Getting to 2050: Canada's Transition to a Low-emission Future

Advice for Long-term Reductions of Greenhouse Gases and Air Pollutants

Canada

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Letter from the Chair

Dear Minister:

On behalf of the National Round Table on the Environment and the Economy (NRTEE), I am pleased to transmit to you our final Advisory Report entitled *Getting to 2050: Canada's Transition to a Low-emission Future.* This report is the culmination of a year of research, analysis, consultations, and deliberations by the NRTEE. This program was undertaken following a formal request by the Government of Canada in Fall 2006.

Our findings and recommendations are based on extensive, original modelling and data analysis that were, in turn, subjected to further consideration by numerous industry and environmental experts and stakeholders across Canada. The Advisory Report sets out clear recommendations for effective action to achieve the government's stated goal of deep, long-term greenhouse gas emission reductions of 65% below current levels by 2050. It concludes that achieving the government's long-term goal is feasible with the right policy pathway, and will result in significant GHG emission reductions at a manageable national economic cost over the long run.

The most central recommendation in that policy pathway is to establish an economy-wide price on carbon as soon as possible. Our research shows that sending such a price signal is the most effective means to achieving the government's deep GHG emission reductions. Our research also indicates that delay in doing so will affect our ability to achieve these targets without higher economic and environmental costs, and that certain sectors and regions of the country are impacted more than others. For these and other reasons, we have also set out five key "enabling conditions" that should be considered as Canada transitions to a pathway for achieving deep emission reductions.

We are aware that some of our recommendations may be challenging and will generate fulsome debate. They are provided on the basis that an important NRTEE role is to consider long-term public policy solutions beyond current approaches. This is meant to inform the public policy debate to assist government and others to consider how best to transition to our proposed long-term climate policy framework. The NRTEE welcomes the opportunity to provide this advice and information to the government based on our unique and proven role in bringing Canadian environmental and economic interests together to agree to consensus solutions on sustainability issues. This report bears that same hallmark.

An additional Advisory Note on national ambient air quality objectives will follow in early 2008.

Sincerely,

Glen Murray
Chair

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National Round Table on the Environment and the Economy

About Us

The National Round Table on the Environment and the Economy (NRTEE) is dedicated to exploring new opportunities to integrate environmental conservation and economic development, in order to sustain Canada's prosperity and secure its future.

Drawing on the wealth of insight and experience represented by our diverse membership, our mission is to generate and promote innovative ways to advance Canada's environmental and economic interests in combination, rather than in isolation. In this capacity, it examines the environmental and economic implications of priority issues and offers advice on how best to reconcile the sometimes competing interests of economic prosperity and environmental conservation.

The NRTEE was created by the federal government in October 1988. Its independent role and mandate were enshrined in the *National Round Table on the Environment and the Economy Act*, which was passed by the House of Commons in May 1993. Appointed by Governor in Council, our members are distinguished leaders in business and labour, universities, environmental organizations, Aboriginal communities and municipalities.

How We Work

The NRTEE is structured as a round table in order to facilitate the unfettered exchange of ideas. By offering our members a safe haven for discussion, the NRTEE helps reconcile positions that have traditionally been at odds.

The NRTEE is also a coalition builder, reaching out to organizations that share our vision for sustainable development. We believe that affiliation with like-minded partners will spark creativity and generate the momentum needed for success.

And finally, the NRTEE acts as an advocate for positive change, raising awareness among Canadians and their governments about the challenges of sustainable development and promoting viable solutions.

We also maintain a secretariat, which commissions and analyses the research required by our members in their work. The secretariat furnishes administrative, promotional and communications support to the NRTEE.

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Executive Summary

Climate change is upon us. Scientific studies are increasingly confident in the assessment of the relationship between observed climate warming and impacts on the earth. They are concluding that a large part of this change is directly related to human sources of greenhouse gases (GHG).[1] Reducing the GHG emissions we put into the atmosphere is central to contributing to the global objective to achieve the stabilization of GHG concentrations in the atmosphere at a level that would prevent dangerous climate change.[2]

> "The story the NRTEE has to tell is one of transition at many levels – transition in policy, transition in technology, transition in economy, and transition in society."

Reducing our own GHG emissions means that Canada is facing a transition to a low emissions society – a transition that will be driven by environmental, economic and social factors. We have a substantial national interest in understanding and anticipating the nature and scope of that change and in proactively seeking to manage our response, with respect to both mitigation and adaptation measures, in a way that benefits Canada. This *Advisory Report* addresses the issue of how to mitigate potential effects of climate change, through deep emission reductions. The National Round Table on the Environment and the Economy (NRTEE) is also working on the issue of adaptation to climate change and will report on this research in 2008.

The Transition to 2050

In the fall of 2006, the Government of Canada asked the NRTEE to look at the issues of national long-term climate change and air pollution policies. Specifically, the NRTEE was asked to provide advice on how Canada could significantly reduce its GHG and air pollutant emissions by 2050. This *Reference* enabled the NRTEE to build upon its current long-term climate change agenda, in which we had previously assessed a technology scenario for a low-GHG future in 2050. It allowed us to explore the economic and environmental implications associated with such a low-emission future, as well as to start an evaluation of potential policies that may allow Canada to attain its long-term commitments.

1. The Intergovernmental Panel on Climate Change (IPCC) states that global warming "is unlikely to be entirely natural in origin" and "the balance of evidence suggests a discernible human influence of the global climate." Working Group III contribution to the Intergovernmental Panel on Climate Change Fourth Assessment Report. Climate Change 2007: Mitigation of Climate Change.
2. United Nations, United Nations Framework Convention on Climate Change. New York: United Nations, 1992, accessed from http://unfccc.int/resource/docs/convkp/conveng.pdf, June, 2005.

The story the NRTEE has to tell is one of transition at many levels – transition in policy, transition in technology, transition in economy, and transition in society. It is a national transformation within the larger context of global change that is to come. Our advice provides a framework through which governments in Canada can seek to manage the necessary change in a way that maximizes economic and environmental benefits for the country.

The federal government – through its *Turning the Corner* policy statement – has committed to deep long-term emission reduction targets for GHGs and air pollutants. For GHGs, these targets are 20% below 2006 levels by 2020, and 60% to 70% below 2006 levels by 2050. Tackling this challenge will require embarking upon a focused and deliberate transition to a low-emission society. The NRTEE research and conclusions show that, with consideration for some key enabling conditions and acknowledgement of certain risks and uncertainties, this transition is manageable, and may even provide some unique opportunities.

Three core assumptions guided our approach:

- First, the overarching objective of our climate change policy should be to contribute to the global goal of climate stabilization;
- Second, Canada's medium- and long-term emission reduction targets have been defined; and
- Third, Canada has national economic and environmental circumstances that need to be taken into account in the design and implementation of its climate change and clean air policies.

Enabling Conditions for Managing the Transition

The NRTEE's research is premised on the federal government's commitment to achieve deep, long-term GHG emission reductions. We acknowledge that achieving these deep reductions poses real challenges given Canada's economic circumstances. But we also recognize that this challenge creates opportunities in terms of innovation and technology development.

It is in Canada's national interest to begin the transition to a low-emission future immediately. This *Advisory Report* concludes that the government's medium- and long-term targets are achievable. We also conclude that delaying action to reduce GHG emissions comes with economic and environmental risks. One such risk is that, in the absence of a long-term climate change policy framework, energy infrastructure choices being made now will be increasingly difficult and costly to address in the future. On the environmental side, the main risk involves higher cumulative GHG emissions over the time period in question.

To minimize these risks and ensure we achieve our long-term targets, the NRTEE sees the need for *five enabling conditions* that should be reflected in Canada's climate change policy framework:

1. *Canada will have to work in concert with the world.*
   This will ensure that the adverse economic consequences of policy action – particularly in relation to the competitiveness of our exporting industries and major trading partners – are minimized.

2. *Policy certainty – beyond the short term – is central.*
   Our analysis points to the need for a transition in policy from a short-term approach to a medium- and long-term focus in order to create the long-term predictability required for new investment in innovation and technology.

3. *An economy-wide emission price signal, implemented with complementary measures, is the core element of a policy framework.*
   The most effective and efficient policy that would result in deep GHG emission reductions is a market-based policy, such as an emissions tax, a cap-and-trade system, or a combination of the two. This core policy then needs to be complemented by other regulatory policies, to force emission reductions from parts of the economy that do not respond to a price policy.

4. *Technology deployment will be imperative.*
   Our analysis shows that existing and near-term technologies are sufficient to meet our emission reduction targets, but all possible low-emission technologies will need to be widely deployed. These point to the need for development and implementation of other specific policies to facilitate and accelerate technology deployment.

5. *An integrated approach to climate change and air pollution should be pursued.*
   Substantial benefits can result from a policy framework in which climate change and clean air measures are designed and implemented concurrently, as many sources of GHGs also produce air pollutants.

A critical point that the NRTEE would like to make, that falls not in the category of enabling conditions but in the category of absolute requirements for Canada moving forward, is that attention must be given to *implementation* of any policy measures considered and put in place. The mere development of a policy framework for climate change should not be confused with its implementation by government, industry, capital markets, and at the consumer level.

Recommendations

Drawing from the findings and conclusions contained in this report, the NRTEE makes the following recommendations to the federal government:

GHG Emissions

1. Implement a strong, clear, consistent and certain GHG emission price signal across the entire Canadian economy as soon as possible in order to successfully shift Canada to a lower GHG emissions pathway, achieve the targeted reductions for 2020 and 2050, avoid higher emission prices that a delay would entail, and reduce cumulative emissions released to the atmosphere.

2. Institute a market-based policy that takes the form of an emission tax or a cap-and-trade system or a combination of the two.

3. Develop complementary regulatory policies, in conjunction with the emission price signal, to address sectors of the Canadian economy that do not respond effectively to such a price signal or where market failures exist. Complementary policies should also provide support for research, development and demonstration of technologies, as well as strategic investments in infrastructure.

4. Establish a Canada-wide plan, in the earliest possible time frame, that leads to better coordination of complementary federal, provincial and territorial GHG emission reduction policies aimed at common or shared targets, time frames and actions.

5. Apply GHG emission reduction policies that incorporate adaptive management practices and have built-in monitoring and assessment mechanisms to allow for regular reviews to ensure efficiency and effectiveness. This approach will ensure that progress is monitored, compliance issues are addressed, and policies are adjusted to match the required level of abatement effort, and will minimize and mitigate unanticipated adverse outcomes.

Air Pollutants

- Address GHG emission and air pollutant reductions concurrently to ensure maximum health benefits to Canadians and greater economic certainty for industry, by designing and implementing co-pollutant reduction policies in an integrated manner.

For Both GHG and Air Pollutants

- Implement, immediately, the development and design of market-based policy instruments, plus complementary policies, for Canadian environmental objectives, economic circumstances and technology needs, following broad consultation with industry, environmental and other stakeholders, experts, and all other levels of government, drawing upon international, national, regional and local knowledge and experiences.

Looking Ahead

In order to better understand how to minimize the risks associated with the transition to a low emission society, we suggest that additional policy research be conducted. These issues include:

- further analysis of data gaps and modelling;
- policy design issues on our proposed market-based instruments;
- a "bottom-up" analysis of sectoral and regional implications of policy design;
- governance issues related to federal-provincial-territorial coordination of climate change policies, linkages to international frameworks and approaches; and
- consideration of potential benefits of addressing climate change.


Introduction




1 Introduction

1.1 Purpose

The overall purpose of this *Advisory Report* is to respond to a request for advice from the federal government to the National Round Table on the Environment and the Economy (NRTEE), in November 2006, on the question of how deep long-term reductions in greenhouse gas (GHG) emissions and air pollutants could be achieved. Specifically, this report focuses on the policy options available to Canada to address these issues and on the economic and environmental implications of those options. This report builds upon the findings and research presented in the NRTEE's *Interim Report* to the Minister of the Environment in June 2007.[3]

A second purpose of this report is to inform the current national debate on climate change as it relates specifically to medium- and long-term GHG and air pollutant emission reduction strategies. Over the past five years, the NRTEE has been examining questions related to the use of fiscal policy to promote long-term GHG emissions reductions, climate change adaptation in the Canadian context, and a long-term technology scenario for how Canada might substantially reduce its GHG emissions. This *Advisory Report* builds on our recent work, adding to the debate a new view on the design of longer-term climate change policy.

1.1.1 Clean Air Act Reference and NRTEE's Advice

In October 2006, the federal government introduced *Canada's Clean Air Act* to Parliament along with the *Notice of Intent to Develop and Implement Regulations and Other Measures to Reduce Air Emissions*. The *Act* and the *Notice* set out the government's proposed plan to develop short-term regulations for GHG and air pollutant emission reductions in the industrial sectors and to a lesser extent in other areas of the economy. Section 10 of the *Notice* identified a role for the NRTEE, which was reiterated and enhanced through a Letter of Reference from the Minister of the Environment to the NRTEE in November 2006 (see Appendix 5.1).

On GHG emissions reductions, the *Reference* was specific in its request for advice on:

- Medium-term emissions reduction targets for 2020–2025 for GHG emission reductions for a number of specified industry sectors;
- A long-term (2050) national emissions target that should be adopted within the range for a 45% to 65% reduction from 2003 levels; and
- Scenarios for achieving such a target.

3. http://www.nrtee-trnee.ca/eng/publications/ecc-interim-report/section1-ecc-interim-report-eng.html

On air pollutants, the *Reference* requested advice on long-term (2050) national emission reduction targets for sulphur dioxide (SO_X), nitrogen oxide (NO_X), volatile organic compounds (VOCs), and particulate matter (PM), for a number of specified industrial sectors.

Recognizing that the *Reference* asked the NRTEE for a broad spectrum of policy advice, this *Advisory Report* responds to those elements of the *Reference* for which the NRTEE is positioned to provide credible and informed insight. We therefore focus our advice on the following:

For taking action on GHG emission reductions:

- Scenarios for achieving deep emission reduction targets;
- Policy options for the attainment of deep emission reduction targets; and
- Environmental and economic cost implications of attaining medium- (2020) and long-term (2050) emissions reduction targets, including national, regional and sectoral effects.

For taking action on air pollutant emission reductions:

- Economic costs associated with significant emission reduction targets for NO_X, SO_X, VOCs and PM;
- Sectoral and regional implications of 50% emission reductions of these air pollutants; and
- An integrated approach to policy that addresses both GHG and air pollutant emissions concurrently.

The NRTEE was also asked to provide advice on national ambient air quality objectives. We have responded to this request by providing advice on process considerations when designing and setting ambient air objectives, rather than on the actual ambient targets themselves. The NRTEE believes it is not in a position to pronounce on such targets. Our advice on process considerations for setting national ambient air quality objectives will be provided under a separate cover.

It is important to note that this report reflects economic analysis conducted on the costs associated with various GHG and air pollutant emission reduction targets. It does not, however, provide any detailed analysis of the benefits – economic, environmental or social – that might accrue from such reductions. Nor is the NRTEE in a position to comment on what the costs of inaction might be if such targets are not achieved. These are very important areas for future consideration and are required if we are to better understand the full extent of both the costs and the benefits of globally moving to a lower GHG emission future.

1.1.2 Federal Regulatory Framework and NRTEE's Reference

In the time since the NRTEE was asked to provide its advice on long-term GHG and air pollutant reduction policy, the Government of Canada released in April 2007 its *Turning the Corner Plan* and the *Regulatory Framework for Air Emissions*. This policy document commits Canada to very specific short-term action to achieve reductions of both air pollutant and GHG emissions. The *Framework* also commits the federal government to medium- and long-term GHG emission reduction targets of 20% below 2006 levels by 2020, and by 60% to 70% below 2006 levels by 2050. While the *Framework* identified short-term actions to achieve emission reductions prior to 2020, it did not specify policies or directions other than the emissions reduction targets after that date.

It is this distinction between short-term regulatory action and thinking about effective climate change policy for the medium and longer term that sets the NRTEE's work apart from the *Regulatory Framework*. In this *Advisory Report*, we focus exclusively on how medium- and longer-term reduction targets might be achieved and the possible environmental and economic implications of attainment. We do not, therefore, comment in this document on the likely success of the current *Regulatory Framework*, or evaluate it in any way, but instead advise how climate change and air pollutant policy might transition to a longer-term view.

