CHARTING OUR COURSE

Bringing clarity to Canada's climate policy choices on the journey to 2050

CANADIAN INSTITUTE FOR CLIMATE CHOICES

ABOUT THE CANADIAN INSTITUTE FOR CLIMATE CHOICES

WHO WE ARE

The **Canadian Institute for Climate Choices** is an unparalleled collaboration of experts from across the country. We undertake rigorous and independent research, insightful analysis and broad engagement to bring clarity to the climate challenges and transformative policy choices ahead for Canada.

WHY WE EXIST

Climate change is one of the most complex challenges of our time. It is already affecting the natural environment, the economy, and the health and quality of life of many Canadians. Science indicates the effects of climate change will intensify as the years go by, creating more risk and unpredictability — as well as new opportunities — for Canada.

It's time for a more integrated approach to developing climate policy: one that addresses the causes and effects of climate change while also keeping life affordable, reducing health risks, and making Canada's communities, infrastructure and economy more resilient to the changes ahead.

VISION

Canadians acting together on climate solutions to create resilient communities, thriving, inclusive economies, and a better world.

MISSION

We clarify Canada's climate policy choices to create a strong foundation for decision making.

GOVERNANCE

The Canadian Institute for Climate Choices is an unparalleled collaboration of experts at the top of their fields, from regions and communities across the country. This report is a product of Climate Choices staff. It does not necessarily reflect the views of the individuals and organizations identified here.

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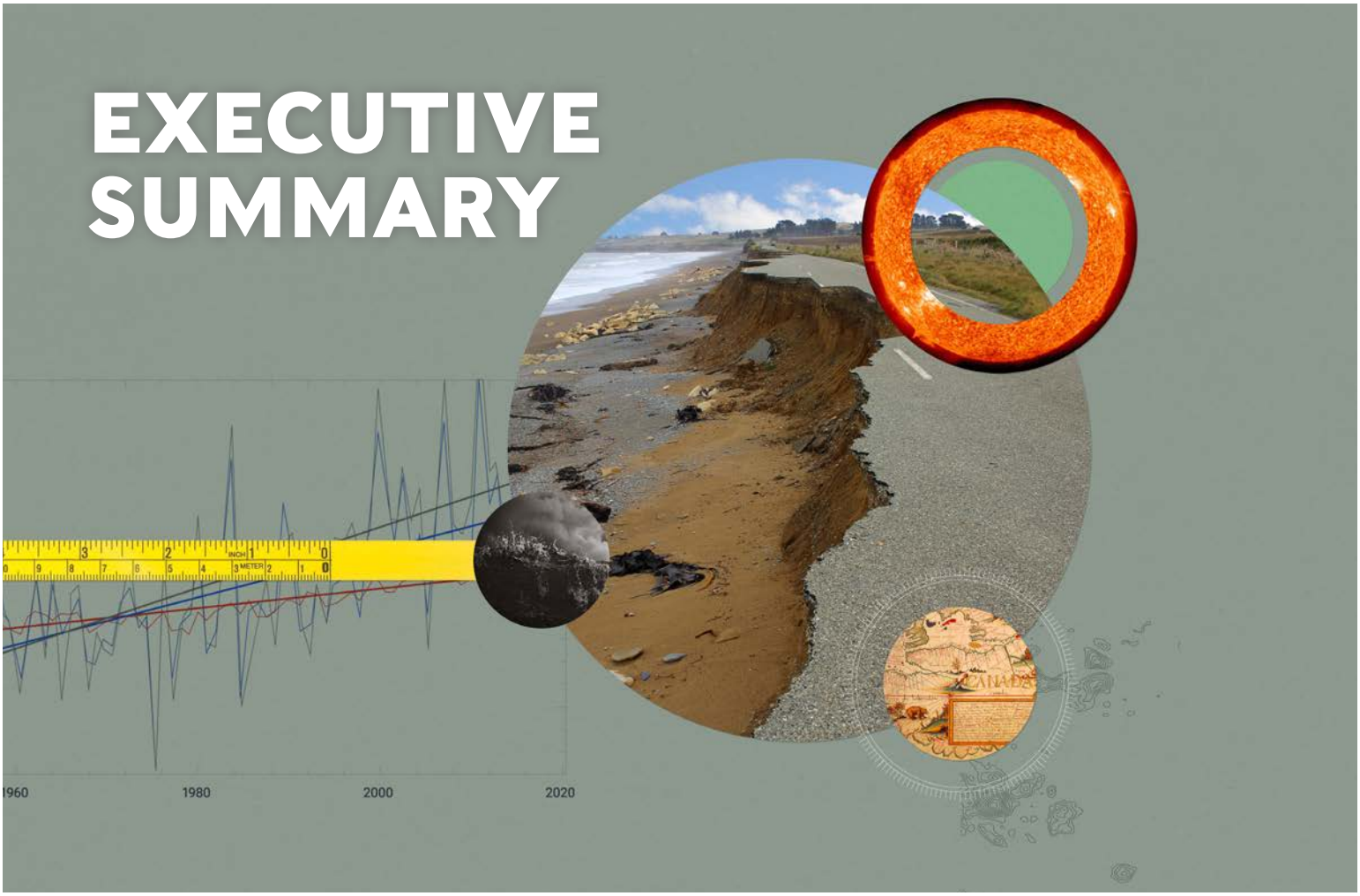
EXECUTIVE SUMMARY



Picture Canada as a ship, and climate change a storm barreling toward us. Already, the seas are becoming treacherous, and the winds threaten to drive us into the shoals. The gathering storm will reshape not just our climate, but also global markets in profound and unpredictable ways. To weather the storm, we must make deliberate choices that lead to cleaner and more inclusive growth, and a resilient and prosperous future for Canada.

Discussion about how to prepare for Canada's future in the face of climate change is dynamic and ongoing. Canada has joined an increasing number of countries, states, municipalities, and firms setting a goal of reducing greenhouse gas emissions to net-zero by 2050. Some Canadian provinces, territories, and municipalities are establishing their own governance and policy frameworks for long-term emissions reductions.

Yet reducing emissions is just one element of a pathway for Canada to a thriving and prosperous 2050. Yes, Canada must transition to a

low-carbon economy alongside the rest of the world. We must also make our communities and infrastructure more resilient to the inevitable impacts of a changing climate, such as more extreme weather and recurring natural disasters. And we must grow the prosperity of Canadians across all regions, all communities, and all socio-economic circumstances.

While these aspirations are clear, the course to that future is not. For many Canadians, climate change remains complex, confusing, and potentially paralyzing. Debates around some climate policy choices—for example, putting a price on carbon pollution—are highly polarized. Debates around others—such as policies that will help us adapt to a changing climate—have received inadequate attention, given the practical benefits it could deliver.

This report tries to bring more clarity to what climate change means for Canada, and the choices we will face. It is a starting point for a deeper, broader, and more constructive conversation about how we can chart a course as a country—through the profound changes ahead—to a resilient and prosperous future with cleaner and more inclusive growth.

MAPPING UNCHARTED WATERS

First, the report brings more clarity as to the nature of the challenges and opportunities that climate change presents for Canada. What are the main hazards and conditions on the way to 2050?

Canada faces risk from the physical impacts of a changing climate, including floods, heatwaves, wildfires, and sea-level rise. By 2050, under current trends, the impacts of climate change are expected to reduce global GDP by three percent, or US$7.9 trillion, according to a recent estimate by the Economist Intelligence Unit.

Canada will not be immune. Our coastal cities will be swamped by rising seas, threatening property and infrastructure. In the face of more frequent and more severe fire and floods, insurance premiums are poised to rise dramatically, making home insurance unaffordable for many Canadians. Extreme heat puts Canadians' health at risk, especially for children, elderly, and other vulnerable populations. Impacts in Canada's North are particularly severe, including the accelerated loss of local food sources and compromised infrastructure from thawing permafrost. The impacts of climate change internationally will also affect Canada—disrupting supply chains, putting stress on the global economy, and even driving mass migration. Parts of Canada may benefit temporarily from a warmer climate but, if we are unprepared, these benefits will be quickly overshadowed by mounting loss and hardship, particularly for the most vulnerable.

Meanwhile, the rest of the world has begun to respond to the threat of a changing climate by implementing new policies. If this trend accelerates, the implications for global markets—and a small trading state such as Canada—will be dramatic. The faster the world reduces emissions, the faster markets and investors shift away from carbon-intensive goods and services.

That transition poses a different set of risks for Canada. Much of Canada's economy—and the prosperity it generates—depends on sectors that export emissions-intensive products and commodities, such as oil and gas and cement. If the rest of the world transitions quickly, sharp declines in global demand for fossil fuels would depress the price of oil and lead to lower levels of investment in Canada's oil and gas sectors. Other sectors face similar risks: Canada's automotive industry, for example, could see plants close as a result of decreasing demand for gasoline-powered SUVs and light trucks, with vehicle manufacturing shifting to foreign plants that produce electric vehicles.

Yet it also presents opportunities. The World Bank estimates that climate commitments in emerging economies alone will create $23 trillion in investment opportunities between 2016 and 2030. If Canada is prepared, its growing cleantech sector could become a significant source of investment, innovation, and employment. Surging domestic and global markets would create demand for low-carbon innovation, and technologies, goods, and services that reduce emissions. Meanwhile, conventional sectors, such as mining and forestry, could benefit from an unprecedented increase in global demand for raw materials.

Looking ahead, Canada has choices to make about how—and how much—to reduce emissions, adapt to the changes around us, and invest in future economic opportunities. We are a big, northern country with a dispersed population, warming at twice the rate of the rest of the world. We are also a small, trade-dependent economy susceptible to global economic downturns, supply chain disruptions, and fluctuating commodity prices. How we choose to navigate the threats and

opportunities presented by those two realities will have profound implications for the next generation of Canadians.

SEEKING SAFE PASSAGE

Accordingly, this report aims to clarify what it would mean to thrive through climate change. What are the essential elements of safe passage, given the complexities of the risks and opportunities ahead?

Effectively addressing and responding to climate change goes beyond reducing emissions. It's about affordability. It's about jobs. It's about our health and wellness. It's about protecting wildlife, ecosystems and our drinking water. It's about preserving the places and things Canadians value today, and the aspects of life in Canada we want to be able to pass on to our kids and grandkids.

The figure below lays out a more comprehensive vision for addressing climate change in a way that contributes to a resilient and prosperous future for Canada with cleaner and more inclusive growth. Put another way, safely navigating the storm ahead requires a healthy and strong crew (thriving Canadians). We need a sturdy and nimble ship (economic prosperity). And we also need to do what we can to calm the waters, working internationally to collectively drive down emissions and dampen the economic and societal shocks of climate change (global action).

Pursuing these goals leads us down a different path than the traditional siloed approach to developing and implementing climate policy. It provides a new, integrated framework for not just weathering the storm, but thriving through the turbulence it brings.

The framework puts the health and wellness of Canadians front-and-centre. This means identifying and proactively addressing health risks. It means supporting and empowering those that are most affected by climate and transition risks, including Indigenous Peoples in Canada. It means preserving the foundation of human life and our economic

FIGURE EX1:

A New, Integrated Framework of Climate Change Goals and Objectives

prosperity by protecting and restoring nature. And it means considering the concerns and needs of youth and future generations when evaluating trade-offs and potential outcomes.

The framework also recognizes that the wellbeing of Canadians is inextricably linked to the strength of Canada's economy. Economic growth generates jobs and wealth. To maintain economic prosperity through the storm of climate change, the Canadian economy must be well-positioned to compete in shifting global markets. Canadian communities must also be prepared to brace for the direct and indirect risks of a changing climate. Making smart, forward-looking policy choices can achieve these goals at low costs.

Finally, the framework illustrates what we can do to calm the storm. Canada is not powerless to affect the direction or magnitude of global change. We can punch above our weight in influencing global action; indeed, doing so is in our own self-interest. We can leverage Canada's efforts to reduce emissions and press other countries to do the same. We can also develop good policies at home and share our experiences internationally. And we can develop innovations that make it easier and less costly for others to transition, reducing climate risk for Canada and the world, but also creating opportunities for our most innovative companies.

STEERING THROUGH THE STORM

Next, the report provides more clarity as to the range of policy choices ahead. What choices can Canada's municipal, provincial and territorial, and federal governments make to steer and accelerate Canada toward a resilient and prosperous future with cleaner and more inclusive growth?

To start, we can build on successes here at home. For instance, Canada stands out as a global leader in phasing out coal-fired electricity. A combination of federal and provincial regulations will phase out conventional coal-fired power generation by 2030. Ontario led the way through its phase-out, which closed coal plants in the province by 2014. The phase-out has also improved air quality and reduced health risks for people living in the province, increasing the net benefits of the policy beyond strictly environmental outcomes.

Federalism can complicate policy choices, but it also creates opportunities for innovation. Similar to the coal phase-out, many policy innovations in Canada originated at the sub-national level. Saskatchewan was the first to implement carbon capture and storage on a coal-fired power plant. Alberta was the first to implement an output-based pricing system for large industrial emitters. British Columbia was the first to implement an economy-wide carbon tax, Quebec was the first to implement a cross-border cap-and-trade system, and Manitoba was the first to set legislated, five-year carbon budgets. In adapting to a changing climate, the Government of Nunavut has initiated risk mapping and new infrastructure standards to reduce the impacts of permafrost thaw. The Governments of the Yukon and Northwest Territories are collaborating to develop community clean air shelters to reduce health impacts from wildfire smoke. And Atlantic provinces are working together to provide communities with online tools to support rural coastal adaptation.

Municipalities also have a clear role to play. Montreal, for example, tracks heat-related deaths. This tracking has allowed the city to identify correlations between deaths and low-income neighbourhoods as well as areas that lacked tree cover and greenery. This information has been critical in developing an integrated plan to address risk. In 2019, Montreal committed to extend the hours of pools, libraries, community centres and homeless shelters during heatwaves. Fire safety workers also go door-to-door to check on people flagged as vulnerable, hand out water bottles to the homeless, and encourage citizens to stay cool and hydrated. In addition, the city is planting more trees to help reduce the urban heat island effect.

We can also learn from best practices internationally. Melbourne, Australia, for example, uses a series of lagoons to treat half of the city's sewage. The plant eliminates greenhouse gas emissions by using lagoon covers that collect biogas for electricity production. At the same time, it creates other ecological and economic benefits. The natural plant produces 40 billion litres of recycled water a year and is energy self-sufficient. It is also an internationally significant wetland for waterfowl, with over 280 bird species identified at the plant.

We must increase the overall ambition of our collection of policies beyond current levels to navigate the course to 2050. Although Canadian governments have made progress, the scope of policies—in terms of the sectors, regions and issues covered—has been far too limited. Too few Canadians, for example, have access to clear flood risk maps that would help them prepare for emergencies and plan their investments. Action to protect and restore wetlands has also tended to be localised and ad hoc, rather than part of a broader strategy or plan. And we still have work to do to achieve our national emissions-reduction targets.

CHARTING OUR COURSE

Change brings risk. But it also brings new opportunities—if we are prepared to seize them. The choices we make today will shape our future. That should give us hope: our actions can directly influence how climate change ultimately affects our children, our communities, and our country.

Even in the face of global changes beyond our control, Canada's climate choices matter. Yet successfully navigating the turbulent waters ahead will rely on strong leadership, openness to new ideas, willingness to collaborate, and innovative thinking. Below, we propose four broad next steps for Canadian policy makers on climate change to set us on course.

RECOMMENDATION #1: Canadian governments should broaden objectives for climate policy

Historically, governments have focused on relatively narrow objectives (achieving emissions-reduction targets, managing specific climate risks). Yet we have often failed to deliver on these objectives, and we remain largely unprepared for future challenges. A broader perspective on policy design—looking beyond the narrow lenses of mitigation, adaptation, and clean growth—can help to clarify what governments are trying to achieve, embed climate change objectives in all policy choices, and guide more innovative policy solutions. By linking objectives more directly to the welfare of Canadians, this approach can also build a broader coalition of support for action.

Canadian governments—at all levels—have roles to play in delivering a future Canada that is resilient to the changes ahead, for our climate and our economy.

RECOMMENDATION #2: Canadian governments should embrace Canada's role in global outcomes

Canada has the potential to influence global change, rather than merely respond to it. We are among the largest economies in the world and have a seat at the table of global leadership through organizations such as the United Nations, G7 and G20. We are also one of the world's largest emitters. We should think strategically about what we can do to drive the action needed to produce better global outcomes. For example, we can demonstrate global leadership through our own actions, we can work internationally to help solve policy challenges that are driving global risks, and we can develop technologies and products that make transition easier and more cost-effective—while realizing economic benefits and new opportunities for Canadian businesses and workers.

RECOMMENDATION #3: Canadian governments should expand the scope, scale, and pace of climate policies

It is not enough to just develop policies aimed at addressing climate change. The policies must also have sufficient ambition. This means expanding the coverage of policies across regions, issues, and sectors, ramping up the magnitude of change, and tightening the timeframe for achieving results. We need to think about where we want to be in 2050 and beyond, and work backwards to determine optimal pathways and choices. Decisions made today should lay the groundwork for long-term success. Canada has made considerable progress in the last decade, but overall action has not been commensurate with the scale of the challenges ahead.

RECOMMENDATION #4: Those analysing and developing policy options should seek out integrated solutions that drive multiple benefits

The complexity and multi-dimensional nature of climate change, combined with the need for greater ambition, demands a more integrated and comprehensive approach to finding solutions. The most effective policies will achieve multiple benefits across a range of climate change and other policy objectives. But the best way to identify and develop these policies is by breaking down traditional policy silos and bringing people with different expertise, backgrounds, and perspectives together.

Charting a course to a resilient and prosperous future for Canada with cleaner and more inclusive growth is possible. To do so, we need more clarity on the nature of the challenges and opportunity along the way. We need clarity as to how we measure our progress along the course. And we need clarity about the choices—and their implications—that we can make to steer toward better outcomes for Canada.

Ultimately, however, charting a course is only a first step. Research organizations such as the Canadian Institute for Climate Choices can support Canada's journey to 2050 and beyond by bringing together top experts from a range of disciplines to analyse pathways, evaluate policy options, and point to solutions that serve the best interests of current and future generations of Canadians

While this report frames important new policy and research questions, answering those questions, and putting practical solutions into action will require hard work from a broad group of Canadians and governments at all levels. It will require all hands on deck.

CONTENTS

1 CLIMATE CHANGE CHOICES FOR CANADA

Climate change, and the global response to it, will affect the wellbeing of Canadians in many ways. A changing climate will have both direct and indirect impacts as the world deals with increasing economic, societal, and environmental disruption. Global efforts to reduce greenhouse gas (GHG) emissions will also trigger shifts in global markets, with less demand for emissions-intensive goods and more demand for lower-carbon alternatives. We know that Canada will face both drivers of change, but their magnitude and pace remains uncertain. For Canada, these changes pose significant risks and opportunities.

How we prepare for these changes—or fail to prepare—matters to Canadians

Uncertainty is no reason to delay action. The only viable strategy is to prepare for both climate change impacts and global decarbonization—hedging against possible future scenarios.

To ensure our future stability and prosperity, Canada faces choices now: the earlier we prepare, the more resilient Canadians and our economy will be to abrupt, costly, and disruptive change. Effective preparation will position Canada to leverage new opportunities as they emerge.

Canada also has an important role to play in influencing global outcomes. We can demonstrate leadership, work with international partners to reduce global risks and enhance opportunities, and develop the policy and technology solutions the world needs.

Canadians need clarity on the choices before us

It is time to move beyond the narrow silos that have characterized climate change policy discussions for decades and bring together a clear, integrated perspective that cuts across efforts to reduce emissions, adapt to a changing climate, and capture clean technology opportunities. We need to work together to identify and implement creative solutions that address a broader range of environmental, societal, and economic climate change objectives. Future generations of Canadians are counting on us to get it right.

About this report

This report aims to provide clarity on the climate change choices facing Canadians. It provides a starting point for a new conversation about Canada's future in a changing world.

The remainder of the report is structured as follows:

Section 2 explores the drivers of global change and disruption that will shape Canada's future. It helps define the scale and scope of risks and opportunities facing Canadians.

Section 3 outlines a broader set of climate change goals and objectives that have been pursued in the past. Together, these goals and objectives aim to improve the resilience of Canadians and our economy to global change—both from climate change and from the world's response—while working to influence global outcomes in our best interests.

Section 4 considers how Canada can achieve its objectives, highlighting the policy levers available to governments and the importance of identifying ambitious and integrated solutions that provide multiple benefits.

Section 5 suggests a series of next steps for Canada to move forward on climate change.

SCIENTIFIC FOUNDATIONS OF CLIMATE CHANGE

The focus of this report is not on the science of climate change, which is detailed in reports by the Intergovernmental Panel on Climate Change (IPCC) as well as national scientific organizations such as Environment and Climate Change Canada. However, since science is the foundation for action on climate change, we provide a brief summary of the evidence below.

Global atmospheric concentrations of GHGs are increasing, primarily due to human activity

Between 1990 and 2018, average global concentrations of GHGs (measured as CO_2 equivalent) rose 43% (NOAA, 2019). According to scientific records, the last time concentrations of CO_2 were this high was about 3 million years ago.

Although there have always been natural variations in the earth's climate, human activity is the primary cause for the steep rise in the concentration of GHGs. These emissions are the dominant driver of global warming and climate change. Other factors, like changes in the heat from the sun and ash from volcanic eruptions (which block sunlight and produce a cooling effect) make only a small contribution to the observed changes (ECCC, 2019a; NOAA, 2019).

In total, the best available evidence and data suggest that human activities have caused a 1.0°C increase in global temperatures above pre-industrial levels. And if emissions continue at current rates, scientists estimate that the increase in global temperatures will reach 1.5°C between 2030 and 2052 (IPCC, 2018). The targets set out in the Paris Agreement are to keep long-term temperature increases beyond 2050 to under 2.0°C and under 1.5°C if possible.

Canada will continue to warm, increasing sea-level rise, ocean acidification, and permafrost thaw

In Canada, between 1948 and 2016, the average temperature increased by 1.7°C, while the north experienced an average increase of 2.3°C (ECCC, 2019a). The increase in average temperatures is expected to continue for all parts of Canada, with northern regions experiencing warming that is more than double the national average (ECCC, 2019a).

