as Sweden that have steadily reduced greenhouse gas emissions have also been successful in producing growing economies combined with high levels of well-being.

Growth is mainly driven by new technologies: technologies to make new products, to make existing products in new ways, and to organize production, distribution, and finance in new ways.

The past hundred years have brought modern dental and medical equipment, penicillin, bypass operations, safe births, control of genetically transmitted diseases, personal computers, compact discs, television sets, automobiles, opportunities for fast and cheap worldwide travel, affordable universities, central heating, air conditioning, and food of great variety free from ptomaine and botulism, much less the elimination of endless domestic drudgery through the use of detergents, washing machines, electric stoves, vacuum cleaners, refrigerators, dish washers, and a host of other labour-saving household products that their great grandchildren take for granted. Twentieth-century technologies also helped address terrible diseases that disabled or killed—plague, tuberculosis, cholera, dysentery, smallpox, and leprosy, to mention only the most common.

Those of us living through the first decades of the 21st century are seeing similarly massive changes but in different directions: biotechnology, nanotechnology, artificial intelligence, and clean technology. If technological change and the growth that it drives continues, we can look forward to such things as longer and healthier lifespans, the end of many inherited diseases, the replacement of body parts with prosthetics that function at the command of artificial intelligence, the innovation of new environmentally friendly materials, and the development of new energy sources that bring an end to the age of fossil fuels.

Modern growth and globalization have benefitted the world as a whole, raising billions from poverty to middle class standards. Yet these benefits have also come undesirable side effects. Income inequality and a lack of social mobility remain persistent problems in many countries, particularly for vulnerable and racialized groups. Unskilled workers in advanced countries were hurt as they transitioned from being relatively scarce locally to relatively plentiful globally. Environmental damages, including greenhouse gas emissions, have also increased. These undesirable side effects need to be ameliorated by public policy, not by throwing the baby out with the bathwater and stopping growth.

These ameliorating policies need to be an important element of clean growth. We who live today can be thankful that some earlier-day Luddite did not persuade governments to stop growth-inducing technological change decades ago—just as our children and grandchildren will be grateful that we did not slow or halt the pace of the technological change from which they will benefit 50 or 100 years from now.

Sources: Lipsey et al. (2006); Lipsey (2019).

process of trying to find indicators and analyzing those we select is informative. They help us better understand the interconnections between climate change, the economy, and societal well-being. It also helps identify areas where additional data collection and analysis would be useful, flags areas for further research, and identifies areas where government policy could better support clean growth.

Our proposed indicator framework starts with two statistics that map out the overarching goals of clean growth (Figure B). The first indicator is most closely linked to the traditional definition of clean growth: **low-carbon growth**. It targets the decoupling of GHG emissions from GDP over time, setting out a dual objective to both grow the economy in a lower-carbon way and reduce emissions without stopping economic growth. Our second indicator targets **economic resilience**, aimed at limiting the costs Canada faces from a changing climate. This indicator suffers from a dearth of data but highlights some of the key areas where improved tracking of the costs of a changing climate could inform policy and investment decisions.

The next set of indicators target areas that **catalyze** low-carbon and resilient growth. These include **technology development**, **technology adoption**, **low-carbon and resilient infrastructure investment**, and **low-carbon and resilient trade**. These interconnected indicators together form the engine needed to accelerate clean growth progress.

If we can develop technologies that make it easier and cheaper to reduce emissions and improve resilience, we can better achieve economic and climate goals simultaneously. One of the biggest barriers to technology development, however, is slow adoption. Accelerating adoption will help drive strong domestic markets for new innovations while reducing the emissions intensity of growth. Investment in long-lived infrastructure is also a critical element. If we invest in infrastructure that is not low-carbon or resilient, we will increase future costs. Infrastructure such as electricity transmission or electric vehicle charging can also be an important catalyst of technology development and adoption.

Trade is also a catalyst of low-carbon and resilient growth. Increased global demand for low-carbon and resilient products and services creates growth opportunities for Canadian businesses, while spurring innovation and economies of scale that drive down the costs of technology adoption over time. Canada can play a role in accelerating this cycle by increasing our own exports and imports of low-carbon and resilient products and services, financing efforts in developing countries, and shifting foreign direct investment patterns.

We have termed the final indicator set **foundations**. While it may be technically possible to make progress on decoupling emissions from growth or reducing the costs of climate change, without progress on the foundational elements, it is less likely to be lasting and durable. We target five key areas where we see the greatest risks—and opportunities—to pursuing a clean growth transition that improves outcomes for all Canadians.

The first is **low-carbon jobs**. Stable and gainful employment is a key concern as Canada and the world accelerate action to reduce GHG emissions. While transition creates both employment risks and opportunities, they may not be experienced evenly across sectors, regions, and individuals. Our focus is therefore on achieving aggregate growth in jobs as emissions decrease, while minimizing regional and individual job loss and ensuring broad access to new employment opportunities.

BOX C: Selecting Clean Growth Indicator Categories and Statistics

To select the indicator categories in this report, Institute Expert Panelists and staff reviewed various approaches relevant to clean growth, such as the Pan-Canadian Framework on Clean Growth and Climate Change, the U.K. government's Clean Growth Strategy, OECD Green Growth Indicators work, World Bank reports on Inclusive Green Growth, UN Sustainable Development Goal indicators, and the concept of Doughnut Economics. The group considered the relevance of these approaches in the context of Canada's climate change objectives and challenges, asking ourselves how we would measure success in 2050. This allowed us to determine the scope of indicator categories and to use an iterative process to finalize the 11 shown in Figure B.

After determining the 11 categories, we considered options for both headline and supporting statistics. In evaluating the options, we used several criteria: relevance to our definition of clean growth; usefulness in informing government policy directions; ability to show medium- and long-term progress; data availability for time series; data quality; and comparability at the national, provincial, and/or municipal level. Few statistics met all our criteria, leading us to complement headline indicators with additional statistics and analysis. We then tested the indicators with several external experts and stakeholders, helping us refine our data selection, presentation, and accompanying analysis.

FIGURE B:

11 Clean Growth Indicators

The second is **affordable energy**, which is another area of worry for Canadians struggling to make ends meet. Lower-income households are more vulnerable to rising costs for essential goods and services such as heat, power, and transportation. Tracking and monitoring their expenditures in these areas can help flag concerns and inform the development of relevant policies as energy systems shift.

The third is **inclusive resilience**, addressing concerns that the most vulnerable in society will bear a larger burden from a changing climate. Those with financial means can move, rebuild, adapt, and recover more quickly than those in poverty or those who face challenges due to health, age, discrimination, or disability. In the absence of action, there is a risk that a changing climate will exacerbate societal inequalities. By improving our understanding of who is most vulnerable to a changing climate, governments can develop targeted policies to protect and support them. We use poverty as an indicator for those that are vulnerable but also identify several other measurement opportunities at the local level.

The fourth is **clean air**. The enormous opportunity to improve the health of Canadians and limit health risks from a warming climate is often lost in efforts to reduce GHG gas emissions. Air pollutants come from many of the same sources as GHGs, and the evidence is growing that air pollution increases the risk of respiratory, cardiac, and neurological disease, causing over 14,000 premature deaths each year in Canada. Tracking progress on clean air can highlight linkages with climate action.

Finally, we consider **thriving ecosystems**. With growing interest in carbon offsets and planting trees, it is important to step back and take a holistic view of the status of Canada's ecosystems and the many benefits they provide as policies are developed. Unfortunately, however, ecosystem data are very limited. We therefore rely on the land use, land use change, and forestry data provided in Canada's National Greenhouse Gas Emission Inventory, which highlights important land-based emission sources and sinks.

The sections that follow outline and analyze each indicator. The final section highlights the main conclusions drawn from these indicators and provides findings and recommendations to inform improved data collection and policy development.

1

LOW-CARBON GROWTH

Economic growth underpins the jobs and income that support Canadians' well-being, as well as the innovation and investment needed to reduce GHG emissions. Within the context of Canada's goal to significantly reduce its GHG emissions, growing the economy will require both reducing the emissions intensity of existing sources of growth and supporting new sources of low-carbon growth.[3] This transition will become increasingly important as the carbon intensity of global trade and investment patterns declines.

HEADLINE INDICATOR

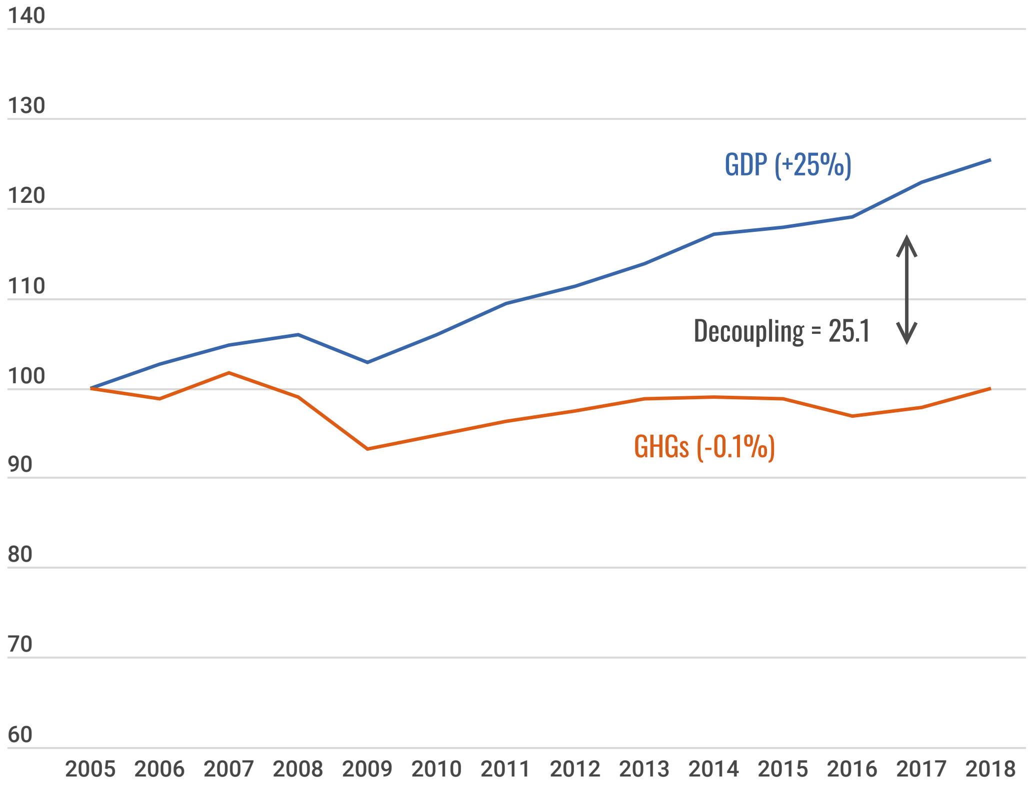
Decoupling GDP from GHGs

Our headline indicator for low-carbon growth is the gap between GDP and GHGs, illustrated in Figure 1.1 using a standardized index (where 2005 levels = 100). For Canada to significantly reduce its GHG emissions while maintaining economic growth, the gap between GDP and GHGs must widen substantially in the coming decades.

At the national level, Figure 1.1 illustrates that Canada has decoupled GHGs from GDP, even though GHG emissions have held relatively constant since 2005. A key benefit of this metric is that it captures GHG progress made relative to economic performance. It provides important context not evident in looking only at GHG trends.

FIGURE 1.1:

Decoupling GHGs from GDP in Canada (Index)



This figure shows a standardized index of GHG emissions and Canadian GDP between 2005 (the base year for Canada's GHG targets) and 2018. Overall, it shows that emissions have decoupled gradually over time: GDP increased by 25 per cent while GHG emissions remained relatively constant across the period.

Sources: Calculations based on ECCC (2020), Statistics Canada (2019a). Note: GDP is expenditure-based and adjusted for inflation, reported in 2012 dollars.

GDP is the most common measure of economic growth, correlates closely with living standards, and is the tax base used to fund government programs that enhance well-being. It is a metric that matters.

At the same time, it is not a complete indicator of prosperity or well-being. GDP measures the total value of the finished goods and services produced within a country for a given year. GDP does not measure other priorities such as jobs, health, or nature. Some activities that increase GDP are the result of a significant loss of wealth or natural assets, such as rebuilding after a wildfire. Rather than dismissing GDP as an indicator, however, we complement it with 10 additional metrics in the following sections.

REGIONAL DECOUPLING

National numbers on decoupling hide strong differences across provinces within Canada. Prince Edward Island, for example, made the most progress on decoupling GHGs and GDP between 2005 and 2018, followed by New Brunswick, Ontario, and Nova Scotia (Figure 1.2). Newfoundland and Labrador, Saskatchewan and Alberta made the least amount of progress. British Columbia, Manitoba and Quebec ranked in the middle of the pack.

There is some indication that Canada's territories are also gradually decoupling GHG emissions from GDP and improving emissions productivity. Given data limitations, however, it was not possible to include them in a direct comparison with provinces (Box 1.1).

While more detailed analysis is required to analyze the specific drivers behind the results shown in Figure 1.2, several regional trends stand out:[4]

- Multiple factors underpin the strong performance of P.E.I., New Brunswick, Nova Scotia, and Ontario. Some relate to policy decisions, including improving energy efficiency, reducing emissions from electricity generation, diverting waste from landfills and capturing methane emissions, and developing and adopting clean technologies (Government of PEI, 2018; Government of NB, 2016; Government of NS, 2020; NSB, 2020). Others relate to economic trends. For example, the closure of natural gas projects, pulp and paper mills, and an oil refinery in Nova Scotia reduced greenhouse gas emissions between 2005 and 2018 (CER, 2020a). Several relatively low-emission sectors have also been key contributors to economic growth, such as lobster exports, residential construction, and public investment in health-care facilities (Bundale, 2020; Statistics Canada, 2019a).
- The biggest factor in Ontario's strong performance was the closure of coal-fired power plants in 2014 (CER, 2020b). Overall growth in Ontario was also driven by lower-carbon service sectors such as high-tech and real estate.
- Newfoundland and Labrador experienced the least decoupling of all provinces for several reasons. GDP growth was relatively slow at seven per cent over the period and was heavily influenced by investment in specific projects such as the Muskrat Falls hydroelectric project and offshore oil. The fishing sector also declined significantly over the period. Provincial emissions are largely from road transport, oil and gas production, and an oil-powered power plant (CER, 2020c).
- Saskatchewan also saw limited decoupling between 2005 and 2018. With over one-quarter of GDP reliant on oil and gas production and mining, and over eight per cent from agriculture, Saskatchewan's growth has been linked with relatively emissions-intensive sectors (Government of SK, 2020; Statistics Canada, 2019b). It managed to achieve some decoupling, however, with GHGs growing at a slower rate than GDP.

BOX 1.1

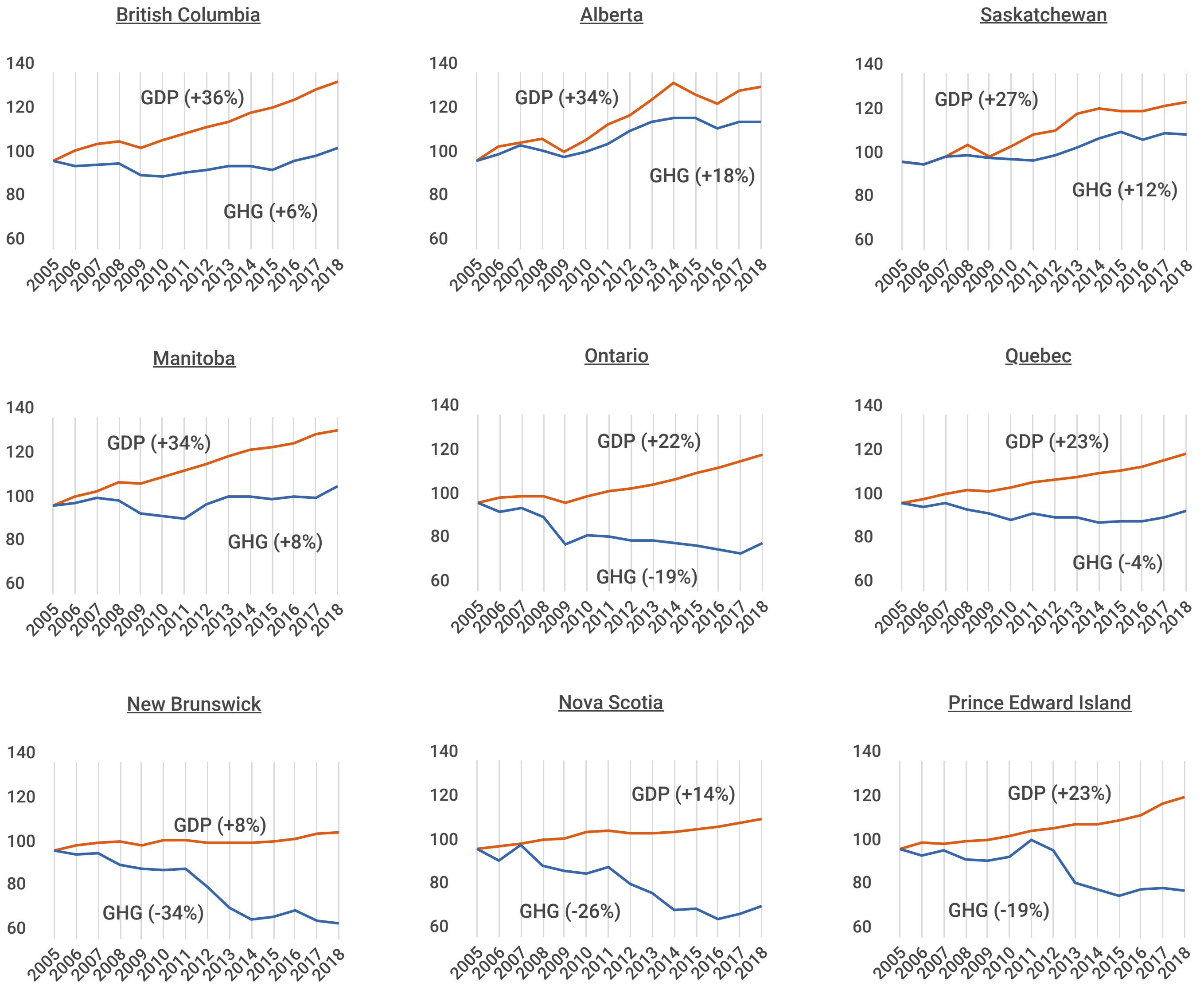
Measuring Territorial Low-Carbon Growth

Measuring and comparing progress on low-carbon growth in Canada's territories—the Yukon, Northwest Territories, and Nunavut—is challenging. The Yukon government, for example, has identified that the national inventory of GHG emissions underestimates territorial emissions because it does not fully account for fuels bought in other jurisdictions. Yukon now develops their own estimates, with data starting in 2009. There are also concerns about the accuracy of GHG estimates in the Northwest Territories and Nunavut. While on a national scale these adjustments are tiny, they make a big difference to territorial decoupling metrics, distorting comparative analyses. We therefore omitted them from Figure 1.2 and Table 1.1 but hope to include them in future reports as work continues to improve estimates.

Sources: OAG (2017); Government of Yukon (2020).

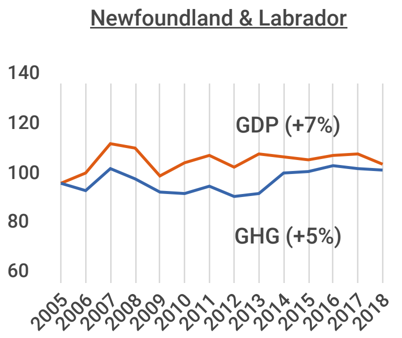
FIGURE 1.2:

Provincial Decoupling of GHGs and GDP (2005-2018)


British Columbia **Alberta** **Saskatchewan**

Manitoba **Ontario** **Quebec**

New Brunswick **Nova Scotia** **Prince Edward Island**

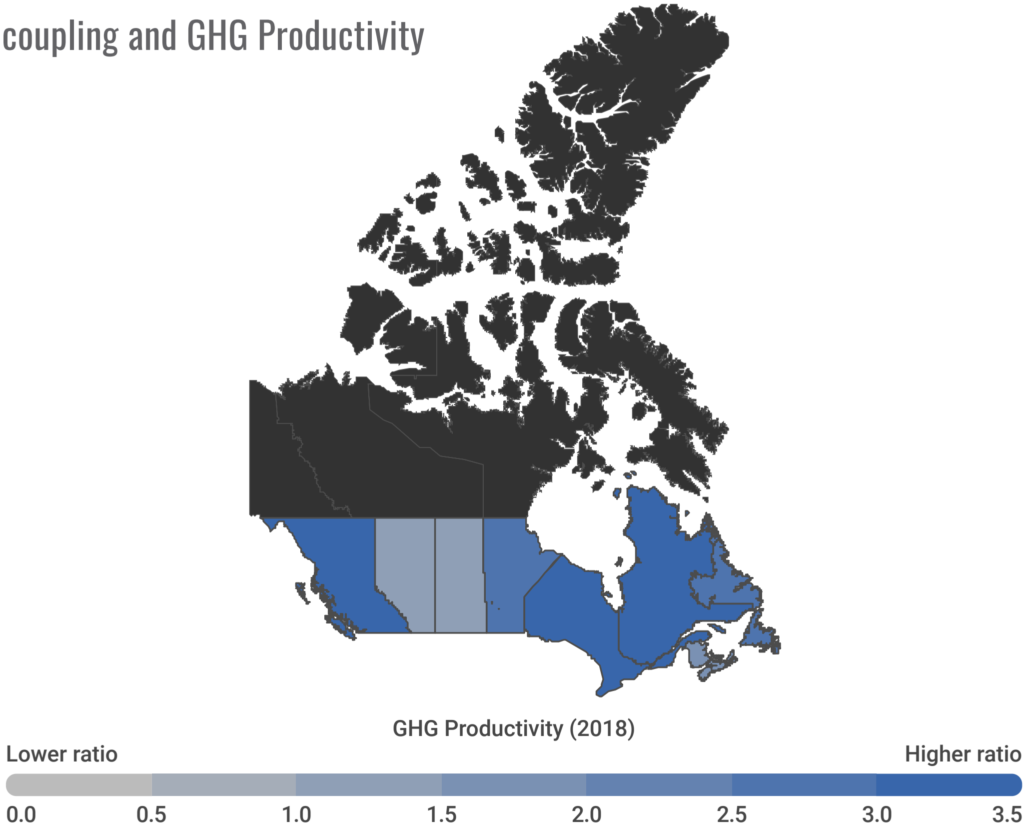

Newfoundland & Labrador

This figure shows the relative decoupling between GDP and GHG emissions in each province between 2005 and 2018. All provinces saw some level of decoupling, but performance varies significantly across provinces. Some provinces, such as New Brunswick, experienced a sharp decrease in emissions (-34 per cent) and a modest increase in economic growth (+8 per cent). In other provinces, such as Alberta, the increase in economic growth was larger (+34 per cent), but GHG emissions continued to grow (+18 per cent).

Sources: Calculations based on ECCC (2020); Statistics Canada (2019a). Note: GDP is expenditure-based and adjusted for inflation, reported in 2012 dollars.reported in 2012 dollars.

TABLE 1.1:

Provincial Decoupling and GHG Productivity



Province/Territory	Decoupling GHGs & GDP (2005–2018)			GHG Productivity (2018) (GDP/CO$_2$e)
	GDP growth (%)	GHG Change (%)	Decoupling Score	Ratio
British Columbia	35.8	5.6	30.2	3.13
Alberta	33.6	17.5	16.1	1.12
Saskatchewan	26.7	12.3	14.4	1.00
Manitoba	34.0	8.3	25.7	2.50
Ontario	21.5	-18.8	40.3	3.15
Quebec	22.5	-4.1	26.6	3.75
New Brunswick	8.1	-33.6	41.7	1.54
Nova Scotia	13.5	-26.4	39.9	1.54
P.E.I.	23.3	-19.4	42.7	2.46
Newfoundland & Lab.	7.4	5.3	2.1	2.89
Canada	***+25.3***	***-0.1***	***25.4***	***2.82***

This table shows the decoupling score for provinces, which measures the gap between the growth in GDP and change in GHG emissions from figure 1.2. Note that territories are not included due to concerns regarding the accuracy of GHG data (see Box 1.1.). For example, Ontario had a decoupling score of 40.3, calculated by subtracting its rate of GDP growth (21.5%) from its rate of GHG growth (-18.8%). The table also includes a GHG-GDP productivity score for each province, which shows the economic activity generated per unit of GHG emissions (GDP is denoted in millions of 2012 dollars, while CO$_2$e is denoted in kilotonnes). A higher productivity score indicates a weaker linkage between GDP and GHG emissions.

Sources: Calculations based on ECCC (2020); Statistics Canada (2019a).

While the decoupling metric can indicate progress over time, comparing emissions productivity of provincial economies provides important insights on the extent to which an economy is tied to GHG emissions (i.e., how much GDP is produced for a given unit of GHG emissions at a given point in time). In 2018, for example, Quebec ranked ahead of other provinces on this metric, followed by Ontario, British Columbia, and Newfoundland and Labrador (Table 1.1). Saskatchewan and Alberta had economies most linked to GHG emissions, followed by New Brunswick and Nova Scotia.

Electricity generation plays a big role in performance on this metric. Provinces that still rely on coal- and thermal-fired power generally perform worse than those with a large proportion of hydroelectric or nuclear power. While it takes time to transition electricity generation, it is not unrealistic within a 2050 timeframe. Oil and gas production is also a significant factor, particularly in Saskatchewan and Alberta. Manitoba's results are interesting, in that it ranks only fifth on productivity despite its reliance on hydroelectric power. The transport sector is now its greatest source of emissions, with emissions from light-duty gasoline trucks (SUVs and pick-ups) and heavy-duty diesel vehicles increasing 59 per cent and 97 per cent respectively between 2005 and 2018. The province has also seen growth in agricultural emissions, with an increase in direct soil emissions of 63 per cent over the period, likely linked to increased fertilizer use (ECCC, 2020)

In many cases, provinces perform very differently across the two metrics. Quebec, for example, has one of the least emissions-intensive economies in Canada but has made slower progress on further decoupling emissions from GDP since 2005, largely due to increasing transport emissions. The three Maritime provinces (P.E.I., New Brunswick, and Nova Scotia), on the other hand, have made significant progress on decoupling since 2005 but still have relatively emissions-intensive economies.

Some of the provincial differences are related to the structure of economies. A 2017 study compared provinces using both the traditional production-based approach to measuring emissions and a consumption-based approach looking at emissions associated with the goods and services consumed within a province (Dobson & Fellows, 2017). The consumption-based approach resulted in a more even distribution of Canada's emissions across provinces, shifting more emissions to provinces such as Ontario, Quebec, and British Columbia that consume goods produced in other provinces. However, per capita consumption-based emissions in Alberta and Saskatchewan still exceed those of other provinces.

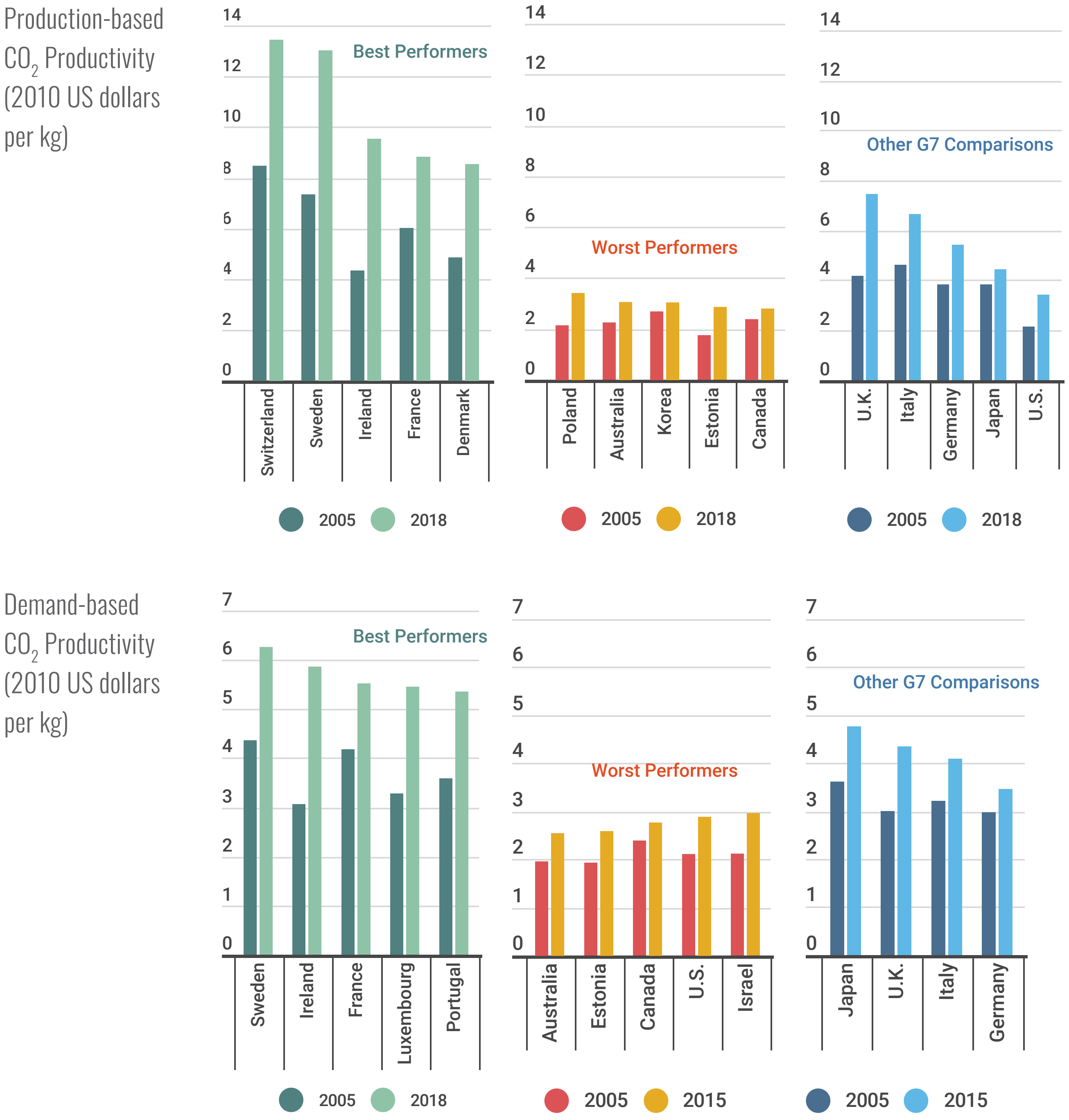
INTERNATIONAL PERFORMANCE

We can use the same GHG productivity metric to compare Canada's low-carbon growth relative to its international peers, measuring the extent to which energy-related CO_2 emissions are linked to economic activity.[5] We also differentiate between *production-based* CO_2 productivity and *consumption-based* CO_2 productivity to address concerns that a production-based approach is biased against goods-producing countries. Production-based CO_2 productivity focuses on emissions generated from producing goods and services within a country, while demand-based CO_2 productivity considers the emissions associated with the goods and services consumed within a country. For both measures, higher scores demonstrate a less carbon-intensive economy (i.e., more economic activity for fewer emissions).

Figure 1.3 illustrates that Canada's economy is more linked to GHG emissions than other developed economies. Canada has a low CO_2 productivity score relative to other countries, using both production and consumption metrics. Both the goods and services we produce and those we consume are more emissions-intensive than most

FIGURE 1.3:

CO_2 Productivity in Select OECD countries, 2005 and Latest Year



This figure shows CO_2 productivity for select developed countries that are members of the OECD. Production-based CO_2 productivity measures a country's total economic output (i.e., GDP), divided by the emissions associated with producing all goods and services within the country. Consumption-based CO_2 productivity measures GDP divided by the total emissions associated with the goods and services consumed within a country. While the differences are less stark with demand-based CO_2 productivity, Canada performs poorly on both metrics and has made slower progress than other countries.

Source: OECD Statistics (2020).

other developed economies. However, the differential between the best and worst performers is greater with the production-based approach than the demand-based approach.

The major differences between the best performers and worst performers relate to electricity generation and economic structure. Countries that perform well on CO_2 productivity tend to rely more on nuclear and renewable sources of electricity, while poorly performing countries tend to rely on coal or shale oil electricity and/or have significant energy-intensive industry or extractive sectors (IEA, 2019a; IEA, 2019b; WEF, 2019). Differences in climate and population density can also play a role.

Canada has also made slower progress than some of its peer countries. Canada's CO_2 productivity has improved since 2005, but other countries have improved more (OECD Statistics, 2020). And while the shift in manufacturing to emerging economies can make countries rank higher on production-based CO_2 productivity, leading economies have also improved their demand-based CO_2 productivity, reducing the emissions intensity of domestic consumption. Some of the factors behind CO_2 productivity—such as climate, population density, and even economic structure—may be difficult to change, especially in the short term, but others can be significantly influenced by the policy choices of governments.

Sweden, for example, has led the world in decoupling economic growth from greenhouse gas emissions. While the circumstances of each country are unique, Canada can draw lessons from some of the strategies used. Sweden's emission reductions resulted from shifting towards low-emitting sources of electricity generation, such as nuclear, hydro, and bioenergy, as well as significant expansion of district heating networks fueled by household waste and wood residues. These two sectors are mainly domestically focused rather than internationally traded, which may have limited impacts on economic growth. Sweden focused primarily on domestic electricity and heating initially and only later included emissions-intensive industries once the European Union Emissions Trading System was established (Schiebe, 2019). At the same time, Sweden supported low-carbon sources of economic growth by investing heavily in research and development in its clean technology sector (CTG/WWF, 2017).

LESSONS LEARNED FROM HISTORICAL DECOUPLING

The data in this section highlight three main ways to achieve low-carbon growth:

1. **Reducing the emissions intensity of existing sources of growth;**
2. **Reallocating resources from high-carbon to low-carbon economic activity; and**
3. **Accelerating the entry and growth of low-carbon firms.**

Multiple factors underpin these three pathways, and they are all decades-long endeavours. The rate of technological development and adoption, Canada's trade in low-carbon and resilient goods and services, and investments in enabling infrastructure will all play a major role in whether Canada makes progress (see Indicators #3, #4, #5, and #6). Interactions with other objectives, such as job creation, affordability, ecosystem health, and Indigenous rights and reconciliation will also shape low-carbon growth pathways.

External factors will also influence performance on decoupling Canada's emissions from its economy. Global and domestic market trends can change investment patterns, create new opportunities, and shift the structure of economies over time. Canada's oil sector, for example, is facing long-term challenges due to fluctuations and uncertainties in oil prices and demand, combined with international policies to reduce emissions

(Leach, 2020; Schumpeter, 2020; BP, 2020; IEA, 2020). These trends may naturally shift the sector towards natural gas or new opportunities in low-carbon hydrogen or geothermal energy.

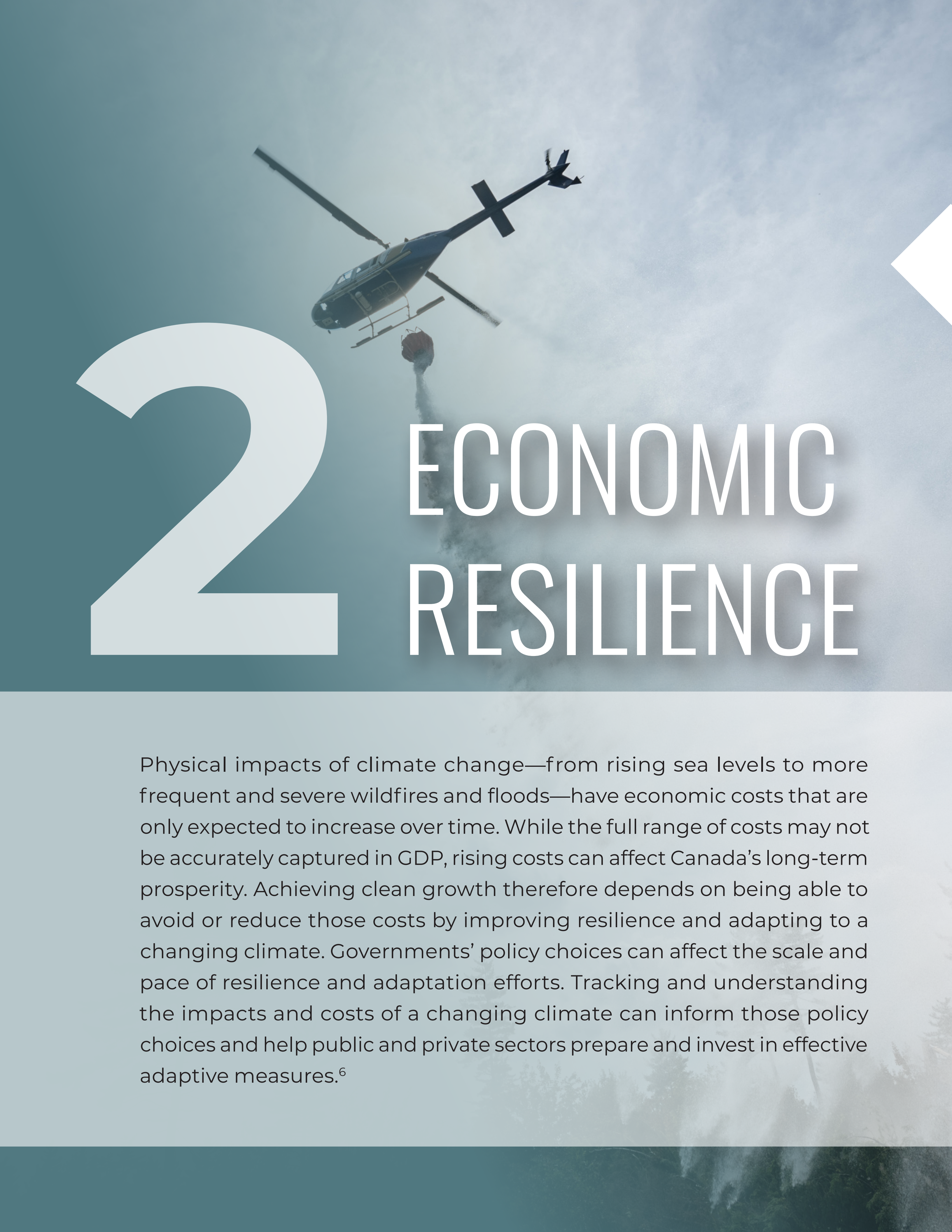
Some future clean growth opportunities may also not be purely low carbon. Canada's mining sector, for example, could benefit from increases in demand for minerals and metals needed for electric vehicles, renewable energy, and batteries. Canadian mining companies are already major global players, and Canada has significant deposits of relevant minerals and metals (IBRD/WBG, 2017). The agricultural sector could also offer new opportunities, as preferences shift towards plant-based meat alternatives that have grown eight per cent per year on average since 2010. Canada is already the world's largest producer of dry peas and lentils (NRC, 2019). To successfully decouple emissions and growth, it could be important to extend the focus on emission reduction opportunities to sectors with significant growth potential. For example, a growth strategy that includes natural gas, agriculture, or mining production would also need to include a plan to significantly reduce emissions associated with those activities.

