Climate's Bottom Line

Carbon Budgeting and Canada's 2035 Target

Volume 2: Second Annual Report to the Minister of Environment and Climate Change

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Prepared by the Net-Zero Advisory Body

Net-Zero Advisory Body
Groupe consultatif pour la carboneutralité

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Overview

Canada's 2035 greenhouse gas (GHG) emissions reduction target will be set in the context of the Paris Agreement which requires increasing global ambition, as well as following the requirements set out in the Canadian Net-Zero Emissions Accountability Act.

The 2035 target is a crucial milestone on Canada's pathway to reaching net-zero emissions by 2050. Our efforts to mitigate climate change over the next decade will be critical to setting Canada up for success on our pathway to net-zero, including realization of benefits such as jobs in the growing renewable energy sector, more affordable and reliable electricity, and improved health through cleaner energy.

Canada's 2035 target will be compared to other countries and large emitters. At the same time, consideration must also be given to the issue of affordability and the time needed to implement policies to reach targets.

Setting a national GHG emissions target is as much about vision as it is about science and economics. That is why, building on important progress in reducing Canada's emissions, **the Government of Canada must signal continued ambition to accelerate towards net-zero.** Governance, accountability, and transparency mechanisms are also key to success, and Canada should adopt additional tools to improve tracking of Canada's decarbonization progress.

In developing a 2035 target for Canada, the Net-Zero Advisory Body (NZAB) advises the Government of Canada to:

01 develop a Canadian carbon budget

02 adopt an emissions reduction target of 50% to 55% below 2005 levels for 2035

03 address Canada's excess emissions

Introduction

Considerations on setting a 2035 target for Canada

Under the Paris Agreement, countries are required to submit national GHG emissions reduction targets and nationally determined contributions every five years. Each successive nationally determined contribution is required to be more ambitious than the previous. Canada's next nationally determined contribution, outlining a 2035 target, is due in 2025.

The Canadian Net-Zero Emissions Accountability Act requires the Government of Canada to set national GHG emissions targets at five-year intervals for 2030, 2035, 2040, and 2045, to develop emissions reduction plans for each target, and to explain how each plan will contribute to reaching net-zero by 2050. The Act further requires that Canada's 2035 target be established no later than December 1, 2024.

In October 2023, the Minister of Environment and Climate Change requested advice from NZAB to inform development of a 2035 target and ensure it is compatible with net-zero emissions by 2050. The Minister encouraged us to provide qualitative advice, such as key considerations the Government of Canada could consider when setting the target.

The Minister further requested that, if NZAB chose to provide a target or range, it be supported by its rationale or key assumptions, and an indication of the relative effort required across key sectors.

We utilized several methods to inform our advice, including analyzing a carbon budget approach informed by an expert workshop, conducting modelling in collaboration with the Canadian Climate Institute, and looking at Canada's past targets and other countries' approaches to setting targets. While we had limited time for engagement, we sought written submissions from 62 experts and partners and summarized the feedback in our 2022-2023 What We Heard Report.

Canada has a key role in the global effort to prevent the worst impacts of climate change

At the current pace of global GHG emissions and warming, the world will soon begin to pass the temperature limits set in the Paris Agreement. The Intergovernmental Panel on Climate Change (IPCC) projected that the world will pass a 1.5°C warming threshold as early as the 2030s[1].

Indeed, nine of the warmest recorded years globally occurred in the past decade[2], and a recent 12-month period was the first to exceed +1.5°C above pre-industrial global temperatures according to some datasets[3]. Evidence suggests these are the warmest global average temperatures since before the last ice age.

The impacts of this warming are clear, both in Canada and in the world. Globally, climate change is contributing to an increased frequency and intensity of extreme weather events such as flooding, heat waves, and forest fires[4]. Canada's Changing Climate Report estimates that the past and future warming in Northern Canada is, on average, double the magnitude of global warming[5], with Indigenous Peoples being disproportionately affected. Canada plays an important role in global efforts to avoid the worst impacts of climate change as a member of the "Group of 20" emitters (along with Argentina, Australia, Brazil, China, France, Germany, India, Indonesia, Italy, Japan, Republic of Korea, Mexico, Russia, Saudi Arabia, South Africa, Turkey, the United Kingdom, the United States, and the European Union) that are responsible for about 76% of global GHG emissions[6].

As reported in the European Union EDGAR (Emissions Database for Global Atmospheric Research) database, in 2022, Canada was the 12th largest GHG emitter globally in both absolute and per capita terms[7]. By contrast, Canada ranks 37th in population size, contributing disproportionately to global emissions[8].

Climate change is a global challenge where all countries need to act together. As noted in the United Nations Environment Programme Emissions Gap Report 2023[9], current actions will not allow the world to reach the Paris Agreement goals of keeping warming well below 2°C while pursuing efforts to limit warming to 1.5°C. The United Nations Environment Programme estimates that achieving the targets set in all unconditional nationally determined contributions, including Canada's 2030 target, puts us on a path to 2.5°C or more warming. The recent global stocktake found that while countries have taken widespread actions to address climate change and its impacts, ambition and implementation must be urgently accelerated[10].

There are important benefits to global collective climate action such as the ability to scale up and to lower the cost of key decarbonizing technologies like solar and wind. Countries can cooperate to take advantage of different and cheaper emissions reduction opportunities.

1. IPCC. 2021. Sixth Assessment Report, Summary for Policymakers.
2. United Kingdom (UK) Met Office. 2023. 2023 the warmest year on record globally.
3. Copernicus. 2024. Copernicus: In 2024, the world experienced the warmest January on record.
4. United Nations. 2023. Global Issues: Climate Change.
5. Government of Canada. 2019. Headline Statements — Canada's Changing Climate Report.
6. United Nations. 2023. Net Zero Coalition.
7. European Union. 2022. EDGAR - The Emissions Database for Global Atmospheric Research (europa.eu).
8. World Bank. 2022. Population in 2022 (PDF).
9. United Nations Environment Programme (UNEP). 2023. Emissions Gap Report 2023.
10. UNFCCC Technical dialogue of the first global stocktake. 2023. Synthesis report by the co-facilitators on the technical dialogue

Climate policy is also a competitiveness issue and challenge. As decarbonizing technologies become increasingly cost competitive and widespread, Canada cannot afford to be left behind. **It is critical that we develop the skills and technologies to succeed in a low-carbon economy.** Having ambitious targets, policies and increasing investment in those technologies are key steps in that direction.

Canada is not alone in taking action, with 140 countries[11], representing 88% of emissions, having committed to some form of reaching net-zero. Every country will have a unique path to net-zero. At the time of this report's publication, relatively few countries had yet committed to 2035 targets, although several key trading partners and similarly high emitters are expected to set targets with greater ambition in the coming months (see Table 1 for a summary). Those GHG targets are reflective of different economic structures and national circumstances and can help to drive the overall ambition to tackle climate change.

Based on a recommendation of the European Scientific Advisory Board on Climate Change[12], a fellow member of the International Climate Councils Network, the European Union Commission is currently considering a potential emissions reduction target of 90% below 1990 levels for 2040 (equivalent to 89% below 2005 levels), following its 55% target for 2030. The United Kingdom has already adopted its sixth carbon budget[13] and has a target of 78% below 1990 levels for 2035 (equivalent to 74% below 2005 levels). The United States has not yet officially established a target for 2035 but has a target of 50% to 52% below 2005 levels for 2030[14].

Table 1: International 2030 and 2035 targets for Canada, the European Union, the United Kingdom, and the United States

Country or region	2030 Target	2035 Target
Canada	40% to 45% below 2005 levels	Under development
European Union	Net domestic[15] reduction by at least 55% compared to 1990 levels[16]	Under development. Reduction of net GHG by 90% by 2040 relative to 1990 under consideration [17]
United Kingdom	Reducing emissions by 68% relative to 1990 levels[18]	78% reduction in emissions[19] below 1990 levels
United States	50% to 52% below 2005 levels[20]	Under development

11. United Nations. 2023. Net Zero Coalition.
12. European Scientific Advisory Board on Climate Change. 2023. Scientific advice for the determination of an EU-wide 2040 climate target and a greenhouse gas budget for 2030–2050
13. UK Climate Change Committee. 2020. Sixth Carbon Budget.
14. Also see the Canadian Climate Institute analysis at Canada's 2030 climate target lines up with its peers. How will 2035 compare?
15. Taking into account both emissions and removals in the country
16. European Commission. 2023. 2030 Climate Targets.
17. European Commission. 2023. 2040 Climate Target.
18. UK Climate Change Commission. 2023. UK Action on Climate Change.
19. UK Climate Change Commission. 2020. Sixth Carbon Budget.
20. US White House. 2023. President Biden's Historic Climate Agenda.

Canada can build on a foundation of success

Emissions in 2022

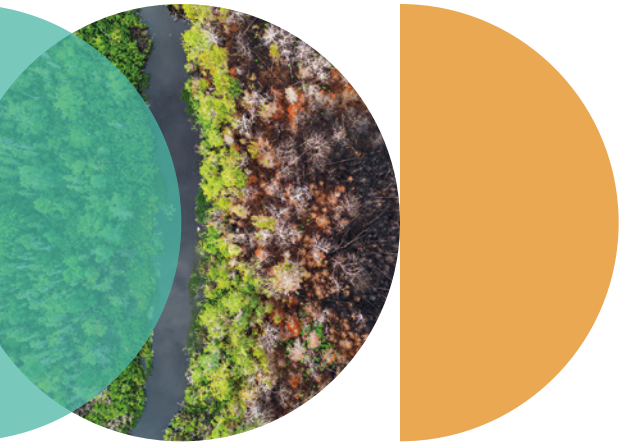
7.1%
Lower than in 2005

According to the 2024 National Inventory Report[21], territorial emissions in Canada climbed steadily between 1990 and 2005. The report indicates that direct emissions due to Canada's economic production went from 608 Mt CO_2e in 1990 to 761 Mt CO_2e in 2005, an increase of 25%.

