EXECUTIVE SUMMARY

Technology and Policy Options for a Low-Emission Energy System in Canada

The Expert Panel on Energy Use and Climate Change

Council of Canadian Academies
Conseil des académies canadiennes

Science Advice in the Public Interest

TECHNOLOGY AND POLICY OPTIONS FOR A LOW-EMISSION ENERGY SYSTEM IN CANADA

The Expert Panel on Energy Use and Climate Change

THE COUNCIL OF CANADIAN ACADEMIES
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Library and Archives Canada Cataloguing in Publication

Technology and policy options for a low-emission energy system in Canada/Expert Panel on Energy Use and Climate Change.

Includes bibliographical references.

ISBN 978-1-926522-15-9 (paperback)

1. Energy policy–Canada. 2. Power resources–Canada. 3. Greenhouse gas mitigation–Government policy–Canada. 4. Energy development–Government policy–Canada. 5. Sustainable development–Canada. I. Council of Canadian Academies, issuing body II. Council of Canadian Academies. Expert Panel on Energy Use and Climate Change

HD9502.C32T73 201 333.790971 C2015-905748-5

This report should be cited as: Council of Canadian Academies, 2015. *Technology and Policy Options for a Low-Emission Energy System in Canada.* Ottawa (ON): The Expert Panel on Energy Use and Climate Change, Council of Canadian Academies.

Printed in Ottawa, Canada

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Expert Panel on Energy Use and Climate Change

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Message from the Co-Chairs

The available evidence clearly supports that the earth's climate is changing, that these changes are driven by greenhouse gas emissions resulting from human activity, and that without substantial mitigation of these emissions the scale and pace of climate change will pose substantial risks to the earth. It is the Panel's view that, both for Canada and for the world in general, the risks arising from climate change justify significant and accelerated efforts to reduce greenhouse gas emissions over the course of the decades to come. This is no small challenge, and requires fundamental societal change.

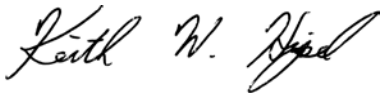
In reality, the complexity of climate change as a technological and policy problem can be overstated. Both the problem of climate change and its potential solutions have been extensively studied and are now well understood, and the technologies and policies needed to mitigate emissions are increasingly being employed. Keeping this progress in mind, the Panel has assembled an accessible though by no means exhaustive summary of the relevant literature. Our goal was to strategically clarify issues and distill ideas that are understood and accepted by energy and climate experts, as supported by the literature. The Panel was also guided by a systems lens recognizing the interconnectedness of society and the natural environment supporting it, and the importance of highlighting lessons learned from the design and implementation of climate change policies around the globe.

It is clear that a low-emission future is possible, but it will depend on the collective will and ambition of federal and provincial governments. Canada is in a particularly advantageous position to meet stringent cutbacks in greenhouse gas emissions, with its abundance of natural energy resources and technological expertise. Accordingly, in the Panel's view Canada can achieve meaningful change if appropriate policies are implemented. Optimal strategies and policies for moving forward will need to be adaptive, evolving as necessary in response to emission trends, new technological developments, and other social, economic, and political changes. They will also need to be based on system level principles of resilience, sustainability, fairness, and integration across jurisdictions and disciplines.

As Co-Chairs, we are most grateful to our fellow Panel members, representing a rich range of disciplines, for contributing their time, knowledge, wisdom, and considerable experience to ensure the report is comprehensive, insightful, balanced, and of an overall quality that meets Council standards. Panel deliberations were always engaging, constructive, and helpful for moving the project forward and it was a pleasure to witness differing views converge to a consensus.

On behalf of the Expert Panel, we are deeply appreciative of the opportunity to explore this important question and we thank Magna International Inc. for requesting the Council to undertake the assessment. In particular, we thank Mr. Donald Walker, Chief Executive Officer, and Mr. David Mark Pascoe, Vice-President of Engineering and R&D, at Magna International Inc. for providing background on the work of their organization as well as guidance on the motivation for the assessment and potential ways to scope the Panel's charge. The Panel also wishes to thank the report reviewers for volunteering their time to make valuable suggestions, which improved the quality, balance, and comprehensiveness of the Panel's work. The final report would not have been the same without their sage advice.