DATA GAPS

While there is no shortage of data on Canada's economy, or on greenhouse gas emissions, the two metrics are often not well linked. For example, it is challenging for researchers to compare decoupling performance at the sectoral level, as sectors are defined differently for GDP and for GHG data.

Statistics Canada has developed a Physical Flow Account for GHG data by sector that conforms with the United Nations System of Environmental Economic Accounting and can be matched with sector-level GDP data (Statistics Canada, 2020). However, the process is time-consuming, and there are important differences between Statistics Canada's dataset and Canada's official National Inventory of Greenhouse Gas Emissions produced by Environment and Climate Change Canada (ECCC) for reporting under the UN Framework Convention on Climate Change (ECCC, 2020). The difference was over 44 Mt for 2017 emissions estimates. To analyze the linkages between GHG emissions and economic growth in more detail, researchers need ready access to GHG data aligned with the North American Industry Classification System (NAICS) used by statistical agencies in Canada, Mexico, and the United States.

As noted in Box 1.1., territorial emissions data in the national inventory may not be fully accurate, as they do not reflect fuels bought in other jurisdictions. Ideally, ECCC and the territorial governments will work together to improve this data over time to allow for inclusion of Canada's territories in comparative analyses with provinces.



2

ECONOMIC RESILIENCE

Physical impacts of climate change—from rising sea levels to more frequent and severe wildfires and floods—have economic costs that are only expected to increase over time. While the full range of costs may not be accurately captured in GDP, rising costs can affect Canada's long-term prosperity. Achieving clean growth therefore depends on being able to avoid or reduce those costs by improving resilience and adapting to a changing climate. Governments' policy choices can affect the scale and pace of resilience and adaptation efforts. Tracking and understanding the impacts and costs of a changing climate can inform those policy choices and help public and private sectors prepare and invest in effective adaptive measures.[6]

HEADLINE INDICATOR

Frequency and Cost of Climate-related Natural Disasters

Ideally, Canada would track the costs of various impacts associated with a changing climate, including acute weather events and slow-onset changes. For clean growth, we want to limit cost increases over time. At a national level, the Canadian Disaster Database—managed by Public Safety Canada—provides a useful proxy for acute weather events. It tracks the annual frequency and estimated cost of natural disasters over time (Figure 2.1).

PUBLIC COSTS

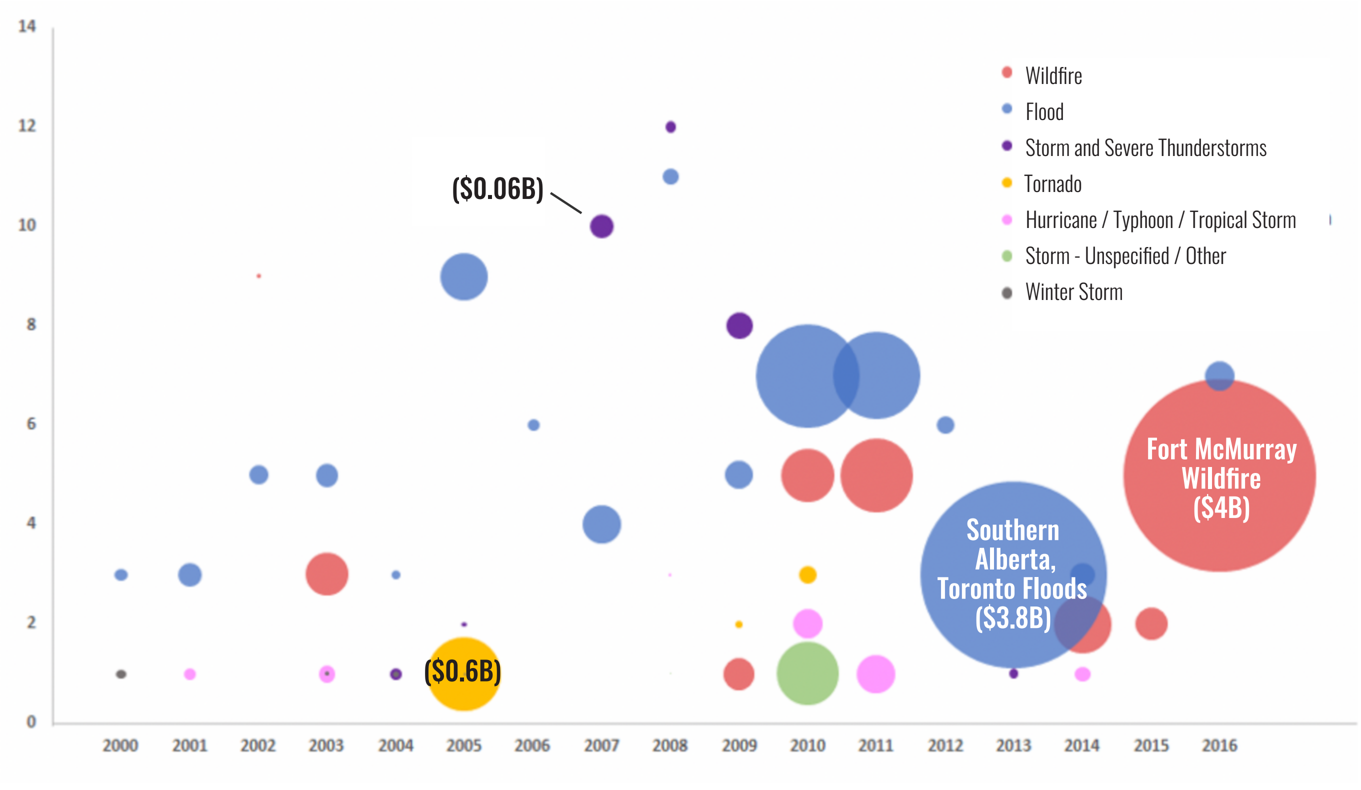
The level of public spending on natural disasters has increased over time, raising concerns globally about the fiscal capacity of governments to manage the impacts of a changing climate. If costs continue to rise, governments will face pressure to cut spending in other areas or raise taxes.

In Canada, the federal government provides post-disaster financing to provincial governments through Disaster Financial Assistance Arrangements (DFAA). This funding mechanism grew from an annual average of $10 million in 1970–1995 to $360 million in 2011–2016 (in current dollars) (PSC, 2017). In the 2018–19 fiscal year, there was a $492 million increase in DFAA accrued liabilities (PSC, 2019). Flooding accounts for about three-quarters of disaster relief funding. Reimbursements under the Emergency Management Assistance Program for Indigenous communities have also increased since 2005, with over $150 million provided in 2018–19 (ISC, 2019).

Many provincial and municipal governments have also faced higher costs from disasters; the magnitude of these costs varies with the type and severity of natural disasters and the types of funding programs available (Henstra & Thistlethwaite, 2017). For example, provinces offer different levels of compensation to homeowners following natural disasters (Bryan-Baynes, 2019). Municipalities face costs from repairing or rebuilding municipal infrastructure or paying for additional hours of work from city staff and contractors. For example, the Quebec government had spent $211 million in compensation for half of the victims of the spring 2019 floods, as of the end of 2019, implying that spending could reach twice that amount (Maratta, 2019). The City of Montreal faced costs from damages and emergency services totalling $17 million (Oduro, 2020).

FIGURE 2.1:

Annual Frequency and Estimated Annual Costs by Disaster Type, Canada, 2000-2016 (Select Natural Disasters, Normalized Canadian Dollars)



This figure shows the annual frequency of climate-related disasters between 2000 and 2016, along with the estimated cost of each type of event. The type of disaster is characterized by colours defined in the legend, while the size of each bubble reflects the total cost. The costliest disasters during this period were the Southern Alberta and Toronto floods in 2013 and the 2016 wildfire in Fort McMurray, Alberta. The data should be interpreted carefully. Entries in the disaster database are self-reported by municipal and provincial governments and lack standardization (see Data Gap section). The frequency and costs shown may not be comprehensive. For example, while the figure shows there were five wildfires in 2016, only the costs for the Fort McMurray wildfire are captured due to a lack of cost reporting. In 2012, there were 10 wildfires that do not show on the chart as there were no costs reported. Note that the disaster database only includes events where 10 or more people were killed, 100 or more people were affected, there was an appeal for national or international assistance, the event was of historical significance, or the damage was great enough to impede the ability of the community to recover on its own.

Source: PSC (2020).

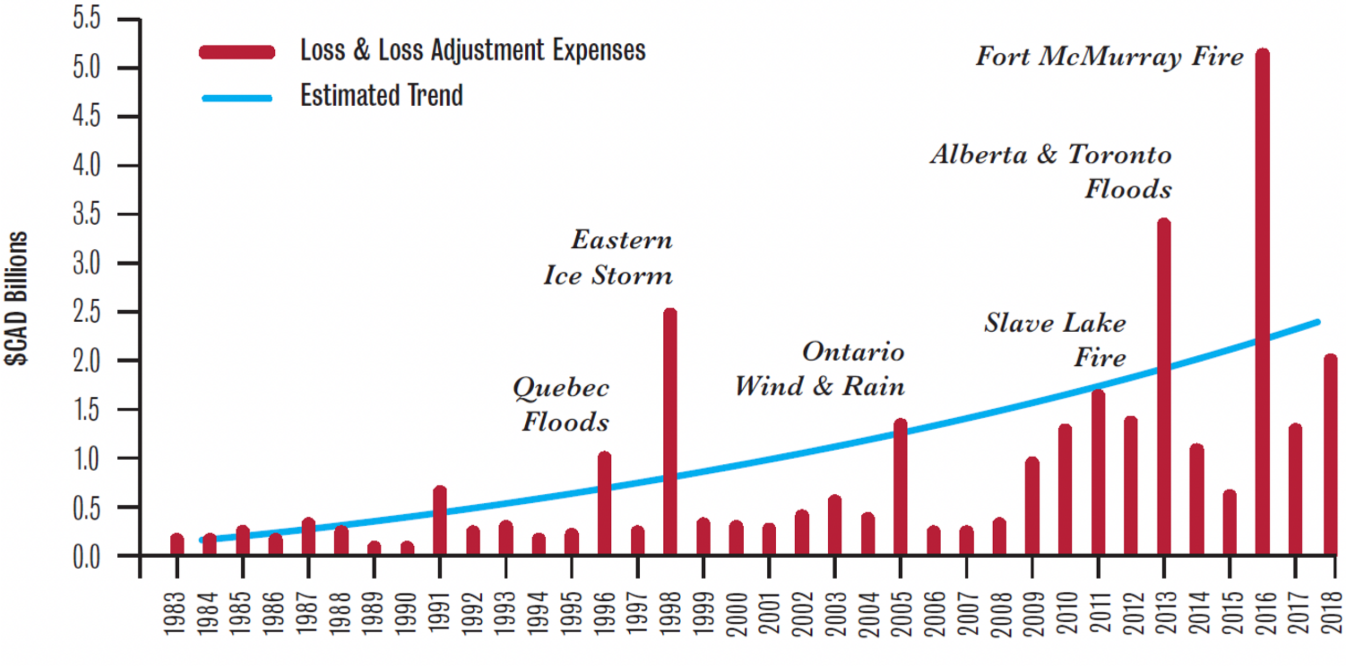
PRIVATE COSTS

Insured losses provide a good indicator of private costs from catastrophic weather events. As illustrated in Figure 2.2, insured losses have trended upwards over the past few decades, in large part due to flooding and wildfire. Residential insurance for overland flooding became available from some providers in 2015, but many at-risk residences in Canada are not covered (OECD, 2019). In 2013, floods in southern Alberta caused about $6 billion in losses, but only about $1.7 billion was insured (Meckbach, 2018).

These trends will be increasingly important to monitor as extreme climate events become more frequent and severe. Insurers facing increasingly large payouts may have to either refuse to insure at-risk areas or increase rates to unaffordable levels (Stone, 2020). Various options have been discussed between insurance companies and governments to shift to a new approach to managing high-risk properties (IBC, 2019).

FIGURE 2.2:

Catastrophic Insured Losses in Canada (1983-2018)



This figure shows the total private insured losses from climate-related events between 1983 and 2018. Overall, the data show an upward trend in private damages.

Source: Intact (2020). Note: all values are adjusted for inflation, reported in 2018 Canadian dollars, and normalized by per capita wealth accumulation.

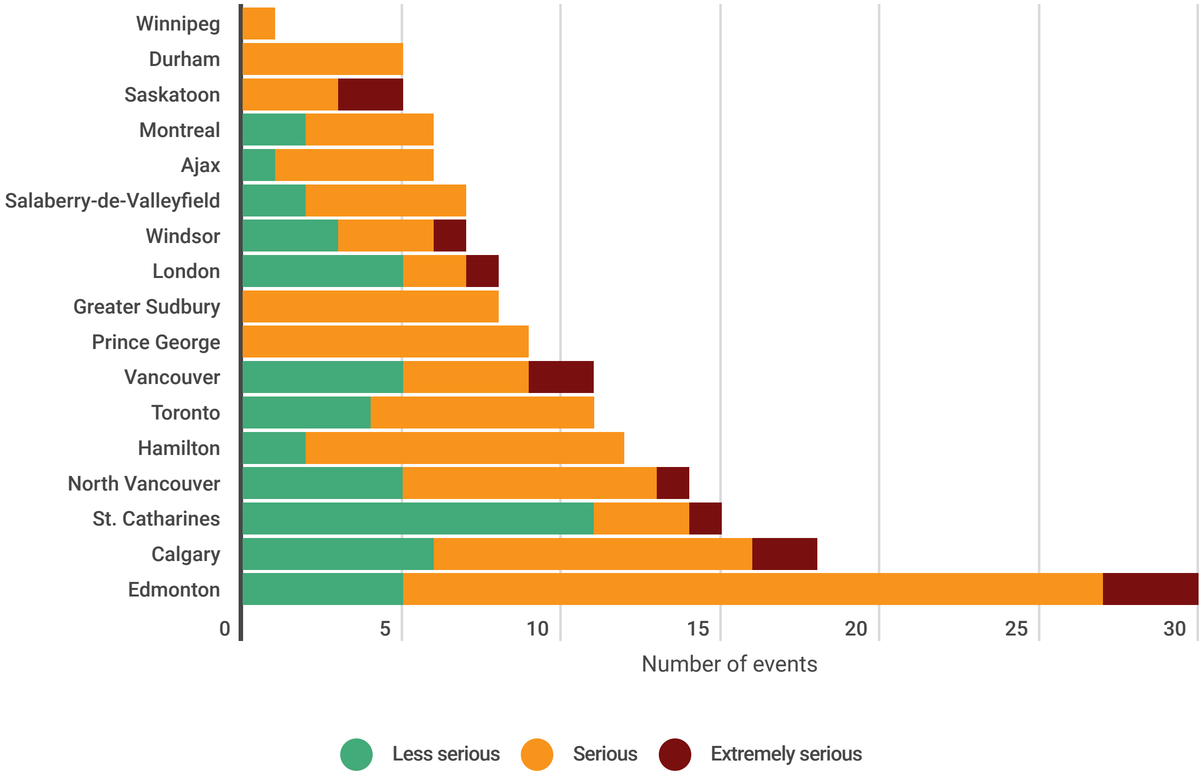
FUTURE COSTS

Assessing future climate risks can help inform policy in ways that ultimately reduce the costs and damages from future events. That is, a better understanding of future risks can help communities prevent damages from occurring in the first place and help them recover faster and stronger afterwards, particularly in remote Indigenous and non-Indigenous communities that are already challenged with limited resources and support.

Many municipalities are making progress in this area. For example, a 2018 study by the U.S.-based organization CDP collected data from 620 cities around the world on the climate hazards they are facing, including several Canadian cities (see Figure 2.3). These Canadian municipalities identified several hazards as "extremely serious," including flooding, storm surges, wildfires, and droughts. "Serious" hazards include heat waves, storms, freeze-thaw cycles, pests, and vector-borne disease (CDP, 2018). However, the data are partial and incomplete. Many municipalities are underreporting their risk, which is likely because they have not completed comprehensive assessments (Tigue, 2019). The fact that Edmonton and Calgary report more climate hazards than other cities is more indicative of greater effort expended on risk assessment than higher risk.

FIGURE 2.3:

Level of Assessment of Climate Hazards by Municipality



This figure shows the number of anticipated climate events identified for each municipality by level of risk, which is more reflective of the effort and capacity for assessment in the municipality than actual climate risk. CDP notes that many cities underreport their risk, particularly longer-term risk. It is not clear, for example, that Edmonton faces significantly higher climate-related risk than Montreal.

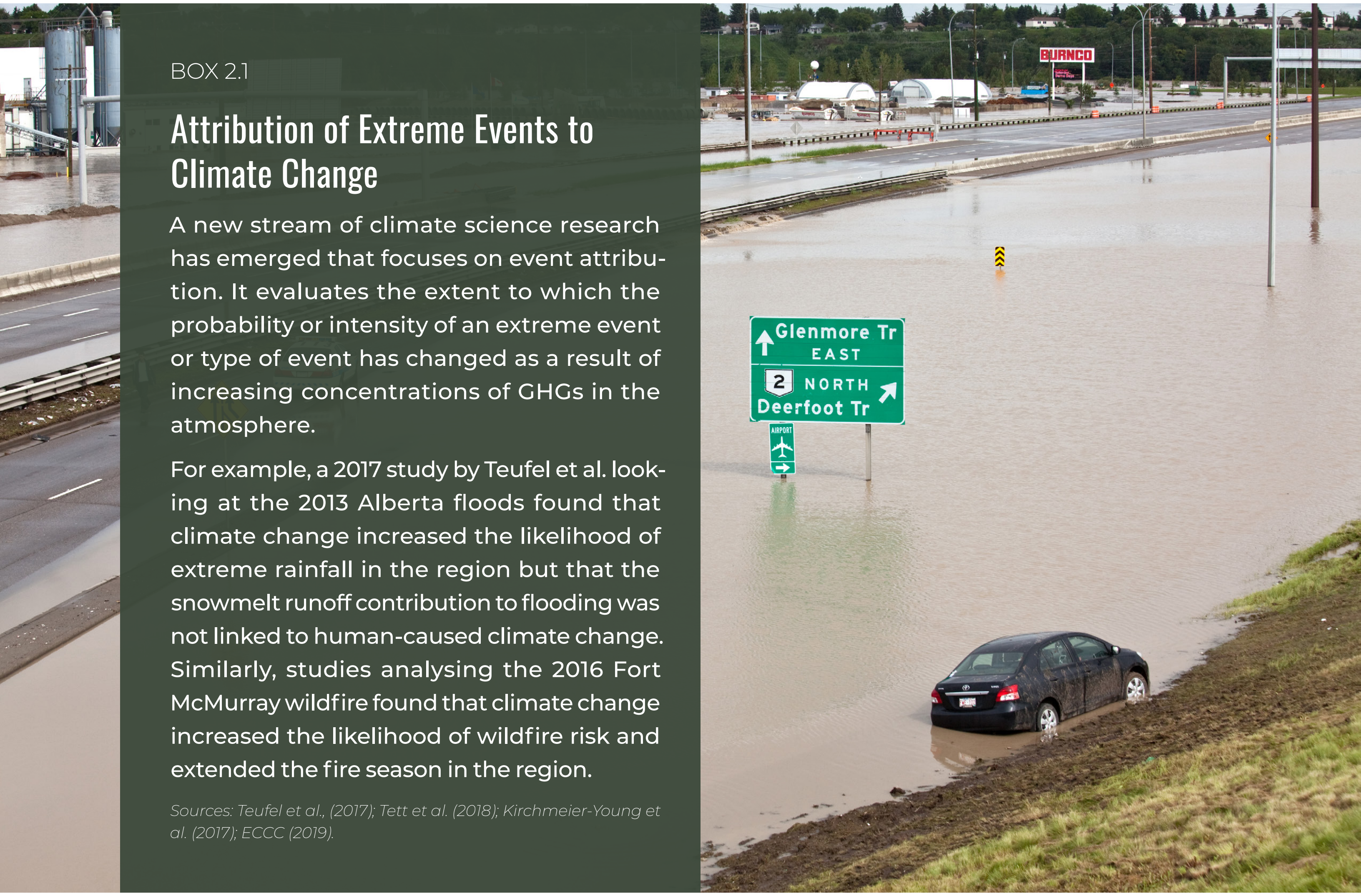
Source: CDP (2018).

LIMITATIONS OF NATURAL DISASTER COSTS AS AN INDICATOR

While natural disaster costs are indicative of the growing economic impact of climate change, the indicator has clear limitations as a metric of progress towards a more resilient economy:

1. **Natural disaster costs alone underestimate the true costs of climate change.** Climate change impacts extend far beyond extreme events. As a result, the costs of natural disasters will significantly understate the costs of climate change. Cascading, long-term, and slow-onset climate impacts may cost far more than single events. A comprehensive understanding of climate change costs requires tracking a variety of impacts, such as lost agricultural productivity, lost worker productivity in warmer temperatures, damage to northern buildings from permafrost thaw, expansion of the range of insects in forestry, and growing health effects from heat waves and Lyme disease.

2. **Natural disasters are influenced by multiple factors.** Some natural disasters can, at least in part, be attributed to climate change (Box 2.1). Climate change is increasing the probability, frequency, and intensity of extreme events,



BOX 2.1

Attribution of Extreme Events to Climate Change

A new stream of climate science research has emerged that focuses on event attribution. It evaluates the extent to which the probability or intensity of an extreme event or type of event has changed as a result of increasing concentrations of GHGs in the atmosphere.

For example, a 2017 study by Teufel et al. looking at the 2013 Alberta floods found that climate change increased the likelihood of extreme rainfall in the region but that the snowmelt runoff contribution to flooding was not linked to human-caused climate change. Similarly, studies analysing the 2016 Fort McMurray wildfire found that climate change increased the likelihood of wildfire risk and extended the fire season in the region.

Sources: Teufel et al., (2017); Tett et al. (2018); Kirchmeier-Young et al. (2017); ECCC (2019).

with different impacts across the country (ECCC, 2019). However, other factors are relevant in shaping disaster losses as well. Flood and fire costs, for example, are affected by expanding development in at-risk areas, expansion of impermeable surfaces, wetland loss, aging infrastructure, construction methods, and increased property values (Intact, 2020). The exact attribution of events to climate change could become less important over time, however. Improving resilience to these types of events is important regardless of whether each event is directly attributed to climate change.

3. **Natural disaster costs do not capture the full impact on economic growth.** Adding up expenditures from an event is not the same as measuring the impact on the economy. However, our usual measure of economic growth—GDP—has drawbacks as well. First, rebuilding efforts typically increase GDP, as they add to economic activity. Second, losses

BOX 2.2:

The Economic Impact of the Fort McMurray Fire

The 2016 Fort McMurray fire resulted in over $5 billion in insured losses. There were also an estimated $1.4 billion in lost revenues from oil production. Federal, provincial, and municipal governments provided $615 million for recovery, with an additional $319 million from the Canadian Red Cross. A 2017 study found that the total cost of the fire was almost $9 billion when mental health and environmental impacts were included. The estimated net impact of the fire on Alberta's 2016 GDP, however, was only 0.1% ($465 million).

Sources: Adriano (2017); MacEwan University (2017); Antunes & Bernard (2016); Conference Board of Canada (2016).

in wealth or assets such as property values are not captured (Antunes & Bernard, 2016). It also does not include the opportunity cost, as more government spending on disaster response and recovery will likely mean spending less on other government services. Aggregate provincial or national estimates of the GDP impacts can also miss important local effects. The Fort McMurray fire, for example, resulted in only a 0.1 per cent impact on Alberta's 2016 GDP (Box 2.2). Tracking multiple types of costs at different levels of disaggregation and analyzing their impact on business and household activity over time would provide a more complete picture of the effects on the economy.

4. **Natural disaster costs do not measure progress towards economic resilience.** Over time, trends in the costs of climate change reflect both increasing climate risks from a changing climate (exposure) and the extent to which Canadian governments (at all levels), businesses, and households are preparing for and adapting to these risks. As a result, selecting an indicator to measure progress on economic resilience is challenging. As more risks are measured and extreme events become more intense and frequent, we could see an increase in costs. This does not mean adaptation efforts are not working, however. In order to assess effectiveness, we would need to compare actual costs to an estimate of what costs would have been in the absence of action. Analyzing future costs associated with different climate scenarios is therefore an important tool to establish a benchmark against which to assess the success of adaptation efforts.

DATA GAPS

Significant data gaps undermine our ability to understand the historical and future (expected) costs from climate change.

In terms of historical data, the Canadian Disaster Database does not provide consistent or comprehensive information to track costs over time. Cost information is not standardized or disaggregated, limiting the ability of researchers to undertake analysis that could identify priority areas for policy intervention. In many cases, certain types of costs (e.g., costs to household property) are unknown and omitted. Some events may not be recorded at all, particularly for small, Indigenous, and Northern communities that lack reporting capacity. Further, the database does not track the costs of non-disaster-related impacts that result from slow-onset climate change, which require very different datasets and analytical tools.

Climate change risk assessment, which is important for adaptation decision-making at both public- and private-sector organizations, is also a key gap. These risk assessments rely on both historical data and forward-looking scenarios of climate change impacts to help governments, homeowners, businesses, insurers, and lenders understand the most significant risks they may experience in the future and can inform adaptation actions. Understanding of historical and current risk is informed by information gathered during past disasters and through tools such as flood risk maps (Minano et al., 2019).

However, data regarding past events are inconsistent, and Canadian risk mapping is either highly inconsistent, incomplete, or absent. Mapping future risks is even more sporadic, due both to the absence of existing baseline risk information and a lack of research on the scope and cost of future climate impacts. If Canada is going to reduce costs, governments at all levels need to ramp up investment in efforts to improve our understanding of risk.

Assessing potential future slow-onset climate risks is yet another challenge. This requires a more comprehensive and systematic assessment of the potential impact of future climate scenarios on different sectors of the economy.

3 TECHNOLOGY DEVELOPMENT

Technology development will be critical both in addressing climate change and in supporting long-term economic growth. When Canadian companies develop new or improved technologies—such as innovative fuels, materials, or software—they provide better and cheaper options for businesses adopting technologies (Indicator #4) and new sources of economic growth and jobs. At the same time, these innovations can ultimately improve resilience and reduce greenhouse gas emissions, both in Canada and internationally.

HEADLINE INDICATOR

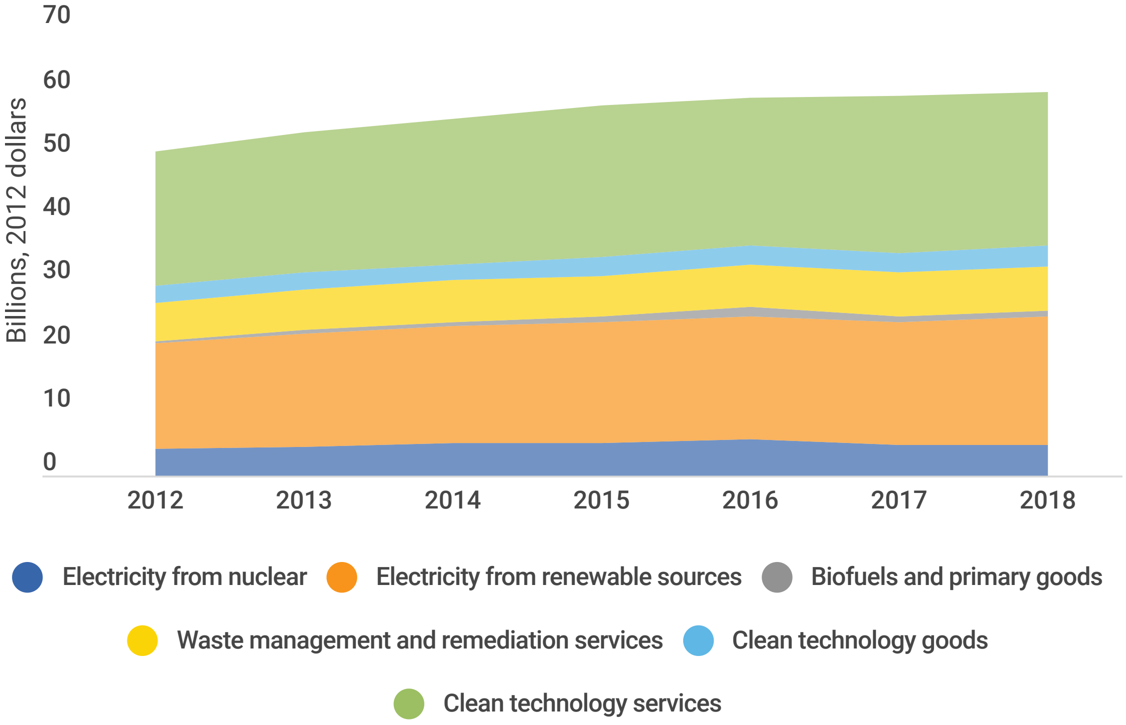
GDP of Environmental and Clean Technology Products

To measure low-carbon technology development, we use Statistics Canada data on environmental and clean technology (ECT) products as an estimate of goods and services sold by Canadian companies (Figure 3.1). An increasing contribution of these technologies over time would be a measure of cleaner growth. In 2018, the sector represented around three per cent of Canada's GDP ($66 billion in 2018 dollars, or $60 billion in 2012 dollars).

ECT products include any process, product, technology, or service that: a) prevents, reduces, or

FIGURE 3.1:

Real Gross Domestic Product, Environmental and Clean Technology Products in Canada (Billions, 2012 Dollars)



This figure shows the real GDP from environmental and clean technology products in Canada between 2012 and 2018. Overall, the sector has grown from about $50 billion in 2012 to over $60 billion in 2018. Electricity generated from renewable sources and clean technology services, such as scientific or construction services, represent the largest share of economic activity in the sector (34 per cent and 40 per cent respectively in 2018). Clean technology goods, which include manufactured products, such as electric buses or batteries, represented only five per cent of the sector's GDP in 2018.

Source: Statistics Canada (2020a). Note: all values are adjusted for inflation and reported in 2012 dollars.

eliminates pollution and environmental degradation; b) makes natural resource extraction more efficient; or c) makes industries less energy or resource intensive relative to the industry standard. This includes environmental products such as low-carbon electricity, biofuels, and recycling services, as well as clean technology manufactured goods, waste and scrap goods, and clean technology services (Statistics Canada, 2019).[7]

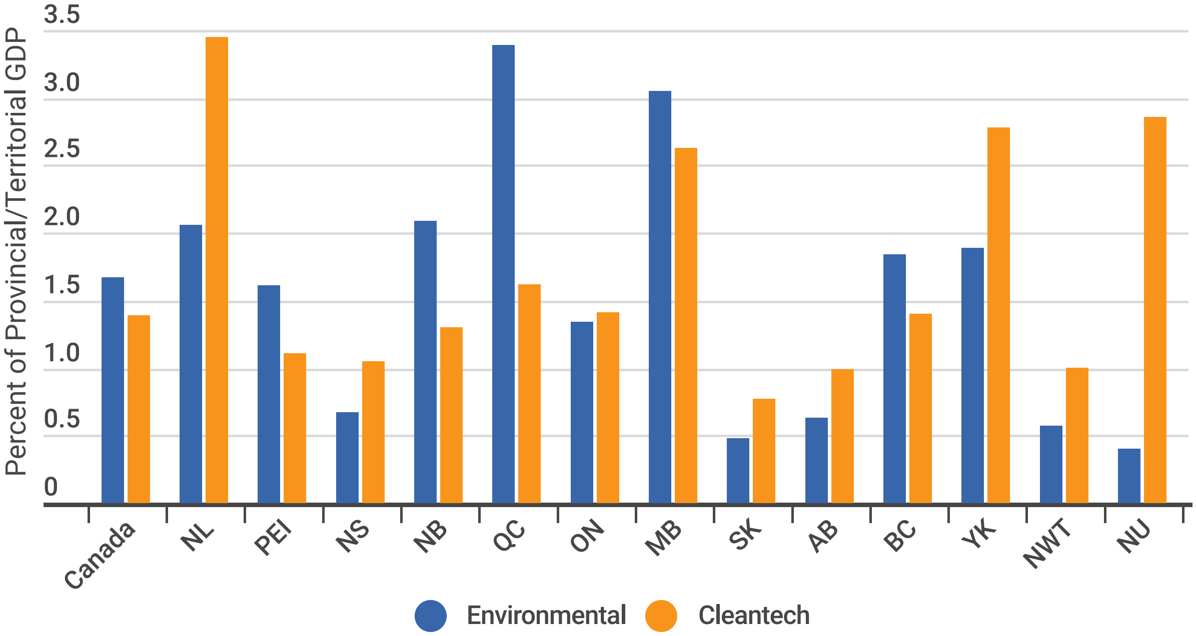
REGIONAL TECHNOLOGY DEVELOPMENT

Historically, growth in environmental and clean technologies has been uneven across the country. Three provinces contributed the most to Canada's environmental and clean technology GDP in 2018: Ontario (33.3 per cent), Quebec (30.5 per cent), and British Columbia (13.6 per cent). This is partly a function of the relative size of these provincial economies. Measured as a percentage of provincial/territorial GDP, however, Newfoundland and Labrador, Manitoba, Quebec, the Yukon, Nunavut, and New Brunswick generate a higher share of ECT products (Figure 3.2). Detailed provincial/territorial data show that a significant proportion of economic activity in leading provinces is driven by hydroelectric production, construction, and services (Statistics Canada, 2020b).

Clusters of clean technology activity are emerging across Canada, underpinning these regional trends, in part. In 2019, the Toronto Stock Exchange included five Canadian cleantech companies with market capitalization exceeding $100 million (Neufeld, 2019). Quebec has developed a strong transportation technology sector, with $1.4 billion in export revenues in 2018. B.C. is leading in bioenergy-related equipment and products (Statistics Canada, 2020d).

FIGURE 3.2:

Environmental and Clean Technology Products, % of GDP 2018



This figure compares economic activity in environmental and clean technology products across provinces and territories. It shows the value added of ECT products as a share of provincial and territorial GDP.

Sources: Statistics Canada (2020b; 2020c).

A 2019 study of the Alberta cleantech sector found significant technology development activity in small and medium-sized enterprises focused on cleantech, particularly in the Calgary region. Out of 78 companies, roughly half were less than five years old. Over half sell to oil, gas, and mining sectors; one-third sell to power and utilities; and one-fifth sell to agriculture and food processing. Almost 80 per cent of reported revenues came from exports to the U.S. market, as discussed in Indicator #5 (ACTia & MaRS Data Catalyst, 2019).

LIMITATIONS OF THE ENVIRONMENTAL AND CLEAN TECHNOLOGY PRODUCTS INDICATOR

While environmental and clean technology economic activity illustrates technology development in Canada, it has several limitations.

1. **ECT data do not provide a sense of potential future technology development.** The ECT GDP data shown in Figure 3.1 capture historical trends in environmental and clean technology product economic activity, not future growth potential. New, high-value innovations might look quite different from previous ones, especially with acceleration of domestic and global efforts to reduce emissions and respond to a changing climate.

   Patent data provide hints about future development but also raises questions. A 2017 study, for example, used patent activity in climate change mitigation technologies to find that Canadian researchers had a relative advantage in smart grids, buildings, traditional energy, clean energy enablers (e.g., batteries, hydrogen), and carbon capture, as well as geothermal, marine, and hydro energy. Companies did not, however, show the same relative advantages (CIPO, 2017). OECD patent data show that environmentally related technology patent applications by Canadian inventors peaked in 2011 and then declined, with a strong decline in patent filings for GHG-reduction technologies towards 2017 (OECD, 2020). Patents do not always result in significant economic activity, however, and innovations that result in significant economic activity do not always have patents.