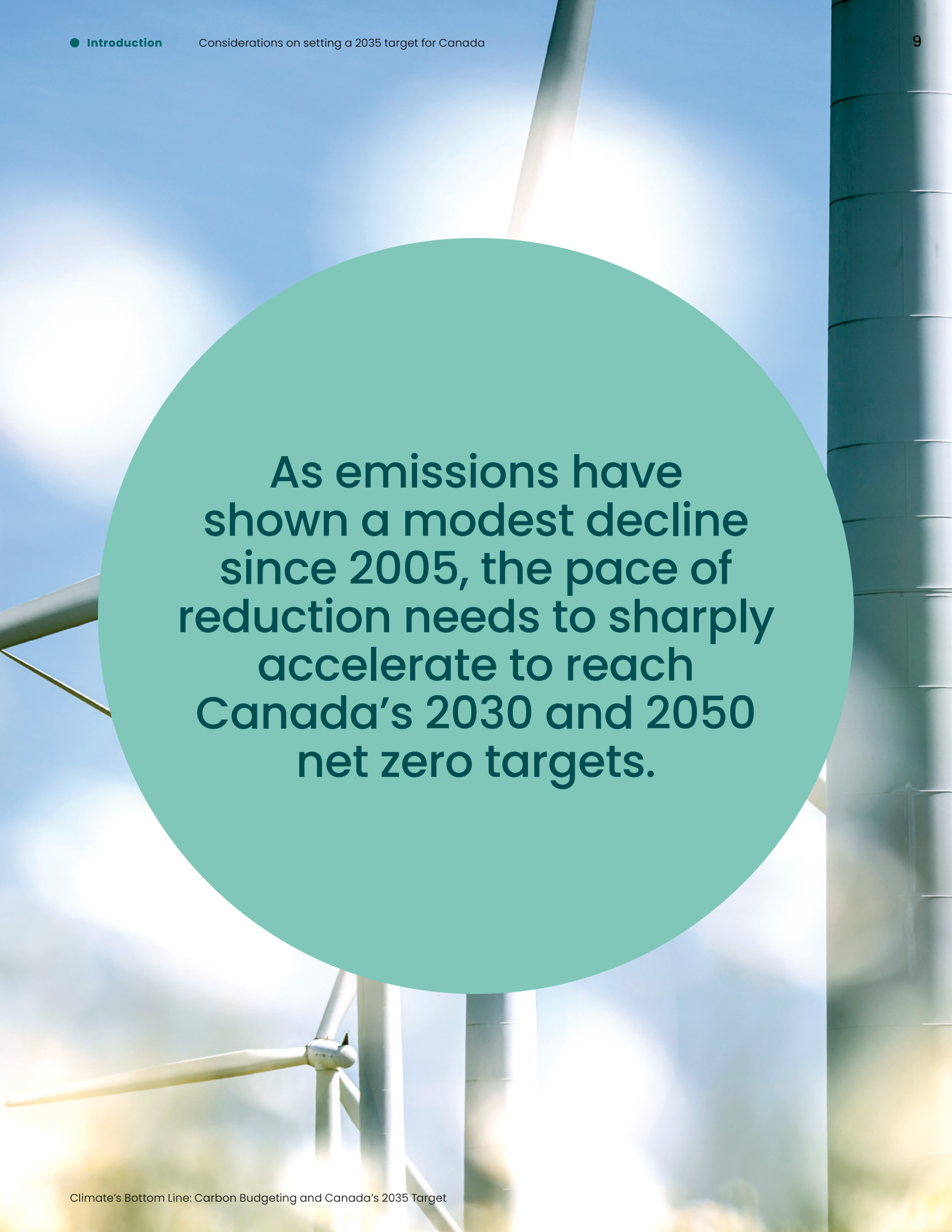
During that period, the GHG intensity[22] decreased by 17%, partially due to phenomena also observed in other countries of the Organisation for Economic Co-operation and Development (OECD)[23], such as structural changes in the economy towards less carbon-intensive tertiary activities and energy conservation measures.

Since 2005, there has been important progress. Despite a continued rise in Canada's population, territorial emissions stopped increasing and generally stabilized, with some annual variability, then began to fall during the COVID-19 pandemic. The initial pandemic-related decline has largely persisted such that emissions in 2022 were 7.1% lower than in 2005[24].

The adoption of the Paris Agreement in December 2015 was a crucial milestone, requiring each country to set a 2030 target and explain the path to the target in its nationally determined contribution. Based on Canadian Climate Institute[25] and Environment and Climate Change Canada (ECCC)[26] analysis, and with full implementation of measures, **Canada has a chance to reach the lower end of its 2030 target of 40% to 45% below 2005 levels. Key climate policies have been implemented or are being implemented, laying the foundation for long-term reductions in emissions.**



21. Environment and Climate Change Canada. 2024. 2024 National Inventory Report (part 1, PDF).
22. GHG emissions per unit of Gross Domestic Product.
23. OECD. 2023. Environment at a glance indicators - Climate Change (part 1, PDF).
24. Environment and Climate Change Canada. 2024. 2024 National Inventory Report (part 1, PDF)
25. Canadian Climate Institute. 2023. Independent assessment shows Canada on track to achieve 85-90% of its 2030 emissions target.
26. Environment and Climate Change Canada. 2023. 2023 Progress Report on the 2030 Emissions Reduction Plan.



As emissions have shown a modest decline since 2005, the pace of reduction needs to sharply accelerate to reach Canada's 2030 and 2050 net zero targets.

Advice 1

Develop a Canadian carbon budget

The Government of Canada should develop a national carbon budget that clarifies the total GHG emissions that Canada should not exceed until it reaches its domestic net-zero state by 2050. We recommend the domestic carbon budget to be set between 10,198 to 11,034 Mt CO_2e. The total domestic carbon budget should then be broken down into five-year interim milestones starting with the cumulative emissions that Canada intends to permit between 2031-2035.

The Government of Canada should also develop, alongside this domestic budget, an accounting of Canada's excess emissions[27] to keep long-term temperature increases to no more than 1.5°C.

Our analysis shows that even very conservative estimates indicate excess emissions through 2050 of more than 8,400 Mt CO_2e.

27. As Canada cannot achieve a fairness-based budget with domestic emission reductions alone, the part that cannot be achieved (excess emissions) could be addressed through international mitigation (see Advice 3).

NZAB's Net-Zero Pathways - Initial Observations report noted that the most likely pathways to net-zero use carbon budgets as a basic tool.

Carbon budgets specify the cumulative amount of GHG emissions permitted over a period of time to limit a specific temperature increase. Carbon budgets differ from point-in-time targets in that emissions not only have to fall to a certain level by a particular year, but the overall emissions allowed leading up to that period are also limited.

Like a household budget, a carbon budget can help ensure we "only spend what we can afford" by tracking our emissions "expenses" and allocating them based on the remaining GHG emissions in the budget. **By tracking emissions over time, a carbon budget also provides a better indication of whether we are on track to meet our climate objectives and the consequences of delaying action.**

From a scientific perspective, the use of carbon budgets is more instructive than point-in-time targets because cumulative emissions have a more direct relationship with warming than emissions in individual target years.

Unlike point-in-time targets, carbon budgets can also help to smooth our trajectories as emissions in a single year can be significantly impacted by external factors and unforeseen events such as pandemics, anthropogenic forest fires, and geopolitical events.

Defining a national carbon budget must take multiple elements into account. The remaining global carbon emissions to avoid specified levels of global warming (including the 1.5°C and 2°C thresholds in the Paris Agreement) are estimated based on climate science and GHG accounting methods. A national carbon budget can then be determined based on the remaining global carbon emissions, the consideration of fairness, equity, national circumstances, and methodological choices[28].

National-scale carbon budgets are currently used with different approaches by several countries, including the United Kingdom, France, and New Zealand. To inform the potential development of a carbon-budget approach for Canada, NZAB hosted a workshop with domestic and international scientific experts on carbon budgets in November 2023. This discussion highlighted key considerations for the Canadian context (see Textbox 1).

28. Carbon Brief. 2022. Guest post: What the tiny remaining 1.5C carbon budget means for climate policy.

Textbox 1: Workshop considerations for developing a carbon budget approach for Canada

- Carbon budgets have been used by several countries and can provide clear trajectories to get to net-zero with accountability and transparency.
- There is scientific dissensus linked to the application of carbon budgets such as the size of the remaining global budget to avoid a given warming level. Using a carbon budget approach can offer different insights than emissions trajectories.
- Defining a fair share of the remaining global carbon budget for Canada should include key ethical principles such as capability, equality, and responsibility. In all credible scenarios, the remaining share of emissions for Canada would be very small or negative.
- Most international approaches do not explicitly consider non-CO_2 gases. There is no agreement on the best way to consider these gases and possible options include separate or similar targets and timelines for CO_2 and non-CO_2 gases.
- It is critical to ensure environmental integrity and clear guidelines for negative emissions and international mitigation transfers if they are to be employed to keep Canada within the determined carbon budget.
- There are different ways of defining the rate of emissions reduction towards net-zero. A straight line is most practical but early reductions would also provide the greater climate benefit.

Building on the key elements of the expert workshop, NZAB sought to assess the merit of carbon budget approaches for determining interim emissions reduction targets and defining pathways to net-zero by analyzing two approaches for developing a budget for Canada (see Technical Annex for more in-depth analysis):

- The **fairness-based** approach, which draws directly from scientific analyses of the remaining global carbon emissions for a specified chance to avoid a given level of warming. Under this approach, Canada is allocated a fair share of the remaining global carbon budget based on historical contribution to global emissions and capacity to act.
- The **target-based** approach, which draws from national emissions targets rather than directly from the remaining global carbon budget as above. The budget can be computed directly from a trajectory between historical emissions and a net-zero target.

A fairness-based carbon budget approach

In line with the findings of the workshop, our analysis concludes that the fairness-based approach, relying on the scientific relationship between cumulative emissions and warming, and on the Paris Agreement's temperature thresholds, implies a **zero or negative budget for Canada**.