1.1.3 Conceptual Framework

In order to think about this problem of designing policy to attain longer-term emission reductions, the NRTEE conceptualized our advice as four distinct, though related, elements – emission reduction *objectives*, *targets*, *pathways* and *policies*:

- *Objectives* are essentially those outcomes that Canada is trying to achieve as a nation. For GHGs they can be expressed as long-term global concentrations of carbon dioxide (CO_2) in the atmosphere that are set based on an understanding of how emissions ultimately adversely impact sensitive climate, ecosystem and human receptors. Canada's climate change policy (or GHG emission reduction) objective, therefore, could be Canada's share of global emissions that stabilize atmospheric concentrations of CO_2 at a level that avoids dangerous climate change.[4] For air pollutants, the overall objective is to have clean air. Objectives, while set at a national level, are best expressed as regional and local ambient air quality objectives that will have a direct and real effect on the health of Canadians and ecosystems.

4. The United Nations Framework Convention on Climate Change provides some guidance about the form of an appropriate long-term objective "to achieve the stabilization of GHG concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system." United Nations, United Nations Framework Convention on Climate Change. New York: United Nations, 1992.

- *Targets* are the emission reductions that contribute to the attainment of the objectives. These targets can differ in timing and stringency (or the level of abatement effort required to attain the target).

- *Pathways* (or scenarios) are the preferred trajectories of emission reductions that achieve the national emission reduction targets while maximizing environmental benefits and minimizing economic costs and dislocations.

- *Policies* that achieve the preferred pathway are then based on a careful consideration of a range of policy effectiveness criteria. The selection of policy instruments largely involves consideration of these criteria including breadth of coverage, environmental effectiveness, economic efficiency, political and stakeholder acceptability, and administrative feasibility.

We use these four elements as the basis for organizing and delivering our advice. The next section provides important context that has influenced our GHG advice specifically.

1.2 Important Context and Assumptions of the NRTEE's Greenhouse Gas Advice

The NRTEE understands and acknowledges that the development of Canada's long-term policy response to climate change will not proceed in a vacuum. A number of key considerations – both domestic and international – will influence our national approach. These considerations form the basis for assumptions that the NRTEE views as either existing or necessary to understand how Canada can and should develop policies to achieve deep long-term GHG emission reductions.

We believe it is important to be explicit about what our key assumptions have been throughout our work, because these have an impact on both the scope and nature of our analysis and recommendations. We view the following assumptions as either current (as they arise from current government policy or commitment) or necessary (as they are explicit in our analysis and therefore necessary to framing our recommendations).

Assumption #1: Climate stabilization is the objective

Canada, like every other country in the world, needs to place its domestic efforts on climate change in an international context. Therefore, the overall objective of Canada's climate change policy framework needs to be calibrated to a global objective. The United Nations Framework Convention on Climate Change (UNFCCC) sets as a global objective "to achieve the stabilization of GHG concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference in the climate system." The Intergovernmental Panel on Climate Change (IPCC) has laid out a number of scenarios linking global average temperature increases to atmospheric GHG concentrations.

Although the NRTEE has stated in the past that a 2°C global average increase would constitute a "dangerous" level of climate change for Canada[5] (since a global average increase would translate into higher average temperature increases for Canada, given its northern location), we are not in a position to offer advice on the atmospheric concentration objective to which Canada should be committing. However, what is clear to the NRTEE is that Canada – as a signatory and ratifier – is committed to the overall objective of the UNFCCC, and so is committed to contributing to climate stabilization as part of global efforts on this issue.

Assumption #2: Medium- and long-term goals have been defined

The Government of Canada, through its 2007 *Turning the Corner* plan and associated regulatory framework, has defined medium- and long-term GHG emission reduction targets for the country. To reiterate, the current commitment is a 20% reduction in GHG emissions (relative to 2006 levels) by 2020, and a 60% to 70% reduction (relative to 2006) by 2050. This is the first time a federal government has set forth such long-term GHG reduction targets for Canada.

And so, although we were asked to provide advice on targets for Canada in the original *Reference* from which this report emanates, there has been – in the time that we have been conducting this work – a commitment by Canada regarding both medium- and long-term GHG emission reduction targets.

Assumption #3: Canada has certain unique national circumstances

Most countries can point to national circumstances that have a bearing on their policy response for climate change. Canada is certainly justified in claiming that its own circumstances frame the choices for its own policy framework. The NRTEE has assumed these circumstances as part of its own conclusions and recommendations. These circumstances affect the choice of the most effective, realistic and sensible pathway to achieving deep GHG emission reductions, while ensuring ongoing economic growth and prosperity.

Among the most significant of these are:

- the fact that Canada, as a northern nation with a long coastline and continent-sized landmass, will be among the most impacted countries in the world;
- the fact that Canada's population will continue to grow during the period reviewed in our analysis, a fact not universal to the Western industrialized economies; and

[5] National Round Table on the Environment and the Economy, 2005, "Advice to the Prime Minister in Advance of COP 11." Ottawa: NRTEE.

- the fact that Canada will likely continue to be a net energy exporter during the period reviewed in our analysis.

The latter two points imply that Canada's emissions will continue to grow at levels that are likely higher than other industrialized nations, and so abatement effort will work from a higher base. However, a final national circumstance that Canada is fortunate to have should also be considered – that is the fact that we are one of the wealthiest countries in the world, and are therefore better positioned to bear the costs and risks of GHG and air pollutant emission reduction policies.

1.3 Transition to 2050

The inescapable effects of climate change and air pollution over the next several decades require Canada to embark upon a focused transition to a low-emission society. As we do so, a dominant feature in the global, national and regional economies will be a constraint on GHG and air pollutant emissions. This constraint will necessitate significant changes to energy systems – both in terms of energy production and consumption, as well as the way in which Canadians work and live their lives. The issues of climate change and air pollution will clearly present challenges to Canadians, in terms of our ability to mitigate potential effects, as well as to adapt to changing conditions.

A central question for Canadians, therefore, is, "How can we, as a nation, ensure that the transition to a low-emission future is done in a sustainable manner?"

A central question for Canadians, therefore, is, "How can we, as a nation, ensure that the transition to a low-emission future is done in a sustainable manner?"

As a starting point, while recognizing the need to implement policies now to start us on the emission reduction pathway, we need to equally focus our attention on designing and implementing policies for the medium and longer term. Defining our future direction now is important since it will influence many capital stock and infrastructure investment decisions made over the next decade that will determine whether Canada can effectively and efficiently move to a low-emission (GHG and air pollutant) pathway in the longer term. In this respect, emission reduction policies are also investment-driving policies. Indeed, the policy choices we make now will determine our ability to achieve deep reductions later.

And if we transition successfully to this low-emission future, what would Canada look like in 2050? Recognizing that there is uncertainty about what the future holds, recent NRTEE research[6] illustrates one possible scenario, including, but not limited to some of the following observations:

- Personal use of energy has changed significantly. For example, housing densities have increased to the point where 70% of Canadians live in some form of multiple dwelling, and personal vehicles and homes are much more energy efficient.

- Energy demand and use will continue to rise but energy systems will have transformed.[7] For example, electricity is made by a much more diverse and widely distributed set of generators, including an expanded role for renewables; however, Canada continues to rely heavily on its hydroelectric resources. Where coal is still used to produce electricity, CO_2 capture and sequestration has been designed into the plants and where possible, this captured CO_2 is used to enhance oil recovery. Existing nuclear plants are replaced, with additional capacity added in Ontario.

- Freight distribution has not changed dramatically since 2000. The efficiency of the trucks used to move freight has doubled or tripled over the past four decades and on average biodiesel now provides about 20% of the energy required for the sector.

- The industrial structure in Canada has continued its gradual shift to services and high technology manufacturing, leading to improved energy efficiency across the economy.

This transition need not be forbidding or overwhelming to Canadians. Think back to technological changes in the past 20 to 30 years alone that have changed the way we live and work, but for which we now take for granted – from computers to cellular phones to the Internet in our homes and offices. We have not only adjusted to these major transformations, we have embraced them throughout our society.

The next section explores how we might manage this transition.

6. National Round Table on the Environment and the Economy, 2006, "Advice on a Long-term Strategy on Energy and Climate Change." Ottawa: NRTEE.

7. The International Energy Agency's "World Energy Outlook 2006" reports that by 2030 global energy demand could increase in the order of 40% to 50%. This report looked at a "world alternative policy scenario" that concluded that there will need to be a deployment of a mix of energy technologies including improved energy efficiency, carbon capture and storage, renewables and – where acceptable – nuclear energy. IEA, 2006.

Managing the Transition to a Low-emission Future

2 Managing the Transition to a Low-emission Future

2.1 Enabling Conditions for Managing the Transition

The Government of Canada has announced a set of long-term emission reduction targets for GHGs and air pollutants. If this low-emission vision for the future is to be achieved, Canada will need to embark on a transition of significant proportions to lower our GHG and air pollutant emissions. As Canada transforms, costs will emerge from the need for large-scale investments in low-emission technologies. The avoidance of future damage from both dangerous climate change and poor air quality will be the related benefits. At the same time, the challenge of attaining this vision poses an important opportunity with respect to innovation and technological development. In addressing this vision for Canada, the shared environmental objective is cleaner air and climate stabilization below levels that are considered "dangerous"; the shared economic objective is sustainable growth, prosperity and higher living standards.

To inform the policy debate on how Canada can transition with a view to minimizing economic, social and environmental risks, five key enabling conditions are put forth:

- **Canada will need to act in concert with the world,** where emission targets align with those of the industrialized world, competitive circumstances are taken into account and global emission reduction opportunities are realized.

- **Policy certainty – beyond the short term – is central** to ensure early and sustained action leads to the attainment of both medium-term (2020) and long-term (2050) targets while minimizing economic costs.

- **Strong, consistent and economy-wide emission pricing is required** as soon as possible if cost-effective emission reductions are to be sustained to mid-century and likely beyond.

- **Widespread low-carbon technology deployment will be imperative** if emission reductions targets are to be achieved.

- **Integrated air pollutant and GHG emission policies are necessary** if economic costs and environmental risks are to be minimized.

Even with the adoption of these enabling conditions there are still important economic risks and other uncertainties associated with the transition:

- **Effects on national economic growth are important, but not significant over time,** with the impacts of transition differing in time but ultimately being small relative to the total size of the economy.

- **Regional, northern and sectoral outcomes will not be uniform** and will need to be managed to mitigate disproportionate impacts on regions, sectors and consumers.

Deviation from these enabling conditions will increase the environmental and economic risks identified in this report, especially if an integrated climate change policy is not followed.

2.1.1 A Note on Our Modelling, Assumptions and Caveats

In assembling information to supplement our knowledge and inform our advice, we relied on the CIMS model, an integrated, energy-economy equilibrium model.[8] The CIMS model was used to identify technically feasible and cost-effective abatement opportunities for the medium-term (2020) and long-term targets (2050). CIMS was selected since it simulates the evolution of the energy-using capital stock for 2000 to 2050 across the entire Canadian energy economy under business-as-usual and emission-reduction change scenarios. This modelling construct then allowed us to explore alterative targets and pathways simultaneously to better understand the associated environmental and economic risks of alternatives.

To conduct this "what if" scenario testing, we applied generic emission "prices" in CIMS, which sent a price signal that carbon will be more expensive in the future. The price signal is similar to an emissions tax and/or an emissions cap-and-permit trading scheme, in that both of these instruments can lead to cost-effective emission reductions. The emissions price signal changes the relative cost of fuel and technologies so that a low-carbon technology is deployed and consumer behaviour changes at a level sufficient to achieve the desired emission reduction. Since all in the economy face the same emissions price signal, costs are equalized so that only the lowest cost emissions reductions are selected. In practice this does not always occur but, for setting targets and exploring pathways, it is an appropriate way to conceptualize and model the issue. The emissions price pathways that are modelled therefore indicate the strength of a market-based price required to achieve a given level of emissions reduction. Policy design options, that is, how to send the price signal to achieve cost-effective emission reductions, is then another question that we explored with the model.

8. See Section 5.5 for an explanation of the key attributes and assumptions in CIMS.

The GHG emissions reductions modelled in CIMS can be realized through energy efficiency, fuel switching, carbon capture and storage (CCS) and overall demand reduction. Similarly, the air pollutant emission reductions can be achieved though these actions, as well as through tailpipe controls. The full technical report, with additional modelling details, is available upon request.[9]

Because CIMS is an energy-economy model, the scope of the NRTEE analysis is limited to "energy-related" GHG and air pollutant emissions. These include the emissions of GHGs (primarily CO_2, but also methane and nitrous oxide) that result from the production and consumption of fossil fuels. Approximately 80% of GHG emissions in Canada are covered by our analysis. The remaining non-energy GHG emissions are beyond the scope of this study. For NO_X, SO_X, PM and VOCs, CIMS covers nearly all emissions in Canada except those from open sources (like forest fires, soils and dust from roads).

Finally, an important caveat – the inherent uncertainty that underpins long-term modelling such as this work. We are forecasting a number of factors in the long term and thus there are uncertainties. What follows, therefore, are not predictions of the specific price of carbon necessary to attain deep reductions. Rather, it is advice on important economic and environmental policy fundamentals for long-term air and climate change policy for Canada.

The following sections explore the enabling conditions presented in the previous section.

2.1.2 Canada Acting in Concert with the World

An important enabling condition to minimize both the environmental and economic risks associated with deep emission reductions, and climate change more generally, is that Canada act in concert with the rest of the world in terms of both domestic emission reduction efforts and access to potentially lower-cost international emission reductions. This is particularly relevant as the world considers a post-2012 approach.

With respect to environmental risk, Canada's share of global emissions and hence its contribution to the stock of atmospheric carbon is low, and if action is not taken globally, Canada's efforts alone could do little to stabilize atmospheric concentrations. But since Canada is particularly sensitive to climate change impacts, it is in Canada's national interest to demonstrate its leadership in emission reductions to ensure that it influences the development of an appropriate international emissions reduction regime.

9. Pathways for Long-term Greenhouse Gas and Air Pollutant Emissions Reductions. J&C Nyboer and Associates. July 2007.

A second obvious rationale for Canada not acting alone is that it limits any possible competitiveness risks that might emerge from unilateral action. We believe that the most critical assumption that the NRTEE has made in its work, particularly in our modelling, is that whatever policy framework Canada puts into place, it is comparable to its competitors and trade partners, predominantly the United States. While this is a fair assumption for major industrialized trading partners, such as Europe and California, which have already made medium- and long-term emission reduction commitments, there is uncertainty with respect to action by the so-called BRIC countries (Brazil, Russia, India and China). If our major trading partners, particularly the United States, do not implement comparable policies within a reasonable time frame, the economic risk of the deep domestic reductions investigated in this report rises.

At the same time, domestic action by Canada can take advantage of potential linkages to policy instruments adopted internationally – in particular emissions trading – and so in theory can reduce the overall costs of achieving deep GHG reductions. The NRTEE views this as particularly imperative given the deep long-term reductions contemplated and the associated high domestic emission reduction prices that are revealed below.

It is not the NRTEE's view that any of this should be justification for Canada not taking action now to either reduce emissions now, or put in place the most effective policy framework for deep, long-term reductions in the future.

2.1.3 Policy Certainty Beyond the Short Term is Central

Targets and Pathways

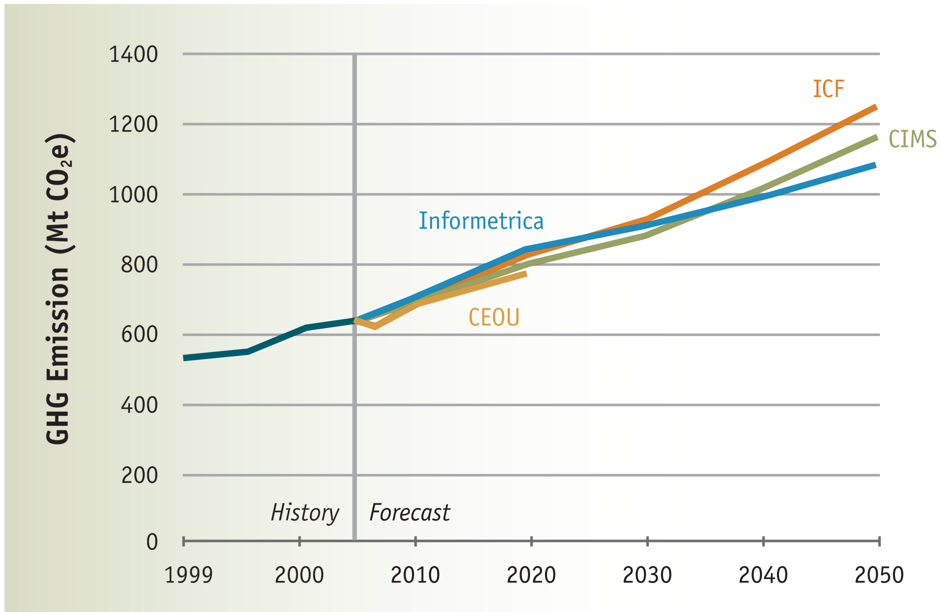
In the absence of government interventions, substantial increases in Canada's GHG emissions can be expected through 2050, primarily as a result of natural resource development and economic growth. GHG emissions in 2020 could be in the order of 65% greater than 1990 levels and according to our projections will be more than double 1990 levels by 2050 (Figure 1).

