CLIMATE PROSPERITY

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NATIONAL ROUND TABLE ON THE ENVIRONMENT AND THE ECONOMY

NRT

FRAMING THE FUTURE: EMBRACING THE LOW-CARBON ECONOMY

// REPORT 06

Canada

NRT

NATIONAL ROUND TABLE ON THE ENVIRONMENT AND THE ECONOMY

THIS IS NOT JUST ABOUT COPING WITH CLIMATE CHANGE, BUT PROSPERING THROUGH IT.

A CANADIAN INITIATIVE

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NATIONAL ROUND TABLE ON THE ENVIRONMENT AND THE ECONOMY
TABLE RONDE NATIONALE SUR L'ENVIRONNEMENT ET L'ÉCONOMIE

ACKNOWLEDGEMENTS

The National Round Table on the Environment and the Economy (NRT) would like to thank the many experts, stakeholders, consultants, and government officials who informed the research and convening that helped shape this report.

We are especially grateful to our regional partners who provided the NRT with insightful input and were instrumental in convening experts and stakeholders across the country. Many thanks to the Canada West Foundation, the Mowat Centre, Écotech Québec, the Atlantic Canada Opportunities Agency, and the Atlantic Provinces Economic Council. Their advice and involvement in the regional aspects of this initiative were invaluable.

Over the course of this project, we heard from close to 150 stakeholders from the private sector, governments, NGOs, and academia through a total of 13 sessions across Canada. Sincere thanks to the people who took the time to participate in these sessions; your insights were instrumental in developing our research findings.

This report required a solid foundation of original economic modelling and analysis. This pioneering work was conducted by several leading Canadian energy/environment researchers and modellers. Our thanks go to the Delphi Group (Bruce Dudley and Brad Fowler), EnviroEconomics (Dave Sawyer), Navius Research Inc. (Noel Melton and Chris Bataille), and Stiebert Consulting (Seton Stiebert).

We would also like to thank a number of additional consultants who assisted the NRT with various aspects of this initiative: Aaron Cosbey from the International Institute for Sustainable Development (IISD) deserves a special mention for his work on trade-related risks and opportunities; Céline Bak (Analytica Advisors) provided information on the state-of-play of Canadian clean technology SMEs; Deborah Murphy and Hilary Hove from IISD conducted a review of governance approaches for low-carbon growth; and Len Coad from The Conference Board of Canada provided an assessment of the state-of-play for low-carbon innovation and investment in Canada. These contributions provided a strong research base for this report. In addition, we recognize the important contribution of several peer reviewers who assisted the NRT in honing both its analysis and the final report.

The NRT would like to acknowledge the efforts of the secretariat staff in the research and convening that made this report possible. Many thanks go to Denise Edwards, administrative assistant, for the organization of the stakeholder and expert sessions. The communications team — Marie-Josée Lapointe, Tony Bégin, Edwin Smith, Richard Pilon, and Nadra Meigag — provided support to the project and managed the design and production of the report.

We thank David McLaughlin, our former President and CEO, without whose leadership this report would not have been possible. David was the driving force behind this report and the NRT's Climate Prosperity series. He relentlessly engaged experts and stakeholders in Canada and abroad in a thoughtful reflection about the global transition to a low-carbon economy. His passion for this policy issue and his insightful contributions were critical to both the vision for this work and its successful completion.

Finally, we thank and acknowledge the contribution of John Cuddihy, who took over this project in March 2011 and brought it to fruition amid significant changes to the policy team and the announcement of the closure of the NRT. We also wish to thank other past and current members of the policy team who contributed to the research, convening, analysis, and writing of the report. Thank you to Jill Baker, Dale Beugin, Joelle Boutin, René Drolet, Jimena Eyzaguirre, Isabella Kavafian, Suzanne Loney, Alex Long, and Sumeet Tandon. The dedication of the team in bringing this report to fruition has been exemplary.

MESSAGE FROM THE INTERIM CHAIR

As Interim Chair of the National Round Table on the Environment and the Economy (NRT), I am pleased to present *Framing the Future: Embracing the Low-Carbon Economy*, the final contribution to the NRT's *Climate Prosperity* series. This report outlines the potential economic opportunity for Canada as the world transitions to a low-carbon economy. It emphasizes Canada's existing strengths and identifies areas for action aimed at developing a strong, resilient, and less carbon-intensive Canadian economy.

A low-carbon economy is no longer a concept of the future. Governments around the world are moving ahead, and a number of jurisdictions already have formal low-carbon growth plans in place. Our research and convening led to a clear conclusion: Canada is well positioned to thrive in a low-carbon context but needs to act now to maximize the potential benefits. While governments need to put in place the conditions that will stimulate innovation, mobilize investment, enhance market access, and foster talent and skills development, private interests need to drive the process, engage with governments, and play a leadership role in developing a vision for Canada's low-carbon future.

Framing the Future: Embracing the Low-Carbon Economy outlines a low-carbon growth framework for Canada, highlighting the policy directions our leaders in public and private sectors need to pursue. Canada's low-carbon future is about energy, innovation, and trade. To get there Canada needs to ensure adequate flows of investment, strengthen its governance and ensure it has the human capital to successfully pull off the transition. The task is not a small one, but one Canadians must collectively pursue to prosper in the twenty-first century.

R.W. SLATER, CM, PH.D.
NRT Interim Chair

ABOUT US

Through the development of innovative policy research and considered advice, our mission is to help Canada achieve sustainable development solutions that integrate environmental and economic considerations to ensure the lasting prosperity and well-being of our nation.

Emerging from the famous Brundtland Report, *Our Common Future*, the NRT has become a model for convening diverse and competing interests around one table to create consensus ideas and viable suggestions for sustainable development. The NRT focuses on sustaining Canada's prosperity without borrowing resources from future generations or compromising their ability to live securely.

The NRT is in the unique position of being an independent policy advisory agency that advises the federal government on sustainable development solutions. We raise awareness among Canadians and their governments about the challenges of sustainable development. We advocate for positive change. We strive to promote credible and impartial policy solutions that are in the best interest of all Canadians.

We accomplish that mission by fostering sound, well-researched reports on priority issues and by offering advice to governments on how best to reconcile and integrate the often divergent challenges of economic prosperity and environmental conservation.

The NRT brings together a group of distinguished sustainability leaders active in businesses, universities, environmentalism, labour, public policy, and community life from across Canada. Our members are appointed by the federal government for a mandate of up to three years. They meet in a round table format that offers a safe haven for discussion and encourages the unfettered exchange of ideas leading to consensus.

We also reach out to expert organizations, industries, and individuals to assist us in conducting our work on behalf of Canadians.

The *NRTEE Act* underlines the independent nature of the Round Table and its work. The NRT reports, at this time, to the Government of Canada and Parliament through the Minister of the Environment. The NRT maintains a secretariat, which commissions and analyzes the research required by its members in their work.

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0.0 EXECUTIVE SUMMARY

The future is low carbon. Economies the world over are making the transition. Canada's actions today on climate, energy, trade, innovation, and skills will shape its economic prosperity for decades to come.

CANADA IN A GLOBAL LOW-CARBON TRANSITION

A global transition to a low-carbon economy is afoot. Markets for low-carbon goods and services (LCGS) are expanding. The upward trend in global investments in renewable and "clean" energy weathered the economic downturn of 2008 and 2009 and remains strong, with investments growing by 30% over the past two years. Nations are seeking first-mover advantages in this global transition. Several have issued low-carbon growth plans, aiming to reduce the energy and emissions intensity of their economies all the while building on their existing competitive advantage. Carbon is increasingly a factor in global trade. Absent a cohesive global climate regime, countries are starting to employ trade measures to limit the entry of high-carbon goods and help achieve objectives for mitigating domestic emissions.

Understanding the implications of the global low-carbon transition for Canada and making choices that maximize the opportunities and minimize the risks are critical to Canada's long-term prosperity. Taking stock of the growing global and domestic demand for LCGS and the opportunity that exists for Canadian firms to meet this demand is fundamental to designing policies that promote current LCGS sectors and grow new ones. Canada can only gain from this. But that is only part of the story: Canada will inevitably need to cut carbon emissions across traditional sectors of the economy. A challenge for Canada is to define a long-term path that takes it from the energy and emissions-intensive economy of today to a future that harnesses innovation and skills to achieve real emissions reductions and drive sustainable resource use. What strategies are available to Canada in an increasingly carbon-constrained world? What are the payoffs if Canada gets it right, the consequences if it gets it wrong? What roles do governments, the private sector, and citizens play?

With this report, the National Round Table on the Environment and the Economy (NRT) lays the foundation for a low-carbon growth plan for Canada. The report brings to a close the NRT's *Climate Prosperity* series, a policy research initiative spanning three years and six major publications that explores the economic risks and opportunities of climate change for Canada. In this report, we combine original economic modelling and qualitative analysis with the perspectives of close to 150 regional stakeholders and subject-matter experts for two purposes: raise awareness of the implications of a carbon-constrained world for our country and set out a framework for action to seize the economic opportunities and maximize Canada's competitiveness under future global carbon constraints.

Canada needs a low-carbon growth plan. This is a basic conclusion of our analysis and of the feedback received from regional stakeholders. The reality is that Canada is unprepared to compete in a carbon-constrained world. Despite a growing cleantech sector, challenges remain in bringing low-carbon ideas to market. Although venture capital investments in cleantech are at a healthy level, overall low-carbon investment and investor confidence is low. Canada's current market share as a global supplier of LCGS is far from what it could be. Canada's LCGS sectors could well face labour shortages in a world competing for skills and innovative talent. Regional emissions profiles and related economic interests differ markedly and have precluded a comprehensive, long-term approach to climate policy to date.

THE NRT'S LOW-CARBON GROWTH FRAMEWORK FOR CANADA

Canada's competitors and trading partners are actively planning for and initiating low-carbon growth. Canada needs a low-carbon growth plan that builds on strengths, involves all governments, engages the private sector, and makes good use of market signals. This plan needs to be developed with clear objectives and through focused consultations. It should also be built on a strong foundation. Based on extensive research and stakeholder consultations, we offer a low-carbon growth framework for Canada, which sets out this foundation.