This approach is based on:

1. Responsibility for climate change through calculation of cumulative GHG emissions
2. Capacity to take action

Organizations like the Climate Equity Reference project provide examples of this type of equity-based approach[29]. As we look to identify an appropriate share of remaining emissions for Canada, we note the importance of considering Canada's fair share of the global effort to confront the climate crisis, given its contribution to climate change as one of the world's top net and per capita emitters of GHGs, and its capacity to take and support action on the crisis as a wealthy Group of Seven (G7) nation.

All this being said, our analysis also shows that employing a science-driven budget approach to set interim emissions reduction targets is not possible for the 1.5°C or the 2°C warming limits without extremely steep near-term emissions reduction and substantial negative emissions[30] or international transfers.

Furthermore, a fairness-based approach that follows United Framework Convention on Climate Change (UNFCCC) principles is not feasible with domestic emissions reductions alone and would require other efforts like carbon removal and/or financing international emissions reduction. Our analysis also indicates that less stringent, and hence more achievable, interim targets embed a structural unfairness in that they imply Canada can claim a disproportionate share of the remaining global carbon emissions to respect the warming limits in the Paris Agreement. To comply with principles of the UNFCCC, additional means like international climate finance would then be necessary to address the structural unfairness.

29. Climate Equity Reference. 2024. Climate Equity Reference - calculator.
30. The IPCC defines negative emissions as the "Removal of greenhouse gases (GHGs) from the atmosphere by deliberate human activities, i.e., in addition to the removal that would occur via natural carbon cycle processes".

A target-based carbon budget approach

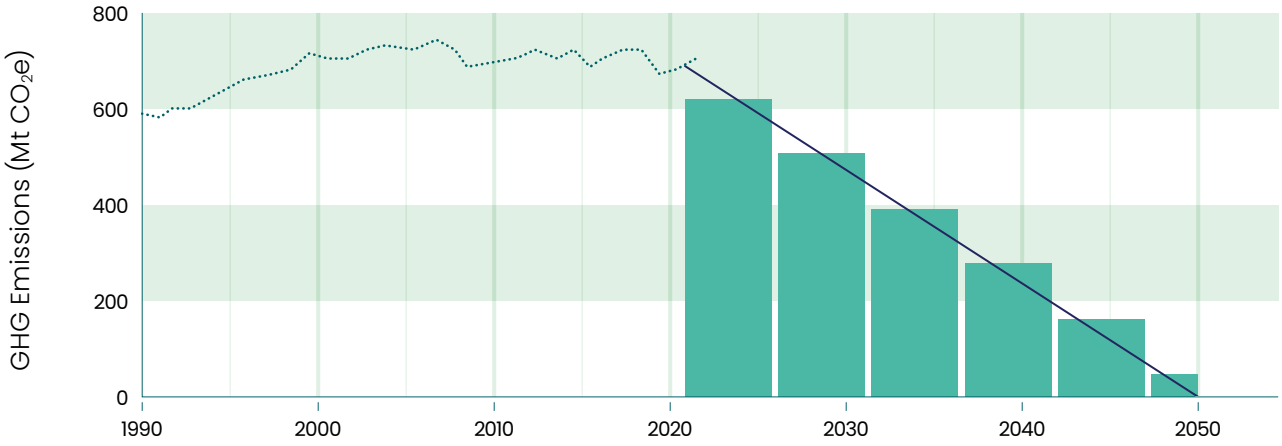
Our analysis shows Canada could establish a budget based directly on emissions targets set per the requirements of the *Canadian Net-Zero Emissions Accountability Act*, Canada's net-zero legislation.

Such a target-based budget would be determined using a trajectory between the emission level when the legislation passed (2021) or the 2030 target, and the established goal of net-zero emissions in the year 2050. This approach maintains the concept of tracking cumulative emissions without adhering to the limits imposed by remaining carbon emissions under a fairness-based approach (we discuss below how to reconcile these two approaches).

Using a target-based carbon budget approach would allow a balance between feasibility and the geophysical reality by considering emission limits that align with Canada's net-zero legislation and allows the calculation of international excess emissions. As Canada cannot achieve a fairness-based budget with domestic emission reductions alone, the part that cannot be achieved (our "excess emissions") could be addressed by methods that act on international mitigation (see Advice 3).

How to best define an emissions trajectory to net-zero, either with a straight line or with varying levels of ambition over time, is a complex question. While the simplest way to distribute the remaining emissions over time would be through a straight line, achieving steeper reductions in earlier budgets with readjustment over time would ensure the greatest climate benefit as this allows for less cumulative emissions into the atmosphere. As a first step, we suggest that the total budget be established using a straight-line trajectory from 2021 to zero in 2050, divided into five-year segments. This can be aligned with interim emissions reduction targets. The carbon budget periods should start as early as possible (see Figure 1 for an example under a linear reduction).

Figure 1: Emissions trajectory and budget for a linear pathway



Source: Technical Annex - Carbon budgeting for Canada

Whichever approach is chosen, our analysis points to the following:

1. **Carbon budgets are better measurement and accountability tools than point-in-time targets**: Developing a carbon budget for Canada would bring federal climate policy more in line with climate science by shifting policy from focusing solely on single-year targets to considering the cumulative emissions over time. In principle, a carbon budgeting approach offers a transparent accounting tool.

2. **Canada should develop a carbon budget including tracking of excess emissions**: A domestic carbon budget compatible with Article 2 of the Paris Agreement and the principles of the UNFCCC is not achievable in the short term for Canada as the value would be near-zero or negative. Alternatively, Canada could develop a domestic budget based on an achievable emissions trajectory from the time when Canada's net-zero legislation was passed to net-zero in 2050 and use the excess emissions to frame its international responsibilities, which could include climate finance, mitigation transfers and/or negative emissions, as well as the development of clear guidelines for ensuring social and environmental integrity of those activities.

3. **Carbon budgets can avoid some of the pitfalls of point-in-time targets**: Assessing emissions reduction action over five-year periods, as well as for individual target years, would mitigate against the inter-annual variability in emissions inventories, particularly for land use, land-use change and forestry emissions. The range in values for these emissions from one year to the next is as high as 38 Mt in the 2024 National Inventory Report[31], which is equivalent to a 5% difference in emissions relative to the 2005 baseline. Assessing progress over five-year periods would avoid the problem of a target being missed, or surpassed, because of non-predictable events influencing carbon exchange with the atmosphere (for example, individual severe fire years) or economic activity (for example, temporary lockdowns due to a pandemic, or shortages and supply-chain bottlenecks).

4. **Interim point-in-time targets and carbon budgets are complementary and can be linked**: The development of an overall budget and interim five-year budget segments can be done in concert with the setting of interim emissions targets under Canada's net-zero legislation. The same emissions modelling exercises used to inform target setting could be used to define the trajectory for establishing the total budget and/or the interim budgets. For example, the trajectories employed in this analysis suggest the range of 2035 targets consistent with a net-zero trajectory is small (that is, 50% to 55% below the 2050 baseline).

5. **The process of setting carbon budgets must be transparent**: Establishing and operationalizing carbon budgets requires nuance. Although carbon budgets are more scientifically grounded than point-in-time targets, setting a national-scale budget still requires normative choices and consideration of international relationships, public acceptance, and other factors. One partial solution could be to set a carbon budget range similar to the use of a range for the 2030 emissions target. Carbon budgets will appear imprecise and be subject to scrutiny if not supported by a clear and transparent process.

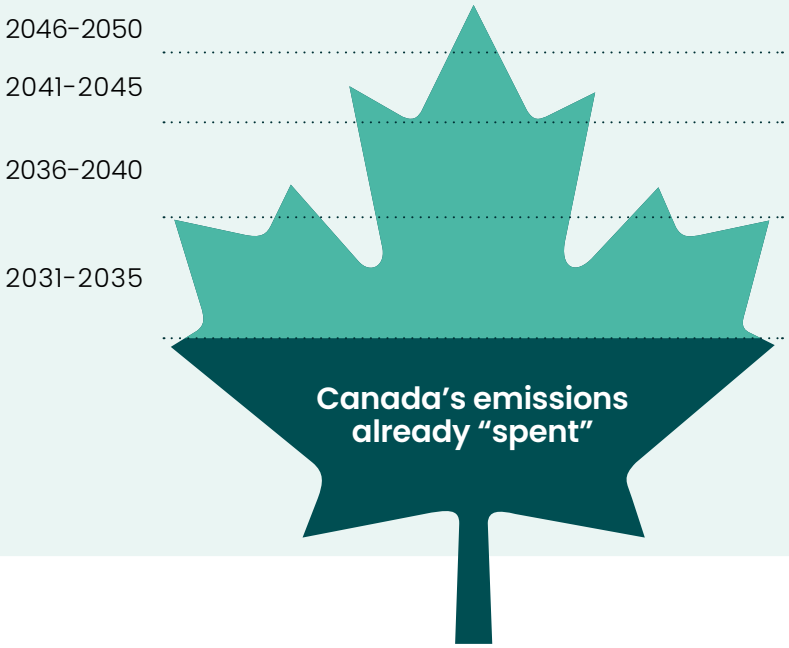
31. ECCC. 2024. 2024 National Inventory Report (part 1, PDF).

Textbox 2: How could a national carbon budget work in Canada?

A national carbon budget would be based on the remaining global carbon budget (the total global amount of carbon left to "spend") to keep the global average temperature increase well below 2°C and to pursue efforts to limit it to 1.5°C above pre-industrial levels per the Paris Agreement. Canada would determine its respective national carbon budget based on considerations of fairness, equity and method choices.

The image below depicts a national carbon budget broken down into five-year interim milestones based on what Canada has already "spent" prior to 2030 and what is left in the national budget (that is, the cumulative emissions that Canada intends to permit). Each interim milestone is progressively smaller as Canada moves closer to its net-zero target in 2050.

Figure 2: Illustrative budget for Canada



Overall, carbon budgets have clear advantages. They more directly represent the country's contribution to climate change than point-in-time targets. While developing a carbon budget would provide many benefits, it would be important to have an ongoing dialogue on the best ways to operationalize and consider policy implications, such as the ability to carry over budget surplus and its status in the current accounting and reporting architecture (for example, Canada's net-zero legislation).