2. **ECT data do not capture a full range of technology developments or innovations.** The data omit several key aspects of innovation. First, it excludes economic activity relating to products that are "cleaner" than comparable alternatives but are not purely "clean." Second, it excludes internal innovations developed by companies to improve their own environmental performance that are not sold to others. Statistics Canada's 2017 Survey of Innovation and Business Strategy provides some insight into these aspects of business innovation (Statistics Canada, 2019a; 2019b). The data illustrate a substantial proportion of firms in emissions-intensive sectors self-reporting the implementation of environmentally beneficial technologies and innovations (e.g., product and process innovations are shown in Figure 3.3).

3. **ECT data omit technologies relevant to economic resilience and low-carbon growth.** Water technologies are included in the ECT dataset and in patent data, but there are few other technologies that directly connect to resilience to a changing climate. A 2016 report prepared for Natural Resources Canada identified an initial list of potential technologies and services, including pest control, flood and fire-resistant building materials, saltwater intrusion remediation, and species monitoring (Deloitte & ESSA Technologies, 2016). And while the dataset includes most clean technologies relevant to reducing greenhouse gas emissions, it misses economic activity that could be important to success-

FIGURE 3.3:

Product or Process Innovations by Sector, 2015–2017 (Percentage of Firms that Implemented Any Type of Innovation During the Three-year Period)

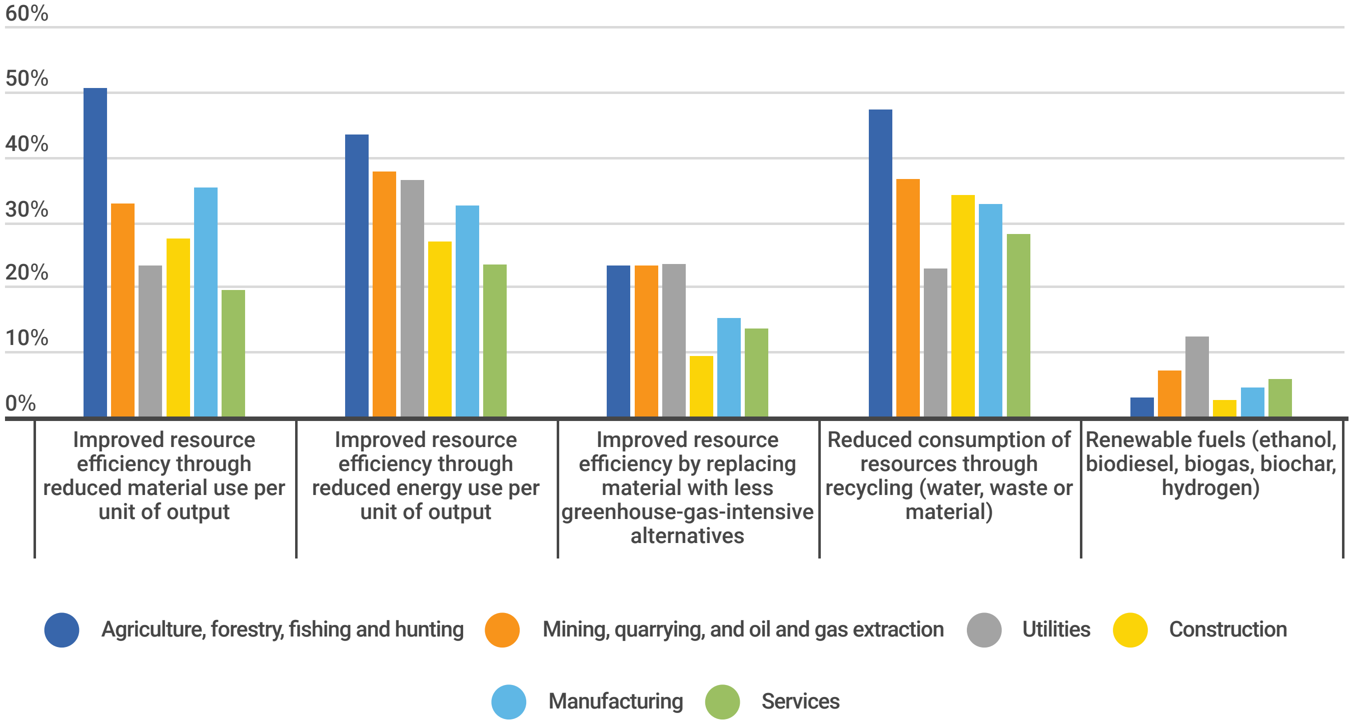


Figure 3.3 shows environmentally beneficial product or process innovations undertaken within sectors between 2015 and 2017. Firms have more innovations relating to energy, resource, and material efficiency than in switching to renewable fuels or less-GHG-intensive alternative materials.

Sources: Statistics Canada (2019a; 2019b).

fully decoupling GHGs from GDP. For example, it does not include activity related to mining of metal and minerals used in electric vehicles and batteries, or the use of bitumen for carbon fibre production that could help make strong, lightweight wind turbines and electric vehicles (JWN, 2020). While these technologies may not be considered "clean," they are likely to play an important role in the global low-carbon transition.

4. **ECT data do not give a sense of barriers to technology development.** Research shows that several factors hinder clean technology development in Canada, for both new and existing firms. These include a risk-averse domestic market, low adoption rates, lack of access to financing, competition for scarce investment dollars, and lack of certainty over climate policy (ESTCT, 2018; Hansen et al., 2017). Understanding these issues at a more disaggregated level would

support government policy decisions. Technology developers face various challenges at different stages in the innovation process. Box 3.1 provides an example of the type of analysis that could help, considering a snapshot of electrification cleantech companies in Canada that sit at various stages of technology development. Many of the companies have trouble accessing financing in the middle stage of technology development, between the lab and commercial demonstration, which generally requires more capital investment and involves greater risk (Fellows, Goodday & Winter, 2019).

5. **ECT data do not provide a sense of whether products are on track for future market needs and opportunities.** Developing technologies in Canada can generate important climate and economic benefits: new technologies can help more cost-effectively address climate change; they can also generate new sources of economic growth and jobs. The first requires an understanding of climate-related technology gaps in Canada to achieve climate objectives. The second requires understanding global market opportunities and identifying areas where Canadian companies could be

TABLE 3.1:

Global Climate Change Mitigation Technology Innovation Gaps (Selected Examples)

SECTOR	TECHNOLOGY INNOVATION GAPS
Electricity	Next-gen renewable and nuclear tech, emerging sources of power such as geothermal and ocean, grid integration, carbon capture utilization and storage (CCUS), grid support and firm power technologies (e.g., nuclear, hydrogen fuel cells or turbines, flexible carbon capture and storage [CCS], batteries, other storage) to support high levels of variable renewables
Buildings	Next-gen envelope, low-carbon concrete, flexible net-zero building and infrastructure building codes and guidance, lighting, and refrigeration tech, integrated storage for renewable energy, heat pumps, artificial intelligence for data centres
Industry	Carbon capture and storage (CCS and CCUS) for cement, chemicals and iron and steel; cheaper production methods for low GHG hydrogen and other inputs; use of waste; next-gen smelting
Transport	Hydrogen fuel cells targeted at the existing diesel motor market, alternative fuels such as cellulosic ethanol and hydrogen, batteries, vehicle to grid electricity, digitization and routing, next-gen commuter trains
Fuel Supply	Leak detection and repair; monitoring and measuring methane; planning and regulations for hydrogen/ammonia infrastructure

Source: IEA (2019); Sartor and Bataille (2019).

competitive. For example, several studies have identified global technological innovation gaps relating to GHG reduction (Table 3.1).

DATA GAPS

The scope of Statistics Canada's Environmental and Clean Technology Products dataset currently provides an imperfect measure of technology development needed to achieve clean growth. However, addressing these issues and limitations would not necessarily require a new approach, but rather supplementing and expanding existing datasets to consider a broader range of technologies and economic activities.

Greater technology disaggregation at a regional level could help identify specific sources of emerging expertise and comparative advantage. For example, the MaRS Data Catalyst (2019) survey shows some emerging technology development concentrations relating to electrification: several Quebec companies are active in off-road and application-specific electric vehicles; companies in Ontario are active in smart grid and smart home technologies; companies in Alberta are focused on industrial processes; and companies in British Columbia are targeting electric vehicles and electrification infrastructure (Filion, 2019; CTG, 2020). Statistics Canada's Survey of Environmental Goods and Services has made significant improvements in providing more detailed breakdowns for domestic sales and export revenues, but the data quality remains poor and detail is not available for some provinces and territories.

Improved tracking and analysis of the various sources of public research, development, demonstration, and commercialization programmes across governments would also help to identify successful approaches or combinations of approaches in terms of both emission reductions and economic growth.

BOX 3.1:

Developing Electrification Technologies in Canada

MaRS Data Catalyst analyzed survey data from 87 electrification-focused small and medium-sized cleantech companies in Canada, considering the stage of technology development and levels of public and private funding. For technology development, companies were slotted into different technology readiness levels (TRL). A TRL of 1–3 is the first stage after research and scientific discovery; TRL 4 verifies the technology in a laboratory environment; TRL 5–6 demonstrates the technology in a relevant environment; TRL 7 involves prototype demonstration; 8 is commercial demonstration; and 9 is commercial deployment.

Electrification Area of Interest	**1-3**	**4**	**5-6**	**7**	**8**	**9**
Battery, battery components (except EV-specific batteries)		4	1	2	2	2
Electric vehicle charging and related electrification infrastructure	1	2		5	1	1
Energy storage		2	2	2	2	
Heat pumps (air source, ground source, water source)				2	1	1
Industrial waste heat recovery		1	1	3	1	3
Light duty and other vehicles, as applicable			3		1	1
Off-road/application-specific electric vehicles	1	2		1	1	4
Smart grids	1		1			7
Smart homes		1	1	2	1	4
Industrial processes (except waste heat recovery)			1	1		
Space and water heating (except heat pumps)			1	1	1	
Other	2		1	2	2	
Grand total	*5*	*12*	*12*	*21*	*13*	*24*

The analysis shows that most of the companies surveyed were in the later stages of technology development, particularly for smart grid, off-road electric vehicle, smart home, and industrial waste heat recovery technologies. Companies at the mid-stages of technology development (TRL 5–6) tended to receive less public or private funding than they were seeking, indicating a struggle for financing. In the earlier stages, public funding dominates as a source of financing, while in later stages financing is primarily from the private sector. Overall levels of financing are lowest between TRL 5 and 7.

Source: MaRS Data Catalyst (2019).

4

TECHNOLOGY ADOPTION

Technology adoption also enables clean growth. It can make existing sources of growth more resilient and generate fewer emissions. It can also expand markets for new sources of growth by building economies of scale and reducing per unit costs. Moreover, many of the technologies needed in a clean growth future already exist at some level of technological development. The challenge is to accelerate adoption.

HEADLINE INDICATOR

Energy Intensity and Share of Low-carbon Energy

The magnitude and scope of technologies that could contribute to low-carbon growth and economic resilience is enormous, and there is limited data on resilience technologies. We therefore focus on adoption of low-carbon technologies to illustrate key aspects of adoption.

GHG emissions from energy use and energy production accounted for over 80 per cent of Canada's GHG emissions in 2018 (ECCC, 2020a). A key aspect of achieving low-carbon growth—where the economy grows as GHG emissions fall—will be to both reduce energy intensity and increase the proportion of low-carbon energy use.

The goal of technology adoption is to make progress in these areas. Therefore, as a metric of low-carbon technology adoption, we compare Canada's energy intensity and share of low-carbon energy to other G7 countries and the global average (Figure 4.1). While Canada has a higher proportion of low-carbon energy (25 per cent) than most other G7 countries, it also has higher energy intensity (using more energy per unit of GDP). Energy intensity fell across all G7 countries since 2005, including Canada, though the drop was larger in the U.S. and European countries (IEA, 2019).

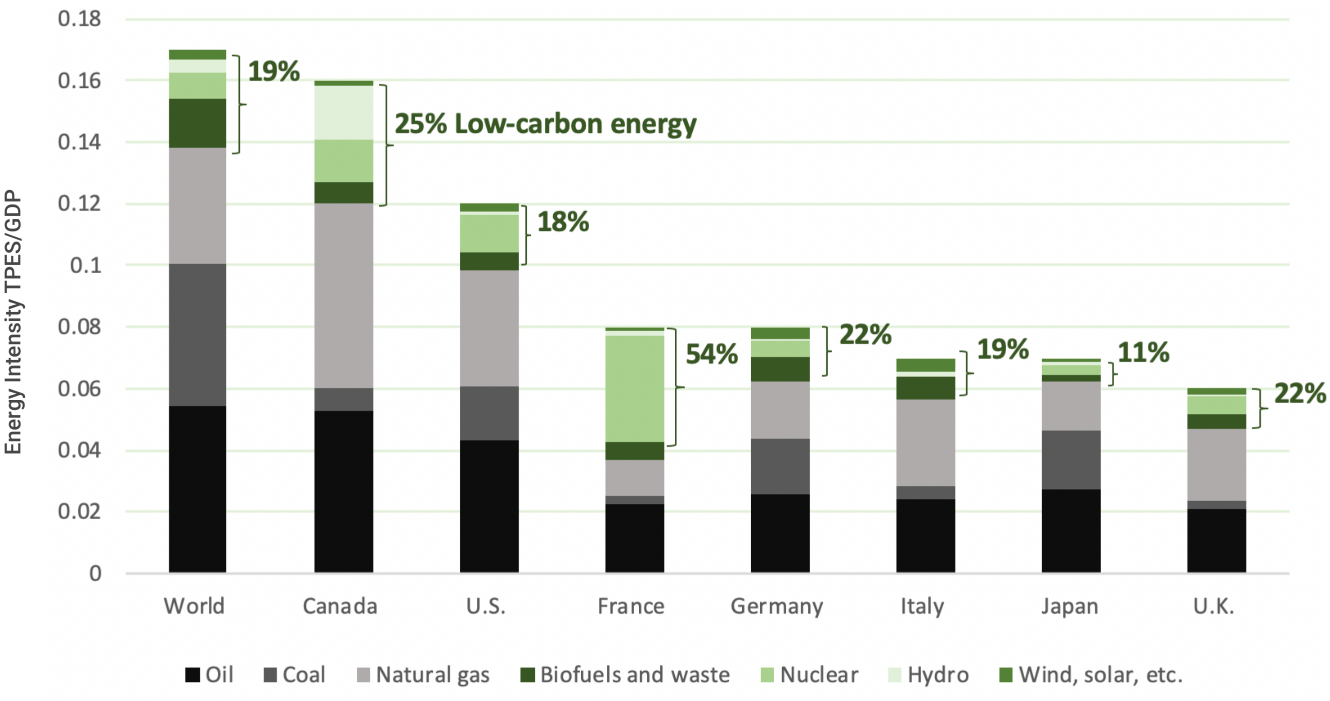
Differences across countries are often the result of varying resource endowments and historical investment decisions. Canada's role as an oil and gas exporter, for example, influences energy intensity results. While energy exports are excluded from the metric, the energy used to extract exported oil and gas in Canada is not. Canada's large territory and relatively cold climate can also partly explain higher levels of energy use than other G7 countries, though the increased frequency and intensity of heat waves linked to climate change is expected to drive higher energy use for air conditioning across countries in the future. France's historical investment in nuclear power, largely for energy security reasons, allows it to claim top spot in the G7 for low-carbon energy (WNA, 2020).

Greater adoption of four primary types of technologies can support progress on this indicator:

1. **Fuel-switching technologies** (e.g., coal to hydro power or gasoline to electric vehicles);
2. **Energy-use-reducing technologies** (e.g., energy-efficient furnaces or better insulation);
3. **Behaviour-changing technologies** (e.g., rapid public transit that enables reduced car use or remote work software and video conferencing that reduces driving and air travel); and
4. **Carbon capture and storage technologies** (e.g., fossil fuel carbon capture or direct air capture).

FIGURE 4.1:

Energy Intensity and Share of Low-carbon Energy, G7 Countries (TPES/GDP, 2018 or Latest)



This figure shows the energy intensity and share of low-carbon energy for G7 countries and the world in 2018. Energy intensity is calculated by dividing total primary energy supply (TPES) by GDP for each country. (TPES is equal to produced energy, plus imported energy, minus exported energy.) The share of low-carbon energy supply (biofuels, nuclear, hydro, wind, solar) is marked by the bracketed portion of total supply. Overall, Canada has a high proportion of low-carbon energy supply (25 per cent) but a higher energy intensity relative to other G7 countries.

Source: IEA (2019). Note: world TPES is from 2017; G7 countries are from 2018; TPES is measured in ktoe (kilotonnes of oil equivalent).

Figure 4.1 captures the first three types of technology, at least in terms of energy-related GHG emissions. Adopting technologies that reduce energy use and change energy consumption behaviour can lower the height of the bar, while fuel-switching technologies can change the percentage of low-carbon energy. The data do not, however, capture the fourth element. For example, it does not reflect the low-carbon aspects of Saskatchewan's Boundary Dam project, where its coal power plant uses carbon capture and storage technology to limit the release of GHGs into the atmosphere (although the energy used to capture emissions is included) (SaskPower, 2020). Technologies that reduce non-energy-related emissions from industrial processes, waste, and agriculture are also not captured.

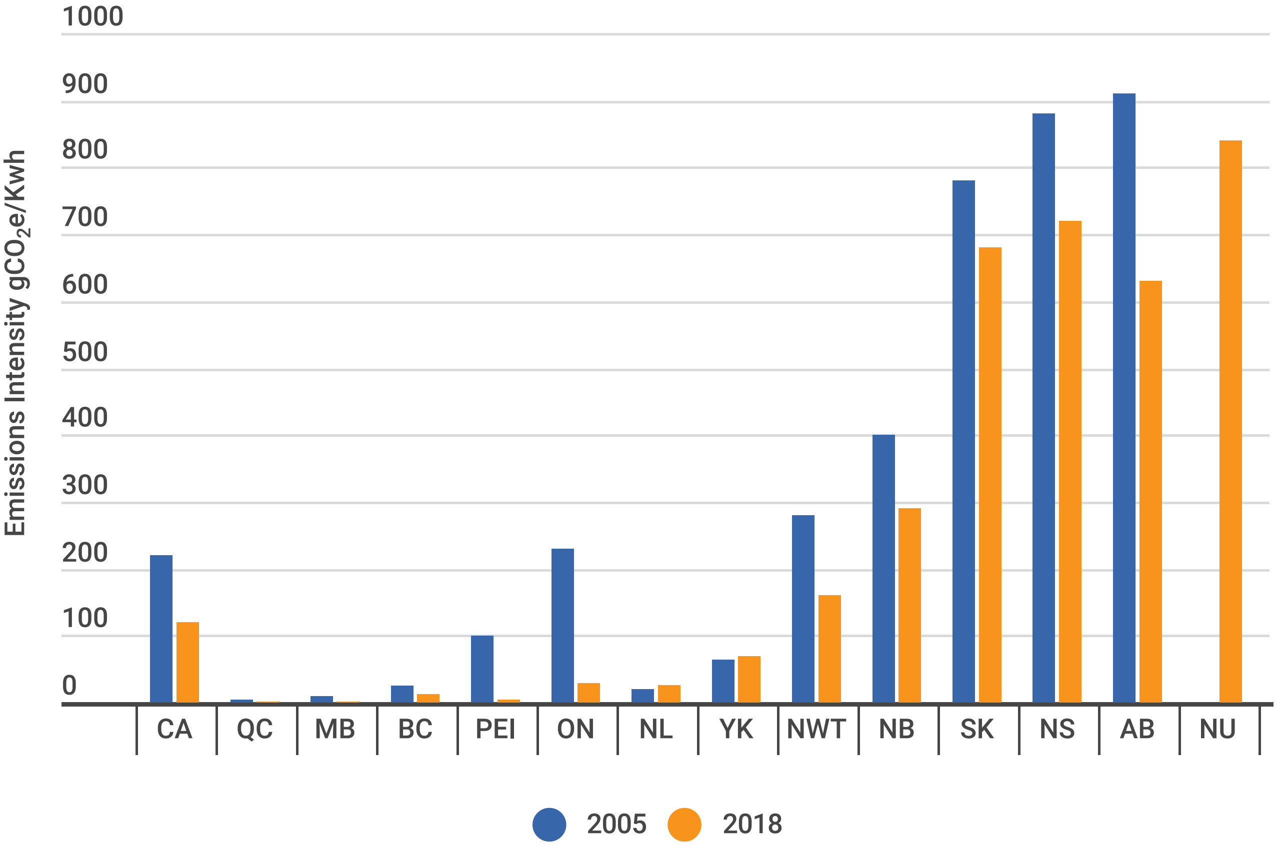
SECTOR-LEVEL LOW-CARBON TECHNOLOGY ADOPTION

To understand the underlying factors in the national results in Figure 4.1, we look more closely at key sectors of Canada's economy.

Canada's **electricity sector** is the main factor behind our relatively high percentage of low-carbon energy. Over 80 per cent of Canada's electricity generation is from low-carbon renewables or nuclear (CER, 2020). Still, there is scope to accelerate adoption further across all four types of technologies. Several provinces have electricity sectors that are more emissions-intensive, which limits their ability to decouple emissions from growth (Figure 4.2).

FIGURE 4.2:

GHG Intensity of Electricity Generation, by Province and Territory (2005 and 2018, CO_2e/kWh)



This figure shows the GHG intensity of electricity generation across provinces and territories between 2005 and 2018, starting with the least-GHG intensive provinces/territories on the left and moving to the most GHG-intensive provinces/territories on the right based on 2018 data. The type of technology used to generate electricity dramatically influences emissions intensity, ranging from low-emitting renewables such as wind and solar to high-emitting coal power. For Nunavut, GHG intensity was not available for 2005.

Source: ECCC (2020c).

Historical trends show significant decreases in emissions intensity over time. Policy is a key factor (for example, accelerated phase-out of coal-fired electricity). Dramatic decreases in the cost of wind and solar power have also played a role, with wind power now competitive with natural gas, coal, and nuclear power in Canada (CER, 2019). These sharp declines in cost reflect learning rates, economies of scale, and increased competition as adoption of wind and solar were scaled up internationally (Rubin et al., 2015). From 2008 to 2018, average global costs of onshore wind generation dropped by 24 per cent and the costs of solar photovoltaics dropped by 77 per cent (IRENA, 2019).

The emissions intensity of electricity generation is likely to become more important to decoupling over time, as electric end-use technologies become cheaper and more widely available, such as electric vehicles or electric heat pumps. The lower the emissions intensity of electricity generation, the greater the decoupling benefit of electrification.

Canada's **transportation sector** is the primary driver behind the oil use shown in Figure 4.1, mainly as a result of road transport (CER, 2020). In many provinces, transportation is now the largest source of GHG emissions (ECCC, 2020c). Emissions from light-duty gasoline trucks (such as SUVs and pick-up trucks) and heavy-duty diesel vehicles continue to increase, with the number of vehicles rising 86 per cent and 57 per cent respectively between 2005 and 2018 (Figure 4.3). The average vehicle in Canada has a lower fuel efficiency than other countries, reflecting preferences for larger vehicles, greater distances driven, and a colder climate (CER, 2019; NRCan, 2018).

Adoption of fuel-switching technologies such as electric vehicles, electric buses, and hydrogen trucks increased over this period, but they remain a small proportion of total vehicles. In 2018, zero- and low-emission vehicles represented four per cent of motor vehicle registrations, up from less than one per cent in 2011 (Figure 4.4). Technology options for fuel switching in aviation, rail, and marine transport are developing, which may increase future adoption rates. Behavioural change is also a key factor in transportation decoupling, particularly in terms of shifting between modes of transport (from car to public transport or from truck shipping to rail). Technologies can help make these types of behavioural changes more attractive (e.g., bike share applications, transit route planning).

FIGURE 4.3:

Road Transport GHG Emissions (Mt)

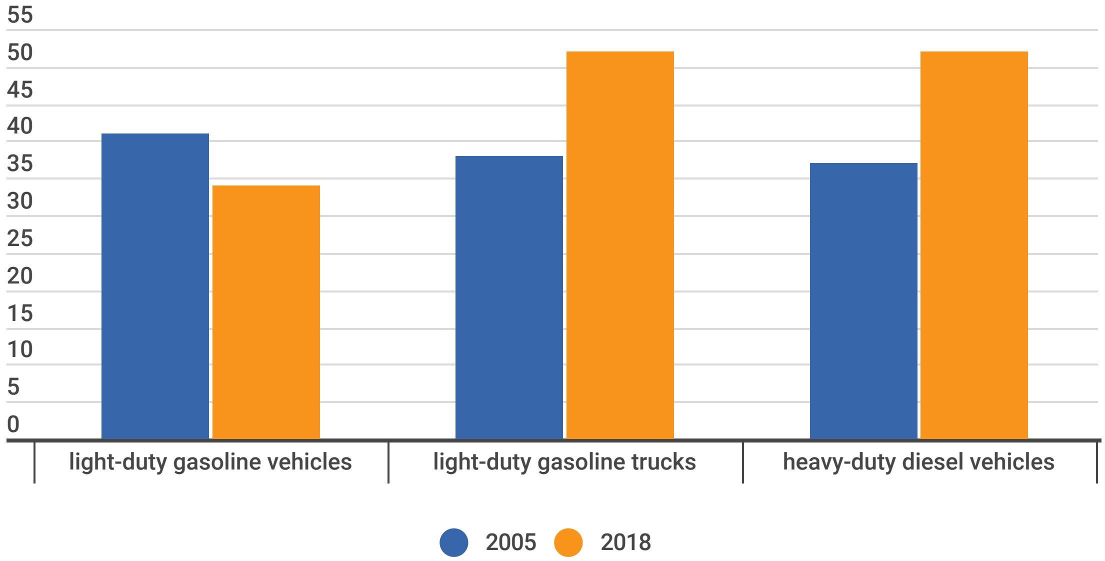
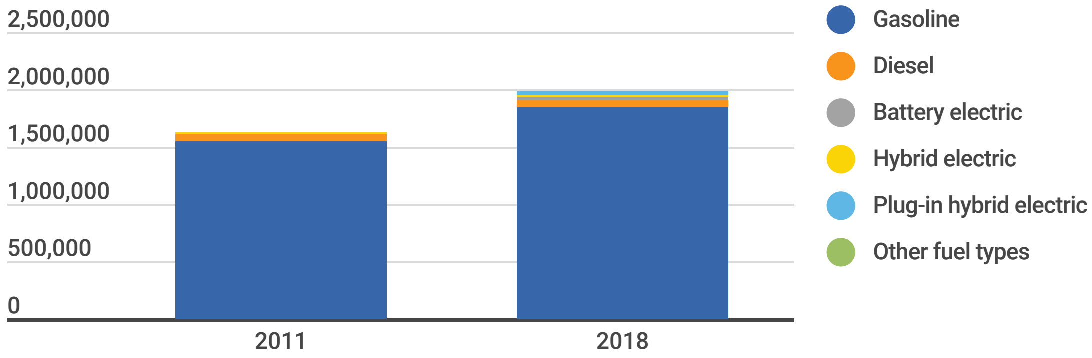


FIGURE 4.4:

Motor Vehicle Registrations (units)



These figures (4.3 and 4.4) show key trends in the transportation sector. Figure 4.3 shows GHG emissions from road transportation by vehicle type for 2005 and 2018. Emissions from light-duty gasoline trucks and heavy-duty diesel vehicles have increased substantially despite improvements in vehicle fuel efficiency, reflecting a consumer preference for SUVs and pick-up trucks and an increase in just-in-time delivery of products by truck. These data correspond closely with continued dominance of gasoline-powered vehicles in motor vehicle registrations, illustrated in Figure 4.4.

Sources: ECCC (2020c); Statistics Canada (2019a).

Emissions from light-duty gasoline trucks and heavy-duty diesel vehicles have increased substantially despite improvements in vehicle fuel efficiency, reflecting a consumer preference for SUVs and pick-up trucks and an increase in just-in-time delivery of products by truck. These data correspond closely with continued dominance of gasoline-powered vehicles in motor vehicle registrations, illustrated in Figure 4.4.

Canada's **industrial sectors** are the greatest source of overall energy use in Canada (CER, 2020). While most industrial sectors reduced their GHG emissions between 2005 and 2018 (Figures 4.5 and 4.6), oil sands emissions more than doubled over the period as production increased. There is some evidence of decoupling in heavy industry (e.g., cement, mining, steel), as emissions declined by more than gross output between 2005 and 2018

FIGURE 4.5:

Oil and Gas Emissions (Mt CO_2e)

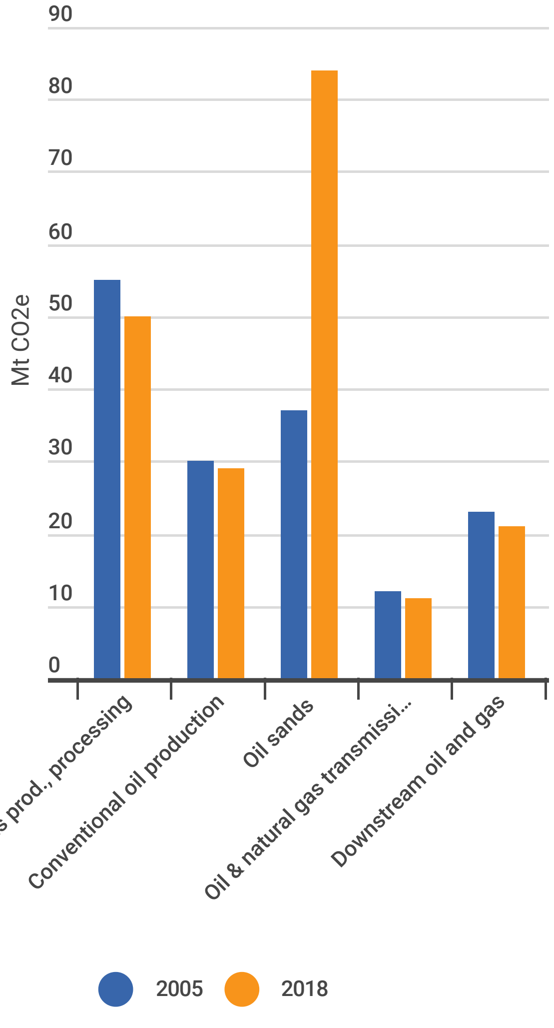
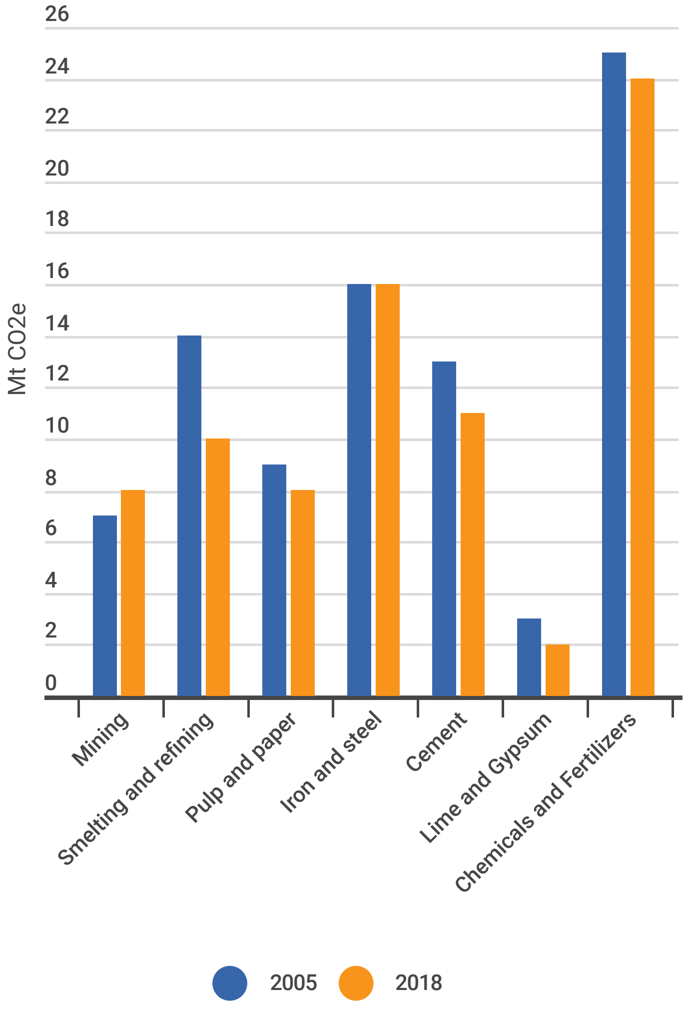


FIGURE 4.6:

Heavy Industry Emissions (Mt CO_2e)



These figures (4.5 and 4.6) show GHG emissions trends for the oil and gas sector and heavy industry for 2005 and 2018. Figure 4.5 shows that oil sands production is the biggest source of oil and gas emissions in 2018, more than doubling since 2005 due to increased oil sands production despite a decline in emissions intensity. Total emissions from most heavy industries declined from 2005 to 2018, with emissions declining by more than gross output. The emission decline reflects reduced output (e.g., cement), shifts within a sector (e.g., discontinuation of adipic acid production in chemicals), and process innovations (e.g., aluminum smelting reductions in perfluorocarbon emissions).

Sources: ECCC (2020b); ECCC (2020c).

(ECCC, 2020b). The emissions intensity of oil sands also declined over the period (ECCC, 2020c), which implies a greater rate of technology adoption. Most technology adoption to date has focused on energy-efficient technologies and cogeneration (combined heat and power). Further decoupling will require a greater emphasis on fuel switching (e.g., electricity, hydrogen, renewable fuels) and carbon capture technologies (Rissman et al., 2020).

After industry, commercial and residential **buildings** are the largest users of natural gas in Canada. Because buildings are some of the longest-lived assets in the economy, energy-use-reducing building technologies can also have a significant impact on long-term, low-carbon growth. New building investments today that are not low-carbon will increase the emission reduction challenge for other sectors in the future. Adoption of energy-use-reducing technologies has reduced emissions per household, helping slow emissions growth to only 1 Mt between 2005 and 2018 (ECCC, 2020c) (Figure 4.7). Energy-use-reducing actions and fuel switching helped reduce emissions per square metre of commercial floor space, but overall emissions still increased by around 6 Mt between 2005 and 2018 (Figure 4.8). Significant further emissions intensity reductions will require fuel-switching technologies. Options include renewable natural gas, hydrogen, electrification, district heating, and geothermal heating (ECCC, 2016).

While **agriculture** is not a large consumer of energy, it is the biggest source of non-energy-related GHG emissions. Emissions from on-farm energy use have increased slightly since 2005

FIGURE 4.7:

Residential Building Emissions Intensity (Mt CO_2e/millions of households)

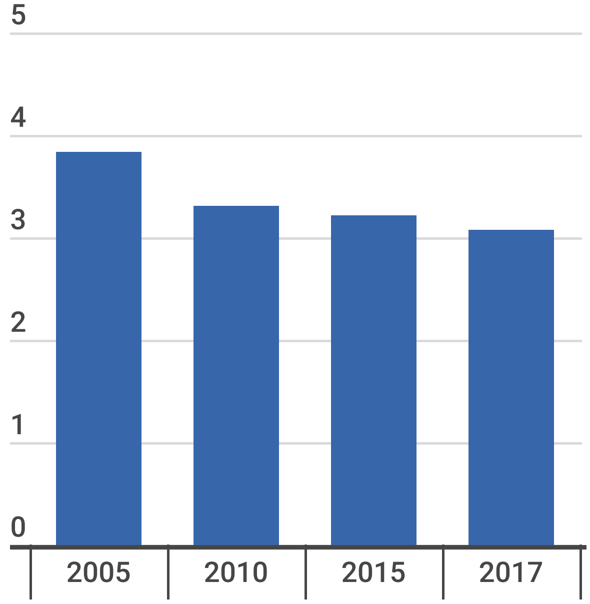
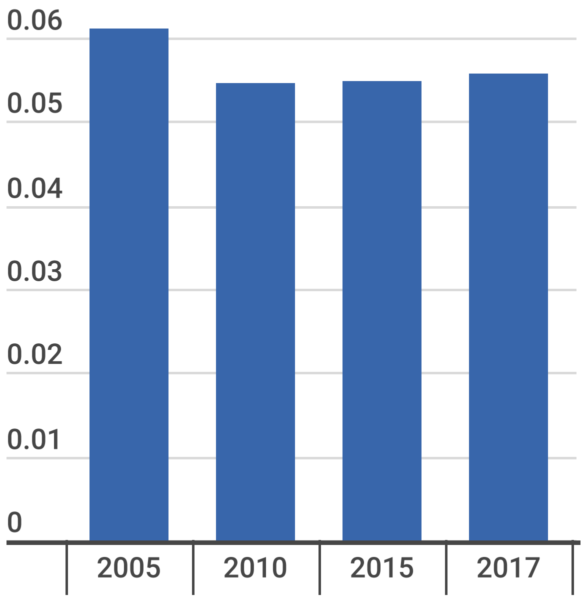


FIGURE 4.8:

Commercial Building Emissions Intensity (Mt CO_2e/m^2 floor space)



These figures show key trends in GHG emissions from buildings. For residential buildings, Figure 4.7 shows residential building emissions intensity, which decreased gradually between 2005 and 2017 as a result of energy-efficiency improvements offsetting an increasing population and demand for larger homes. Figure 4.8 shows GHG commercial building emissions intensity, which decreased sharply between 2005 and 2010, but has gradually increased since due to growing demand for commercial space, including large-scale warehouses for product distribution.