The NRT's framework includes a low-carbon vision for our country and the objectives, key actions, essential conditions, and governance required to achieve it.

OUR VISION SEES CANADA IN 2050 AS A NATION OF

// diverse, clean, and sustainable energy and electricity systems;

// responsible, respectful, and sustainable natural resource development;

// reputable global exporters of low-carbon energy, technology, and expertise; and

// innovators with renowned successes in bringing low-carbon ideas to market.

IT ALSO SEES CANADA AS A NATION WHERE

// benefits from the growing demand for low-carbon jobs flow to all regions, and

// citizens and decision makers in public and private sectors stay committed to meeting low-carbon goals.

TO ACHIEVE THIS VISION, THE NRT RECOMMENDS KEY ACTIONS ALONG FOUR OBJECTIVES.

FIRST, federal and provincial governments need to **stimulate low-carbon innovation**. Many actions are important: putting low-carbon priorities on innovation policy agendas; providing incentives to undertake and foster demand for low-carbon innovations; reviewing and streamlining funding programs and frameworks within which innovation occurs; and establishing innovation clusters to bring together innovators, potential users of the innovation, and investors.

SECOND, public and private sectors need to **mobilize investment in low-carbon infrastructure and technology**. Public investment is insufficient to finance Canada's low-carbon transition. Government actions that engage key players like institutional investors and balance the risk-reward ratios for low-carbon investment will be necessary to leverage private-sector capital. Financial institutions, too, play a role: they should create new vehicles for low-carbon investment; seek economies of scale in evaluating low-carbon proposals to facilitate project finance; and build their advisory capacity on technical, regulatory, commercial and financial risks of low-carbon technologies and projects. Partnered approaches that bring ownership of low-carbon goods such as electric vehicles within Canadians' reach are also important.

THIRD, federal and provincial governments need to **enhance Canadian firms' access to fast-growing low-carbon markets**. Governments should expand trade promotion activities, make better use of diplomacy and international standards-setting processes, and create domestic procurement policies and technology verification programs to increase Canada's market share as a global supplier of LCGS. Federal action to rein in carbon emissions and contribute to multilateral climate initiatives will be necessary to strengthen Canada's "brand" internationally. Tackling interprovincial barriers to trade and augmenting low-carbon thermal energy and electricity sources are key actions to bring down the emissions intensity of the Canadian economy overall and that of economically important resource sectors.

FOURTH, federal and provincial governments need to work together to **foster low-carbon talent and skills development**. As Canada transitions to a low-carbon economy, human resource requirements will shift. Governments should move quickly to compile official statistics on skills requirements and employment levels in LCGS sectors and related occupations. At the same time, governments can make use of existing information on known demands for low-carbon skills to link innovation, energy, and climate policies to job creation and skills development strategies.

To increase Canada's success in advancing the objectives and key actions that we set out here, some fundamental changes to our economic and policy context are needed. We call these **essential conditions for low-carbon growth** and they include the following:

- policy certainty on climate, energy, and innovation;
- economy-wide, long-term pricing of carbon;
- a level playing field for energy investments; and
- adaptive and outcome-oriented policy and regulatory approaches.

Strong **low-carbon governance** is a foundational element that sits alongside our essential conditions. The NRT identifies five characteristics of governance that will help deliver on a low-carbon agenda:

- a clear, coordinated, and politically supported national vision of Canada's low-carbon economy;
- participation of the private sector in the development and implementation of that vision;
- engagement with Canadians on climate policy, Canada's energy context, and low-carbon growth;
- coordinated and integrated low-carbon efforts within and across levels of government; and
- a credible, independent mechanism to monitor, advise, and maintain momentum on Canada's low-carbon performance.

Leadership by the private sector — in articulating a vision for Canada's low-carbon future and determining the path to achieving it — will be critical to progress and success.

WHAT IF WE DON'T MOVE NOW?

The potential consequences of Canada's collective failure to act promptly sum up as follows: missed opportunities and growing economic risk.

In the global low-carbon transition, firms supplying low-carbon goods and services will make money. Annual global spending on LCGS is significant and growing quickly. Spending stood at roughly $339 billion in 2010. Our analysis shows that global spending could reach between $3.9 and $8.3 trillion by 2050, depending on climate policy assumptions. The growth potential in Canada is also notable. Taking into account existing and proposed climate policies, annual domestic spending on LCGS could rise from the $7.9 billion estimated for 2010 to $36 billion in 2050. Climate policies that cut emissions by 65% from 2005 levels could drive domestic spending of roughly $60 billion in 2050. In either scenario for 2050, LCGS sectors grow more rapidly than the Canadian economy overall.

Provided we as a nation go about it strategically, Canadian firms can become global suppliers of low-carbon technologies, services, and know-how, and Canada can become a global player in low-carbon markets. Canada's diverse and abundant low-carbon natural resources, highly educated workforce, research capacity, advanced manufacturing skills, and strong institutions are but a few reasons to support this. The challenges our nation faces in bringing down the energy and emissions intensity of its economy also present opportunities. For example, solutions to cutting emissions from transportation, Canada's single largest source of emissions, could target export markets.

To remain competitive in a global low-carbon economy Canada needs to do more than harness the low-carbon opportunities available to it. Governments should build on the current discussions about a Canadian energy strategy and put in place stringent climate policy that would affect the country's economic make-up. The economic risks of inaction are too significant to ignore. For one, billions of dollars in Canadian exports could be subject to trade measures that penalize emissions-intensive industries and products. For another, our international reputation could suffer and with it the marketability of Canadian products and the ability of Canadian firms to invest abroad. The cost of policy delay is also clear. Every year of delay in sending strong, economy-wide policy signals represents a wasted opportunity to take advantage of natural cycles of infrastructure and equipment renewal, making it more difficult and expensive to meet emissions reduction targets. Our analysis shows that waiting until 2020 to implement climate policy aimed at cutting emissions by 65% from 2005 levels by 2050 implies close to $87 billion in refurbishments, retrofits and premature retirement of assets.

Canada needs to move quickly to seize the opportunities and manage the risks inherent in a low-carbon future. The NRT offers a framework for action to get going. Our country's approach will be uniquely Canadian, and will undoubtedly involve course corrections along the way, but it needs to start now.

A LOW-CARBON GROWTH FRAMEWORK FOR CANADA

VISION FOR 2050

- Our energy and electricity systems are diverse, clean, and sustainable.
- We develop our vast natural resources responsibly, respectfully, and sustainably.
- Our firms are reputable global exporters of low-carbon energy, technology, and expertise.
- We are an innovation nation, and our successes in bringing low-carbon ideas to market are globally renowned.
- Canadians in all regions benefit from the growing demand for low-carbon jobs.
- Canadians expect federal and provincial decision makers to support and prioritize the low-carbon economy.

OBJECTIVES	STIMULATE INNOVATION	MOBILIZE INVESTMENT	ENHANCE MARKET ACCESS	FOSTER TALENT AND SKILLS DEVELOPMENT	LOW-CARBON GOVERNANCE
KEY ACTIONS	Establish a low-carbon innovation policy agenda	Proactively engage key capital market players (institutional investors, pension, and insurance fund managers) to increase low-carbon investment streams	Strengthen domestic innovation capacity and international competitiveness by implementing procurement, demonstration, and verification programs	Compile and report statistics on employment levels and contributions to regional economies of current and emerging low-carbon goods and service sectors	Articulate clear, coordinated national vision of a low-carboneconomy, short-, mid-, and long-term targets
	Provide both supply-push and demand-pull signals	Establish public-private partnerships to finance energy efficiency and renewable energy applications	Reduce barriers to commercialization by facilitating international collaboration between firms and between innovators and investors		Engage Canadians to shape agenda that meets vision Prioritize dialogue on the full cost of electricity
	Review and streamline funding and regulatory frameworks	Aggregate low-carbon infrastructure and technology applications for financing to reduce transaction costs	Engage in international diplomacy to remove barriers to investment and to build emerging and developing economies' capacity to absorb innovations		
		Build analytical capacity of financial sector for risk assessment of low-carbon assets and developments	Actively participate in formulation of international standards and labels	Link low-carbon innovation, energy, and climate policies with job creation and skills development strategies	Private sector participates and provides leadership with respect to low-carbon vision and path forward
	Support low-carbon innovation clusters: reduce barriers to commercialization by facilitating collaboration between firms and between innovators and investors	Create and promote financial products for low-carbon purchases and investments by Canadian households	Expand trade promotion role to match international needs with Canadian low-carbon goods and services		
		Provide financial incentives to balance risk-reward ratio for low-carbon investment by private sector	Improve Canada's international brand on climate policy		Coordinate and integrate low-carbon efforts within and across government departments
		Prioritize investment in electricity infrastructure and oil and gas sector	Promote and prioritize low-carbon thermal energy and electricity sources to limit "carbon exposure" of key sectors		
			Remove sector-specific, interprovincial barriers to trade		
ESSENTIAL CONDITIONS	A unified, long-term price on carbon Outcome-based, adaptive regulatory regimes that integrate economic and environmental costs and benefits A level playing field for fossil and non-fossil energy sources Transparent and long-term climate, energy, and innovation policy				Establish impartial credible mechanism to monitor national progress and provide unbiased advice

LOW-CARBON ECONOMY

A SIZEABLE, SEIZABLE OPPORTUNITY

// CHAPTER 1.0

1.0 // LOW-CARBON ECONOMY: A SIZEABLE, SEIZABLE OPPORTUNITY

1.1 // WHY LOW CARBON?

1.2 // OUR CONTRIBUTION

1.3 // OUR APPROACH

1.1 WHY LOW CARBON?

The world is transitioning to a low-carbon economy. Canada's public and private sectors need to act now to exploit the opportunities and mitigate the risks that this transition creates.