Consistent with the *Reference*, the NRTEE examined the implications of long-term GHG emissions reductions of 45% to 65%[10] (from current levels) by 2050.[11] Our examination of the implications of these targets points to a trade-off between environmental effectiveness and economic efficiency. The following section explores these trade-offs.

10. The NRTEE analysis is based on *absolute* emission reduction targets, not *intensity-based* targets.

11. In this report, all estimates of emissions exclude agricultural land use, waste, solvent, hydrofluorocarbons (HFC) and some other non-energy emissions and therefore covers ~80% of total Canadian GHG emissions.

Figure 1: Comparison of "Business-as-Usual (BAU)" forecasts for GHG emissions (excluding agricultural land use, waste, solvent, HFC and some other non-energy emissions; this covers ~80% of total GHG emissions).



Notes: CIMS is our forecast. ICF forecast comes from NRTEE, 2006, "Advice on a Long-Term Strategy on Energy and Climate Change," Ottawa: NRTEE. Informetrica forecast comes from Informetrica, 2007, "Projection of Total GDP for the Long term." CEOU forecast comes from Analysis and Modelling Division, 2006, "Canada's Energy Outlook: The Reference Case 2006," Ottawa: Natural Resources Canada.

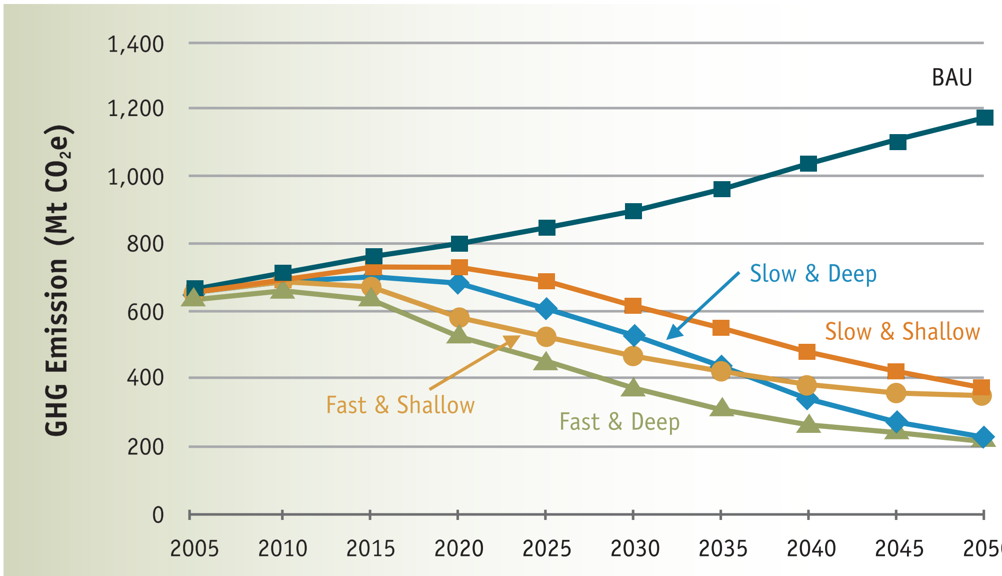
Four GHG emission reduction scenarios were evaluated for two different targets (45% and 65%), and two different GHG price path scenarios ("slow" and "fast")[12] (Figure 2). A "slow" start sought a pathway to meet the 2050 target by stabilizing emissions in 2020. A "fast" start also met the 2050 target, but aimed to reduce emissions in 2020 in the order of 20% below 2005 levels. Alternative GHG emissions price trajectories were then revealed by the modelling for these four pathways (Figure 3).

The primary finding from the NRTEE's research on these alternative pathways is that reducing GHG emissions by 45% and 65% by 2050 is achievable using current abatement options such as energy efficiency, fuel switching, renewables and CCS. This finding is consistent with many other recent studies including one by the NRTEE.[13]

12. In the scenarios modelled here, this is a price that applies throughout the economy and begins immediately. The model did not necessarily simulate an "optimal" emissions price trajectory; instead, it simulated a GHG price trajectory that is shown by the model to achieve the given target.

13. National Round Table on the Environment and the Economy, 2006, "Advice on a Long-term Strategy on Energy and Climate Change." Ottawa.

Figure 2: GHG emissions forecasts in business-as-usual and the alternative prices scenarios (excluding agricultural land use, waste, solvent, HFC and some other non-energy emissions; this covers ~80% of total GHG emissions)



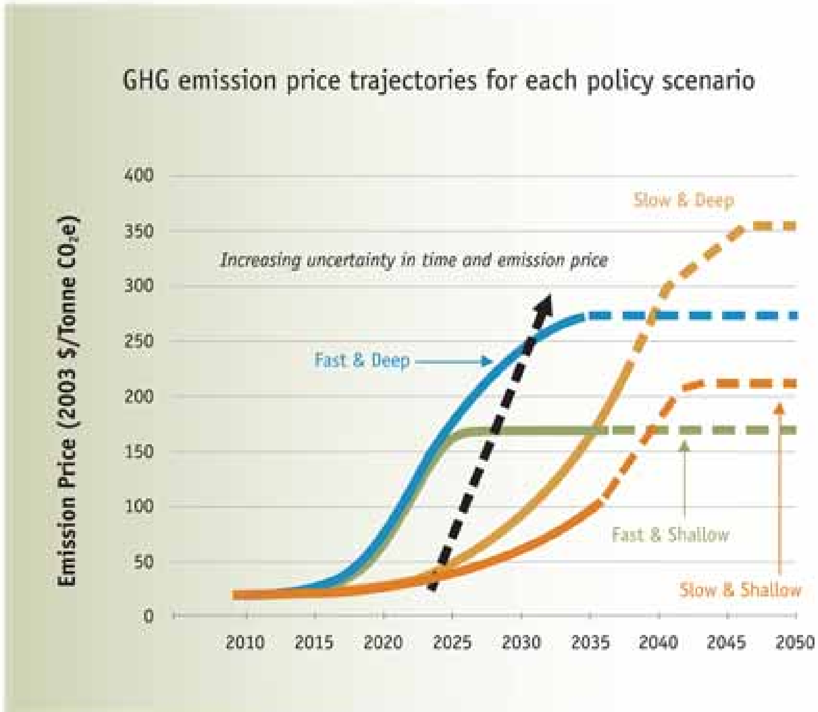
Another important observation is that a strong, economy-wide price signal is required – regardless of pathway – to get at the substantial GHG reductions contemplated for 2050 (Figure 3). The modelling suggests that GHG prices in the range of $190 to $240 (in 2003 Canadian dollars) per tonne of carbon dioxide-equivalent (CO_2e) are required to attain a reduction of 45% from 2005 levels by 2050 if Canada were to meet the target using domestic actions only. These price ranges are similar to GHG emission prices reported in other studies. For example, a study by the IPCC (2007) suggests that GHG prices in the range of US$15 to $130/tonne CO_2e are required to attain a global reduction of approximately 20% from 2005 levels by 2050.[14] Our research is an analysis of much deeper reductions for Canada without international emissions trading, which explains our higher emissions prices. That said, they are of a similar magnitude.

An important caveat is that all emission prices predicted beyond the year 2025 are speculative (greater than $200/tonne); there is no doubt a great deal of uncertainty exists regarding the price of GHG abatement. At higher carbon prices, there is no way to accurately predict how the markets will react or how innovation will accelerate in response. These two factors alone could significantly affect the emission price. Similarly, the domestic emission price will be

14. IPCC, 2007. "Climate Change 2007: Mitigation of Climate Change," World Meteorological Organization/United Nations Environment Program, New York: Cambridge University Press. The IPCC (2007) report does not specify a GHG price required to attain a given emissions reduction; it reports a GHG price required to attain a stabilization in the atmospheric concentration of CO_2e at around 550 ppm. The range of emissions reductions required to attain this concentration of CO_2e is estimated to be between 0% and 35% from 2005 levels by 2050.

influenced by international emission prices and market conditions. Hence the prices are depicted as dotted lines in Figure 3 at higher levels and further into the future.

Figure 3: GHG emission price trajectories for each policy scenario



Note: See Section 5.5 for the key scenario assumptions in CIMS, including starting energy prices for natural gas, electricity, coal, gasoline, oil and other refined petroleum products.

Pathway Trade-offs

The NRTEE research demonstrates that the choice of pathway to a low-GHG emission future involves trade-offs between environmental objectives and economic outcomes, as is illustrated in Figures 2 and 3. Clearly there is a potential for greater economic cost (in terms of $/tonne CO_2e) associated with deeper (65%) GHG emission reductions. In considering these trade-offs, the NRTEE found that any delay in abatement action sooner rather than later could lead to three specific risks:

- not attaining deep emission reduction targets;
- higher economic costs; and,
- higher cumulative GHG emissions.

Risk for target non-attainment

The scenarios in our research illustrate that if GHG emissions are to be reduced by 65% from current levels in 2050, absolute emissions reductions of at least 20% are necessary by 2020.[15] Furthermore, the research suggests that a delay in action will likely result in not attaining the 2020 target. This "non-attainment" risk exists because there is a high rate of capital stock turn-over in the period from 2020 to 2025. There is an opportunity now to shift the economy onto a lower emissions path because capital investment decisions for new lower-emissions technologies are already being made today. If we miss this opportunity to deploy lower emitting technologies, the economy will most likely become locked into a future emissions path from which reductions to the 65% level will either be extremely costly or simply unattainable. An early, strong and certain emission price is therefore a critical enabling condition to influence technology choice in capital stock to be replaced between now and 2025.

Higher emissions price

Figure 3 illustrates that for the 45% and the 65% targets, the "slow" start requires a significantly higher emission price in the latter years to compensate for the low price at the start (which allows emissions to continue to increase). Conversely, the "fast" start requires a higher emission price in the medium-term (2020), which results in a lower emission price over the long term but results in greater emission reductions in the earlier period.[16]

"The scenarios in our research illustrate that if GHG emissions are to be reduced by 65% from current levels in 2050, absolute emissions reductions of at least 20% are necessary by 2020."

The research concludes that a delay in action in reducing emissions will likely result in the need for higher emission price to achieve the targets. Since expected future emission prices will influence investment decisions now, long-term policy certainty is a key element of a successful transition strategy. There is, therefore, a need for government to clearly and consistently communicate that an economy-wide emission price will occur, and will escalate appropriately on a scheduled basis from now to mid-century to allow for planning, investment in new technologies, and sectoral and consumer transition.

15. This analysis did not contemplate a scenario in which a later and more vigorous ramp-up of CCS and nuclear energy might occur post-2020, and whether such a scenario might achieve a 65% reduction target in 2050.

16. Note that the prices shown here are not meant to be exact or prescriptive, but demonstrate trade-offs between early and late actions.

Higher cumulative emissions

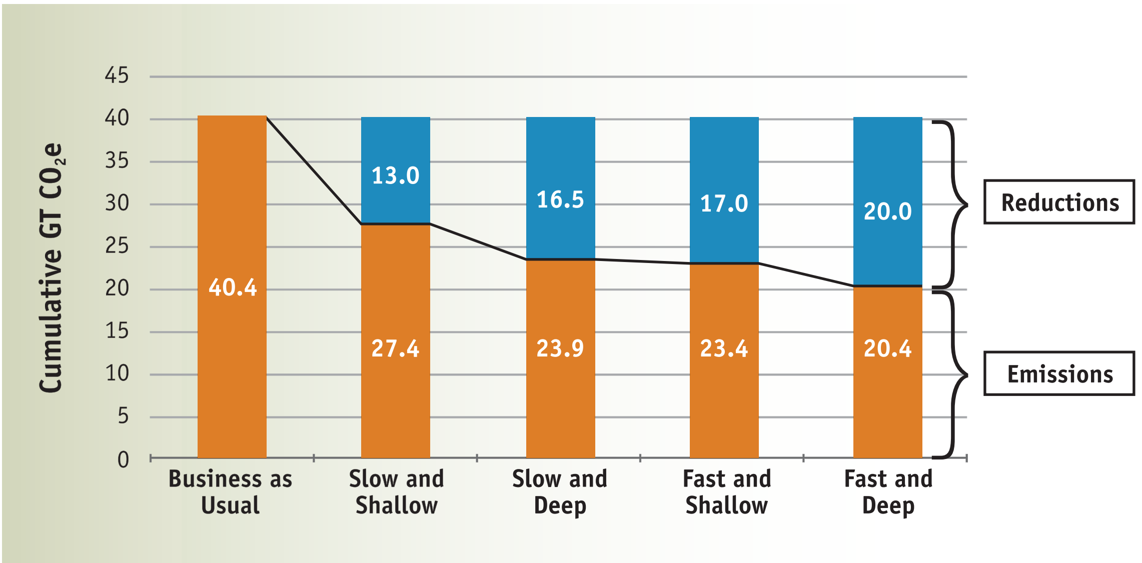
While annual targets in the medium and long term are important, it is critical to keep in mind that the cumulative emissions between now and 2050 will influence the stock of carbon in the atmosphere into the next century. Figure 4 illustrates the cumulative GHG emissions from now to 2050 in the BAU scenario and each of the four policy scenarios, as well as the cumulative emission reductions for comparison.

With the BAU scenario, GHG emissions released to the atmosphere are predicted to be in the order of 40 gigatonnes (Gt). Emission reductions from the BAU are 13 Gt (slow and shallow), 16.5 Gt (slow and deep), 17 Gt (fast and shallow), and 20 Gt (fast and deep). In our most aggressive scenario, cumulative emissions are reduced by about 50% for the entire period to mid-century. Figure 4 also illustrates that the more aggressive scenarios, with "fast" starts, reduce cumulative GHG emissions significantly more than the pathways where the start is delayed. This leads to the conclusion that, even though the "fast" and "slow" pathways can be designed to reach the same annual target, the overall additions to the stock of atmospheric carbon will be less for a fast start relative to a slow start. This "savings" between now and 2050 are equivalent to about four to five years of the Canadian GHG emissions under the business-as-usual scenario or about 3,500 to 4,000 Mt of CO_2e.

"This "savings" between now and 2050 are equivalent to about four to five years of the Canadian GHG emissions under the business-as-usual scenario or about 3,500 to 4,000 Mt of CO_2e."

In choosing a GHG emission reduction pathway, one should consider not only the annual reduction target, but the potential cumulative emission reductions associated with the pathway.

Figure 4: Cumulative emissions and reductions in the BAU and the alternative GHG pathways, 2006 to 2050 (excluding agricultural land use, waste, solvent, HFC and some other non-energy emissions; this covers ~80% of total GHG emissions).



2.1.4 An Economy-wide Emission Price with Complementary Policies

With the conclusion that an economy-wide signal is needed sooner rather than later and that it needs to be certain, the question then becomes how to send such a broad and strong signal. While voluntary programs, information programs, subsidies and targeted regulations may result in some emission reductions, they simply cannot deliver the deep 65% reductions currently contemplated for Canada. Therefore, the NRTEE concludes that an economy-wide emission price policy will need to be the main policy lever.[17] This price policy will not be fully effective on its own, and thus complementary policies will also be needed. This leads the NRTEE to observe that in order to successfully transition, Canada will need to:

1. Implement a strong, consistent long-term emission price signal across the entire Canadian economy. Applying the emission price broadly ensures an equitable distribution of cost while seeking reductions from all segments of the economy; and

2. Complement emission pricing with targeted measures. These could include regulations, strategic investments in infrastructure, and support for research, development and demonstration programs that address areas where the price signal is less effective. To a lesser extent

17. National Round Table on the Environment and the Economy, 2005. "Economic Instruments for Long-term Reductions in Energy-based Carbon Emissions." A key finding of this research was that the use of economic instruments, such as tax measures and tradable permits, was the most effective and efficient means of achieving long-term GHG emission reductions.

information programs will be required to educate Canadians and build support so that individuals will take action on climate change.