Finally, the Panel is most grateful for the outstanding research support that it received from staff members of the Council of Canadian Academies. They were full partners in this endeavour and deserve to be recognized as such.



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The Expert Panel on Energy Use and Climate Change

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Report Review

This report was reviewed in draft form by the individuals listed below — a group of reviewers selected by the Council of Canadian Academies for their diverse perspectives, areas of expertise, and broad representation of academic, industry, policy, and non-governmental organizations.

The reviewers assessed the objectivity and quality of the report. Their submissions — which will remain confidential — were considered in full by the Panel, and many of their suggestions were incorporated into the report. They were not asked to endorse the conclusions, nor did they see the final draft of the report before its release. Responsibility for the final content of this report rests entirely with the authoring Panel and the Council.

The Council wishes to thank the following individuals for their review of this report:

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The report review procedure was monitored on behalf of the Council's Board of Governors and Scientific Advisory Committee by **Jean Gray, C.M., FCAHS,** Professor of Medicine (Emeritus), Dalhousie University (Halifax, NS). The role of the report review monitor is to ensure that the Panel gives full and fair consideration to the submissions of the report reviewers. The Board of the Council authorizes public release of an expert panel report only after the report review monitor confirms that the Council's report review requirements have been satisfied. The Council thanks Dr. Gray for her diligent contribution as report review monitor.

Janet W. Bax
Interim President, Council of Canadian Academies

Executive Summary

A reliable energy system is essential for a functioning society, and improvements in humanity's capacity to harness energy from a range of sources have helped raise living standards around the world. Canada, like many countries, relies on fossil fuels for most of its energy. Coal, oil, and natural gas together account for 72% of Canada's energy supply, and they are the dominant sources of energy used for transportation, space heating, many industrial processes, and electricity generation in some provinces. The burning of these fuels is increasing the amount of carbon dioxide in our atmosphere and causing pervasive changes in the Earth's climate. The resulting widespread and substantial risks to society and ecosystems justify significant, accelerated efforts to reduce greenhouse gas emissions from human activity over the coming decades.

The Council of Canadian Academies (the Council) was tasked with synthesizing the evidence on select energy sources and technologies, as well as public policies, that would be involved in a transition to a low-emission energy system in Canada. This charge came in response to frustration among some business leaders that stemmed from a lack of clarity about key facts relating to energy technologies and climate change, and policy options to address this challenge. To address this charge, the Council convened a multidisciplinary, eight-member expert panel (the Panel) comprising people with expertise in economics, public policy, engineering, and energy systems and technologies. From its discussion and review of the evidence, the Panel identified three key findings.

Finding 1: Canada could achieve major emission reductions with the adoption of commercially available technologies.

Over the course of the next several decades, a transition to a low-emission energy system would involve three main strategies: improvements in energy efficiency, a shift from high-emission to low-emission energy sources (i.e., energy substitution), and possibly the adoption of carbon capture and storage (CCS) technologies. Improvements in energy efficiency can result in early gains and provide a foundation for the cost-effective introduction of low-emission technologies, but deeper emission reductions will require energy substitution and potentially the application of CCS in conjunction

with continued fossil fuel use. Taking advantage of existing technologies in these areas and across the transportation, building, and industry sectors could result in emission reductions on a large scale. Promising options for reducing emissions include:

- *Transportation:* Ongoing efficiency gains for all vehicles, increasing reliance on low-emission electricity for passenger transportation, expanding use of biofuels in freight transportation, and long-term urban planning and investments in transportation infrastructure.
- *Buildings:* Ongoing efficiency gains in new buildings or in conjunction with building renovations, transitioning to electricity for space heating in highly energy-efficient buildings, and selective adoption of community heating systems that capture and use waste heat and/or rely on renewable energy sources.
- *Industry:* Ongoing efficiency gains in industrial processes, reduction of fugitive emissions, application of CCS in suitable industrial processes, and electrification and enhanced use of biomass in applicable industrial applications.