THE FUTURE IS LOW CARBON. A global transition toward a low-carbon economy is well underway. Climate change, rising energy costs, security concerns, global population growth, and rapidly expanding economic activity are combining with a growing understanding of limitations to ecosystem health to create increasingly favourable conditions for countries and companies across the world to invest in and develop markets for "clean" or "green" technologies. This investment has the potential to transform energy and transportation systems around the world. In order to remain competitive, Canada's economy will also need to transition to a greener, less carbon-intensive state.[a] The manner in which this is done, the timing, pace, and scale at which this is accomplished, will have significant implications for the Canadian economy and for individual regions, sectors, and firms.

THE GLOBAL GROWTH POTENTIAL FOR LOW-CARBON GOODS AND SERVICES IS SUBSTANTIAL. A study for the U.K. government estimated the 2008 global market for the renewable energy and emerging low-carbon sectors in the range of $4.4 trillion.[b1,2] This same study forecasted global market growth of 45% from 2007/08 to 2014/15. The International Energy Agency (IEA) estimates that achieving a low-carbon energy sector will require total global investments of $136 trillion from 2012 to 2050.[3] Markets for low-carbon goods and services are expanding quickly as nations look to reduce the carbon intensity of their energy systems.

CARBON IS INCREASINGLY CENTRAL TO TRADE. Low-carbon and clean energy have increasingly been cited as factors or motivations in global trade discussions and bilateral relations. As an example, the UK-China Low Carbon Co-operation agreement, signed in January 2011, is a memorandum of understanding demonstrating a commitment to collaboration on energy markets and low-carbon technology.[4] And in the context of a climate change policy vacuum at the multilateral level, there is increasing use of unilateral trade measures to achieve climate goals. France has mandated carbon labelling under its La Grenelle 2 Act,[c] potentially introducing non-tariff trade barriers to imported products. Low-carbon fuel standards are under discussion in numerous jurisdictions, and the relative carbon content of oil from Canada's oil sands has been a subject of much discussion south of the border and in the context of bilateral free trade discussions with Europe. Border carbon adjustment (BCA) has cropped up as a proposed measure in many pieces of U.S. climate legislation, and is being heavily promoted by France within the EU. The EU's use of unilateral aviation levies

a In this report we refer to carbon intensity and emissions intensity interchangeably to mean the average quantity (mass) of carbon dioxide equivalent (CO_{2e}) associated with the generation of one dollar of gross domestic product (GDP). The inverse of this metric — carbon productivity, or how much income the economy generates per unit carbon expended — is also useful.

b All dollar figures in $2010 Cdn unless otherwise indicated.

c The *La Grenelle 2 Act* provides a framework for a national Environmental Product Declaration (EPD) program. France completed a one-year trial period of an EPD program in July 2012 focused on carbon labelling. France will be evaluating the program before making the determination as to whether or not it should be more broadly implemented (Le Grenelle Environnement 2011).

is an example of this measure in practice.[d] Given Canada's heavily resource-oriented economy with expectations of continued strong growth in carbon-intensive oil and gas production and energy-intensive mining operations, this focus presents obvious trade risks; however, given Canada's fast-growing low-carbon goods and services (LCGS) sectors that are disproportionately oriented toward international markets, the focus on carbon also presents opportunities.

LOW CARBON DOES NOT MEAN NO OIL. Low carbon is explicitly not about sacrificing the economic benefit Canada is currently deriving from oil sands development and energy-intensive resource extraction more broadly. In our modelling,[e] despite uncertainties, we assume significant growth in crude exports. It should be clearly understood that growth in crude production is already heavily targeted toward exports with Canadian demand for refined petroleum products growing more slowly than Canada's population.[f] World oil prices and world oil consumption are factors fully outside Canada's control. International forecasts suggest continued strong growth in global oil demand,[g] and in its 2011 energy market assessment, the National Energy Board also projects significant growth in the production of Canadian crude with output doubling 2010 levels by 2035.[5] Canada is an energy-producing nation, and the global transition to a low-carbon economy will impose costs on fossil energy producers. However, these costs do not necessarily preclude a profitable energy sector. The advent of product carbon-footprinting will add a new dimension to competition; however, smart investments today to reduce the carbon intensity of the sector (e.g., through carbon capture and storage [CCS]) will position it to compete well into the future. By making strategic investments today, Canada can continue to benefit from its natural resource endowment while transitioning to a low-carbon economy. There is also precedent for such a model in Norway, which despite continued development of its significant oil interests has made marked progress on the path toward carbon neutrality.[h] Suffice it to say that low-carbon and oil sands production are not mutually exclusive in the time frames considered.

LOW-CARBON PLANNING IS GAINING MOMENTUM. Canada's competitors and trading partners are actively planning for and initiating resource-efficient growth, and 2011 was a banner year: the European Commission published its 2050 low-carbon growth roadmap in March 2011, UNEP published its *Green Economy Report* in early May, and the OECD released its series *Towards Green Growth* in May.[6] Emerging economies are also forging ahead: China released its twelfth five-year plan (its primary economic planning document) in March 2011, highlighting climate change as a priority issue and the reduction of the carbon intensity of the Chinese economy as an area for action.[7] This is notable as being the first of China's economic plans to

d The EU aviation levy was implemented at the beginning of 2012 as a result of the extension of the EU emissions market into aviation. It requires airlines to monitor and report their emissions on all flights in and out of Europe, and to purchase carbon permits for these emissions. Countries that have equivalent measures on aviation emissions may be exempt from the EU levy. A block of countries are fighting EU's aviation levy, with China refusing to comply. For additional information, please see: Sundaram 2012; The Economist 2012.

e NRT commissioned Navius Research Inc. to undertake original modelling and analysis to assess the implications of greenhouse gas abatement timing on Canada's emission profile and the capital investment required to meet abatement targets.

f In our modelling, the reduction in oil consumption occurs most substantially in its use as a transportation fuel.

g According to the International Energy Agency (IEA) under the Current Policies scenario (i.e., business-as-usual conditions) annual growth in oil consumption will be 0.8% / year from now to 2035 leading to demand for 107 million barrels per day (25% over 2010 demand). Under their New Policies scenario which takes account of policy commitments and cautious implementation of published targets, the IEA projects a 15% increase over 2010 levels (99 mb/d) by 2035 (International Energy Agency 2011a).

h While Norway's plan to achieve carbon-neutrality by 2030 relies measurably (roughly 1/3 of planned GHG reductions) on offsets generated through investment in "clean" projects internationally and trading of emissions quotas (Economist 2008), it is strongly positioned in terms of its carbon-productivity and other low-carbon benchmarking metrics (National Round Table on the Environment and the Economy 2010).

focus on the environment. South Korea, a pioneer among emerging economies, has been positioning itself for low-carbon growth since launching its long-term "green growth" strategy in 2008. In June 2011, South Korea also co-hosted the 2011 Green Growth Summit with the OECD.[8]

SIGNIFICANT INVESTMENTS ARE BEING MADE BY BOTH PUBLIC AND PRIVATE SECTORS. Worldwide annual private and public investment in "clean energy" (excluding R&D) has grown over 600% to $242 billion since 2004, growing in excess of 30% over the last two years as the world economy emerged from recession.[9] Following the financial crisis of 2008, the world's major economies committed $191 billion in clean energy stimulus funds.[10] Most OECD countries devoted significant shares of their economic stimulus packages to fostering a "green recovery" with the EU at 64%, Norway at 30% and the U.S. at 12%.[11] Despite successive cuts in its recent federal budgets and a downward spending trajectory, the United States continues to invest in low-carbon energy as part of its economic recovery and job creation strategy[i] and ranked first globally in 2011 in terms of attracting clean energy venture capital and equity investments.[12] In 2010, the Australian government announced a $664 million Renewable Energy Future Fund as part of its $5 billion Clean Energy Initiative.[13,14] Investors in the EU, led by Germany (ranked third globally in attracting clean energy investment), are allocating significant capital to clean energy systems. In 2010, for the first time, renewable energy investment in developing economies exceeded that in developed economies ($71 billion vs. $69 billion).[15] China was ranked second only to the U.S. in terms of attracting renewable energy investment in 2011 and currently leads the world in wind energy investment. China is also a leader in solar and wind manufacturing, and in the deployment of wind power generation.

CANADA HAS LOW-CARBON OPPORTUNITIES *NOW*, NATIONALLY AND REGIONALLY. They are significant, diverse, and regionally specific. Canada has substantial low-carbon electricity resources across the country. These include vast hydropower capacity and potential in many provinces, significant on- and off-shore wind resources across the country, high-quality tidal and wave regimes on both east and west coasts, a solar regime that is better than Germany's with particularly strong resources in the Prairie Provinces,[17] sizeable deep geothermal resources concentrated in western and northern Canada, and the second largest uranium production globally coming from Saskatchewan.[18] Canada has national strengths in its highly educated workforce, significant R&D capacity, and solid institutional support. There is advanced manufacturing capacity present across the country, but concentrated in Ontario and Québec. The country has a history of innovating and both depth and breadth in energy sector experience — Canada has the potential to be a significant global player in low-carbon energy. Canada is also faced with significant challenges in which lie opportunities: the country relies heavily on transportation to connect both people and goods across this vast country, and transportation is the single largest source of GHG emissions; the buildings in which Canadians live, work, and play have the potential to be far more efficient; industries, while improving in their efficiency, have considerable remaining room for improvement; and remote communities need alternatives to expensive, polluting, and GHG-intensive diesel-generated electricity. There is both potential and reason to be motivated.

i For details on breakdown and timing of expected investments see Jenkins et al. 2012.