The world's oceans are absorbing most of the additional heat, increasing average temperatures and sea levels. Part of the observed sea-level rise is caused by the expansion of water as it warms. The other major factor is the steady reduction in the size and mass of glaciers and ice sheets that are on land, which, as they melt, enter the world's water systems and increase sea levels (ECCC, 2019a). Melting ice (both on land and at sea) is expected to continue throughout the 21st century and could result in a nearly ice-free Arctic during late summers by the 2040s (NOAA, 2017; IPCC, 2014; Overland & Wang, 2013). In total, global mean sea level has risen about 20 centimetres since the late 19th century and about 7cm of this occurred since 1993. Sea-level rise increases risks of erosion, flooding, storm surge, and salt-water contamination of fresh water and soil in coastal areas (ECCC, 2019a).

At the same time, the world's oceans are acidifying. Oceans absorb roughly a quarter of the CO_2 emitted into the atmosphere each year, which increases acidity levels and decreases oxygen levels. The current rate of acidification is unparalleled in at least the past 66 million years (NOAA, 2013). Higher acidity and lower oxygen levels are projected to have negative impacts on marine ecosystems.

Warmer temperatures are also causing permafrost to thaw across Canada's North, releasing stored methane deposits into the atmosphere. Although the science is still unclear on what this means for global temperatures, it is possible that thawing permafrost could accelerate the concentration of GHGs in the atmosphere and create a positive feedback loop of warming. Thawing permafrost also increases the risk of soil erosion, disappearance of lakes, landslides, and ground subsidence (Ciais et al., 2013).

Extreme weather events will create conditions for more frequent and intense wildfires, flooding, drought, and other high-impact phenomena

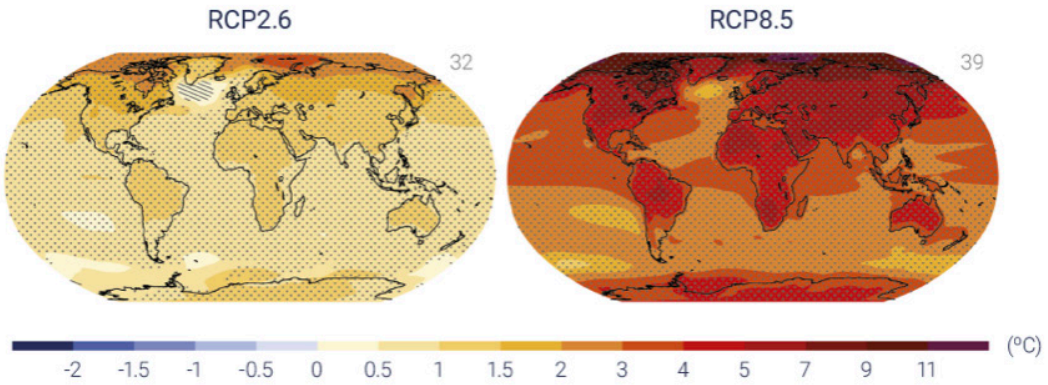
Higher concentrations of GHGs in the atmosphere are expected to increase the frequency, intensity, and duration of many types of extreme climate and weather events. The clearest outcome will be an increase in the number of days with extreme heat and longer and more intense heatwaves, along with fewer days of extreme cold in winter. In addition, the risk of drought and wildfire is expected to increase. The combination of higher evaporation rates, earlier snowmelts, smaller snowpacks, and the loss of glacier ice is expected to increase the risk of water supply shortages during summer months, particularly in parts of British Columbia and the Prairies (ECCC, 2019a).

Average levels of precipitation are also projected to increase everywhere in Canada, particularly during winter months and in Canada's north, delivering more rain and snow over shorter periods of time. These higher and more intense levels of precipitation are expected to increase urban flood risks. The combination of more extreme precipitation, stronger storm surges, and higher sea levels are projected to increase the frequency and extent of coastal flooding (ECCC, 2019a).

Reducing global GHG emissions decreases risks to Canada, particularly after 2040

Due to the lag between when GHGs are emitted and their eventual impact on the climate, scientific models suggest little variability in climate impacts between now and 2040 across different scenarios (ECCC, 2019a; IPCC, 2014). Beyond 2040, however, climate models show very different possible outcomes. In a low-emissions scenario, the average increase in temperatures for Canada is an estimated 2°C higher than the 1986–2005 reference period and would remain relatively steady after that. In a high-emissions scenario, the average temperature in Canada could increase by more than 6°C (ECCC, 2019a). In the figure below, the map on the left shows changes in average surface temperature under a low-emission scenario (IPCC representative concentration pathway or RCP 2.6) and the map on the right shows temperature change under a high-emission scenario (IPCC RCP 8.5).

Change in average surface temperature (1986-2005 to 2081-2100)



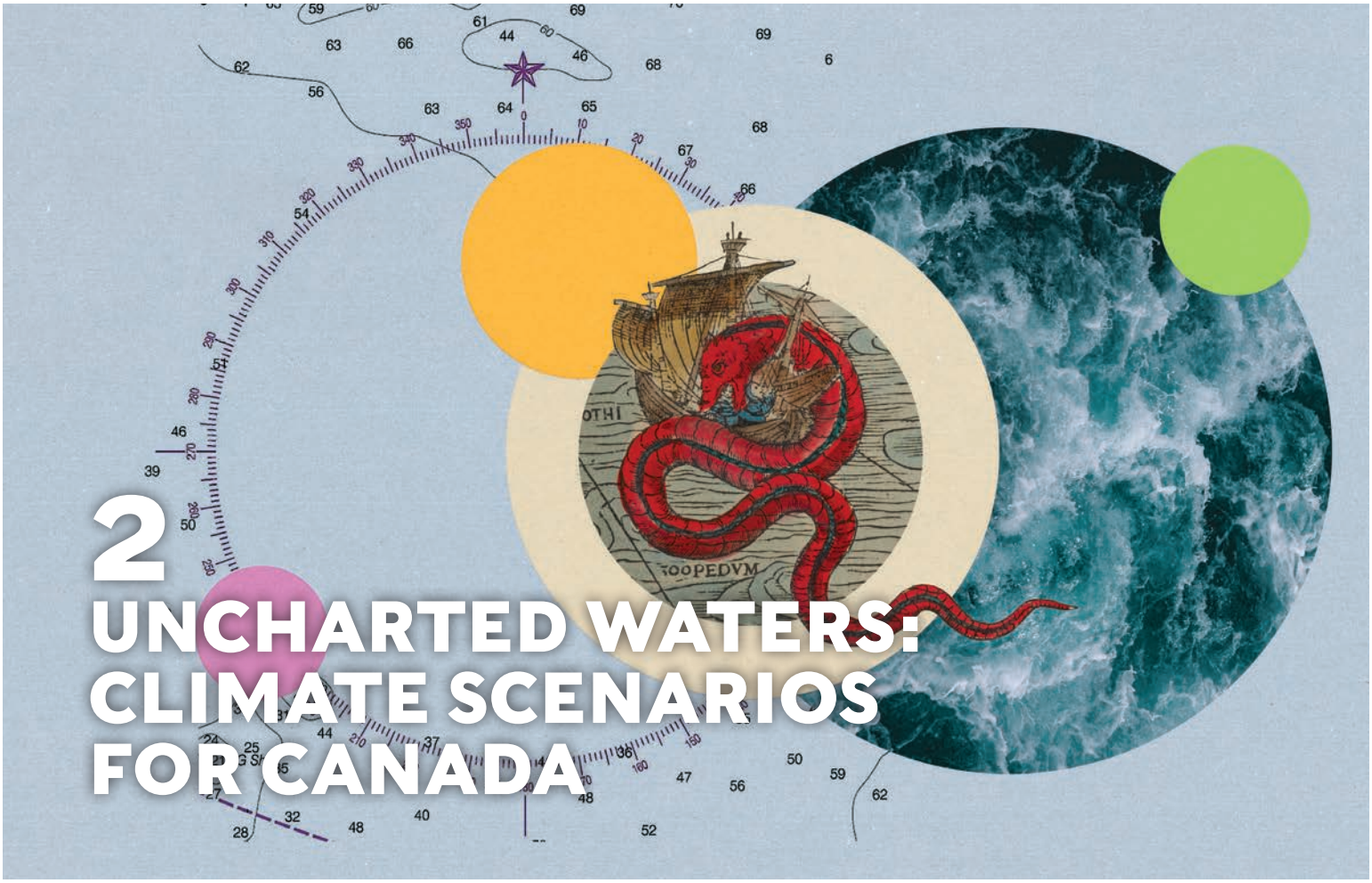
Source: ECCC (2019a) based on Collins et al. (2013)

High-emissions scenarios involve the greatest range of uncertainty. The earth's systems are complex and have natural tipping points where, once crossed, could cause catastrophic and irreversible impacts. They can be triggered by positive feedback loops that cause chain reactions that rapidly accelerate climate impacts, such as the loss of Arctic sea ice, the Greenland ice sheet, or the Amazon rainforest (Lenton et al., 2008; Nobre and Lovejoy, 2018). While some of these feedback effects are known and can be quantified, and are included within climate models, others are less well understood or are unknown and cannot be quantified (IPCC, 2014; USGCRP, 2017; UNEP, 2017). Feedback loops can also interact with other natural and human-induced factors, adding an additional layer of complexity.

Achieving the 2015 Paris Agreement implies urgent and deep cuts in emissions

In 2015, 196 countries signed the historic Paris Agreement, which aims to keep the average increase in global temperatures well below 2° C in this century (relative to pre-industrial levels), and to "pursue efforts" to keep temperatures below 1.5° C. For any particular temperature threshold above pre-industrial levels (e.g. 2° C), there is a fixed total amount of emissions that cannot be exceeded (including all emissions that have already been produced since the start of the industrial period) (IPCC, 2018).

As part of the Paris agreement, each country set its own emissions-reductions target, known as Nationally Determined Contributions (NDCs). Current NDCs will not be sufficient to achieve the 2° C target. Achieving each of the NDCs would likely result in average global temperature increases of about 3° C relative to pre-industrial levels (UNEP, 2017). Canada's target is to reduce emissions by 30% below 2005 levels by 2030, or 513 Mt. In 2017, Canada's emissions were 716 Mt.



2 UNCHARTED WATERS: CLIMATE SCENARIOS FOR CANADA

Picture Canada as a ship on open seas. The crew are Canadians from across the country, each with their own role in strengthening and sailing the ship. Our destination is 2050 and beyond—ideally in a future where Canada and Canadians thrive and prosper. The journey is an important one: future generations of Canadians depend on it.

Climate change is a storm on the fast-approaching horizon. It's already putting the health and safety of the crew at risk and is getting worse. Its high waves and strong winds threaten to make our journey turbulent and difficult.

To a large extent, the severity of the storm depends on the collective actions—or inaction—of the global community. The choice before the world—making rapid and deep cuts in emissions or letting global emissions continue to climb—will have a profound impact on the risks and opportunities that lie ahead.

At the same time, our own choices as Canadians matter. The ultimate success of our journey depends on our own actions and how we chart

our course. Canada's level of preparedness will influence how well we cope and manage with changing conditions. Canadians will be better off taking actions that anticipate change, limit risk, and lay the foundation to seize future opportunities. Our choices today and in the years ahead will have lasting impacts on current and future generations.

This section explores two climate scenarios for Canada. We use these scenarios to illustrate the broad range of challenges—and opportunities—that Canada could face with climate change and how understanding these challenges can better inform how we respond.

2.1 A SPECTRUM OF CLIMATE FUTURES

Canada's climate future will be defined by two main external drivers. The first driver of change is the climate impacts resulting from increases in global GHG emissions. The more GHG emissions the world emits, the more frequent and severe physical impacts of climate change, such as heatwaves, wildfires, and sea-level rise, become. The second driver, which pulls in the opposite direction, is the extent to which countries decarbonize. The faster the world reduces GHG emissions, the faster market demand shifts away from emission-intensive goods and services.

The future will ultimately involve both types of change. The question, however, is which driver of change will dominate.

Possible climate futures lie along a spectrum of varying degrees of change. On the one end of the spectrum, rapid and deep cuts to global emissions (i.e., Deep Decarbonization) translate into moderate increases in global temperatures and, as a result, moderate climate impacts. However, ambitious and widespread actions to decarbonize trigger a transformational shift toward a low-carbon economy, bringing both new opportunities and risks. The world still faces the threat of more extreme climate events, but they are more manageable and predictable.

The other end of the spectrum, by contrast, paints a very different picture (i.e., Runaway Climate Change). As global emissions increase, and as average global temperatures rise, the physical impacts from climate change become the dominant source of global change and disruption. The world experiences dramatic and potentially irreversible climate impacts, which, as we continue to emit GHGs, become worse and less predictable. The magnitude of social, economic, and environmental disruption is far greater as a result. The global economy still reduces emissions but the pace and scale is much slower and smaller.

The analysis in this section focuses on the two extreme ends of this spectrum: Deep Decarbonization and Runaway Climate Change. We start by describing each scenario and the global trends that facilitate its trajectory. We then explore the different risks and opportunities each scenario could hold for Canada and how our choices can influence outcomes. For the Deep Decarbonization scenario, we focus on market risks and opportunities from global economic transformation. For the Runaway Climate Change scenario, we focus on the physical, economic, and societal risks of a changing climate. In each scenario, we describe two hypothetical cases: one where Canada is proactive and prepared, the other where Canada is reactive and ill-prepared (Table 1).

To inform our analysis, the scenarios in this section draw on a broad range of scientific and economic research.[1] They are, however, illustrations rather than predictions. We do not assess the likelihood of either outcome, or the range of outcomes in between the two scenarios. The scenarios are also necessarily simplified. Even with robust scientific evidence, it is uncertain how climate change will affect our economy, environment, and society. Other global trends (e.g., changes in population, environmental degradation, increasing living standards, technological advancements) interact with climate change and make such analysis immensely complex. Nevertheless, the scenarios shine a light on the key economic and societal pressure points from climate change, and how the choices made by Canadian governments, businesses, and individuals will affect our future.

(1) The two scenarios notionally look out 50–80 years from today, but the exact timing and trajectory will vary under any scenario.

TABLE 1: SUMMARY OF THE TWO SCENARIOS				
Global Driver	**#1: Deep Decarbonization** **In a world with deep decarbonization, countries take significant action to reduce emissions, leading to large-scale economic transformation in global markets. Climate change still gets worse, but impacts are less volatile and intense.**		**#2: Runaway Climate Change** **In a world with runaway climate change, there is a steep increase in emissions. As a result, large-scale economic, societal, and environmental disruption occurs, leading to lower incomes, health crises, mass migration, inequality, and conflict.**	
Canadian Response	**Slow and Uneven** Canadian businesses are slow to adjust, which reduces competitiveness and slows economic growth and prosperity. High-carbon sectors face reduced demand and investment, lower prices, and border carbon tariffs, leading to domestic job loss.	**Quick and Coordinated** Canada develops low-carbon innovations and products, which propels economic growth and prosperity. High-carbon sectors limit risk by reducing carbon intensity and diversifying their business models. Suppliers of low-carbon technologies and products thrive with growing global and domestic markets.	**Reactive and Ad Hoc** Canada is caught in cycle of shifting from one economic and societal crisis to the next, as a result of domestic shocks (e.g. floods, drought, wildfires) and global disruption (e.g. supply chains break down, massive demand for international development assistance).	**Proactive and Comprehensive** Disruption in Canada is minimized (to the extent possible) due to widespread and integrated adaptation. Vulnerable communities and populations become more resilient, emergency response measures are planned and organized, and Canada takes a leadership role in the globally coordinated response to climate-related crises.

2.2 SCENARIO #1: DEEP DECARBONIZATION

In the first scenario, the global community decarbonizes rapidly and achieves the emissions goal set out in the Paris Agreement: to keep the rise in average global temperatures well below 2° Celsius (C) above pre-industrial levels. Some extreme climate events still become more frequent and severe; however, the impacts are far less severe and disruptive relative to higher emissions scenarios (IPCC, 2018).[2]

Limiting global temperature increases to well below 2° C requires rapid and significant cuts to global emissions and is much more challenging than achieving a 2° C goal. For example, while achieving 2° C would require global CO_2 emission reductions of about 25% below 2010 levels by 2030, achieving 1.5° C requires reductions of around 45%. Figure 1 illustrates the different possible pathways to keep the rise in global temperatures to 1.5°C. Global emissions need to reach their peak between 2020 and 2030 and decrease rapidly after 2030. The world would also needs to achieve net-zero emissions between 2050 and 2060 and net-negative emissions thereafter (IPCC, 2018).[3]

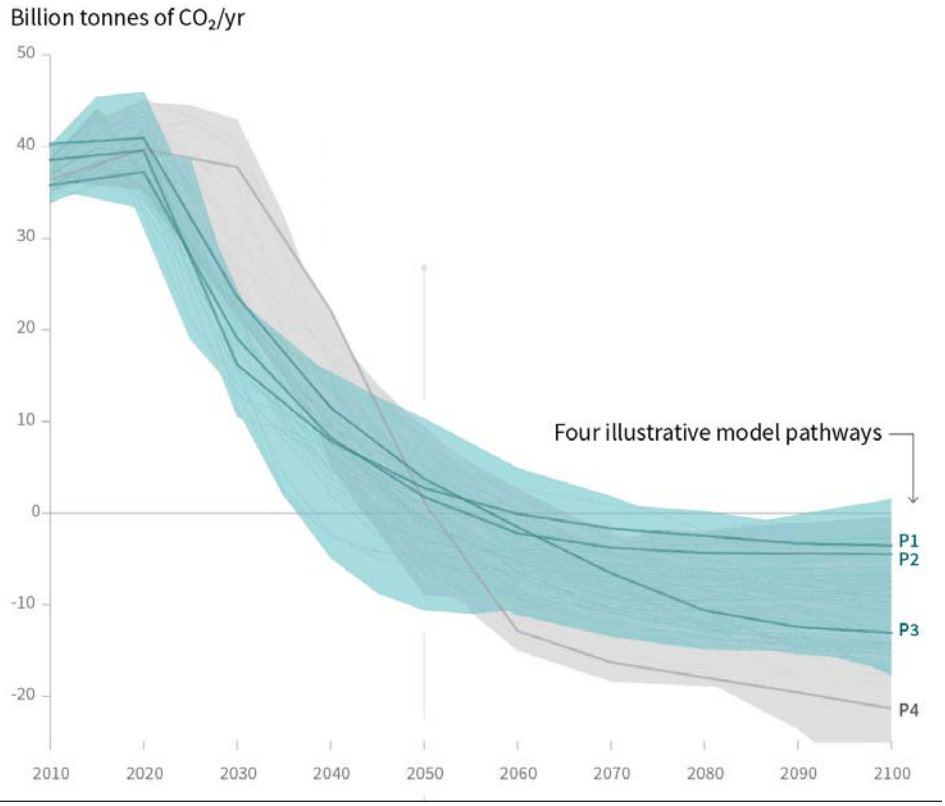
The urgency and depth of emissions reductions required to achieve the Paris emissions goal trigger an economic transformation on a scale not seen

(2) This scenario assumes the international community achieves the goal set out in the Paris Agreement, keeping the average increase in global temperatures well below 2° C (above pre-industrial levels). Even with these deep cuts in global emissions, however, the world still experiences an increase in the frequency and severity of climate change impacts. Impacts already being felt—from increased heatwaves, flooding, wildfires, to sea-level rise—get worse, but are less severe than in our Runaway Climate Change scenario.

(3) There is a significant difference between the 1.5° C and 2° C temperature goals. Keeping the average rise in global temperatures to 1.5° C requires policy that is far more stringent, driving more rapid and wide-ranging disruption to the global economy. At the same time, the physical risks from climate change are substantially higher in a world with a 2° C increase in global temperatures (IPCC, 2018; Carbon Brief, 2018). The analysis in this section draws on various scenarios between 1.5° C and 2° C. Many of the scenarios consider pathways consistent with a 1.7 or 1.8 ° C temperature increase.

FIGURE 1:

Global Emissions Pathways to 1.5° C



This figure shows several different emissions pathways to keep the rise in average global temperatures to 1.5° C above pre-industrial levels. Using historical emissions in 2010 as the starting point (measured in billion tonnes of CO_2 per year), the analysis includes four different pathways (P1, P2, P3, and P4) out to the year 2100. Across all pathways, global emissions peak around 2020 and decrease rapidly thereafter. The world achieves net-zero emissions between 2050 and 2070 and net-negative emissions soon after. The lighter lines and shaded areas represent different ranges for each pathway.

Adapted from: IPCC, 2018

since the first and second industrial revolutions. It represents deep emissions reductions across all sectors of the economy, including energy, heavy industry, agriculture, transportation, and manufacturing. The transformation unleashes unprecedented demand for low-carbon goods and services, triggering a significant shift in global markets.

Although the exact timing and magnitude of these changes is uncertain, five main trends drive the transformation:

- **Fossil fuel combustion is dramatically reduced.** Keeping the rise in average global temperatures well below 2° C causes global demand for oil to peak by 2020, dropping by 27% below 2017 levels by 2040 (IEA, 2019a). The share of fossil fuels as a primary energy source drops from 80% in 2020 to less than 20% by 2100 (Shell, 2018). A large share of proven fossil fuel reserves become uneconomic as demand for fossil fuels sharply decline (McGlade & Ekins, 2015).[4]
- **Electrification of key economic sectors such as manufacturing and transportation accelerates.** The rate of replacing fossil fuels with cleaner sources of electricity triples by 2070 relative to 2018 levels (Shell, 2018; IEA, 2019a, 2019b, 2018a). More than half of global car sales are electric by

(4) Achieving a 2-degree goal could make a significant share of proven oil, gas, and coal reserves uneconomic, creating stranded assets. McGlade and Ekins (2015), for example, estimate that this means a third of global oil reserves, half of gas reserves, and over 80% of coal reserves cannot be used for combustion (assuming no technological advancements that significantly reduce emissions). Estimates by Citigroup suggest that the value of these stranded reserves is $100 trillion (Channell et al., 2015).

2030 and 100% are electric by 2050 (Shell, 2018). For light industry, the use of electricity doubles between 2020 and 2040, while the shift in heavy industry comes later, around 2050.