There is a critical need to instill confidence in the policy direction over the long term by clearly and consistently communicating these policies of economy-wide emission pricing and targeted measures. An early and clear price signal is needed in order to influence the investment, production and consumption decisions of industry and consumers today that will shift Canada onto a pathway to reduce GHG emissions over the long term. This is strongly linked with the issue of capital stock turnover within the entire economy. As discussed above, decisions are being made *today* that will determine the technology and capital stock that will persist in the Canadian economy for the long term. Many of these decisions subsequently affect the level of released emissions. If investors and business leaders are confident in the future policy direction of governments, then they will be able to make better-informed decisions regarding their capital stock and technology choices and can cost them accordingly. Therefore, policy certainty regarding the future regulatory regime is central to a successful transition.

"An early and clear price signal is needed in order to influence the investment, production and consumption decisions of industry and consumers today that will shift Canada onto a pathway to reduce GHG emissions over the long term."

Choosing an Appropriate Emission Price Policy

The choice of the preferred emission price policy involves considering either a tax on emissions,[18] a cap-and-trade system[19] or a combination of the two. A GHG emissions tax imposes a price on each unit of CO_2e emitted by a source, whereas a cap-and-trade system is a regulatory program under which government sets a limit on the volume of GHG emissions, distributes permits for allowable emissions and enables firms to buy and sell the permits after the initial distribution. Both options are market-based in that they transfer abatement decisions to emitters, and both will signal that GHG emissions have a monetary value, stimulating actions that will lead to emission reductions.

18. We use "tax" in this report; however, this could also be referred to as a levy or a charge since we have not defined what the "tax" would involve with respect to recycling considerations.
19. Also referred to as "emissions trading program" or other related nomenclature.

Our research did not determine a single "best" option between these two market-based price signals – each has its strengths and limitations when it comes to scope of coverage, administrative ease, economic efficiency, cost certainty, reductions certainty or other factors. While a government's selection of the preferred emission price policy requires an assessment of these numerous trade-offs, the NRTEE's research is focused on their ability to deliver deep, long-term emission reductions, in short, on their environmental effectiveness and economic efficiency. Essentially, the policy imperative to ensure a successful transition is to assemble an emission price policy package with complementary measures that deliver sustained emission reductions to mid-century at the lowest possible cost to the economy.[20] The specific policies we assessed include the following:

"Essentially, the policy imperative to ensure a successful transition is to assemble an emission price policy package with complementary measures that deliver sustained emission reductions to mid-century at the lowest possible cost to the economy."

1. An economy-wide emission tax;

2. A downstream cap-and-trade system (with broad offsets and a complementary emission tax); and

3. An upstream cap-and-trade system.

How these options might be designed is first explained and their expected relative performance is then evaluated.

1. Economy-wide tax on GHG emissions

An economy-wide tax on GHG emissions could take one of two forms. It could require importers, producers and distributors of fossil fuels to pay a fixed fee on the CO_2 contained in fuel sold and/or it could require emitters to pay based on their actual emissions. Importantly, this latter case would provide the impetus for Carbon Capture and Storage (CCS). An emission tax, unlike a

[20] This report only considered domestic options and did not consider international options. We have noted that access to international mechanisms may lower domestic costs, depending upon circumstances.

[21] This will be particularly important for Northern Canada.

cap-and-trade scheme, does not provide certainty in meeting a given emissions reduction target, because emitters have flexibility to pay the tax or to reduce emissions. As a result, it will likely be necessary to adjust the level of the tax over time to meet a given emission target. It does, however, provide price certainty where the tax level ensures the cost burden is known and fixed in advance of the policy.

The impact of the tax on energy exporters would not be clear-cut and would depend on their ability to pass on the carbon cost of producing the energy exported to international energy markets. They would not, however, be taxed on the embodied carbon in the exports.

Since all domestic fossil fuel would be taxed based on its carbon content or actual emissions, a significant amount of revenue would be raised in addition to the abatement effort undertaken. There would be a need for government to consider how to recycle revenue back to emitters, including firms and households. There are many forms that recycling could take, including compensating adversely impacted firms and segments of society,[21] proportionally returning revenue based on tax paid, reducing other labour or capital taxes, or investing in technology and innovation.

While the NRTEE is not proposing a particular emission tax design, we are aware of the very sensitive issues associated with developing and instituting a new tax such as this. Our early take on the principles associated with an emissions tax include:

- ensuring it is applied economy-wide for maximum efficiency and to keep the price as low as possible;
- having a recycling component so the revenue is returned to the regions, sector and consumers that pay it;
- linking, in the first instance, the revenue to specific technology development and application aimed at GHG emission reductions;
- computing, accounting and auditing the revenue and its distribution in a fully transparent manner; and
- considering the benefits of broader-based tax relief for taxpayers as part of this tax-shifting effort.

2. Downstream cap-and-trade system

A downstream emission cap-and-trade (DCT) system sets an aggregate *cap on emissions from large industrial emitters*. In this system, the total number of permits allocated to emitters is equal to the overall cap on emissions. At the end of each year, all firms must remit one permit to the government for each tonne of CO_2 emitted during the year (or each tonne of embodied CO_2 in purchased fuels, depending how emissions are measured). Permits can be traded from one emitter to another, which should result in cost-effective emissions reductions provided transaction costs are not prohibitively high and the permit market functions well.

The DCT system modelled by the NRTEE differs from the current federal government plan in a number of ways. First, the NRTEE scenario sets an absolute cap on emissions, whereas the government plan involves an intensity-based system.[22] Second, the NRTEE scenario also differs from the federal plan in that it does not consider credits for early action, international offset credits or credits for investments in technology.

A DCT system would be applied most effectively to a subset of large emitters because of the difficulty in monitoring emissions from small sources, as well as the potential transaction costs involved with emissions trading from small sources. The federal government has been in the process of developing a DCT with approximately 700 large industrial firms (known as the large final emitters or LFE), representing close to half of total Canadian emissions. Unlike the scenario we assessed, the system currently under development by the government is intensity-based because it reduces the emissions per unit output of the large final emitters but does not cap overall emissions, which can grow with increasing economic output.

Because the DCT system only covers about half of Canada's energy-based emissions, we added two other policies in our scenarios and modelled these also: domestic offsets and carbon tax. This was done in an attempt to send a comprehensive price signal that would reduce GHG emissions in sectors not covered under the cap. Carbon offsets would enable individuals and businesses to reduce the CO_2 emissions they are responsible for by paying for GHG reductions in another place, typically where it is more economical to do so. Carbon offsets typically include renewable energy, energy efficiency and reforestation projects. Because these subsidy-type programs are never as effective, we account for the failure rates in our estimates. A second case – a broadly applied emission tax – was also assessed as a complement to the DCT. Because the industrial emitters are covered by the emission price under cap and trade, the tax would need to be designed to provide exceptions, such as tax rebates, for emissions covered by the DCT.

3. Upstream cap-and-trade system

Under an upstream cap-and-trade system (UCT), the government sets an aggregate *cap on the amount of carbon content in the fossil fuel* that can be sold by Canadian energy producers and importers, and allocates tradable permits to all entities covered by the program. The trading scheme would be imposed at the "upstream" points of fossil fuel production, at the level of the oil refinery, natural gas plant, and coal mine mouth (as well as directly on energy importers). The government issues permits equal to the total level of emissions allowed by the cap. Participating firms can then

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22. The DCT assessed in this report also differs from the federal government's DCT in that we set an absolute cap on emissions, and then added broad offsets and a carbon tax to the DCT.

trade permits among themselves in an established market, which should result in cost-effective emissions reductions, provided transaction costs are not high and the market functions well.

A UCT would cover almost all energy-related emissions, thus decreasing impacts on any particular economic sector and reducing the potential for pressures for offset measures that weaken the end result of any signal. With fewer participants, it also might be less administratively burdensome than a system involving downstream users. While no countries currently are implementing a UCT, such an approach should mesh well with international systems, providing permits are transferable between systems. This option has appeal because of its simplicity and the breadth of coverage across the entire economy.

Comparison of Market-based Policy Packages

To compare the three emission price policy packages, identical emission price paths were applied in the model to determine the performance of each package relative to a target of 65% below current levels in 2050. The emission price path gradually increased from \$20/tonne in 2015 and was then capped at \$200/tonne of CO_2e from 2030 onward. This upper limit on the price recognizes that there might be resistance to high emissions prices, international permits might be available and that some sectors are insensitive to price signals, notably buildings and transportation. But this price cap is below the level required for the deep reductions in our scenario, and thus in all policies there is a gap between the target reductions and the policy reductions. The size of this gap is a measure of the relative performance of each of the policy packages and enables a consistent comparison by fixing the overall cost while allowing policy emissions to vary.

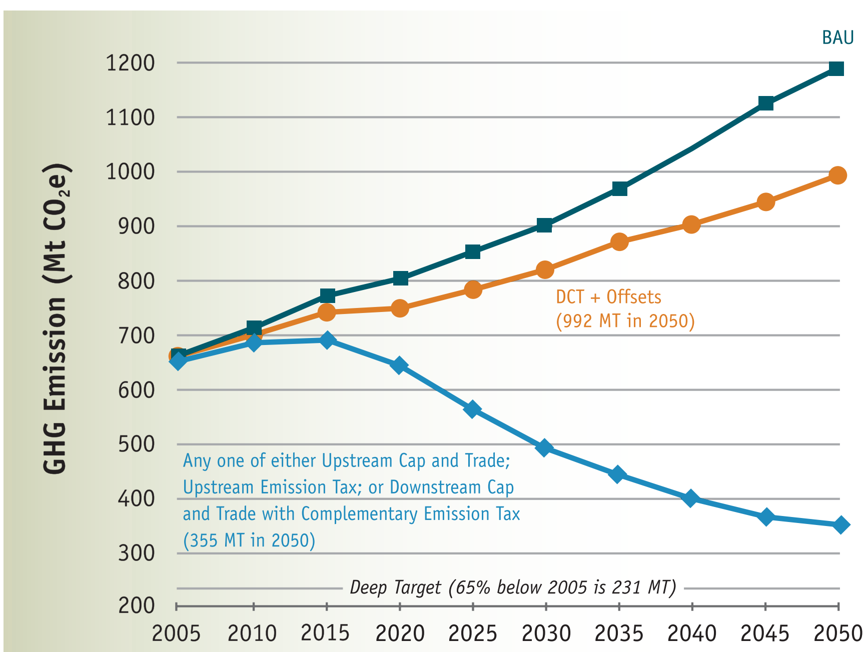
> "These results lead to one core conclusion: broadly applied carbon price policies– starting with a modest price signal that will predictably escalate over time – all have the potential to deliver cost-effective and deep emission reductions."

Figure 5 shows the expected GHG reductions for each of the policy packages. The orange line shows the expected reductions from a DCT with broad offsets. The single light blue line shows the expected reductions from either a UCT, or an upstream tax, or a DCT with a tax – that is, all of these policy packages result in essentially the same emission reductions.

One observation is that the DCT system complemented with broad offsets is the least effective of the policy packages (see DCT + offsets). Emissions are reduced in 2050 in comparison with the BAU scenario, but continue to rise overall. The DCT system only covers about half of the economy's emissions, while the broad offsets system is ineffective because it provides incentives to technology and behaviour that would likely have occurred in the absence of the offsets system (i.e.,"free-riders"). While offsets seem to be a feasible short-term strategy, their use in the longer term does not align with our observation that an economy-wide price signal is necessary to ensure a successful transition.

If the NRTEE's broad projections for the DCT system prove to be the case, Canada will also need a policy signal that is broader in scope, more stringent and administratively simpler. In that event, options include adding a carbon tax for uncovered sectors to the downstream trading system, or moving to an economy-wide tax or an upstream trading regime. If the DCT were complemented with a carbon tax (CTax) on the remaining sectors not covered by the DCT, the effectiveness could be expected to increase substantially (see Figure 5). The research shows that the complementary tax decreased emissions threefold. Similarly, the UCT and economy-wide emission tax (Upstream Tax) will be more effective than a downstream system with broad offsets but on par with the DCT plus CTax.

Figure 5: GHG reduction paths of the market-based policy options (excluding agricultural land use, waste, solvent, HFC and some other non-energy emissions; this covers ~80% of total GHG emissions)



Note: DCT is downstream cap-and-trade, UCT is upstream cap-and-trade, DCT with CTax includes complementary carbon tax on remaining emissions. Offsets is a system of broad economy-wide emission reductions for sectors not covered by downstream cap-and-trade systems.

These results lead to one core conclusion: broadly applied carbon price polices – starting with a modest price signal that will predictably escalate over time – all have the potential to deliver cost-effective and deep emission reductions. There is no single-best carbon price policy if applied broadly and consistently. Selection of the appropriate market-based policy will require trade-offs between competing policy evaluation criteria; no one policy design is optimal in terms of all criteria based on the research we have conducted.

This leads to the key point, mentioned previously, that policy design matters. More detailed analysis and, perhaps more importantly, a focused dialogue with industry, the public and other stakeholders is needed before any emission price policy option is either abandoned or embraced. While there are many critical design considerations, an important aspect of the policy design will be the consideration of potential compliance mechanisms, particularly as they relate to industry and other stakeholders who will be required to meet mandatory GHG emission reductions.

Complementary Policies

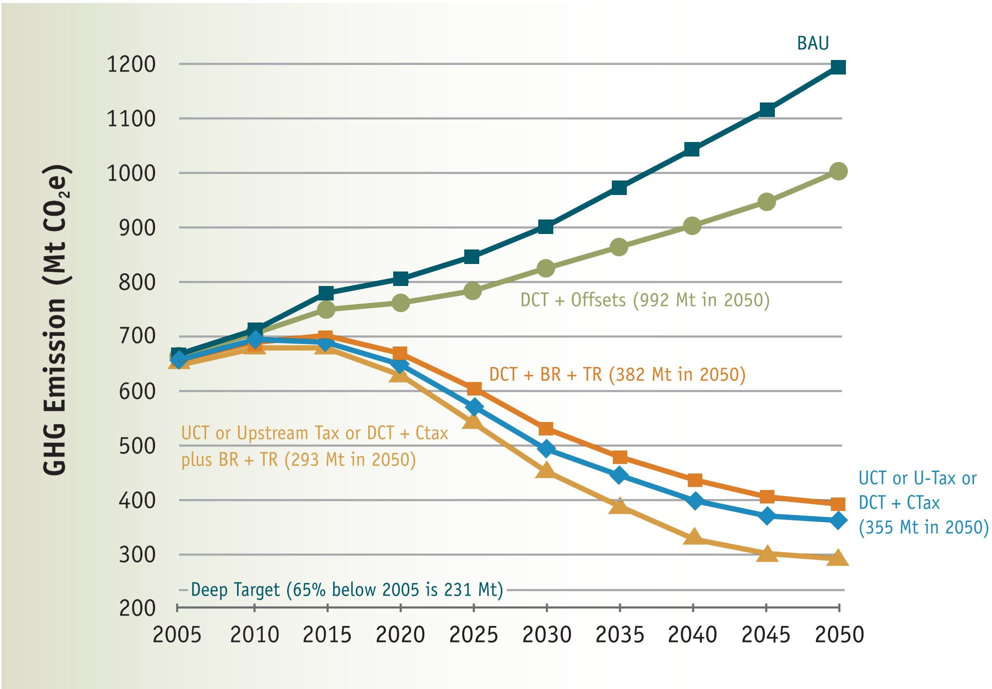
While the broad price signal policies (i.e., tax or cap-and-trade) would form the core of an emissions reduction policy package, other complementary policies will be required to address hard-to-get-at emissions. Our research shows that, while most of the options result in significant emission reductions, these will not fully attain the defined target of 65%. As a result, there will be a need for complementary policies to attain further emission reductions by 2050; specifically regulatory mechanisms that will force GHG emission reductions from parts of the economy that may not respond to a price signal. These gaps arise through the following:

- market failures and other barriers that reduce the responsiveness of certain sectors to changes in emission costs – particularly in the transportation and building sectors—and some consumer markets such as vehicles, houses and appliances; and

- emissions from sectors of the economy not covered by the broad price signal, including agriculture, forestry, waste and portions of the upstream oil and gas extraction system (such as fugitive emissions of methane from oil and gas wells and coal mines, and gas leaks from pipelines).