In providing this advice, NZAB notes that carbon budgets are a tool already utilized by some of Canada's key trading partners that have also been piloted at the provincial and municipal level in Canada. We also note significant momentum and action by cities like Edmonton, Montreal, Toronto and Vancouver, as well as the province of Manitoba, which has adopted the concept of cumulative emissions reductions in five-year periods with its Second Carbon Savings Account[32].

32. Government of Manitoba. 2022. A Second Carbon Savings Account for Manitoba.

Advice 2

Adopt an emissions reduction target of 50% to 55% below 2005 levels for 2035

The Government of Canada should adopt a 2035 target of 50% to 55% below 2005 levels. The proposed target meets the Paris Agreement requirement to increase ambition and it puts Canada on track to meet its 2050 target. Meeting the target will require greater ambition on decarbonization from not just the federal government, but also provinces, territories, municipalities, and the private sector.

This target, like previous targets, is a "net emissions" target. This means that while direct domestic reductions of emissions should be the primary focus, reaching the target will also require additional actions such as negative emissions and internationally financed emissions reductions.

NZAB's recommended range of 50% to 55% below 2005 levels for the 2035 target is informed by its own carbon budget analysis (see Technical Annex) and analysis by the Canadian Climate Institute of various 2035 emissions target scenarios. It is also informed by the ambition of key international partners, the feasibility of achieving the target, and implications at the regional and national level for affordability, Indigenous reconciliation, competitiveness, jobs, and environmental health.

We have decided to recommend a range due to advantages over a single number target, such as better reflecting uncertainties about future economic growth and technological progress, as well as striking a balance between different objectives.

In our assessment, we considered targets ranging between 46% to 61% below 2005 levels, whereby 46% represents the minimum ambition over the high-end of the 2030 target (45% below 2005 levels) and 59% represents the year 2035 on a straight-line emissions reduction trajectory from the high-end of the 2030 target to net-zero in 2050.

In establishing the low end of our recommended range, we noted that targets between 46% to 50% below 2005 levels, while more feasible to achieve given existing technologies and the current economic context in Canada, are also very close to Canada's 2030 target. This would risk putting Canada too far behind its net-zero goal and would likely represent insufficient ambition in contrast to Canada's key international partners, including other G7 countries like the United States.

In establishing the high end of our recommended range, we noted concerns about the social and economic consequences for targets above 55% despite the climate benefits of greater early reductions given the cumulative impact of emissions.

For our recommended target, the high-end of the range (55%) is intended to drive overall ambition to keep Canada on track to achieve net-zero by 2050 and is aligned with international obligations and consistent with a target-based carbon budget approach. The low end of the range (50%) is consistent with Canada's international obligations and economic feasibility. It also ensures that Canada's target for 2035 considers the implications of the target established by the United States for 2030 (50% to 52% below 2005 levels). With 2035 being roughly the midpoint year between 2021 and 2050, a minimum target of 50% signals Canada's intention to pass the midpoint of ambition on its long-term pathway to net-zero. It is important to note our recommended 2035 target is for "net" emissions. While we recommend that the target be met primarily via domestic emissions reduction, there is a case for considering additional negative emissions measures and/or international transfers, such as internationally transferred mitigation outcomes, provided that environmentally sound rules are followed. We will analyze the potential for these measures more closely in the coming year.

The recommended target range applies at the national level. **Achieving the target range will require effort from all actors, including provinces, territories, municipalities, and the private sector.** While we are not proposing regional or sectoral targets, we emphasize that all sectors must contribute a fair share of emissions reductions, and regional differences must be recognized.

Textbox 3: Target analysis

Our recommended target range is informed by the target-based carbon budget approach previously described. The middle of the target range (53% below 2005 levels) emerges from a target-based approach (that is, a straight-line emissions reduction trajectory) from 2021 (the passing of Canada's net-zero legislation) to zero in 2050, while the upper bound of the range (55% below 2005 levels) represents a straight-line emissions reduction trajectory from the lower bound of the 2030 target (40%) to zero in 2050 (see Table 2). The 50% was not directly derived from carbon budget analysis but indicates a lower bound corresponding to halfway to net-zero.

Table 2 GHG emissions for selected years in Canada (numbers rounded)

Year	GHG Emissions (Mt)	% reduction over 2005	Data source
2005 (reference year)	761	N/A	National Inventory Report 2024
2021 (Canada's net-zero legislation passed)	698	8%	National Inventory Report
2035 (recommended target - low)	381	50%	Halfway to net-zero
2035 (recommended target - middle)	358	53%	Straight line from 2021 to 0 in 2050
2035 (recommended target - high)	342	55%	Straight line from the target in 2030 (40%) to 0 in 2050.
2050 (Net-zero goal)	0	100%	Net-zero goal

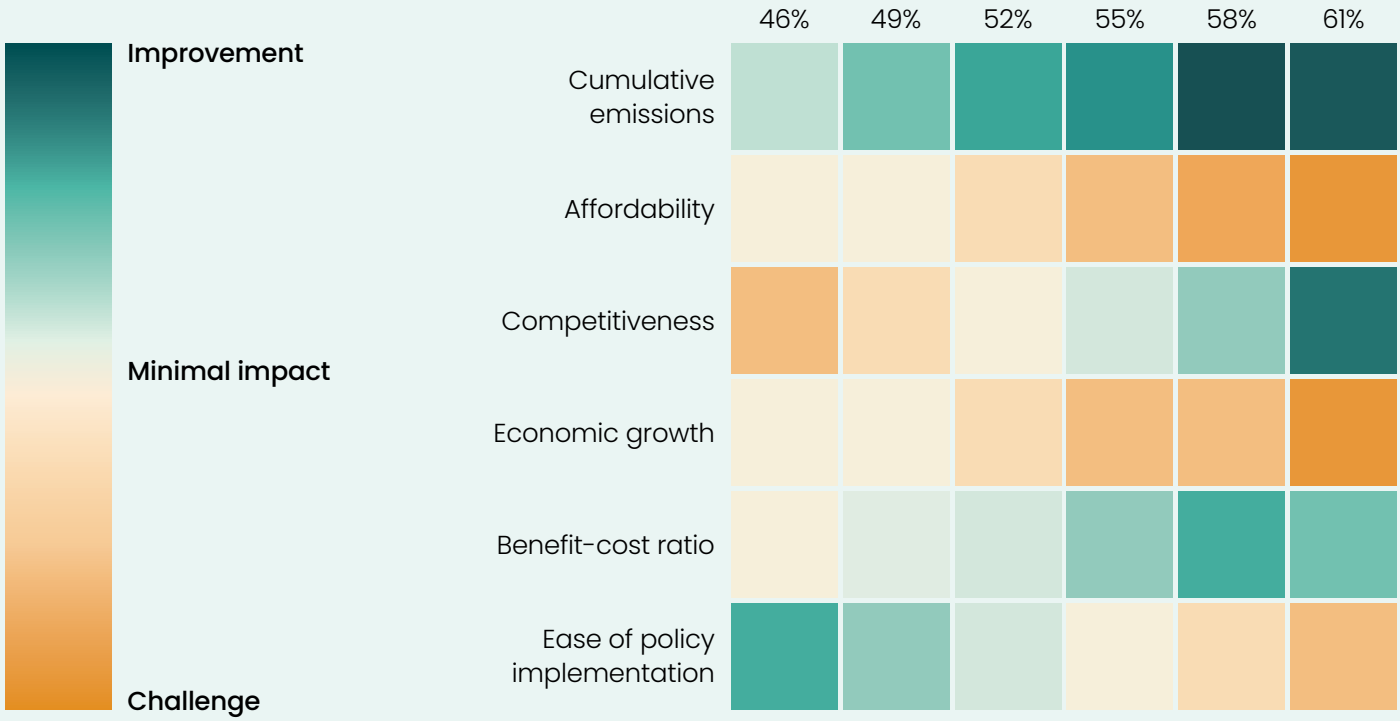
Textbox 4: Canadian Climate Institute analysis

NZAB partnered with the Canadian Climate Institute to evaluate credible options for a 2035 emissions reduction target for Canada. The Institute, in partnership with Navius Research, modelled emissions reductions of 46%, 49%, 52%, 55%, 58%, and 61% below 2005 levels. These were assessed relative to an Emissions Reduction Plan baseline scenario on different criteria such as emissions, affordability (the consumption portion of GDP), competitiveness (the investment portion of GDP), economic growth (GDP), benefits-costs (based on the social cost of carbon), and ease of policy implementation (see Figure 3 for details).

First, the analysis concluded that delaying action would be costly. Second, it showed that an overly aggressive target might erode affordability for some consumers, but that this conclusion should be monitored regularly since the future price of decarbonization technologies are uncertain but expected to decline. Finally, the Institute suggested an optimal target in the range of 47% to 50% to balance those two considerations, but noted that at NZAB's request, its analysis excludes potential emissions reductions from nature-based solutions and agriculture measures, which could increase the target range up to 49% to 52%.

Figure 3: Impacts on indicators, relative to the Emissions Reduction Plan, by 2035 target scenario

Relative to ERP baseline



Source: Canadian Climate Institute

Advice 3

Address Canada's excess emissions

Due to the 2035 target and a carbon budget exceeding a fair share of global emissions, we encourage the Government of Canada to develop an approach to identify and pursue near- and long-term additional measures that can address Canada's excess emissions, including enhancing international climate financing (for mitigation, adaptation, and loss and damage), negative emissions (that is, carbon dioxide removal, including natural processes and other biological or chemical processes that can accelerate the removal of carbon from the atmosphere) and internationally financed emissions reductions.

As part of this approach, the Government of Canada should ultimately set numerical targets to track progress in taking additional measures to address its excess emissions.

As part of our carbon budget analysis, we have advised that a target-based carbon budget would not be compatible with a fair share of the global mitigation burden under Article 2 of the Paris Agreement, which Canada has committed to meeting. **Canada should therefore estimate and address its excess emissions** (that is, the difference between the national carbon budget and a fairness-based budget that is compatible with the Paris goals).