GOVERNMENT ACTION IS CRITICAL. Canada's low-carbon future will require vision and it will demand commitment, resources, and effort. Canada needs to actively position itself to most effectively manage the risks and harness the opportunities inherent in the global low-carbon transition. While it is not necessarily a matter of "being left behind," Canada does need to position itself to compete in those areas where it has economic advantage. If Canada doesn't occupy the space, someone else will. Existing windows of opportunity will close if Canada is not prepared and positioned to take advantage of them. Canadians will not be leaders in all areas related to "low carbon." As recognized recently by the Council of the Federation, Canada will need to focus and build on its strengths as it transitions.[19] If Canada approaches this inevitable global transition in an ad hoc or delayed manner, it will unlikely be able to realize the full potential opportunity and will incur higher costs. Planning and investing now provide opportunities to shape possibilities and secure prosperity for the future.

PRIVATE SECTOR ACTION IS CENTRAL. While governments set the policy context — the environment within which business operates — the private sector ultimately delivers. The innovation required, the scale of investment, and the scope and magnitude of the change speak to the centrality of the private sector in effecting the low-carbon transition. This requires leadership, collaboration, and proactive dialogue with government with respect to both what the sector needs and what constitutes effective policy so that signals can be appropriately aligned. It will also demand increased proactive involvement in Canada's national low-carbon dialogue and the exercising of market leadership in promoting low-carbon approaches. In particular, Canada's financial sector, energy sector, and energy-intensive and trade-exposed (EITE) industries are heavily implicated. Small- and medium-sized enterprises are expected to continue to be core to Canada's low-carbon innovation.

1.2 OUR CONTRIBUTION

Framing the Future: Embracing the Low-Carbon Economy is the final report in the *Climate Prosperity* series by the National Round Table on the Environment and the Economy (NRT). *Climate Prosperity* is a comprehensive policy initiative spanning three years and six major publications, exploring the economic risks and opportunities of climate change for Canada in the contexts of climate impacts and adaptation, and the global transition to a low-carbon economy. It has sought to broaden the conversation about climate change through the assertion that ***"this is not just about coping with climate change, but prospering through it."***

In this report, we outline a national framework for low-carbon growth, highlighting the policy directions Canada needs to pursue to harness this opportunity, mitigate risks, and minimize costs, and outlining the main elements of a comprehensive low-carbon growth plan. This report considers the investment required in the transition to a low-carbon economy and outlines the inherent opportunity. The federal government's moves to begin reducing the carbon intensity of the economy are positive; however, Canada needs to continue to move forward, do more, and act boldly. This is not just about climate policy, though it features strongly. It is also about energy, innovation, and trade — and the linkages and relationships among all. It is about ensuring the flow of investment, strengthening governance, and ensuring Canada has the human capital to pull it off.

THE REPORT OBJECTIVES ARE TWO-FOLD:

1 // to increase awareness on the part of Canadian public-sector and private-sector decision makers of both the economic risks and opportunities associated with the expected reduction in the carbon intensity of the global economy, and

2 // to articulate a coherent and realistic policy framework for ensuring Canadian economic growth and competitiveness under future global carbon constraints so that Canada's economy and industry succeed in this transition.

Creating a low-carbon growth plan (LCGP) is fundamental to furthering these objectives. This report represents a first step in constructing an LCGP for Canada by putting forward a framework for low-carbon growth, highlighting the policy directions Canada needs to pursue and outlining the main elements of a comprehensive low-carbon growth plan.

The public policy debate in Canada has mostly revolved around issues of climate targets, carbon pricing, and clean energy, rather than considering a comprehensive "low-carbon economy" approach focused on opportunity and the preconditions for low-carbon growth. There is a growing consensus on the need to

change the nature of the dialogue on climate policy to facilitate a meaningful path forward. This work is intended to help spur this change in the dialogue.

There is also limited information available concerning the economic risks and opportunities associated with the global low-carbon transition. Our analysis seeks to at least partially fill this gap.

1.3 OUR APPROACH

Our approach to the report aligns with NRT's pillars: broad-based convening, thorough research and analysis, and considered advice. In concert with our regional partners, we convened meetings across Canada to gather input from a broad base of stakeholders to ensure our advice was sound, grounded, and realistic.[j] We then combined this with insights from energy, trade, and innovation advisors. Our research was conducted by some of Canada's brightest minds and includes original modelling on both risks and opportunities.

Our modelling and associated analysis focused on three related but distinct objectives: 1) developing an understanding of both the current magnitude and future growth potential of Canadian and international LCGS markets, 2) understanding the investment implications of a low-carbon growth trajectory for Canada under a variety of plausible GHG policy futures, and 3) exploring the implications of emissions "lock-in." Our international analysis covers two scenarios as presented in **Table 1**.

TABLE 1

INTERNATIONAL SCENARIOS

INTERNATIONAL SCENARIOS	DESCRIPTION
BUSINESS-AS-USUAL (BAU) SCENARIO	We used the IEA's New Policies Scenario for our international business-as-usual scenario. The New Policies Scenario is the reference case used for the IEA's 2011 World Energy Outlook. It assumes that policy commitments and plans announced by countries around the world will be implemented, even where specific measures have not yet been specified.
LOW-CARBON SCENARIO	We used the IEA's 450 Scenario as our global low-carbon scenario. The 450 Scenario is consistent with a 50% chance of meeting the goal of limiting the increase in average global temperature to two degrees Celsius (2°C) compared with pre-industrial levels.

j We met with stakeholders in nine Canadian provinces. While the low-carbon transition is anticipated to have significant implications for Canada's territories, comprehensive treatment of their reality and opportunities was not possible within the scope of this work. In this report, discussion of governance, government initiatives and actions, and related recommendations focus on federal and provincial governments.

Our domestic analysis includes both an assessment of total spending on LCGS and an assessment of the incremental investment implications associated with different domestic GHG policy approaches. This included differences in targets and implementation timelines. A total of five scenarios were explored in addition to the Reference Case (Table 2); however, for the most part our analysis focuses on the Reference Case and the Target 2050 scenario. Descriptions of the other scenarios are also included below for the readers' reference.

TABLE 2

DOMESTIC SCENARIOS

DOMESTIC SCENARIOS	DESCRIPTION
REFERENCE CASE	"New Policies" reference case that includes existing and proposed abatement measures for both federal and provincial governments. This Reference Case is consistent with NRT's work in *Reality Check*.
TARGET 2050 SCENARIO (CARBON-CONSTRAINED SCENARIO)	Achieves emissions reduction target of 65% below 2005 levels by 2050 in the most "economically efficient" manner (largely consistent with NRT's "Getting to 2050" and "Achieving 2050" analyses).
S&L TARGETS SCENARIO	This scenario includes both short- (2020) and long-term (2050) targets. The long-term emissions reduction objective is consistent with the Target 2050 scenario (65% below 2005 levels by 2050). The short-term requirement is to hit Canada's 2020 emissions target of 17% below 2005 levels, starting in 2012.
DELAY SCENARIO	Explores the implications of policy delay while striving for the same annual emissions reduction target in 2050 as the Target 2050 scenario.
LOCK-IN SCENARIO	Explores the implications of emissions' "lock-in" through delayed implementation of climate policy while ultimately achieving close to the same cumulative emissions reductions as the Target 2050 scenario.
BEST-IN-CLASS REGULATORY SCENARIO	Approximates a best-in-class performance standard regulatory approach and explores the associated emissions and investment implications.

Low-carbon growth plans will all be unique to the circumstances and economies for which they are developed. In our analysis and development of a low-carbon policy framework for Canada we have chosen to focus on five areas: innovation, investment, trade and market access, labour markets and skills, and governance.

OUR REPORT IS STRUCTURED IN THE FOLLOWING MANNER:

CHAPTER 2 presents a discussion and analysis of Canada's low-carbon opportunities, specifically in the low-carbon goods and services sectors (LCGS). This chapter quantifies the global and domestic opportunity in LCGS markets, and presents the NRT's findings from its regional discussions assessing Canada's low-carbon opportunities.

CHAPTER 3 explores the risks to Canada of delaying the development and implementation of a low-carbon growth plan, further establishing the need for action.

CHAPTER 4 presents the key elements of low-carbon growth planning and examines Canada's low-carbon preparedness in terms of innovation, investment, trade and market access, labour markets and skills, governance, and economic competitiveness.

CHAPTER 5 reflects on the challenges and barriers to harnessing these opportunities and identifies key policy directions required for success.

The appendices present additional information on regional low-carbon opportunities and on Canada's preparedness for low-carbon growth, as well as supporting materials for some of our analysis and background information concerning our convening activities.

EXPLOITING OPPORTUNITIES

IN THE GLOBAL LOW-CARBON TRANSITION

// CHAPTER 2.0


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2.0 // EXPLOITING OPPORTUNITIES IN THE GLOBAL LOW-CARBON TRANSITION

2.0 EXPLOITING OPPORTUNITIES IN THE GLOBAL LOW-CARBON TRANSITION

There is great opportunity for early movers in the low-carbon transition. The global market for low-carbon goods and services is growing rapidly, and may reach $4 trillion to $8 trillion by mid-century. In Canada, the NRT estimates that total LCGS spending will grow from $8 billion in 2010 to between $36 billion and $60+ billion in 2050.

International debates about low-carbon fuel standards, the publication of a suite of low-carbon growth plans around the world, and the clean energy stimulus spending in response to the global economic downturn are all evidence that the world is in the midst of a transition to a low-carbon economy. As with any economic shift, the low-carbon transition will create winners and losers. Growing demand for low-carbon goods and services (LCGS) has already begun to create winners in the solar, biofuels, and energy-efficient vehicle industries, among others.

This chapter assesses the opportunity for Canada. It sets out current and forecasts future LCGS expenditures at the global and national levels. Our analysis considers how various climate policy futures could influence that spending. From that basis, we identify Canadian LCGS sectors that are currently capturing a greater than expected share of global expenditures and assess the trade balances of LCGS sectors to identify areas where Canada may be well positioned to maintain or gain market share in the future. This empirical analysis is complemented by a qualitative assessment of opportunities at the regional level, informed by pan-Canadian discussions with expert stakeholders.