The complementary policy toolkit includes policies such as regulatory standards, subsidies and infrastructure investments. To assess the effectiveness of possible complementary policies, a series of regulations in the building and transportation sectors were combined with the market-based options. The resulting GHG emission reduction pathways are shown in Figure 6.

Figure 6: GHG reduction paths of the market-based policy options with complementary regulatory policies (excluding agricultural land use, waste, solvent, HFC and some other non-energy emissions; this covers ~80% of total GHG emissions)



Note: DCT is downstream cap-and-trade, UCT is upstream cap-and-trade, DCT with carbon tax includes complementary carbon tax on remaining emissions. BR is building and equipment regulations. TR is transport (freight and passenger) regulations. Offsets is a system of broad offsets for sectors not covered by the downstream cap-and-trade system.

Figure 6 shows that more reductions occur when targeted regulations complement broadly applied carbon prices, with building regulations (BR) and transport regulations (TR) increasing the effectiveness of all policies. Importantly, the addition of building and transportation regulations results in significantly more reductions when added to the DCT-plus-Offsets package (resulting in approximately 600 Mt further reductions in 2050) and when added to any one of the UCT, upstream tax or DCT plus tax (resulting in approximately 90 Mt additional reductions).

This shows that regulatory policies can be very effective in closing gaps between actual emissions and targets when some segments of the economy are insensitive to emission prices.[23] This gap could be closed further through international purchases of emission permits, provided the international price was below the cost of domestic reductions and real reductions could be assured.

23. Since the price signal was capped, there is a gap between the annual target emission reductions for 2050 (231 Mt) and what each of the policy packages delivers given the emission price assumptions.

There is, currently, uncertainty regarding the extent to which lower-cost emission reductions will be available internationally. That said, the NRTEE analysis supports policy that enables access to international purchases of real emission reductions, whereby such reductions reduce the domestic cost burden.

In conclusion, if deep long-term GHG emission reductions are to be achieved, the federal government needs to send a clear, consistent and economy-wide policy signal that places a price on GHG emissions sooner rather than later. The only effective and efficient policy that would result in deep GHG emission reductions is a market-based policy, such as a tax, a cap-and-trade system or a combination of the two. These mechanisms are the most effective and efficient means to send a signal throughout the entire economy. This core policy then needs to be complemented by other regulatory policies, which may force emission reductions from parts of the economy that do not respond to a price policy. Strategic investments in infrastructure and R&D investments will also be necessary. Offsets would be phased out over time as the price signal is transmitted more broadly in the economy.

Policy Sequencing and the Transition

The NRTEE's conclusion that a market-based policy applied broadly throughout the economy, complemented with other targeted policies such as regulations, is supported by previous NRTEE research.[24] These previous reports also conclude that policy design is critical and is a major determinant of important policy outcomes such as economic efficiency, environmental effectiveness, political acceptability and administrative feasibility. While there are policy trade-offs among these important considerations, a package of emission reduction policies designed to balance these considerations has the best chance of success.

We now add to these observations the importance of sequencing policy to ensure a successful transition. Any emission price policy implemented in the medium term (2020) will need to dovetail with the government's currently proposed domestic emission trading (DET) system for the large emitters. It is therefore reasonable to consider the DET as a starting point for policy sequencing to the long term. Issues that will have to be addressed include expanding the sectoral coverage to bring in more emission sources (it currently covers about only 50% of national GHG emissions), and ultimately moving from an intensity-based system to absolute binding caps.

Given the pricing options we have evaluated, our research indicates that either (1) an upstream-cap-and-trade (UCT) system will need to replace the DET, or (2) a complementary

24. Cairns, S., 2006. "Long-term Energy And Climate Change Strategy: Advice on Scoping of Phase II Research, Wrangellia Consulting. Final Report submitted to the National Round Table on the Environment and the Economy"; Marbek Resource Consultants, 2006, "Long-term signals for deep greenhouse gas emission reduction," Final Report submitted to the National Round Table on the Environment and the Economy; MK Jaccard and Associates, 2006. "Advice on a long-term strategy on energy and climate change: Phase 2," Final Report submitted to the National Round Table on the Environment and the Economy.

emission tax be added to the DET. In the first instance, the broad-based emission price will necessarily involve expanding trading from the downstream to the upstream. This would mean that the currently proposed intensity-based system would have to move upstream to energy importers and producers sooner rather than later.

Alternatively, in the second instance, we see an opportunity to treat an emission tax and the DET system as complements since our analysis reveals advantages and disadvantages of both policies. Importantly, a major strength of an emission tax is to achieve a wide breath of coverage in the uncovered sectors. Administrative ease, price certainty and low transaction costs further support the case for a complementary emission tax. We observe therefore that there are good reasons to consider implementing an emission tax concurrently with the DET system.

In addition to consideration of the pricing policy shifts, the sequencing of the complementary policies will also need some attention. First, the current slate of regulations will need to be expanded to more fully address sectors such as transportation and buildings. Support for research, development and demonstration programs will be important so that innovation can occur and technology can be deployed as soon as possible. Finally, strategic infrastructure investments will need to be made as soon as possible, and will necessarily need to increase as we move out to 2020.

"An adaptive management approach will need to be adopted so that progress is monitored and policies are adjusted to match the required level of abatement effort, and also to minimize and mitigate adverse outcomes on certain groups or regions."

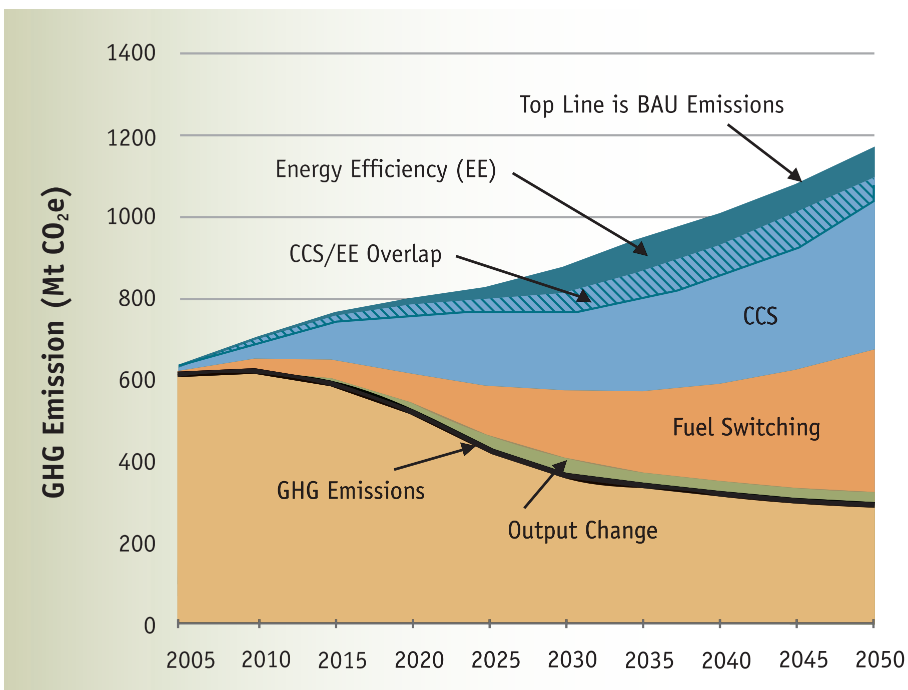
As we move forward in time, sequencing will require that the stringency of all policies be increased. An adaptive management approach will need to be adopted so that progress is monitored and policies are adjusted to match the required level of abatement effort, and also to minimize and mitigate adverse outcomes on certain groups or regions. Adaptive management is a systematic process for continually improving policies and practices by learning from the outcomes of operational programs. Essentially, it is the integration of design, management and monitoring of policies and programs to regularly verify their effectiveness in order to learn and adapt accordingly.

While we point to some initial observations regarding the transition from the short- to the medium-term policy regime, we are careful to note again that we have not evaluated the federal government's proposed regulatory plan, and that these are general observations are based on our current research agenda. This transition is an important consideration for the design and implementation of the medium- and long-term policies and therefore require further investigation.

2.1.5 Technology Deployment Will Be Imperative

When we contemplate the deep GHG reductions it becomes apparent that the scale and scope of the necessary technology deployment is significant and perhaps unprecedented in the modern industrial era. This leads to our key "technology" observation that attaining medium- and long-term targets will require widespread deployment of low-carbon technology in all segments of the economy. This assertion is supported by previous NRTEE work in 2006,[25] which concluded that deep GHG emission reductions are attainable from a technological standpoint using existing and foreseeable commercially available technology (CCS falls within the latter category).

Figure 7: GHG reductions "wedge" for 20% reductions by 2020 and 65% reductions by 2050 (as demonstrated through the "fast start" scenario)



Note: CCS represents the carbon capture and storage wedge. CCS/EE represents the carbon capture and storage (CCS) and energy efficiency (EE) overlap. The fuel switching wedge represents the contribution of switching from coal to oil products to natural gas to electricity; this portion also includes the contribution of renewables (wind, hydroelectricity, etc.) and nuclear power. The output wedge represents the GHG reductions due to lower physical output.

25. National Round Table on the Environment and the Economy, 2006, "Advice on a Long-term Strategy on Energy and Climate Change." Ottawa.

Our current work supports the assertion that there are technologically feasible opportunities in areas such as energy efficiency, switching fuels to less carbon-intensive sources, CCS and overall demand reductions (output such as energy conservation and activity such as kilometres travelled).[26] Figure 7 provides an overview of the scale of the technology deployment that underpins the emission reductions in our fast and deep pathway.[27] Each wedge indicates the technology effort required from current levels to attain the deep long-term reductions.[28]

While our knowledge, modelling and intuition tell us that technically we possess the capacity to achieve substantial emission reductions, there are some important risks or barriers to deployment:

- *Technologies such as CCS are largely untested on a massive scale, yet represent a significant abatement opportunity.* While small-scale CCS has been proven, the scalability of these small initiatives is untested. Importantly, technology demonstrations and infrastructure investments are required sooner rather than later to move the knowledge base forward on CCS.

- *The enabling conditions for large-scale technology deployment are not fully developed; there is a need to develop a supportive public policy framework and new regulatory systems, and to remove existing regulatory barriers.* Both of these speak to a need for governments to systematically seek ways to reduce impediments to the private sector deploying low-carbon technology while at the same time implementing new processes to facilitate deployment.

- *There may be development bottlenecks in terms of technology, labour and material availability* such as those currently experienced by the upstream oil and gas sector in Alberta. Year over year, growth rates in ethanol and other biofuels will also need to climb steadily, raising important questions about scalability and non-GHG air impacts such as increased particulate matter. Planning for these bottlenecks then becomes an important task for governments and the private sector alike.

- *The scope of the required technology deployment in virtually all areas of the economy limits the reliance on a technology silver bullet that can emerge and then solve the problem.* The 40-year period may be too short for significant technological breakthroughs to permeate the economy fully and thus radical backstop technologies are unlikely, even with high emission prices that trigger significant R&D and innovation.

- *Behind the technology deployment story is the need to make choices.* Individual choices will need to change or be changed to stimulate the necessary widespread investments in low-carbon

26. CIMS represents the economy's input and output based on energy supply, energy-intensive industries, and key energy end-uses in the residential, commercial/institutional and transportation sectors. Technologies are limited to those foreseen as likely to become commercially available in the time frame of the analysis.

27. See Section 5.5 for a discussion of the attributes and assumptions of CIMS.

28. The NRTEE's 2006 report "Advice on a Long-term Strategy on Energy and Climate Change" identified more specifically a number of areas where emission reductions could occur, such as energy efficiency, CCS, renewables, biofuels and nuclear energy.

technologies. This places onus on governments to enable the change through emission pricing and complementary policies, and on individuals to make low-carbon technology and lifestyle choices.

These considerations point to a technology deployment risk that will require more than an economy-wide emission price to ensure success. Indeed, it will be a requirement of government to systematically address these important enabling conditions to support and foster widespread low-emission technology deployment that deep emission reductions require.

2.1.6 Air Pollutant Reductions and an Integrated Approach

Air pollutants, including VOCs, SO_X, NO_X, and PM[29] (individually or in combination as smog and acid rain) have been shown to cause adverse health and environmental effects. Scientific evidence indicates a strong correlation between ambient air concentrations of the pollutants and significantly adverse effects on human health, ranging from respiratory conditions such as asthma and chronic bronchitis to premature death and increased mortality. From an environmental perspective, smog has been linked to reduced plant productivity resulting in reduced agricultural crop yields and forest growth. Acid rain and acid deposition from SO_X and NO_X emissions also present a well-known threat to ecosystems, notably lakes and forests.

The NRTEE looked at potential long-term (2050) national emission reduction targets for a number of air pollutants including SO_X, NO_X, VOCs and PM. Specifically, we assessed potential emission reductions of 50% and 80% below current levels. We also looked at an integrated approach whereby significant GHG and air pollutant emission reductions could be addressed in the same time frame (using a 65% GHG reduction target and 50% reduction targets for the air pollutants). The goal of this integrated analysis was to assess the integrated effects between the pricing pathways for the two GHG targets while incorporating any co-benefits and integrated effects of the shallow prices for the air pollutants. We explored to what extent we could take advantage of the co-reductions to reduce the GHG prices and still meet a 65% GHG reduction target.

The following section first discusses the findings of the air pollutant analysis, followed by a discussion of the conclusions of an integrated approach.

Air Pollutant Reductions

As with GHG emissions, anthropogenic air pollutant emissions, result primarily from fossil fuel combustion. However, air pollutant emissions differ in three important ways. First, they have the greatest effect in the local area around the emissions' source. Second, most air pollutants have a fairly short residence period in the atmosphere, so impacts can vary significantly over time. Finally, while combustion-based GHG emissions can be linked closely to the amount of fossil

29. Airborne particulate matter (PM) consists of many different substances suspended in air in the form of particles (solids or liquid droplets) that vary widely in size. The size of the particles determines the extent of environmental and health damage.

fuel combusted, combustion-based air pollutant emissions can vary greatly depending on conditions by sector, fuel quality and end-of-pipe emission controls. As a result of these differences the forecasts generated in the modelling undertaken for the NRTEE should be considered indicators of overall trends, rather than precise values.[30]

Based on our research into potential air pollutant reductions the NRTEE makes the following observations:

- Reducing NO_X and SO_X emissions by up to 50% by 2050 is achievable with a relatively modest emissions price signal. However, with PM and VOCs, high process level emissions make these deep reductions very costly.

- To achieve reductions in the order of 50% in PM, the research indicates that the only option to attain deep emission reductions is to reduce industrial output in some sectors, notably oil sands and mining. This is because major portions of reductions are process related with no known mitigation actions. Reducing output is a very high cost option for reducing emissions, and leads us to conclude that reductions of PM in the order of 50% are prohibitively expensive.

- For VOCs, targeted regulations may be required given the large number of very small sources and the high process level emissions for which control technologies are not effective.

- Achieving very deep reductions beyond 50% requires a much higher price signal. For example, the emissions prices required to reach the very deep target (80%) for both NO_X and SO_X are about six to ten times greater than the price required to reach the deep target (50%). This suggests that the marginal costs of reducing NO_X and SO_X emissions will increase substantially if policy makers wish to reduce these air pollutant emissions by 80%.

The research suggests that the sectoral implications of significant, long-term emission reductions are not uniformly distributed. The transportation sector is responsible for a large portion of the reductions of NO_X, PM_{10} and VOC emissions. However, these reductions are largely the result of regulations set to be implemented in the near future, and therefore will occur regardless of (and not because of) the emissions prices.