The Ireland Climate Change Advisory Council undertook a comparative study to assess how the European Union and seven countries (France, United Kingdom, the Netherlands, Finland, Denmark, New Zealand and Ireland) define their share of the global carbon budget as their national carbon budget[33]. All use different methods and rely on different assumptions about negative emissions or temperature goals. For example, while Finland integrates a fair share in its national budget, most countries do not explicitly consider fair share or include it outside of their carbon budget. We believe that recognizing and quantifying explicitly the difference between Canada's fair-share obligations and Canada's actual national carbon budget as excess emissions is both transparent, responsible, courageous, and necessary to address climate mitigation ethically.

The excess emissions, which can be calculated from the difference between target-based and fairness-based carbon budgets, is an estimate of the emissions that will need to be accounted for to ensure Canada is fairly contributing to global efforts to respect the Paris Agreement. Even with conservative estimates, Canada's estimated excess emissions through 2050 is more than 8,400 Mt CO_2e.

While the estimated excess emissions may seem daunting (representing approximately 12 times Canada annual emissions as of 2022), **tracking and addressing Canada's excess emissions would bring clarity and credibility to the country's role in global efforts on climate change.** It would position Canada as a leader in the ethical thinking and action to tackle climate change and could open the way for fairer contributions to emissions reduction between developed and developing countries.

Determining the quantity and relative importance of the different options to account for the excess emissions will require broad consultation. For example, a strict emissions accounting approach would imply that Canada account for the excess emissions via investment in negative emissions, domestically or internationally, and/or international emissions reductions efforts. This would align directly with the Paris Agreement goal. An alternative approach would use excess emissions to inform the scale of international climate action supported by Canada, including financing for adaptation in the developing world, compensation for loss and damage, as well as investment in negative emissions and international mitigation efforts.

33. Sadhbh O'Neill for the Ireland Climate Change Advisory Council. 2023. Carbon Budgeting in Selected Countries.

This approach would consider the broader international obligations under the Paris Agreement and the United Framework Convention on Climate Change given the increasing magnitude of international climate impacts, but it also could leave more carbon in the atmosphere relative to the first approach. In either case, the mix of methods used to account for excess emissions will depend on both domestic considerations, including relative capacity and equity, as well as international considerations, including the needs and values of developing nations impacted by Canada's and other more developed countries' disproportionate contribution to warming to date.

A focus on Canada's excess emissions brings to the fore the role of negative emissions or activities that remove carbon dioxide from the atmosphere. Carbon dioxide removal options include nature-based solutions such as afforestation and the restoration of forests, soils, and coastal ecosystems, as well as more early-stage technology-based solutions like bioenergy with carbon capture, direct air capture, enhanced rock weathering, carbon mineralization and ocean-based removal.

Some carbon dioxide removal will inevitably be necessary to achieve net-zero due to emissions sources which cannot be abated (for example, emissions from agricultural soils). In addition, reliance on carbon dioxide removal is found in all pathways employed by the IPCC which avoid 1.5ºC or 2ºC warming[34]. **While Canada, like any other country or entity, must focus primarily on reducing or eliminating emissions, the effort to address Canada's excess emissions must be pursued in tandem and requires analyses of negative emissions options.**

We recognize that the concept of excess emissions is new for the federal government and many Canadians. As part of our forward workplan, we will undertake more analysis and provide further guidance on options Canada could pursue to frame and address its excess emissions.

34. IPCC. 2021. Sixth Assessment Report of the IPCC.

Conclusion

Mobilize all efforts to achieve Canada's climate bottom line

This report has presented three pieces of advice which are to develop a carbon budget, establish an emissions target range of 50% to 55% below 2005 levels, and address Canada's excess emissions. Building on important progress in reducing Canada's emissions, the Government of Canada must signal continued ambition to accelerate towards net-zero.

Governance, accountability, and transparency mechanisms are also key to success, which is why Canada should also adopt additional tools to improve tracking of Canada's decarbonization progress, including a carbon budget.

Putting all the policies in place to achieve the 2035 target is critical and will require action by all actors and not just the federal government. Purposeful action, including on negative emissions, is essential given the recommended target range. The choice of a target must also consider other societal benefits and objectives, especially reconciliation with Indigenous Peoples. We encourage increased ambition and leadership from all actors in the country and will continue to monitor goals over time as circumstances and technological costs change.

We emphasize the importance of thinking about climate objectives in the larger environmental context of biodiversity and human health preservation, and especially to prevent damaging impact transfers that could occur along our race to net-zero. We also note a growing discussion and consideration of net-negative[35] targets globally. We will take some time over the next year to reflect on the potential relevance of such targets for Canada.

Over the next year, we will also work to better understand key emissions sources and sinks that are particularly uncertain, such as emissions and removals from agriculture and land use, land-use change and forestry, and negative emissions. We will also aim to better understand some international mechanisms that can potentially support our achievement of domestic targets (for example, Internationally Transferred Mitigation Outcomes) and reflect further on the appropriate use of such tools as part of our future work.

It is our sincere hope that our advice will provide a meaningful contribution to the Government of Canada's consideration of Canada's 2035 emissions reduction target. Whatever target is established by the government, it should be explicit about the underlying rationale and the factors that were considered, including social, environment, economic, technology, scientific, Indigenous, risks, and geopolitical considerations.

35. The IPCC clarifies that "a situation of net negative emissions is achieved when, as result of human activities, more greenhouse gases are removed from the atmosphere than are emitted into it".

Glossary

Carbon budgets specify the cumulative amount of GHG emissions permitted over a period of time to limit a specific temperature increase. Carbon budgets differ from point-in-time targets in that emissions not only have to fall to a certain level by a particular year, but the overall emissions allowed in a given period is also limited.

Excess emissions are the remaining emissions when comparing a fairness-based carbon budget with a target-based carbon budget.

Fairness-based carbon budgets draw directly from scientific analyses of the remaining global carbon emissions for a specified chance to avoid a given level of warming. Under this approach, Canada is allocated a fair share of the remaining global carbon budget based on historical contribution to global emissions and capacity to act.

Negative emissions[36] are the removal of GHGs from the atmosphere by deliberate human activities, which is in addition to the removal that would occur via natural carbon cycle processes.

Net negative emissions[37] occur when, as a result of human activities, more GHGs are removed from the atmosphere than are emitted into it.

Point-in-time targets are emissions targets for a given year (2030, 2035, etc.)

Target-based carbon budgets draw from national emissions targets rather than directly from the remaining global carbon budget as with fairness-based carbon budgets. A target-based carbon budget can be computed directly from a trajectory between historical emissions and a net-zero target.

36. IPCC, Glossary.
37. IPCC, Glossary.

Technical Annex

Carbon budgeting for Canada

The Net-Zero Advisory Body (NZAB) undertook analysis to evaluate the scientific basis for, and key considerations in, the development of a national carbon budget to inform its advice in setting a 2035 GHG emissions reduction target for Canada. NZAB proposes a carbon budgeting approach to calculate Canada's excess emissions and determine Canada's domestic emission reduction obligations.

A fairness-based approach allocates a fair share of the remaining global carbon budget to Canada based on historical contribution to global emissions and capacity to act.

A target-based approach is based on national emissions targets and calculates the carbon budget directly from a trajectory between Canada's historical emissions and a net-zero target.

Our analysis concludes that:

1. **carbon budgets are better measurement and accountability tools than point-in-time targets**
2. **Canada should develop a carbon budget which tracks excess emissions**
3. **carbon budgets can avoid some of the pitfalls of point-in-time targets**
4. **interim point-in-time targets and carbon budgets are complementary and can be linked**
5. **the process of setting carbon budgets must be transparent**

1. Introduction

At the current pace of global GHG emissions and warming, the world will soon begin to pass the temperature limits set in the Paris Agreement and which are supported by Canada. The Intergovernmental Panel on Climate Change (IPCC) projects that the world will pass the 1.5°C warming threshold, defined as the average year surpassing that global mean temperature, in the early 2030s, and the 2°C threshold as early as the 2040s[38].

Nine of the ten warmest years globally since records began occurred in the past decade[39], and a recent 12-month period was the first to exceed 1.5°C above the baseline commonly used to define the global temperature limits[40]. Paleoclimate evidence suggests these are the warmest global average temperatures since the development of agriculture and human civilization at the end of the last ice age, roughly 10,000 years ago, and possibly in the past 120,000 years, since before the last ice age.

The collective emissions reduction efforts necessary to avoid these and other global warming levels is often characterized by the climate science community in terms of the total amount of carbon or carbon dioxide that can be emitted over time. This is possible due to a near-linear relationship between the cumulative human-derived CO_2 emissions and the mean global warming[41].

This relationship allows scientists to estimate a remaining carbon budget, which is the net amount of CO_2 that human activities can emit while keeping the planet below a specified global warming level, such as 1.5°C, and taking into account the effect of non-CO_2 gases. For example, the recent IPCC Sixth Assessment Report (AR6), computed that as of January 2020, the global remaining carbon budget for a 67% chance of avoiding 1.5°C warming level was 400 Gt CO_2[42]. This is equivalent to less than 10 years at the current rate of global emissions (see Section 2.1), and hence consistent with the conclusion that, at the recent rate of global emissions, the world will surpass 1.5°C warming in the early 2030s.

The NZAB's Net-Zero Pathways - Initial Observations report noted that the most likely pathways to net-zero use carbon budgets as a basic tool. Carbon budgets are also valuable tools for tracking and communicating the pathway to net-zero with accountability and transparency. Defining a remaining carbon budget is, from a scientific perspective, more instructive than defining emissions targets for individual years because cumulative emissions, or the pathway between target years, has a more direct relationship with warming than the emissions in individual target years[43].

Unlike emissions targets for individual years, the budget clearly defines how much CO_2 is left to emit in the effort to avoid dangerous levels of climatic change and/or achieve a long-term net-zero goal. National-scale carbon budgets are currently used by several countries including the United Kingdom[44], France[45], New Zealand[46], and Germany (at the sectoral level)[47].