2.1 DEFINING THE LOW-CARBON ECONOMY

Our consideration of Canada's low-carbon opportunities is in the context of the global transition to a low-carbon economy, which, for the reasons outlined in Chapter 1 we believe is already well underway. We further suggest that to achieve Canada's 2020 GHG mitigation targets and longer-term (e.g., 2050) targets consistent with this level of effort, Canada will need to engage more fully in its own transition to a low-carbon economy. But what do we mean by a "low-carbon economy"? What does it look like?

FIRSTLY, while we cannot describe with full certainty what a low-carbon economy for Canada would look like once achieved, we can articulate our current understanding. The low-carbon economy is a transition — a shift — in the existing economy from heavy carbon intensity to a significantly reduced average GHG intensity of economic output; it is *not* a subset of the current economy. Furthermore, while the low-carbon economy *does* imply a change in the GHG intensity of this production, it does not necessarily imply a significant shift away from oil and gas production and other resource-based industries.

SECONDLY, while there are many parallels in this conversation with the dialogue around the "green economy," we are not addressing the full suite of issues and considerations inherent in the broader green economy discussion. A "green economy" *is* of necessity a "low-carbon economy," but while low-carbon is a significant consideration in what makes a "green economy" green, there are many other aspects of sustainable development beyond climate change considerations that need to be factored into this broader discussion. For the purpose of this work, we are exclusively focusing on the actions needed to bring about the low-carbon aspect of the "green economy," consistent with the vision for NRT's *Climate Prosperity* series that is focused on understanding how Canada can prosper through climate change.

While this chapter considers the potential growth in LCGS sectors, in a global low-carbon economy it is not strictly these LCGS sectors that will provide economic growth. The LCGS sectors do not comprise the low-carbon economy, but rather enable it. Low-carbon innovation in manufacturing will enable Canadian firms to be more competitive in world markets, positioning them to gain market share. Innovation in the extraction and processing of bitumen could ensure long-term opportunity for the oil sector. Highly GHG-efficient mineral extraction and processing could position Canada to be recognized as a world leader providing further opportunities to supply expertise and technology internationally. So, while we focus on the opportunity available in the pursuit of LCGS to supply growing global demand, we also recognize the broader economic benefits that the development of LCGS sectors and the pursuit of low-carbon innovation can deliver to the economy as a whole. **Table 3** presents the key LCGS sectors considered in our analysis. Detailed profiles of these sectors are provided in Appendix 6.1.

TABLE 3

LCGS SECTORS

		DEFINITION	DOMESTIC CAPACITY
UPSTREAM	WIND	Projects that generate power from wind *Our analysis includes large scale utility wind projects (> 300 kW)*	4,000 MW (2010)[21]
	SOLAR	Projects that generate power from the sun *Our analysis includes utility-sized solar projects (grid connected solar PV and concentrated solar power)*	95 MW (2009)[22]
	HYDRO	Projects that generate power from hydrological resources *Our analysis includes small and large hydro-electric systems*	69 GW (2009)[24]
	GEOTHERMAL	Projects that generate power from the use of super-heated water or steam from the Earth's interior	No significant capacity (2010)
	BIOMASS	Biomass used for the production or cogeneration of electricity *Our analysis includes large utility-sized projects*	5,050 MW (2008) thermal and electrical[23]
	NUCLEAR	Projects that generate power from nuclear energy *Our analysis includes implementation and refurbishments of nuclear power installations, but excludes uranium mining and nuclear medicine*	13 GW (2007)[25]
	BIOFUELS	Projects that generate biofuels used for transportation, heating, and other end-uses *Our analysis excludes biofuels used for power generation*	2.25 billion litres (2010)[26]
	CARBON CAPTURE AND STORAGE (CCS)	Projects that capture and sequester carbon from power plants or industrial sources *Our analysis includes transportation to the storage site and geological storage or use in enhanced oil or gas recovery*	Currently no capture, 3 MT per year of CO_2 storage
UPSTREAM & DOWNSTREAM	INDUSTRIAL PROCESSES	Goods and services that contribute to emission reductions in industry and manufacturing through energy efficiency, changing processes to less emission intensive processes or fuel switching to renewable energy supplies	N/A
DOWNSTREAM	BUILDINGS	"Green" construction of residential and commercial buildings, efficient HVAC equipment, major appliances, lighting equipment and water-heating equipment, non-grid connected electricity generation from solar PV or wind	N/A
	EFFICIENT VEHICLES	Low-carbon passenger and freight vehicles including plug-in hybrid electric vehicles, pure electric vehicles, and vehicles offering substantial emission reductions compared to current fleet	N/A

2.2 LOW-CARBON GROWTH POTENTIAL

Due to the emerging nature of the LCGS sectors and the difficulty in isolating these "sectors" within national economic accounts, measuring the current size of LCGS economic activity is a challenge. In order to estimate the size of the LCGS market globally, we built on analysis conducted by the International Energy Agency, which forecasts the evolution of LCGS sectors under both a business-as-usual future and a future characterized by a significant carbon constraint, leading to a stabilization of atmospheric CO_2 concentrations at 450 ppm. Our estimates of domestic market size were developed using a wide variety of information sources including the CIMS energy-economy model, Statistics Canada data, and a broad literature review (see Appendix 6.2 for a description of our methodology).[a] Table 4 presents our estimates of 2010 domestic LCGS sector value to the Canadian economy in terms of total expenditures,[b] gross domestic product (GDP, added value), and employment.

TABLE 4

ESTIMATED 2010 DOMESTIC LCGS MARKET DATA

		ESTIMATED 2010 LCGS CAPITAL EXPENDITURE (APPARENT DOMESTIC MARKET) (C$2010M)	MODELLED LCGS VALUE ADDED (GDP) (C$2010M)	MODELLED 2010 EMPLOYMENT
UPSTREAM	WIND	$1,829	$494	7,470
	SOLAR	$324	$120	1,720
	HYDRO	$1,596	$680	42,600
	GEOTHERMAL	-	-	-
	BIOMASS	$18	$15	41
	NUCLEAR	$1,714	$979	8,460
	BIOFUELS	$185	$81	960
	CARBON CAPTURE AND STORAGE (CCS)	$23	$27	141
UPSTREAM & DOWNSTREAM	INDUSTRIAL PROCESSES	$451	$312	1,153
DOWNSTREAM	BUILDINGS	$1,540	$501	5,436
	EFFICIENT VEHICLES	$191	$33	214
TOTAL		$7,871	$3,242	68,195

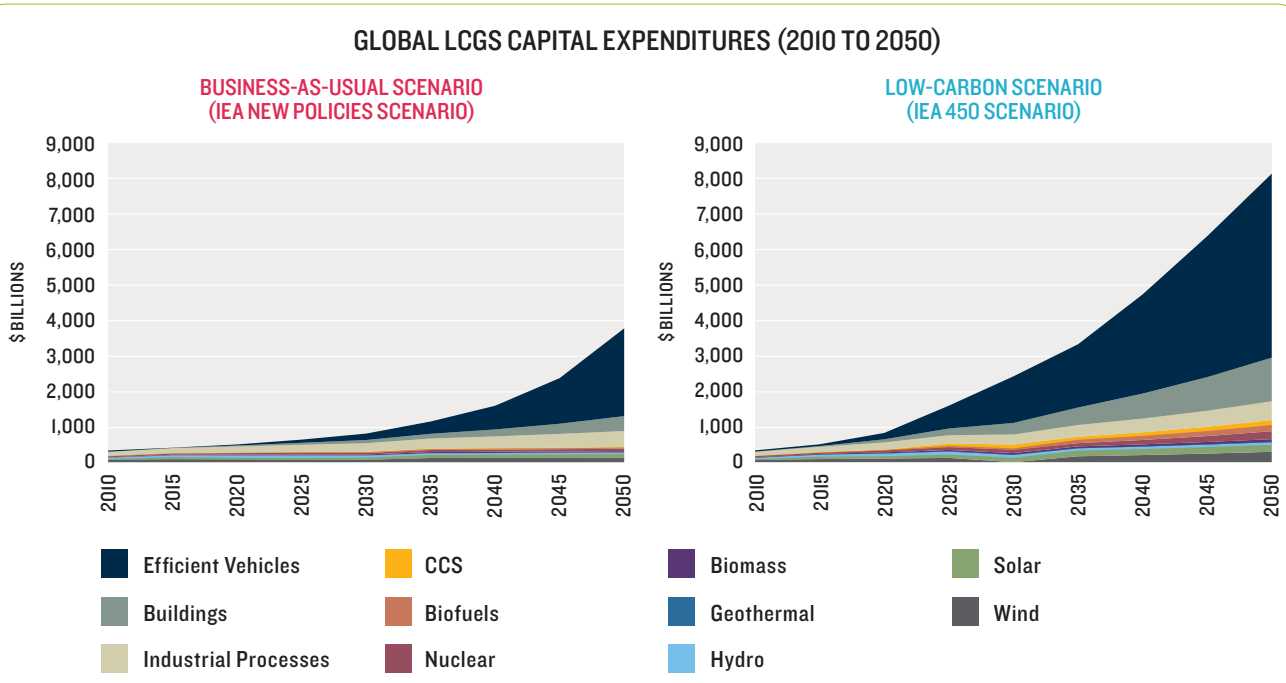
a At the request of the NRT, quantification of low-carbon growth potential was undertaken by the Delphi Group in partnership with EnviroEconomics (Delphi Group and EnviroEconomics 2012). Follow-up analysis was conducted by Stiebert Consulting (Stiebert 2012). All reports available upon request.

b Our estimates include domestic production plus imports, net of exports, and focus exclusively on capital expenditures.

Our extension of analysis undertaken by the International Energy Agency[27] suggests that global expenditure on LCGS is significant and growing quickly. Starting from a value of $339 billion in 2010, the global market for LCGS will reach $3.9 trillion by 2050 under a business-as-usual scenario. Estimates of 2050 expenditures more than double under an emissions-constrained scenario, reaching $8.3 trillion in annual spending — a growth rate of about 8% annually relative to a growth rate of 6.3% under the BAU scenario. For comparison, in their World Energy Outlook, the IEA assumes an average annual economic growth rate of 3.6% from 2010 through 2035.