The allocation of the remaining emissions reductions is highly dependent upon the air pollutant in question. In general, the sectors that contribute the most to reductions had high emission rates in 2005 and lower marginal costs of abatement. For example, reductions in SO_X emissions are highly concentrated in the electricity generation sector, which contributes 26% of the 2005 levels assumed in the model, and has a relatively low marginal cost of abatement. In some sectors, the emissions price is insufficient to cause a reduction in emissions from 2005 to 2050. For example, the petroleum crude

30. The national forecast that was used in this analysis provides a useful indicator for potential health and environmental effects from air pollutant emissions, but it is not sufficient to accurately measure these outcomes, which can only be determined by detailed analysis at a regional level.

extraction industry experiences an increase in SO_X emissions from 2005 to 2050 when the national -50% price is implemented, simply because overall activity increases almost five-fold. In these cases, the emissions price is not large enough to offset the emission effects of increased output from the sector.

An Integrated Approach

Industrial emissions of GHGs and air pollutants each account for approximately 50% of Canada's total air emissions and share many common sources. Therefore it makes sense to explore the possibility of addressing both sources in an integrated regulatory approach.

The first finding of this assessment is that an integrated approach lowers the prices associated with emission reductions. Specifically, the research shows that the GHG price necessary to hit the -65% target is significantly lower when implemented along with air pollutant prices, than when the GHG price is implemented alone (Figure 8). The air pollutant prices encourage investment in higher efficiency and lower emissions technologies and processes, and therefore the GHG prices do not have to be as strong to hit the target. This finding confirms that the GHG co-pollutant reduction experienced with air pollutant pricing effectively reduces the final GHG price needed to reach the target.

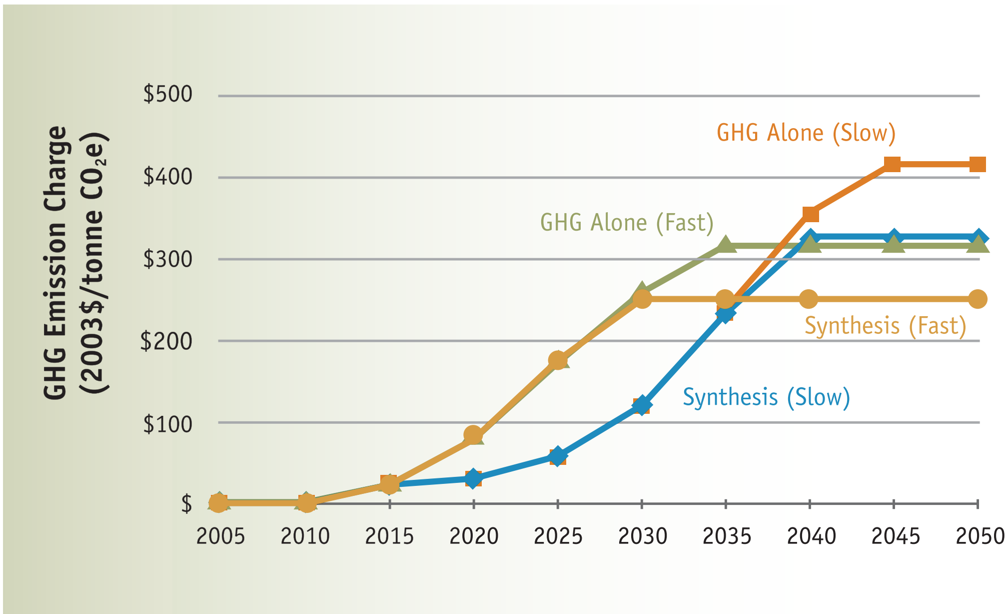
> "The first finding of this assessment is that an integrated approach lowers the prices associated with emission reductions."

Many actions that reduce GHG emissions also reduce air pollutant emissions. For example, climate change policies focused on improved energy efficiency also will lower air pollutants associated with producing energy, thereby improving local air quality. The use of CCS eliminates most SO_X and PM emissions associated with combustion. Fuel switching from coal to natural gas will decrease air pollutant emissions. Similarly, policies targeting air pollutants, especially SO_X, encourage fuel switching from relatively sulphur-intense (and GHG-intense) coal to less sulphur-intense (and GHG-intense) natural gas and electricity.

The second key finding of this analysis was that an integrated approach will likely result in co-benefits related to air pollutant reductions. For example, our research shows that the SO_X price that attains a 50% reduction when implemented alone triggers a reduction of 83% when implemented in conjunction with the GHG and other air pollutant emissions charges.

In conclusion, the NRTEE research suggests that there are significant opportunities to reduce GHG and air pollutant emissions in an integrated approach. The application of relatively inexpensive air pollutant emission reduction actions, induced by emissions pricing, may significantly reduce the GHG emission price necessary to achieve deep targets, while reaping the co-benefits of lower local air pollution.

Figure 8: Comparison between the GHG prices required to reach the -65% GHG target when the GHG price is implemented alone, or in conjunction with air pollutant prices



2.2 Understanding the Economic Risk and Uncertainties of the Transition

A key question for Canada's policy makers, and indeed all Canadians, is what effect a deep GHG emissions reduction pathway could have on Canadians and the Canadian economy. Of primary concern are economic growth, and regional and sectoral prospects. Energy price impacts on households are also of interest. The NRTEE research indicates that the overall effects on economic growth over the long term are quite limited. However, this masks important regional and sectoral implications that are not uniform in time or proportionate in scale. There are other areas of macroeconomic impact that we did not assess and that clearly need to be investigated to more fully articulate the likely effect of deep GHG emission reductions. The following discussion explores these two points.

2.2.1 Long-term National Economic Growth Prospects

While all forecasts of economic growth are inherently uncertain, Canada can nevertheless expect that the size of the economy will more than double between now and 2050. Current growth projections, accounting for demographic trends, immigration and productivity changes all point to continued prosperity for Canada through mid-century with annual economic growth averaging in the order of 1.5% to 2%.[31] An important question is how deep carbon reductions may alter this prosperity.

31. A national long-term economic forecast was developed by Informetrica for the NRTEE.

With a climate change policy that enables cost-effective emission reductions through broad-based emission pricing and in a world where Canada's major trading partners undertake similar deep GHG emission reductions, it is reasonable to conclude that Canada's economy will continue to thrive with a relatively limited impact on economic growth. This assertion holds for a variety of assumptions about the pace of economic growth as well as the pace and depth of emission reductions (i.e., our modelled pathways). The assertion does not hold, however, if Canada acts alone and out of step with its major trading partners.

Figure 9, below, provides an overview of the possible *magnitude* of the impact on national economic growth that may be expected under alternative pathways for a 65% reduction below current levels in 2050.[32] While recognizing the uncertainty in these long-term projections, we conclude that the economy will continue to grow, albeit at a slower pace in certain periods.

Specifically, our modelling implies that over this period about one to two years of economic growth may be "lost" due to a climate change policy that seeks deep GHG reductions. This means that with the economy growing at an annual rate of about 2% between now and 2050, one to two of these years of growth will be lost over the entire 43-year period. In effect, the likely impact on economic growth is limited and not significant under our modelled pathways. The reduction in the size of the economy would be smaller for a lower target, such as 45%, and higher with deeper domestic reductions. It also seems plausible that having access to international trading with emission reduction costs below domestic levels, the impact on economic growth would be lessened even more.

"Specifically, our modelling implies that over this period about one to two years of economic growth may be "lost" due to a climate change policy that seeks deep GHG reductions."

Figure 9: Comparison of changes in total GDP to 2050 (in 2003 dollars)
Fast and Slow Start to 65% reduction (from current levels) in 2050

	GDP in 2011 ($trillion)	GDP in 2050 ($trillion)	Years of lost growth between now and 2050
BAU	~$1.441	~$2.968	
Slow start (-65%)		~$2.934	~2
Fast start (-65%)		~$2.957	~1

32. See Section 5.5 for a discussion of how these economic impacts were calculated by CIMS.

While the eventual size of the economy could be somewhat similar under the alternative pathways, our assessment found that the annual fluctuations in gross domestic product (GDP) will likely not be uniform between 2011 and 2050 or between the pathways. The bulk of the transitions and possible dislocations occur around 2030, with the economy restabilizing at about forecast levels along its new less-GHG-intensive path by 2050. With an early start, fewer transitional fluctuations occur before 2030 but are later intensified. Conversely, with a fast start, the fluctuations are more pronounced before 2030, but then ameliorate with time. This implies that under a fast start pathway more economic dislocation can be expected in the medium term with the gain of a higher overall level of economic activity in 2050. Thus, the chosen pace of emission reductions will most likely involve a trade-off between medium-term transitional impacts (such as dislocations) and longer-term economic growth.

We acknowledge the following important caveats about these predictions of GDP impact. The model used is not a general equilibrium model, and focuses mostly on key energy-consuming sectors of the economy. Implicitly, the model assumes that other economic activity is unaffected by policies. Furthermore, the model does not capture the effects of a GHG policy on the labour or capital markets. Therefore, these estimates of GDP should be interpreted as the impacts on economic activity that would occur if the activity from sectors excluded from CIMS is held constant. In reality, a climate policy is likely to have feedback on activities excluded from CIMS. Finally, although GDP is used as a standard measure of the change in economic activity, it is not a direct measure of the change in human welfare. Finally, our findings say little about other important macroeconomic effects such as income, savings and investment trade-offs for low-carbon technologies, capital formation, changes in prices and employment.

2.2.2 Regional and Sectoral Outcomes

The apparently small impacts on national economic performance under a broad-based carbon price mask regional and sector implications that may be of greater concern. Understanding the real or perceived distribution of impacts on regions and sectors is important since it tends to drive climate change policy in Canada. Where real income or employment effects are forecasted, the appropriate climate change policy response is to maintain the carbon "signal" and design complementary income and employment policies to smooth the transition and minimize dislocation. With this in mind, the following discussion explores regional abatement efforts, sectoral price and output effects, and costs to consumers. Again, the NRTEE recognizes the uncertainty inherent in our analysis, and therefore the following should be viewed as directional at best.

Regional abatement effort could ultimately be uniform but will differ in time:

- Regions will transition differently over time in response to emission pricing, with some taking action early and some later. Under a 65% reduction scenario, all regions ultimately contribute reductions more or less proportionate to their baseline emissions over the long term (See Figure 10). However, in the medium term, some provinces move first in response to the price signal, like Alberta and Saskatchewan, which would reduce about twice as much as the other provinces by 2020.

- Regions with the higher levels of emissions contribute more to the national reduction target. Since Ontario and Alberta emit more GHG emissions, they reduce more total emissions, with Ontario accounting for about 20% of the national reductions and Alberta about 45%.

Figure 10: Provincial GHG emission reduction effort for 20%/65%. Share of national reductions and below regional baseline

	2020 Baseline	-20% in 2020		2050 Baseline	-65% in 2050	
	Share of National Emissions	Share of National Reductions	Reductions below Baseline	Share of National Emissions	Share of National Reductions	Reductions below Baseline
British Columbia	12%	9%	-14%	10%	9%	-58%
Alberta	36%	48%	-24%	43%	43%	-66%
Saskatchewan	6%	10%	-27%	5%	6%	-72%
Manitoba	2%	1%	-13%	1%	1%	-61%
Ontario	27%	20%	-14%	27%	27%	-66%
Quebec	11%	7%	-13%	9%	9%	-64%
Atlantic	6%	5%	-14%	5%	5%	-66%

Sectoral abatement effort will likely not be uniform over time with some acting earlier than others. Notably, the industrial and energy supply sectors would likely provide more emission reductions by 2020, but in 2050 there could more or less be a convergence as the residential, transportation and commercial sectors catch up in response to the higher emission prices. Figure 11 provides the distribution in time of abatement effort by sector. The different responses of the sectors in terms of timing and magnitude point to the need for a flexible climate change policy signal, such as the emission price we have advocated in this *Advisory Report*.

Figure 11: Sectoral abatement effort

	2020	2050
Canada	**-20%**	**-65%**
Residential	**-15%**	**-70%**
Commercial/Institutional	**-13%**	**-64%**
Transportation	**-7%**	**-61%**
Total Industrial	**-17%**	**-64%**
Chemical Products	-13%	-67%
Industrial Minerals	-36%	-75%
Iron and Steel	-6%	-54%
Non-Ferrous Metal Smelting	-5%	-49%
Metals and Mineral Mining	-9%	-37%
Other Manufacturing	-14%	-66%
Pulp and Paper	-32%	-71%
Energy Supply	**-26%**	**-68%**
Coal Mining	-3%	-13%
Electricity Generation	-23%	-72%
Natural Gas Extraction	-10%	-33%
Petroleum Crude Extraction	-41%	-69%
Petroleum Refining	-14%	-75%

Sectoral profitability impacts and possible economic dislocations seem plausible under either a 45% or 65% reduction scenario, even when we assume that the world (and especially the United States) acts in concert to reduce GHG emissions. The extent to which domestic firm output may further decline and profitability effects intensify will be a function of how much product prices rise relative to international competitors. The logic of this assertion is straightforward and starts with the impact of the emission price on product prices. In domestic markets with little international competition, Canadian firms face the same emissions price with impacts differentiated by the relative abatement costs and emission intensities, where higher carbon-intensity firms face higher costs and possibly lower market shares. In this case, the major determinant of the profitability or economic impact will be any reduced demand for the

> "But if countries do not move in concert and Canada imposes deep limits on emissions, there will be more pronounced competitiveness impacts leading to profitability reductions."

product, for example a reduction in national coal demand as identified in Figure 12 below. For sectors exposed to international competition, either in domestic or international markets, the impact will be more strongly linked to relative emission prices between countries. If all countries more or less act in concert on emission pricing, competitiveness impacts largely disappear. But if countries do not move in concert and Canada imposes deep limits on emissions, there will be more pronounced competitiveness impacts leading to profitability reductions.

Figure 12: Impacts on production costs and output

	Changes in Production Costs Relative to the BAU		Changes in Output Relative to the BAU	
	2020	**2050**	**2020**	**2050**
Residential	**6%**	**1%**	**-8%**	**-5%**
Commercial/Institutional	**1%**	**1%**	**-2%**	**-2%**
Transportation	**8%**	**1%**	**-6%**	**-5%**
Industrial				
Chemical Products	17%	15%	-6%	-5%
Industrial Minerals	24%	20%	-49%	-50%
Iron and Steel	9%	13%	-3%	-4%
Non-Ferrous Metal Smelting	7%	7%	-3%	-2%
Metals and Mineral Mining	3%	6%	-2%	-7%
Other Manufacturing	5%	5%	-1%	-1%
Pulp and Paper	2%	2%	-6%	-2%
Energy Supply				
Coal Mining	25%	93%	-6%	-20%
Electricity Generation	31%	24%	6%	35%
Natural Gas Extraction	19%	39%	-4%	-9%
Petroleum Crude Extraction	30%	34%	-3%	-5%
Petroleum Refining	6%	6%	-12%	-50%

Figure 12 traces out some of the possible price and output outcomes under our scenario where Canada acts with the industrialized world on deep reductions. With emission pricing under this scenario, we would expect the domestic energy system to move toward less carbon intensive energy sources. This is indeed observed in our modelling with significant growth in low-emitting sources of electricity (+40% from business-as-usual projections) and large reductions in carbon-intensive refined petroleum products (-50%) and coal (-20%). Figure 13 presents the associated fuel supply and demand under a long-term 65% reduction scenario.

The output of oil and gas remains more or less unaffected in our scenario reflecting the observation that continued global demand for oil will drive energy exports, even under global emission constraints and rising domestic production costs. If coal and petroleum product exports follow this possibility, the output declines we observe in Figure 13 could be reduced. That said, there would then be the associated issue of rising global emissions (or leakage) with more Canadian energy exports.

The reduction in output from industrial sectors, either in response to higher energy prices or as an abatement option, could be small on aggregate. Our modelling suggests decreases in the order of 3% below forecast levels in 2020 and 4% in 2050. Some sectors, like pulp and paper, may invest earlier and experience transitional output reductions that are largely reduced over time. Other sectors such as metals and mineral mining may make investments later in response to higher emission prices. The one exception to this story of a low overall output effect is industrial minerals, which primarily includes cement. This sector could experience large output reductions due to high abatement costs that raise product prices significantly (i.e., 30%), thereby reducing demand.

For the most part, the provincial and national stocks of housing remain stable, with some medium-term reductions in 2020 but a return to BAU forecasts by 2050. The quantity of commercial buildings and the transport sector remain unaffected in terms of size but instead would need to lower their carbon intensity considerably.