38. IPCC. 2021. Sixth Assessment Report, Summary for Policymakers
39. UK Met Office. 2023 The warmest year on record globally.
40. Copernicus. 2023 is the hottest year on record, with global temperatures close to the 1.5°C limit.
41. IPCC. 2021. Sixth Assessment Report, Summary for Policymakers. Figure SPM.10.
42. IPCC. Table 5.8, Chapter 5 in *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the IPCC*.
43. Rogelj et al. 2019. Nature. Estimating and tracking the remaining carbon budget for stringent climate targets.
44. Government of the UK. 2024. Carbon Budgets.
45. Gouvernement de France. 2022. Stratégie Nationale Bas-Carbone.
46. Government of New Zealand. 2022. Emissions budgets and the emissions reduction plan.
47. OECD. 2022. Germany's annual sectoral emissions targets.

The application of carbon budgets requires nuance[48]. The global remaining carbon budget to avoid a specified level of warming itself depends on the selected temperature limit, the historical emissions, the warming to date, and the relationship between cumulative emissions and warming. Due to fundamental scientific uncertainty (see Textbox 5), remaining carbon budgets are expressed probabilistically as values that provide a given percent chance of avoiding the specified warming level.

Nevertheless, carbon budgets remain the best tool available for relating a country's GHG emissions over time to the impact on the climate and placing national decarbonization efforts in a global context. The inherent uncertainties are motivation to take a precautionary approach to setting a carbon budget in case the remaining budget to avoid a desired level of warming is overestimated.

In order to assess the merit of carbon budget approaches for determining interim emissions reduction targets and defining pathways to net-zero, this report analyzes two contrasting approaches for developing a carbon budget for Canada:

- The **fairness-based** approach draws directly from scientific analyses of the remaining global carbon budget for a specified chance to avoid a given level of warming. Canada is allocated a fair share of the remaining global carbon budget based on historical contribution to global emissions and capacity to act.
- The **target-based** approach draws from national emissions targets rather than directly from the remaining global carbon budget as above. The budget can be computed directly from a trajectory between historical emissions and a net-zero target.

Textbox 5: Carbon budget uncertainty

Scientific estimates of remaining global carbon budgets are frequently updated based on model developments and new data on temperature and historical emissions of CO_2, non-CO_2 gases and aerosols. Non-CO_2 gases are not explicitly modelled in global carbon budgets because warming from non-CO_2 GHG like methane and nitrous oxide scales with the rate of emissions over time, rather than their cumulative emissions, due to their short lifetime in the atmosphere.

However, scientists must estimate the contribution of those other gases to future warming to calculate the remaining carbon budget. These estimates are sensitive to the assumptions like the rate of decline in aerosol pollutants over time and contribute to carbon budget uncertainty. The modelling approach also influences budget estimates and was the primary driver of differences in budget estimates between the Working Group I and III contributions to the IPCC AR6[49].

48. Peters. 2018. Nature Geoscience. Beyond Carbon budgets.

49. IPCC. AR6 WGIII, Chapter 3, Box 3.4

2. Fairness-based carbon budget for Canada

Establishing a fairness-based national carbon budget requires determining Canada's share of the remaining global carbon budget. Among the many different considerations in the national allocation may be international and intergenerational equity, the human right to development and the capability to decarbonize[50].

The concept of a fair national share of global emissions can be rooted in international climate governance. Under the United Nations Framework Convention on Climate Change (UNFCCC), countries committed to "taking into account their common but differentiated responsibilities and their specific respective national and regional development priorities, objectives and circumstances[51]." In other words, climate change is a collective action problem in which different members of the collective are responsible for different levels of action. As one of the historically highest per capita emitters and wealthiest countries, Canada has a disproportionate responsibility for climate action under UNFCCC.

The principles of equity, capability, and responsibility, derived from the UNFCCC, have been proposed to guide fair national allocations of the remaining global carbon budget[52].

- Equity refers to the sharing of the right to development and to the production of GHG (allocated via population).
- Capability refers to the means to mitigate GHG and can be allocated by gross domestic product (GDP).
- Responsibility refers to countries having contributed differently to emissions over history and having different understanding of the impact on the climate[53] (allocated via historic contribution to emissions).

Following these principles, the experts[54] and literature[55] suggest that the equitable remaining carbon budget aligned with Article 2 of the Paris Agreement ("limiting global temperature increase to well below 2 degrees Celsius, while pursuing efforts to limit the increase to 1.5 degrees") for high per capita emitters like Canada is near-zero or negative.

50. Van der Berg et al. 2020. Climatic Change. Implications of various effort-sharing approaches for national carbon budgets and emission pathways.

51. UNFCCC. 1992. United Nations Framework Convention on Climate Change.

52. Matthews et al. 2020. Nature Geoscience, Opportunities and challenges in using remaining carbon budgets to guide climate policy; Höhne et al. 2014. Climate Policy. Regional GHG reduction targets based on effort sharing: a comparison of studies.

53. Gignac and Matthews. 2015. Environmental Research Letters. Allocating a 2°C cumulative carbon budget to countries.

54. NZAB Carbon Budget Approaches for Canada Workshop, held on November 23, 2023.

55. Van der Berg et al. 2020. Climatic Change. Implications of various effort-sharing approaches for national carbon budgets and emission pathways; Donner. 2019. Policy Options, No party's climate plan will avoid dangerous global warming levels; Holz et al. 2018. International Environmental Agreements: Politics, Law and Economics, Fairly sharing 1.5: national fair shares of a 1.5°C-compliant global mitigation effort.

2.1 Illustrative fairness-based budget

Here we provide an illustrative analysis of the remaining fairness-based carbon budget for Canada, following from IPCC AR6 Physical Science Basis Working Group (WGI) estimates[56] of the global remaining carbon budget and the principles of equity, capability, and responsibility (see Appendix).

Given the uncertainty around the global carbon budget estimates (see Textbox 5), the analysis was repeated using global budget estimates from IPCC's Mitigation Working Group (WGIII)[57] and a 2023 analysis by Lamboll et al.[58] which included data and methods developed since the publication of the IPCC report.

Results are presented for a 50% and 67% chance of avoiding 1.5°C of warming, and a 67% chance of avoiding 2°C of warming[59]. The presented budgets are scaled to reflect all greenhouse gases, based on the fraction of national emissions (in CO_2e) in the form of CO_2[60], to be comparable to the emissions inventory data. The full methods are provided at the end of the report.

Following on the principles of equity and capability, the WG1 remaining carbon budget for Canada from January 1, 2023, onwards is very small (see Table 3). The budget for a 50% or 67% chance of avoiding 1.5°C warming is equivalent to roughly two years or less at the current emissions rate[61], implying that the budget could be consumed by the end of 2024. The budget for a 67% chance of avoiding 2°C of warming is equivalent to 7 to 8 years at the current emissions rate, implying that without a reduction in emissions, the budget would be consumed around the end of this decade. These budgets based on equity and capability are small because of Canada's disproportionate share of global emissions relative to the country's population, and because of the limited mitigation action to date relative to the country's GDP.

56. IPCC. AR6 WGI, Chapter 5, Table 5.8.
57. IPCC. AR6 WGIII, Chapter 3, Table 3.2. A 67% chance at avoiding 1.5 C is not available from IPCC WG1
58. Lamboll et al. 2023. Nature Climate Change, Assessing the size and uncertainty of remaining carbon budgets.
59. The budget for a 67% chance at avoiding 1.5°C is only available from WG1. The most common interpretations of the language in Article 2 of the Paris Agreement is a 50% chance of avoiding 1.5°C and a 67% chance of avoiding 2°C, e.g. "Technical dialogue of the first global stocktake. Synthesis report by the co-facilitators on the technical dialogue"
60. 77% in 2022, excluding LULUCF; 2024 National Inventory Report.
61. 708 Mt CO_2e; 2024 National Inventory Report.

Table 3: Remaining carbon budgets for Canada from January 1, 2023, onward and number of remaining years at 2022 emissions levels

Remaining Budget (Mt CO_2e)	>67%, 1.5°C	>50%, 1.5°C			>67%, 2°C		
	IPCC WGI	IPCC WGI	IPCC WGIII	Lamboll et al.	IPCC WGI	IPCC WGIII	Lamboll et al.
Equity (population)	901	1,539	1,603	685	5,687	4,028	5,133
Years remaining	**1.3**	**2.2**	**2.3**	**1.0**	**8.0**	**5.7**	**7.3**
Capability (GDP)	680	1,257	1,315	485	5,009	3,508	4,508
Years remaining	**1.0**	**1.8**	**1.9**	**0.7**	**7.1**	**5.0**	**6.4**
Responsibility (past emissions)	-14,292	-13,654	-13,590	-14,508	-9,506	-11,165	-10,060
Years remaining	**0**	**0**	**0**	**0**	**0**	**0**	**0**

Following the principle of responsibility, the remaining carbon budgets are negative for all warming levels due to amassed emissions in excess of an equitable-based share of the global emissions since the creation of the UNFCCC in 1992 (see Table 3). The responsibility-based remaining carbon budget became negative by the year 2005 for a 67% chance of avoiding 1.5°C warming, and the year 2011 for a 67% chance of avoiding 2°C warming.

The results using global budget estimates from IPCC's Mitigation Working Group (WGIII) and the recent budget update by Lamboll et al. are similar, with the remaining budgets for a 50% chance of avoiding 1.5°C warming equivalent to 0 to 2 years of current emissions using the equity and capability principles, and negative using the responsibility principle (see Table 3).

These illustrative remaining carbon budgets confirm that a fairness-based carbon budget for Canada that aligns with climate science, strictly follows the principles in the UNFCCC, and adheres to the warming limits in the Paris Agreement would be near-zero or negative. The small or negative budget arises because Canada has been a disproportionate source of GHG emissions relative to its population and its broad economic capability to decarbonize, as roughly represented by GDP, and because the world is nearing the temperature limits in the Paris Agreement.

Employing a science-driven budget approach for setting interim emissions reduction targets is not possible for the 1.5°C warming and/or for the responsibility cases without assuming substantial negative emissions or international transfers.