As illustrated in Figure 1, global capital expenditures on LCGS are dominated by the efficient vehicles sector. That sector alone accounts for approximately 40% of spending by 2025 and 64% of spending by 2050 in the low-carbon scenario, owing to the rapid turnover rate in vehicle investments as compared with other sectors. Low-carbon buildings and efficient industrial processes account for an additional 12% and 15% respectively by 2025 and 15% and 6% by 2050. Wind and hydro represent a larger portion of the spending in the 2012–2025 period under the BAU scenario together representing over 20% of LCGS expenditures in 2025. However, by 2050 the percentage breakdown of expenditures by LCGS sector is similar to that under the low-carbon scenario with close to 90% of the expenditures distributed among low-carbon vehicles (66%), efficient industrial processes (12%), and low-carbon buildings (11%).

FIGURE 1



SOURCE: STIEBERT 2012; ADAPTED FROM INTERNATIONAL ENERGY AGENCY 2011A; AND INTERNATIONAL ENERGY AGENCY 2010

c Compound annual growth rate.

These results demonstrate that there will be considerable new LCGS spending in the years to come. Canadian firms and policy makers should consider how best to position Canadian industries to be suppliers of choice as LCGS markets expand. The results further suggest that regardless of what climate policy path is ultimately taken globally, efficient vehicles, and to a lesser extent low-carbon buildings and efficient industrial processes, will feature strongly as growth sectors.

Our analysis establishes substantial growth potential for Canada's LCGS sectors. Under the Reference Case, total LCGS expenditures in Canada are expected to grow from an estimated $7.9 billion in 2010 to approximately $36 billion in 2050, an annual growth rate of 3.9%. In a more carbon-constrained future LCGS expenditures are estimated at just over $60 billion by 2050, corresponding to an annual growth rate of 5.2%. Under both scenarios, the rate of value-added growth in the LCGS sectors is forecast to substantially exceed average GDP growth.[d]

Similar to the global results presented above, efficient vehicles and low-carbon buildings comprise a significant portion of the overall domestic spending (**Figure 2**). Other large domestic expenditures include hydropower and wind, with CCS becoming an important expenditure in the carbon-constrained scenario.

These results demonstrate overall significant growth in domestic LCGS markets over time and show the potential for future policies to influence the size of these markets. LCGS sectors including efficient vehicles, buildings, industrial processes, hydro, solar, and wind are positioned to grow irrespective of future policies. In contrast, significant expenditures on CCS and biofuels are only projected in the context of additional carbon constraint imposed by new policies. The results also demonstrate sizeable domestic market opportunities that merit consideration by Canadian firms as they develop business strategies for the future. For example, Canada's well-established automobile manufacturing sector will want to consider what actions may be needed to benefit from the growing demand for energy-efficient vehicles. In addition, expenditures on industries supporting low-carbon electricity development such as smart-grid and electricity storage technologies, while not explicitly captured by the modelled LCGS sectors, are anticipated to increase substantially (particularly under the carbon-constrained scenario) as electricity meets a significantly higher proportion of final energy demand and there is increased need for integration of intermittent renewable power sources.

Our analysis estimated that direct employment in the LCGS sectors would increase from approximately 42,000 today to 91,000 and 159,000 by 2050 in the reference and carbon-constrained scenarios respectively. Our analysis further suggested that LCGS investment would require total labour inputs (direct, indirect, and induced) of about 96,000 full-time equivalents (FTE) in 2010 rising to 224,000 in 2050 under the Reference Case and 402,000 under the carbon-constrained scenario. Total cumulative employment in LCGS sectors over the forecast period is estimated to be more than 60% higher under the carbon-constrained scenario.

d Canada's GDP compound annual growth rate averaged 1.7% between 2001 and 2010. Under the reference and carbon-constrained scenarios respectively, overall LCGS value-added (GDP) growth is projected to be 3.4% and 5.1%, respectively.

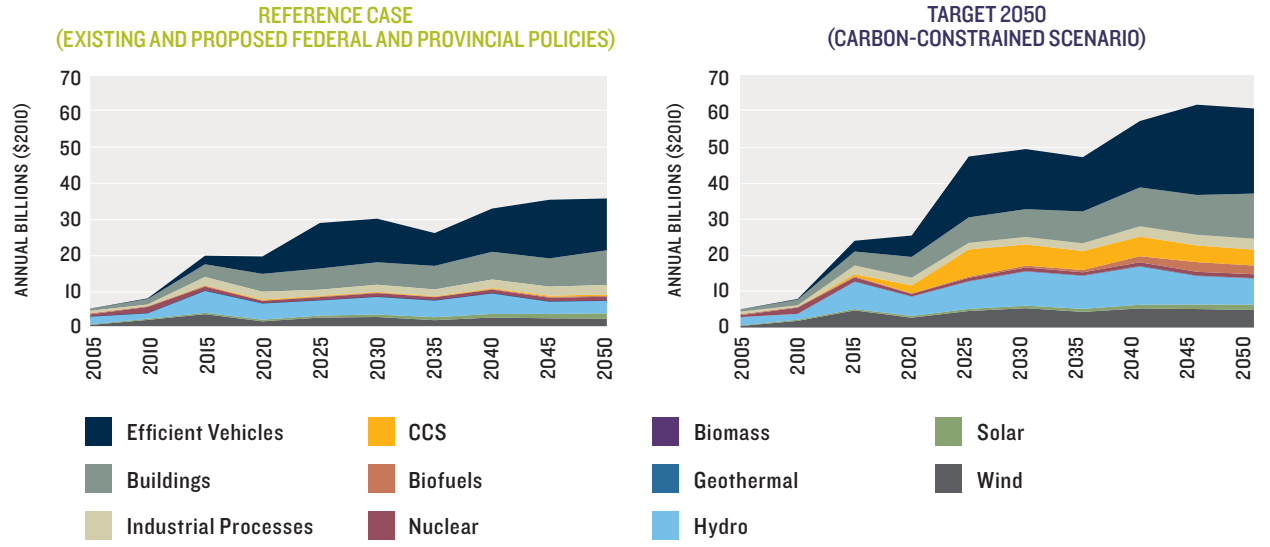
TABLE 5

DIRECT, INDIRECT AND INDUCED EMPLOYMENT FOR REFERENCE AND TARGET 2050 SCENARIOS

SCENARIO	EMPLOYMENT (1000s FTE)											
	2010				2030				2050			
	DIRECT	INDIRECT	INDUCED	TOTAL	DIRECT	INDIRECT	INDUCED	TOTAL	DIRECT	INDIRECT	INDUCED	TOTAL
REFERENCE CASE	42	30	24	**96**	87	78	56	**221**	91	77	57	**224**
TARGET 2050 (CARBON-CONSTRAINED SCENARIO)	42	30	24	**96**	160	149	110	**419**	159	140	104	**402**

FIGURE 2

DOMESTIC LCGS CAPITAL EXPENDITURES (2010–2050)