Figure 13: Change in energy mix by sector

Residential			Transportation		
	2020	2050		2020	2050
Natural Gas	-4%	-6%	RPPs	-1%	-57%
RPPs*	-5%	-28%	Electricity	0%	11%
Electricity	9%	35%	Hydrogen	0%	5%
Wood	0%	0%	Renewable	0%	40%
Industrial			**Electricity**		
	2020	**2050**		**2020**	**2050**
Natural Gas	-3%	-6%	Natural Gas	4%	8%
Coal	0%	-1%	Coal	-11%	-29%
RPPs	-6%	-19%	RPPs	0%	-2%
Electricity	4%	18%	Renewable	7%	23%
Wood	5%	7%			

*Refined Petroleum Products

For the average household, price effects can be expected, with both "pain" and "gain" associated with deep GHG reductions. But these price effects are likely not outside the ongoing energy price swings we have experienced, and thus increased energy costs for households are probably important but not significant:

- Electricity price increases for households could be expected in carbon-intensive provinces, such as Alberta and Ontario, in the order of 50% by 2050. Electricity price effects in other provinces would likely be lower. For space heating and domestic hot water in houses, natural gas costs could increase by about 60% by 2050, which is well below recent price swings. Gasoline prices could roughly double by 2050 from their historic level. To put this in context, Canadian retail gasoline prices in 2005 increased by 50%, fluctuating from about $0.80 per litre to $1.20 per litre, before closing the year at about $1.05 per litre, an increase of over 30%.

- While many energy costs would increase, there could also be savings for households. The combined effect of building regulations that increase energy efficiency and emission pricing, which increases energy efficiency and demand conservation, is that households could consume considerably less energy. In our assessment, total energy expenditure per household falls 15% despite the increases in price. The cost of these savings is an increase in capital expenditure for energy efficiency actions, but the overall effect is positive with net overall savings for consumers.

2.2.3 The Importance of the Enabling Conditions

A major observation from our assessment is that with deep reductions there will be adverse impacts on regions, sector and households. The second major observation is that any deviation from our enabling conditions will intensify the possible adverse effects we envision. Thus to minimize economic costs and adverse environmental effects and successfully transition to a low-emission economy, Canada must act in the coordinated, integrated manner we have set out in our "enabling conditions." This means:

- acting in concert with the rest of the world on setting targets, implementing emission pricing and trading global emissions;

- setting targets that place Canada on a path to sustained reductions, where any delay in target attainment has environmental and economic risks;

- using broad-based emission pricing that is consistently communicated;

- enabling widespread technology deployment; and

- integrating air and GHG policies more fully.





Key Findings and Recommendations

3 Key Findings and Recommendations

Key Findings

The policies contained in the federal government's *Regulatory Framework for Air Emissions*, which are largely focused on the large industrial sources of GHG emissions, are first steps toward achieving deep GHG emission reductions in Canada. While these policies are focused on the near term, it is imperative for Canada to start immediately planning for a transition to the medium and long terms. This should involve the design and implementation of economy-wide pricing policies that will effectively move our economy toward a low-emissions future. The NRTEE's advice and research is meant to inform the policy debate that will begin over choosing and designing the right market-based instruments for achieving deep and sustained GHG emission reductions in Canada across our economy.

The federal government has committed to deep long-term emission reduction targets for GHGs and air pollutants. For GHGs, these targets are 20% below 2006 levels by 2020, and 60% to 70% below 2006 levels by 2050; these targets match those of the NRTEE's "fast and deep" scenario in this report. Achieving this vision of a low-emission economy for Canada requires embarking upon a focused and deliberate transition beyond current policy approaches. Our research shows that achieving the 2050 target of a 65% reduction in GHG emissions from current levels requires meeting the stated 2020 target of a 20% reduction. Missing the 2020 target will put at risk the attainment of the longer-term target, or make achieving that target come at both higher economic and environmental costs. It will result in higher cumulative GHG emissions into the atmosphere over the time period in question. This is significant because climate change is both an emissions "stock" and an emissions "flow" problem. Early action offers the best guarantee of maximum success at minimum cost.

"Achieving this vision of a low-emission economy for Canada requires embarking upon a focused and deliberate transition beyond current policy approaches."

The research, analysis and consultations conducted by the NRTEE over the past year lead it to conclude that the next step for Canada on climate change is the development and *implementation* of a truly national, integrated long-term plan based on the goal of attaining deep GHG emission reductions by 2050. This plan should be based on market-based instruments and solutions because they offer the most effective and sustainable pathways to environmental success and economic certainty.

Our research illustrates that deep, long-term reductions are achievable based on known policy mechanisms and expected technologies deployment. The main conclusion from our work is that the policy package required to achieve deep long-term reductions must place a price on carbon emissions, and needs to be complemented by other policies, such as regulations for certain sectors that may not respond to a pricing mechanism.

The core of this policy would establish a pricing mechanism for emissions, either through an emission tax, a cap-and-trade system or a combination of the two. To provide policy certainty and a level of predictability, the price signal must be communicated clearly, with an expectation that the price of emissions would escalate over a scheduled time period. Attaining deep GHG emission reduction targets will have a minor effect on the long-term growth prospects for the economy. It will, however, cause some economic dislocation and impact, particularly in certain regions of Canada and sectors of our economy. Over the long term these are manageable with the right mix of policy instruments and by adopting a phased, realistic, but sustained implementation approach.

The NRTEE's research and analysis supports a plan that addresses GHGs and air pollutants together in an integrated approach. Important health benefits to Canadians can be realized by doing so. As energy-related emissions of GHGs and air pollutants share many common sources, there appears to be value in designing and implementing concurrently integrated reduction policies and actions.

Finally, it is imperative to note that our research, the conclusions that we draw from it, and the advice that we putting forward for consideration, are based on what we know today, using known policy mechanisms, the best available modelling, and the knowledge base of many experts in the field of climate change mitigation and related disciplines. The state of knowledge on this issue in general, and many of the specific aspects considered in this *Advisory Report*, is rapidly advancing. Therefore, as policies to address climate change, and emission reductions specifically, are designed and implemented, there will need to be a mechanism put in place that will track the state of the knowledge to ensure that the policies and approaches continue to be appropriate. These adaptive management practices should be built into the design of the policies and approaches Canada adopts, not only to track the effectiveness of our domestic policies, but to also monitor the policies of the international community, and the scientific evidence that will continue to come to light on this issue over time.

Recommendations

Based on the research and analysis contained in this report and supporting documentation, the NRTEE makes the following recommendations to the federal government:

GHG Emissions

1. Implement a strong, clear, consistent and certain GHG emission price signal across the entire Canadian economy as soon as possible in order to successfully shift Canada to a lower GHG emissions pathway, achieve the targeted reductions for 2020 and 2050, avoid higher emission prices that a delay would entail, and reduce cumulative emissions released to the atmosphere.

2. Institute a market-based policy that takes the form of an emission tax or a cap-and-trade system or a combination of the two.

3. Develop complementary regulatory policies, in conjunction with the emission price signal, to address sectors of the Canadian economy that do not respond effectively to such a price signal or where market failures exist. Complementary policies should also provide support for research, development and demonstration of technologies, as well as strategic investments in infrastructure.

4. Establish a Canada-wide plan, in the earliest possible time frame, that leads to better coordination of complementary federal, provincial and territorial GHG emission reduction policies aimed at common or shared targets, time frames and actions.

5. Apply GHG emission reduction policies that incorporate adaptive management practices and have built-in monitoring and assessment mechanisms to allow for regular reviews to ensure efficiency and effectiveness. This approach will ensure that progress is monitored, compliance issues are addressed, and policies are adjusted to match the required level of abatement effort, and will minimize and mitigate unanticipated adverse outcomes.

Air Pollutants

- Address GHG emission and air pollutant reductions concurrently to ensure maximum health benefits to Canadians and greater economic certainty for industry, by designing and implementing co-pollutant reduction policies in an integrated manner.

For Both GHG and Air Pollutants

- Implement, immediately, the development and design of market-based policy instruments, plus complementary policies, for Canadian environmental objectives, economic circumstances and technology needs, following broad consultation with industry, environmental and other stakeholders, experts and all other levels of government, drawing upon international, national, regional and local knowledge and experiences.

Looking Ahead

4 Looking Ahead

In addressing the federal government's *Reference* and conducting our research, the NRTEE examined a number of important issues related to GHG and air pollutant emission reductions. However, our research, analysis and dialogue also identified a number of key emerging issues that require further consideration as part of Canada's successful transition to a low-emission future. In order to better understand how to make the transition so that risks are minimized, we have identified five core areas that need further detailed research and evaluation:

Knowledge

Important analytical knowledge gaps exist that need to be filled. This includes work on a standard macroeconomic forecast upon which to base future modelling work for comparative purposes, developing technology cost curves to project effective deployment of clean energy technologies, comparing clean energy technology experience curves with other large-scale technology development and deployment experiences to identify barriers to deployment, and assessing emission abatement cost curves for various sectors and technologies that offer the most potential.

Policy Design

A comprehensive climate change public policy framework based on market-based instruments and the deployment of technology is central to achieving deep, long-term emission reductions. Our modelling sets out several market-based pathways that offer real promise, yet also raise issues that need more detailed examination. Policy design details can demonstrably affect the effectiveness and efficiency of one pathway over another. More work is therefore required on comparing the most feasible market-based instruments of cap-and-trade versus carbon tax. This includes how each should be designed and implemented; their sensitivity to various price scenarios and revenue-raising projections; recycling revenue to regions, sectors, and taxpayers; tax shifting possibilities; and how auctioning of emission permits can be undertaken. The link of each to fostering technology deployment must also be examined. The current NRTEE research begins to explore potential sectoral and regional effects of pricing emissions; however, the importance of these considerations warrants further detailed exploration during the design and development of policies.

Governance and Federal-Provincial-Territorial Coordination

While the NRTEE examined emission reduction scenarios from a federal government perspective only, it is clear that the linkage to provincial/territorial climate change policies being developed and implemented must be considered for a truly domestic emissions perspective to be obtained. This is necessary to enhance coordination of approaches on behalf of industry and consumers, thereby keeping costs down for both, and maximizing approaches that lead to greater certainty of outcomes. Given the "horizontal" nature of climate change policy, which affects many departments of government, it is also important to examine policy development, governance and accountability mechanisms, as well as measure progress on achieving targets and assess areas for improvement with respect to further integration of policies and reported outcomes.

Opportunities of Climate Change Action

Climate change action is not just an economic cost but offers the prospect of certain economic opportunities and benefits to society. Becoming a "clean energy superpower," for example, implies a leading innovative role for Canada in identifying, developing and deploying new climate change technologies that can be exported or otherwise assigned value. This is an important shift in approach that needs to be contemplated as part of an evaluation of the potential benefits of addressing climate change.






Appendix

5 Appendix

5.1 Letter of Reference from the Minister of Environment

Minister of the Environment   Ministre de l'Environnement

Ottawa, Canada K1A 0H3

NOV 1 0 2006

Mr. Glen Murray
Chair
National Round Table on the Environment
and the Economy
Canada Building, Suite 200
344 Slater Street
Ottawa ON K1R 7Y3

Dear Mr. Murray:

I am writing to request that the National Round Table on the Environment and the Economy provide advice to the Government in support of Canada's new Clean Air Regulatory Agenda.

The Government of Canada is committed to an integrated, nationally consistent approach to reduce emissions of air pollutants and greenhouse gases in order to protect the health and environment of Canadians. Concurrent with the introduction in Parliament, on October 19, of Canada's Clean Air Act, the Government issued a Notice of Intent to Develop and Implement Regulations and Other Measures to Reduce Air Emissions.

In order to better provide clear, long-term direction in the development of effective and efficient regulation in this important area, I request the National Roundtable to develop advice for the Government of Canada on medium- and long-term targets for both pollutants and greenhouse gas emissions (GHGs). The specific advice I am seeking includes:

- national objectives for ambient air for particulate matter and ozone for the periods of 2020-2025 and 2050;
- national emission reduction targets for 2050 for total emissions of sulphur dioxide, nitrogen oxides, gaseous ammonia, volatile organic compounds, and particulate matter for the following sectors: oil and gas, electricity, base metals, iron and steel, aluminum, cement, chemicals, forest products, transportation, consumer products, commercial and institutional, residential and agriculture;

.../2

Canada

- 2 -

- medium-term targets for 2020-2025 for GHG emission reductions from the sectors named above. The advice should recognize the outlook for Canadian economic growth and the Government's intention to build upon the emissions intensity approach with targets that are ambitious enough to translate effectively into a fixed cap on absolute emissions; and,

- the national emissions target that should be adopted within the range of a 45 – 65 percent reduction from 2003 levels by 2050, and scenarios for how this target could be achieved, including the role of technology and capital stock renewal.

Given the Government's regulatory timetable, the National Round Table's interim advice should be provided to the Government no later than spring 2007, with a final report in the autumn. I expect the process to be carried out within the current budget of the National Round Table.

I encourage the National Round Table to draw on a wide body of opinion to develop its advice. There will be considerable interest in this work in provincial and territorial governments, business and industry, non-government organizations, the academic community, and the Canadian public. Experts in other countries may also be able to provide valuable advice on the medium- and long-term targets and policy approaches under consideration or implementation in other countries.

Environment Canada, Health Canada, and other departments and agencies of the Government, as necessary, are ready to contribute to the work of the Round Table in the areas of research, monitoring, risk assessments and risk management considerations.

Thank you in advance for your members' commitment and their contribution to the health of Canadians, the environment, and the Canadian economy.

Yours sincerely,

Rona Ambrose

5.2 NRTEE Approach to the Reference

The NRTEE has prepared this *Advisory Report* in several stages:

November 2006 – February 2007:
- *NRTEE's mandate was defined.* The NRTEE scoped out a research agenda and verified its response to the *Reference* with stakeholders.

February 2007 – July 2007:
- *Research was commissioned from experts.* The research covered a range of topics, including but not limited to pathways for long-term reductions of emissions of GHGs and air pollutants, economic implications of such reductions, feasibility of GHG emission reduction policies, co-benefits of GHG and air pollutant emission reductions, and comparative international approaches to emission reductions.[33]

January 2007 – July 2007:
- *Expert advisory groups vetted the main elements of the research.* The NRTEE engaged expert advisory groups to debate and validate the research approach, findings and conclusions.

June 2007:
- *Interim results were reported.* The NRTEE presented an Interim Report to the Minister of the Environment that summarized initial findings.

September – October 2007:
- *Experts and stakeholders were consulted.* The NRTEE discussed the research with a targeted number of knowledgeable and interested stakeholders in early fall, in an effort to solicit broader views and opinions on the findings and conclusions. A summary of these discussions is provided in Section 5.6.

October 2007:
- *NRTEE members endorsed the Advice.* Finally, the findings and recommendations were subjected to a thorough review and dialogue by NRTEE members.

33. See Section 5.4 for a complete list of the commissioned research studies.

5.3 Glossary

Abatement: Reducing the degree or intensity of, or eliminating, pollution.

Airborne Particulate Matter (PM): Solid particles or liquid droplets suspended or carried in the air (e.g., soot, dust, fumes, mist).

Business As Usual (BAU): An estimate of the trajectory that society is currently on in order to test policy impacts.

Cap-and-trade system: A regulatory program under which government sets a cap on the volume of GHG emissions, distributes permits for allowable emissions and enables firms to buy and sell the permits after the initial distribution.

Capital Stock Turnover: The total value of stock sold in a year divided by the average value of goods held in stock. This ratio refers to the frequency of new investments in assets available for use in the production of further assets.

Carbon Capture and Storage (CCS): An approach to mitigating global warming by capturing carbon dioxide (CO_2) from large point sources such as power plants and subsequently storing it instead of releasing it into the atmosphere.

Carbon Offset Credit: A carbon offset reduces the net carbon emissions of individuals or organizations indirectly, through proxies who reduce their emissions and/or increase their absorption of greenhouse gases.

Emission Pricing: An emissions "price" is a price placed on carbon emissions through the implementation of an emissions cap-and-permit trading scheme, and/or an emissions tax.

Emissions (carbon) Tax: A fee imposed by a government on each unit of CO_2-equivalent emissions by a source subject to the tax. Since virtually all of the carbon in fossil fuels is ultimately emitted as carbon dioxide, a levy on the carbon content of fossil fuels – a carbon tax – is equivalent to an emissions tax for emissions caused by fossil fuel combustion.