Source: ECCC (2020b).

(from 12 to 14 Mt CO_2e). Most agricultural GHG emissions come from fertilizer use in crop production and methane emissions from farm animals. Emissions from crop production increased by 50 per cent between 2005 and 2018, while yields grew by around 30 per cent over the same period (ECCC, 2020c, Statistics Canada, 2020). Emissions from animal production decreased by around 16 per cent over the period, largely due to decreased cattle herds (ECCC, 2020c). Agriculture technology adoption is slowly increasing, particularly in terms of efficiency. Precision agriculture, for example, is driving increased yields with fewer inputs such as fertilizer, pesticides, and water through the use of technologies such as GPS, sensors, drones, and specialized software (Shorthouse, 2019).

Statistics Canada's Survey of Innovation and Business Strategy also provides an indication of clean technology adoption by sector and region (Figure 4.9). While only 10 per cent of firms in the survey use clean technologies, there is variation across sectors. For example, 36 per cent of utilities (electricity, natural gas, and water) use clean technologies, including energy-efficiency equipment, smart grid technologies, low-carbon energy, and energy storage (Statistics Canada, 2019b, 2019c). Utilities are also the highest users of technologies relating to geomatics and the Internet of Things, linked to smart grid technologies, particularly in Ontario (Statistics Canada, 2019c). In Atlantic Canada, 84 per cent of utilities are using clean technologies. Ontario, on the other hand, has greater uptake of clean technologies than other regions in the agriculture, forestry, hunting and fishing sector and in mining, quarrying, and oil and gas (Statistics Canada, 2019b).

BARRIERS TO TECHNOLOGY ADOPTION

Tracking the rate of technology adoption is important, but data can also inform the underlying reasons why adoption rates for a technology may be slow. Drawing on surveys by Statistics Canada, the DEEP Centre, and others, we distill various reasons into four factors that influence the rate of low-carbon technology adoption: stock turnover timelines; technical feasibility; cost; and government policy (DEEP Centre, 2016; Statistics Canada, 2019d; Dow, 2019).

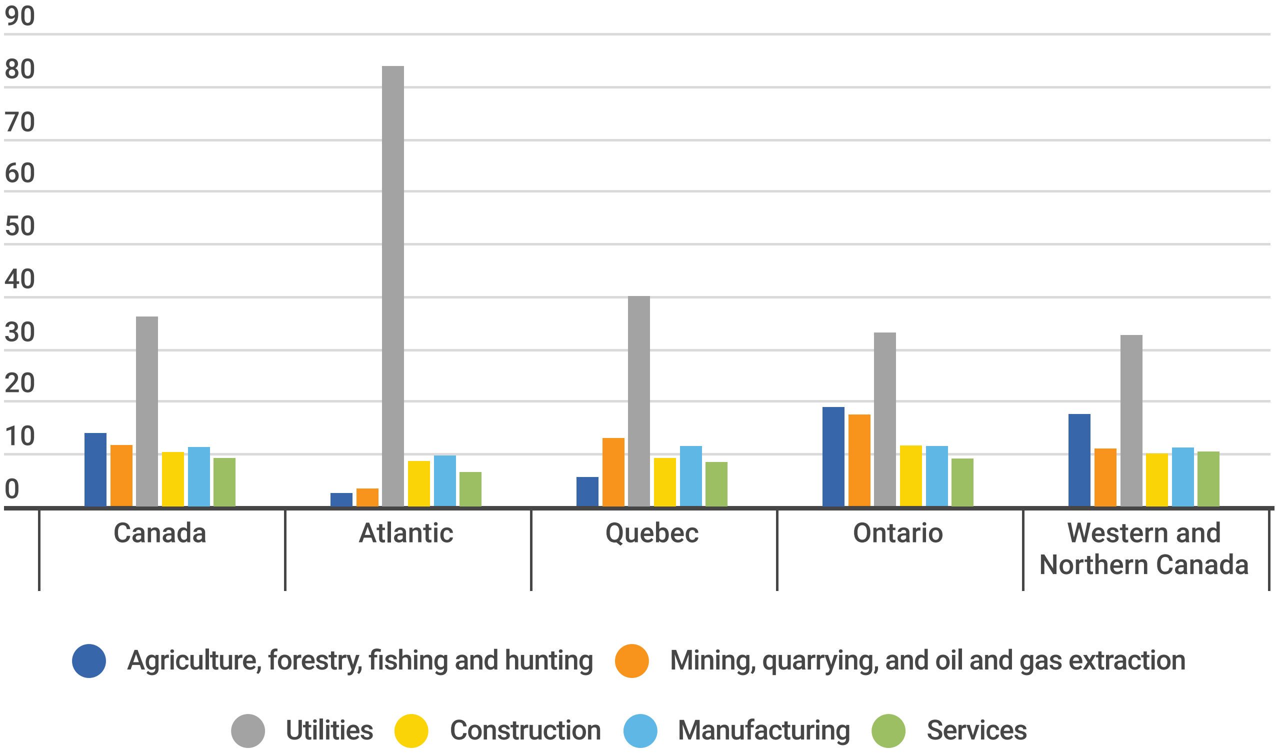
Stock turnover timelines play a major role in adoption rates. Businesses and households normally wait until existing stock wears out and requires replacement before investing in something new. Vehicle turnover is in the range of 10 years, but the timeframe is much longer for industrial boilers (25–50 years) and residential buildings (25–100 years) (DDPP, 2015). Replacing technology before the end of its useful life is generally higher cost than taking advantage of natural turnover cycles for capital stock.

Technical feasibility refers to how the adoption of technology influences product quality from a user perspective. For example, if adopting a certain technology results in higher levels of production for a business or improves product quality, it would have a higher technical feasibility. Consider electric vehicle adoption. Consumers concerned about battery range (how far a vehicle can drive before it needs a charge) would view vehicles with more range to have higher technically feasibility than those with lower ranges (Dow, 2019). Technical uncertainty, and a lack of technical knowledge or skill, can also hinder adoption rates (DEEP Centre, 2016).

Cost, both upfront and ongoing, is also a significant factor in determining adoption rates. In a 2016 survey of 72 firms in Canada, three-quarters said that cost was the number one challenge in adopting clean technologies (DEEP Centre, 2016). Cost considerations also fall along a spectrum. While most technology adoption is likely to involve some level of upfront cost, there can be net savings over time. Energy efficiency technologies, for example, can reduce energy costs. The challenge for businesses is how the rate of return compares to other potential investments they can make. If the upfront cost is high, the time to

FIGURE 4.9:

Use of Clean Technologies by Region and Sector, 2017 (Percentage of Firms)



This figure shows the use and adoption of clean technologies by sector and region in Canada in 2017. It is measured as the percentage of firms that use a defined set of technologies. Aside from utilities, where adoption rates range between 30 per cent to 80 per cent, the adoption rate of clean technologies in other sectors is less than 20 per cent. Notably, over 80 per cent of utilities in Atlantic Canada adopted clean technologies, which is over double the Canadian average.

Source: Statistics Canada (2019b).

payout is long, and the rate of return is uncertain, firms will be less likely to choose low-carbon investments (DEEP Centre, 2016).

Government policy (and the stability and certainty of those policies) plays an important role in influencing the cycle of technology adoption and development. Climate policies such as regulations, building codes, pricing, or financial incentives lead companies and individuals to increase adoption of climate-related technologies. Clear policy signals can help provide a level playing field within sectors and strengthen the case for business investment. Increased adoption in turn increases the size of the market, driving the investment and innovation underpinning additional technology development, which then improves technical feasibility and cost over time. Early government policies such as Germany's feed-in tariff, for example, increased the size of the market for wind and solar, attracting more investment for companies developing these technologies and improving global economies of scale. Policies and investments in China further increased market size and drove competition that improved both technical feasibility and cost. Wind and solar are now often cost-competitive with fossil fuel alternatives, which has led to higher adoption rates (IRENA, 2019).

DATA GAPS

There is limited publicly available data on technology adoption rates relating to resilience and adaptation to a changing climate. Resilience technologies can be divided into three primary categories: **prevention technologies** (e.g., robot firefighters that can put fires out before they spread, water-permeable concrete, or biopesticides); **avoidance** technologies (e.g., early-warning systems or tick-tracking systems to avoid Lyme disease); and **protection technologies** (e.g., fire-resistant building materials, drones, or urban cooling technologies). There is less publicly available information on adoption rates of these technologies, nor is there even a comprehensive menu of technologies that could be beneficial to improving resilience in Canada. Developing a list of priority technologies relevant to Canada, and tracking adoption rates over time, would support more detailed research and analysis, while informing government policy.

As efforts to address climate change accelerate, the distinction between mitigation and adaptation technologies may blur. For example, carbon-negative concrete, energy-efficient air conditioning, or green roofs can support both objectives. There may therefore need to be a third category of low-carbon and resilient technologies.

5

LOW-CARBON AND RESILIENT TRADE AND COMPETITIVENESS

By engaging in international markets for low-carbon and resilient products and services, Canada can enable and reinforce clean growth over time. Trade in low-carbon and resilient products and services is also an important measure of Canada's competitiveness as global markets shift.

HEADLINE INDICATOR

Trade in Low-carbon and Resilient Goods and Services

Canada can contribute to a positive global cycle in trade. Development of better and cheaper climate-related technologies, goods, and services in Canada can help grow exports to countries seeking to improve climate outcomes—which provides new (and clean) opportunities for economic growth here at home. At the same time, imports of climate-related products and services from other countries can help grow global markets, driving additional global innovation and cost reductions. Imports can also provide Canadian consumers with more choice at better prices, while reducing the carbon emissions embodied in goods and services that Canadians produce and consume. If enough countries become part of this positive cycle, climate action will become cheaper and easier over time.

To measure Canada's climate-related trade, we track the country's exports and imports of environmental and clean technology (ECT) merchandise and services between 2012 and 2018.[8] As Canada transitions to 2050, expanding ECT trade over time is an important component of clean growth and making Canada more competitive in a low-carbon global economy.

As Figure 5.1 illustrates, trade increased in absolute terms and as a share of GDP since 2012. In 2012, trade in ECT represented about 1.2 per cent of Canada's total economy, generating $20 billion in GDP; by 2018, the share of GDP increased to nearly 1.6 per cent and generated $30 billion (inflation-adjusted). This trend in Canada is consistent with broader trends in international markets, where demand for climate-related goods and services continues to grow at a rapid pace (Analytica Advisors, 2017; Elgie & Brownlee, 2017).

As Figure 5.1 illustrates, the current share of trade in ECT is small, representing roughly one and a half percent of Canada's total economy. It also shows that growth in ECT trade has been relatively slow when adjusted for inflation. Still, it is important not to minimize the total value of these traded goods and services. Trade in ECT grew at a faster rate than Canada's total economy. And as discussed in Indicator #3, the sector represents around three per cent of Canada's GDP when both exports and domestically purchased ECT are considered.

Several other trends are noteworthy. For both exports and imports, manufactured goods were the most heavily traded type of ECT merchandise or service by value (about 65 per cent of total ECT imports and 45 per cent of exports in 2018). In particular, trade in complex manufactured goods experienced some of the largest growth. Trade in biofuels (both exports and imports) also increased significantly, driven in large part by mandated blending requirements by provincial and federal governments. Finally, it is notable that while exports of clean electricity (nuclear, renewables) represent over one-tenth of Canada's total ECT exports (by value), they did not grow over this period. In every category, most of Canada's trade in ECT—like the rest of Canada's international trade—was with the U.S., accounting for 75 per cent of exports and 61 per cent of imports (Provenzano et al., 2019).

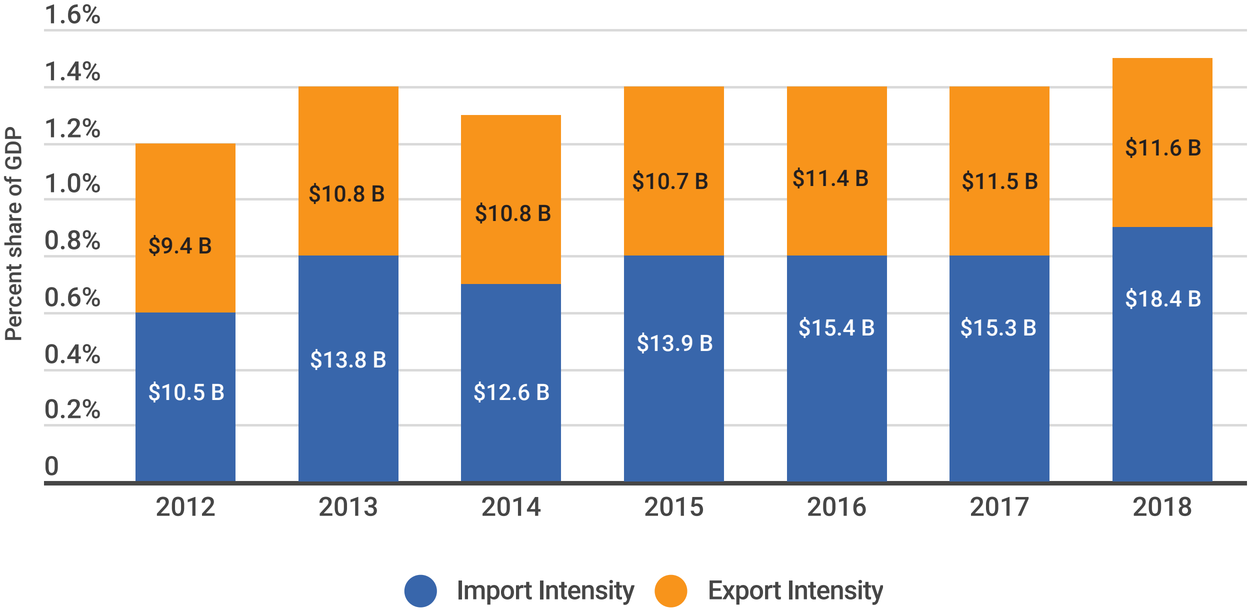
PROVINCIAL TRADE IN CLIMATE-RELATED GOODS AND SERVICES

Provincial trade in ECT varies across provinces. Figure 5.2 shows the relative trade intensity of ECT merchandise and services across provinces for 2018 (i.e., ECT exports and imports as a share of provincial GDP). It also shows absolute values to help illustrate the provinces where ECT trade is highest (in 2012 dollars). New Brunswick, for example, had among the highest share of ECT trade as a percentage of its GDP (about 1.8 per cent), driven largely by increasing trade (both imports and exports) of nuclear electricity, biofuels, biomass, and other primary goods (Statistics Canada, 2020a). However, at $0.5 billion, the value of this trade was smaller than in most other provinces.

Overall, a few high-level trends stand out. In dollar terms, Ontario, Quebec, and British Columbia were the largest exporters and importers of ECT merchandise and services in 2018 (by value), accounting for 80 per cent of total Canadian trade. At the same time, not all provinces saw an increase in ECT trade between 2012 and 2018 as a share of provincial/territorial economies. While the share of ECT trade grew in New Brunswick, Quebec, Ontario, Manitoba, Saskatchewan, Alberta, and B.C., it shrank in Newfoundland and Labrador, P.E.I., Nova Scotia, and the territories.

FIGURE 5.1:

Canadian Exports and Imports of Environment and Clean Technology Merchandise and Services as a Share of GDP (millions, 2012 dollars)

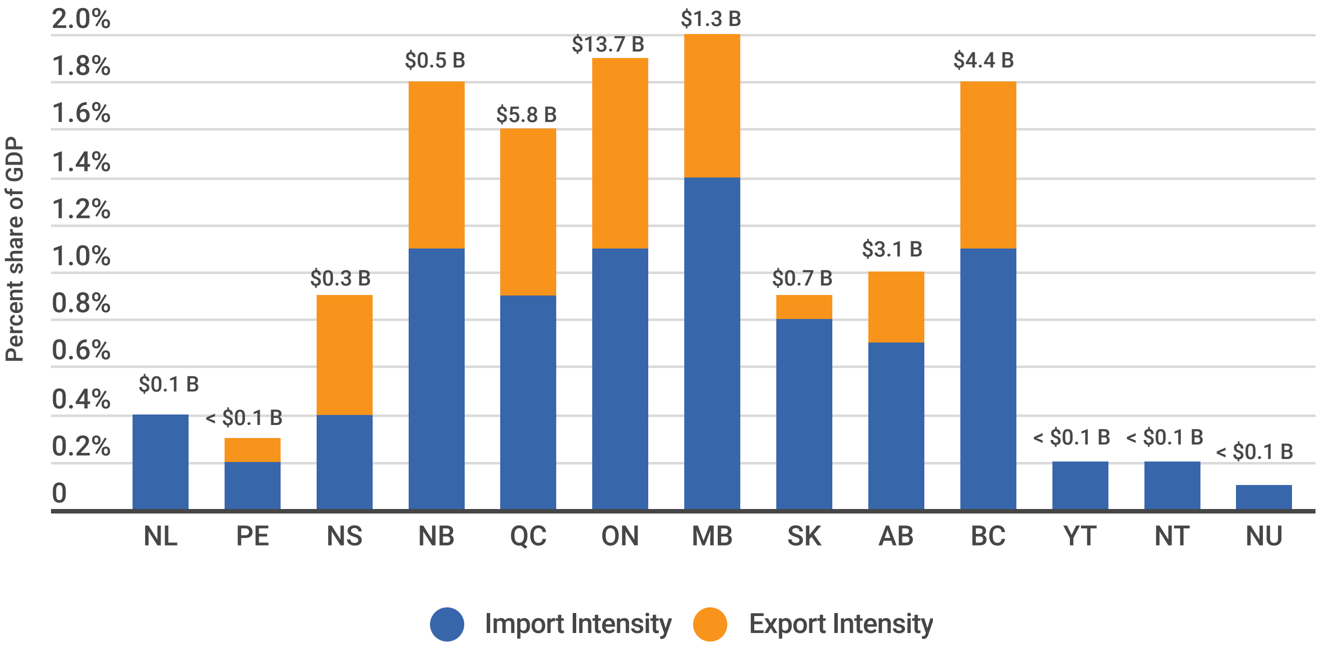


The figure measures the total value of exports and imports in ECT merchandise and services between 2012 and 2018 in real terms relative to the size of the Canadian economy (GDP). Overall, ECT trade as a share of Canada's GDP has increased from 1.2 per cent in 2012 to nearly 1.6 per cent in 2018. Total trade volumes increased as well, increasing from roughly $20 billion in 2012 to $30 billion in 2018.

Source: Statistics Canada (2020a). Note: Values are adjusted for inflation, reported in constant 2012 dollars.

FIGURE 5.2:

ECT Trade Intensity, by Province (2018)



This figure shows provincial ECT exports and imports as a share of each province and territory's GDP in 2018. Overall, the share of ECT varies significantly. Territorial economies, for example, have little or no exports of ECT goods and services. In contrast, provinces such as B.C., Manitoba, Ontario, Quebec, and New Brunswick generate between 0.6 per cent to 0.8 per cent of their GDP from exports of ECT goods and services. With the exception of Nova Scotia, imports of ECT comprise a larger share of ECT trade across provinces and territories.

Source: Statistics Canada (2020a). Note: All values are adjusted for inflation, reported in 2012 dollars.

Comparisons between specific provinces can also provide important information on trade. The differences between B.C. and Alberta are particularly interesting. Despite having similar populations, the share of ECT trade in British Columbia's economy was roughly double the share of ECT trade of Alberta's economy in 2018 (1.8 per cent compared to 0.9 per cent). Total ECT trade in B.C. generated $4.4 billion, compared to $3.1 billion in Alberta.

GLOBAL INFLUENCE THROUGH CLIMATE-RELATED FINANCE

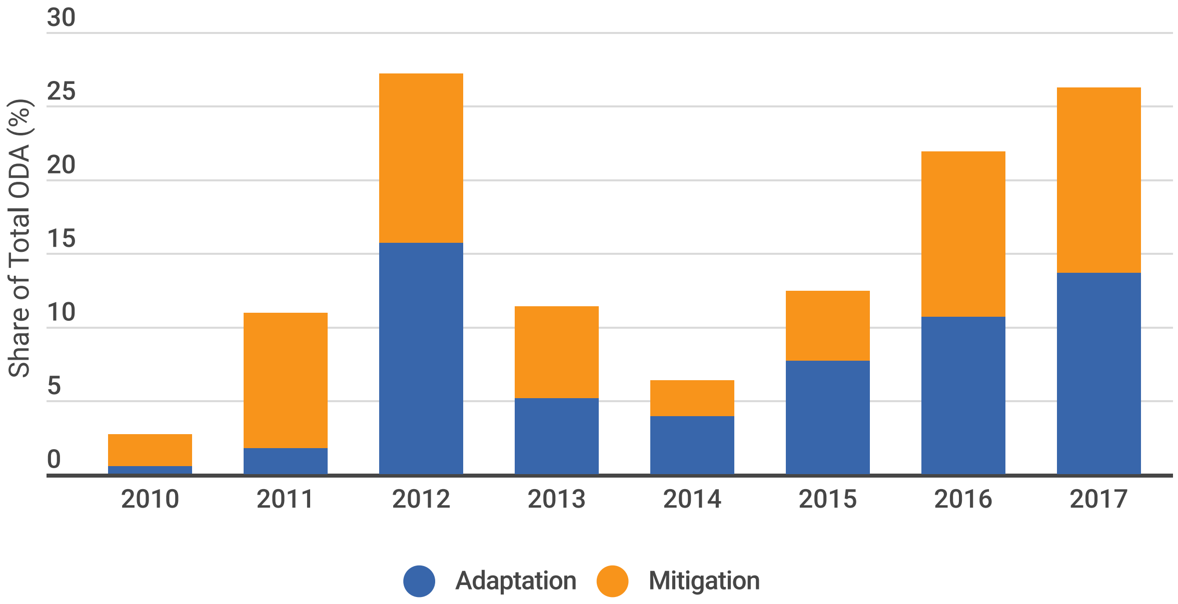
Exporting and importing directly with other countries is not the only way that Canada can influence global trade in low-carbon and resilient goods and services.

Financing climate initiatives abroad offers an important way that Canada can support the positive cycle associated with trade in low-carbon and resilient goods and services. Public and private sources of finance can provide critical access to capital in developing countries, helping support investments that reduce emissions and improve resilience. Financing from Canada can help build essential capacity, knowledge, and skills that generate other important economic and social benefits (OECD, 2017; IFC, 2018).

Although there are different types of public and private international financial flows, official development assistance (ODA) data illustrate that Canadian funds can help catalyze climate-related trade abroad. ODA includes financial aid provided by Canadian governments to developing countries to

FIGURE 5.3:

The Share of Canadian Official Development Assistance Going towards Mitigation and Adaptation Initiatives



This figure shows the relative share of Canadian official development assistance (ODA) dedicated to climate-related initiatives between 2010 and 2017. Although ODA is tagged as either adaptation or mitigation, it should be noted that projects often overlap. As well, not all government funding is categorized as ODA and included in the figure. In 2017–2018, for example, Canadian governments provided a total of $1.5 billion in international climate-related funding. Of this, about two-thirds was counted as ODA (ECCC, 2019).

Source: OECD (2020).

promote economic development and overall welfare, often through grants, soft loans, and technical assistance (OECD, 2018). Figure 5.3 shows the share of Canadian ODA going towards mitigation and adaptation initiatives between 2010 and 2017. While the share of ODA for climate-related measures decreased substantially after 2012, it has since returned to its previous high. In 2017, over one-quarter of Canadian ODA went towards mitigation and adaptation initiatives abroad, which was higher than the average share in other OECD countries (17 per cent). Generally, the increasing share of Canada's ODA related to mitigation and adaptation is consistent with the broader trend across OECD countries (OECD, 2017).

Foreign direct investment (FDI) is another important area of climate-related finance and trade. Investments flowing into Canada from abroad (domestic FDI) can help the Canadian economy adjust as global markets shift and provide a key source of economic growth. At the same time, FDI flowing abroad from Canadian investors can support international activities that address climate change while increasing global clean technology market size and driving economies of scale. With better disclosure requirements, FDI can also help achieve other important social and environmental goals, such as fulfilling requirements relating to free, prior, and informed consent as well as meaningful engagement with Indigenous people (see Box 5.1).

Figure 5.4 shows Canadian FDI flows between 2005 and 2018 in the 10 largest sectors. Importantly, these investment flows do not necessarily support global efforts to reduce emissions or improve resilience to a changing climate. FDI in oil and gas extraction and petroleum and coal product manu-

BOX 5.1:

Using Disclosure to Fulfill Requirements of Free, Prior, and Informed Consent

Disclosure requirements at the firm level can play a significant role in directing foreign direct investment (FDI) towards projects that meet multiple environmental and social objectives. The Sustainability Accounting Standards Board, for example, tracks whether resource projects are consistent with the United Nations Declaration on the Rights of Indigenous Peoples. While these international standards are nascent and voluntary, they show a path to incorporating the use of free, prior, and informed consent (or consultation) processes into FDI—both in Canada and abroad.

Sources: Rohan (2019); SASB (2018).

facturing, for example, nearly doubled between 2005 and 2018. These trends highlight the importance of investors incorporating climate-related risks into their decision-making processes.

The data in Figure 5.4 do, however, suggest significant growth in service sectors, which are typically less carbon-intensive than natural resource extraction and goods manufacturing. The biggest area of growth across all sectors was finance and insurance FDI abroad, which more than tripled between 2005 and 2018. As global markets shift, tracking investment flows can highlight areas where Canadian investors may be exposed to risk from carbon-intensive activities or are successfully capturing emerging opportunities.

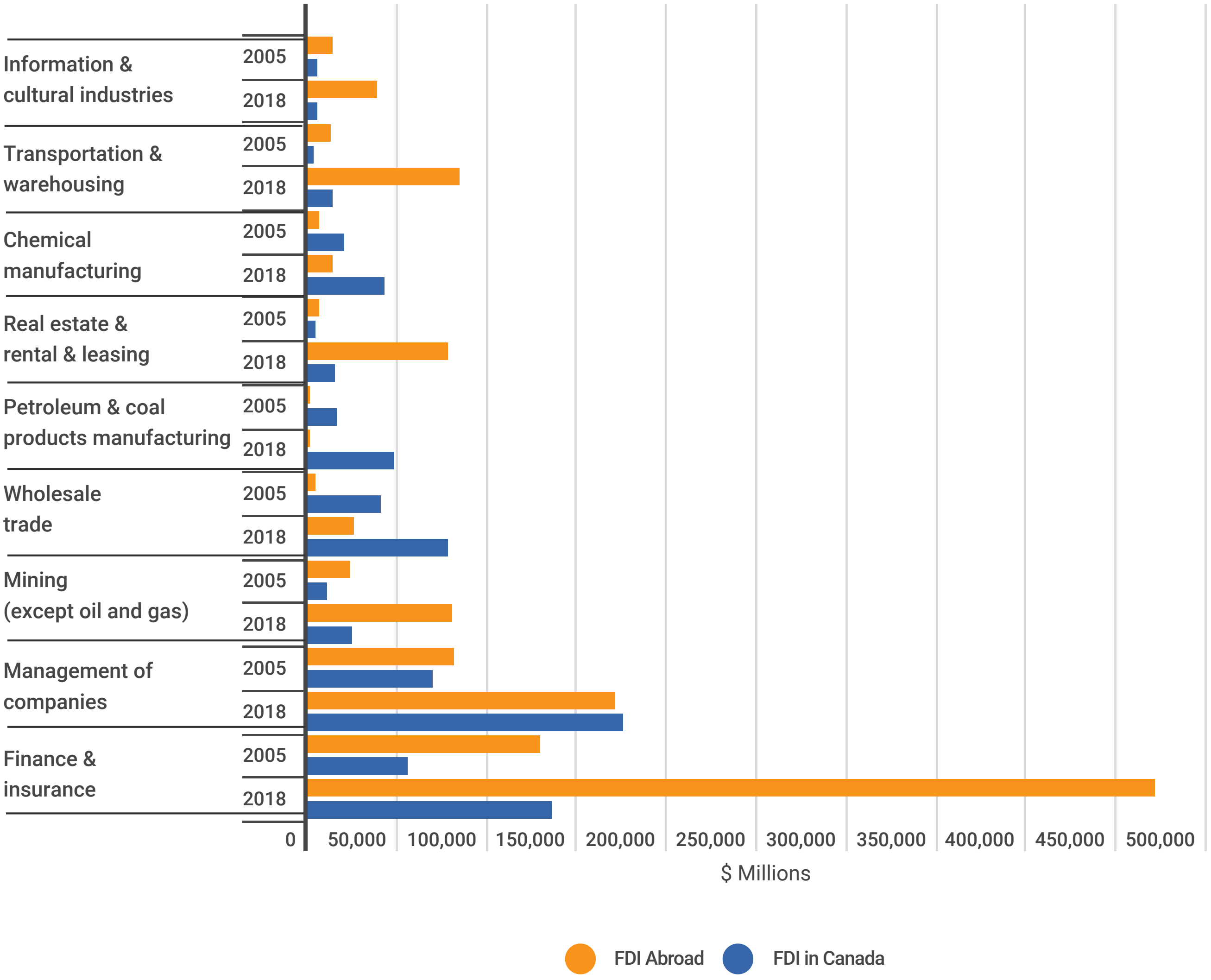
DATA GAPS

As mentioned in Indicator #3, broadening the technologies, products, and services included in Statistics Canada's Environmental and Clean Technology Products data would provide a more complete picture of clean growth progress relevant to climate change. The database does not include technologies relating to resilience and adaptation or to mining and minerals for clean technologies, for example. Some of these missing technologies could be important sources of low-carbon and resilient trade.

Data on climate-related public and private international financial flows raise similar challenges. Within Canada, climate-related finance comes from both the private and public sector—sources that are spread across the country. In many cases, these funds are added to financing from other sources outside Canada (which could be governments, organizations, and the private sector), which is then used to leverage additional private-sector funding in the recipient country. Tracking these individual contributions from Canada is complex.

FIGURE 5.4:

Foreign Direct Investment Flows in and out of Canada (2005 and 2018)

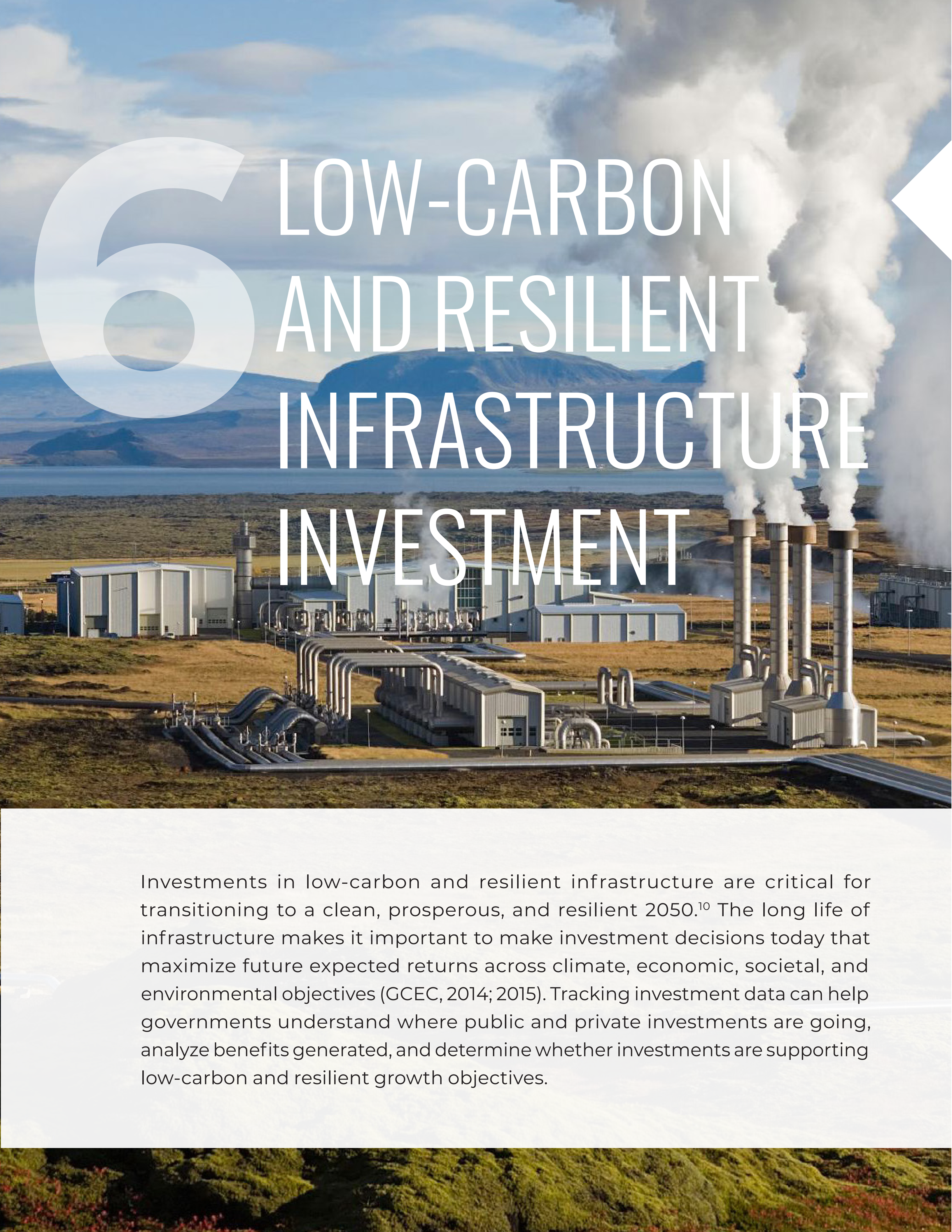


This figure shows FDI flows in Canada for 2005 and 2018, including domestic FDI and FDI going abroad. Importantly, these data show all FDI investments going in and out of Canada, including those that are not climate-related. It is intended to show general FDI trends, such as the marked increase in oil and gas extraction investment. Over time, FDI flows will play an increasingly important role in how Canada supports (or detracts from) the global growth in low-carbon and resilient trade and investment. The top 10 sectors were selected by summing total FDI over the 2005–2018 period.

Source: Statistics Canada (2020b).

Methods to track financial flows are, however, improving. The OECD, for example, is leading international efforts with work by its Research Collaborative for Tracking Finance for Climate Action. The group is developing international standards for tracking public finance and the extent to which it mobilizes private finance (ECCC, 2019). Such initiatives are helping Canada more accurately identify the impact of its investments abroad.

Lastly, better data on ECT trade and financial flows can provide a clearer picture on Canadian competitiveness in the global economy, but they are an incomplete measure by themselves. As global markets shift, a large portion of the Canadian economy could be exposed to competitiveness risks. These risks will be highest for emissions-intensive and trade-exposed sectors, such as oil and gas, chemicals manufacturing, and iron and steel. But other sectors in the Canadian economy could face competitive pressures too, such as Canadian automotive manufacturers that produce gasoline-powered cars, SUVs, and trucks. While pursuing clean growth in Canada requires a more comprehensive understanding of these carbon risks, there is currently limited data and analysis available.



6

LOW-CARBON AND RESILIENT INFRASTRUCTURE INVESTMENT

Investments in low-carbon and resilient infrastructure are critical for transitioning to a clean, prosperous, and resilient 2050.[10] The long life of infrastructure makes it important to make investment decisions today that maximize future expected returns across climate, economic, societal, and environmental objectives (GCEC, 2014; 2015). Tracking investment data can help governments understand where public and private investments are going, analyze benefits generated, and determine whether investments are supporting low-carbon and resilient growth objectives.

HEADLINE INDICATOR

Public & Private Investment in Climate-related Infrastructure

To measure climate-related infrastructure, we use the flow of annual public and private investments in select categories in 2009 and 2019, illustrated in Figure 6.1. For clean growth success, we want to see investments increase and become lower-carbon and more resilient over time.

Overall, the level and composition of investment within each category changed significantly between 2009 and 2019, with the total level of investment increasing in six of the 11 categories. Investments in hydroelectric production, power transmission, and power distribution experienced the largest growth over the 11-year period and also attracted the highest levels of investment in absolute terms, driven primarily by the public sector (Statistics Canada, 2020). Big hydroelectric projects, such as the Site C Dam in British Columbia and the Muskrat Falls Dam in Newfoundland and Labrador, were likely large contributing factors to these trends.

Investments in pollution abatement and control were another area of significant growth. Although starting from a much smaller base relative to investments in the electricity system, spending on pollution and abatement increased 23-fold between 2009 and 2019. The bulk of this spending was in the private sector, where investments grew from $12 million in 2009 to $413 million in 2019, reflecting a shift to comply with broader and more stringent environmental policies across the country.

Notably, total investments in wind and solar decreased 78 per cent between 2009 and 2019 after reaching a peak of nearly $2.7 billion in 2013. And while the majority of investment in wind and solar came from the private sector between 2009 and 2015, the public sector was the dominant investor between 2016 and 2019. Ontario's feed-in-tariff program for renewables (which ran from 2009 to 2017) was a major driver of private investment in renewables in Canada (Oji & Weber, 2017; NRCan, 2020), and its cancellation likely played a role in the notable decline in new investment.