In the 2ºC warming case, keeping within the equity and capability budgets would involve extremely steep near-term emissions reductions. That is, a linear rate of reduction implies a 2035 target of 82% to >100% below 2005 levels using the IPCC WG1 or Lamboll et al. budgets, which could also only realistically be achieved via substantial negative emissions or international transfers.

A strict science- and fairness-based approach that follows UNFCCC principles is therefore not advisable for establishing carbon budgets or interim targets for Canada that are to be achievable via domestic emissions reductions.

The analysis also indicates that less stringent, and hence more realistic and achievable, interim targets embed a structural injustice in that they imply Canada is claiming a disproportionate share of the remaining global carbon budget to avoid the warming limits in the Paris Agreement. To comply with UNFCCC principles, other means like international climate finance would then be necessary to address the structural injustice, as described in the next section.

3. Target-based carbon budget approach for Canada

An alternative approach for Canada is to establish a budget based directly on emissions targets set by the *Canadian Net-Zero Emissions Accountability Act*, Canada's net-zero legislation. The budget would be determined based on a trajectory between the emissions level when the legislation passed and the established goal of net-zero emissions in the year 2050. This approach maintains the concept of tracking cumulative emissions without adhering to the limits imposed by Paris-and UNFCCC-compatible remaining carbon budgets described above.

A domestic budget determined in this manner would not be compatible with a fair share of the global mitigation burden under Article 2 of Paris Agreement without extensive development and deployment of negative emissions technologies. However, the difference between the target-based and fairness-based budgets should be used to estimate a quantity of "excess emissions"[62]. These excess emissions would then be used to inform the scale of international climate finance, international mitigation effort, and negative emissions investment spearheaded by Canada.

This approach lends well to developing interim budgets, for example, five-year budget periods, within the overall remaining emissions budget as done in the United Kingdom and France. The budget for a subsequent interim period would be adjusted based on any surplus or deficit during the previous period, while still maintaining the long-term total budget.

62. For example, the Climate Action Network Canada used a variation of this approach. A fairness-based budget approach was used to determine an emissions trajectory compatible with 1.5ºC, but then divided the effort between domestic initiatives (60% below 2005 levels by 2030) and international cooperation and support; CAN-Rac Fair Share — Methodology Backgrounder (climateactionnetwork.ca)

3.1 Illustrative target-based budget

Here we provide examples of target-based budgets for Canada developed directly from Canada's net-zero legislation. In each case, the budget is determined as the total cumulative emissions (all gases, in Mt CO_2e) along a trajectory between the starting point in 2021[63], when the legislation was passed, and the legislated goal of net-zero emissions by 2050. Assigning an initial emissions reduction trajectory or a pathway is necessary in this approach to determine the budget.

The five different emissions reduction trajectories and associated budgets draw from different common representations of deep decarbonization pathways. These are theoretical examples presented for illustrative purposes, and are not based on modelling the effect of current or announced policies on emissions:

- **Linear**: linear decline, the simplest approach for determining a budget[64]
- **Sigmoid**: two different inverse logistic- or sigmoid-shaped trajectories, commonly assumed to represent realistic decarbonization pathways involving rapid progress in the middle of the time period and slower progress at the beginning and the end[65]
- **Hybrid**: a sigmoid trajectory to the lower end of the 2030 target range (40% below 2005 levels) followed by a linear decline
- **Decay** with negative emissions: exponential decay[66] to 50 Mt CO_2e in 2050

In the first four examples, any negative emissions measures would be incorporated within the budget. For comparison, the fifth example presumes negative emissions are represented separately from the positive emissions budget and reach a level of 50 Mt CO_2e by 2050. This 50 Mt is simply illustrative and should not be seen as any attempt by NZAB to forecast the appropriate and realistic amount of carbon removal for 2050.

Although the trajectories were arbitrarily determined using mathematical functions, the budgets based on these trajectories fall within a relatively narrow range (see Table 4; Figure 4). The mean value across the five examples of 10,591 Mt CO_2e is roughly 12 to 15 times larger than that of the equity and capability carbon-based budgets for a 67% chance of avoiding 1.5°C, and twice that of the budgets for 67% chance of avoiding 2°C. The results show that the pathway to net-zero matters. The budget, and hence the implied global warming effect, is larger in a trajectory assuming slow initial progress, even when followed by sharp declines (for example, Sigmoid Case 2), because it locks in more early years at high emissions levels. The budget is also higher if negative emissions, such as the decay example, are accounted for separately.

63. 698 Mt CO_2e (excluding LULUCF), according to 2024 National Inventory Report.
64. For example, a linear pathway between 2030 and 2050 is employed in Article 8(1) of the European Climate Law, European Climate Law - European Commission (europa.eu).
65. Millar et al. 2017. Nature Geoscience, Emission budgets and pathways consistent with limiting warming to 1.5°C.
66. Rockström et al. 2017. Science, A roadmap for rapid decarbonization.

Table 4: Sample emissions budgets and associated data from 2021-2050 based on the five example emissions trajectories

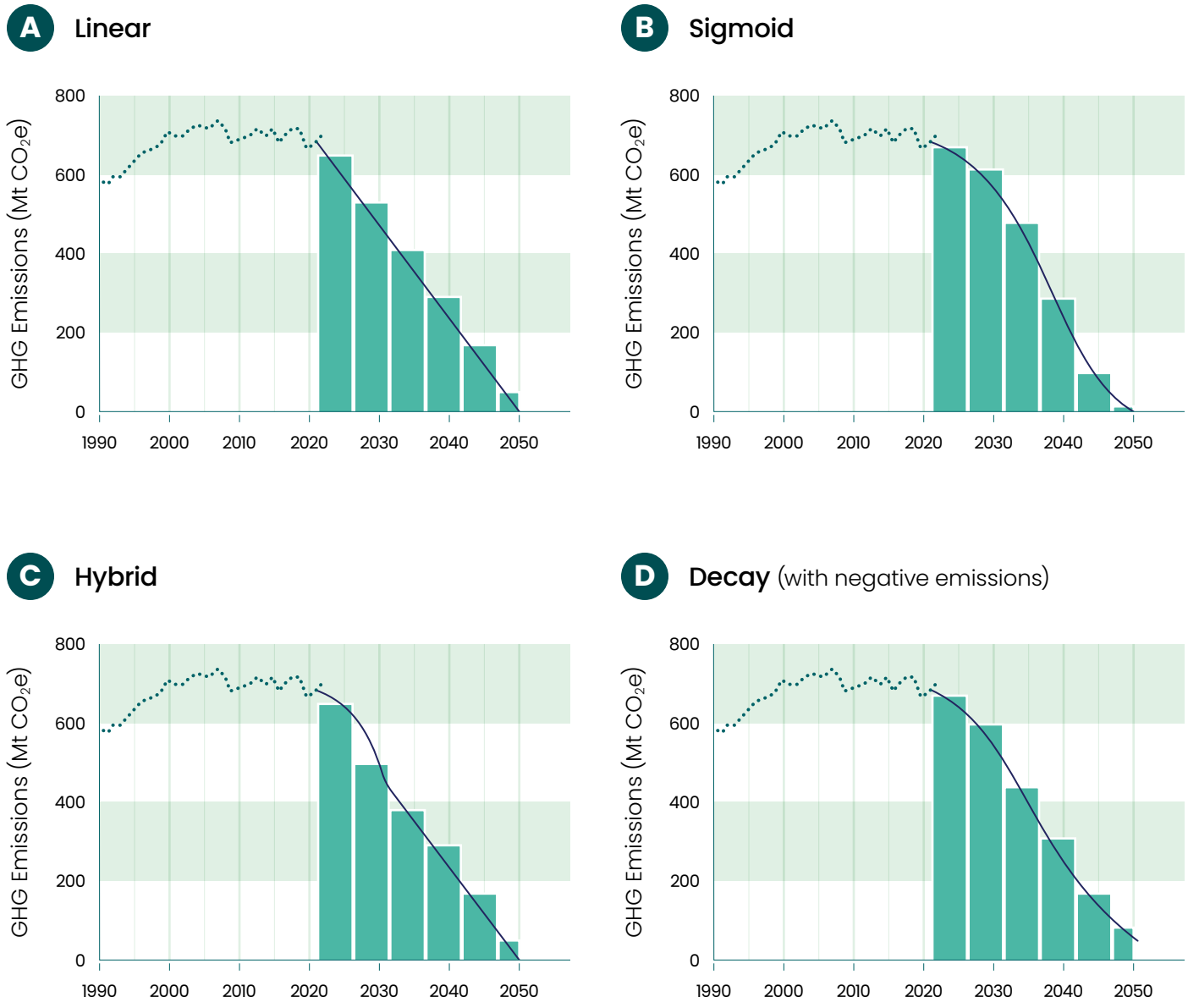
Key features	Linear (from 2021)	Sigmoid		Hybrid	Decay (+ negative emissions)
		Case 1	Case 2		
Amount (Mt CO_2e)	10,477	10,198	10,852	10,397	11,034
2035 emissions, relative to 2005	-53%	-52%	-46%	-55%	-51%
Implied global warming (°C)					
Equity principles	2.45	2.42	2.49	2.44	2.51
Capability principles	2.56	2.52	2.60	2.55	2.62
Emissions Debt (Mt CO_2e), for a 67% chance of avoiding 1.5°C					
Equity	-8,692	-8,413	-9,067	-8,612	-9,249
Capability	-8,863	-8,584	-9,238	-8,783	-9,420
Responsibility	-20,445	-20,166	-20,820	-20,366	-21,003

The emissions in the year 2035 along these trajectories range from 46% below 2005 levels in the sigmoid case with slow initial progress to 55% below 2005 levels in the hybrid trajectory designed to meet the lower end of the 2030 target range. The range of values is relatively small, in part because 2035 is the midpoint between the passage of Canada's net-zero legislation and the 2050 net-zero goal.