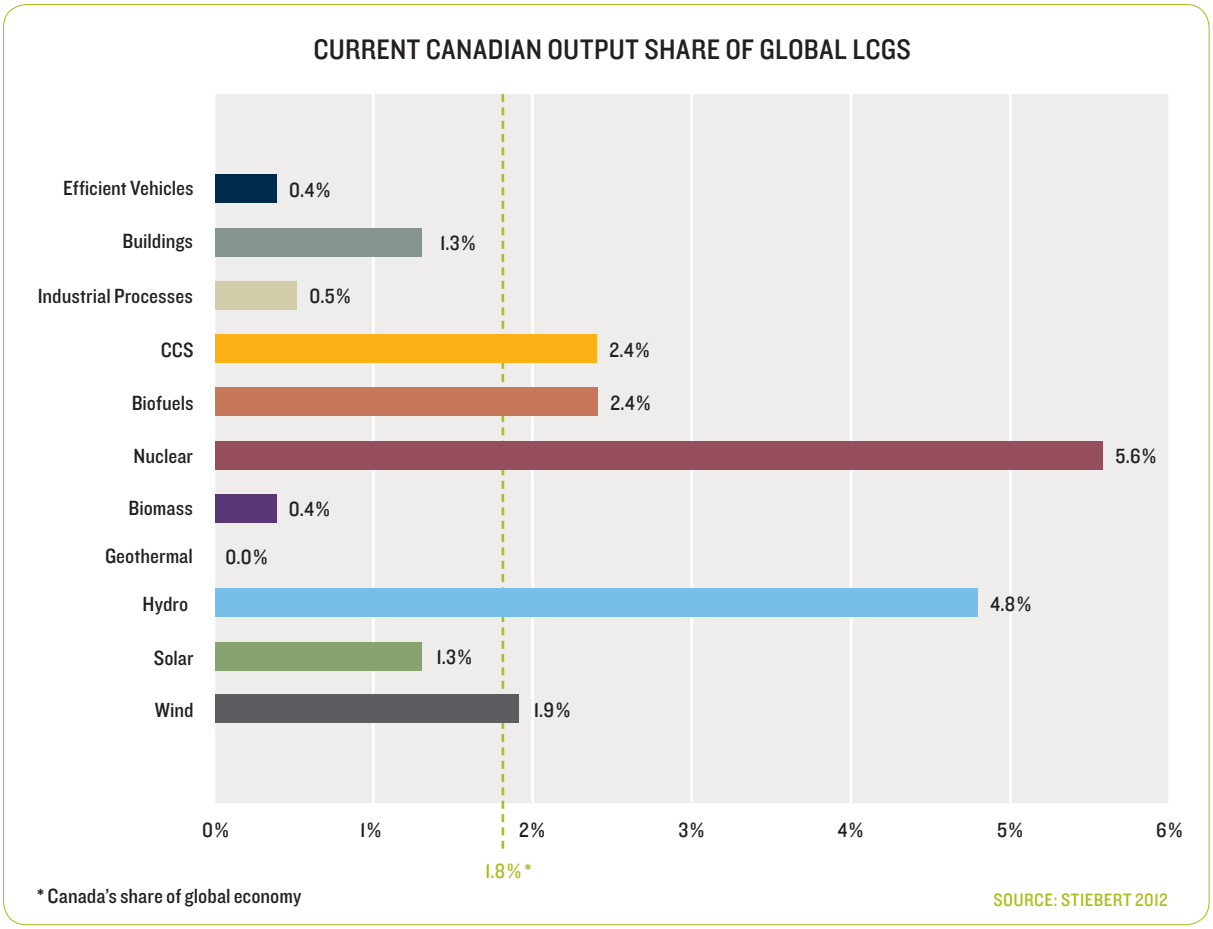


SOURCE: STIEBERT 2012

2.3 OPPORTUNITIES FOR CANADA

Canada's share of the world economy, based on GDP for all goods and services, is estimated at approximately 1.8%.[e] Canada's total share of the annual global LCGS market is approximately $6.3 billion of a total of $339 billion (or approximately 1.85%). While this puts Canada's current overall share of the global LCGS market on par with its relative share of the world economy, the share for each individual LCGS sector varies substantially. **Figure 3** presents our estimates of Canada's relative share of output for the LCGS sectors. In 2010, Canadian output in the nuclear, hydro, biofuels, CCS, and wind LCGS sectors all exceeded Canada's share of the global economy.

FIGURE 3



e Canada's GDP compound annual growth rate averaged 1.7% between 2001 and 2010. Under the reference and carbon-constrained scenarios respectively, overall LCGS value-added (GDP) growth is projected to be 3.4% and 5.1%, respectively.

A comparison of the global share results presented above with our analysis of how LCGS sectors will evolve over time reveals that the areas where Canada has a large share of the global market do not coincide with the areas that are expected to benefit from the largest demand in the years to come (i.e., efficient vehicles, buildings). While Canada's apparent existing strength in hydro would be expected to continue under both the reference and carbon-constrained scenarios, the global share of Canada's CCS, and to a lesser degree wind sectors, would be expected to remain above average only under the carbon-constrained scenario.[f,g,h] If Canada were to capture its average 1.8% of global LCGS output in 2050, domestic production would range between $70 billion and $149 billion under the global BAU and carbon-constrained scenarios, respectively. This represents roughly double Canada's forecasted domestic market under comparable scenarios and highlights the magnitude of the opportunity to supply growing global demand for LCGS.

While in 2010 Canada came very close to a balanced position for merchandise trade, overall, Canada's trade balance for manufactured goods was negative, balanced by exports of raw materials, energy, and primary / intermediate goods. Particularly given this overall trade landscape, Canada's trade balance for its LCGS sectors (presented in **Figure 4**) points to the potential significance of hydro, nuclear, and efficient industrial processes, which exhibit sizeable, positive trade balances in 2010.[i] Biomass and CCS also demonstrate net positive trade balances.

Combining Canada's relative share of world output with information concerning Canada's trade balance provides a starting point for assessing Canada's current contribution to meeting global demand in these 11 sectors. This can be seen as a rough proxy of Canada's competitive position for these sectors, in the absence of more comprehensive trade data that could provide an understanding of revealed comparative advantage. Hydro and nuclear are uniquely positioned as exhibiting both above-average shares of global output and significant positive trade balances. CCS also presents a small positive trade balance as well as an above-average share of global output. The efficient industrial process sector is shown to have a sizeable trade surplus and a below-average contribution to global output. This is perhaps indicative of economic strength in an area currently in greater demand globally than domestically.

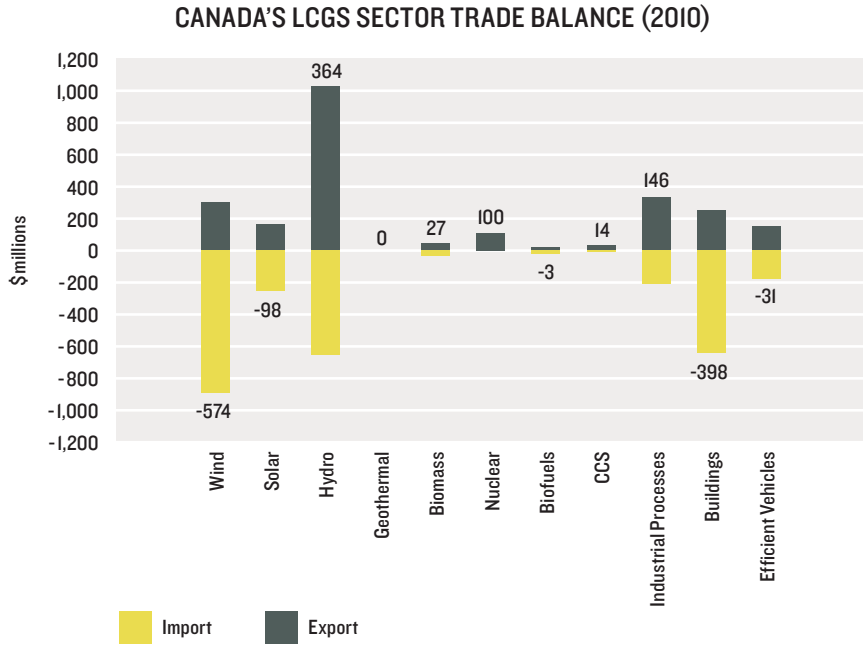
f Complete results are presented in Stiebert 2012 (available upon request). Comprehensive analysis was limited by the use of two separate models (IEA and CIMS), which precluded dynamic expression of trade relationships and introduced the possibility of underlying differences in model assumptions despite efforts to align definitions.

g Canada's apparent existing strength in the nuclear industry was not apparent in the long-run analysis due to an underlying policy assumption concerning potential future increases in nuclear capacity. For the purposes of this exercise, it was assumed that nuclear capacity would increase to align with planned refurbishments and expansions, but that no new capacity requiring facility siting would be included. This effectively capped nuclear capacity at 2030 levels for the forecast period.

h Canada's apparent existing strength in biofuels was only maintained under the Lock-in scenario, which required deep GHG reductions within a compressed time period.

i The geothermal sector's zero trade balance is evidence of the increasing complexity of global value chains and the role of direct investment in global markets, particularly for technologies which are difficult to transport (Conference Board of Canada 2010). As of 2010, Canada had six geothermal projects actively under development domestically, and Canadian-based geothermal companies had four operational facilities in Iceland and the U.S. (Islandsbanki Geothermal Research 2010).

FIGURE 4



SOURCE: STIEBERT 2012

While such analyses contribute to understanding Canada's strengths, the potential for success of companies in specific sectors and the benefits to the Canadian economy are not limited to product areas / sectors identified through such methods. In a 2010 analysis of global climate-friendly trade, the Conference Board of Canada highlighted a number of products for which Canada exhibited a revealed comparative advantage (i.e., for which Canada's proportion of global exports is greater than its overall average proportion of global exports).[28] It also highlighted four product areas where, despite lower-than-average proportional trade, Canada's global exports for each product category exceeded $100 million in 2008.[j] The analysis also identified Canada's strength in the manufacturing of gas turbines of less than 5 MW. While Canada's exports accounted for fully 20% of global exports for this product category and its share was growing rapidly, the overall market for this product was noted to be relatively small and growth had been flat over the previous several years. Together, these examples point to the importance — particularly from a supportive policy perspective — of understanding sector growth potential and the potential benefit in capturing even a very small portion of a quickly expanding market.

As Canadian investors consider where the greatest potential for future growth lies and policy makers assess how best to support low-carbon growth, they will require intelligence about Canada's current share of global LCGS markets, competitiveness, and forecast future spending domestically and abroad to inform good decision making. Awareness of global markets for different LCGS sectors including the presence of trade or other barriers to entry will be critical to the success of Canadian companies.

j These four areas were solar collectors, solar system controllers, and heat exchangers; equipment for heat treatment (excluding furnaces, ovens, etc.); gas turbine parts not elsewhere specified (does not include turbo-jets or turbo-propellers); and gears and gearing and other speed changers (specifically for wind turbines).

2.4 REGIONAL PERSPECTIVES — WHAT WE HEARD

Building on this empirical assessment of Canada's relative strengths, additional insights were gained from discussions with stakeholders across the country who had a more nuanced understanding of regional strengths and weaknesses. Regional discussions, facilitated by the NRT and its Regional Partners (see **Box 1**), highlighted strengths in terms of both Canada's physical low-carbon resources and its intellectual capital, related experience and expertise, and institutional capacity. Low-carbon opportunities were described in terms of what currently exists and what *could* be given participants' understanding and views of existing strengths and capacity. **Figure 5** and **Figure 6** respectively provide a graphical representation of Canada's low-carbon energy resources and low-carbon electricity capacity, and Canada's low-carbon strengths and opportunities as identified by regional stakeholders.

Participants in our cross-Canada dialogue were united in identifying that Canada's low-carbon opportunities are as significant and diverse as its geography. They were further unified in citing Canada's innovative capacity as an area of significant strength and potential (see **Box 2** for examples of centres of low-carbon innovation). From Nova Scotia's Fundy Ocean Research Centre for Energy (FORCE) to Ontario's MaRS Discovery District, Québec's Écotech, Saskatchewan's Canadian Centre for Nuclear Studies, Alberta's concentration of CCS expertise, and B.C.'s thriving "cleantech cluster,"[k] Canadians see their regions as being centres of innovation capable of contributing actively to a low-carbon future. They also emphasized the need to do things "right" from the outset to minimize impacts and inconvenience down the road (e.g., with respect to building energy efficiency and urban design). Regional challenges (e.g., regional transportation networks, lack of sufficient inter-regional electricity infrastructure) were also frequently identified as opportunities (i.e., the flip side of the coin). Energy efficiency in the context of transportation, buildings, and industry was cited frequently as a key opportunity remaining to be tapped. The potential for using electricity to displace fossil fuels where there is significant low-carbon electricity potential ("electrification") was also noted in several provinces. More detailed descriptions of the opportunities identified in these discussions are presented in Appendix 6.2. We summarize the key messages from each region below.

k "Cleantech" refers to the development and marketing and/or use of technology to deliver products or services that reduce or eliminate negative environmental impacts, and address social needs while delivering competitive performance, and/or using fewer resources than conventional technologies or services (Analytica Advisors 2011).