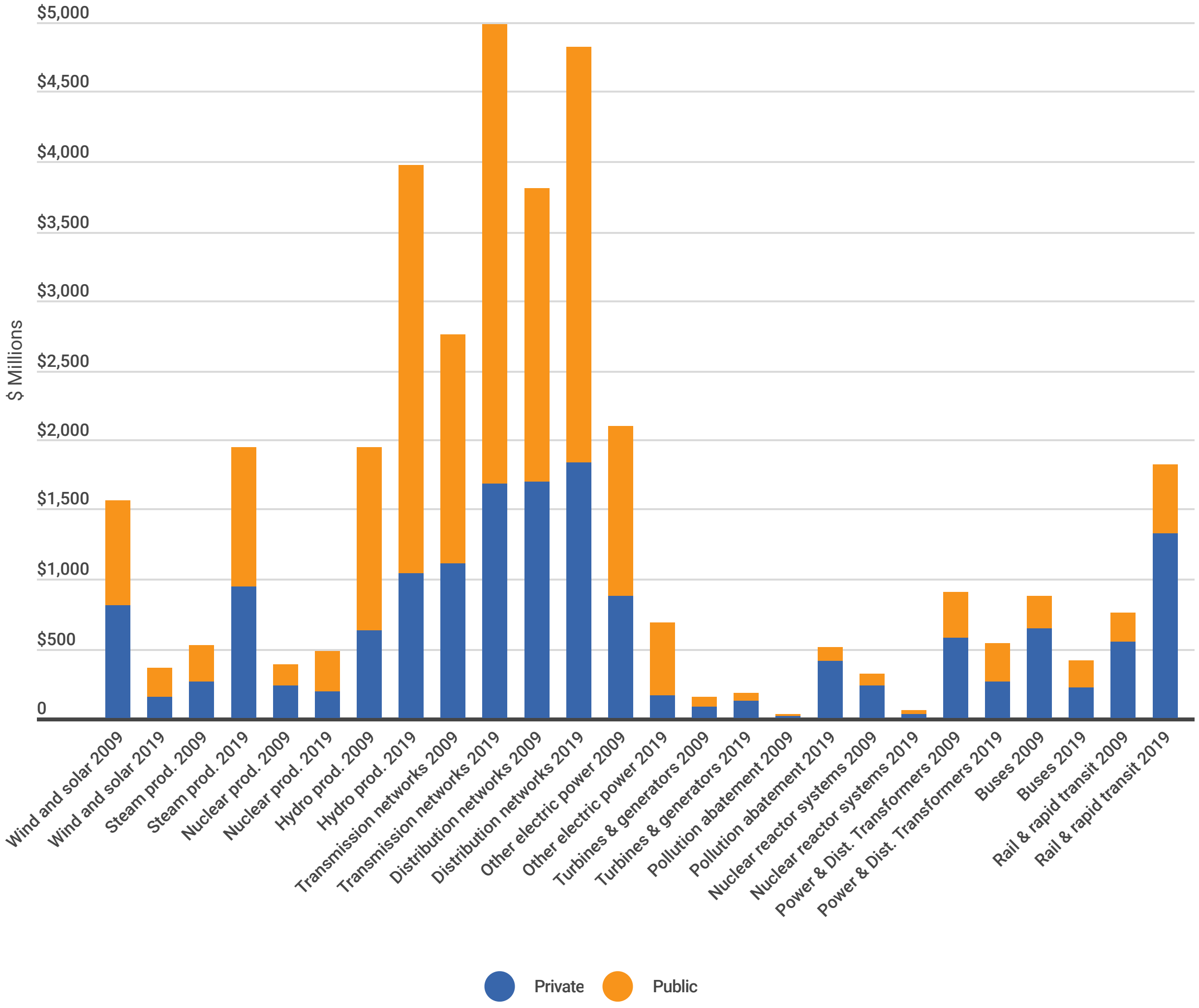
STOCK OF CLIMATE-RELATED INFRASTRUCTURE

The total stock of infrastructure matters at least as much as the flows of annual investment described above. In the transition to 2050, the stock of low-carbon and resilient-related infrastructure—the result of those investment flows—should increase over time, whereas the stock of GHG-intensive infrastructure should decrease.

Figure 6.2 shows the total value of select infrastructure categories important in the transition to 2050, totalling over $250 billion in 2019. In absolute terms, electricity power infrastructure is the highest-value infrastructure asset in the figure, which is consistent with the investment flows from Figure 6.1. Within this category, hydro power generation infrastructure and

FIGURE 6.1:

Low-carbon and Resilient Infrastructure Investment, 2009 and 2019



This figure shows the level of real (inflation-adjusted) public and private investment in select climate-related infrastructure categories. It includes investments in electricity systems (generation, transmission, distribution), pollution abatement technologies, and transportation systems (buses, railways, rapid transit). In absolute terms, investments were highest for electricity transmission and distribution, where the majority of capital came from the public sector. Notably, these categories are a subset of total infrastructure investments and are determined by Statistics Canada. As such, the categories in the figure are illustrative and do not cover the full spectrum of climate-related investments discussed in this section. Investment includes both spending on new infrastructure and maintaining existing infrastructure.

Source: Statistics Canada (2019); Statistics Canada (2020). Note: All values are adjusted for inflation, reported in 2012 dollars.

transmission and distribution networks have the highest asset value, which typically include massive infrastructure projects that are capital intensive to build and maintain. Nuclear production plants, along with wind and solar, are also important components of Canada's electricity power infrastructure, albeit smaller in terms of asset size. Taken together, continued growth in the stock of Canada's electricity system infrastructure will have a significant impact on reducing the country's long-term emissions but also increase the importance of addressing physical risks from a changing climate in the sector.

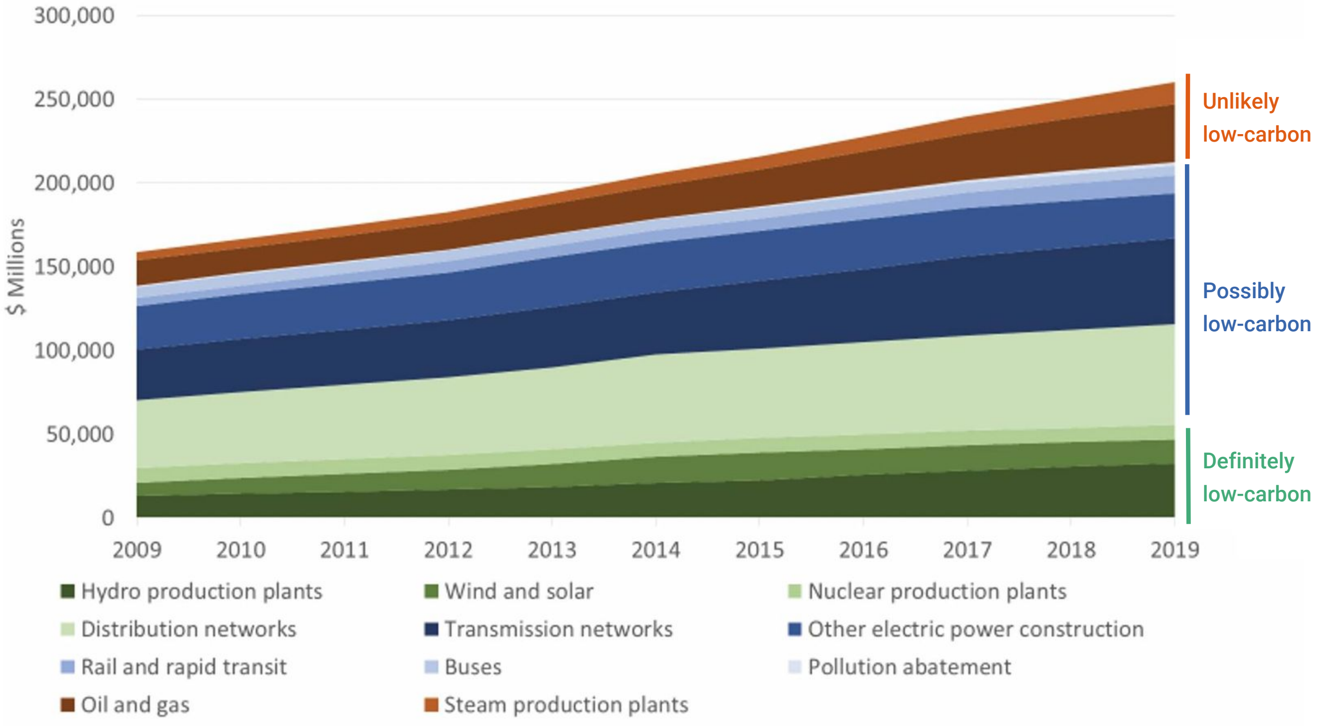
The climate-related impacts of other types of infrastructure categories are more complicated, especially when we start considering other clean growth objectives. The total value of bus infrastructure in

Canada, for example, declined slightly (-13 per cent) between 2009 and 2019, while the value of rail and rapid transit infrastructure more than doubled (120 per cent). These trends may signal a transition to cleaner, more efficient rapid transit replacing older, less efficient, and polluting diesel bus fleets. Yet as electric and hydrogen buses become more feasible, continued growth in both bus infrastructure and rapid transit could be a desirable outcome.

Figure 6.2 also includes oil and gas infrastructure to illustrate the difficulty in determining the climate-related impacts of infrastructure. The stock of steam production plants (i.e., fossil fuel electricity generation), for example, more than doubled between 2009 and 2019. And while we might expect the stock of these fossil fuel assets to decline over time as Canada dramatically reduces its GHG emissions, this is not necessarily the case. Carbon capture utilization and storage (CCUS) and other emerging technologies could help reduce the GHG emissions associated with fossil fuel infrastructure.[11] At the same time, the air pollution and ecosystem impacts from all types of infrastructure may also factor into decision-making, as explored in Indicators #10 and #11.

FIGURE 6.2:

Net Stock of Select Climate-related (and Fossil Fuel) Infrastructure (2009–2019)



This figure shows the net stock (inflation-adjusted) of select climate-related infrastructure categories between 2009 and 2019. While Figure 6.1 shows the investment flows going to each of these infrastructure categories each year, this figure shows the total net stock of value for each category (i.e., new investments + existing value – depreciation), totalling over $250 billion in 2019. It also includes fossil fuel infrastructure assets, given that they could be considered lower carbon in combination with carbon capture and storage technology. In absolute terms, infrastructure for Canada's electricity power system dominates; however, the stock of oil and gas infrastructure more than doubled over the period and is the third largest category, by value, in 2019. The categories are grouped as either "definitely low-carbon," "possibly low-carbon," and "unlikely low-carbon" to help illustrate whether these investments will lead to reductions in GHGs, though there could be significant variation across individual projects.

Source: Statistics Canada (2020). Note: All values are adjusted for inflation, reported in 2012 dollars.

LIMITATIONS WITH THE STOCK AND FLOW INVESTMENT INDICATORS

The data in Figures 6.1 and 6.2, while helpful in identifying historical infrastructure investments in key sectors, provide an incomplete picture of the consistency of investment trends with clean growth.

First, the data provide insights on only a small subset of climate-related infrastructure in Canada. The figures do not include national-level investment trends in other important areas, such as energy efficiency upgrades, climate resilience, and natural infrastructure. While part of the problem is poor and patchy data in these other areas (see Data Gap section), the larger issue is that Canada lacks a comprehensive definition and taxonomy of climate-related infrastructure investments.

Table 6.1 proposes a new approach to better define and track climate-related infrastructure investments across four types of infrastructure: low-carbon infrastructure, enabling low-carbon infrastructure, resilient infrastructure, and natural infrastructure. Each of these categories plays an important role in achieving clean growth. Importantly, the categories in Table 6.1 are not mutually exclusive. Investments can meet several objectives simultaneously; in fact, the framework provides a more structured way to identify infrastructure investments that offer the highest clean growth return. It also offers a way to identify projects that perform well on one objective but detract from other objectives, such as low-carbon electricity infrastructure not designed to withstand extreme climate events (i.e., maladaptive).

Second, the data do not provide insight regarding the extent to which investments are aligned with long-term clean growth goals. Investments may reduce GHG emissions or improve resilience; that does not necessarily mean, however, that they are consistent with long-term goals.

Box 6.1:

Public Role in Driving Private and Institutional Investment in Climate-related Infrastructure

Private and institutional capital (e.g., pension funds) generally flows to projects with the largest financial returns (NRDC et al., 2016). Yet because markets have historically failed to fully value climate and social benefits, and because low-carbon and resilient investments may be higher risk or yield lower returns than alternatives, government policy intervention may be needed. Policies could include disclosure requirements, public-private partnerships, infrastructure banks, regulations, and pricing that provide an incentive for investors to channel and redirect capital towards lower-carbon and more resilient infrastructure.

Sources: GCEC (2015); Infrastructure Canada (2018); NRDC et al. (2016); Canada Infrastructure Bank (2020); TFCD (2019).

TABLE 6.1:

Types of Climate-related Infrastructure Investments

Type of Climate-Related Infrastructure	Primary Climate Benefits	Potential Economic Impacts	Potential Co-benefits
LOW- OR NO-CARBON (e.g., renewable or nuclear energy, net-zero buildings)	Reduced GHG emissions	▸ Increased economic activity and jobs ▸ Avoidance of emissions-intensive stranded assets in the future	▸ Reduced air pollution & improved human health & well-being
LOW-CARBON ENABLING (e.g., electricity transmission, EV charging infrastructure, battery storage)	Reduced barriers for low-carbon technologies/ behaviour (e.g., cost, network, convenience)	▸ Increased economic activity and jobs ▸ Creation of valuable, long-term assets	▸ Reduced air pollution & improved human health & well-being ▸ Improved convenience & mobility
RESILIENT (e.g., dykes, sea walls, higher bridges, fire- and flood-resistant buildings)	Reduced risk & costs from climate impacts for individuals and communities	▸ Increased economic activity and jobs ▸ Reduced risk of property and infrastructure damage ▸ Reduced risk of supply chain or business disruption	▸ Improved human health & safety outcomes ▸ Enhanced local autonomy ▸ Protection of vulnerable populations
NATURAL (e.g., wetland restoration, tree planting)	Reduced GHG emissions and/ or improved resilience	▸ Increased economic activity and jobs ▸ Potential to reduce costs and economic disruption associated with flooding and heat waves	▸ Improved biodiversity & habitat creation ▸ Improved greenspaces & recreation ▸ Reduced “heat island effect”

Given the long life of infrastructure, decisions made today have significant implications for the future. In particular, they can create “path dependencies” that are challenging and expensive to undo. For example, improvements to coastal infrastructure might be directionally consistent with Canada’s goal of improving resilience to rising sea levels. But if the system is only a marginal improvement—for example, it protects high-value assets against small increases in sea-level but not the larger increases expected under potential future climate scenarios—it is not necessarily consistent with Canada’s long-term objective of economic resilience.

This limitation also means that trends in investment data have limited value in informing forward-looking choices (both public and private). Historic data can highlight potential gaps that require policy intervention, but additional analysis is ultimately needed to determine where limited public investment dollars are best placed in the future. Setting priorities also requires understanding barriers to private-sector investment in different types of climate-related infrastructure, as well as an assessment of current and future societal benefits that could flow from different projects (Box 6.1).

DATA GAPS

Although Canada already has good data on select types of infrastructure investments in Canada—illustrated in Figures 6.1 and 6.2—the breadth and resolution in these datasets can improve. Carbon capture, utilization, and storage technologies, for example, could play an important role in decarbonizing Canada’s emissions-intensive industries and are already being deployed at some facilities. However, the datasets from Statistics Canada do not provide detail on this type of specific investment spending. The datasets also do not include new and emerging areas of investment, such as EV charging infrastructure. Adding new categories to existing data surveys to capture low-carbon and low-carbon-enabling infrastructure and reporting at a more detailed level would help provide key insights and would be relatively straightforward.

Other climate-related investment data are less simple to capture. For example, national and provincial-scale data on natural infrastructure investments are poor in Canada, along with investments in climate-resilient infrastructure. Data on climate-related investments to Canada’s building stock is also scarce, especially for retrofits. These types of small-scale investments are diffused across Canada, which makes them difficult to track and monitor. Yet each of these areas are expected to play a big role in the transition to 2050. Fortunately, various initiatives may offer the potential to include additional data in the future (Box 6.2).

Canada could also draw on international experience and approaches to implement a more comprehensive climate-related infrastructure investment reporting framework consistent with the categories proposed in Table 6.1. International official development assistance funding is, for example, “tagged” as either climate mitigation or climate adaptation. Investments could be tagged based on their primary, secondary, or tertiary objectives to help identify infrastructure investments that achieve multiple objectives.

Finally, Canadian governments can benefit from forward-looking data and analysis to ensure that current public and private infrastructure investments align with Canada’s long-term clean growth objectives. The Canadian Institute for Climate Choices has ongoing research in these areas that will inform these important discussions in the future.

BOX 6.2:

Emerging Efforts in Tracking Climate-related Investments

Organizations such as the National Research Council, for example, are working with Infrastructure Canada to develop standards for buildings and other infrastructure for flood, fire, and extreme weather resilience. This type of data could feed into a broader tracking system that provides provincial- and national-level insights on resilient infrastructure. It could be integrated with the investment data already tracked by Statistics Canada. Some local governments are also starting to integrate climate-related investments into asset management planning; however, this type of approach is not widespread across local governments and data do not exist at an aggregate level (FCM, 2019). Efforts to scale up best practices in asset management provide an important opportunity to also improve how climate-related investments are prioritized, developed, and tracked.

Sources: FCM (2019); Infrastructure Canada (2019).

7

LOW-CARBON JOBS

Global and domestic climate policy, as well as the resulting shifts in markets and investment, will drive both positive and negative effects on employment in Canada. Ultimately, a clean growth transition can only be successful if the Canadian economy continues to provide quality jobs to Canadians across the country. Data can help us understand and track various trends over time, informing policy decisions that improve outcomes for Canadians. While aggregate effects on employment are important, policy choices must consider challenges at the sectoral, regional, and individual level to protect people at risk of job loss and help more Canadians take advantage of emerging new job opportunities.

HEADLINE INDICATOR

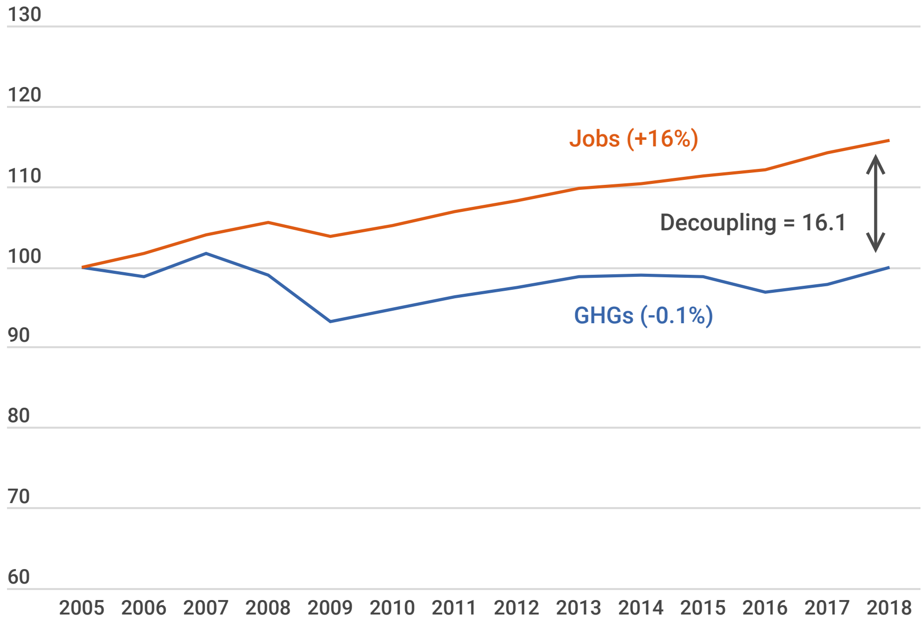
Decoupling Jobs and GHGs

Under a successful transition to a clean growth future, Canadian jobs will continue to increase as GHGs decrease. Our headline indicator for low-carbon jobs is therefore the gap between trends in jobs and GHGs between 2005 and 2018 (Figure 7.1). The metric captures the importance of existing jobs as well as new sources of lower-carbon jobs as Canada reduces its GHG emissions. Over the 2005–2018 period, the aggregate number of jobs grew by 16 per cent while GHGs remained relatively constant (-0.1 per cent).

Notably, this indicator does not distinguish between "green" jobs or "brown" jobs, terms often used to describe the labour market transition to a low-carbon economy (ILO, 2016). This is an advantage: there are many challenges associated with labelling specific jobs according to their green credentials but limited benefits. Instead, the decoupling metric values all jobs equally and considers the net effect on employment, accounting for both job losses and gains. As Canada decouples GHGs from GDP growth, many jobs will evolve and increasingly

FIGURE 7.1:

Decoupling Jobs and GHGs, Index Comparison of Change in Employment and GHGs, 2005–2018



This figure shows the degree of decoupling between jobs in the economy and GHG emissions between 2005 and 2018. It is a standardized index, where levels of both employment and GHGs in 2005 equal 100. Overall, the number of jobs increased by 16 per cent while GHG emissions remained roughly stable.

Sources: Calculations based on Statistics Canada (2020a); ECCC (2020a).

BOX 7.1

Low-carbon Jobs and Labour Productivity

If labour is viewed as an input to economic output, using more labour per unit of GDP is inefficient. In fact, slower growth of jobs in comparison to GDP growth indicates an improvement in labour productivity. Increased labour productivity can translate into higher profits, increased wages, new investments, and a larger tax base, supporting economic growth and higher standards of living. Increased automation, for example, may reduce the need for labour in some sectors.

However, new productivity measures are emerging that may justify less efficient employment activities that improve environmental outcomes. The OECD, as part of its green growth indicator work, has been developing a broader measure of Environmentally Adjusted Multifactor Productivity that incorporates labour, capital, and natural resources as inputs and greenhouse gas emissions and air pollution as negative outputs. Fully incorporating environmental considerations into productivity measures could alter determinations of the most efficient use of inputs such as labour, capital, and natural resources.

There may also be societal objectives that justify less efficient employment activities. For example, the 2020 investment by the Canadian government in the clean-up of orphan and abandoned oil and gas wells provides a source of work for service companies affected by the 2020 COVID-19 pandemic restrictions and the drop in oil price. This may be inefficient in terms of the GDP generated per hour worked but will help companies stay afloat and limit layoffs while reducing a costly environmental liability not captured in GDP.

Sources: Anderson (2020); Baldwin et al. (2014); OECD (2017); Winter and Moore (2013).

require work relevant to climate change. As long as overall GHGs are declining, it does not matter where the jobs come from. What matters is that Canadians have meaningful and stable employment.

At the same time, however, simply increasing the number of jobs relative to GHG emissions should not necessarily be the sole objective. The goal is to increase the number of jobs and reduce GHGs while also promoting an efficient use of labour. The fact that job growth has been slower than GDP growth (Indicator #1) indicates an increase in labour productivity, which is generally a positive driver of economic growth (Box 7.1). That legitimate limitation does not invalidate the metric we use here; economic growth without employment growth can bring social challenges.

REGIONAL JOB DECOUPLING

Provincial decoupling of jobs from GHGs varies substantially. Nova Scotia, Ontario, New Brunswick, Quebec, and P.E.I. have all reduced emissions while maintaining or increasing employment (Figure 7.2). British Columbia, Newfoundland and Labrador, Manitoba, Saskatchewan, and Alberta have likewise increased employment since 2005 but have also seen an increase in GHG emissions.

While these decoupling trends—both at the national and provincial level—generally follow the decoupling trends between GHGs and GDP (Indicator #1), job growth has been slower than GDP growth. Slower job growth is particularly notable in Manitoba, where GDP increased by 34 per cent over the period but jobs only increased by 12 per cent. As noted above, this may be a positive development for economic growth objectives in terms of increased labour productivity. Manitoba had an employment rate of 63 per cent in 2019, above the Canadian average. Employment is not evenly distributed throughout the province, however, with the Parklands and Northern Manitoba region seeing below-average employment rates (Statistics Canada, 2020a).

To consider the linkages between jobs and GHG emissions, we measure GHG-job productivity as the number of jobs per kilotonne of CO_2e emitted (Table 7.1). Employment in Quebec, P.E.I., and Ontario is less connected to GHG emissions, while employment in Saskatchewan, Alberta, and Newfoundland and Labrador is more connected to GHG emissions. As noted in Indicator #1, this is due to the greater proportion of emissions-intensive industries, such as oil and gas, in the three latter provinces.

Aggregate measures of employment can mask sectoral, community, and individual challenges. Global and domestic efforts to reduce GHG emissions will drive changes to the economy, which will in turn lead to changes in the nature and type of workers and skills needed. As a result, some sectors, communities, and people could face a higher risk of job loss and a greater need to upskill or retrain to maintain employment or capture new opportunities. A smooth and fair transition requires finding ways to minimize job loss, preparing workers for transition, and ensuring broad access to new opportunities.

SECTOR RISKS AND OPPORTUNITIES

To identify sectors likely to experience climate-change-related employment risks or opportunities, we consider four factors: (1) risks from a domestic transition to a low-carbon economy; (2) risks from a global transition to a low-carbon economy; (3) risks from a changing climate; and (4) opportunity from low-carbon transition (Table 7.2). Drawing on a variety of sources, we estimate the order of magnitude of employment risk and opportunity by sector. Further research and scenario analysis are, however, needed to fully understand the complex dynamics of employment risk and opportunity.

For each sector, transition will create both employment opportunities (e.g., increased demand for lower-carbon technologies, products, and services

FIGURE 7.2:

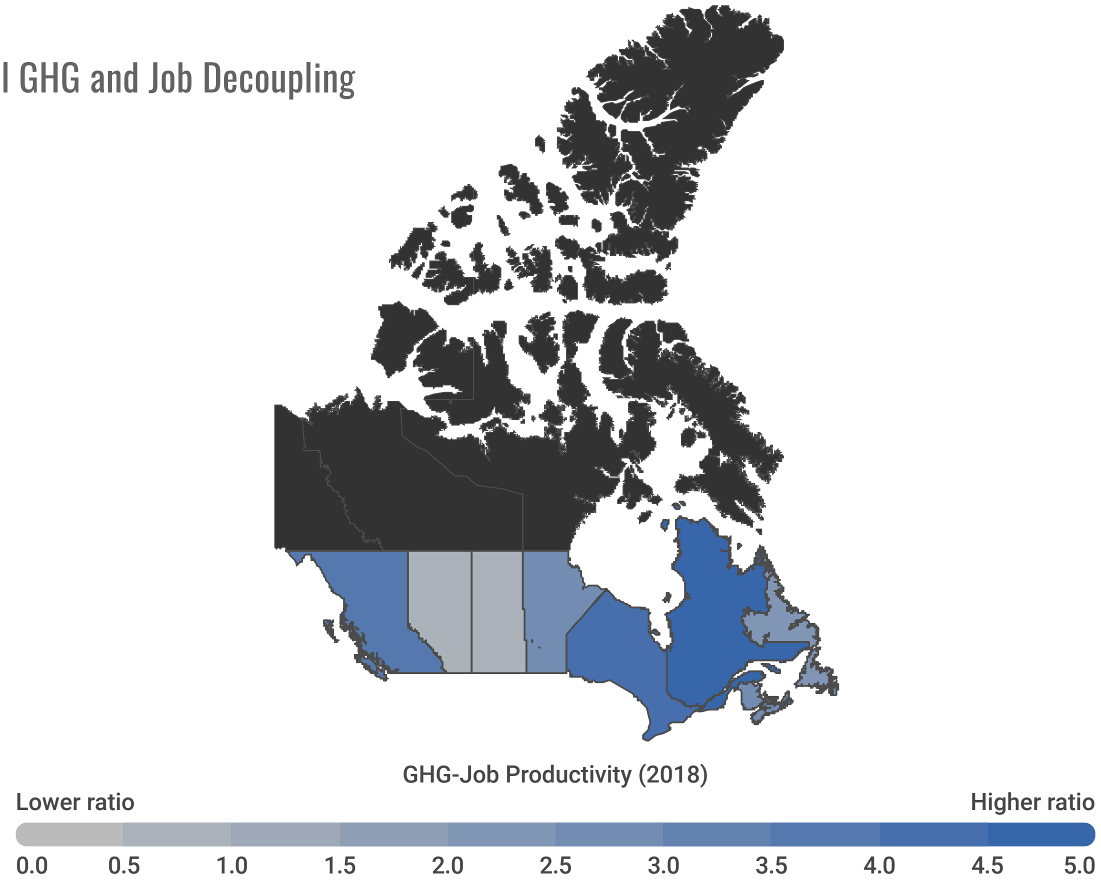
Decoupling Jobs and GHGs, Index Comparison of Change in Employment and GHGs by Province 2005–2017

This figure shows decoupling of employment and GHGs across provinces between 2005 and 2018, using the same standardized index as Figure 7.1. Note that territories are not included due to concerns regarding the accuracy of GHG data (see Box 1.1). While the number of jobs has increased in every province, the degree of decoupling with GHGs varies significantly. In Nova Scotia, for example, the number of jobs grew by only 3 per cent, while GHGs fell by 26 per cent. By contrast, the increase in jobs in Newfoundland and Labrador, British Columbia, Manitoba, Saskatchewan, and Alberta were matched with increased GHG emissions.

Sources: Calculations based on Statistics Canada (2020a); ECCC (2020).

TABLE 7.1:

Provincial GHG and Job Decoupling



Province/Territory	Decoupling Jobs and GHGs (2005–2018)			GHG-Job Productivity (2018) (Jobs/CO_2e)
	Job Growth (%)	GHG Change (%)	Decoupling Score	Ratio
British Columbia	19.3	5.6	13.7	3.81
Alberta	28.0	17.5	10.5	0.86
Saskatchewan	18.3	12.3	6.0	0.75
Manitoba	12.4	8.3	4.1	2.97
Ontario	13.5	-18.8	32.3	4.39
Quebec	15.0	-4.1	19.1	5.16
New Brunswick	2.1	-33.6	35.7	2.67
Nova Scotia	3.1	-26.4	29.5	2.68
P.E.I.	12.3	-19.4	31.7	4.53
Newfoundland & Lab.	6.1	5.3	0.8	2.05
Canada	***+15.7***	***-0.1***	***15.8***	***2.56***

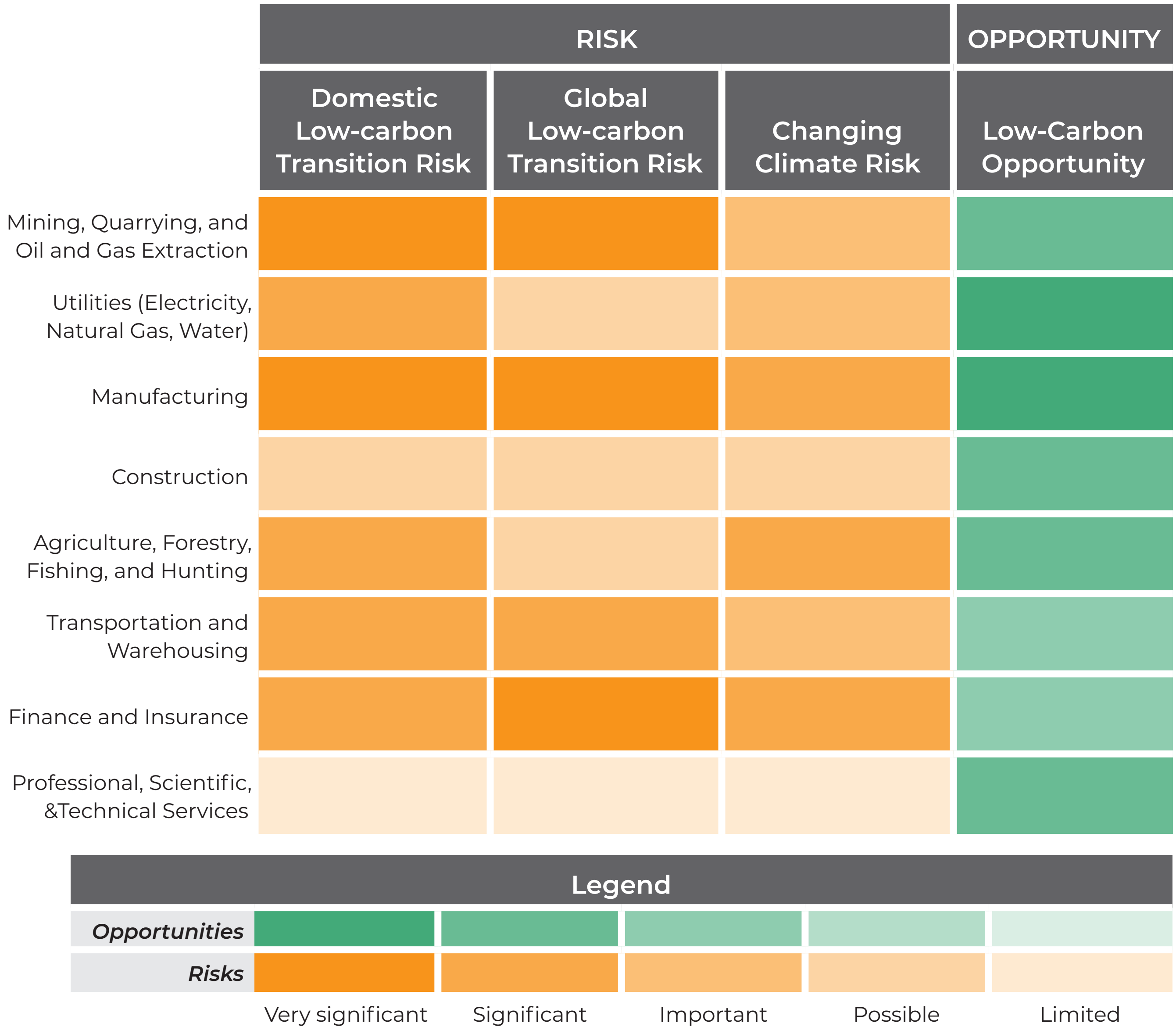
This table shows the decoupling score for provinces, which measures the gap between the growth in jobs and change in GHG emissions from Figure 6.2. Note that territories are not included due to concerns regarding the accuracy of GHG data (see Box 1.1). For example, Ontario had a decoupling score of 32.3, calculated by subtracting its rate of job growth (13.5 per cent) from its GHG growth (-18.8 per cent). The table also includes a GHG-job productivity metric for each province, which shows the number of jobs in the economy relative to the amount of CO_2e produced in the economy (jobs are denoted in the thousands, while CO_2e is denoted in kilotonnes). A higher productivity score indicates a weaker linkage between jobs and GHG emissions.

Sources: Statistics Canada (2020a); ECCC (2020).

or minerals and metals) and risks (e.g., higher capital and operating costs or reduced product demand and investment). How companies manage risks and adjust to capture opportunities will influence the ultimate net effect on employment. Companies considered vulnerable to climate policy could innovate and diversify product lines, reducing their vulnerability and capturing new market opportunities. Some companies may instead be more likely to pursue cost-cutting strategies that reduce their workforce, while others invest in new technologies that reduce their emissions intensity.

TABLE 7.2:

Approximate Significance of Long-term Employment Risk and Opportunity by Sector



	RISK			OPPORTUNITY
	Domestic Low-carbon Transition Risk	Global Low-carbon Transition Risk	Changing Climate Risk	Low-Carbon Opportunity
Mining, Quarrying, and Oil and Gas Extraction	Very significant	Very significant	Important	Significant
Utilities (Electricity, Natural Gas, Water)	Significant	Possible	Important	Very significant
Manufacturing	Very significant	Very significant	Significant	Very significant
Construction	Possible	Possible	Possible	Significant
Agriculture, Forestry, Fishing, and Hunting	Significant	Possible	Significant	Significant
Transportation and Warehousing	Significant	Significant	Important	Important
Finance and Insurance	Significant	Very significant	Significant	Important
Professional, Scientific, &Technical Services	Limited	Limited	Limited	Significant

Legend					
Opportunities	🟩	🟩	🟩	🟩	🟩
Risks	🟧	🟧	🟧	🟧	🟧
	Very significant	Significant	Important	Possible	Limited

This table provides an approximate indication of the scale of potential employment risk or opportunity, by sector. Sectors that were not rated as significant or very significant in any of the four factors are omitted. The assessment is based on a range of sources, as well as the knowledge of Institute experts and staff, looking out to a 2050 horizon. It is illustrative only and does not account for variations across time or regions. The sectors are aggregated and do not reflect significant variation across sub-sectors.

Sources: CICC (2020); ECCC (2016); ECCC (2019); ECCC (2020); EDC (2020); EPSF (2019); JTC (2017); NRCan (2015); Iron and Earth (2016); NCE (2018); Statistics Canada (2020c); Moffat (2019).