- **An expansion of renewables largely displaces the sharp decline in the conventional use of fossil fuels.** By 2040, 65% of global electricity generation comes from renewables (up from about 25% in 2016), driven mainly by growth in solar, wind, and bioenergy. Renewables become increasingly cheaper than fossil fuels by the 2020s and supply 40% of global electricity generation by 2040 (IEA, 2018a, 2019a). Nuclear power capacity triples between 2020 and 2070 (Shell, 2018).
- **New low-carbon technologies emerge, disrupting markets and trade patterns.** As the market for low-carbon goods and services grows, so too does growth in innovative low-carbon technologies. Breakthrough innovations are impossible to predict but can trigger positive feedback loops: a new low-carbon innovation can disrupt markets, which leads to yet more innovation and disruption (Lipsey et al., 2003). Cost-competitive fusion and hydrogen technologies, for example, could radically transform global energy systems.[5]
- **Options to remove and capture carbon become more widely deployed.** Achieving the Paris Agreement likely requires large-scale carbon removal from the atmosphere (IPCC, 2018, 2014). This means scaling up afforestation and reforestation, reforming agri-food systems, and greater use of direct air capture technology. Carbon capture, storage, and utilization will also be critical.[6] By some estimates, this could require constructing some 10,000 large carbon capture and storage (CCS) facilities by 2070, compared to the 50 operating in 2020 (Shell, 2018).

Importantly, Canada still experiences the physical impacts of climate change in this low-carbon world; however, impacts are far less severe than in a future with runaway climate change (see next section). Historical emissions, and the additional emissions generated as the world transitions to a net-zero economy, will continue to increase global temperatures and cause the climate to change. While adapting and preparing for the physical impacts of climate change are critical to reducing disruption and damage from these impacts, the following two cases focus primarily on the risks and opportunities associated with a global transition to a low-carbon economy.

Canada's Response: Slow and Uneven

In this version of the Deep Decarbonization scenario, Canada delays ambitious climate action and fails to prepare to compete in a low-carbon economy. Overall, high-emissions sectors do not reduce their emissions intensity or diversify, and companies developing low-carbon technologies and products struggle to commercialize and grow. Once global trends become apparent, it is too late to change investments in long-lived capital stock (e.g., buildings, vehicles, and equipment) or develop new low-carbon product lines that can compete against foreign firms that have been investing in research and development for decades.

The rapid transition globally, coupled with inadequate preparation domestically, creates large-scale disruption and job loss in Canada.

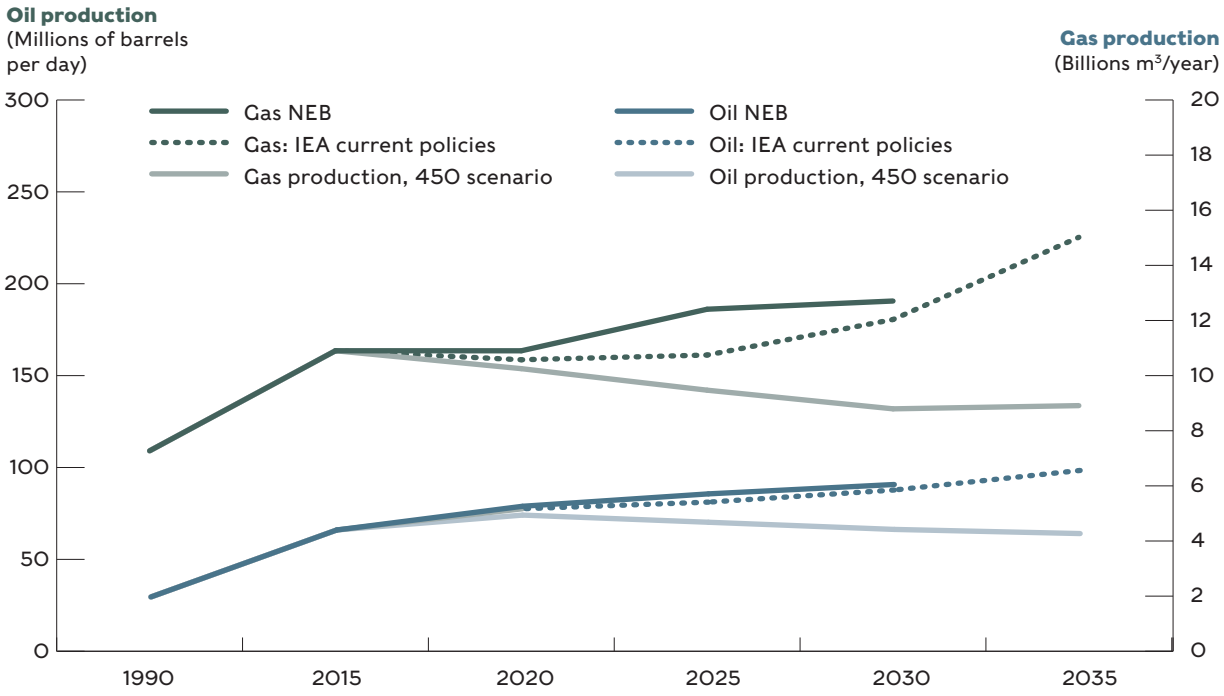
Much of Canada's economy—and the prosperity it generates—depends on sectors that export emissions-intensive products and commodities such as oil and gas (Box 1). As global demand for fossil fuels drops, it leads to lower levels of investment in the sector. Oil sands projects are particularly affected, given their relative carbon intensity, timeframe to payout, and upfront capital cost (Leach, 2019). As a result, Canada's oil and gas sector sees lower levels of revenue, profits, and

(5) Other technological advancements, new business models, and societal innovations will interact with climate-related technologies in different ways. The development of autonomous vehicles, artificial intelligence, block chain, and cloud-based services are a few examples of different emerging technologies that could have profound impacts on climate change.
(6) CCS technologies capture the carbon released during combustion (e.g., at an oil refinery) and deposit it underground, preventing it from entering the atmosphere. Carbon capture and utilization (CCU), by contrast, uses captured carbon to make new products, such as fuels, plastics, or cement.

BOX 1:
RISKS TO CANADA'S OIL AND GAS SECTOR

As global demand for fossil fuels declines, the market for Canada's traditional energy exports shrinks. Energy scenarios produced by the International Energy Agency show Canada's oil and gas production declining under a low-carbon scenario consistent with the 2° C goal (i.e., the 450 scenario in the figure below). In the longer term, well past 2035, the drop in global demand is likely to be more pronounced.

Energy Production Scenarios for Canada



Note: IEA projections are from the December 2016 IEA World Energy Outlook.
* National Energy Board (NEB) projections for 2020-30 are based on growth rates from 2015 from the NEB's Energy Future Report applied to the same starting point as the IEA projections.
Source: IEA (2016), World Energy Outlook 2016.

Canada's oil and gas sector is highly exposed to such a dramatic change in global demand. In 2018, the sector accounted for 6% of Canada's total GDP, provided roughly 1% of all jobs, and generated billions of dollars in government revenues. Yet emissions from this sector account for 25% of Canada's total inventory. The oil sands represent 97% of Canada's proven oil reserves, which are the third largest in the world. Crude oil from Canada's oil sands is relatively carbon intensive and is among the most expensive types of oil to extract and refine.
The financial sector is also exposed to risk from changes in this sector. The six largest banks in Canada held a combined $52 billion worth of outstanding loans to the oil and gas sector in 2019.

Sources: EPSF (2018, 2019); OECD (2017); World Bank (2019); ECCC (2018a); Statistics Canada (2019d); Natural Resources Canada (2018a, 2018b); Weber & Kholodova (2017); USGAO (2016); Bank of Canada (2019); Masnadi et al. (2018); Leach (2019).

employment. The hardest-hit firms are those that are slow to adjust to market trends and continue to depend on long-lived, emissions-intensive infrastructure and assets (Potvin et al., 2017; OECD, 2017).

Other Canadian sectors are also unprepared for the global shift in demand that puts a higher premium on low-carbon goods and services. They are slow to adjust to investor preferences and are caught off guard by export markets that erect trade barriers that penalize high-emissions imports. Emissions-intensive manufacturers in Canada, for example, become less competitive as other countries develop lower-carbon alternatives that are more attractive to markets facing increasing carbon constraints. Investors limit their exposure to carbon risk by favouring firms that are profitable in a decarbonized marketplace. Canada's automotive industry, for example, sees plants close as a result of decreasing demand for gasoline-powered SUVs and light trucks, with vehicle manufacturing shifting to foreign plants that produce electric vehicles (Potvin et al., 2017; Yates & Holmes, 2019; Tanguay, 2018).

Over time, as global action mounts, the shocks to Canada's most exposed sectors ripple throughout the economy. Lower incomes and weaker job growth in the oil and gas sector, for example, affect key sectors such as construction, manufacturing, retail, transportation, and real estate. Canada's financial sector—heavily invested in fossil fuels—is exposed to greater risk as lending and investment in these assets weakens (Bank of Canada, 2019).

The rapid shift away from emissions-intensive goods and services also increases the risk of unemployment and widespread social disruption. Social support systems come under increased pressure (e.g., food banks, employment insurance, social assistance), particularly in communities that rely heavily on emissions-intensive industries (Mertkins-Kirkwood, 2018). Impacts are felt differently across provinces but occur from coast to coast, as many of the affected sectors employ Canadians from across the country (e.g., oil and gas workers in Alberta that live in Eastern Canada). Similar to coal communities in the Maritimes devastated by collapsing global demand in the mid-twentieth century, many small communities in oil-producing provinces (e.g., Alberta, Saskatchewan, and Newfoundland and Labrador) struggle with high unemployment and stretched government budgets that increasingly lead to cuts in health and education.

At the same time, Canada fails, in this scenario, to capture the opportunities associated with increased global demand for low-carbon technologies, goods, and services. With limited domestic demand, innovation from the private and public sectors is insufficient to develop leading technologies. In many respects, Canada becomes a technology-taker: it benefits from developments and innovations in other countries, but it loses out on the economic benefits associated with developing and exporting these technologies.

Inevitably, some progressive firms adapt and benefit from the shift in global demand, even without an early, coordinated and planned response. Increasing global demand sends clear market signals that lead to new investment strategies. Some mining companies, for example, increase copper and zinc production to respond to growing demand for metals and minerals needed for renewable electricity and battery production (Box 2). Relative to the next case, however, Canada fails to fully capture the opportunities available and leaves large segments of the economy at risk. Benefits are smaller and less widely distributed across the economy.

Canada's Response: Quick and Coordinated

In this version of the Deep Decarbonization scenario, Canada is proactive and takes immediate and coordinated action to prepare for a low-carbon future. As a result, the economic transition for Canada is smoother and far less disruptive. Canada positions itself to capture growing market opportunities and to become a global leader in low-carbon innovation.

Importantly, early and coordinated action helps protect and improve Canada's competitive edge in the global economy. High-carbon sectors make substantial adjustments to reduce emissions and diversify product streams, leaving them less vulnerable to sudden shifts in global markets. These actions also help insulate Canada from trade barriers that penalize carbon-intensive goods and services. Canadian firms are able

BOX 2: CANADA'S MINING AND FORESTRY SECTOR IN A LOW-CARBON WORLD

The global transition to a low-carbon economy could drive significant growth in some of Canada's resource development sectors. Growing demand for solar panels, wind turbines, and battery storage, for example, could dramatically increase demand for key metals and minerals such as copper, iron, lead, nickel, zinc, cobalt, and lithium.

Canada is already one of the largest mining countries in the world, making it well positioned to benefit from this new global demand. Based on analysis by the World Bank, Canada has significant deposits of almost all metals critical for growth in clean technologies.

Canada's forestry sector is also likely to benefit. In a low-emissions scenario, the use of bioenergy could double globally by 2050, putting forestry inputs in high demand. Biomass is also expected to become a much bigger input to consumer goods such as chemicals, plastics, food additives, and textiles. Canada is home to roughly 6% of the world's bioenergy potential and is the second largest exporter of forestry products in the world.

Sources: CCFM (2017); FPAC (2017); OECD et al. (2017); Canada Senate (2018); World Bank (2017).

to avoid border carbon tariffs and maintain—and even extend—their competitive advantage (Sawyer, 2013).

A rapid expansion of low-carbon energy is a key driver in Canada's transition to a low-carbon economy. The supply of non-emitting electricity triples by 2050, driven by new investments in hydro, nuclear, wind, and solar power (Langlois-Bertrand et al., 2018).[7] At the same time, provincial agreements lead to new investments in inter-provincial transmission infrastructure that help share the benefits of low-carbon electricity projects. Provinces and territories historically dependent on fossil fuels (e.g., Alberta, Saskatchewan, Nova Scotia, New Brunswick, the Northwest Territories, and Nunavut) gain access to non-emitting electricity, driving significant emissions reductions.

The growth in non-emitting electricity generation helps electrify key sectors in the Canadian economy, such as buildings, agriculture, transportation, natural gas, and industry, giving Canadian products and services a low-carbon advantage in international markets. Several developing technologies also become more cost-competitive, such as second-generation biofuels and hydrogen fuel, enabling additional GHG reductions. Some segments of the economy eliminate the use of fossil fuels entirely, such as residential and commercial buildings and agriculture (Langlois-Bertrand et al., 2018; Weber & Kholodova, 2017).

Gains in energy efficiency and conservation play a supporting role, especially for households. Clean technologies, such as smart thermostats, heat pumps, and more efficient furnaces become cheaper and more widely deployed. These measures help keep total energy demand relatively stable over time, despite a growing population and higher incomes (Langlois-Bertrand et al., 2018; TEFP, 2016). Investing in efficient technologies and appliances also helps households reduce their energy bills.

Over time, the Canadian economy becomes more diversified and less susceptible to falling oil and gas prices. In the financial sector, investors diversify their portfolios quickly and on a broad scale, with a greater emphasis on low-carbon assets. Canada's natural resource sectors also diversify their operations, with

(7) Technologies that are currently less commercially viable, such as second-generation biofuels and carbon capture and storage, could also play a role in this scenario.

increased near-term focus on natural gas exports and longer-term investments in renewable electricity, hydrogen, and biofuels (Shell, 2019). Sectors such as oil and gas still suffer losses due to declining demand, but actions taken by government and business help these sectors diversify earlier, which makes the transition less disruptive.

At the same time, education and retraining programs help unemployed workers find employment in new and emerging sectors (OECD, 2015a). These programs reduce the risk of prolonged unemployment and social disruption, particularly in rural and small communities with local economies that are less diversified.

As the demand for emissions-intensive goods and services fades, the cleantech sector becomes a significant source of growth, innovation, and employment. Driven by surging domestic and global markets, Canada becomes a global leader in low-carbon innovation and a major exporter of low-carbon technologies, goods, and services. Meanwhile, resource sectors, such as mining and forestry, benefit from an unprecedented increase in global demand for raw materials used for clean technologies (Box 2).

2.3 SCENARIO #2: RUNAWAY CLIMATE CHANGE

Our second scenario considers a very different global context, where the international community does not take action to reduce emissions. Many countries do not meet existing emission reduction commitments and global GHG emissions rise rapidly. Global demand for energy continues to increase and is met by expanded coal, gas, and oil production. Renewable energy supplies some of this new energy demand, but fossil fuels play a dominant role.

Under this very high-emissions scenario, average global temperatures increase by as much as 5° C by 2100 (above pre-industrial levels).[8] Belatedly, after experiencing the devastating consequences of inaction, some countries start to make deep cuts in emissions. These efforts are too late to avoid severe impacts.

Economic and societal disruption increases significantly in this scenario. As extreme climate events around the world become more common, local economies suffer repeated shocks that dramatically reduce global income (by 6% to 10% annually according to some estimates). Vulnerable regions, such as Africa, suffer the biggest losses, where average national incomes fall by as much as 25%. These economic impacts cascade throughout entire economies, disrupting market demand, trade patterns, and supply chains. Parts of the world also experience severe food and water shortages, driving an increase in conflict, humanitarian crises, and mass migration in the most affected regions (Nordhaus & Moffat, 2017; Kompas et al., 2018, Dasgupta et al., 2007).

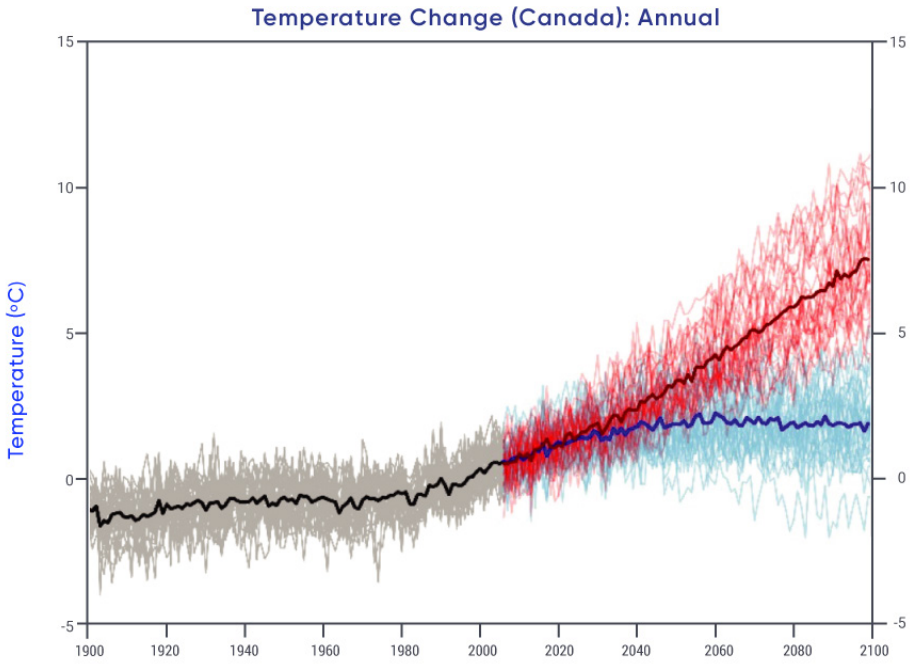
The continued rise in global emissions cause profound changes to local and regional climates in Canada. The dark red line in Figure 2 shows the implications for Canada in a very high-emissions scenario (ECCC, 2019a). By 2100, average annual temperatures rise an additional 5–10° C relative to pre-industrial levels, with even greater changes in the North.

The rapid increase in average temperatures causes significant disruption over the next century—far more disruption than we are currently experiencing from climate change and far more than in the first scenario. Extreme precipitation events intensify (in some cases by as much as 20%), particularly during winter months. With more rain and snow over shorter periods, combined with other non-climate factors, such continued drainage of wetlands and increasing rates of urbanization and paved (impervious) surfaces, flood risk increases significantly in many regions (ECCC, 2019a; Statistics Canada, 2016; Feltmate & Fluder, 2018; AAFC, 2015).

(8) Temperature increase consistent with the representative concentration pathway RCP8.5, used by the International Panel on Climate Change, represents a very high-emissions baseline scenario (see our insert on the Scientific Foundations of Climate Change above) (Hausfather, 2019).

FIGURE 2:

Annual Temperature Change (Canada, 1990 to 2100)



The grey lines in this figure show the (estimated) variations in temperature over the historical period (1900–2005); the solid black line represents the average over the same period. The dark red line represents average temperatures under a high-emissions scenario, based on the IPCC representative concentration pathway (RCP) 8.5. The dark blue line represents average temperatures for a low-emission scenario (RCP2.6).

Source: ECCC, 2019a

At the same time, many parts of Southern Canada become drier during summer months (ECCC, 2019a). Heatwaves become longer and more intense, causing an increase in severe droughts, water stress, and wildfires (Kharin et al., 2018; ECCC, 2019a). The chance of record-setting heat increases ten-fold by mid-century. By century's end, Canadian glaciers lose more than 95% of their volume, based on 2006 levels (ECCC, 2019a).

Sea levels continue to rise, but at a much faster rate relative to the low emission scenario. By 2100, average sea levels in Atlantic Canada are as much as 100 centimetres higher and between 25 and 50 centimetres higher on Canada's west coast.[9] These higher water levels increase the risk of extreme storm surges and flooding in Canadian coastal communities. Ocean acidification increases at a faster rate, with devastating effects on some marine ecosystems (IPCC, 2014; ECCC, 2019a; NOAA, 2013).

Critically, there is a chance that impacts from runaway climate change are far worse than what this scenario describes. Climate impacts are non-linear, where gradual changes (e.g., increasing ocean acidification) can cause sudden and unexpected changes (e.g., the rapid collapse of marine ecosystems or mass extinctions). In worst-case scenarios, positive feedback loops could push delicate and complex natural ecosystems beyond tipping points, causing irreversible and catastrophic damages (NRTEE, 2011; Yumashev et al., 2019; Schneider et al., 2019; IPCC, 2014).

(9) The amount of sea-level rise experienced in coastal communities is, and will continue to be, different based on geography. This is due to the vertical movement of coastal lands. In some cases, like in Atlantic Canada, coastal land is gradually sinking (i.e., land subsistence), which amplifies the threat of sea-level rise. In other cases, like on Canada's west coast, coastal lands are rising (i.e., land uplift), which helps offset the increase in sea-level rise (ECCC, 2019a).

BOX 3:
THE HEALTH RISKS FROM HEATWAVES

The increasing risk of more extreme heatwaves illustrates the wide range of potential impacts to Canadians. Climate models suggest that as average temperatures in Canada increase, the chance of extreme heat increases dramatically. Even in moderate warming scenarios, the frequency of heatwaves in parts of Canada could more than triple.

The immediate impacts from extreme heat in Canada—like other climate impacts—will be felt most acutely by children, the elderly, and other vulnerable populations. More intense heatwaves are projected to increase mortality rates and will also increase the risk of other illnesses, like heat exhaustion and heat stroke. It is also expected to exacerbate pre-existing health conditions, such as asthma and cardiovascular disease. Over time, more frequent and intense heatwaves can trigger and exacerbate mental health issues, such as post-traumatic stress, anxiety, and depression.

Warmer temperatures are also projected to increase the spread of insect-borne illnesses and diseases, such as Zika virus and Lyme disease, as well as pests that affect agriculture and forestry.

Sources: Kharin et al. (2018); Carbon Brief (2018); Hayes et al. (2018); Decent & Feltmate (2018); Ryan et al. (2019); Government of Canada (2017); ECCC (2019a); Ebi et al. (2018); Bouchard et al. (2019); Bickis, (2019).