However, given the higher cost of these technologies relative to conventional options, they are unlikely to be widely adopted unless stringent, compulsory policies are introduced. Further innovation and technological development is also essential for reducing the costs of low-emission energy technologies over time.

Finding 2: Low-emission electricity is the foundation for low-emission energy systems.

Switching to low-emission electricity eliminates carbon dioxide emissions from power generation and allows for further emission reductions as the transportation, building, and industry sectors gradually increase their use of electricity as an energy source. Many Canadians live in jurisdictions that already benefit from low-emission electricity; however, future emission reductions will require a transition in provinces that still depend on emission-intensive electricity sources such as coal, as well as expanding low- and non-emitting generation in all provinces to meet growing demand. This expansion will require careful planning to integrate higher shares of electricity generation from intermittent renewable sources (such as solar, wind, and run-of-river hydro) with additional energy storage capacity and other dispatchable energy sources (such as hydropower, nuclear, geothermal, biomass, and coal or natural gas with CCS). Investments in electricity transmission lines, interconnections, and grid modernization can

also enhance flexibility and enable greater reliance on low-emission generation technologies. The costs of low-emission electricity generation technologies, while still generally higher than those for fossil fuel-fired power plants, have been falling rapidly. Given the relatively low electricity prices in Canada in most jurisdictions, the increased cost of electricity from low-emission energy sources is not likely to pose a major burden for most consumers and businesses.

Finding 3: A transition to a low-emission energy system is achievable with the right combination of stringent and flexible policies.

There is no one right policy for reducing energy-related emissions. However, experience to date has shown that voluntary measures alone are insufficient, and policies that focus exclusively on further technological progress offer no guarantee of emission reductions. Stringent, compulsory, economy-wide emission reduction policies are therefore essential if Canada is to successfully undertake an energy system transition. Carbon taxes, cap-and-trade systems, and other regulations are all possible approaches. Regardless of the instrument, certain design features can improve performance of such policies across a range of criteria. These include linking policies to binding and increasingly stringent emission limitations, or to binding and increasingly high carbon prices; including appropriate monitoring and penalty provisions; providing extensive compliance flexibility; treating new and existing firms fairly; harmonizing policies across Canada and establishing international linkages; compensating groups that are adversely impacted by policies (at least on a transitional basis); and involving the public in decision-making. In addition to compulsory policy, enabling policies are very important for supporting emission reductions. These include direct government investment, adjustment of subsidies, enabling infrastructure, innovation support, and making regulatory processes more efficient. Support for energy innovation can accelerate the adoption of low-emission technologies by making them more affordable. With flexible economy-wide policies in place, individuals, businesses, and other decision-makers can choose the technology and energy responses that are right for their context and adjust these choices over time to adapt to further scientific progress, technological developments, and emission reduction trends.

MOVING FORWARD

Addressing climate change will ultimately require globally coordinated action to protect a common resource — the Earth's atmosphere — and society must be willing to pay now for benefits that accrue largely to future generations. However, climate change as a technological and policy problem may not be as complex as is often assumed. Both the consequences of climate change and its potential solutions have been extensively studied and are now well understood. While energy system transitions typically require many decades due to the long-lived nature of infrastructure and massive investments required, they can be accelerated with strategic policy support, and they are already under way in many jurisdictions across Canada. Due to the risk of getting locked in to new emission intensive capital and infrastructure, delaying mitigation increases the cost of meeting emission reduction goals over time. Ensuring that transitions are fully realized will require policies that are adaptive to changing economic, technological, and environmental conditions and persistent over time. With appropriately stringent and flexible policies in place, large emission reductions from Canada's energy system are achievable over the course of several decades. This transition will not be without cost for consumers, businesses, or the economy as a whole. It can, however, be achieved without jeopardizing Canada's long-term economic growth and competitiveness.

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