Because emissions in 2021 were lower than in the baseline year of 2005, a linear trajectory implies 2035 emissions should be 53% below the baseline. A 2035 interim target of less than 53% equates to leaving more emissions reduction burden to the latter half of the time period covered by the legislation. The trajectory designed to meet the lower end of the 2030 target range (40% below 2005 levels) achieves a 55% reduction below 2005 levels in the year 2035[67].

67. A similar trajectory designed to meet the upper end of the 2030 target range (45% below 2005 levels) achieves 59% reduction below 2005 levels in 2035.

Figure 4: Emission trajectories and budgets, A Linear, B Sigmoid #2, C Hybrid, D Decay with negative emissions



The excess emissions associated with a 67% chance of avoiding 1.5°C of warming are equivalent to 12 to 13 years of emissions at current (2022) levels using the equity or capability approach, and 28 to 31 years using the responsibility approach. Another way to conceptualize the excess is via the warming implied by the selected budgets. If the global remaining carbon budget from Section 1.1 were inverted, and the Canadian emissions budgets were translated back into implied global temperature change, these budgets would be the equivalent of a fair share based on equity or the capability of a 67% chance of avoiding 2.42°C to 2.62°C warming[68]. Accounting for the emissions debt via international action or negative emissions would be necessary to lower the implied global warming down to 1.5°C.

68. Computed using the relationship between remaining carbon budget and global temperature change in IPCC AR6 WG1 (Table 5.8), assuming the Canadian budget is 77% CO_2, as in Section 2.1. Calculation only possible using the equity and capability principles.

As mentioned, choosing an emissions trajectory is necessary for establishing a total budget amount. The analysis presented here involves arbitrary emissions reduction pathways not based on projected policy or innovation. Notably, the range value of the budgets is nevertheless similar across the different pathways, that is, less than 8%.

Since the starting point of 698 Mt in 2021 and the ending point of 0 Mt in 2050 are the same in each pathway, the total budget values will be similar unless an unusual pathway is chosen (for example, very steep initial reductions or limited action followed by very steep reductions late in the time period). Given that the total budget value is not highly sensitive to the choice of the pathway, a simple linear decline pathway or a hybrid that incorporates the 2030 target range may be most suitable for establishing the budget.

This initial assumed trajectory is only necessary to establish the budget. Once an emissions budget has been established, the emissions pathway used to set interim targets and interim budget segments becomes flexible provided the segments remain consistent with the total allotted budget. However, as noted above, because 2035 is the midpoint between the passage of Canada's net-zero legislation and the 2050 net-zero goal, the range of interim targets for 2035 that put Canada on a realistic trajectory to net-zero is small.

For Canada, the pathway to 2050 could be divided into five-year segments[69] covering the 30-year period between the passage of the legislation and the net-zero-by-2050 objective (for example, 2021 to 2025, 2026 to 2030 through to 2046 to 2050). Figure 4 on the previous page provides an illustration of the sample budgets divided into five-year segments (linear at top, followed by sigmoid and exponential decay).

The trajectories line (green) extends from the 2021 historical emissions from the National Inventory Report[70] (dark blue line) to the 2050 target, and the five-year budgets are computed based directly on the trajectory used to estimate the total budget. Note that the exponential decay budget is intended as an example of negative emissions being represented separately from the budget, hence the trajectory reaching the assumed negative emissions total (50 Mt CO_2e) rather than zero by the end of 2050.

Using this approach, the five-year budget segments could be set and adjusted over time, based on projected emissions impact of enacted policy and debt, or surplus, accrued from exceeding, or not exceeding, previous five-year budget segments. This could directly inform the setting of interim emission reductions targets. Employing budget segments could necessitate holding regular reviews of interim emissions targets based on implications of debt or carryover from previous budget segments on future budget segments. For example, if Canada was to exceed the 2026 to 2030 budget, the 2031 to 2035 budget would need to be smaller than previously expected, which could imply also revising a previously established 2035 target. Decisions would also need to be made about whether surplus from previous budget segments, as has occurred in the United Kingdom, could be used to increase future budget segments[71], or to reduce the overall budget and the associated excess emissions.

69. Five-year segments are used in France's Stratégie Nationale Bas-Carbone and the UK's Climate Change Act.

70. ECCC. 2023. 2023 National Inventory Report (part 1, PDF).

71. UK CCC. 2024. Letter: Advice on the Third Carbon Budget carry-over.

4. Key findings

This analysis of two approaches to develop and employ national carbon budgets for Canada points to the following key findings:

1. **Carbon budgets are better measurement and accountability tools than point-in-time targets**: Developing a carbon budget for Canada would bring federal climate policy more in line with climate science by shifting policy from focusing solely on single-year targets to considering the cumulative emissions over time. In principle, a carbon budgeting approach offers a transparent accounting tool.

2. **Canada should develop a carbon budget including tracking of excess emissions**: A domestic carbon budget compatible with Article 2 of the Paris Agreement and the principles of the UNFCCC is not achievable in the short term for Canada as the value would be near-zero or negative. Alternatively, Canada could develop a domestic budget based on an achievable emissions trajectory from the time when Canada's net-zero legislation was passed to net-zero in 2050 and use the excess emissions to frame its international responsibilities, which could include climate finance, mitigation transfers and/or negative emissions, as well as the development of clear guidelines for ensuring social and environmental integrity of those activities.

3. **Carbon budgets can avoid some of the pitfalls of point-in-time targets**: Assessing emissions reduction action over five-year periods, as well as for individual target years, would mitigate against the inter-annual variability in emissions inventories, particularly for land use, land-use change and forestry emissions (LULUCF). The range in values for these emissions from one year to the next is as high as 38 Mt in the 2024 National Inventory Report[72], which is equivalent to a 5% difference in emissions relative to the 2005 baseline. Assessing progress over five-year periods would avoid the problem of a target being missed, or surpassed, because of non-predictable events influencing carbon exchange with the atmosphere (for example, individual severe fire years) or economic activity (for example, temporary lockdowns due to a pandemic, or shortages and supply-chain bottlenecks).

4. **Interim point-in-time targets and carbon budgets are complementary and can be linked**: The development of an overall budget and interim five-year budget segments can be done in concert with the setting of interim emissions targets under Canada's net-zero legislation. The same emissions modelling exercises used to inform target setting could be used to define the trajectory for establishing the total budget and/or the interim budgets. For example, the trajectories employed in this analysis suggest the range of 2035 targets consistent with a net-zero trajectory is small (that is, 50% to 55% below the 2050 baseline).

5. **The process of setting carbon budgets must be transparent**: Establishing and operationalizing carbon budgets requires nuance. Although carbon budgets are more scientifically grounded than point-in-time targets, setting a national-scale budget still requires normative choices and consideration of international relationships, public acceptance, and other factors. One partial solution could be to set a carbon budget range similar to the use of a range for the 2030 emissions target. Carbon budgets will appear imprecise and be subject to scrutiny if not supported by a clear and transparent process.

72. ECCC. 2024. 2024 National Inventory Report (part 1, PDF).

Appendix

Fairness-based budget methods

The remaining carbon budgets for Canada for a specific chance of avoiding 1.5°C and 2°C of global average surface warming were estimated using available national and international emissions and economic data. First, the global remaining carbon budgets from IPCC WG1, IPCC WGIII and Lamboll et al. were adjusted to start in 2021 to align with Canada's net-zero legislation using historical global CO_2-only emissions data (fossil fuels, bunker fuels and LULUCF) from the Global Carbon Project[73]. Canada's share of the global remaining carbon budget, referred to below as RCB, using the principles of equity, capability and responsibility were then calculated using historical population and GDP data from the World Bank[74] as well as the Global Carbon Project and 2024 National Inventory Report[75] historic emissions data, as follows.

73. Friedlingstein et al. 2023. *Earth System Science Data*, data available here: Global Carbon Budget Data.

74. Available here: World Bank Open Data.

75. ECCC. 2024. 2024 National Inventory Report (part 1, PDF).

The equity-based RCB is allocated based on Canada's mean share of global population from 1992 to 2021. The time frame spans from the creation of the UNFCCC, when the principle of common but differentiated responsibility was enshrined in international climate governance, and the passage of Canada's net-zero legislation[76]:

$$RBC_{Equity} = RBC_{World} \times \frac{Population_{Canada}}{Population_{World}}$$

The capability-based RCB is based on the means to reduce emissions and is allocated based on Canada's share of cumulative CO_2-only emissions from 1992 through 2021, corrected for Canada's per capita GDP relative to that of the world in 2021, when Canada's net-zero legislation was passed:

$$RBC_{Capability} = RBC_{World} \times \frac{\frac{Emissions_{Canada}}{Emissions_{World}}}{\frac{per\ capita\ GDP_{Canada}}{per\ capita\ GDP_{World}}}$$

The responsibility-based RCB is based on historical contribution to emissions and is allocated based on equitable share of the global RCB over time. It is calculated as the equity-based RCB minus historical excess emissions, that is, cumulative CO_2 emissions in excess of fair population share since 1992[77]:

$$Carbon\ Debt = \sum_{1992}^{2020} \left[Canada\ Emissions - \left(Global\ Emissions \times \left(\frac{Canada\ population}{Global\ population} \right) \right) \right]$$

Since Canada's national GHG reporting and emissions target includes all GHGs, the RCBs (units of Mt CO_2) for 2021 onwards were then scaled to all GHGs (Mt CO_2e) by dividing the total by the percent of 2021 national GHG emissions in the form of CO_2 (77%) according to the 2024 National Inventory Report[78].

The scaling was only for the purposes of comparison with commonly used emissions values in Canada. The years remaining in each RCB at the current emissions rate are the same regardless of the scaling.

Each RCB was then updated to January 1, 2023, and onwards by subtracting the reported 2021 and 2022 emissions from the 2024 National Inventory Report. The number of years remaining in each RCB was computed based on that early estimate of 2022 emissions.

76. Note: Gignac and Matthews (2015) use 1990 as baseline year that human role in warming was recognized internationally.

77. Based on Gignac and Matthews (2015).

78. Based on Table A10-1, available here: Canada's Official Greenhouse Gas Inventory - ECCC Data Catalogue.