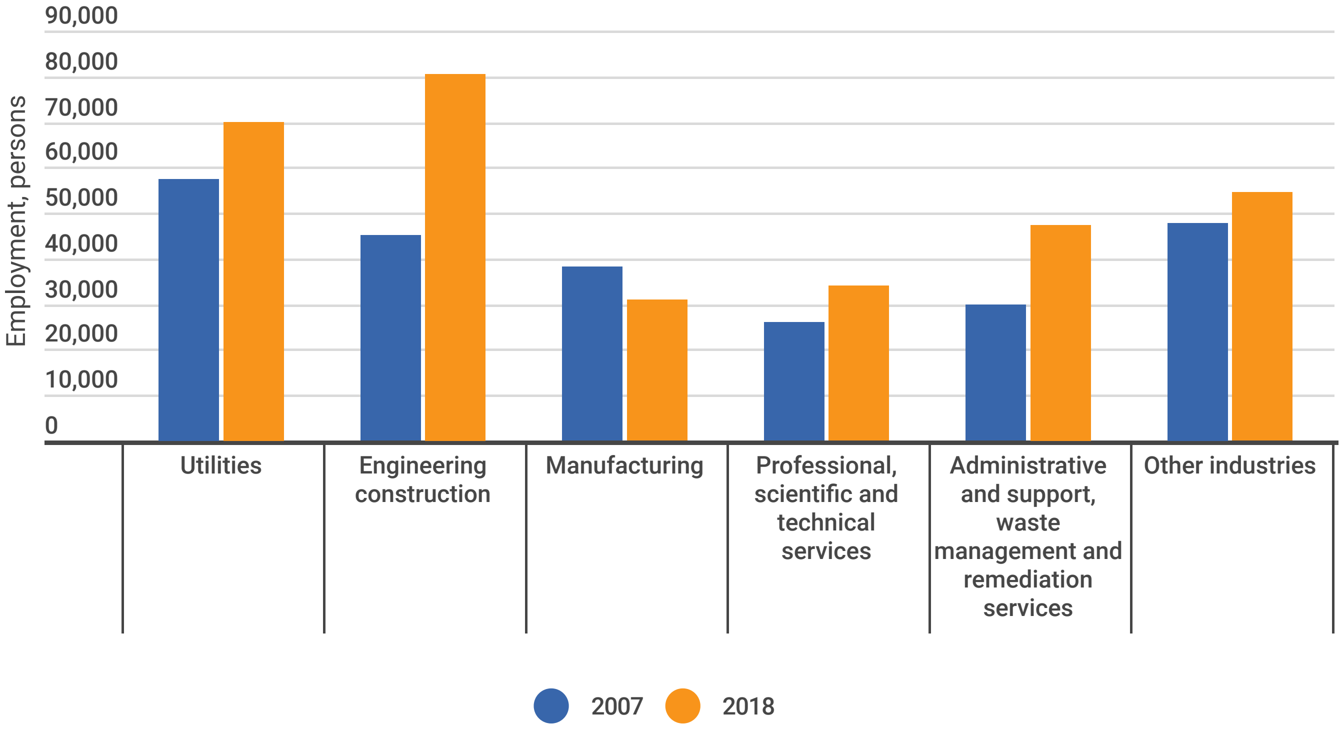
Notably, climate and non-climate market risks interact in both short-term and long-term employment trends. Historically, most dramatic changes in employment come from non-climate factors, including recessions or changes in global commodity prices. Tracking gains and losses in employment by sector over time, combined with an analysis of climate and non-climate factors, can help provide important context for climate-related policy development. A sector that is facing multiple risks may be more vulnerable to employment loss from a low-carbon transition.

Future employment trends will also depend on the growth of new job opportunities. Global and domestic technological trends are shifting markets, with a greater emphasis on big data, artificial intelligence, automation, health technology, clean technology, and consumer goods for growing emerging markets (Manyika, 2017). While these market shifts pose challenges, they also create opportunities for new entrants, as well as incumbents that can adapt and adjust.

This shift in market opportunities is partly reflected in Figure 7.3, which shows the change in employment across Canada's environmental and clean technology sector. Overall, 73,033 more people were employed in the sector in 2018 than in 2007, accounting for 1.7 per cent of total employment in Canada or 317,085 jobs (Statistics Canada, 2020c). Over three-quarters of workers in the sector are in three provinces: Ontario, Quebec, and British Columbia. Major hydroelectric projects have been an important source of employment growth in engineering and construction, particularly in Newfoundland and Labrador and Manitoba (Statistics Canada, 2020c). Employment increased across all sub-sectors except

FIGURE 7.3:

Environmental and Clean Technology Employment by Sub-sector, Canada, 2007 and 2018



This figure shows employment in environmental and clean technology sub-sectors between 2007 and 2018. With the exception of manufacturing, all other sub-sectors experienced an increase in employment. In absolute terms, utilities and engineering construction were the largest sources of employment. For a detailed list of what is included in the environmental and clean technology sector, see Statistics Canada.

Source: Statistics Canada (2020c).

clean technology manufacturing. However, clean technology manufacturing GDP grew by 20 per cent between 2012 and 2018. The difference between GDP and employment may represent a shift towards less labour-intensive clean technologies or an improvement in labour productivity.

COMMUNITY RISKS AND OPPORTUNITIES

Communities with a high concentration of employment in one sector are most at risk from shocks to employment, which could come from climate impacts (e.g., fires and pine beetle in forestry, drought in agriculture) or shifts in global market conditions (e.g., decreased demand for carbon-intensive goods, climate-related supply chain disruptions). If a large facility or company in the community closes or has significant layoffs, the loss of income can risk broader employment loss. If new employment opportunities are not located in the region, there is a risk of longer-term unemployment and movement out of the community.

Using 2016 data from the Canadian Business Counts—a database which measures employment at the local level for all sectors—we estimate employment concentrations across the first six sectors identified in Table 7.2.[12] Figure 7.4 shows the top 20 most concentrated economic regions in terms of employment in a single subsector. Three communities appear twice: Nechako, British Columbia (forestry and wood product manufacturing); Wood Buffalo-Cold Lake, Alberta (oil and gas and specialty trade contractors); and Red Deer, Alberta (support activities for oil and gas and mining, specialty trade contractors). Of the regions shown, only two regions had unemployment rates above 8 per cent in 2019: Southern Nova Scotia (8.3 per cent) and Notre Dame-Central Bonavista Bay, Newfoundland and Labrador (16.8 per cent) (Statistics Canada, 2020a). Both regions concentrate in food manufacturing linked to fish and seafood.

Employment concentrations can help to identify communities at risk, as well as those positioned to capture new opportunities. For example, Northern Saskatchewan's employment concentration in mining (mainly uranium) may lead to employment gains if the global low-carbon transition favours nuclear power. Indigenous governments may also be able to capture new employment opportunities in transition (Box 7.2). In general, however, greater economic diversification reduces community risk.

INDIVIDUAL RISKS AND OPPORTUNITIES

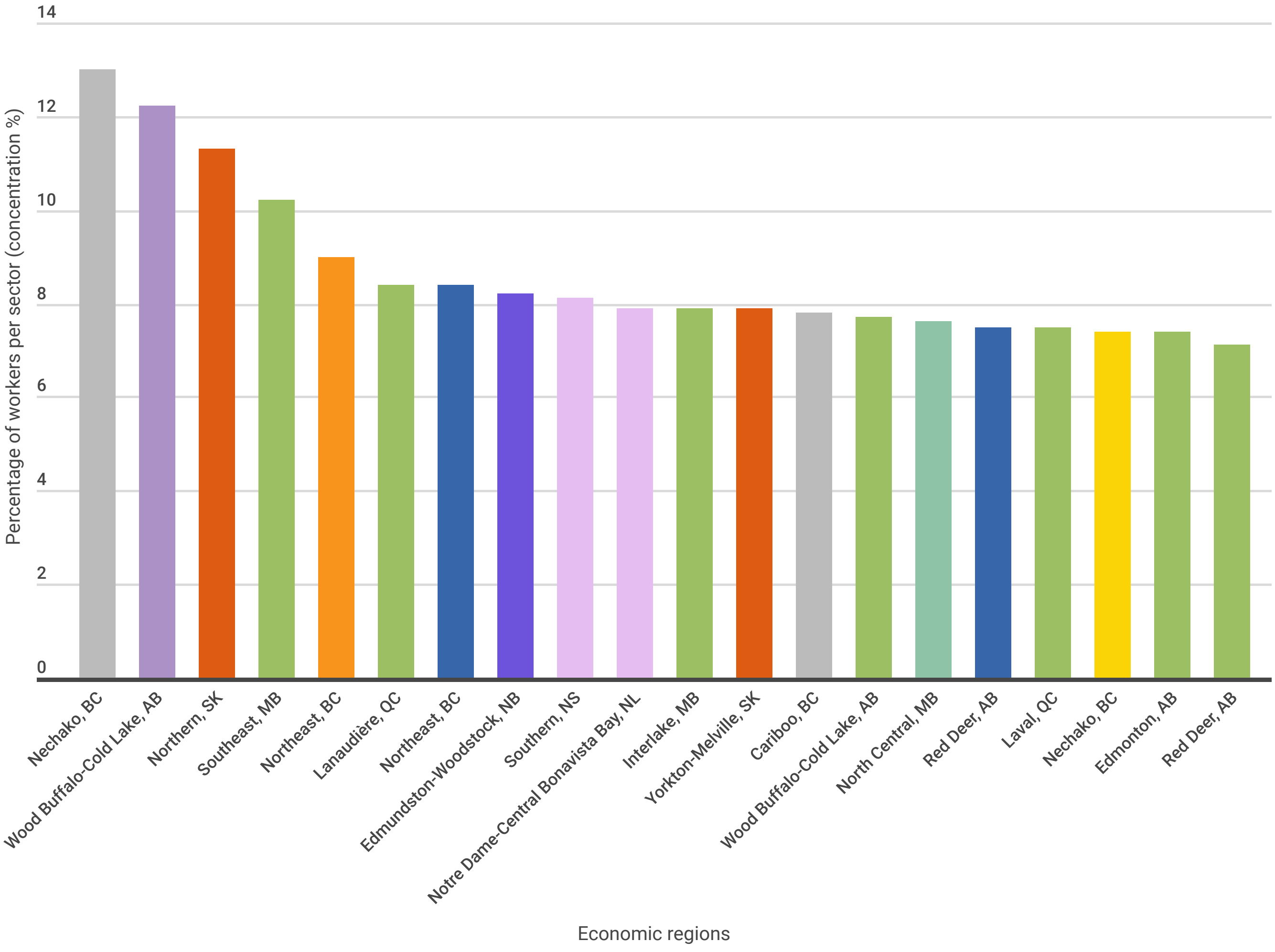
Unemployment and underemployment are closely linked to education and skills. Those without a high school diploma have historically faced higher levels and longer durations of unemployment (Statistics Canada, 2020d). Age and gender also matter, with younger males generally at greater risk of job loss (though the 2020 COVID-19 recession has affected more women than men) (Lundy, 2020). Indigenous people also face higher levels of unemployment and have higher proportions of people working in occupations that could be at risk, such as natural resource production and trades (Statistics Canada, 2019; 2020b).

Clean growth implies significant changes to the structure of our economies over time. Workers that have the skills to adjust to new types of work or capture emerging employment opportunities will face lower risk through transition. Those with a skills mismatch will face greater risk unless they are able to adapt and reskill quickly. Studies looking at the employment impact of automation, for example, identify occupations at risk by assessing whether the skills of those occupations are transferrable to occupations at lower risk (Conference Board of Canada, 2019).

The Alberta-based organization Iron & Earth focuses on supporting the transition of skilled tradespeople from oil and gas to renewable energy. They conducted a 2016 survey of oil and gas workers

FIGURE 7.4:

Concentration of Employment by Sector and Economic Region, 2016



This figure shows economic regions that have a significant percentage of their workforce in one sector. It shows employment as a percentage of total workforce by sector and economic region from 2016. In cases where employment percentages are given as a range, we use the lower bound estimate.

Source: Statistics Canada (2017). 2016 Canada Business Counts Database.

BOX 7.2

Indigenous-led Clean Growth Projects Provide Employment Opportunities

Indigenous communities have been significantly involved in over 150 large renewable energy projects in Canada, as well as numerous smaller community energy projects. These initiatives are helping to provide sources of employment while improving energy independence and reducing health risks from diesel use. The Dokis First Nation in north-central Ontario, for example, created its own land code under the First Nations Land Management Act, allowing it to move forward with the Okikendawt run-of-river hydro project in partnership with an independent renewable energy producer—Hydroméga.

There are many other examples of Indigenous people driving clean energy and nature-based climate solutions, supported by organizations such as Indigenous Climate Action, Indigenous Clean Energy and the Indigenous Circle of Experts.

Sources: Indigenous Climate Action (2020); Indigenous Clean Energy (2020); Indigenous Circle of Experts (2020); INAC (2016).

that found strong interest in retraining opportunities in solar power and heating, wind power, and geothermal energy, where there is already a close match with existing skillsets. Iron & Earth recommends both short-term training programs and updated apprenticeship programs to support effective transition (Iron & Earth, 2016). The success of such programs, however, depends on the availability of jobs for those that invest in retraining.

For many, success will be about more than employment levels. The quality of work also matters. For some, quality will mean the level of income provided. Sectors such as mining, quarrying, and oil and gas extraction have tended to provide higher average earnings than other sectors. For others, a quality job means security and benefits. A growing number of younger Canadians are also interested in meaningful work that supports a greater purpose and jobs that provide learning opportunities (Weikle, 2019). In Iron & Earth's survey of oil and gas workers, 59 per cent said that they were willing to take a pay cut to transition to renewable energy and 74 per cent said they were interested in boosting the environmental health and well-being of their children and future generations (Iron & Earth, 2016).

DATA GAPS

To minimize job loss and maximize job gain through low-carbon transition, we need a more detailed understanding of sectoral, regional, community, and individual vulnerabilities. We also need a better sense of future knowledge and skill requirements, employment and skills transformation trends, and emerging employment opportunities. Data availability on employment is generally good, though it can be difficult to find disaggregated details in smaller provinces and the territories, and we encounter the same challenge identified in Indicator #1 in terms of matching employment data with GHG data. We have provided some insight on employment vulnerabilities, but a deeper dive—particularly in communities and regions with a high concentration of employment in one sector—could better inform future policy development.

8

AFFORDABLE ENERGY

The policies required to achieve Canada's climate goals will directly and indirectly affect household budgets. Whether a policy subsidizes energy-efficient retrofits to make them more affordable or raises the price of gasoline to encourage the use of cleaner alternatives, households will be affected by the transition to a low-carbon economy. Even policies targeting businesses and industry can trickle down to households through prices for things like vehicles and food. Policies can also positively affect household incomes: for example, by rebating carbon price revenues to households or by influencing the types and availability of jobs in the economy.

HEADLINE INDICATOR

Household Energy Expenditures as a Share of Total Expenditures

The costs and benefits of climate policies are often distributed unevenly. In some cases, mitigation policies, such as subsidies for public transit or means-tested rebates, can make low-income households and marginalized groups better off. In other cases, policies can have regressive impacts, disproportionately affecting those least able to afford it and exacerbating pre-existing inequities.

Governments can take steps to design policies to ensure they are fair. Monitoring household costs and impacts allows policy makers to see the real-world implications of climate policies within the context of pre-existing vulnerabilities and assess the affordability of essential goods and services. Such data can help policy makers pivot and adjust accordingly. And while climate policies cannot be expected to address complex and deep-rooted socio-economic problems, they can at least ensure those with fewer means are not left worse off. In many cases, they can address climate issues and social issues in parallel.

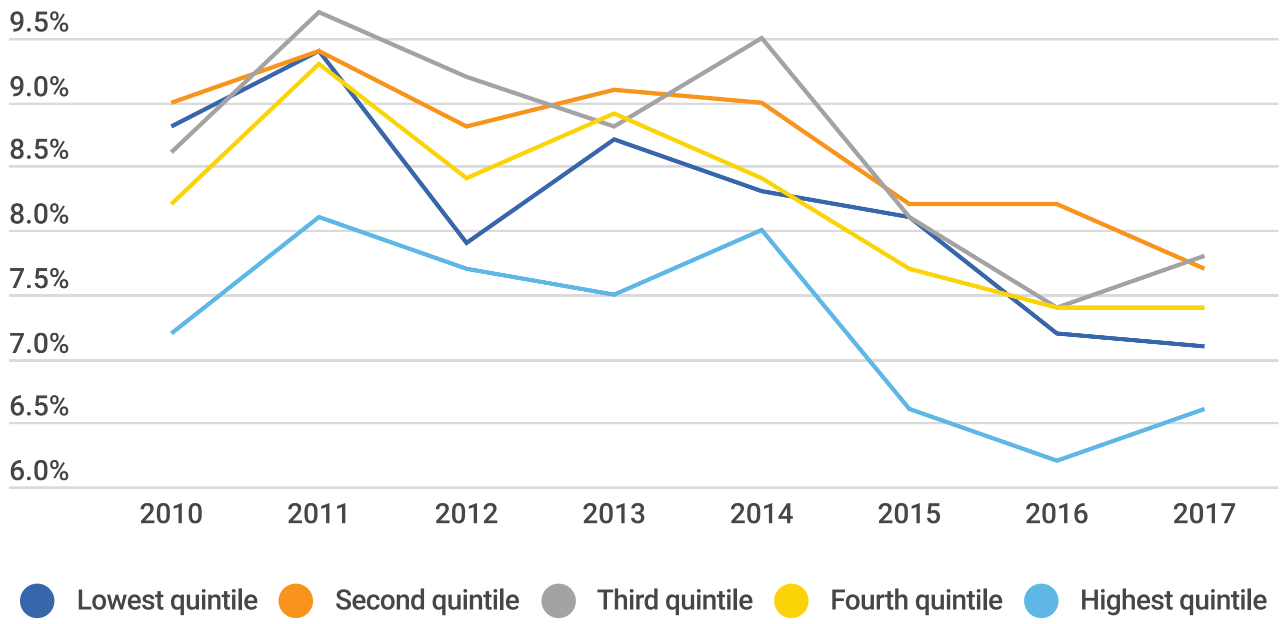
To inform distributional impacts of climate policies, we focus on three areas of household energy expenditure most likely to be affected by mitigation policies: energy use in homes, vehicle fuel, and public transit. Figure 8.1 shows the (average) share of these household expenditures across income quintiles between 2010 and 2017.[13]

The data suggest that households in the second, third, and fourth income quintiles spend a larger share of their budget on energy expenditures and therefore might be the most financially vulnerable to increases in energy expenditures. These three quintiles include lower-middle-class to upper-middle-class households that might live in medium- to large-sized suburban homes, sometimes with multiple vehicles, which together result in higher energy expenditures.

Climate policies have likely had some influence on changes in household expenditures over time but the aggregate impact is unclear. Regulations to reduce GHG emissions from electricity production, for example, have put upward pressure on electricity prices in some provinces (Doluweera et al., 2018). Mandates to blend biofuels with gasoline and diesel put upward pressure on fuel prices at the pump (Canada's Ecofiscal Commission, 2016). At the same time, improvements in energy efficiency standards (e.g., for vehicles, appliances, light bulbs, furnaces, etc.) and household rebates/subsidies have helped reduce energy bills but do not show up explicitly in the data, including rebates in provinces and territories where the federal carbon price is applied. Critically, each of these policies have helped Canada reduce its GHG emissions.

FIGURE 8.1:

Total Energy Expenditures as Share of Total Current Expenditures



This figure shows total energy expenditures (household energy/heating and vehicle fuel) as a share of total current expenditures for each quintile in Canada from 2010 to 2017. To develop the quintiles, Statistics Canada ranks all households from lowest to highest according to the value of their before-tax income. Overall, energy expenditures fell across all income quintiles between 2010 and 2017. The share of expenditures on energy were highest for the second, third, and fourth income quintile. In absolute terms, total expenditures on energy increased for each quintile (except the lowest); however, because total expenditures increased at a faster rate, the share of energy-related expenditures increased at a slower rate than the increase in total household expenditures. Note that the differences between shares are not statistically significant and reflect multiple factors beyond energy expenditures.

Sources: Statistics Canada (2020a); Statistics Canada (2020b).

Other factors are also at play with the trends in Figure 8.1. Total household spending on energy over this period increased for every quintile, except the lowest. But because total household expenditures increased at a faster rate (i.e., household spending on everything else), the share spent on energy went down.[14] At the same time, changes in global commodity prices, increasing energy demand, and consumer preferences also affect household expenses. Natural gas and gasoline prices, for example, have trended downward since 2014, whereas electricity prices have generally trended upward (CER, 2017a).

ENERGY EXPENDITURES ACROSS PROVINCES

Energy expenditures also vary across provinces. Figure 8.2 shows the share of energy expenditures across provinces and income quintiles for 2017. Overall, households in the Atlantic provinces spent a much larger share of their household budgets on household energy, transportation fuel, and public transit than other provinces, while households in B.C. had the lowest share of expenditures. It is also notable that households in the second income quintile tended to spend more of their budget on energy than the bottom quintile, in part because households in the second quintile typically spend more on owning and operating private vehicles relative to those in the lowest quintile, which are less likely to own vehicles (Statistics Canada, 2020b).

The concept of "energy poverty" is particularly relevant here, as it highlights the risks for financially vulnerable households. By one definition, households experience energy poverty when they spend 10 per cent or more of their total income on household heating/electricity and vehicle fuel (Boardman, 1991; Boardman, 2010; CER, 2017b). And while the precise 10 per cent threshold is instructive, more important is that it highlights the number of households that spend a disproportionate share of their income on energy.[15] Households that experience energy poverty can face higher health risks (e.g., keeping households colder to save money) and typically have less money to spend on other needs and wants.

Based on the 10 per cent threshold for energy poverty, households in Atlantic Canada were most at risk (CUSP, 2019). In 2017, for example, households in first, second, and third income quintiles in the Atlantic region spent 11 per cent of their income on energy and public transit. These higher shares in Atlantic Canada are likely a result of lower incomes relative to the rest of Canada and higher energy costs. Moreover, because the data in Figure 8.2 are averages, it means some households spent well above the 10 per cent benchmark on energy—in Atlantic Canada and in other provinces.

Figure 8.2 also includes the GHG intensity of electricity generation in each province/region to help illustrate the connection between energy costs and GHG emissions (ECCC, 2020).[16] Notably, households in provinces with low-emission electricity grids tend to pay less for their electricity than in provinces with emissions-intensive grids. Quebec residents, for example, enjoy some of the lowest energy costs in the country and also emit fewer GHG emissions from household heating and electricity. And while the emissions intensity data in Figure 8.2 exclude emissions from fossil fuels used in homes and vehicles, the data from Indicator #1 show that provinces with higher GHG productivity (i.e., more economic activity and fewer GHGs) generally have lower household energy costs (B.C., Manitoba, Ontario, Quebec). The exception to this is in the Atlantic provinces, which have both the highest GHG productivity (except Newfoundland and Labrador) and the highest energy costs.

Finally, the data in Figure 8.2 do not include the territories and Northern communities, which face significant energy poverty challenges. Data are often scarce, which makes it difficult to track and monitor household expenditures. Generally, however, energy and transportation are more expensive in the North, which makes these communities even more exposed to potential climate policy distributional impacts. These communities are also more likely to experience poverty and other factors of vulnerability (see Indicator #9).

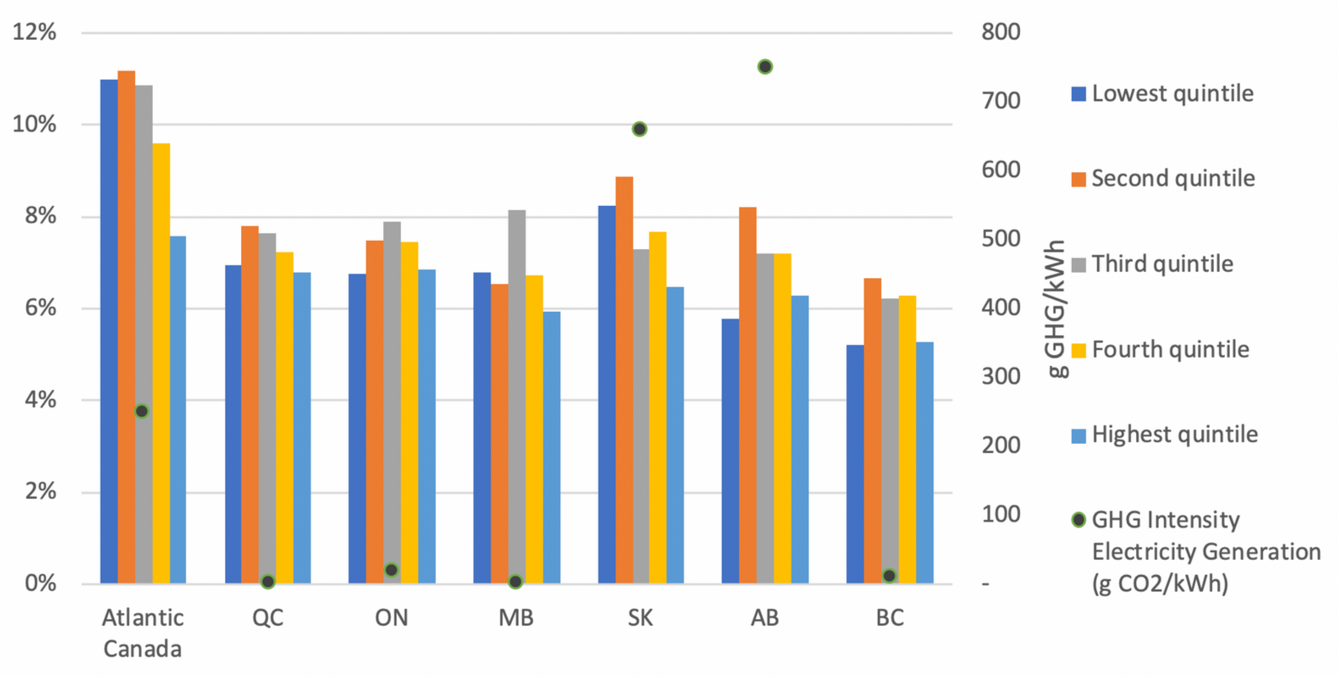
LIMITATIONS WITH USING HOUSEHOLD EXPENDITURES TO MEASURE DISTRIBUTIONAL IMPACTS

Household energy expenditures provide important insights on overall costs for households but are an incomplete measure.

First, expenditure data do not show the aggregate impact from climate policies. Ideally, indicators of distributional impacts would isolate and measure the effects on household budgets from all climate policies—including subsidies, regulations, taxes, and rebates. This would allow policy makers to understand the aggregate effect of climate policy over time and how it affects different types of households (e.g., low-income, high-income, marginalized groups, etc.). Household expenditure data alone do not provide this type of information.

FIGURE 8.2:

Total Energy Costs (Household + Vehicle + Public Transit) as Share of Expenditures (2017)



This figure shows total energy expenditures (household energy/heating and vehicle fuel) as a share of total expenditures across income quintiles and across Canadian provinces. Overall, households in Atlantic Canada spent a much higher share of their total expenditures on energy compared to other provinces. In most provinces, households in the second, third, and fourth income quintile spent a larger share of their household budget on energy costs and public transit. While the households in these quintiles may be more financially vulnerable to climate policies, grouping households into quintiles likely masks large differences in circumstances. The poorest households in the bottom quintile, for example, may spend a much larger share of their income on energy relative to the average. The figure also includes the GHG intensity of electricity generation in each province (using 2017 data). While these GHG intensity data exclude transportation and household emissions from using fossil fuels, it is notable that most households in provinces with low-emission electricity grids spend less on energy.

Sources: Statistics Canada (2020b); ECCC (2020).

Second, expenditure data do not provide information on individual policy design. The design of climate policies is critical to determining how the costs and benefits are distributed across households (and the economy more broadly). Design also determines the cost-effectiveness of policy and thus the overall costs and benefits (Canada's Ecofiscal Commission, 2015). Yet the high-level energy expenditure data in Figures 8.1 and 8.2 provide no meaningful information on whether governments are designing policies to minimize overall or distributional costs on households.

Table 8.1 illustrates several types of policies, all of which have distributional implications for the most vulnerable and marginalized in Canadian society. Some were designed to specifically protect and help low-income households, such as the national carbon price, which provides direct rebates to households and leaves the bottom three income quintiles better off (all else being equal). Other policies, however, can narrowly benefit those with higher incomes, such as EV subsidy and household solar financing programs.

TABLE 8.1:

Distribution of Policy Costs from Select Climate Policies

TYPE OF POLICY	JURISDICTION IMPLEMENTED	POLICY IMPACT ON LOW-INCOME HOUSEHOLDS
National carbon price	**Alberta, Saskatchewan, Ontario, New Brunswick**	The most recent analysis by the Parliamentary Budget Office finds that the federal carbon price is progressive, in that the bottom three income quintiles receive a net benefit after revenue recycling is considered. This outcome is supported by the broader literature, which shows that carbon pricing can be a progressive policy and leave low- and middle-income families better off (Winter et al., 2019; Stone, 2015).
Electric vehicle subsidy	**British Columbia**	Rebates are between $1,500 and $3,000, with a maximum qualifying price of $55,000. While the rebates have helped B.C. achieve the highest rate of EV sales per capita in North America, they primarily benefit wealthier people, property owners, and those living in single detached households (Robinson, 2019). Disproportionate uptake by wealthier households is common, however, at the early stages of new technologies that eventually become more affordable.
Solar panel financing	**Halifax, Nova Scotia**	The Solar City Program reduces the upfront barriers of installing rooftop solar by offering a 10-year loan with a fixed interest rate. The program has been effective but, like other home energy and retrofit programs in North America, is targeted mostly at property owners and wealthier households (Borenstein & Davis, 2016). Other policies would be required to reach lower-income households and renters.
Public transit subsidies	**Calgary, Alberta**	The City of Calgary offers low-income households a discount on monthly transit passes. Discounts are offered on sliding scale and range between 50 per cent and 95 per cent. Participation in the program grew from 175,000 riders in 2014 to 409,000 in 2018 (City of Calgary, 2019).

Ideally, policy design would consider multiple factors such as distributional household impacts, cost-effectiveness of GHG reductions, and incentives for behavioural change. Controlling energy prices or subsidizing energy use can distort price signals needed for investment in lower-carbon technologies and reduce incentives to limit energy use. Rebates that are not tied to energy use can help address affordability concerns without these effects. Time-limited subsidies that primarily benefit higher-income populations can also sometimes be justified if they help kick-start an emerging market for new or higher-cost technologies (Popp, 2016).

Pre-existing vulnerabilities and socio-economic pressures are also important to consider, as they can ultimately impact the fairness, effectiveness, and long-term durability of climate policy (see Box 8.1). Fortunately, there are many ways to design and implement policy to ensure they do not disproportionately affect Canada's most vulnerable populations.

BOX 8.1:

The Link between Inequality, Social Trust, and Climate Policy

Climate policies cannot be developed in a vacuum. Policies are implemented within the context of dynamic, complex, and often unpredictable political discourse, affected by changes in global and domestic markets, employment, technological change, and culture, among other factors. They exist within the context of pre-existing socioeconomic challenges, such as income inequality, poverty, systemic discrimination, and deprivation of essential services.

Climate policies interact directly with this underlying context, with lines of causality running in both directions. Creating effective and durable climate policies requires a strong foundation of social and political trust—confidence that governments can solve big challenges and make Canadians better off. High rates of inequality, poverty, and deprivation can erode this foundation and make implementing climate policy more difficult. At the same time, poorly designed climate policies can exacerbate pre-existing inequities, making it harder to implement ambitious and lasting solutions.

Despite modest gains, income inequality and poverty remain big challenges in Canada. By nearly every measure of income inequality, Canada ranks in the middle of the pack relative to other wealthy countries. In 2018, for example, the bottom 20 per cent of Canadian households earned 6 per cent of all income generated in Canada, whereas the top 20 per cent of households took in 41 per cent. Poverty rates have declined in recent years (from 16 per cent in 2006 to 10 per cent in 2017) but remain high for certain groups, such as single persons (25 per cent), young single mothers (27 per cent), and Indigenous children (40 per cent). While climate policies likely play a small role in these trends, they could amplify these inequities in the future if they are not carefully designed.

When it comes to social and political trust, Canada scores high relative to other wealthy, democratic countries. In 2017, Canada ranked fifth of 35 OECD countries in terms of the confidence citizens held in their national governments. Yet Canada has also experienced significant national and regional tensions, centred on issues such as pipelines, natural resource development, carbon prices, and Indigenous rights and land title.

Given the pace and scale of change required for Canada to transition to a low-carbon economy, these complex linkages between climate policy and social and political trust matter more than ever and deserve detailed ongoing examination. In many ways, addressing climate change while also addressing social inequities is mutually reinforcing.

Sources: CCPA (2013); Neuman (2018); OECD (2018); Vallier (2019).

DATA GAPS

Assessing the distributional impacts of climate policies on households is admittedly a complex challenge. Household expenditures change based on a wide range of factors; climate policies are only one factor, with cost pressures moving in both directions. A single climate policy can interact with other climate and non-climate policies.

Despite these challenges, governments can improve how they assess the distributional costs and benefits of climate policy. In particular, governments can conduct more detailed financial analyses upfront—as policy is being designed—to help ensure that the most disadvantaged and vulnerable households are not made worse off by policy decisions. Similar to the data in Figures 8.1 and 8.2, this type of analysis could assess policy impacts across income quintiles. The federal carbon price is one of few examples where this type of financial analysis was completed.

Developing standards for this type of analysis—nationally and across provinces—could help. They could ensure that costs and benefits of a particular climate policy are weighed against existing cost factors, including those from other climate and non-climate policies. They could also help standardize a more detailed level of analysis across household characteristics. Here governments could apply a wider intersectional lens to data analysis, looking at age, gender, ethnicity, and income category. This type of data, for example, would allow researchers to identify the incidence of energy poverty in Canada by region, income group, and household characteristic.

Finally, improving financial analysis of climate policies could help governments weigh household outcomes against other policy objectives. Maintaining energy affordability is an important objective—especially for those with lower incomes—but other objectives matter as well, such as reducing GHG emissions and minimizing total economic costs.

9

INCLUSIVE RESILIENCE

The physical impacts of climate change pose complex risks to Canadians. Climate impacts—wildfires, floods, droughts, heat waves, permafrost thaw, sea-level rise—will be felt unevenly across individuals, communities, provinces, and regions. Some Canadians are more vulnerable to a changing climate than others. Clean growth requires increasing the resilience of those that are vulnerable.

HEADLINE INDICATOR

Poverty Rates in Canada

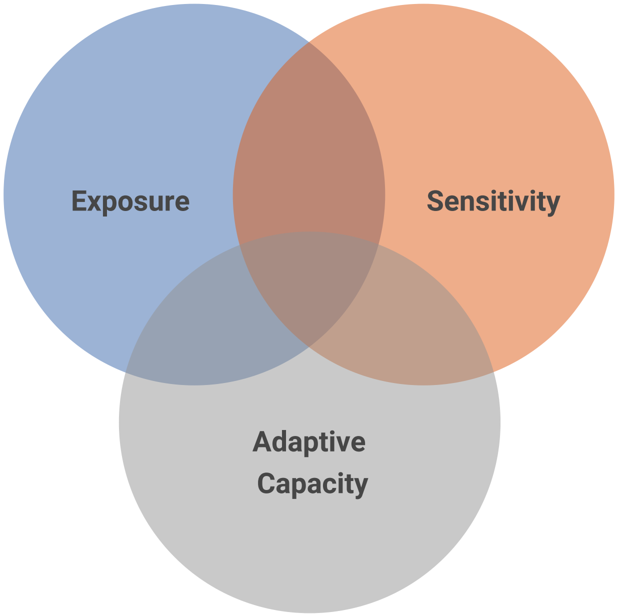
Vulnerability to climate change has three key dimensions (see Figure 9.1). Some regions and communities in Canada face higher **exposure** to climate risks than others, based on location-specific climate risks (e.g., flood, wildfire, heat waves) and other key variables, such as where people work and live and how they move around. Other individuals and households are more **sensitive** to climate impacts when they occur. This group includes children, disabled persons, pregnant women, the elderly, those with pre-existing health conditions, or those with low incomes. Lastly, vulnerability is shaped by how much **adaptive capacity** people and communities have before, during, and after climate-related events occur (USGCRP, 2016). Vulnerability is shaped by the confluence of all three dimensions (IPCC, 2007; Lavell et al., 2012; Manangan et al., 2016).

Importantly, all people and communities in Canada can experience vulnerability. It does not imply weakness; rather, vulnerability is shaped by the scale of change individuals and communities face—in combination with other challenges and historical circumstances (Haalboom & Natcher, 2012). Measuring vulnerability is about better understanding the risks that different individuals, groups, communities, and regions face and how to leverage existing strengths and community values to improve resilience.

We use poverty rates to measure the resilience (and vulnerability) of Canadians (see Figure 9.2).

FIGURE 9.1:

Elements of Vulnerability



Although an imperfect proxy, poverty is a driving factor behind all three dimensions of vulnerability. Those that can afford to prepare, move, rebuild, or recover are not as vulnerable as those that are poor (Hallegatte et al., 2020). Poverty is also highly correlated with other key factors that shape vulnerability, such as inadequate access to housing, clean drinking water, education, health care, and other factors such as discrimination and colonization (Heisz et al., 2016; ESDC, 2016; Thomas et al., 2015).

At the same time, poverty is indirectly connected to exposure to climate risks. Some low-income communities, for example, are more exposed to climate hazards, such as communities located in flood plains or in urban areas where the "heat island effect" is most intense (Health Canada, 2020). Nearly 22 per cent of residential properties on Indigenous reserve lands in Canada, for example, are at risk of a 100-year flood (Thistlethwaite et al., 2020). Moreover, key social programs can become disrupted during climate emergencies, leaving vulnerable populations isolated and more exposed. Low-income populations are also more vulnerable to higher food prices from disrupted supply chains.