Emitters: In the context of climate change, emitters include industrial facilities that produce and release GHGs.

Fuel Switching: The use of different energy sources or fuels to achieve the same energy services.

Greenhouse Gas (GHG) Emissions: Emissions into the atmosphere of gases that affect the temperature and climate of the earth's surface. The main greenhouse gases emitted due to human activity are carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O).

Greenhouse Gas (GHG) Tax: A tax on the unit GHG content of energy and other commodities. The level of the tax is set to induce changes that achieve a targeted level of emission reductions.

Large Final Emitters (LFEs): Industrial facilities in sectors producing an average of eight kilotonnes or more of carbon dioxide equivalent (CO2e) per facility and producing an average of 20 kilograms or more CO2e per $1,000 gross production annually.

NO_X: A generic term for mono-nitrogen oxides (NO and NO_2). These oxides are produced during combustion, especially combustion at high temperatures. In areas of high motor vehicle traffic, such as in large cities, the amount of nitrogen oxides emitted into the atmosphere can be quite significant. In atmospheric chemistry the term NO_X is used to mean the total concentration of NO plus NO_2.

Offsets: Actual emissions reductions, which are used to mitigate (offset) emission increases of air pollutants. In Canada offsets are usually invested in by non-regulated industries as a means to reduce their environmental impacts.

SO_X: Sulphur dioxide and other sulphur oxides. They are formed during the combustion of fossil fuels and cause acidification.

Upstream vs. Downstream: Upstream is defined as the point of production and importation, whereas downstream is at the point of distribution of energy.

Volatile Organic Compound (VOC) Emissions: Chemical substances containing hydrocarbons (hydrogen and carbon atoms) that evaporate into the atmosphere.

5.4 Research Commissioned by the NRTEE in Support of the Reference.

Pathways for Long-term Greenhouse Gas and Air Pollutant Emission Reductions. J&C Nyboer and Associates.

Demographic and Population Projections to 2050. Informetrica Ltd.

Transitioning an Emissions Trading System from Intensity Allocations to a Binding Cap. Margaree Consultants Inc.

Understanding Canada's Emission Reduction Requirements Under Alternative Climate Stabilization Objectives and Burden-sharing Approaches Submitted. Ecofys Germany.

International Experiences in Setting Medium and Long-term Emission Reduction Targets. Wrangellia Consulting.

Emissions of Greenhouse Gases and Air Contaminants in Canada – Toward Harmonized Strategies. ICF International.

National Interests and Other Considerations in Determining Canada's Share of Global Greenhouse Gas Emissions in 2050. IISD.

What National Ambient Air Objectives Could Look Like. SENES Consultants Limited and Stratos Inc.

Lessons Learned from the Canada-wide Standards Process. Cheminfo Services Inc.

5.5 Key Attributes of the Energy Economy Model – CIMS

Key Attributes

The CIMS model, developed by the Energy and Materials Research Group at Simon Fraser University, simulates the technological evolution of fixed capital stocks (mostly equipment and buildings) and the resulting effect on costs, energy use, emissions, and other material flows. The stock of capital is tracked in terms of energy service provided (square metre [m2] of lighting or space heating) or units of physical product (metric tonnes of market pulp or steel). New capital stocks are acquired as a result of time-dependent retirement of existing stocks and growth in stock demand. Market shares of technologies competing to meet new stock demands are determined by standard financial factors as well as behavioural parameters from empirical research on consumer and business technology preferences. CIMS has three modules – energy supply, energy demand, and macro-economy – which can be simulated as an integrated model or individually. A model simulation comprises the following basic steps:

1. An exogenous base-case macroeconomic forecast initiates model runs. If the forecast output is in monetary units, these must be translated into forecasts of physical product and energy services.

2. In each time period, some portion of existing capital stock is retired according to stock lifespan data. Retirement is time dependent, but sectoral decline and changing input costs can also trigger retirement of some stocks before the end of their natural lifespans. The output of the remaining capital stocks is subtracted from the forecast energy service or product demand to determine the demand for new stocks in each time period.

3. Prospective technologies compete for new capital stock requirements based on financial considerations (capital cost, operating cost), technological considerations (fuel consumption, lifespan) and consumer preferences (perception of risk, status, comfort), as revealed by behavioural-preference research. Market shares are a probabilistic consequence of these various attributes.

4. A competition also occurs to determine whether technologies will be retrofitted or prematurely retired. This is based on the same type of considerations as the competition for new technologies.

5. The model iterates between the macro-economy, energy supply and energy demand modules in each time period until equilibrium is attained, meaning that energy prices, energy demand and product demand are no longer adjusting to changes in each other. Once the final stocks are determined, the model sums energy use, changes in costs, emissions, capital stocks and other relevant outputs.

The key market-share competition in CIMS can be modified by various features depending on the evidence about factors that influence technology choices. Technologies can be included or excluded at different time periods. Minimum and maximum market shares can be set. The financial costs of new technologies can decline as a function of market penetration, reflecting economies of learning and economies of scale. Intangible factors in consumer preferences for new technologies can change to reflect growing familiarity and lower risks as a function of market penetration. Output levels of technologies can be linked to reflect complementarities. Personal mobility provides an example of CIMS' operation. The future demand for personal mobility is forecast for a simulation of, say, 30 years and provided to the energy demand module. After the first five years, existing stocks of personal vehicles are retired because of age. The difference between forecast demand for personal mobility and the remaining vehicle stocks to provide it determines the need for new stocks. Competition among alternative vehicle types (high and low-efficiency gasoline, natural gas, electric, gasoline-electric hybrid, and eventually hydrogen fuel cell) and even among alternative mobility modes (single-occupancy vehicle, high occupancy vehicle, public transit, cycling and walking) determines technology market shares. The results from personal mobility and all other energy services determine the demand for fuels. Simulation of the energy supply module, in a similar manner, determines new energy prices, which are sent back to the energy demand module. The new prices may cause significant changes in the technology competitions. The models iterate until quantity and price changes are minimal, and then pass this information to the macro-economic module. A change from energy supply and demand in the cost of providing personal mobility may change the demand for personal mobility. This information will be passed back to the energy demand module, replacing the initial forecast for personal mobility demand. Only when the model has achieved minimal changes in quantities and prices does it stop iterating, and then move on to the next five-year time period.

CIMS' technology data are collected and reviewed in collaboration with the Canadian Industrial Energy End Use Data Analysis Centre (CIEEDAC), an independent data collection and analysis agency co-funded by the Canadian federal government and industry associations and the other residential, commercial and transportation sectors DACs across Canada. CIMS' technology competition behaviour parameters are researched and established in cooperation with the Energy and Material Research Group of Simon Fraser University; the key parameters in CIMS are set using revealed and stated preference discrete choice studies, and literature review where necessary.

Key Scenario Assumptions

Several key scenario assumptions were required to run CIMS for this project. These include the following:

- The population and economic growth forecasts. The growth forecasts are based on Natural Resource Canada's Canadian Economic Outlook (CEO) 2006 and Informetrica Ltd. long-run population forecast. Besides overall output, the assumptions about industrial structure were taken from CEO 2006.

- Starting energy prices for natural gas, electricity, coal, gasoline and other refined petroleum products. Theses are directly taken from the CEO 2006, except for coal, which is from the United States Energy Information Administration (EIA). We also adjusted coal price to reflect regional markets.

- The costs of carbon capture and storage (CCS). CCS technology, while proven for other applications, has not yet been implemented on a large scale. All the CCS cost information is based on the IPCC (2007).

- The presence and absence of international trading in emissions credits, and their clearing price. These scenario conditions have very large impacts on the final results.

- The world clearing price of crude oil. We used the EIA price, which was US$45/barrel in 2000 out into the future.

- The world price of oil stays high enough to support growth in oil sands. Oil sands growth is a major component of Canada's future emissions, and is highly contingent that the world oil price remains above about US$35/barrel over the entire forecast period.

- The world, including the United States, is also imposing carbon emission pricing. Implicit in our macroeconomic assumptions is that our trading partners and competitors are also experiencing significant carbon emission pricing, removing the incentive to switch to other suppliers. If we were imposing carbon emission pricing alone, the macro effects would have been stronger. The remaining macroeconomic response represents the overall substitution by consumers of our carbon intense products away from carbon intense goods.

- The energy end-use and supply technology options in CIMS represent a reasonable prediction of the set that could make up a significant portion the energy-using capital stock during the forecast period. In other words, the model is not missing technological options that could take over a significant portion of the capital stock between now and 2050. While it is certain new technologies will emerge that do not currently exist in

CIMS, especially under the influence of carbon emission pricing, these must first pass through the stages of invention, refinement, commercialization, and finally purchase before they can constitute a significant portion of the capital stock.

- In the policy scenarios an infinite amount of capital is available at the going interest rate (a commonly held assumption for Canadian Computable General Equilibrium models), and wage rates are unaffected.

Please visit the Energy and Materials Group website for further documentation of CIMS, www.emrg.sfu.ca.

5.6 Messages from Regional Meetings Across Canada

Why the Consultations Were Important

The NRTEE's research is based on more than just modelling and analysis. From the initial scoping of the research approach, to testing and vetting the research and conclusions, we sought input from a broader spectrum of stakeholders, including environmental experts and industry representatives from across Canada. We also initiated cross-country meetings in September and October 2007 with a targeted set of individuals who possess detailed knowledge on climate and clean air policy in Canada. In total, we met with 65 individuals in Halifax, Montréal, Ottawa, Toronto, Calgary and Vancouver. Typically ten to fifteen people participated in each session to keep the discussions manageable. Below is an overview of what we heard and how it influenced our advice.

> "Our objective is to be the architect of this transformation."
>
> — A participant's comment in Vancouver

What We Heard

Given the scale of the proposed targets and the associated required action and outcomes, we heard a great deal from participants. A major theme that emerged was uncertainty: uncertainty in what we assumed, uncertainty about its importance, in the targets and what others are doing globally, uncertainty on the required level of reductions, on technology deployment, lifestyle change and policy effectiveness. Indeed, participants told us that there is a great deal left unknown and that given the scale and scope of the proposed abatement effort, the risks of an unsuccessful transition to a low-carbon future are correspondingly large. As one participant noted "there is a fundamental question of uncertainty, risks and therefore a need to manage the risks associated with transition." This widely held view supports and indeed strengthens our advice that Canada needs to successfully manage the transition.

The following discussion provides a summary of some major themes we heard repeatedly.

On the modelling, there was a widespread questioning of modelling assumptions, baselines and technologies available for reductions. Generally, there was a diversity of opinions and concerns expressed related to the model, its feasibility and credibility, and how the results should be communicated to the public. As on participant observed, "*The devil is in the details.*" In the end however, there was consensus that the modelling provided valuable insight into the implications of achieving the targets for 2020 and 2050. The observations of the participants reminded us that we needed to be clear in the advice about what we assumed, and how alternative assumptions might change the advice.

Canada acting in concert is a key driver of outcomes. Unquestionably, a major theme and therefore addition to the advice was a question regarding the actions of the rest of the world. In short, what are others doing? This related to both the targets and actions of others but also enabling access to lower cost international emissions reductions.

There was widespread support for Canada aligning domestic action with international goals. One participant summed up this common refrain nicely:

> *"Canada should align its starting point and the pace of its emission reductions with other economies. If international partners are on a fast path, Canada should adopt a fast path as well. If not, Canada should work slowly or risk damaging its own economy. Either way, the process cannot be undertaken in isolation from the rest of the international community."*

A related point, brought forward by a number of participants, is that even if Canada acts alone, there is uncertainty with respect to the improvement in the atmospheric stock of carbon:

> *"As Canada's share of global emissions is only 2%, nothing that Canada does in isolation, not even 100% [reduction], will stabilize the climate."*

This reasoning was not, however, brought forward as a reason to go slow or to avoid abatement entirely. Instead, there was widespread caution about misaligning abatement effort with other industrialized nations so that competitiveness impacts were minimized. For example, one participant stated:

> *"Canada should strive for mid-term targets, especially in relation to international partners. But important pieces of the puzzle are missing. While information on costs and timing is available, more evidence is needed on sectoral and regional implications, the impact of transitions, and the relative impacts of short- versus moderate-term targets."*

There was also widespread support for international trading of carbon. This was supported primarily due to concerns over costs and perceived domestic limits on accessing possibly lower cost international purchases:

> *"Let's say we can get 30% of the target internationally. What does that cost? Wouldn't you arbitrarily force the price of carbon very high in Canada, by restricting [abatement] in Canada?"*

There was a belief that the scale of the challenge needed more clarity. Here there were two distinct themes: technology deployment and lifestyle change. First, the question of technology deployment was widely discussed, with some supporting the notion that technological fixes were readily available while others disagreed entirely. Many participants agreed, however, that one of the report's main messages must be to highlight the need for a significant technology shift.

Closely allied was the notion that there is a role for government to help enable the technology. For example, it was suggested that government identify areas of intervention so that new scalable, deployable technologies become readily available "on the shelf, not the drawing board." The notion of a technology risk was indeed widely held.

Second, while the NRTEE did not research the types of lifestyle changes associated with the transition to a low carbon future, there was widespread interest in exploring the implications for "the ordinary Canadian" to explore "how we'll live in 2050." This was closely aligned with better understanding the significance of the transformation and how to manage it. Typical observations from participants included:

"I think we will have deep societal transformation anyway; attaining deep targets requires their careful management."

"I don't think Canadians can imagine—to reduce carbon that much—how much different a place this country will be…It's a much different Canada, at a very personal level."

We heard that policy design plays a crucial role in implementation. Policy design was a major focus for many participants. Simply, it is imperative that policy design enables cost-effective action to attain the targets. While there was support for the NRTEE's advice that economy-wide emission pricing is the core of cost-effective reductions, there was also strong support for complementary measures:

"A carbon price is absolutely necessary…but a carbon price without a technology policy is a bankrupt strategy."

"You're making the assumption that the way to drive the [emissions] change is with a price signal, and I'm not convinced that that is the only means."

Also there was widespread support for the notion that long-term policy certainty is a core enabling condition for a successful transition. One participant commented, for example:

"You cannot have all of your action directed at the 2020 date, and then get there and ask 'What can we do for 2050, because our technology is already locked in?' We need-long term visibility now for 2050."

Influencing investment decisions now for the long term was a common theme. This extended to the air pollutant GHG policy integration, where to avoid costs the observation was made that "You do need to have a very good integrated policy about air pollutants and GHGs."

There was demand for more resolution on the regional and sectoral detail and impact. There was a widespread call for more information on the regional and sectoral implications of the targets. For example, when looking at the implications of alternative slow and fast pathways, a participant commented that "this tells someone that fast and deep gets the best bang for my buck, but when you look at it for different regions, or companies, that might not be the case — something shallow can look deep." Providing more disaggregated detail on the implications was indeed a widely held view. We therefore provided more detail in the final advice.

Finally, many participants stated that the benefits story is missing. Regardless of the pace of reductions, we heard that we as a country need to bring the public and stakeholders along. But with an incomplete articulation of what we get for the costs, there will likely be a continued focus on the affordability and distributional impacts of long-term GHG reductions. And thus there is a real need to better articulate the benefits story. As one participant succinctly commented:

> *"Not only are the costs associated with adaptation missing, but so are the benefits of climate change."*

5.7 Meeting Participants — NRTEE's Research on Clean Air and Climate Change – 2007

Note: Meetings were carried out over a number of months and some participants' organizations may have changed during that time.

Expert Participants in NRTEE Research Program Meetings

Christopher Bataille
J&C Nyboer and Associates

Andy Bowcott
Environment Canada

Matthew Bramley
Pembina Institute for Appropriate Development

Paul Burke
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Experts Meetings on Providing Advice on National Ambient Air Quality Objectives

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Experts Workshops – Discussion on a Long-Range Macro-Economic Forecast for Canada (Macro2050) – June 21 & July 10

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Regional Stakeholders Meetings
Toronto, ON – September 18, 2007

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Dartmouth, NS – September 19, 2007

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Calgary, AB – September 25, 2007

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Vancouver, BC – September 26, 2007

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Montréal, QC – October 1, 2007

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World Energy Congress – MONTREAL 2010

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Ottawa, ON – October 2, 2007

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