Canada's Response: Reactive and Inconsistent

In this version of the Runaway Climate Change scenario, Canadians fail to adequately prepare for the severe impacts from climate change. The response is entirely reactive, and Canada becomes caught in a continual cycle of impact and recovery. Canada is hit from all sides, facing both localized physical impacts such as floods and drought, and economic impacts from global disruption.

A lack of preparedness increases health and safety risks to Canadians. In some cases, Canadians suffer direct physical harm from severe climate events that become far more frequent and intense, such as floods, wildfires, drought, storm surges, and heatwaves (Box 3). In other cases, impacts are indirect. Canadians experience poorer air quality from wildfire smoke, contaminated water from flooding, and other environmental factors. The economic effects of domestic and global disruption are also indirect, as affected investments lose value, companies lay off workers, and goods—food included—become more expensive.

The most vulnerable in Canada bear a disproportionate share of these costs (Ebi et al., 2018; Health Canada, 2007). Those with more wealth and resources are better able to adapt and protect their families and property. Inequality in Canada increases as a result.

A lack of preparation also imposes massive, systemic risks to the Canadian economy. Being unprepared for longer and more intense dry periods, for example, lowers agricultural yields. Warmer air and water temperatures, coupled with ocean acidification, undermine the sustainability of Canadian fisheries. Hotter temperatures also increase the risk of forest fires and invasive species, such as the mountain pine beetle, threatening the sustainability of Canada's forestry sector (ECCC, 2019a, Bickis, 2019).

Damages to public infrastructure and private property increase dramatically. Governments own and operate a large portfolio of infrastructure that is critical to the economy, including bridges, ports, roads, railways, water and wastewater facilities, communications infrastructure, defence and military installations, and transmission lines.

BOX 4: SEVERE FLOODS IN THAILAND ILLUSTRATE SUPPLY CHAIN RISKS

The increasing frequency and severity of extreme climate events, among other factors, is already disrupting global trade. The World Economic Forum, for example, estimates that weather-related disruptions to the production and delivery of goods and services are up 29% since 2012. Hurricanes and wildfires in North America were a key factor in this increase.

The severe flooding in Thailand in 2011 illustrates how a single event can disrupt global trade. In addition to the immense human and social cost inflicted by these floods, the economic cost was also significant. Flooding caused nearly 10,000 factories to close, reducing output by 36%. Some automotive assembly plants in Canada were forced to cut production by 50% due to a shortage in parts from Thailand factories. The floods also caused a worldwide shortage of hard drives, as Thailand produced 45% of the world market, causing global prices to double.

Sources: CBC News (2011); NOAA (2016).

Over time, extreme weather events compromise the effectiveness, lifespan, cost, maintenance, rehabilitation, and renewal of this infrastructure (Infrastructure Canada, 2018).

At the same time, extreme events impose larger damages on Canadian homeowners and businesses. Insurance premiums increase over time, making insurance unaffordable for the most vulnerable. As the costs from natural disasters mount, the entire private insurance industry comes under pressure. Government funding for uninsured losses and disaster relief continues to increase, meaning higher taxes and less spending on other public goods and services. Municipalities in particular come under increasing fiscal pressure (Giuzio et al., 2019; Dolynny, 2019; Feltmate et al., 2017; Armstrong, 2019).

Risks also extend beyond Canadian borders. Over time, more frequent and intense climate events make food and water shortages more common in other parts of the world, driving an increase in conflict, humanitarian crises, and mass migration. Although Canada is not directly affected by these events, it is overwhelmed with requests for assistance. For example, Canada is ill-equipped to deal with the sharp increase in migrants seeking refuge from the most affected regions of the world (IPCC, 2019).

Increasing levels of global disruption also create economic risks, which Canada is not prepared to manage. Many Canadian companies hold assets abroad and rely on complex, integrated supply chains to produce and deliver their goods (Wei & Chase, 2018). In addition to the immediate damages to property and disrupted operations, initial shocks cascade throughout entire supply chains. The price of imported foods, for example, increases substantially and some consumer goods and materials become unavailable (Box 4) (NOAA, 2016). Such shocks impose additional risks to Canada's banks, which tighten lending and investment practices due to sudden and repeated spikes in climate-related losses (Bank of Canada, 2019).

Without protective measures, damage and degradation to Canada's natural ecosystems becomes more widespread. Earlier spring melts and drier summers with hotter temperatures increase pressure on freshwater supplies, compounded by excessive water use. As a result, reactive measures become more common across Canada, such as emergency water restrictions. Extreme temperatures and weather events also damage other critical ecosystems, like wetlands and salt marshes, which provide both climate change and biodiversity benefits. Impacts to Canada's North are particularly devastating, including

BOX 5: POTENTIAL OPPORTUNITIES IN A WORLD WITH RUNAWAY CLIMATE CHANGE

Some parts of Canada can capitalize on a high-emission scenario in the short term. Canada's emissions-intensive sectors (e.g. oil, gas and chemicals) benefit from buoyed global demand, high commodity prices, and a delayed transition to a low-carbon economy. Rising incomes across developing countries could, for example, trigger an increase in demand for carbon-intensive sources of energy and raw materials, keeping commodity prices high and driving further investment in fossil fuels. These emissions-intensive sectors continue to benefit until the global community makes a belated attempt to decarbonize and broader economic losses affect energy demand.

As inhabitants of a cold and northern country, people living in parts of Canada could benefit from warmer temperatures. Warmer winters could, for example, result in fewer cold-related deaths and illnesses and lower heating costs for households and businesses. Warmer temperatures in spring, summer, and fall could also open new tourism opportunities that previously did not exist. Some farmers could benefit from warmer temperatures and longer growing seasons. And if agricultural production in other countries is hampered by extreme climate change, Canada could play a key role in meeting shortages in global demand.

Critically, any benefits in a high-emissions scenario are likely temporary and short-lived. Benefits diminish as extreme climate events become more common and intense. Fewer deaths due to extreme cold are offset by more deaths from extreme heat. Savings in heating bills are offset by increased use of air-conditioners in the summer. Longer seasons for growing crops are offset by an increase in heatwaves, droughts, and flooding. Potential benefits do not negate the need to prepare for risks.

Sources: Mintz-Woo & Leroux (2019); Carbon Brief (2018).

the accelerated loss of loss of access to wildlife as a local food source and comprised infrastructure from permafrost thaw (IPCC, 2018; NCCC, 2019).

In many cases, governments are forced to replace these ecosystem services with costlier engineered alternatives. Examples include rebuilding Northern infrastructure to cope with sinking land, transporting clean water from further away, and physically moving species such as salmon to cooler waters. In extreme cases, ecosystems experience irreversible damage and collapse.

Canada's rich biodiversity also suffers major losses in this scenario. The geographical range of species changes and shrinks, altering migration and breeding patterns and shifting the distribution and growth rates of species. On a larger scale, such drastic changes in climate alter entire food webs. And while plants and animals continuously adapt to changes in climate, the rate and magnitude of disruption is much greater than in past millennia, increasing the risk of extinction (IPCC, 2014; 2019; UNEP, 2018; Bernier et al., 2019).

Despite widespread disruption from runaway climate change, some parts of Canada benefit in the short term (Box 5). These benefits, however, are not evenly distributed or fully captured. Some Canadians face very high costs with no benefits, while others experience lower costs and greater benefits. Over time, benefits from a hotter climate become overshadowed by increasing disruption and instability. Canada also becomes more affected by extreme climate events in other countries, which increase trade disruption, create new health emergencies, and trigger mass migrations.

BOX 6:
INNOVATIVE CLIMATE ADAPTATION

Countries around the world are innovating to adapt to climate change. The Netherlands, for example, is on the leading edge of flood risk and water-supply management. Over a quarter of the Netherlands is below sea level, exposing over half the country to flood risk. To address these risks, the country has adopted a comprehensive adaptation strategy, combining protection against flooding, drinking water security, and managing extreme heat or rainfall in cities.

Perhaps more impressive is that the Dutch integrate design, art, and livability into how adaption projects are built. These innovations have made the Netherlands world-renowned experts in flood-risk adaptation. The Global Centre of Excellence on Climate Adaptation is located in the Netherlands. Annual exports of water technology and expertise from the Netherlands have also doubled since 2000, adding over $10 billion to national GDP.

Sources: Ligtvoet et al (2015); NEAA (2019); Corder (2017); Delta Programme 2019 (2019).

Canada's Response: Proactive and Comprehensive

In this version of the Runaway Climate Change scenario, Canada prepares itself for a future with extreme climate change. While there are still significant costs and risks to human health, Canadians do what they can to adapt to worsening climate change. Where possible, individuals, businesses, and communities make changes and investments that improve their resilience to the direct and indirect impacts of climate change. Canada also demonstrates leadership in managing global risks, such as destabilization of the financial system and large-scale humanitarian crises in Africa and India.

Actions that improve climate adaptation and resilience become widespread and integrated throughout Canada. Collectively, these efforts reduce the overall risk to Canadians, ensuring that businesses, households, and communities are less vulnerable to extreme climate events. Major health and safety risks described in the previous case are actively managed, as are risks to private property and public infrastructure (ECCC, 2019a).

Due to the wide range of climate risks across Canada—along with the unique context in each community—various actions are taken to improve resiliency. Wildfire risk-reduction measures, for example, are implemented across high-risk areas, such as British Columbia and Alberta, to reduce the damage associated with fires. Better emergency response planning in these communities also helps reduce the likelihood of injury and death when wildfires do occur. Improvements in air filtration in buildings help protect communities, including the most vulnerable, from wildfire smoke. Wildfire prevention measures also become integrated with land- and water-use planning and asset management.[10]

Communities also become more resilient to flood risk. Resources focus on high-risk areas, involving large infrastructure projects such as engineered dykes, flood barriers, and stormwater infrastructure upgrades. More resources are also devoted to protecting and restoring natural ecosystems that provide flood protection and absorb carbon, such as wetlands, marshes, and forests. Canada takes its cue from other countries that are already adopting innovative adaptation measures (Box 6).

The number of people living and building in high-risk areas decreases and improved warning systems give residents more time to prepare when catastrophic

(10) It should be noted that no amount of planning or resources can fully protect communities and individuals from the extreme climate impacts described in this scenario. While being prepared can reduce total costs, Canada would still experience widespread damage and disruption.

events occur, reducing the risk of miscommunication and disorder. In extreme cases, some communities—particularly on the east, west, and northern coasts—are relocated to avoid costly damages from higher sea levels and more intense storm surges.

With additional support and incentives from governments, businesses take more direct actions to better understand and prepare for operational and supply-chain risks. Farmers, for example, invest in smart irrigation systems to conserve water and manage fluctuations in precipitation. Auto manufacturers diversify their suppliers to ensure they are not overly reliant on vulnerable trade routes. At the same time, companies move to capture global market opportunities in countries seeking to manage climate change impacts. Water shortages, for example, drive an explosion of demand for water efficiency, desalination, and wastewater recycling technologies.

Adaptation measures also become more integrated into other government services. Social programs that protect the most vulnerable, for example, integrate the risk of extreme climate events directly into daily operations. This includes ensuring the homeless, seniors, pregnant women, persons with disabilities, and citizens who do not speak English are protected during intense summer heatwaves and get immediate assistance during severe storms or flooding.

2.4 SUMMARY

The scenarios illustrate that both global decarbonization and the physical impacts of climate change stand to profoundly affect Canadians. These changes—and our response to them—will affect almost every facet of our lives, from health care, drinking water, social services, public finances, and infrastructure to the types and availability of jobs.

Yet the two scenarios are bookends. In reality, aspects of both scenarios will matter for Canada. Some warming is inevitable, and so too are shifts in global markets in response to carbon constraints. Canada faces a future with elements of each.

Uncertainty is central to the challenges facing Canada. We do not know exactly how bad climate change will become, how fast the world will decarbonize, or even exactly how those impacts will play out in Canada.

As trends become clearer, governments and companies can adjust. However, many preparatory actions require long lead times that make waiting for certainty impractical. We cannot replace infrastructure, develop new technology, or diversify economies overnight.

As a result, Canada must make decisions today that lay a foundation for both futures. Canadians can thrive and prosper, but only if we make choices now that recognize the future risks and opportunities that we could face. Uncertainty is not justification for inaction; in fact, it is precisely the opposite. Being prepared requires action. Seizing opportunity requires making choices. Preparing for the future requires both preparing for a changing climate and preparing for a decarbonizing global economy. It requires comprehensive and integrated solutions that address multiple economic and societal risks outlined in both scenarios. Solutions, in other words, must help Canada be not only quick and coordinated as we build a strong, low-carbon economy, but also proactive and comprehensive in making that economy—and the people it supports—more resilient to climate impacts.

3 SEEKING SAFE PASSAGE: GOALS AND OBJECTIVES FOR CANADA

As a northern country dependent on trade, Canada is particularly vulnerable to global change and disruption, both from climate change and global decarbonization. As a result, we cannot afford to wait for certainty or hope for a specific outcome. We must hedge our bets across multiple scenarios and be ready for inevitable change.

In short, we must seek safe passage through the storm. To do so, we need a healthy and strong crew (thriving Canadians) and a sturdy and nimble ship (economic prosperity). We also need to do what we can to calm the waters, working internationally to collectively drive down emissions and dampen economic and societal shocks (global action).

The complexity and magnitude of climate change mean that we cannot consider challenges in isolation. This section presents a new, integrated framework for weathering the storm, and even thriving through it as much as possible. It outlines three high-level goals and ten specific objectives that, together, reframe Canadian climate policy (Table 2). The framework connects actions focused on reducing emissions (mitigation), capturing

TABLE 2: CLIMATE CHANGE GOALS AND OBJECTIVES FOR CANADA	
GOALS	**OBJECTIVES**
Thriving Canadians	Healthy Canadians
	Resilient Canadians
	Sustainable Ecosystems
	Intergenerational Fairness
Economic Prosperity	Low-Carbon Competitiveness
	Climate Resilience
	Cost-Effectiveness
Global Action	Global Emission Reductions
	Policy Spillovers
	Technology Spillovers

clean technology opportunities (clean growth), and preparing for climate impacts (adaptation) more directly to the welfare of current and future generations of Canadians. This broader approach helps situate and clarify policy choices by identifying shared objectives across and within governments.

3.1 THRIVING CANADIANS

We know that the risks and opportunities of climate change will not be distributed evenly. Those that are most vulnerable will bear the brunt of negative impacts, and those that are privileged will capture most of the opportunities. In fact, the distributional impacts of climate change are likely to be more significant than aggregate impacts at the national level. How well we succeed at creating a future where Canadians thrive will depend on how we address four key objectives: (1) healthy Canadians, (2) resilient Canadians, (3) sustainable ecosystems, and (4) intergenerational fairness.

Objective 1: Healthy Canadians—managing risks and improving outcomes

Health consistently ranks as a top priority among Canadians (CMA, 2019). However, many Canadians are unaware of the risk climate change poses to their health or of the climate change solutions that could improve their health outcomes.

Climate change will exacerbate pre-existing Canadian health challenges such as an aging population, high rates of diabetes, mental health concerns, and increasing healthcare costs (CIHI, 2015, 2017). Heatwaves, for example, are particularly dangerous for older Canadians and those with pre-existing health issues. Climate change could

BOX 7: AN INNOVATIVE APPROACH TO TRACKING THE SPREAD OF LYME DISEASE

Researchers at Ouranos mapped the potential spread of Lyme disease across Quebec using a model of the expected future habitat of the white-footed mouse, the favourite host of the black-legged tick that carries the Lyme disease bacteria. Comparing the characteristics of current white-footed mouse habitat, such as vegetation, average temperature, snow cover, and winter length, with modelling of future conditions under climate change, researchers projected the northern expansion of the species over time. This in turn provides a prediction of the likely spread of Lyme disease. Governments can use this information to warn residents and visitors of the risk.

Source: Ouranos (2013).

BOX 8: IMPROVING CHILDREN'S HEALTH AND SCHOOL PERFORMANCE

Caravans of idling school buses and concentrated air pollutants inside buses expose children to high levels of diesel exhaust. Young children have greater vulnerability to lung and heart impacts from air pollution, as they breathe in more air relative to their body weight. Studies have also linked air pollution to poor school performance.

Electric school buses offer an opportunity to eliminate the emissions risk for children, while also reducing greenhouse gas emissions. School boards in California and Quebec have started making the switch. While the cost of an electric bus can be as much as $200,000 more than a diesel bus, operating costs are 10 times cheaper. Since buses can travel around 120 kilometres after a 4.5- hour charge, they are ideal for school bus routes. Canada also has its own school e-bus manufacturers. The Lion Electric Co., for example, is supplying a fleet of 14 electric school buses in Montreal, QC, that will reduce nearly 4,000 tonnes of GHG emissions over the vehicles' lifetimes.

Sources: CBC News (2017); CBC News (2016); Government of Canada (2017); Health Canada (2016); Perara (2017); Torrie Smith Associates (2005); Wargo (2002); The Lion Electric Co. (2018); Smart Cities World (2018).

increase the threat of diseases transmitted by mosquitoes, fleas, and ticks such as Lyme disease and West Nile, further increasing healthcare costs (Hierlihy, 2017). All of these health risks increase significantly as average global temperatures rise.

If communities are unprepared, extreme weather events could also significantly affect the physical and mental health of Canadians. For example, breathing in smoke from wildfires provokes an immune system response that leads to systemic inflammation, creating issues throughout the body, including the brain. The elderly, young, and those with pre-existing health issues such as asthma or emphysema are particularly vulnerable (Ferreras, 2019; Reid et al., 2016).

Canadian researchers have improved their understanding of the health risks of climate change, but the information could be better channelled into actions that meaningfully improve outcomes. Communities and healthcare workers need a better understanding of the interaction of risks with other factors. More detailed information on risks could empower individuals to take protective measures themselves (Box 7). Response strategies following extreme weather events could better reflect physical and mental health risks. Municipalities could also take a more proactive role in protecting those at risk, such as setting new standards for snow and ice management to reduce the risk of falls and the mental health impacts of isolation.

Many of the options to reduce GHG emissions, and short-lived climate pollutants such as black carbon, can also generate important health benefits. Reducing the use of fossil fuels such as coal, oil, or natural gas can also reduce air pollution, which is linked to heart disease, stroke, chronic obstructive pulmonary disease, lung cancer, and acute respiratory infections (World Health Organization, 2019). Air pollution from diesel school buses also affects the ability of children to concentrate in class (Box 8). Shifting to electric alternatives can improve both GHG emissions and health outcomes.

Questions that must be considered to support Healthy Canadians:

- How will climate change affect the health of Canadians?
- To what extent are existing policies protecting Canadians from health risks linked to climate change?
- How can we best capture opportunities that improve health outcomes and address climate change?

Objective 2: Resilient Canadians—protecting, supporting, and empowering vulnerable people

Canada's actions on climate change should, at a minimum, seek to ensure that vulnerable Canadians are not worse off than they are today. Ideally, they will lead to better outcomes in the future for all Canadians.

Who are vulnerable Canadians? They are living in poverty or on low-incomes; they are old and young; they have health issues or disabilities; they live in rural, northern, or Indigenous communities; they rely on social support systems; they are recent immigrants; they work in emissions-intensive sectors; and they live near Canada's forests, rivers, or coastlines. This includes the vast majority of Canadians.

Vulnerability, however, does not imply weakness. In fact, many of those vulnerable to climate change are strong and resourceful Canadians (Cameron, 2012). It is the scale of change they are facing—in combination with other challenges and histories—that makes them vulnerable. The problem is we do not always have the data or analysis to understand the specific risks they face or how to leverage existing strengths to improve resilience.

Vulnerable Canadians will be disproportionately affected by climate change, and risks to these Canadians increase with the severity of global temperature change. Research in the U.S., for example, has started to explore differences in climate change damages between counties based on income (Box 9). Other studies have looked at the distributional impacts of natural disasters and the implications for women in particular (Government of Canada, 2019). One study, for example, found that low-income women and women of African American descent disproportionately bore the impacts of Hurricane Katrina since they had nowhere to go when they were forced from their homes (Butterbaugh, 2005). Internationally, there has been growing interest in taking an intersectional and gender-based analytical approach that considers the impacts of climate change across a range of pre-existing vulnerabilities (Kaijser and Kronsell, 2014; Government of Canada, 2019).

Some Canadians may be more vulnerable to job loss in a low-carbon economy than others, whether it is driven by shifts in global markets or domestic policy. While currently only 0.8% of Canada's labour force is unemployed for longer than one year, those most at risk of long-term unemployment are normally male, older, and individuals with lower levels of education (OECD, 2019b; Canadian Index of Wellbeing, 2016). Workers in high-carbon sectors and communities dependent on those sectors could be at a higher risk if the world transitions rapidly to a low-carbon economy. Around 200,000 workers, a little more than 1% of Canada's workforce, are directly dependent on fossil fuel industries in Canada (Mertins-Kirkwood, 2018).

Planning for the transition can help reduce risk and create new opportunities. Indigenous communities, for example, will be disproportionately affected by climate change, yet some have started to benefit from their expansion of clean energy projects (Box 10). Targeted skills training and education programs could also position vulnerable populations for employment in low-carbon goods, technologies, or services.

Protecting vulnerable Canadians requires a greater focus—both in research and policy development processes—on the risks they face. It also requires integrating more diverse perspectives from across Canada. To move forward, we need better data on vulnerabilities, as well as more disaggregated, more nuanced, and more human-centred analysis of impacts.

BOX 9: POORER REGIONS BEAR THE BRUNT OF CLIMATE CHANGE IMPACTS

U.S. researchers used climate science, econometric analysis, and process models to analyze future climate change risks across six areas: agriculture; crime; coastal storms; energy; human mortality; and labour. At the national level, they show costs of roughly 1.2% of GDP per 1° C increase in global mean temperature. However, the risk is not distributed evenly. By the late 21st century, the poorest third of counties in the U.S. would experience damages between 2% and 20% of county income under a business-as-usual emissions scenario.

Source: Hsiang et al. (2017).