Despite progress over time, the data indicate that some Canadians remain highly sensitive and poorly equipped to deal with climate impacts, given high poverty rates. People under the age of 18 who live in households parented by single females, for example, are nearly three times more likely to experience poverty than the average Canadian. Poverty rates are also higher for males and females not in an economic family (27 per cent and 22 per cent, respectively). Several climate risk assessments in Canada highlight the climate vulnerability of these specific groups (Council of Canadian Academies, 2019; Government of British Columbia, 2019).

FIGURE 9.2:

Market-based Poverty Rates across Select Categories (2006–2018)

This figure shows poverty rates across select groups between 2006 and 2018. Poverty rates are based on Statistics Canada's market-based measure, which standardizes poverty rates according to the cost of living in different parts of the country and is considered Canada's official measure of poverty. Overall, poverty rates declined across most groups over this period (not just the groups in the figure); however, rates remain relatively high for youth under 18 years old with single mothers, as well as males and females not in an economic family. Other measures of poverty in Canada, including the low-income cut-off and the low-income measure, also show a reduction in poverty, albeit not as steep. Much of this reduction in poverty was due to an increase in the national child benefit, along with a stronger labour market.

Source: Statistics Canada (2020). Note: see Statistics Canada's Table: 11-10-0135-01 for poverty rates not included here.

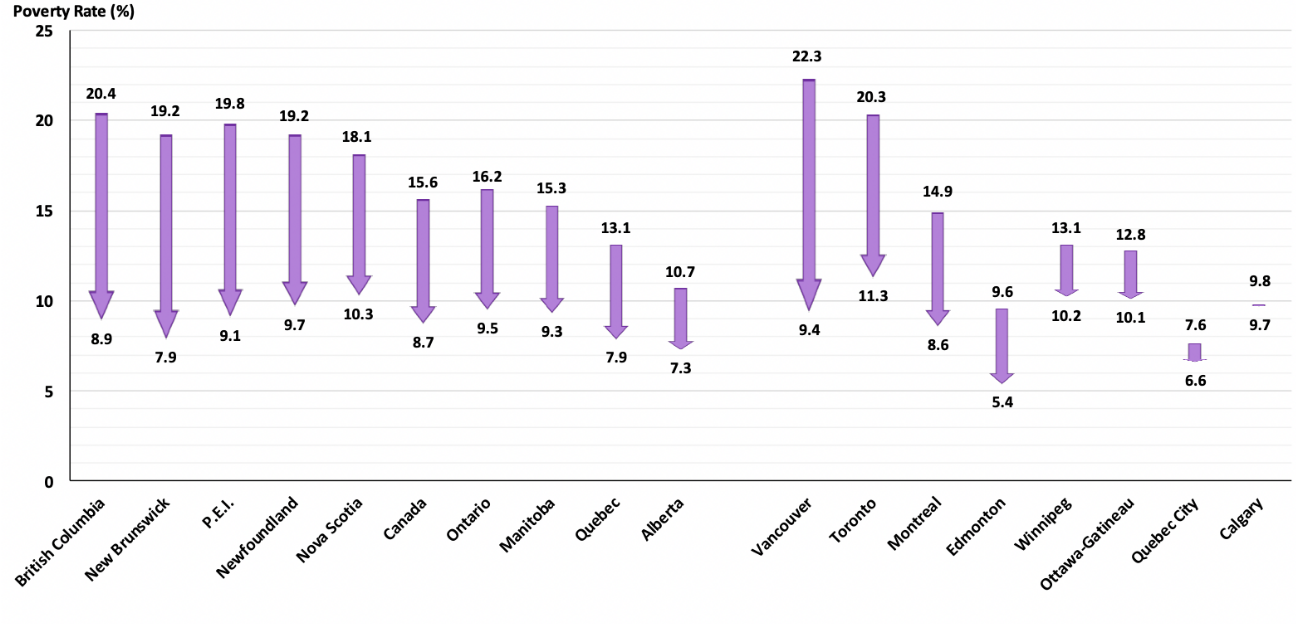
POVERTY RATES ACROSS PROVINCES AND CITIES

Similar to national trends, poverty rates have declined across provinces and cities, though to varying extents. Here, too, poverty data give a clue as to how climate vulnerability might vary across Canada. Figure 9.3 shows poverty rates for all 10 provinces and eight of Canada's largest cities. At the provincial level, the biggest reductions in poverty rates were in British Columbia, New Brunswick, and Prince Edward Island. At the municipal level, the biggest reductions were in Vancouver, Toronto, and Montreal.

Notably, these data do not include poverty rates for the territories or Indigenous and Northern communities. Data from other sources suggest poverty rates are generally much higher in these communities relative to the Canadian average, especially for children (ESDC, 2016). According to census data from 2006 and 2016, 47 per cent of status First Nations children live in poverty (53 per cent for those living on reserve and 41 per cent for those living off reserve). And unlike national poverty rates, which declined over time, child poverty rates in Indigenous

FIGURE 9.3:

Poverty Rates across Provinces and Select Cities, 2006 and 2018



This figure shows the change in poverty rates (using the market-based measure) across provinces and select cities between 2006 and 2018. Similar to the national trend, poverty rates declined across all provinces over this period., with the greatest reductions occurring in British Columbia, New Brunswick, and Prince Edward Island. Across Canada's major cities, the largest reductions were in Vancouver and Toronto. Poverty rates in places like Quebec City and Calgary sarted from a much lower base and declined only modestly.

Source: Statistics Canada (2020).

communities have remained largely unchanged. Child poverty rates are highest in Manitoba and Saskatchewan (Beedie et al., 2019). Across Canada, these high poverty rates in Indigenous communities are linked to historic and ongoing colonization and systemic discrimination (Cameron, 2012).

LIMITATIONS WITH USING POVERTY RATES AS A PROXY FOR RESILIENCE AND VULNERABILITY

Poverty rates provide key insights on Canadians' resilience to climate change but have clear limitations:

Poverty rates are an incomplete measure of sensitivity and adaptiveness. Individuals with significant financial resources may still be highly sensitive to climate impacts because of their age or pre-existing health conditions. At the same time, poverty rates within a community might be improving, but other underlying inequities—such as access to clean drinking water, transportation, or discrimination—may make the community highly sensitive to climate impacts and inhibit its adaptability. Remote Indigenous communities, for example, lack basic infrastructure relative to Southern Canada (Johnston & Sharpe, 2019), which makes them less resilient and less accessible to outside help when disasters strike.

Poverty rates provide limited information on the relative exposure to climate impacts. Exposure to climate risks is a critical part of vulnerability (Cardona et al. 2012). Overall, Canadians' exposure to extreme climate risks—floods, droughts, sea-level rise, permafrost thaw, wildfires, etc.—is expected to increase over time as global temperatures increase (ECCC, 2019). These risks will also vary across provinces, regions, and even neighbourhoods.

Poverty rates do not capture direct local exposure and how exposure is changing over time. While decreasing poverty rates may help Canadians become less sensitive and more adaptable to climate impacts, increasing exposure may easily offset these gains.

True vulnerability lies at the intersection of exposure, sensitivity, and adaptability. The most comprehensive way to measure vulnerability is at the intersection of exposure, sensitivity, and adaptability. Layering and mapping each dimension of vulnerability—at a high level of disaggregation—can help researchers and policy makers truly understand the complexities and interactions of climate risks facing Canadians (Minano et al. 2019).

For example, Chakraborty et al. (2020) uses 2016 census data to construct a socio-economic status index that includes 49 different indicators of sensitivity and adaptiveness (e.g., racial and ethnic composition, household and family structure, access to financial resources, and demographic characteristics). The index is then layered on top of each communities' exposure to flood risk to identify the most vulnerable communities in Canada. This type of data and analysis is key to designing policies that help build resilience amongst these affected populations. Poverty rates are a component of this larger picture but are incomplete on their own.

DATA GAPS

Although Canada generally has good data to identify at-risk populations, governments can improve existing datasets and connect them directly to climate change (see Table 9.1). The biggest data gaps involve Indigenous and Northern communities. National datasets often do not include these communities due, in part, to challenges with data collection and small sample sizes. Yet these communities are some of the most vulnerable to climate change. Canada also lacks data on specific factors of sensitivity that have historically not been connected to climate change, such as mental health, immigrant

TABLE 9.1:

Potential Data Solutions to Improve Resilience

DATA GAP	POTENTIAL DATA SOLUTIONS
Tracking deaths, injuries, illnesses, and displacement from extreme weather events	▸ Standardize how these data are reported ▸ Track the demographics of people affected, with specific focus on social determinants of vulnerabilities ▸ Map expected climate risks (e.g., floods, wildfires, heat waves) against pre-existing societal vulnerability data
Tracking changes to insurance premiums and coverage	▸ Track changes in insurance premiums and availability, by household income level, race, gender, and family structure ▸ Track the number of households without insurance, or households that lose coverage, by income level, race, gender, and family structure ▸ Track local insurance premiums following specific events (e.g., Fort McMurray wildfire)
Tracking climate impacts in Indigenous and Northern Communities	▸ Improve data collection on poverty rates and other socio-economic indicators of vulnerability for Indigenous and Northern communities ▸ Apply the Canadian Index of Multiple Deprivation to Indigenous and Northern communities and map this data on top of climate risks
Tracking changes in physical and mental health	▸ Standardize tracking and reporting of vector-borne disease with regional detail ▸ Track linkages between mental health and climate change ▸ Track air quality data during wildfires, and track physical and mental health outcomes of wildfires (by municipality, age, gender, and income level) ▸ Track changes in mental health following extreme weather events

communities, racial discrimination, and the long-term employment impacts from natural disasters.

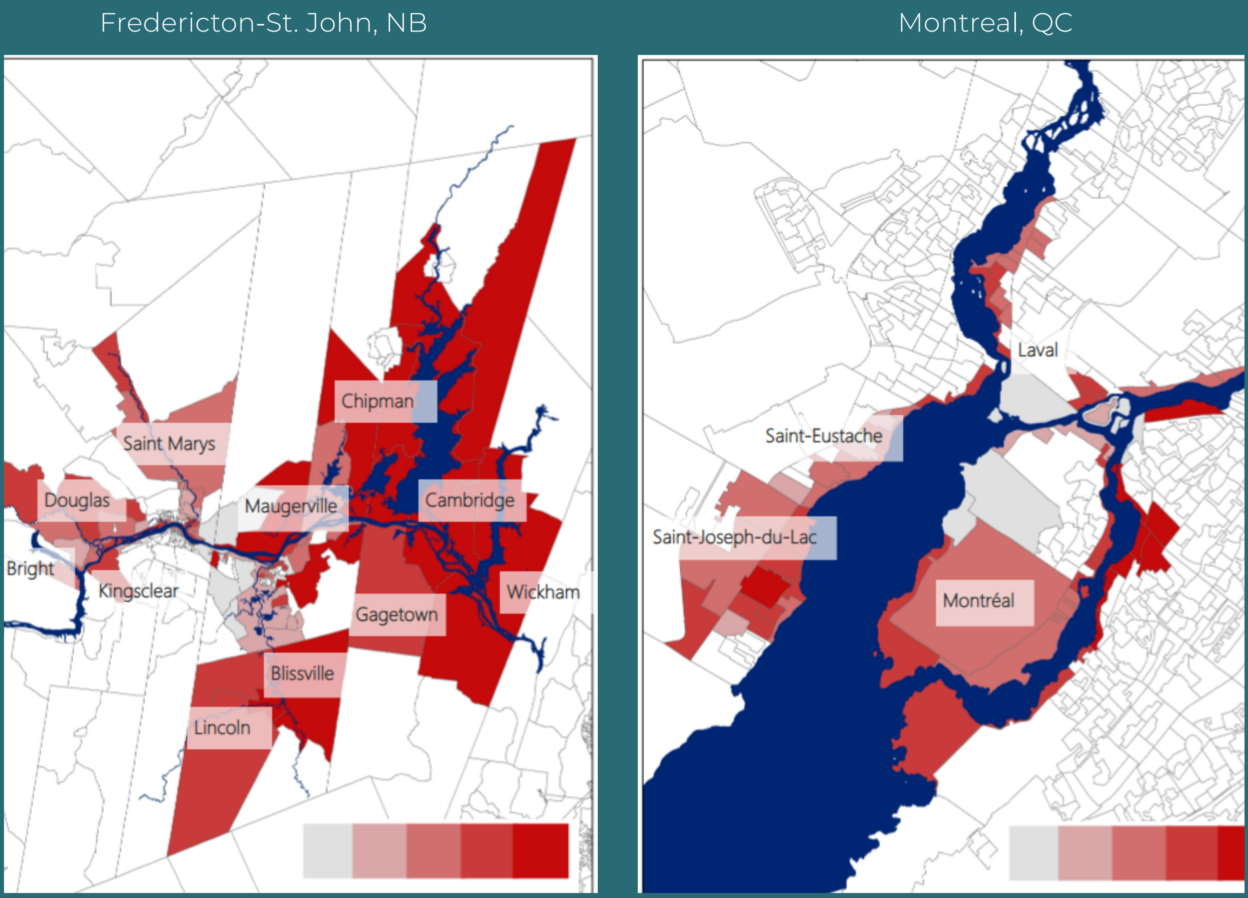
More consistent and standardized data across communities can help, as data collection standards vary across provinces and municipalities. The City of Montreal has developed some leading approaches to tracking vulnerability and heat wave risk. Due to better reporting standards, Montreal can appear to suffer higher damages and health risks from heat waves relative to other provinces. During the heat wave of 2018, for example, Montreal experienced 66 heat-related deaths, whereas Ottawa reported zero, despite experiencing similar temperatures (Oved, 2019).

Finally, Canada could benefit from more research on the interaction and overlap between the different dimensions of vulnerability. Statistics Canada has made progress, for example, by combining its Canadian Index of Multiple Deprivation with historical flood data from several cities in Canada. These data were used to identify the most exposed and sensitive communities to spring flooding in Fredericton-St. John, Montreal, Southern Manitoba, and Ottawa-Gatineau (Figure 9.4).

More of this type of data and research could dramatically improve our understanding of the most vulnerable populations to climate change (Chakraborty et al., 2020). It can help governments design policies that improve Canadians' adaptability and resilience while avoiding policies that exacerbate pre-existing vulnerabilities (e.g., providing inequitable flood relief to low-income households and renters). This type of data can also be used to conduct forward-looking analyses to better understand how vulnerabilities might change over time.

FIGURE 9.4:

Mapping Sensitivity and Exposure to Climate Risks



This figure from Statistics Canada shows areas of Fredericton and Montreal that were affected by spring flooding in 2019, along with the relative sensitivity of these affected communities. To measure sensitivity, Statistics Canada uses its Multiple Deprivation Index, which considers housing conditions, household composition, demographic and socio-economic characteristics, employment levels, and language barriers. Areas that are more deprived and therefore more sensitive to flooding are marked by dark red, while areas that are less deprived and therefore less sensitive are marked by light red. The purpose of the mapping exercise is to show how exposure to climate risk can be compounded for those that are highly sensitive and less adaptable to climate risks and show that each community faces its own distinct needs and challenges.

Source: Statistics Canada (2019b); Statistics Canada (2019c).

10

CLEAN AIR

Improving and protecting human health is a key part of a clean growth transition. Health and climate outcomes are linked by the emissions we release into the atmosphere: some are greenhouse gas emissions and contribute to climate change, while others are air pollutants that are harmful to human health. In many cases, these air pollutants and GHG emissions are emitted at the same time from the same sources. As a result, Canada has significant opportunities to improve health as it accelerates action to reduce GHG emissions.

HEADLINE INDICATOR

Ambient Air Quality across Canadian Cities

To measure air quality in Canada, we consider ambient air quality data in several Canadian cities across four major air pollutants (Figure 10.1). For comparison, we also include the Canadian Ambient Air Quality Standards (CAAQS) for 2020 and 2025, which are the baseline standards for air quality in Canada (see Box 10.1). Although we only have data for 2017–18 (see Data Gap section), the goal is to see ambient air quality improve over time.

The data in Figure 10.1 highlight a few notable trends.

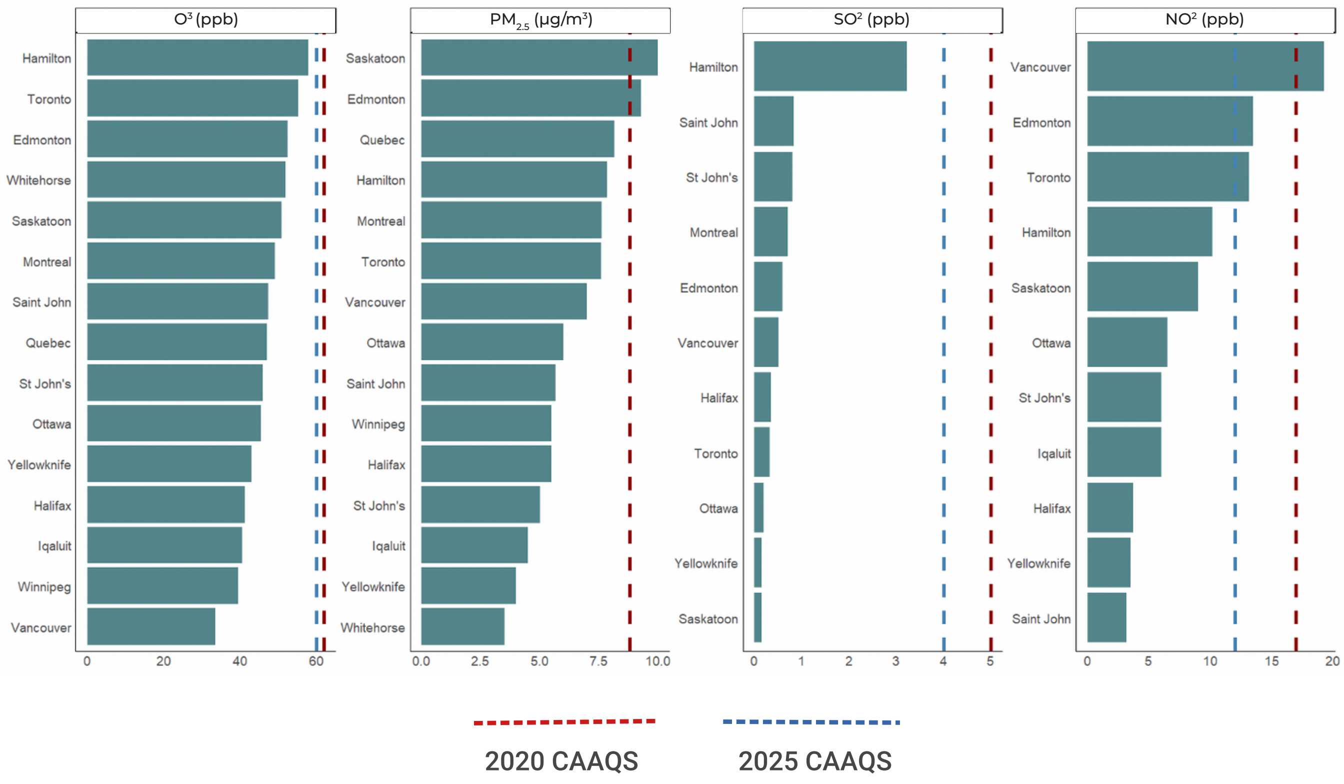
Overall, most Canadian cities in the figure achieved the 2020 and 2025 CAAQS in 2017–18, with a few exceptions. Vancouver was the only city in the figure that failed to meet the 2020 CAAQS for nitrogen dioxide; however, NO_2 levels in Edmonton and Toronto exceeded the 2025 CAAQS. Two cities failed to meet the 2020 CAAQS for fine particulate matter (Edmonton, Saskatoon). None of the listed cities exceeded the CAAQS for ground-level ozone (smog), but many came close to the standard. As CAAQS continue to tighten over time, many towns and cities across the country (including many not in Figure 10.1) will need to improve ambient air quality to meet the national standards.

The figure also highlights major differences in air quality across cities. Hamilton, for example, had among the highest concentration of sulphur dioxide (SO_2) emissions in the country (concentrations were higher only in Trail, B.C., and Saguenay, Quebec). Industrial activity—and smelters in particular—are the largest source of SO_2 emissions in Ontario and likely contributed to these high levels in Hamilton (Government of Ontario, 2017). Levels of fine particulate matter were nearly twice as high in Saskatoon and Edmonton compared to St. John's and Halifax, which were likely driven by differences in wildfire activity and heavy industry.

Air quality can also be dramatically different within a city, as illustrated by the concentration of nitrogen dioxide (NO_2) in Vancouver, which was twice as high as many other cities. One of Vancouver's two monitoring stations is located on a busy stop-and-go trucking corridor (Clark/Knight Street) that serves Canada's busiest port. Concentrations of NO_2 at this station were nearly twice as high as levels in downtown Vancouver (located only a few kilometres away), pulling up the city's average. In these urban driving conditions, heavy-duty trucks can emit NO_2 emissions equivalent to 100 cars (Badshah et al., 2019).

FIGURE 10.1:

Ambient Air Quality, Annual Average Concentrations, Select Cities



This figure shows average ambient air quality levels across select Canadian cities for 2017–2018. It includes data on three different air pollutants: fine particulate matter (PM$_{2.5}$), sulphur dioxide (SO$_2$), and nitrogen dioxide (NO$_2$). It also includes ground-level ozone, which arises from other pollutants and is the main ingredient in smog. Air quality levels are benchmarked against the 2020 and 2025 Canadian Ambient Air Quality Standards (CAAQS), which are jointly set by federal and provincial governments. Overall, all cities in the figure achieved the CAAQS for sulphur dioxide, while several had levels above the CAAQS for PM$_{2.5}$ and nitrogen dioxide. Multiple cities came close to exceeding the CAAQS for ozone.

Source: ECCC (2018a). Note: While CCME (2017) recommends using a three-year average to estimate ambient air quality for a given period, data were only available for 2017 and 2018. Currently, there is no CAAQS for fine particulate matter for 2025.

Lastly, the data in Figure 10.1 show that air pollution is not just a big-city problem. Ozone levels in Whitehorse, for example, were the fourth highest out of the 15 cities surveyed. Similarly, small and rural communities in southeastern and northeastern British Columbia have the highest levels of fine particulate matter (PM) in the country for 2017–18 (not included in the figure). Heavy wildfires during these two years were likely the primary cause of these high PM emissions, although emissions from forestry and resource extraction industries may have also contributed to poor air quality. Many Indigenous communities also grapple with poor air quality due to their proximity to industrial facilities and a heavy reliance on diesel generators in remote communities (MacDonald, 2019; CIRNAC, 2012).

BOX 10.1: **Ambient Air Quality Standards in Canada**

Ambient air quality refers to the concentration of pollution within a given airshed and changes based on the types and quantities of pollutants released into the local atmosphere. While pollution from human activities is the primary driver of poor air quality, weather conditions (wind, temperature, precipitation, etc.) and natural events (wildfires, volcanic eruptions) can also affect air quality.

To improve ambient air quality in Canada, the Canadian Ambient Air Quality Standards were developed collaboratively between federal, provincial, and territorial governments. Although there is no safe level of air pollution, the CAAQS establish baseline air quality standards for Canada that tighten every five years.

Sources: CCME (2017).

AMBIENT AIR QUALITY AND CANADIANS' HEALTH

Although Canadians generally enjoy relatively clean air compared to other countries, the ambient levels of air pollution presented in Figure 10.1 pose significant health risks, even in communities that achieve official air quality standards. Short-term exposure to air pollution—even at low levels—can cause shortness of breath, coughing, and chest pain. These health risks increase over time with longer and more regular exposure, increasing the risk of cancer, lung disease, irregular heart functions, cardiovascular disease, and even premature death (Health Canada, 2019; Wang et al., 2018; OECD, 2014).

Air pollution can also make existing problems worse. Emerging evidence from the COVID-19 global pandemic in 2020, for example, suggests that higher levels of air pollution increased the severity of the illness (Wu et al., 2020). Higher levels of air pollution can also exacerbate effects from climate change (Box 10.2).

In many cases, these health impacts are most acute in populations with other risk factors, such as children, seniors, and those with underlying health conditions. In children, for example, exposure to air pollution can increase the risk of respiratory issues and adversely affect cognitive development, such as weakened intelligence, memory, and behaviour capabilities (Heissel et al., 2019). Evidence also suggests some air pollutants (e.g., black carbon, particulates) can negatively affect prenatal development, leading to higher risk of

BOX 10.2:

A Changing Climate Will Exacerbate Air Pollution Challenges

Air quality typically deteriorates in warmer temperatures. Concentrations of ground-level ozone, for example—a big component of smog—intensify in strong sunlight and heat. As global temperatures increase, the number of days with dangerously high levels of air pollution in Canada could increase, undoing some of the gains made over the past few decades in lowering air pollutant emissions.

Higher background levels of air pollution from buildings, transportation, and industry also worsen the health impacts from wildfire smoke. During the summer of 2018, for example, intense wildfire smoke over Metro Vancouver caused air quality to plummet, exposing over 1 million residents to a record-setting 22 days of air quality advisories. The wildfire smoke coincided with hot and dry summer conditions and was likely exacerbated by background levels of air pollution from buildings, transportation, and industry. As the risk of wildfires in Canada increases with worsening climate change, exposure to poor air quality also increases.

Sources: Metro Vancouver (2019); Lancet Countdown & Canadian Public Health Association (2017); Reid et al. (2016)..

TABLE 10.1:

Major Sources of Greenhouse Gas Emissions and Air Pollutants

SOURCE	GHGS/SHORT-LIVED CLIMATE POLLUTANTS (% OF TOTAL POLLUTANT EMISSIONS)	AIR POLLUTANTS (% OF TOTAL POLLUTANT EMISSIONS)
Transportation	GHGs (24%); Black Carbon (54%); Ground-level Ozone (unknown)	NO_X (52%); CO (54%); VOCs (16%); $PM_{2.5}$ (2%); SO_2 (2%); Ammonia (1.7%); Ground-level Ozone (unknown)
Oil and Gas Industry	GHGs (27%); Black Carbon (7.9%); Ground-level Ozone (unknown)	VOCs (37%); SO_X (27%); NO_X (27%); CO (9.8%); $PM_{2.5}$ (0.8%); Ground-level Ozone (unknown)
Electricity (mainly coal)	GHGs (10%); Black Carbon (0.6%)	SO_2 (26%); NO_X (8%); CO (0.7%)
Agriculture	GHGs (10%); Black Carbon (0.1%)	Ammonia (94%); $PM_{2.5}$ (23%)

This table highlights GHG and air pollutant emissions from four sectors of the economy. Other sources of GHGs and air pollutants include industry, buildings, and waste. While ground-level ozone is included in the table with the other pollutants, it is slightly different because it is generated from the interaction of nitrogen oxides (NO_X) and volatile organic compounds (VOCs) in the atmosphere. This makes it difficult to attribute ground-level ozone to particular sectors.

Sources: ECCC (2019a); ECCC (2019b); ECCC (2020a). Note: GHGs = greenhouse gas emissions; NO_X = nitrogen oxides; CO = carbon monoxide; VOCs = volatile organic compounds; $PM_{2.5}$ = fine particulate matter; SO_2 = sulphur dioxide.

autism, developmental delays, reduced IQ, anxiety, depression, ADHD, and reduced brain size (Bove et al., 2019; Payne-Sturges et al., 2018; Lancet Neurology, 2018; Fu et al., 2018; de Prado Bert et al., 2018). In elderly populations, air pollution is linked to respiratory issues and a higher risk of dementia, Parkinson's disease, and multiple sclerosis (Sunyer et al., 2015; Chen et al., 2017).

Figure 10.1 helps illustrate that a large portion of the Canadian population is regularly exposed to harmful levels of air pollution (Health Canada, 2017; Health Canada 2019; CCME, 2017). Over 70 per cent of Canada's population lives in urban areas where concentrations of air pollutants are highest (Statistics Canada, 2019; Landrigan et al., 2017). Nearly one-third of Canadians live within 100 metres of a major road or 500 metres of a highway, with over 10 per cent of all elementary schools and over 35 per cent of long-term care facilities located within 50 metres of a major road or highway (Brauer et al., 2013). At the same time, a large proportion of Canadians are exposed to transboundary pollution originating from the U.S., particularly in Quebec and Ontario (ECCC, 2017).

In dollar terms, the health costs of air pollution are substantial. An estimate by Smith and McDougal (2017), for example, finds that the cost of fine particulate matter and ground-level ozone in Canada was between \$26 billion and \$48 billion in 2015. A broader analysis by Health Canada (2019) finds that air pollution causes approximately 14,600 premature deaths each year, at a cost of \$114 billion—or seven per cent of Canadian GDP.[17]

CLIMATE CHANGE AND AIR POLLUTION

Reducing the health risks from air pollution in Canada is closely tied to actions that address climate change. Indeed, one of the most significant opportunities to improve air pollution in the coming decades is capturing the co-benefits from policies primarily aimed at reducing GHGs. Mitigation policies directed at transportation, coal-fired electricity, buildings, and oil and gas extraction have the potential to significantly reduce air pollution. Table 10.1 shows the overlap between sources of GHG emissions and air pollutants.

Canadian governments have already made progress in implementing policies that address both air pollution and GHG emissions. The phase-out of coal-fired electricity in Ontario, for example, reduced SO_2 emissions from Ontario's electricity sector by 99.7 per cent and NO_X emissions by 86 per cent (Government of Ontario, 2017). As a result, the number of smog days throughout the province decreased from 53 in 2005 to zero in 2014.[18] It also helped reduce electricity sector GHG emissions by 87 per cent. Other notable air pollution/climate policies include efficiency standards for heavy machinery and vehicles and renewable energy policies that displace fossil fuel combustion (ECCC, 2016; 2018b).

Still, more can be done to create cleaner air and reduce GHGs. Notably, particulate matter emissions in Canada increased between 2005 and 2017, driven primarily by an increase in dust emissions (up 44 per cent) and emissions from the mining and oil and gas sectors (up 30 per cent and 29 per cent, respectively). Here, the link between climate policy and air pollution is particularly important: not only is particulate matter one of the most harmful types of air pollution for human health, but black carbon—a short-lived climate pollutant—is a key component of fine particulate matter.[19]

Actions that reduce particulate matter can help drive significant climate and air quality benefits, particularly in urban areas where exposure is highest. Heavy-duty vehicles, for example, represent 15 per cent of Canada's entire vehicle fleet yet produce 42 per cent of the sector's total carbon dioxide emissions and 52 per cent of particulate matter emissions (Kodjak, 2015). Policies that encourage greater fuel efficiency or greater uptake of electric and hydrogen-fuel-cell vehicles could make substantial gains in air quality, while also reducing GHG emissions.[20]

Finally, reducing GHGs does not always improve air quality. Climate policies promoting biomass combustion, for example, can increase PM emissions. At the same time, technologies that scrub out air pollutants from industrial activities can increase energy consumption and therefore increase GHG emissions. Considering the air pollutant implications of GHG policies will be important to fully capturing health benefits in the transition to 2050 (Koornneef et al., 2011).

DATA GAPS

Although Canada has good data on ambient air quality, governments can improve how they track trends in air pollution and its impacts on human health. Data from Environment and Climate Change Canada's National Air Pollution Surveillance (NAPS) program (used in Figure 10.1), for example, are only available for 2017 and 2018 (ECCC, 2018a). Ideally, ECCC would make historical data (before 2017) publicly available while also publishing data for years 2019 and beyond. This data would help identify trends over time and areas where air quality poses the largest health risks. Making the NAPS data platform more accessible and user-friendly would also be helpful, as these data are difficult to find and collate.

In addition, expanding monitoring stations can help build a clearer picture of local trends and health risks. The NAPS program is missing data for several major cities (e.g., NO_2 and SO_2 emissions in Montreal, Quebec City, and Winnipeg) and in Indigenous communities.

Perhaps the biggest data gap is the inability to trace the local sources of air pollution in Canada. ECCC publishes extensive data on air pollution sources through its National Pollutant Release Inventory, but this dataset only covers major industrial (stationary) sources of emissions. It excludes air pollution from commercial and residential buildings, construction, and non-stationary sources, such as transportation, mobile equipment, and wildfires.[21] Other datasets from ECCC do track emissions from each of these sectors but they are aggregated at the national level and of little use when examining local trends. Provincial databases (where they exist) also lack information on local pollution sources.

Without better data on the sources of emissions at the local level, determining the causes of air pollution in specific communities is a major challenge. We cannot say with certainty, for example, why NO_2 levels in Vancouver are double the levels in other cities, or why Hamilton has extremely high concentrations of SO_2 emissions. Better local data would allow policy makers and researchers to identify where air pollution is emitted and prioritize policies that tackle the biggest sources. Such data can also help identify policies that drive the biggest climate and air quality benefits.

More regional airshed modelling should be the ultimate goal of federal, provincial, and local governments. Regional airshed modelling combines data on ambient air quality, pollutant sources, and weather patterns to better understand how different air pollutants mix and move in the atmosphere and how the resulting ambient air pollution affects human health. Models, for example, allow researchers to estimate mortality and morbidity rates from air pollution in each community. These results can then be layered on top of other socio-economic data to see how air pollution affects the most at-risk populations (Indicator #9). Given that airshed modelling is computationally intensive (and expensive), governments could conduct this sort of analysis every five or 10 years to identify patterns and trends.

11

THRIVING ECOSYSTEMS

Maintaining and improving the health of Canada's ecosystems can provide multiple benefits that contribute to clean growth, including:

- **Sequestering and storing carbon**. Preserving and restoring ecosystems can contribute to efforts to reduce Canada's GHG emissions.
- **Supporting resilience in a changing climate.** Ecosystem services such as local climate regulation, flood moderation, air filtration, and soil erosion prevention can help reduce climate impacts and related costs.
- **Underpinning economic growth and human well-being more broadly.** Healthy ecosystems provide clean water, clean air, food, natural resources, recreational space, and wildlife habitat and are integral to Indigenous cultures.

HEADLINE INDICATOR

Land Use, Land Use Change and Forestry

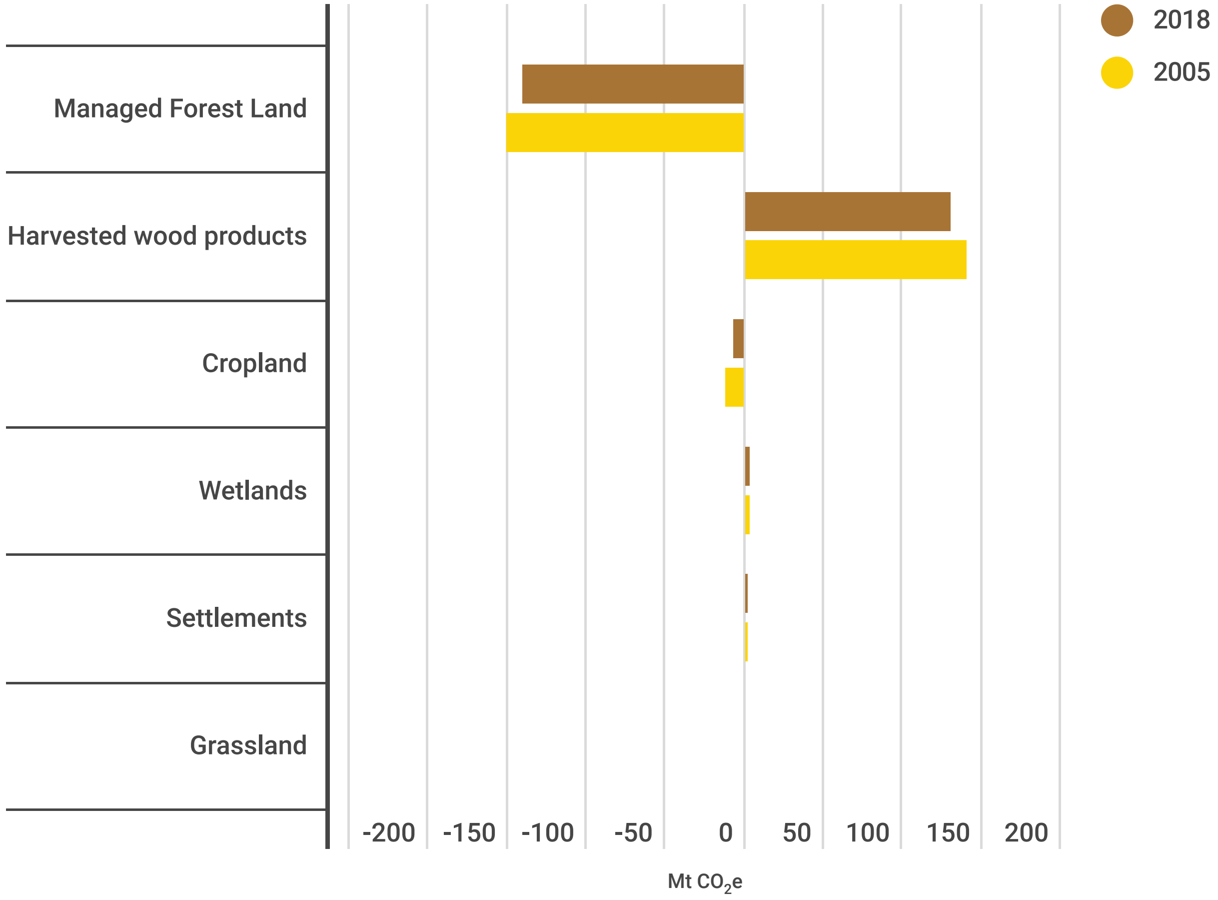
Nature-based climate change policies—such as Indigenous-led ecosystem management, ecosystem-based carbon offsets or natural infrastructure investments—offer the potential to generate both climate and non-climate benefits. Yet a changing climate, coupled with human activities, is leading to loss and degradation of ecosystems and the services they provide, reducing the capacity of ecosystems to offset GHG emissions and support resilience. Measuring the state, functions, and trends of ecosystems can help track progress in protecting natural assets but also inform the design of nature-based climate policies that provide multiple climate and non-climate benefits.