BOX 10: CHALLENGES AND OPPORTUNITIES FOR CANADIAN INDIGENOUS COMMUNITIES

Climate change will have a disproportionate impact on Canada's Indigenous and northern communities and could have future implications on their treaty rights. Important cultural activities such as hunting, fishing, and foraging could be impacted by ecosystem changes such as melting sea ice. Many Indigenous Peoples and communities—especially in Canada's North—also rely on the natural environment for their food and livelihoods. Extreme climate events and thawing permafrost will exacerbate existing challenges such as poverty, housing, access to clean drinking water, and transportation access, all of which have complex and deep-rooted connections to colonialism and systemic discrimination.

Some communities are, however, leveraging new opportunities. A survey by Lumos Clean Energy Advisors found Indigenous participation in 152 medium and large-scale clean energy projects and 1,200 small renewable energy projects in operation, with many more planned. The projects are estimated to have provided 15,300 person-years of direct Indigenous employment. Local projects in Indigenous communities can also help transition away from diesel energy, improving health outcomes and long-term affordability

Sources: Assembly of First Nations (2019); Council of Canadian Academies (2019); Council of Canadian Academies (2014); ECCC (2019a); Van Tassel (2019); NRTEE (2009); ESDC (2018).

Questions that must be considered to support **Resilient Canadians:**

- Who is most vulnerable to the impacts of a changing climate and how are they vulnerable?
- Who is most vulnerable to economic transitions related to global and domestic decarbonization?
- What policies could protect Canadians most vulnerable to risks from climate change?
- What policies could help vulnerable Canadians capture opportunities that arise in response to climate change?

Objective 3: Sustainable Ecosystems—preserving the foundation of human wellbeing

Sustainable ecosystems protect the natural assets that underpin our economy and our society. Ecosystems are the foundation of human wellbeing—they are critical to our economy, health, and culture (Table 3). They provide food, raw materials, fresh water, and medicine. They also help to cool local climates, filter air and water pollutants, and limit the impact of floods and storm surges. Birds, bats, flies, wasps, frogs, and fungi, for example, help control pests and

TABLE 3: ECOSYSTEM SERVICES PROVIDE IMPORTANT ECONOMIC AND SOCIAL BENEFITS

Provisioning Services	Regulating Services	Supporting Services	Cultural Services
• Food • Raw materials • Fresh water • Medicine	• Local climate & air quality • Carbon sequestration and storage • Moderation of extreme events • Water filtration • Soil erosion prevention • Pollination • Pest and disease control	• Habitat for species • Genetic diversity	• Recreation • Health • Tourism • Aesthetic appreciation • Spiritual experience

Source: TEEB (2019)

BOX 11: THE VALUE OF PEATLANDS

Peatlands—a type of wetland—provide habitat and food for species, filter water, and help limit flood risk. Peatlands also store more carbon than all other vegetation types combined, helping mitigate climate change. Damaged peatlands, on the other hand, are a source of greenhouse gas emissions. Drained peatlands contribute to over 5% of global human-caused CO_2 emissions. Wildfires and thawing permafrost can also turn peatlands from a sink into a source of emissions.

In Canada, 12% of our territory is peatland (mainly bogs and fens). While there are efforts in some provinces to protect these valuable ecosystems, Canada does not have a national inventory or monitoring program for wetlands. Since the 1800s, Canada has lost 80% to 90% of its wetlands in and around settled areas. Loss and degradation continue as a result of development, agriculture, hydroelectric flooding, pollution, invasive species, recreation, grazing, and climate change.

Protection and restoration efforts by governments and non-profit organizations can slow this trend if they are large enough in scale. In 2018, for example, a series of agreements between the Tallcree Tribal Government, Nature Conservancy of Canada, the governments of Alberta and Canada and Syncrude Canada led to the creation of the Birch River Wildland Provincial Park, now part of the largest stretch of protected boreal forest in the world. The agreement also seeks to address long-standing issues around reconciliation and treaty rights, as it will give Indigenous communities responsibilities in both the management and preservation of the park.

Sources: Assembly of First Nations (2019); Council of Canadian Academies (2019); Council of Canadian Academies (2014); ECCC (2019a); Van Tassel (2019); NRTEE (2009); ESDC (2018).

vector-borne diseases (TEEB, 2019). Ecosystems are the homes, nesting grounds, and food sources for Canada's wildlife, and support recreation and tourism. Indigenous peoples also have a strong spiritual connection to the earth and all things living on it (Assembly of First Nations, 2019).

Natural ecosystems are critical to addressing climate change. Trees and wetlands absorb carbon dioxide, helping reduce the concentration of GHG emissions in the atmosphere. Some studies show that nature could contribute more than 30% of the emission reductions needed to achieve net-zero global emissions by 2050 (Wu, 2019). With 9% of the world's forest and 30% of its peatland, Canada is responsible for a significant proportion of global carbon stores (CCFM, 2018; Canadian Wildlife Federation, 2013).

Vibrant and healthy ecosystems can also play a pivotal role in climate adaptation. Trees and green spaces have a cooling effect that can reduce health effects during heatwaves, particularly in large cities. Wetlands and forests can help limit flooding and storm surges. Vegetation can help prevent soil erosion.

Unfortunately, however, the value of ecosystems is often not well understood or factored into decision making. Valuable Indigenous ecological knowledge is often not considered (Robbins, 2018; Council of Canadian Academies, 2014). At the global level, and in Canada, natural ecosystems are being destroyed, degraded, and reduced by human activity on an unprecedented scale, jeopardizing the invaluable benefits that humans receive from them. A recent report by the United Nations (2019a), for example, finds a 47% reduction in the extent and condition of ecosystems compared to what they would have been in the absence of human activity.

Canada's ecosystem services are also vulnerable to climate change—particularly in high-emissions scenarios—and require additional effort to protect and restore (Box 11). Forests, for example, can suffer from the increased frequency and intensity of wildfires, insect infestations, and changing climate and precipitation patterns (Natural Resources Canada, 2017). Lakes, rivers, and aquifers can deteriorate from too much or too little precipitation, which influences water availability and quality. Risks to pollinators, soils, and water can combine to affect the availability and cost of food. Thawing permafrost and peatland fires can also release greenhouse gas emissions, worsening climate change.

Questions that must be considered to support Sustainable Ecosystems:

- How can ecosystems contribute to Canada's mitigation and adaptation efforts?
- What valuable ecosystem services are at risk from climate change?
- What policies could improve the contribution of ecosystems to climate change efforts?

Objective 4: Intergenerational Fairness—considering youth and future Canadians

Our descendants are the future of Canada. They are our legacy and often our inspiration. Is it fair to burden them with the impacts of climate change? Should the decisions we make today not reflect their concerns and their needs? Intergenerational fairness considers how costs and benefits can be more fairly distributed over time.

As illustrated in Section 2, climate risks will increase over time, with costs growing toward the end of the century under all emission scenarios. Under a high global emissions trajectory, costs and health risks become devastating by mid-century (OECD, 2015b). While many of today's decision makers may not be alive in the latter half of the century, the decisions we take today will influence the extent of impacts on youth and future generations, both in terms of global outcomes and Canada's preparedness.

Most relevant decisions, however, largely focus on short-term criteria. Businesses focus on positive quarterly results for shareholders. Governments focus on delivering policies that fit within election cycles. And human nature drives most of us to focus on the here and now, instead of what may come. In reaction to the short-term nature of decision making,

BOX 12: A GROWING VOICE FOR THE VOICELESS

Decades of insufficient climate policy, coupled with a growing awareness of the future risks of inaction, has sparked a global youth movement on climate change. The movement started with a 15-year old Swedish girl in 2018, Greta Thunberg. She started missing school to protest a lack of adequate climate action by the Swedish government. By 2019, students from an estimated 2,300 schools across the world participated in school strikes, covering some 130 countries.

While the demands of youth vary across the world, the united purpose of the strikes is to get more ambitious, accountable, and aggressive climate action. Top officials at the UN have since adopted the language from the growing youth movement, declaring that "Climate justice is intergenerational justice."

In Canada, a group of young Quebecers launched a class action lawsuit against the federal government for what they argue is a failure to combat climate change. The group ENvironnement JEUnesse argues that those under 35 years old are being deprived their right to a healthy environment and will suffer the effects of climate change more than older generations.

Sources: United Nations (2019b); Irfan (2019), Marin (2019).

a global youth movement has garnered considerable momentum (Box 12).

Some government decision-making processes consider longer-term impacts. At the federal level, and in some provinces, decision makers evaluate regulations using estimates of costs and benefits over 30-plus years. The Climate Lens for federal infrastructure investments also requires consideration of climate change emissions and impacts over the life of the asset (Infrastructure Canada, 2018).

Still, despite this progress, most public and private actors fail to adequately consider long-term implications. Rarely do we consider, for example, impacts beyond 30 years. Most long-term analyses discount future impacts, putting greater weight on short-term considerations. The range of benefits and costs considered is also usually limited and rarely evaluates cumulative impacts on the overall quality of life of future generations. To truly achieve intergenerational fairness, we need to do a better job of thinking longer term and reflecting the welfare of youth and future generations in our decisions.

Questions that must be considered to support Intergenerational Fairness:

- What are the potential impacts of climate change on the quality of life of youth and future generations?
- How should we balance costs and benefits today against costs and benefits for future generations?
- How can we better incorporate the interests of future generations into near-term decision making?

3.2 ECONOMIC PROSPERITY

The wellbeing of Canadians is inextricably linked to the strength of Canada's economy. Economic growth supports jobs and income. Ensuring economic prosperity in the face of change requires both managing risks and seizing opportunities. Three objectives sit at the nexus of climate change and the economy: (1) low-carbon competitiveness, (2) climate resilience, and (3) cost-effectiveness.

Objective 5: Low-Carbon Competitiveness —preparing for shifting global markets

Low-carbon competitiveness means being well positioned to compete in global markets that are beginning to recognize constraints on GHG emissions. It matters in terms of maintaining the competitiveness of existing industries facing new market conditions, but also positioning Canadian firms to take advantage of markets for new, emerging low-carbon products and services.

While global decarbonization is not the only challenge facing Canadian firms, these trends pose a particular risk to high-carbon sectors and are a growing opportunity to generate new sources of income and jobs. Firms that adapt, innovate, and respond to trends can emerge stronger than they were before, but those that are slow to change may be left behind.

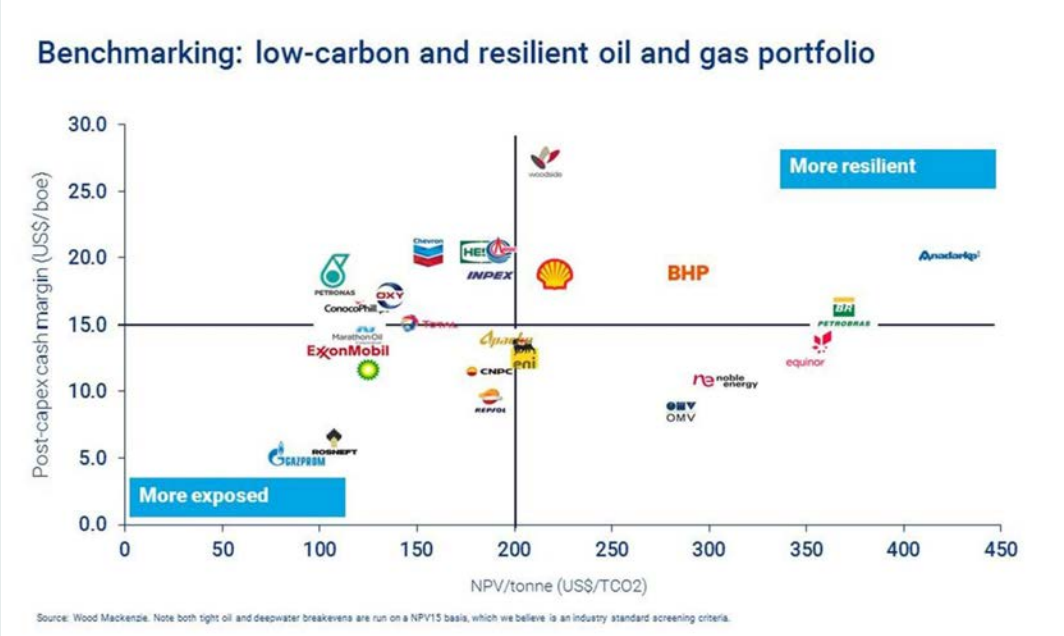
Despite continual improvements, Canada remains vulnerable, particularly if the world decarbonizes quickly. Key sectors of our economy are relatively emissions intensive (i.e. with high emissions generated per unit of output) and we have a large proportion of jobs linked to high-carbon sectors (OECD Statistics, 2019a). The Bank of Canada has raised concerns that asset prices may not reflect carbon-related risk as a result of a lack of information on carbon exposures, misaligned incentives, and difficulty in accounting for uncertain and complex events in the future (Bank of Canada, 2019).

Canadian companies have also been slow to adopt innovations that could lower their costs of reducing emissions (WGCTIJ, 2016). In 2017, only 10% of Canadian enterprises reported using clean technologies (Statistics Canada, 2019c).

As a result, Canada's economy faces significant risks if the global economy decarbonizes rapidly. Pressure to reduce emissions quickly—from changing investor preferences or trade measures linked to the carbon-content of goods—would pose high costs and competitiveness challenges, particularly for emissions-intensive regions and sectors. Internationally, many firms are starting to explicitly measure and consider carbon risk in response to investor concerns and guidance issued by the international Task Force on Climate-related Financial Disclosures (Box 13) (Financial Stability Board, 2019). However, few are fully integrating climate change risks and opportunities into core business strategies (CDP, 2018).

BOX 13:
BENCHMARKING RESILIENCE TO A LOW-CARBON FUTURE

One example of measuring firm-level risk to a low-carbon future is the approach developed by Wood Mackenzie, a global energy, chemicals, renewables, metals, and mining research and consultancy group. It uses two metrics to assess the low-carbon resilience of oil and gas companies. The first is a measure of carbon efficiency, defined as net present value (NPV) per tonne of CO_2. The second is an oil and gas price resilience metric, measured as the measured as the cash margin after capital expenditures (post-cape) cash margin. It measures the relative level of upstream cash flow generation per unit of production.



Shell, for example, is deemed relatively resilient. Shell proactively developed a long-term strategy for resilience to the global energy transition, using their own future scenarios to inform decision making. Their strategy provides assurance to investors and shareholders concerned about the company's exposure to carbon risk.

Pre-2030, Shell's strategy focuses on diversifying its portfolio, improving CO_2 performance, and maintaining a strong financial framework. Shell's business segments include conventional oil and gas, deep water, shale, integrated gas, oil products, chemicals, and new energies in power and fuels. It also operates in more than 70 countries, including Canada. Individual projects incorporate lower-carbon options, such as using electricity instead of natural gas at a B.C. processing plant. Every year, they test their portfolio under different scenarios and CO_2 prices to identify vulnerabilities.

Post-2030, Shell is much more ambitious, aiming to reduce the full life cycle carbon footprint of its portfolio of energy products by around half of its current value by 2050. They commit to reporting their net carbon footprint numbers every year to measure progress. In practice, this could mean shifting into large offshore wind farms and biofuels, increasing the proportion of gas produced relative to oil, greater use of carbon capture and storage (building on their Quest plant in Alberta), and planting large areas of forest to offset remaining emissions.

Sources: Wood Mackenzie (2018); Shell (2019).

BOX 14: CLIMATE-RELATED OPPORTUNITIES IN EMERGING ECONOMIES

An analysis by the International Financial Corporation of the World Bank Group found $23 trillion in investment opportunities between 2016 and 2030, from climate-related commitments in 21 emerging economies representing 62% of the world's population and 48% of global GHG emissions.

Investment Opportunity	Region	US $ trillions (2016–2030)
Green buildings	East Asia	16
Sustainable transport	Latin America	2.6
Climate-resilient infrastructure	South Asia	2.2
Clean energy	Africa	0.78
Energy efficiency & transport	Eastern Europe	0.67
Renewables	Middle East & North Africa	0.27

Source: International Finance Corporation (2016).

Canada can also tap into opportunities from changing global markets. The Canadian clean technology sector has grown steadily over the past decade. It contributed $58 billion in Canadian gross domestic product (GDP) in 2017, growing at an average rate of 3.9% between 2007 and 2017, compared to an overall rate of economic growth of 2.2% (Peters, 2019; Statistics Canada, 2018a). Exports of clean technologies, goods, and services rose almost 50% over the same period, more than double the growth in exports from other sectors (Statistics Canada, 2019b).

However, the sector may not be capturing its full potential, as many companies cite ongoing barriers to financing, commercialization, and growth (WGCTIJ, 2016; Felder and Gouvela, 2018). With investment opportunities in emerging economies alone estimated at US $23 trillion between 2016 and 2030, addressing these barriers quickly is critical to positioning Canadian firms to compete (Box 14).

Improving the low-carbon competitiveness of Canada's economy will require a major push on innovation in areas where Canada has carbon risk or potential to compete internationally. And while Canada has made progress, the scale of our effort pales in comparison to other countries, who are using domestic markets as a springboard for international success (Box 15). Some of the key ingredients include certainty and flexibility of government climate policy; assessing and disclosing climate risks and opportunities; making significant investment in research, development, and demonstration; financing to scale and commercialize innovations; building strong skills and education systems; enabling infrastructure; and government procurement (Smart Prosperity Institute, 2018).

Questions that must be considered to strengthen Low-Carbon Competitiveness:

- How exposed is Canada's economy to decarbonization risk?
- What are the opportunities for Canada in the global transition to a low-carbon economy?
- Are existing policies appropriately targeted and at the right scale to manage carbon risk and capture opportunity?

Objective 6: Climate Resilience—Preparing for direct and indirect climate risk

Climate resilience means preparing the economy to withstand the risks associated with a changing climate under various future scenarios. At the same time, it also means being ready to capitalize on opportunities where they exist.

How climate resilient is Canada? Canada is warming at twice the rate of the rest of the world, and as a small open economy, it is vulnerable to global economic downturns, supply chain disruptions, and fluctuating commodity prices linked to a changing climate (ECCC, 2019a). Yet our level of preparedness is unclear. Data and analysis of risk are uneven across sectors and regions in Canada (EPCCARR, 2018). There are, however, strong indications that we need to do more (Box 16).

Information on direct physical risks to Canada, such as changes in temperature and precipitation,

BOX 15: CHINA PLANS TO DOMINATE THE ENERGY AND AUTO SECTOR MARKETS OF THE FUTURE

China has been positioning itself for market success in renewable electricity and electric vehicles for over a decade, ready to seize the opportunities created by a global transition away from fossil fuels. Through a combination of subsidies, infrastructure investments, and stringent regulations, China is driving strong domestic demand that is fuelling the growth of companies increasingly able to compete on a global scale. In 2017, for example, China represented 99% of the global e-bus market. The city of Shenzhen alone has 16,000 e-buses, with 80% supplied by Chinese manufacturer BYD. Bloomberg New Energy Finance expects almost 80% of global municipal bus fleets to be electric by 2040.

Source: BNEF (2019; 2018; 2017); GCGET (2019); Niu (2019); Ren (2018).

BOX 16: INDICATORS OF INSUFFICIENT PREPAREDNESS FOR CLIMATE RISK

- Only 31% of publicly-traded companies in Canada disclose physical risks from climate change in regulatory filings (CPAC, 2017)
- Only 58% of core public infrastructure owners are including some element of climate change risk as a factor in decision making for core infrastructure assets (Statistics Canada, 2018b)
- Insured losses from catastrophic weather events exceeded $1 billion per year in eight of the nine years between 2009 and 2017, up from an average of $400 million per year from 1983 to 2008 (values are in 2017 dollars, adjusted for inflation and per-capita wealth accumulation) (Moudrak et al., 2018)
- The average annual federal share of natural disaster response and recovery costs reached $360 million 2011–2016, up from $110 million 1996–2010 (in nominal terms) (Public Safety Canada, 2017)

has gradually improved through efforts such as the Canadian Centre for Climate Services and the Pacific Climate Impacts Consortium. Yet physical risk information alone is not enough to drive the actions needed to adapt and improve economic resilience. The Expert Panel on Climate Change Risks and Adaptation Potential identified major areas of climate change risk facing Canada that could involve significant losses, damages, or disruptions over the next 20 years. These risks include damages to infrastructure and disruption of government services, along with financial losses in key sectors, such as agriculture, fisheries, and forestry. Their work underscored the need for additional research and analysis to address gaps in understanding the complex and interconnected linkages between climate change, the economy, and society (Council of Canadian Academies, 2019).

In 2019, British Columbia published its first province-wide Strategic Climate Risk Assessment. It first identified a list of risk events that would have provincially significant consequences. It then evaluated the likelihood of each risk event scenario, as well as potential consequences, to develop an overall risk rating for each event. Severe wildfire seasons and seasonal water shortages were ranked as the highest risks (MECCS, 2019). While the approach did not develop a quantitative estimate of the potential economic impact of climate change, it helped to clarify risks and identify areas of priority.

Some international studies have tried to quantify the economic risk of climate impacts using comprehensive climate and economic modelling. While such analyses do not cover every possible impact, they can help identify key issues and how they may interact across the economy (Benzie et al., 2018). For example, the analysis could look at disruptions to trade infrastructure from flooding and wildfires, heatwave impacts on worker productivity,

BOX 17: COMPREHENSIVE ASSESSMENTS OF CLIMATE RISK IN AUSTRIA

In 2015, the Austrian Climate and Energy Fund financed a research project to develop a national-scale economic evaluation of the potential negative and positive implications of climate change under three scenarios. The project consisted of 18 research teams looking at 13 impact fields, including agriculture, forestry, water supply and sanitation, tourism, energy, construction and housing, human health, ecosystem services, transportation, manufacturing, cities, natural hazards, and disaster risk management. The analysis used a consistent approach across the impact field, allowing researchers to capture cross-sectoral linkages and economy-wide effects. It also undertook supplementary analysis of non-market impacts.

The research detailed the impact on Austria's GDP out to 2065, while also highlighting important sector-level issues. For example, the analysis projected tourism to improve in the summer but decrease in winter, with important feedback effects to the rest of the economy. It projected that manufacturing and trade sectors will face significant costs from increased cooling needs, the impact of extreme weather on transport networks, and labour productivity loss during heatwaves.

Source: Steininger et al. (2015).

the potential for increased demand for tourism, and how shifting global agricultural markets could impact farmers. A comprehensive assessment of economic risk provides a more complete picture of direct and indirect national, regional, and sectoral economic risks and opportunities, including interactions and feedback effects (Box 17).

Improving climate resilience will require better information and analysis, as well as increased effort by businesses and governments to use that information to assess their own specific vulnerabilities and develop responsive actions. At the local level, Canadian communities are already beginning to build resilience into planning and decision making. The City of Vancouver, for example, updated its adaptation strategy in 2018 to focus on core impact areas, integration, and mainstreaming across city operations and services (Box 18).

Preparation at home can also help position Canada to capture opportunities internationally. For example, crop losses in other parts of the world could lead to increased demand for resilient Canadian crops. Canadian expertise could also help other countries enhance their own resilience. Canada is already a leader in water technology, which could be an advantage as water shortages related to climate change drive demand for water efficiency, recycling, and desalination.

Questions that must be considered for improving **Canada's Climate Resilience:**

- How exposed is Canada's economy to direct and indirect impacts of a changing climate, and which sectors and regions are most vulnerable?
- What additional information and capacity building is required to enable better, broader, and faster adaptation?
- What are the economic opportunities for Canada in a changing climate?
- What policies would improve resilience to climate change?

Objective 7: Cost-Effectiveness—Making smart choices along the way

Objectives 5 and 6 lay out two key elements—competitiveness and resilience—for economic prosperity. Yet the ways in which we achieve these objectives also matter. In particular, some solutions cost more than others. Actions or policies that reduce

BOX 18: THE CITY OF VANCOUVER ADAPTATION STRATEGY FOCUSES ON INTEGRATION AND MAINSTREAMING

The City of Vancouver updated its climate change adaptation strategy in 2018, refocusing actions into five core areas as well as mainstreaming adaptation across city operations and services. It also seeks to increase integration with other efforts and consider equity implications. The update draws on new climate projections downscaled for Vancouver that show wetter, warmer winters and hotter, drier summers. For example, cooling requirements for buildings are expected to increase fourfold by 2050.

One of the core action areas in the strategy is "Climate Robust Infrastructure," with plans to improve the understanding of water flow in the city and integrate management across green and grey infrastructure, parks and public spaces. Another is "Climate Resilient Buildings" with a focus on future-proofing the building stock. Others focus on coastline preparedness, natural areas, and prepared communities.

Source: City of Vancouver (2019).

risk or enable opportunities at very high cost can backfire; they can undermine growth and international competitiveness while exacerbating societal vulnerabilities. Choosing more cost-effective solutions—and phasing out costly and ineffective ones—is also a key part of supporting economic growth for Canada.

Innovation is a key factor in cost-effectiveness. Innovation in technologies or processes can help lower the costs of reducing emissions or adapting to climate change, especially over time. It can also generate new opportunities, offsetting the costs of transition. While businesses and individuals play a key role in developing and adopting innovations, governments can enable innovation by relying on more flexible policies and creating the right incentives for innovation (Popp, 2016).

Efficiency also tends to reduce costs. Using less energy can not only reduce emissions but save money (Box 19). Reducing water use is a cost effective way to reduce risks from seasonal water shortages. Finding ways to reuse, repair, or recycle products can save money while reducing the emissions associated with producing and transporting new products.

Timing is another important element of cost-effectiveness. Making dramatic changes quickly makes it difficult for companies and workers to adapt. But waiting too long for change can also increase costs. This is particularly true for long-lived infrastructure. If we are not building infrastructure to withstand future climate impacts and decarbonization trends, costs will increase down the line. It is generally cheaper to make changes at the time of construction than retrofit or replace existing structures. The City of Vancouver, for example, is working to assess major capital projects against known climate hazards and risks to support decision making (City of Vancouver, 2019).

More cost-effective government policy drives lower-cost actions. In deliberating policy options, governments should consider not only the full range of environmental, social, and economic benefits, but also the full range of costs. Many lessons can be learned from policy experience in Canada, and around the world, to help improve the cost-effectiveness of policy approaches.

Has Canada done a good job thus far in advancing a cost-effective transition? Could we do more? Without comprehensive indicators, the answer is unclear. At the national level, Canada's GDP has continued to rise during the past decade of increased climate policy, and provinces with over a decade of policy experience have seen strong growth (Statistics Canada, 2019a; Monahan & McFatridge, 2018b).

There are, however, indications that we have not yet captured all cost-effective opportunities. A 2018 report highlighted the significant potential for greater energy efficiency in Canada out to 2050 (IEA, 2018b). Canada has also persistently underperformed relative to its peers on innovation metrics, including clean

BOX 19: METAL FABRICATION COMPANY FINDS MONEY SAVING EFFICIENCIES

Veriform, an emissions-intensive metal fabrication company in Cambridge, Ontario, reduced its carbon footprint by 77% between 2006 and 2019 through over 100 energy-saving measures. This is even more remarkable given that its staff increased by 30% and it doubled its building size over that period.

The changes helped reduce emissions, but they also improved the company's bottom line. Its sales per kilowatt hour of energy consumed tripled. Some of the measures were simple, such as turning off the lights at night and reducing the temperature of the water heater. Others required making different decisions when it was time to invest in new machinery, choosing models that use less energy.

One of the key drivers of change has been the extensive data gathering and calculations done at the company to measure emissions and cost savings. These led the company to conclude that every tonne of emissions eliminated results in $900 in cost savings.

Source: Craig-Bourdin (2019).

innovation (OECD, 2017). Additionally, governments do not always comprehensively assess the cost-effectiveness of a range of options to address climate risks. For example, a U.S. Gulf Coast study comparing the costs of different protection measures for sea-level rise found that after sandbags, the most cost-effective adaptation measures were nature-based, including wetland and reef restoration (Reguero et al., 2018). Too often, Canadian governments do not consider these types of nature-based solutions.

Questions that must be considered to support Cost Effectiveness:

- What climate change actions and policies are likely to be most cost-effective?
- What can we learn from climate policy experience, both here in Canada and internationally, that could support cost-effective action?

3.3 GLOBAL ACTION

While global climate change outcomes rely on the collective actions of all countries, Canada is not powerless to influence change. Our actions at home can echo internationally, in sometimes subtle but important ways.

Canada can, and should, punch above its weight by influencing global outcomes across three objectives: (1) leveraging Canada's efforts to reduce emissions to press other countries to do the same (global emission reductions), (2) developing good policies at home and sharing our experiences (policy spillovers), and (3) developing innovations that make it easier and less costly for others to transition (technology spillovers).

Objective 8: Global Emission Reductions—Leveraging Canadian commitments to influence global effort

Reducing global GHG emissions is a collective action problem. Everyone would be better off if all countries took significant action to achieve deep decarbonization, but no individual country wants to move too far ahead of the others. Since there is no global government that can mandate emission reductions, the only solution is for countries to work together through international, multilateral, and bilateral co-operation.

Yet we need not be paralyzed by the challenges of collective action. Canada has a role to play in

BOX 20: CANADIANS AMONG WORLD'S TOP EMITTERS OF CARBON POLLUTION

- **GHG Emissions per person:** 3rd highest out of 45 (OECD + 9 emerging)
- **GHG Emissions per unit of GDP:** 3rd highest out of 45 (OECD + 9 emerging)
- **Total CO_2 Emissions:** 10th highest out of 195 countries
- **Cumulative CO_2 Emissions since 1750:** 9th highest out of 195 countries

Sources: Fleming (2019); Carbon Brief (2019); OECD (2019b).

supporting global emissions reductions. Doing so serves our own interests as well.

Canada contributes 1.6% of global CO_2 emissions. It also has the 10th highest emissions in the world, meaning that 185 countries have lower emissions than Canada (Box 20) (Fleming, 2019). In terms of cumulative emissions since 1750, Canada is 9th highest (Carbon Brief, 2019). We are also the third largest emitter per person and per unit of GDP across developed and emerging economies (OECD, 2019b).

If Canada does not pursue ambitious emission reductions consistent with the global goal of keeping average temperature increase well below 2° C, our calls for others to pursue ambitious action will ring hollow. The power of our voice comes from demonstrating that the global goal is achievable through our own independent commitments and actions.

As we saw in Section 2, meeting the Paris Agreement temperature goal requires global emissions to reach net-zero between 2050 and 2060. Finland has committed to achieve a net-zero target by 2035. Sweden has done the same for 2045. And the U.K. has committed to reach net-zero emissions by 2050, bolstered by research and analysis from its independent Committee on Climate Change that concluded the target was feasible and achievable (Box 21). The number of EU countries supporting an EU-wide net-zero target for 2050 is growing (Climate Change News, 2019). The

BOX 21: RESEARCH BEHIND THE UK COMMITMENT TO NET-ZERO EMISSIONS BY 2050

In May 2019, the independent U.K. Committee on Climate Change released a report detailing a specific pathway to achieve a net-zero GHG target by 2050. It concluded that the target was both feasible and cost-effective. It also noted that despite being responsible for a relatively small proportion of emissions, the U.K. could have significant influence by setting the standard for the EU and other developed countries as they consider their own approaches.

The report called for greater urgency on current plans, a broader scope than previous plans, and greater integration across all levels of government. Achieving net-zero emissions in the U.K. requires capturing resource and energy efficiency across the economy, societal shifts in diet, electrification of transport and heating, hydrogen to service industrial processes and ships, carbon capture and storage in industry, and changes in agricultural practices and land-use. The report also highlighted the importance of a just transition across society, of a just transition across society and protecting vulnerable workers and consumers. The predicted result is not economic devastation, but rather improved quality of life and lower climate risks, with potential for market opportunity from being an early mover in certain areas.

Source: UKCCC (2019).

UN Secretary General is also calling on all countries to pursue more ambitious targets.

Within this context, Canada must decide what its long-term emission reduction ambition should be. Our circumstances are different than those of the EU, but decisions we are taking today could make it more challenging and costly to achieve an ambitious 2050 goal. Like the U.K., Canada needs thorough research and analysis of the feasibility and cost-effectiveness of various emissions pathways. Canada's Mid-Century Strategy lays out some considerations but is short on specifics and does not really consider distributional impacts (ECCC, 2016b). We need to move to the next level of detail. If we find a way to do as much as we can, we will have the right to call on others to do the same.

Questions that must be considered for Canada on Global Emissions Reductions include:

- What points of leverage does Canada have in supporting global action?
- What are practical pathways for greater, long-term ambition for Canada?
- What are the implications of emission reduction pathways for Canadians?
- What policies are needed today to lay the foundation for long-term transition?

Objective 9: Policy Spillovers—encouraging international adoption of good policy

Selecting and designing policies to meet ambitious targets and climate-resilience objectives is hard. A multitude of considerations exist, including the impact on the economy and employment, implications for government budgets, costs faced by individuals, as well as all the implications of insufficient action. Countries around the world struggle with many of the same challenges as Canada.

If Canadian governments develop policies that achieve results, while managing concerns, foreign governments will be interested in hearing the details. In this way, *policy spillovers* can demonstrate successful policy at home to catalyze action abroad.

Canada has been working on climate change mitigation policy for over two decades and has evolved from the initial pursuit of largely ineffective voluntary and subsidy measures toward predominantly flexible regulations and pricing tools. Canada has also become a global leader in some key areas, such as phasing out coal-fired electricity (Section 4.4) and using output-based pricing to limit competitiveness concerns

BOX 22: WIDESPREAD ADOPTION OF OUTPUT-BASED PRICING POLICIES IN CANADA

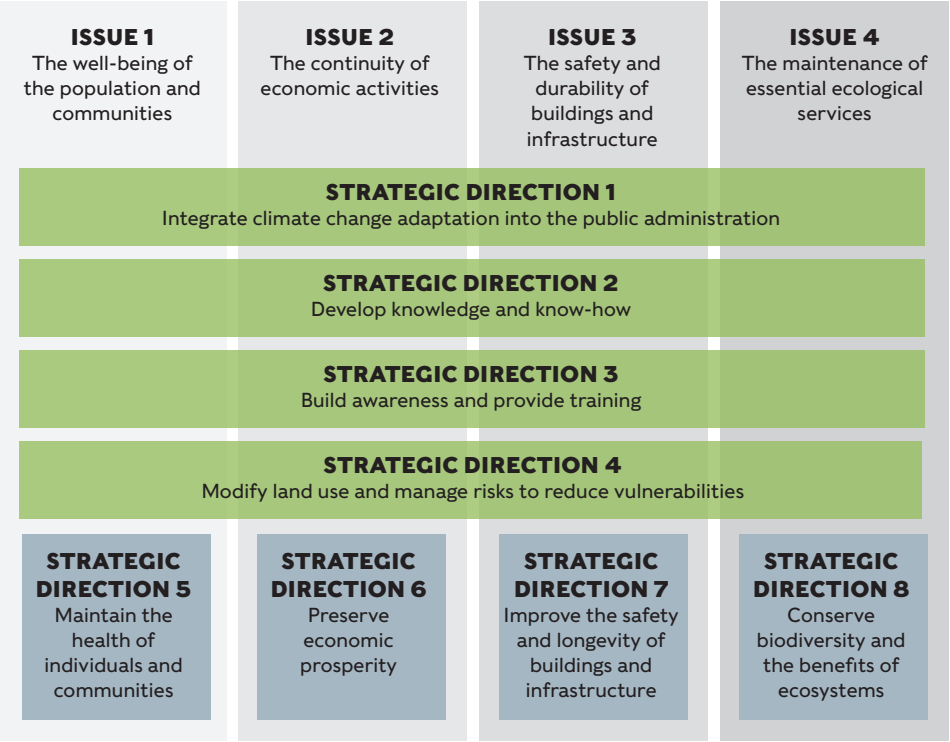
A Canadian policy that is of significant interest internationally is the output-based pricing system (OBPS) for large industrial emitters. Firms with emissions above an established emissions-intensity benchmark must either purchase credits or pay a carbon price. Those that are below the benchmark can earn credits or and sell them to other firms. The system maintains incentives to reduce emissions but discourages reductions in output, limiting incentives to slow or shift production and investment to jurisdictions with weaker policy. In a world with uneven levels of action, this type of approach can help give countries the courage to move ahead of their trading partners.

In the case of OBPS, innovative policy in one province clearly led to advancements elsewhere in Canada. Alberta was the first to introduce the policy in 2007 (and later amended it in 2018 and 2019).). Since then, similar approaches have been adopted by Saskatchewan, Ontario, British Columbia, and the federal government.

Sources: Fischer & Fox (2007); Ragan (2019); Dobson et al. (2017).

FIGURE 3:

Quebec Adaptation Strategy 2013–2020



This figure shows the Quebec Adaptation Strategy 2013–2020. It contains eight specific objectives across four directions. The strategy is one of the most comprehensive adaptation strategies in the country.

Adapted from: Gouvernement du Québec, 2012

associated with regulating emissions-intensive, trade-exposed sectors (Box 22).

While adaptation only became an explicit international goal in the 2015 Paris Agreement, Canada has useful experience in managing climate-related impacts that is capturing international interest (UNEP, 2019). Southern Alberta has had a market-based water trading system in effect since 2006 to manage water shortages (Alberta Water Portal, 2018). FireSmart Canada developed standards for protecting communities from wildfire that have been adopted by Canadian provinces as well as Australia and New Zealand (FireSmart Canada, 2018a). Cities such as Victoria and Halifax use stormwater user fees to provide incentives to reduce hard surfaces such as driveways or parking lots on private property, helping reduce runoff and flood risk (Canada's Ecofiscal Commission, 2018; Smart Prosperity Institute, 2019). Quebec has been one of the early Canadian leaders in climate change adaptation, with a 2013–2020 comprehensive adaptation strategy that addresses both economic and societal resilience (Figure 3).

Canada could do more to champion its policy learnings and successes across jurisdictions within Canada and abroad. Canadian governments could also learn from experiences in other countries. Detailed policy case studies, for example, can help governments understand decision-making processes and important design details that would improve their ability to adopt a similar approach.

Canada also has the potential to play a leadership role in setting international climate change rules. It could contribute to climate finance, as well as initiatives to address global risks to the financial sector, approaches to international aid efforts aimed at countries vulnerable to climate impacts, and challenges associated with increased migration and conflict.

TABLE 4: CANADIAN COMPANIES LISTED IN THE 2019 CLEANTECH GROUP GLOBAL CLEANTECH 100

Company Name	Type of Technological Innovation
Axine Water Technologies	Cost-effective, chemical-free solution for treating industrial wastewater
CarbonCure Technologies	Carbon-sequestering equipment for precast concrete production
Cooledge Lighting	Adaptable LED lighting solutions
Ecobee	Wi-fi enabled smart thermostats for residential and commercial applications
Enbala Power Networks	Platform enables electricity companies to navigate a more distributed power grid
GaN Systems	Range of efficient gallium nitride power switching transistors
Inventys	Technology for capturing post-combustion CO_2 from various sources
Metamaterials Technologies	Smart materials and photonics to provide solutions in the field of optics
MineSense Technologies	Sensor technology that improves energy, water and chemical efficiency in mining
Opus One Solutions	Intelligent data analytical platform for smart grids
Semios	Precision agriculture, biological pest control, and data management
Terramera	Plant-based pest control products

Source: Global Affairs Canada (2019); Cleantech Group, 2019

Questions that must be considered to support Policy Spillovers:

- How have climate policies in Canada performed in terms of their effectiveness in reducing emissions, their costs, and their distributional impacts?
- What international climate policy experiences are relevant to challenges in Canada?
- Where and how should Canada play an international leadership role?
- Which Canadian policies should be championed internationally as options to help achieve global goals?

Objective 10: Technology Spillovers—driving global change through innovation

Technological change has the potential to be a game changer for international climate change action. It can lower the costs of emission reductions and climate adaptation. It can help save lives and reduce economic and societal disruption.

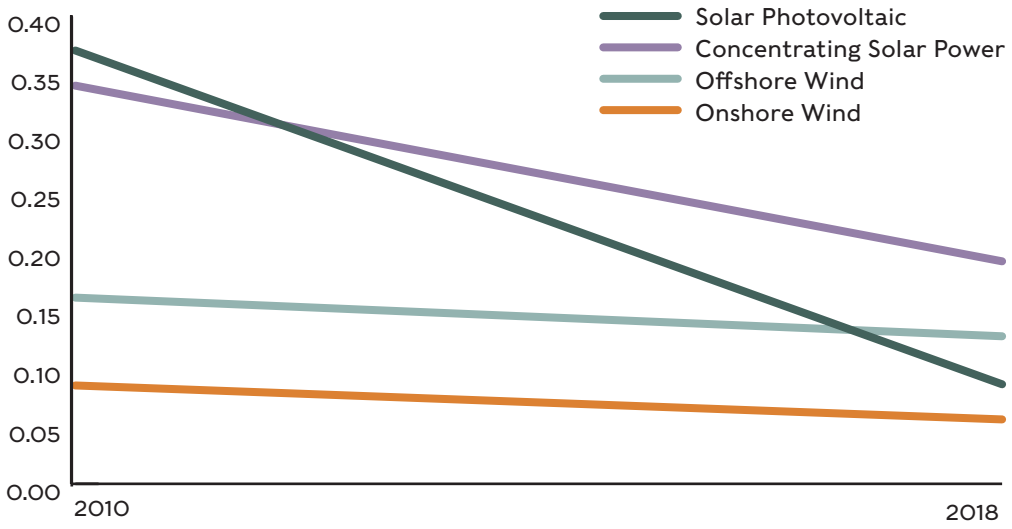
Canada can be a source of technological change with technology spillovers into other countries that provide global benefits. The international Mission Innovation initiative—tasked with accelerating global clean energy innovation—identified eight innovation challenges critical to reducing GHG emissions: (1) smart grids, (2) off-grid access to electricity, (3) carbon capture, (4) sustainable biofuels, (5) converting sunlight, (6) clean energy materials, (7) affordable heating and cooling of buildings, and (8) renewable and clean hydrogen. Climate change adaptation will also need innovation in water use efficiency, water recycling and desalination, building resilience to flood and fire, urban cooling, crop resilience, and climate-resilient infrastructure (Deloitte & ESSA Technologies, 2016). Canada is already developing many of these technologies.

In 2019, Canadian companies took 12 of 100 spots on the Global Cleantech list of 100 companies most likely to make a significant market impact in the next 5-10 years (see Table 4). Canada is also a recognized world leader in carbon capture and storage and water technologies, in large part due to significant public sector resources invested in research and development.

While early stage research and development is essential to developing new ideas, getting technologies to market, helping them to scale up will be critical to realizing climate benefits. Growth in market demand, scaling up production, and competition help drive down technology costs over time. As costs fall, adoption increases, and the global benefits grow.

FIGURE 4:

Global Costs of Renewable Technologies Continue to Fall



This figure shows the weighted average global levelized cost of energy (2018 USD/kWh) for utility-scale solar and wind power generation technologies between 2010 and 2018. Levelized cost of energy is a metric that enables comparison by combining capital, operating and maintenance, performance, and fuel costs.

Source: IRENA (2019)

Consider, for example, the case of wind and solar power. Germany was once the hottest market, thanks to its feed-in-tariff policies for renewable energy. China then dominated with huge government investments in renewable electricity. The surge in demand from the two countries, as well as others, led to significant market entry and competition, helping drive down costs in a relatively short time. Two decades ago, wind and solar electricity were costly mitigation options. Today, they are in many cases cost-competitive with fossil fuels (Figure 4).

Innovation in low-carbon products can also improve global outcomes. If we find ways to lower the emission content of our exports, we can displace more emissions-intensive products elsewhere. For example, our low-carbon electricity sector has a comparative advantage in this regard. Canadian aluminum manufacturers have a significantly lower emissions profile than those in other countries (Simard, 2015). Canadian provinces with hydroelectric power are also increasingly selling to U.S. customers seeking low-carbon sources.

Canadian innovation also has the potential to support international assistance objectives. The need for climate adaptation solutions will be greatest in developing countries that are already struggling to feed, house, and provide electricity to their populations. Canadian companies are working on possible solutions. For example, AWN Nanotech from Dorval, Quebec, sells a scalable technology that efficiently converts humidity into potable drinking water, providing a cost-effective solution to water shortages (McMillan, 2019; AWN Nanotech, 2019).