Ideally, we would track metrics that account for climate and non-climate services provided by ecosystems. This would help identify the full implications of changes in ecosystems due to human activities and natural disturbances. The best national-level climate-related ecosystem indicator currently available measures anthropogenic carbon sequestration (sinks) and emissions (sources) associated with land use, land use change and forestry (LULUCF) on managed lands for the purposes of Canada's GHG emission reporting under the United Nations Framework Convention on Climate Change (UNFCCC). Figure 11.1 illustrates the change in GHG emissions from different LULUCF categories in Canada between 2005 and 2018.

For the purposes of UNFCCC reporting and the setting of GHG reduction targets, the Government of Canada estimates LULUCF as a net carbon sink in 2018, sequestering around 130 Mt of net CO_2 equivalent in total. Given the linkages between managed forest land and harvested wood products, they can be considered together as a net sink of around 10 Mt of CO_2e in 2018. Croplands are the second-largest sink (ECCC, 2020). While this indicator does not capture natural disturbances, such as wildfires or insects, or all ecosystems and their services, trends over time give an approximate sense of the role ecosystems play in Canada's greenhouse gas emissions. The goal is to see overall sinks grow over time.

FIGURE 11.1:

LULUCF Net GHG Flux Estimates, 2005 and 2018 (Mt CO_2e)



This figure shows the change in anthropogenic (human-caused) GHG sources and sinks across six different types of LULUCF categories for 2005 and 2018. Managed forest land (accounting for 65 per cent of Canada's forests) provided the largest carbon sink for Canada, but the total amount of GHG emissions sequestered declined from 150 to 140 Mt CO_2e between 2005 and 2018. Harvested wood products was the largest single source of GHG emissions from LULUCF, at roughly 130 Mt CO_2e in 2018, though it is important to note that harvested wood products store carbon over time and can offset other GHG emissions if wood products are used in place of more GHG-intensive options. The wetlands category only includes peat extraction and flooding from hydroelectric reservoirs.

Source: ECCC (2020).

REGIONAL AND SECTOR-LEVEL IMPLICATIONS

To assess Canada's performance at a more disaggregated scale, we consider net LULUCF emissions by ecozone (Figure 11.2). Ecozones are defined by historical and evolutionary distribution of plants and animals.

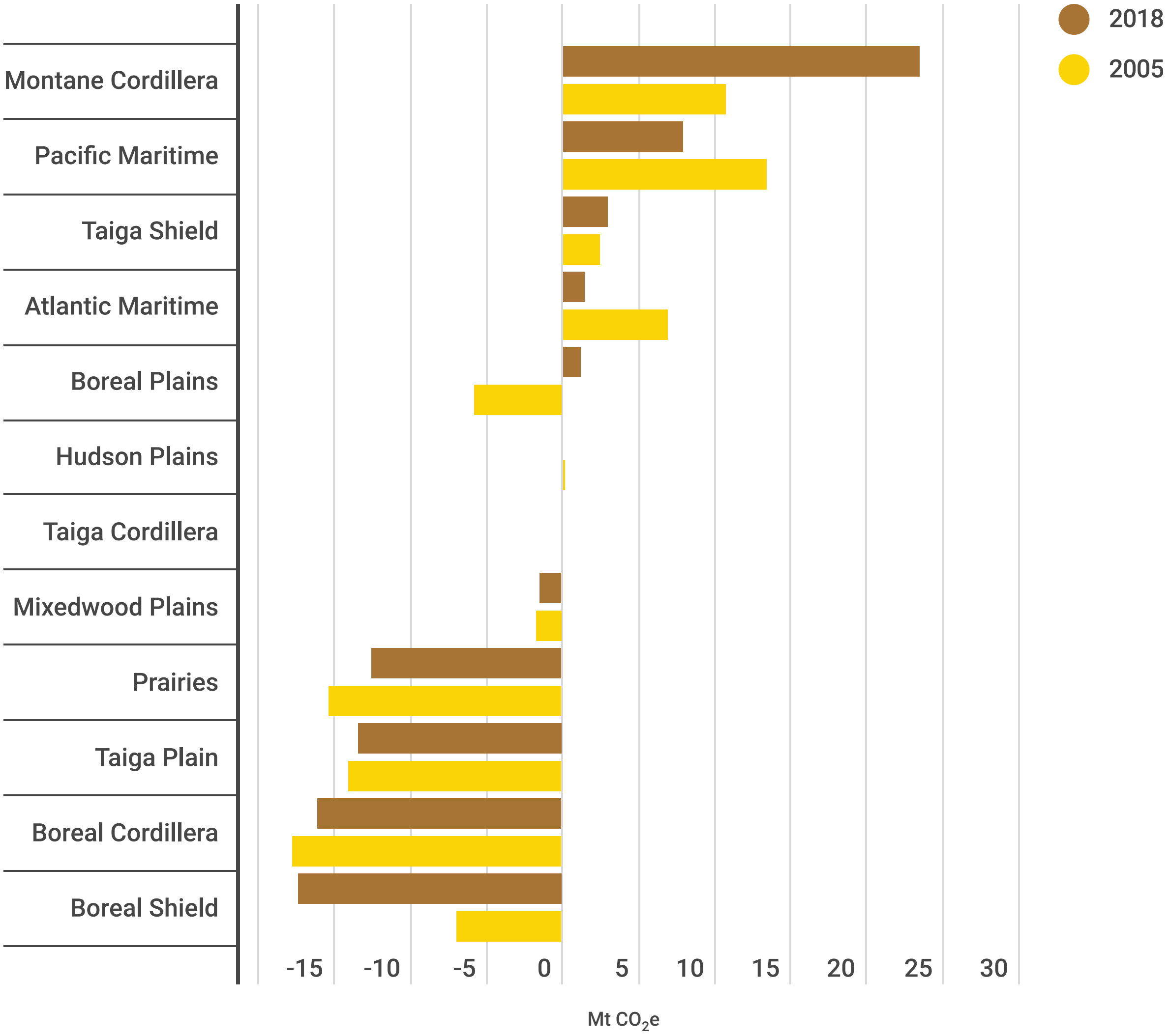
The Montane Cordillera and Pacific Maritime ecozones in British Columbia are the largest sources of LULUCF emissions, contributing over 405 Mt cumulatively from 2005 to 2018, and 23 Mt and 8 Mt annual emissions respectively in 2018 (NRCan, 2020a; ECCC, 2020a).

There are several reasons for these high LULUCF emissions in B.C. Despite a relatively high proportion of protected areas in the province, the practice of slash burning is common in these two major "source" ecozones, which releases significant quantities of particulate matter and GHGs into the air. Slash burning is used in 15 per cent of B.C.'s coast and 50 per cent of the rest of the province where clear cutting is practised (Government of British Columbia, 2020a; ECCC, 2019).[22] Estimates by the federal and B.C. governments suggest slash burning is responsible for between 3 and 5 Mt of CO_2e annually (Government of B.C., 2020b; Kurz, 2020). Other important drivers of LULUCF emissions in these regions are the impacts of mountain pine beetle infestations and the unprecedented 2017–2018 fire seasons in B.C. At a national level, emissions from forest parcels suffering less than 20 per cent mortality due to insects are included in LULUCF inventory estimates, while burnt areas are removed entirely from national reporting (which, in 2018, were nearly 2.3 million hectares) (ECCC, 2020; NRCan, 2020b).

The largest LULUCF sinks are in the Boreal Shield ecozone that stretches across northern Quebec,

FIGURE 11.2:

Net LULUCF Sinks/Sources by Ecozone (Mt CO_2e)

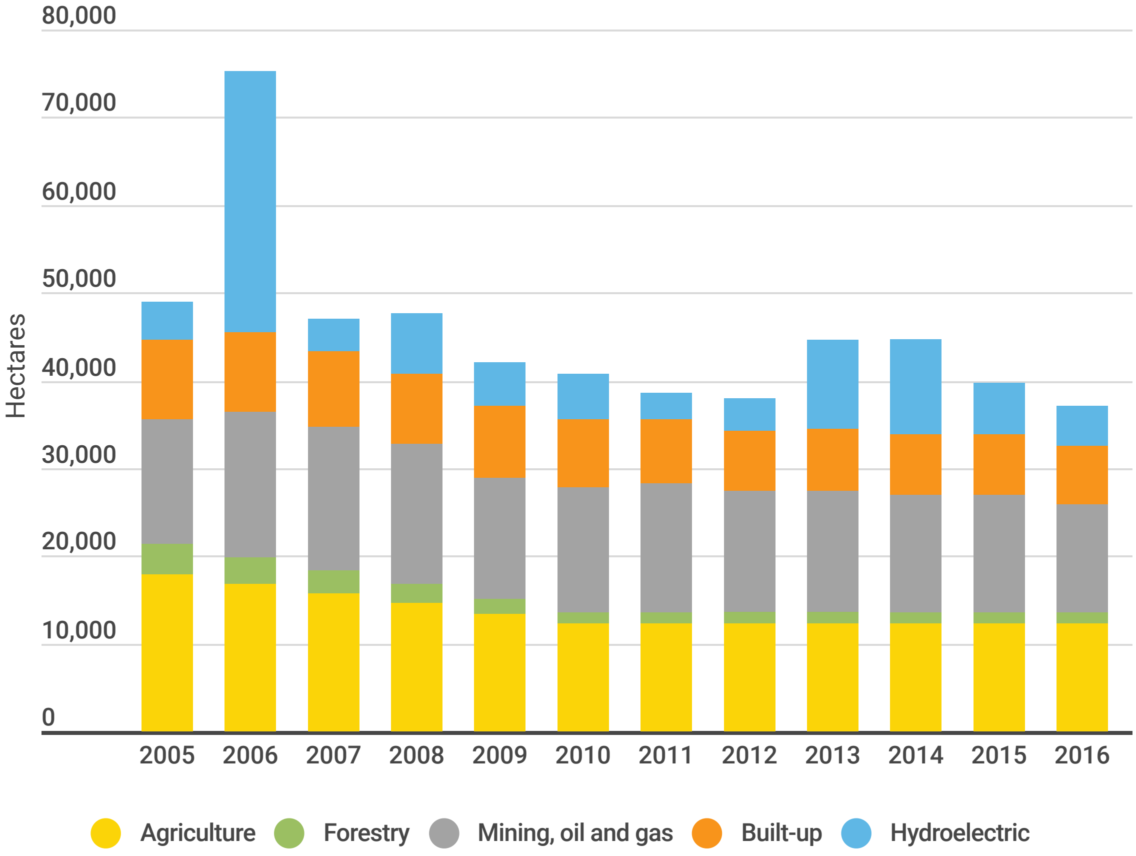


This figure shows the flux in net LULUCF GHG estimates for each ecozone in Canada for 2005 and 2018. Emissions from the Montane Cordillera ecozone doubled, making it the largest source of anthropogenic LULUCF emissions in the country. Canada's boreal forest (Boreal Cordillera and Boreal Shield) is the largest GHG sink.

Source: ECCC (2020).

FIGURE 11.3:

Annual Deforestation in Canada by Sector (Ha)



This figure shows the amount of annual deforestation in Canada between 2005 and 2016 by type of human activity (measured in hectares). With the exception of 2006, where deforestation levels were unusually high due to hydroelectric damming, levels have remained relatively consistent over time. Built-up areas generally refer to housing and business development in towns and cities.

Source: NRCan (2018).

Ontario, Manitoba, and Saskatchewan, and the Boreal Cordillera ecozone covering northern B.C. and southern Yukon. These areas are home to Canada's boreal forest, which is the largest continuous and most intact forest ecosystem remaining on Earth (OECD, 2017).

Multiple human activities contribute to ecosystem loss over time. For example, agriculture, industrial, and new settlement activities have all contributed to deforestation (Figure 11.3). Canada's forestry sector is not a major factor, with internationally recognized standards for sustainable forest management (OECD, 2017). Since the 1800s, Canada has lost 80 per cent to 90 per cent of its wetlands in and around urban areas, mainly due to land use conversion (CICC, 2020; NRCan, 2018).

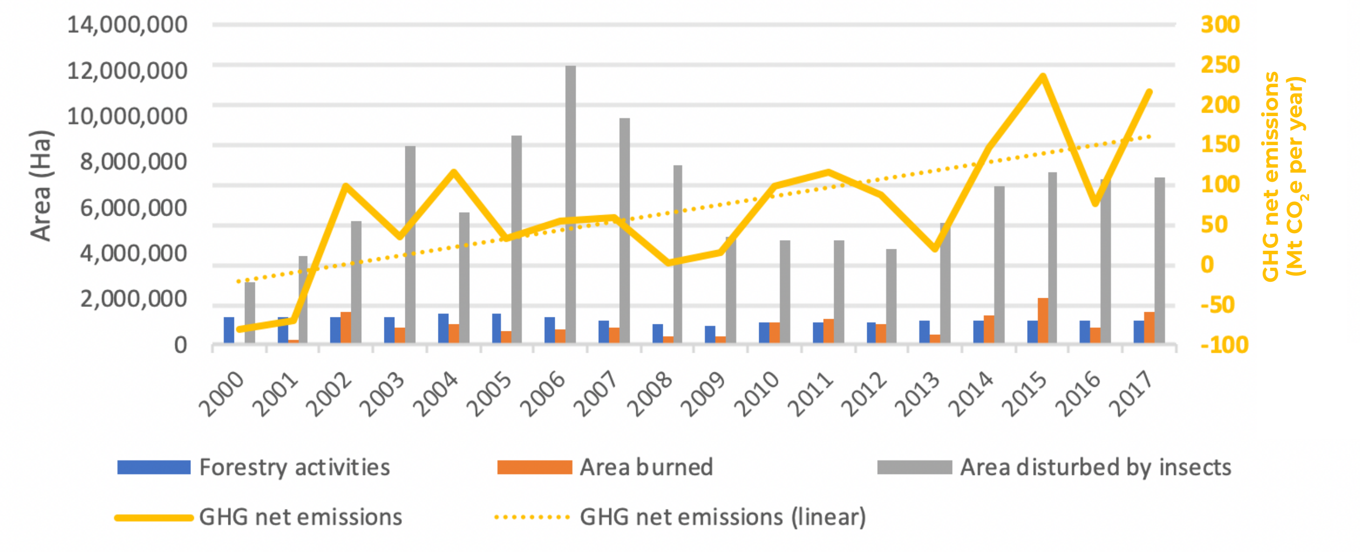
LIMITATIONS OF LULUCF INDICATOR

Using LULUCF data as an indicator of ecosystem health and nature-based climate benefits has several limitations.

First, it does not represent the full impact of natural disturbances, such as wildfires. The LULUCF indicator captures only anthropogenic (human-caused) sources and sinks relating to land

FIGURE 11.4:

Carbon Emissions from Canada's Managed Forest Including Natural Disturbances



This figure shows how natural disturbances in forests, such as wildfire and insects, can affect GHG emissions. Canada's managed forests are a net source of GHG emissions when natural disturbances are considered. The bars in the figure correspond to the left axis, showing the number of hectares of land affected. The lines correspond to the right axis and show the impact on net GHG emissions over time, with an increasing trendline.

Source: NRCan (2018).

use, land-use change, and forestry. This is a reasonable approach for the purposes of setting national GHG targets. However, natural disturbances that are not directly linked to human activity nevertheless contribute to global GHG emissions and increased climate change.

For example, the LULUCF forest land indicator reports net emissions on managed land, which represents only 65 per cent of Canada's forested area. Unmanaged forest lands can be both significant sinks or source of emissions, particularly as a result of natural disturbances such as wildfires and insects and the regeneration of disturbed areas.

LULUCF data also do not report directly on emissions from natural disturbances on managed lands except in areas under fire protection (Figure 11.4). Accounting for these disturbances would shift 2018 net sink estimates for forest land of 140 Mt to a net source of 110 Mt (NRCan, 2020a; ECCC, 2020). This is a 250 Mt difference for managed forests alone.

Tracking emissions associated with natural disturbances and unmanaged lands more closely would, for example, highlight the climate benefits of efforts to limit the extent and damage of wildfires and manage insect infestations. While these are often thought of as outside of human control, there is significant scope for innovation in technology and practice (e.g., forest management practices, fire fuel treatments, protection and planting of deciduous trees, Indigenous fire management practices) (FPAC, 2019).

Second, LULUCF data do not capture carbon sinks and sources from all ecosystem types. LULUCF wetland estimates, for example, are limited to areas of peat extraction and flooding for hydroelectric reservoirs, capturing only a very small proportion of Canada's wetlands (ECCC, 2020). Over thousands of years, peatlands have stored twice as much carbon as the world's forests and can therefore be a significant source of emissions if they catch fire during a wildfire or are

TABLE 11.1:

Climate Change Issues Not Captured in LULUCF Estimates (in Mt CO^2eq)

Category	2018 net emissions	GHG emission impacts not included in LULUCF indicator	Resilience benefits, costs not captured in LULUCF indicator
Harvested Wood Products	130		Loss of resilience services through replacement of mature with successional forest
Forest Land	- 140	▸ Natural disturbances ▸ Unmanaged lands	Species migration, habitat loss, soil erosion, flood attenuation
Settlements	2	▸ Natural disturbances	Flood attenuation, stormwater management, cooling, human health
Cropland	- 6	▸ Cropland trees	Soil erosion, flood attenuation
Grassland	0	▸ Broader range of grasslands	Soil health, soil erosion, species migration, habitat loss
Wetlands	3	▸ Broader range of wetlands ▸ Natural disturbances	Flood attenuation, habitat loss
Blue carbon	n/a	▸ Sink/source estimates for seagrass ▸ Natural disturbances ▸ Human activities	Storm surge attenuation
Permafrost	n/a	▸ Broader range of wetlands	Ice road loss, building stability

Source: ECCC (2020).

removed for mining activity (UNEP, 2019; Johnston, 2017). Canada is home to the world's largest peatland carbon stores, with peatlands covering approximately 12 per cent of Canada's total land area, with the largest peatland complexes in northern Ontario and Quebec (WCS, 2020).

Northern ecosystems, dominated by permafrost, are largely not included in LULUCF estimates. Climate change is increasing permafrost thaw, turning Arctic ecosystems from long-term sinks to potential long-term sources of emissions (Ogle et al., 2018; Jeong et al., 2018; Price et al., 2013). Depending on the climate scenario, Canada could lose 16 to 35 per cent of its permafrost area by 2100 from a 2000 benchmark (Price et al., 2013). The data also miss estuarine and coastal ecosystems such as seagrasses (e.g., eelgrass) that can sequester and store up to 90 times more carbon than a comparable area of forest (though Canada's seagrass area is much smaller than its forest area) (Molnar et al., 2012).

Tracking these carbon sinks and sources more closely would highlight climate benefits from a broader range of ecosystems, enhancing the case for greater protection and restoration efforts.

Third, LULUCF data do not measure climate resilience benefits of ecosystems. Wetland, coastal and forest ecosystems can contribute to increased resilience of communities through flood and storm surge attenuation and reduced effects of extreme weather events, extreme temperatures, and soil erosion (ICABCCI, 2020; CICC, 2020; Simard et al., 2019; Molnar, 2012).

Measuring these services and recognizing their value could provide an additional incentive for protection and restoration. Different types of wetlands may be more valuable for different climate benefits. For example, while peatlands are highly valuable carbon stores to conserve, mineral wetlands in and around urban areas may provide the greatest flood attenuation benefits (Pattison-Williams, 2018).

Biodiversity can also be an important contributor to resilience. For example, the Great Bear Rainforest on British Columbia's west coast, home to the Heiltsuk First Nation, thrives on the nitrogen left by salmon carcasses brought into the forest by bears (BBC, 2014). Improved tree and soil health in turn reduces the risk of forest fires.

DATA GAPS

Canada is still a long way from a comprehensive and integrated database of its ecosystems, their role as GHG sinks and sources, and the multiple additional services they provide (e.g., resilience benefits). The national inventory for wetlands is yet to be completed. And annual tracking of ecosystem loss and degradation is not standardized across jurisdictions.

Inconsistent vegetation patterns and difficult access for on-field measurements have made it hard to measure the extent of wetlands (Johnston, 2017; ECCC, 2016). Remote sensing technologies such as satellite imagery and aerial photography can help reduce measurement challenges. There has been significant progress in remote sensing data and tools (Mahdianpari et al., 2020; World Bank, 2020). Natural Resources Canada is also working to model boreal peatland sources and sinks, which could eventually be added to Canada's national inventory. A human impact metric has also been developed for Atlantic Canada's estuarine coastal ecosystems that provides a sense of the impact of multiple ecosystem pressures (Murphy et al., 2019).

Offset markets may also create incentives for more accurate quantification of emission sources and sinks. Unlike forested lands, wetlands store carbon up to three metres deep, adding complexity to carbon measurement (Johnston, 2017). Here, too, work is moving forward. For example, the Saskatchewan Research Council has partnered with the forestry sector to develop a rapid and reasonably accurate protocol for forest managers to estimate carbon storage in wetlands (Johnston, 2017).

Connecting ecosystem-based carbon offset and resilience policies with other initiatives, such as local adaptation plans and regional to national biodiversity protection programs, can help realize multiple policy objectives. Voluntary carbon offset markets are perfect venues to include these objectives, as many buyers would be willing to pay a premium for credits that provide additional benefits such as increased resilience and biodiversity (Monahan et al., 2020; Hamrick & Gallant, 2018).

Environmental assessments, Indigenous consultations relating to major projects, and expanded understanding of Indigenous management of protected areas and ecosystems provide creative opportunities to advance new approaches to measure and value ecosystem services. For example, discussions between mining company Noront and First Nations in the James Bay lowlands of Northern Ontario led to a chromite project redesign to mine underground to limit degradation of valued peatland and hunting grounds (Gamble, 2017).

CONCLUSIONS & RECOMMENDATIONS

By identifying 11 clean growth indicators, this report set out to achieve three main objectives.

First, it defines clean growth—within the context of climate change—as inclusive economic growth that reduces greenhouse gas emissions, strengthens resilience to a changing climate, and improves the well-being of Canadians. This definition will guide future Institute work in the clean growth research stream and offer an approach that could usefully be adopted by all levels of government in Canada. Thinking about climate change, economic, societal, and environmental challenges in an integrated way can help shift from a focus on trade-offs towards collaborative solutions that achieve multiple objectives simultaneously. This type of approach will become increasingly important as action to address climate change accelerates.

Second, it provides a framework for measuring Canada's clean growth progress over time. By tracking the indicators identified in this report, Canada can quantify clean growth success over time and inform an ongoing dialogue within and outside governments on optimal pathways and policy choices. We offer these clean growth indicators not as a definitive guide but rather as a starting point to a broader conversation on how Canada can address climate change while also meeting important economic, societal, and environmental objectives. This broader conversation would benefit from contributions of people with different perspectives, backgrounds, experiences, and interests from across Canada.

Third, it helps identify opportunities for government policy to better support clean growth. Benchmarking progress helps identify past successes as well as next steps in Canada's transition as a country. Areas or regions where progress has been slow or sliding backwards on one or more indicators can signal the need for new or expanded policy. Areas or regions where progress has been strong can highlight important lessons learned that could be accelerated or replicated elsewhere.

Based on our analysis, the three main findings below emerge. For each, we make recommendations for governments. We also highlight areas for further exploration in cases where our analysis does not suggest definitive recommendations but does highlight potential policy options or questions that merit further consideration and analysis.

CONCLUSION #1: Achieving climate, economic, and well-being objectives simultaneously is possible but requires substantial collaborative effort

The more governments understand the interconnectedness of climate and non-climate actions, the better the chance of cost-effectively achieving multiple objectives. Our analysis has only scratched the surface. Complex and interconnected drivers underpin each of our proposed indicators of clean growth. As Canada ramps up ambition to reduce GHGs and as the impacts of a changing climate intensify, understanding climate-economy-well-being interconnections will become more important.

With the right policies and actions, reducing GHG emissions, improving resilience, growing the economy, and increasing well-being can be mutually reinforcing. However, the level of effort required should not be underestimated. It is easy to say that Canada wants to achieve economic growth and significant GHG reductions at the same time but much harder to spell out how to do so. It is also easy to say that no one should be left behind, but much more difficult to put mechanisms in place to protect vulnerable Canadians.

Recommendations for governments:

Establish explicit cross-mandate accountabilities within government. To achieve simultaneous progress on climate, economic, and well-being outcomes, governments should select and design policy packages with more than one objective in mind. This will not happen without clear direction from government leaders (such as mandate letters) and formalized horizontal governance structures (such as a low-carbon growth committee) that clarify shared objectives and priorities. This direction could apply to climate change policies, economic policies, environmental policies, or social policies at all levels of government. While there will inevitably be some trade-offs and compromises, it is often possible to improve overall outcomes through careful collaborative design and complementary measures. Sometimes one policy instrument, carefully designed, may be appropriate. In many cases, however, multiple policy tools from different levels of government and departments will be most effective.

Area for further exploration for governments and policy researchers:

Strategic clean growth assessments? Several governments in Canada require policy proposals to include a strategic environmental assessment. The federal government has also developed a climate lens for major public investments in infrastructure, and now requires a strategic assessment of climate change for designated projects under the Impact Assessment Act. It is worth exploring an expansion of these tools to explicitly incorporate a broader set of criteria linked to clean growth objectives. For example, while an infrastructure project would naturally consider general economic objectives such as near-term GDP or jobs it might not consider longer-term low-carbon growth objectives such as ensuring exports align with the anticipated global low-carbon transition. A low-carbon growth lens could lead to a greater emphasis on “enabling” infrastructure investments that support low-carbon technology development and adoption (e.g. electricity transmission, hydrogen-ready pipelines, carbon capture and storage pipelines).

CONCLUSION #2: Governments and researchers lack much of the data needed to measure clean growth progress

Measuring clean growth is not a simple exercise. In some cases, the indicators are so multi-dimensional that they are difficult to measure with only a handful of statistics. In others, the data are not available to comprehensively assess progress.

Data are fundamental to identifying connections and interactions relevant to clean growth. Data allow for governments to measure progress and can inform potential course corrections. Investing in new and better data that connect climate change to economic growth and the well-being of Canadians will lay the foundation for future research and the development of policies that support clean growth success. The ambition and scale of Canada's climate change goals merits a similar scale of effort to improve data, and the financial and human capacity needed for its development.

There are multiple important data gaps highlighted in this report. We highlight some of the key priorities for measuring clean growth below.

Recommendations for governments:

- **Better connect GHG data to the economy.** Clean growth research and policy development requires easily accessible GHG data that match GDP, employment, trade, and other data (Indicator #1).
- **Improve GHG data for Canada's territories.** Researchers need better data to include territories in comparative analyses with provinces (Indicators #1 and #7).
- **Collect more and better data on the costs of extreme weather events.** The consistency and comprehensiveness of the Canadian Disaster Database should be improved (Indicator #2).
- **Broaden cleantech data to include more climate-relevant technologies.** Cleantech data should include economic activities that may not be purely "clean" but are consistent with low-carbon growth pathway. It should also include technologies that support adaptation and resilience to a changing climate (Indicators #3 and #5).
- **Tag public infrastructure investments for better tracking.** We propose slotting climate-related infrastructure investments into four categories: 1) low- or no-carbon, 2) low-carbon enabling, 3) resilient, and 4) natural (Indicator #6).
- **Develop more complete metrics of societal vulnerability to a changing climate.** Vulnerability to a changing climate depends on multiple factors, including pre-existing sensitivities such as poverty or underlying health conditions, exposure to climate impacts, and ability to adapt before and after climate events occur. Right now, few metrics fully capture all components (Indicator #9).
- **Improve data on wetland and marine ecosystem trends and related climate implications.** Canada needs an organization with capacity comparable to the Canadian Forest Service for ecosystems such as wetlands and coastal and estuarine areas to coordinate improved measurement of carbon sinks and sources and undertake analysis on climate resilience benefits (Indicator #11).

CONCLUSION #3: Several aspects of Canada’s clean growth progress have been slow or uneven

Our indicator analysis highlights some key areas where Canada could accelerate progress:

- **Decoupling of GHGs from GDP** is inconsistent across the country, with the economies of several provinces still closely tied to GHG emissions. Decoupling economic growth and GHG emissions will require a focus on three areas: reduced emissions intensity of existing sources; reallocation of resources from high-carbon economic activity towards low-carbon economic activity; and accelerated entry and growth of low-carbon firms.
- Growth in the **development of clean technologies** has been slow and concentrated in a handful of provinces. The sector will not provide the growth and jobs needed without significant expansion.
- Low-carbon **technology adoption** has been uneven across sectors, with increasing emissions in road transport and commercial buildings.
- **Job loss related to climate change transition** has been limited to date, but certain sectors, communities, and individuals could be at risk in the future.
- Human activities continue to drive losses in climate-related **ecosystem services**.

The analysis also flagged some opportunities that are not being fully captured with current approaches:

- There is a wide range of investment possibilities in low-carbon and resilient infrastructure, which could generate employment opportunities for vulnerable regions and individuals while laying the foundation for future low-carbon growth and resilience to a changing climate.
- There are additional opportunities to generate health benefits from reduced air pollution, particularly in relation to urban transportation.

Further research and analysis will support comprehensive policy development in these areas, but there is scope for near-term investment to plant the seeds for future clean growth.

Recommendation for governments:

Use near-term investments to support a long-term clean growth transition. The indicators we have developed in this report are measures of long-term success. Yet policies and investments made today can plant the seeds that grow into long-term low-carbon and resilient economic growth. Governments can play a key role in overcoming barriers to private investment, particularly at a time when economies are struggling and capital is limited. Investments in long-lived infrastructure that is not low-carbon or resilient will also have lasting consequences.

AREAS FOR FURTHER EXPLORATION BY GOVERNMENTS AND RESEARCHERS:

Connect technology development with technology adoption?

Given that a lack of domestic technology adoption is a key barrier to growth for clean technology companies, policy tools aimed at accelerating adoption rates could incorporate consideration of areas where Canadian companies are showing signs of success but struggling to find domestic buyers. This could help grow strong domestic markets that better position Canadian companies for international success.

Connect economic development and skills policies to climate-related employment risks and opportunities?

Some communities and regions may be more vulnerable than others because they have a concentration of employment in an at-risk sector. Individuals with lower levels of skills or education may also be at greater risk. A stronger connection between forward-looking climate change transition scenarios and economic development and skills policies could help reduce vulnerability and connect people with low-carbon growth opportunities.

Target urban transportation?

With slower levels of technology adoption in transport, rising GHG levels, and increased evidence of a link between urban air pollution and adverse health outcomes, our indicators show multiple reasons to consider a greater emphasis on clean urban transportation.

Slow the loss of climate-related ecosystem services?

Slash burning practices of logging companies, draining of wetlands for agriculture or development, deforestation for industrial activities, and many other actions are reducing the benefits that current and future Canadians obtain from nature. The changing climate will exacerbate many of the pressures on ecosystems.

Support more Indigenous-led opportunities?

Indigenous-led initiatives can achieve multiple economic, social, environmental, and climate benefits. Additional support for Indigenous protected areas, land management, renewable energy projects, resilient housing, fire management, and other opportunities could help accelerate clean growth progress in Canada.

While this report does not provide a single clear pathway towards clean growth, it identifies many interesting research and policy questions that can help identify possible pathways. These questions will be better answered with improved data. The Canadian Institute for Climate Choices will continue to further analyze the issues raised, engaging organizations from across Canada in the process.

ENDNOTES

1. Note: this report uses the term “carbon” as a shorthand for carbon dioxide equivalent of all GHG emissions.

2. Resilient technologies can include anything that helps prevent, avoid, or protect against the impacts of a changing climate (e.g., robot firefighters, tick-tracking systems, or fire-resistant building materials).

3. Note that we use “low-carbon” in the sense of carbon dioxide equivalent, which includes all GHGs.

4. An example of more detailed analysis of decoupling trends is a 2015 paper by Arik Levenson on the decoupling of sulfur dioxide emissions from growth in U.S. manufacturing. Levinson considers two different contributions: changes in the composition of the sector and changes in technique, finding that technique changes accounted for 90% of decoupling between 1990 and 2008 (Levinson, 2015).

5. The OECD uses CO_2 productivity as a “headline green growth indicator.” It is based on energy-related CO_2 emissions, and therefore does not include other GHG emissions such as methane from agriculture. If other GHG emissions were included, the overall country ranking would be similar to that shown in Figure 1.3, with worse performance for some agriculture-intensive countries such as New Zealand.

6. Note that this section focuses specifically on the economic costs associated with a changing climate. The human costs—and the distribution of these costs across society—are covered in Indicator #9 (Inclusive Resilience).

7. The ECT product database is developed by tagging economic activities spread across a range of other sectors already captured in traditional metrics of GDP (usually allocated to industries using the North American Industry Classification System). Since there is no classified clean technology sector, this approach is the only way to get a full picture of environmentally related economic activity.

8. See full definition of ETC in Indicator #3.

9. For example, under the OECD measurement standard, an estimated US$309 million of private finance for climate-related initiatives was mobilized between 2017 and 2018 from Canada’s contribution of US$213 million. All of these contributions were made to developing countries (ECCC, 2019).

10. We define infrastructure as any basic physical system that is essential for the economy and society to function. It includes engineered infrastructure (e.g., buildings, transportation systems, communication networks, water, wastewater, electricity systems, heating systems) and natural or “green” infrastructure (e.g., wetlands, forests, estuaries, lakes, etc.). Infrastructure assets are generally long-lived and can be capital intensive to build.

11. According to Statistics Canada, investments in CCUS technologies should be counted under “Pollution Abatement” in Figures 6.1 and 6.2. However, in some cases, these infrastructure investments might get counted in the oil and gas infrastructure category.

12. We exclude the Finance and Insurance category, as well as Professional, Scientific and Technical Services, as there is significant diversity within the sectors that makes them unlikely to all simultaneously be affected (beyond a general economic downturn) and they are concentrated in larger metropolitan areas more likely to see growth in a range of new employment opportunities.

13. These expenditures include all home electricity and heating energy use (electricity, natural gas, furnace oil), transportation fuels (gasoline, diesel), and public transit (fares for bus, rapid transit, subway, commuter train, and taxis). We include public transit to create a fair comparison for households that do not use private vehicles. Due to incomplete data, we excluded natural gas expenditures for the Atlantic provinces and Quebec. Similarly, we excluded expenditures on ‘other fuels’, such as furnace oil and firewood, for the Western provinces. These missing data are unlikely to change the trends in Figure 8.2, as these fuel sources comprise a relatively small share of the energy system in each respective region.

14. These higher total expenditures likely reflect higher incomes and higher levels of household debt.

15. The 10 per cent benchmark for energy poverty was developed by Boardman (1991). It measures households spending more than twice the median amount on household energy and vehicle fuel. Even though the threshold was developed in the 1990s in the U.K., it is still relevant in Canada. While we do not have access to median household expenditures, the average household spent approximately seven per cent of their total expenditures on household energy, vehicle fuel, and transit. Given that the median is likely less than the average, a threshold of 10 per cent would likely work out to close to double the Canadian median.

16. To estimate the emissions intensity of electricity generation in the Atlantic provinces, we took the average intensity across the four provinces for 2017: Nova Scotia (680 g/kWh), Prince Edward Island (14 g/kWh), New Brunswick (260 g/kWh), and Newfoundland and Labrador (40 g/kWh). Data is from Canada's National Inventory Report for 2020 (ECCC, 2020).

17. Estimate is in 2015 dollars and based on 2015 population counts. It includes annual mortalities associated with three pollutants: $PM_{2.5,}$ NO_2, and O_3 (Health Canada, 2019). Dollar estimates are likely conservative.

18. A similar policy at the national level—implemented after the Ontario coal phase-out—is expected to prevent approximately 1,008 premature deaths and 871 hospital admissions or emergency room visits between 2015 and 2035, a benefit valued at $5 billion (Pembina Institute, 2016). It is also expected to generate $3.4 billion in avoided climate change damage (ECCC, 2018b).

19. Black carbon is a component of fine particulate matter and is generated through the incomplete combustion of fossil fuels and biomass (ECCC, 2019c). It is considered a short-lived climate pollutant because it stays in the atmosphere for only a few days or weeks (C2ES, 2020). Black carbon is the third-biggest contributor to global climate change, after methane and carbon dioxide emissions.

20. Note that about 13 per cent of total $PM_{2.5,}$ emissions from on-road transportation are generated from brake and tire wear. These emissions would likely be unaffected by fuel efficiency improvements or a shift to EVs (ECCC, 2019a)

21. Particulate matter and black carbon emitted from controlled burns are included in ECCC data at the national level, but they do not include emissions from uncontrolled wildfires and do not provide this information at a local level.

22. In 2015, clear cutting was the most common harvesting method and was used in 85 per cent of total harvested areas across Canada, though burning logging slash is more prevalent in B.C. due to differing regulatory and economic circumstances (Statistics Canada, 2018).

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