Technology development, commercialization, and growth to scale does not happen by itself, however. An essential driver of technology development will be ambitious government policy, which generates increased market demand for low-carbon and climate-resilient solutions. Companies and entrepreneurs also need support in their journey, with government help to overcome barriers such as financing and international market access. High-priority needs for technological innovation can also be targeted through prizes or specialized research and development programs.

Questions that must be considered to support Technology Spillovers:

- What Canadian technologies or products offer the greatest potential for international climate change benefit?
- What countries or regions have the greatest need of mitigation and adaptation technologies?
- What Canadian policies could help better capture global climate technology benefits?

3.4 SUMMARY

This section laid out key goals and objectives that can serve as a guide to a credible, practical, and comprehensive approach to climate change in Canada. They help clarify what Canada should ultimately try to achieve on climate change, linking actions that reduce emissions, build resilience, and develop clean technologies for the wellbeing of Canadians. They also help to break down silos, identifying shared interests across multiple policy agendas.

Our aim is to support governments across the country in defining and shaping coherent climate change policy agendas, and to help Canadians better understand the breadth and depth of the challenge. Taking a broader and longer-term approach helps capture the diversity of needs and interests in Canada on climate change and build toward a unified vision.

The key questions posed for each objective highlight the significant work ahead to achieve the goals and objectives, and the scope of research and analysis needed to support decision making. Climate change is often described as one of the world's "wicked problems," given the immense complexity of the challenge. However, with a concerted and collaborative effort, Canadians can find and refine solutions that lay the foundation for future success.

4 NAVIGATING THROUGH THE STORM: FINDING PRACTICAL CLIMATE CHANGE SOLUTIONS

Getting to the destination outlined in Section 3 requires practical solutions that steer and accelerate Canada toward our goals and objectives. Choices made today will determine whether Canada is prepared for the full range of risks and opportunities that lay ahead in the coming decades. Governments at all levels play a critical role.

In many cases, we know what solutions can work. There are countless examples of success in Canada and abroad. The challenge is broadening implementation while also developing new, better solutions.

This section considers solutions for achieving Canada's climate change goals and objectives. It starts by highlighting the menu of policy levers available to governments, describes how to calibrate policy ambition to achieve results, and proposes a more integrated approach to policy development. We conclude with five tangible policy case studies.

This section does not provide a complete policy map. But it does provide a starting point for considering next steps on the journey toward a prosperous, resilient, low-carbon Canada in 2050.

BOX 23: SOLUTIONS TO CLIMATE CHANGE CHALLENGES ARE OUT THERE

For many climate change challenges, solutions are readily available. By deploying existing technologies, making new investments, changing processes, and adjusting behaviours, Canada could make significant progress. For example, we have already gone a long way toward decarbonizing our electricity supply by switching from coal-fired generation to non-emitting sources, such as wind, solar, and hydro. And we know there is the technical potential to do more.

Many adaptation solutions are also available. Canadians can, for example, reduce their flood risk at home by extending downspouts, installing window well covers, maintaining sump pumps, and grading property away from foundations.

These solutions, however, are not yet widely implemented. Cost, lack of knowledge, other competing priorities, and resistance to change are all factors. Individuals, communities, and businesses need support to make the small and large decisions that will improve Canada's overall outcomes. Choices and incentives need to be clear, and they need to be as easy and cost-effective as possible. This is where government policy levers can play a critical role.

Sources: CCRE, 2016; ICCA, 2019

4.1 POLICY LEVERS TO DRIVE SOLUTIONS

In many cases, we know what solutions can work (Box 23). The challenge is implementation. Government policy levers can enable, guide, and encourage choices that drive implementation of existing solutions and the development of new solutions. These policy levers range from simply providing better information to mandating particular actions. No single policy lever will achieve all climate change objectives. Success instead requires a mix of policies.

To be effective—and cost-effective—we need to make thoughtful and deliberate policy choices. Table 5 provides a menu of policy levers that governments can choose from. Not every policy is appropriate in every situation. Governments must select and design policies carefully, based on rigorous analysis of a broad range of costs and benefits.

Some policy instruments are likely to be more fundamental than others. In particular, pricing and regulatory instruments are an essential foundation of ambitious climate policy. They are the only tools that can drive behaviour at a magnitude commensurate with the scale of the challenges ahead (OECD, 2017; Canada's Ecofiscal Commission, 2017). Other policies, however, can also play an important complementary role to improve overall outcomes.

Best practices for climate change policies are evolving in Canada and around the world. Canadian governments can benefit from these experiences, which can help demonstrate results, identify lessons learned, and facilitate policy analysis and design (Box 24).

4.2 INCREASING AMBITION

Pointing our ship in the right direction, however, is not enough. Achieving Canada's climate change objectives—and hedging against possible future risks and opportunities—requires significant and sustained forward momentum. Governments need to calibrate the policy mix to the level of ambition required to achieve meaningful results. Calibration requires considering who is covered by the policies, the degree of change required, and the timeframe for realizing that change. While in some cases gradual and incremental change may be appropriate, bold and swift action is required to address the scope and urgency of the climate change challenge.

TABLE 5: POLICY LEVERS AVAILABLE TO GOVERNMENTS	
Regulations/Standards	Mandating change over a specified period of time (e.g., emissions standards, building standards, land-use restrictions, reporting)
Pricing Tools	Using pricing tools such as taxes, fees, cap and trade, or offsets. (e.g., carbon pricing, water use pricing, charges for plastic bags)
Procurement	Using the purchasing power of governments to increase demand for cleaner technologies, products, and services (e.g., renewable energy, electric vehicle fleets, net-zero buildings)
Financing/Tax Incentives	Shifting business and individual decision making through financial products, loans, subsidies, or tax incentives that encourage desirable investment
Infrastructure Investment	Direct investment toward infrastructure critical to the transition (e.g., electric vehicle charging stations, stormwater systems)
Innovation Policy	Supporting innovators from early-stage research and development through to commercialization and expansion, reflecting broader societal benefits of innovation
Information/Analysis	Gathering and disseminating data, research, and analysis that supports improved decision making by communities, businesses, and individuals
Capacity Building	Filling gaps in financial and human capacity to analyze, develop, and implement solutions, while developing skills to manage risks and capture opportunities
Coordination	Bringing different actors together to pool resources toward shared challenges and limit duplication of effort (e.g., municipalities, companies, government departments)
Mainstreaming	Incorporating climate change considerations into long-term strategic plans and everyday decision making across governments

BOX 24: LESSONS LEARNED IN CANADIAN CLIMATE POLICY

Canadian climate policy has come a long way over the past few decades. Experience highlights important lessons learned.

Early efforts relied on information and voluntary programs. For example, the "One Tonne Challenge" in 2003 used television and print ads to call on Canadians to try to reduce their greenhouse gas emissions by one tonne per year, through changes such as using public transit, adding weather stripping to windows, or composting. A 2006 evaluation of the program concluded that, while it raised awareness, it was not effective at changing behaviour.

More recently, governments have shifted toward more comprehensive—and more effective—approaches such as regulations and pollution pricing to reduce emissions.

British Columbia, for example, became the first jurisdiction in Canada to implement an economy-wide price on greenhouse gas emissions in 2008. Studies isolating the effects of the policy found that it reduced gasoline consumption by 7% per capita over the first four years and encouraged people to buy more fuel-efficient vehicles.

Source: Environment Canada (2006); ECCC (2017); Canada's Ecofiscal Commission (2015); ECCC (2016a); Beale et al. (2019).

TABLE 6: DEFINING AMBITION		
Elements of Ambition		
Scope	**Scale**	**Pace**
Extent of regions, sectors, issues addressed	Stringency or strength of measures applied	Rate of increase in scope and scale over time

Although Canadian governments have made progress, their collective ambition has not been nearly enough (OAGC, 2018). The scope of policies, in terms of the sectors, regions, and issues covered, has been far too limited. Too few Canadians, for example, have access to clear flood risk maps that would help them prepare for emergencies (Henstra & Thistlethwaite, 2018). Action to protect and restore wetlands has also tended to be localized and ad hoc, rather than part of a broader strategy or plan (Hoye, 2017).

Some governments have constrained the scale, or stringency, of policies, often pursuing incremental change rather than working towards a longer-term vision. Residential and commercial building construction, for example, has seen only marginal improvements in emissions performance over the past few decades with limited adoption of innovative approaches used in other countries such as electric heat pumps and district heating. Decisions being made today could affect Canada's ability to manage risks or capture opportunities in the future.

Overall, the pace of policy change has been too slow. Rather than creating a planned schedule to increase scope or scale to help drive continual innovation and investment, policies stagnate, backslide, or undergo excessively lengthy review processes. British Columbia's zero emission vehicle (ZEV) mandate stands out as an example of a policy that lays out a long-term pathway to increased stringency, with legislated targets of 10% ZEV sales by 2025, 30% by 2030, and 100% by 2040 (Government of British Columbia, 2018).

To effectively meet the objectives laid out in Section 3, while also being prepared for the full range of risks and opportunities outlined in Section 2, Canadian governments need greater policy ambition (Table 6).

Research and analysis can support governments in their efforts, providing a better understanding of risks and opportunities, evaluating possible pathways to 2030, 2050, and beyond, exploring policy design options, and assessing current policy performance.

4.3 FINDING MULTI-BENEFIT SOLUTIONS THROUGH INTEGRATION

Climate policy usually falls into one of three categories: mitigation, adaptation, or clean growth. However, the complexity of challenges identified in Section 2 and the diversity of objectives outlined in Section 3 show the need for broader and more integrated approaches to policy development, particularly since the effects of climate change are so pervasive. Opportunities exist for shared solutions that have benefits in other policy areas, as well as risks of unintentionally exacerbating challenges. Different levels of government and jurisdiction complicate matters further.

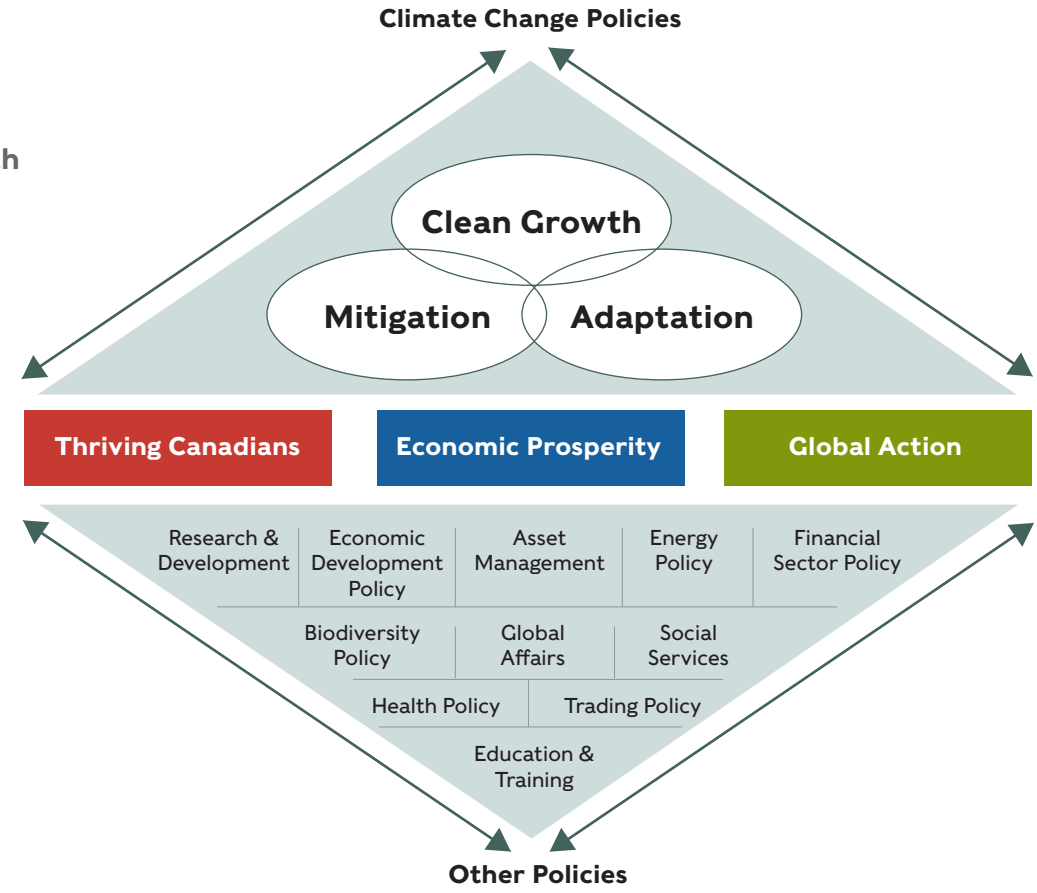
One example of the need for integration is nature. Protecting and restoring urban natural assets such as wetlands and forests improve the resilience of communities to flooding and heatwaves while removing carbon from the atmosphere and supporting biodiversity. Yet these solutions have not emerged as a climate change priority in Canada because their full range of benefits are often viewed in isolation and not well understood. Buildings, being long lived assets, will significantly impact Canada's future emissions, as well as our resilience to climate change impacts. Yet approaches to building standards often consider mitigation and adaptation separately.

It is also possible for solutions to have unintended consequences that work against objectives. Consider investments in urban green spaces that help reduce the impacts of heatwaves, protecting vulnerable populations. While there are important benefits, some studies have shown that urban green spaces can lead to increased local property values, which can exacerbate housing affordability (Jennings et al., 2017). Identifying these interactions is important to finding ways to improve overall outcomes.

Climate change challenges across the economy and society affect policy areas that may, on the surface, seem unrelated to climate change (e.g., finance,

FIGURE 5:

Integrated policy thinking can lead to creative solutions with multiple benefits



This figure illustrates how the broader set of climate change goals outlined in Section 3 integrate mitigation, adaptation, and clean growth actions with other non-climate policy areas. Integration cuts both ways. Just as non-climate policies should consider broad climate objectives, climate policies should also consider a broader set of social and economic implications. The greatest potential for widespread and long-term benefit lies at the intersection of multiple policy objectives.

global trade, technology). Aligning non-climate policy approaches with climate change objectives can help avoid counterproductive outcomes or even improve effectiveness. The growing use of block chain technologies, for example, is dramatically increasing energy demand and, if left unchecked, could have serious implications for local electricity grids (Barnard, 2018). Similarly, integrating increased heatwave risk into social services for older, low-income individuals could be more effective than developing an isolated heatwave adaptation strategy.

The need for integration and co-operation grows with ambition. To move from incremental change to large-scale transformation, we need creative approaches that cost-effectively target multiple policy objectives. The chance for creativity and innovation improves when people with different knowledge, backgrounds, and perspectives work together. Actively seeking multi-benefit solutions requires moving away from a narrow approach to policy development, connecting across a broader set of objectives, making policy linkages, and increasing emphasis on multidisciplinary research and analysis (see Figure 5). It also requires recognizing the inherent challenges with Canadian federalism and developing methods to leverage its advantages (Box 25).

4.4 PRACTICAL APPLICATIONS

To make the discussion above more meaningful, we explore five policies that address multiple objectives outlined in Section 3. We consider a diverse set of policies to illustrate the breadth of the approach

BOX 25: CANADIAN FEDERALISM PRESENTS BOTH CHALLENGES AND OPPORTUNITIES FOR AMBITIOUS, INTEGRATED POLICY

Canadian federalism adds a layer of complexity to ambitious, integrated, and coordinated policy development. Federal, provincial, territorial, and Indigenous governments share jurisdiction over climate policy. Regions across the country will face different circumstances, with unique opportunities and challenges. For example, while Nova Scotia may be most concerned with adapting to sea-level rise, Northern territories might prioritize measures to address the risk of thawing permafrost. And while Alberta may focus on reducing emissions from its oil and gas sector in a way that preserves competititeness, Quebec will likely be more concerned with reducing emissions from transportation and capturing opportunities from its low-carbon hydroelectricity production. These differences mean that the mix of policy levers selected across governments will naturally vary.

Policy variation can create challenges to achieving national objectives and providing a level playing field for business. However, it also has advantages. It allows various levels of government to try different policy approaches on a smaller scale, creating the opportunity to replicate successful solutions in other jurisdictions.

For example, many of the leading climate policy innovations in Canada have originated at the subnational level. Ontario was the first to phase out coal-fired electricity. Saskatchewan was the first to implement carbon capture and storage on a coal-fired power plant. Alberta was the first to implement an output-based pricing system for large industrial emitters. British Columbia was the first to implement an economy-wide carbon tax, Quebec was the first to implement a cross-border cap and trade system, and Manitoba was the first to set legislated, five-year carbon budgets. In adapting to a changing climate, the Government of Nunavut has initiated risk mapping and new infrastructure standards to reduce the impacts of permafrost thaw. The Governments of Yukon and the Northwest Territories are collaborating to develop community clean air shelters to reduce health impacts from wildfire smoke. And Atlantic provinces are working together to provide communities with online tools to support rural coastal adaptation.

Finding ways to develop ambitious, integrated, and coordinated climate policies that achieve national objectives while allowing for regional variation and experimentation will be an ongoing challenge, and opportunity, for Canadian climate change policy.

Source: Government of Canada (2018).

needed to make progress: federal regulations to phase out coal, the use of transition bonds in high-carbon sectors, a policy that invests in protection and restoration of urban wetlands, a policy focused on identifying people vulnerable to heatwaves, and finally, a program to reduce wildfire risk.

These five case studies highlight the importance of policy development processes that calibrate their ambition to achieve objectives and continually seek out creative and integrated solutions. They are neither policy recommendations nor a complete policy package. In each case, more information, analysis, and research can determine what an optimal policy or suite of policies might look like to achieve long-term results.

Table 7 below situates the five case studies across the objectives outlined in Section 3 and the policy levers presented in Section 4.2. It shows that individual policy levers can address multiple climate change objectives at

the same time. Understanding the breadth of objectives for each policy lever can help identify areas where integration can improve overall outcomes.

Analysis of policy options should consider many possible interlinkages between the objectives. It may be the case that a policy lever has positive impacts on some objectives, but negative impacts on others. Identifying these positive synergies and tradeoffs is important to make design changes or introduce complementary policies that improve overall outcomes.

TABLE 7: EXAMPLES OF POLICY LEVERS WITH MULTIPLE BENEFITS

		Climate Change Goals and Objectives									
		Healthy and Resilient Canadians				Clean and Resilient Growth			Collaborative Global Action		
		Healthy Canadians	Resilient Canadians	Sustainable Ecosystems	Intergen-erational Fairness	Low-Carbon Competi-tiveness	Climate Resilience	Cost-Effective-ness	Emission Reductions	Policy Spillovers	Technology Spillovers
Policy Levers	Regulation/ Standards	CP		CP	CP	CP		CP	CP	CP	CP
	Pricing										
	Procurement										
	Financing/Tax Incentives		TB		TB	TB		TB	TB	TB	TB
	Infrastructure Investment	NI		NI	NI	NI	NI	NI	NI	NI	
	Innovation Policy										
	Information/ Analysis	HM	HM				HM			HM	
	Capacity Building	FS	FS				FS	FS		FS	FS
	Coordination										
	Mainstreaming										

CP Coal phase out: regulations that require coal plants to reduce or eliminate their emissions.

NI Natural infrastructure: Investments in urban wetland protection and restoration.

FS FireSmart Program: building individual and community capacity to reduce wildfire risk

TB Transition bonds: financing to reduce carbon intensity in high-carbon sectors

HM Heatwave mapping: Identifying people vulnerable to heatwaves

Using our five case studies, this table provides examples of policy levers that achieve multiple objectives. The coal power phase-out policy, for example, makes progress on eight of the ten objectives outlined in Section 3. The FireSmart Program, by comparison, can help make progress on six of the ten objectives. While ideally there would be a mix of policy levers in place to achieve each of the objectives, it is not necessary to fill all the boxes by having ten policy levers used for each objective. Rather, the value of the analytical approach is to consider the potential positive and negative impacts of policy levers on a broader set of objectives, identifying synergies and tradeoffs that can lead to a more cost-effective policy mix and better overall outcomes.

CASE 1:
Regulating the Transition Away from Coal Power

This case highlights the domestic and international value of pursuing ambitious policies for high-value, multi-benefit solutions.

Reducing emissions from coal-fired electricity generation is critical to keeping global temperature increases well below 2° C. Coal combustion accounts for around one-quarter of global GHG emissions (30% of energy-related CO_2 emissions). The International Energy Agency has attributed coal combustion to more than 0.3° C of the 1° C increase in global average surface temperatures above pre-industrial levels, making it the single largest source of global temperature increase (IEA, 2019c).

Canada stands out as a global leader in the phase out of coal-fired electricity. A combination of federal and provincial regulations will phase out most conventional coal-fired power generation by 2030. Ontario led the way through its phase out commitment in 2003, which led to the closure of all coal plants in the province by 2014. In other provinces, however, any new coal plants risked locking in significant emissions over their 40- to 50-year lifetime (Environment Canada, 2012).

To address the risk of new capacity coming online in other provinces, and the associated implications for Canada's GHG emissions, the federal government moved to phase out all coal-fired electricity in 2011. At this point there were 45 operating coal units in Canada, with 28 forecast to cease operation by 2025. With lower emission alternatives available, such as natural gas, hydro, wind, and solar, a regulated phase out seemed feasible. In 2012, regulations required the phase out of coal generation at the market-driven end of life of existing plants (50 years) (Environment Canada, 2012). Amended regulations published in 2018—which closely mirrored the 2015 coal phase-out legislation in Alberta—accelerated the timeline to require all emitting coal plants to be phased out by December 31, 2029 (ECCC, 2018b). This change is expected to lead to an additional 94 Mt of GHG emission reductions over the 2019 to 2055 period (ECCC, 2018b).

Phasing out conventional coal plants has also driven significant air quality and health benefits, which increase the overall benefits of the policy (Canada's Ecofiscal Commission, 2017). Improvements in health outcomes have helped build a strong coalition of support in the medical community and health organizations. In addition, as the phase out drives greater decarbonization of electricity generation, it will support long-term emission reduction objectives and innovation by increasing the emissions benefits of electrification of transportation, buildings, and industry.

The policy has faced challenges, however. Some of the early concerns focused on electricity prices and the impact on coal workers. Concerns over electricity prices led some provinces to cap or limit rate increases. Concern for coal-power workers and communities led to the launch of a task force on a just transition for coal workers and communities that made recommendations for transitional financial support (ECCC, 2019c). Interactions with other policies, such as the output-based pricing system for GHG emissions,

have proved challenging (Box 22). While to some it may seem unfair to have coal plants slated to close pay for emissions while they remain operational, others feel it distorts near-term incentives if high-emission coal plants do not face greater costs relative to natural gas generation (Shaffer, 2018).

The coal phase out has had impacts beyond Canada's borders. In 2017, Canada moved to leverage its leadership by partnering with the U.K. to create the Powering Past Coal Alliance. The Alliance encourages other countries to implement similar policies (ECCC, 2019c). To date, 30 countries have joined the coalition along with over 50 subnational governments, businesses, and other organizations (PPCA, 2019).

As Canada considers pathways to decarbonization, a low-carbon electricity sector could enable bold policies in other sectors that could benefit from electrification. Insights from Canada's policy successes and challenges can also make it easier for other countries to transition away from coal, increasing

CASE 2:
Developing Financial Instruments to Support Low-Carbon Transition

This case highlights the benefits of making connections outside the traditional sphere of climate change policy.

Green bonds, which are sold to generate revenue earmarked for green projects, have become an important way to finance low-carbon projects. In 2018, global green bond issuance totalled US $167.6 billion, of which around US $4.2 billion was issued in Canada (Climate Bonds Initiative, 2019; SPI & CBI, 2019). Investors often use green bonds to meet sustainability commitments and boost their environmental credentials. Governments can play an important role in growing green bond markets through the establishment of robust principles and standards, strategically issuing bonds themselves, reducing barriers to investment such as scale and risk, and providing tax incentives to encourage private bond issuance (Climate Bonds Initiative, 2019).

Canada's green bonds have been largely dominated by renewable electricity and public transit, with some growth in low-carbon buildings and municipal adaptation-related projects (EPSF, 2019; City of Vancouver, 2018). Canada's high-carbon sectors have been essentially left out of the market, with a lack of guidance and criteria for financing transitional projects with significant emission reduction benefits that are not categorized as purely "green". This has led to growing interest in a new category of "transition bonds" to support high-emission firms interested in transitioning their business models (EPSF, 2019).

While the potential scale of issuing transition bonds is uncertain, there are indications it could be significantly larger than the current green bond market. In Canada, a successful low-carbon transition requires diversification and emissions reductions in high-carbon sectors. As companies diversify and invest in low-carbon technologies, new market opportunities can emerge. Corporate Knights and Alberta Innovates, for example, estimate that non-combustion uses of bitumen from Alberta's oil sands—such as carbon fibres for steel replacement or pelletized asphalt—could have an annual market value of US $1.5 trillion by 2030

(Heaps, 2018). Global loans tied to environmental, social and governance (ESG) metrics, which provide greater flexibility in projects than green bonds, reached US $247 billion in 2018 (Poh, 2019).

Given our economy's reliance on emissions-intensive resource sectors, Canadian governments could play a role in developing transitional financial products. The final report of the Expert Panel on Sustainable Finance highlighted the opportunity of transition bonds and recommended that Finance Canada, in partnership with major financial institutions and the Canadian Standards Association, convene key stakeholders to develop Canadian green and transition-oriented fixed income taxonomies that detail criteria for eligible investments. The report noted the potential for Canada to provide international leadership on the issue, which could have important implications in financing the global low-carbon transition (EPSF, 2019).

While transition bonds would be a financial product, robust principles and standards can ensure that they generate climate benefits that are additional to what would have happened anyway. This requires strong collaboration between governments, financial institutions, emissions-intensive sectors, and environmental experts. In 2018, Corporate Knights and the Council for Clean Capitalism developed a "Clean Financing for Heavy Industry Taxonomy" that reflected input from 40 bond issuers, raters, underwriters, and institutional investors. The taxonomy specifies eligible transition project categories for the oil and gas, mining and metals, heavy industry, and energy utilities sectors (Heaps, 2018). While Canada could develop its own unique approach, it would be preferable to collaborate with international efforts in the U.K., France, Japan, China, and the Netherlands, given the long-term benefits of an international standard (EPSF, 2019).

The financial sector can play a major role in supporting Canada's transition, and Canada is well placed to lead the development of products that address the needs of high-carbon sectors. The result has the potential for significant economic benefit, particularly in sectors vulnerable to a low-carbon transition. An international standard could have widespread benefits, accelerating global emission reductions and reducing the risk of economic disruption.

CASE 3:
Investing in Wetlands

This case highlights the benefits of shifting mindsets and seeking creative, integrated solutions.

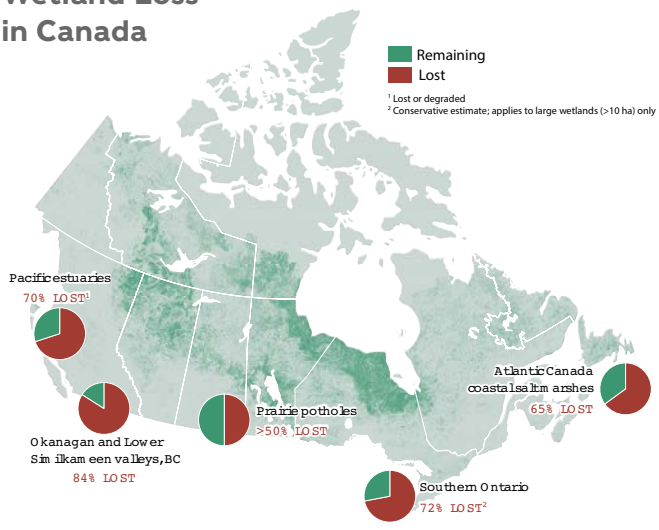
Natural assets such as wetlands can help make communities more resilient to floods, while, at the same time, absorbing carbon from the atmosphere, providing cleaner water, and supporting biodiversity. Often, measures to restore, maintain, or protect wetlands are lower cost than alternative engineered assets (Cairns et al., 2019). However, most programs that finance infrastructure have historically focused on engineered assets over natural assets. Some federal and municipal programs have started to change this trend, but a series of financing and regulatory barriers continue to favour engineered solutions (Cairns et al., 2019). Wetland loss also continues in proximity to urban areas and agriculture (See Figure 6).

If urban, suburban, and rural municipalities started to identify and prioritize natural solutions ahead of engineered options, and all the various programs that finance infrastructure projects supported this shift, investments could start to flow toward actions that protect, enhance, and restore wetlands in Canada.

The required shift in mindset could be challenging. In some cases, investing in wetlands would mean buying land or compensating private landowners for lost income and land value. This is very different from a traditional infrastructure investment. In others, it could mean constructing new wetlands to pool excess water instead of an engineered option such as agricultural drainage into a local river or stream. The community of Holland, Manitoba, built a retention structure to create an engineered wetland and reservoir that reduces spring flood risk. It also allows for a late-season recharge of downstream reservoirs, improves habitat protection, and reduces the flow of phosphorus pollution into the watershed. Harvesting cattails as a feedstock for biofuels could create additional benefits (Moudrak et al., 2018; Stevenson, 2015; Grosshans & Grieger, 2013).

FIGURE 6:

Wetland Loss in Canada



Source: Kraus, Dan (2019), Nature Conservancy of Canada

In 2018, the town of Gibsons, British Columbia, became the first municipality in Canada to use its Development Cost Charge to fund restoration of a wetland that provides stormwater drainage services to a subdivision. Expanding the town's valuable natural asset provides the same services as engineered drainage at only 25% of the cost. Residents benefit from reduced costs for drainage services, while the wetland produces other benefits, such as enhanced biodiversity, recreation, and carbon removal benefits (MNAI, 2019b).

Melbourne, Australia, uses a series of lagoons to treat half of the city's sewage. The natural plant produces 40 billion litres of recycled water a year and is energy self-sufficient. The plant eliminates GHG emissions by using lagoon covers that collect biogas for electricity production. It is also an internationally significant wetland for waterfowl, with over 280 bird species identified at the plant (Melbourne Water, 2018).

Governments often have a traditional notion of what infrastructure is and what it is not. Wetlands do not fit within the traditional view. Given their high value and cost-effective potential to address multiple climate change objectives, it may be time for a new perspective that measures and values a broader range of benefits.

CASE 4:
Identifying Canadians Vulnerable to Heatwaves

This case highlights the important role that information and analysis play in developing integrated and effective plans.

The frequency and intensity of heatwaves is expected to increase across Canada, particularly in high-emissions scenarios, resulting in greater risk of heat-related illness and death. The challenge is worse in cities, which are subject to the heat-island effect where paved surfaces, buildings, and warm air released by air conditioners and vehicles combine to increase temperatures relative to outlying areas (Climate Atlas, 2019). The most vulnerable in a heatwave tend to be low-income and elderly and have pre-existing health challenges.

Consider the city of Montreal. In July 2018, during a weeklong heatwave where temperatures hit highs over 35° C, hospitalizations almost doubled, deaths outside hospitals more than tripled, almost 6,000 ambulances were called, and 66 heat-linked deaths occurred. The people who died were mainly low-income, elderly, and living alone. Some had mental health illnesses, struggled with alcohol addiction, or had chronic heart or lung disease (Oved, 2019).

Improving the resilience of Canadians to heatwaves, and protecting their health, will require governments to identify those at risk. Montreal, unlike many other cities, tracks heat-related deaths. Health care workers fill out forms detailing pre-existing conditions, whether the deceased had air conditioning, and the room temperature when they are found. This tracking has allowed the city to identify correlations between deaths and low-income neighbourhoods as well as areas that lacked tree cover and greenery (Oved, 2019).

This information has been critical in developing an integrated plan to address risk. In 2019, Montreal committed to extend the hours of pools, libraries, community centres, and homeless shelters during heatwaves. Fire safety workers also go door to door to check on people flagged as vulnerable, hand out water bottles to the homeless, and encourage citizens to stay cool and hydrated. In addition, the city is planting more trees to help reduce the urban heat island effect (Coriveau, 2019).

As the frequency, intensity, and duration of heatwaves increases, the scope of information gathered by municipalities could be broadened. For example, heatwaves affect worker productivity and have been associated with increased levels of crime (Aubrey, 2018; Otto, 2017). In addition, heatwave innovation is expanding and could offer opportunities. The EU is exploring the potential for blockchain to provide continual feedback on city conditions and options to cool urban water bodies (Climate Innovation Window, 2019).

CASE 5:
Building Capacity to Reduce Wildfire Risk

This case highlights the role that governments can play in empowering individuals and communities to develop and implement their own climate change solutions.

With the increased temperatures and droughts associated with climate change, wildfires are likely to become more frequent, grow more intense, and last longer. They can be devastating for communities and individuals. They are also costly. Researchers estimate the 2016 Fort McMurray fire cost almost $9 billion through physical, financial, health, mental, and environmental impacts (Snowdon, 2017).

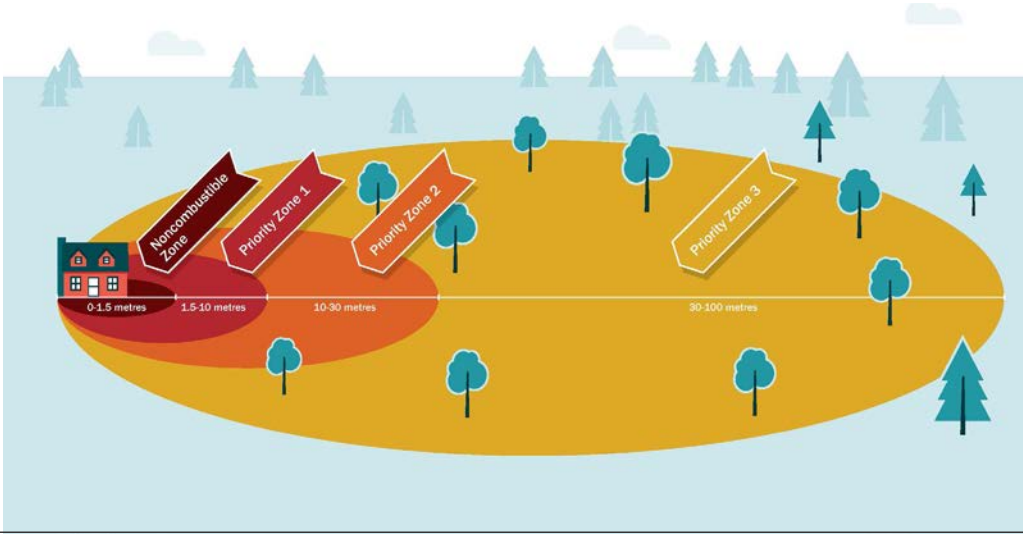
FireSmart programs aim to build the capacity of communities and homeowners at the wildland-urban interface to reduce risk. Alberta spearheaded the initiative, now adopted in other provinces and at the national level (FireSmart Canada, 2018a).

For example, FireSmart informs and empowers the public to protect their property from wildfire. Research shows that the main source of damage to homes is from wildfire embers igniting something combustible near the home. It could be a woodpile next to the house, gutters with dried leaves, or long grass. Removing these materials within 10 metres of the home is a cost-effective way to reduce risk (Figure 7). Over the longer term, homeowners can invest in more costly solutions such as protective roofing materials that decrease their vulnerability to fire (FireSmart Canada, 2019a; 2018a; 2018b).

Alberta's FireSmart Program is making it easier for homeowners to act. Trained firefighters inspect homes directly, pointing out simple preventative measures as well as longer-term investment options. They then return after a couple of years to assess progress. FireSmart Alberta is rolling out a new mobile app that will allow homeowners to conduct the self-assessment and identify key vulnerabilities on their own, with access to information resources and expert networks. The program is also planning to make it easier for homeowners to shop for FireSmart materials, developing a logo for products that can reduce vulnerability to fire. It has developed an "authorized

FIGURE 7:

FireSmart Ignition Zones around Property



service provider" program to protect homeowners, and their brand (Stewart, 2019). Product labelling could drive innovation, encouraging producers to develop more non-combustible materials.

The program also encourages entire communities to become FireSmart, by adopting a plan, tracking progress, and making investments in risk reduction. As more properties within a community adopt FireSmart practices, the heat and speed of fire can be reduced (FireSmart, 2019b).

This case study demonstrates how clear and easily accessible information and support can help homeowners protect themselves and their neighbours. Creating a link to business decisions through product labelling also helps encourage innovation, which in turn makes it easier for homeowners to act.

4.5 SUMMARY

This section explores some the ways in which Canada could achieve the goals and objectives outlined in Section 3. In many cases, we have solutions available. The challenge is to drive widespread implementation. Government policy levers are critical to enabling, guiding, and encouraging transition. Simply adopting policies is not enough, however. They need to be ambitious in their scope, scale, and pace to drive stepwise change.

As ambition increases, it becomes more important to find collaborative, integrated solutions that offer multiple benefits across climate and other policy objectives. Integration comes from bringing together people with different knowledge, backgrounds, and perspectives to identify shared solutions and address potential tradeoffs. It also comes from recognizing different needs and interests across Canadian regions and communities. While Canadian federalism is a challenge, it also provides significant opportunity for policy innovation.

The need for long-term, multi-disciplinary thinking has never been greater. Canada is at crossroads in climate change policy. To truly prepare for the future, the next phase of Canadian policies must be more creative, more ambitious, more collaborative, and more integrated than those of the past.

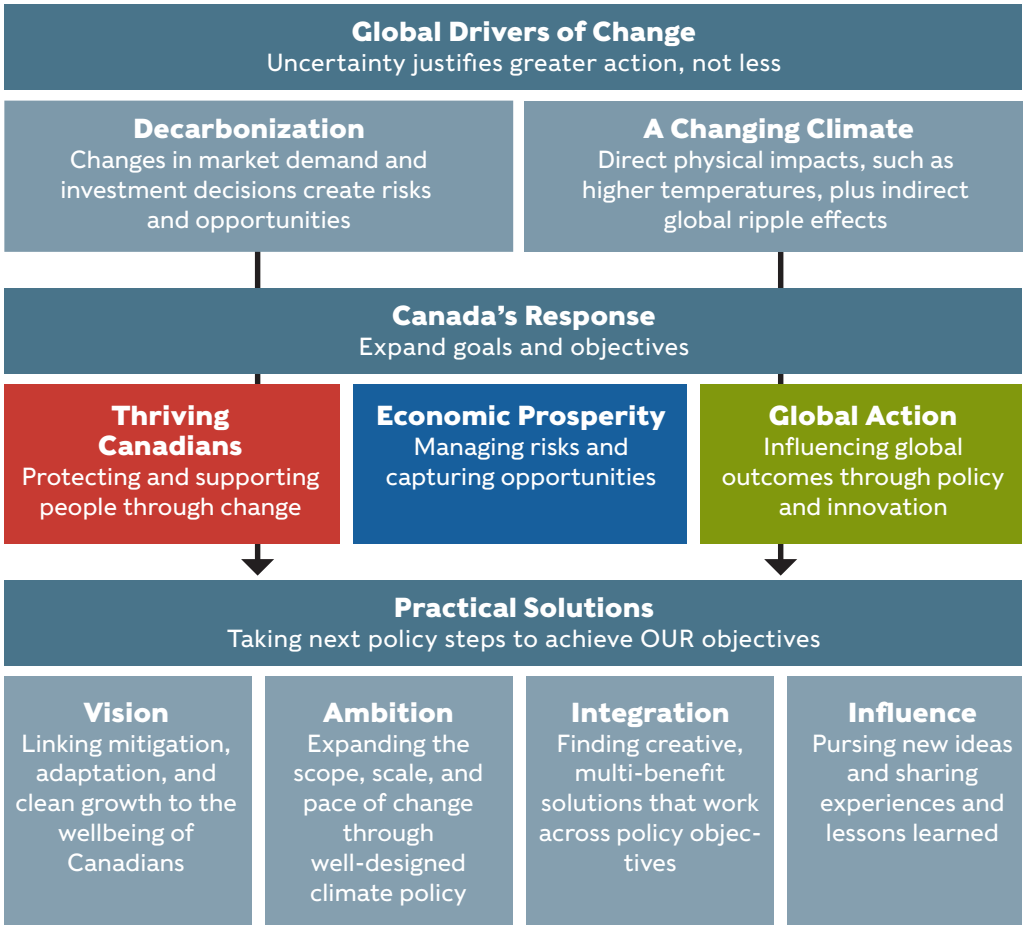
5 CONCLUSIONS AND RECOMMENDATIONS

The world is entering uncharted waters as climate change drives unprecedented global environmental, societal, and economic disruption. We know change is coming, but the extent, direction, and magnitude of this change remains uncertain. Canada needs more clarity on how to chart our course through these uncertain waters. This starts with understanding what we are ultimately trying to achieve.

Canada and Canadians *can* weather the storm—but only if we take an integrated approach to preparing for the changes that are coming. We can manage risks and capture opportunities. We can protect and support those who are vulnerable. And we can leverage our ability to influence global outcomes. This implies a broader set of climate change goals and objectives than we have seen in the past, that better reflect the diversity of needs and interests across Canada. Climate change has wide-reaching implications for Canada; to prepare, our response must be just as broad.

FIGURE 8:

Charting our Course on Climate Change



Well-designed climate policies—at all level of governments—can help Canada make deliberate choices that lead to cleaner and more inclusive growth, and a resilient and prosperous future for Canada. To chart Canada's course, we must build on our successes, moving toward broader, more ambitious, more coordinated, and more integrated policy solutions (Figure 8).

To move forward, we propose four recommended next steps for all levels of Canadian governments to consider:

RECOMMENDATION #1: Canadian governments should broaden objectives for climate policy

Historically, governments have focused on relatively narrow objectives (achieving emissions-reduction targets, managing specific climate risks). Yet we have often failed to deliver on these objectives, and we remain largely unprepared for future challenges. A broader perspective on policy design—looking beyond the narrow lenses of mitigation, adaptation, and clean growth—can help to clarify what governments are trying to achieve, embed climate change objectives in all policy choices, and guide more innovative policy solutions. By linking objectives more directly to the welfare of Canadians, this approach can also build a broader coalition of support for action.

Canadian governments—at all levels—have roles to play in delivering a future Canada that is resilient to the changes ahead, for our climate and our economy.

RECOMMENDATION #2: Canadian governments should embrace Canada's role in global outcomes

Canada has the potential to influence global change, rather than merely respond to it. We are among the largest economies in the world and have a seat at the table of global leadership through organizations such as the United Nations, G7 and G20. We are

also one of the world's largest emitters. We should think strategically about what we can do to drive the action needed to produce better global outcomes. For example, we can demonstrate global leadership through our own actions, we can work internationally to help solve policy challenges that are driving global risks, and we can develop technologies and products that make transition easier and more cost-effective—while realizing economic benefits and new opportunities for Canadian businesses and workers.

RECOMMENDATION #3:
Canadian governments should expand the scope, scale, and pace of climate policies

It is not enough to just develop policies aimed at addressing climate change. The policies must also have sufficient ambition. This means expanding the coverage of policies across regions, issues, and sectors, ramping up the magnitude of change, and tightening the timeframe for achieving results. We need to think about where we want to be in 2050 and beyond, and work backwards to determine optimal pathways and choices. Decisions made today should lay the groundwork for long-term success. Canada has made considerable progress in the last decade, but overall action has not been commensurate with the scale of the challenges ahead.

RECOMMENDATION #4:
Those analysing and developing policy options should seek out integrated solutions that drive multiple benefits

The complexity and multi-dimensional nature of climate change, combined with the need for greater ambition, demands a more integrated and comprehensive approach to finding solutions. The most effective policies will achieve multiple benefits across a range of climate change and other policy objectives. But the best way to identify and develop these policies is by breaking down traditional policy silos and bringing people with different expertise, backgrounds, and perspectives together.

Our proposed next steps for Canada are not easy, but they are achievable. Success will rely on strong leadership, openness to new ideas, willingness to collaborate, and innovative thinking.

Research organizations such as the Canadian Institute for Climate Choices can support Canada's journey to 2050 and beyond by bringing together top experts from a range of disciplines to analyse pathways, evaluate policy options, and point to solutions that serve the best interests of current and future generations of Canadians.

This report is only a starting point. It frames important new policy and research questions. Hard work from a very broad group of Canadians will be required to answer these questions and help guide Canada to a resilient and prosperous future with cleaner and more inclusive growth.

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