BOX 1

NRT'S REGIONAL PARTNERS

WESTERN CANADA

The Canada West Foundation is an independent nonprofit organization that provides a common voice for Canada's West (British Columbia, Alberta, Saskatchewan, and Manitoba). Its vision is "a dynamic and prosperous West in a strong Canada." For over 40 years, the Canada West Foundation has produced research and commentary that has improved government policy and decision making on a range of issues including economy, environment, education, healthcare, taxes, energy, social services, urban issues, provincial-federal relations, or any other policy area of importance to the West. **For more information visit www.cwf.ca**

ONTARIO

The Mowat Centre for Policy Innovation is "Ontario's voice on public policy" as an independent, non-partisan think tank. In terms of its research agenda, the Mowat Centre conducts research, commissions research from leading and emerging scholars, and engages in collaborative research projects with other organizations. As its public policy approach, the Mowat Centre builds new connections between government decision makers, public policy researchers, and groups and social innovators in the broader community in order to help shape better policy outcomes considering Ontario's new realities. **For more information visit www.mowatcentre.ca**

QUÉBEC

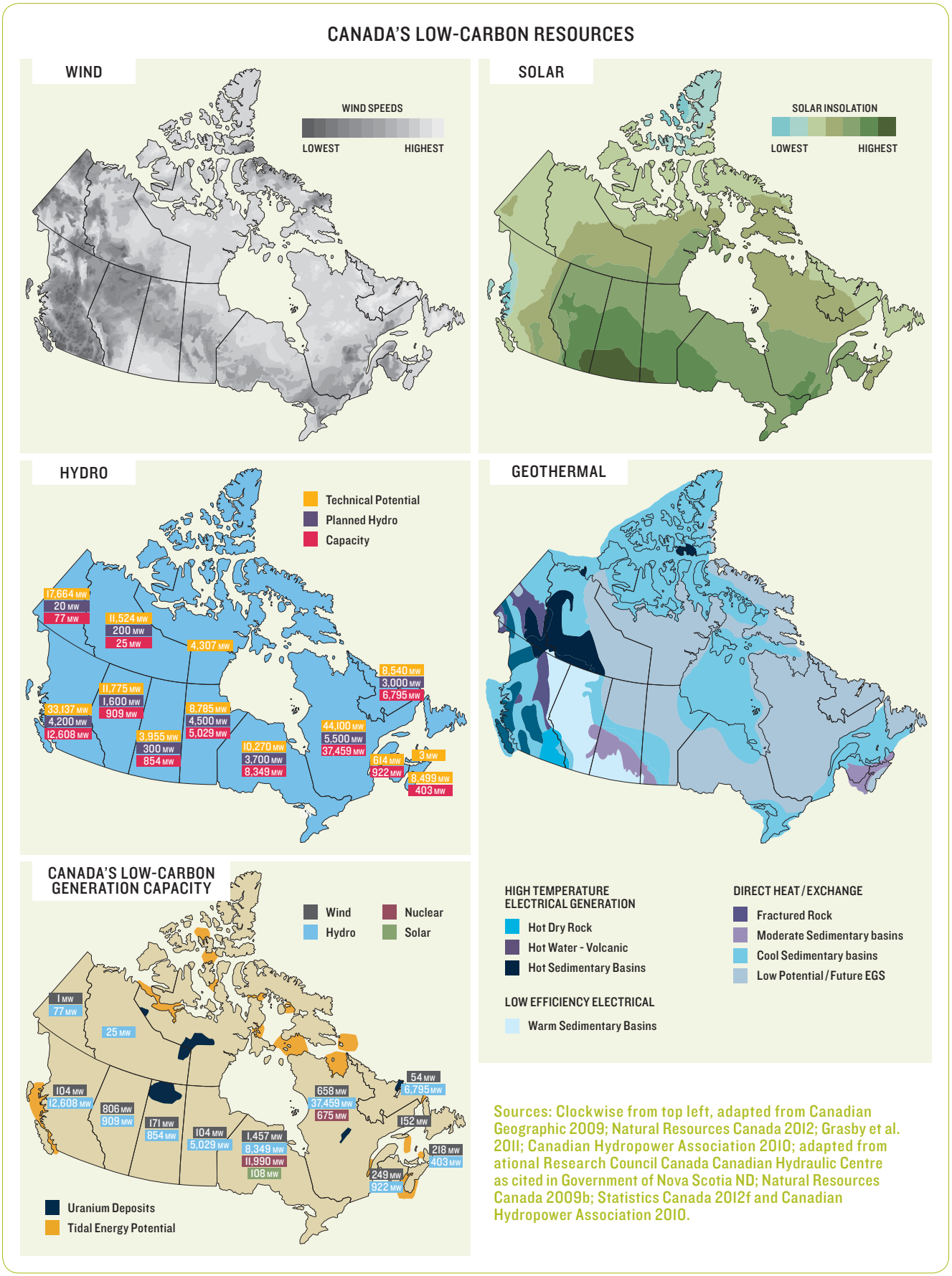
Écotech Québec aims to position Québec and its regions as a centre of excellence for clean technologies in North America. This Québec cleantech cluster unites and mobilizes the cleantech industry around common goals and actions. It participates in the "greening" of the Québec economy through sustainable development. It supports entrepreneurs in accelerating the design, development, adoption, commercialization, and export of clean technologies.
For more information visit www.ecotechquebec.com

ATLANTIC CANADA

The Atlantic Canada Opportunities Agency (ACOA) is a regionally based economic development agency of the federal government that has been operating for 25 years. ACOA's goal is to create opportunities for economic growth in Atlantic Canada by helping businesses become more competitive, innovative, and productive; by working with diverse communities to develop and diversify local economies; and by championing the strengths of Atlantic Canada. **For more information visit www.acoa-apeca.gc.ca**

Founded in 1954, the Atlantic Provinces Economic Council (APEC) provides the Atlantic region a trusted source of analysis and advice. It is an independent think thank dedicated to the economic progress in Atlantic Canada. APEC is currently studying economic development, labour markets and education, trade and investment, and energy and the environment, among a variety of other research themes. **For more information visit www.apec-econ.ca**

FIGURE 5



Sources: Clockwise from top left, adapted from Canadian Geographic 2009; Natural Resources Canada 2012; Grasby et al. 2011; Canadian Hydropower Association 2010; adapted from ational Research Council Canada Canadian Hydraulic Centre as cited in Government of Nova Scotia ND; Natural Resources Canada 2009b; Statistics Canada 2012f and Canadian Hydropower Association 2010.

FIGURE 6

LOW-CARBON STRENGTHS AND OPPORTUNITIES IDENTIFIED BY STAKEHOLDERS

WESTERN CANADA

Strengths – intellectual capital
// AB: Energy sector financial expertise and resources
// AB: Energy expertise (drilling, project staging, etc.)
// BC: Emerging clean technology cluster
// Sask: Nuclear research capacity
// Entrepreneurial spirit

Strengths – institutional capacity
// MB & BC: low-carbon electricity provider
// BC: Smart grid interest (smart meters)
// BC & AB: carbon-pricing programs

Opportunities – existing
// Resource industries (agricultural, hydropower, oil & gas, mining)
// Waste heat recovery for energy efficiency
// AB & Sask: efficient urban design, buildings, etc. to accommodate growth

Opportunities – potential
// Energy expertise applied to geothermal resource use
// CCS commercialization
// Electrification

QUÉBEC

Strengths – intellectual capital
// Expertise in transportation equipment manufacturing
// Partnerships to develop and test low carbon aircrafts

Strengths – institutional capacity
// Residual materials management regulations

Opportunities – existing
// Manufacturing industry powered by low-carbon electricity
// Transportation equipment manufacturing
// Information and communications technology (ICT) sector
// Cleantech industry

Opportunities – potential
// Energy recovery from non-recyclable residual materials
// Manufacturing of low-carbon transportation equipment (electric buses, aircraft)
// Testing and deployment of electric vehicles and related infrastructure
// Low-carbon products from forest sector
// ICT applications for energy efficiency

ONTARIO

Strengths – intellectual capital
// Nuclear expertise
// Car manufacturing talent pool
// Financial expertise
// Several Cleantech companies, exporters of innovation
// Highly educated workforce, concentration of innovation clusters

Strengths – institutional capacity
// Low-carbon electricity provider
// Smart grid interest (smart meters, storage technologies)
// Green energy regulations & programs

Opportunities – existing
// Nuclear industry
// Regionally integrated car manufacturing industry

Opportunities – potential
// Off-grid low-carbon energy technologies for remote communities
// Low-carbon vehicle manufacturing
// Energy and emissions literacy
// Waste CO_2 recovery from industrial emissions

ATLANTIC

Strengths – intellectual capital
// Expertise in marine energy technologies
// Innovative capacity a function of quality research infrastructure, supportive start-up environment, and high quality of life

Strengths – institutional capacity
// Regulations for offshore resource development
// Regional co-operation (e.g., Atlantic Energy Gateway)

Opportunities – potential
// Ocean technologies (e.g., remote sensing)
// Pilot site for technology and regulatory processes (NL: pilot site for off-grid low-carbon energy technologies for remote communities)
// Proximity to U.S. (New England) Markets

BOX 2

CANADIAN CENTRES OF LOW-CARBON INNOVATION

Canada's National Research Council (NRC) supports collaboration through its Centres of Excellence for Commercialization and Research (CECR) program and through support to technology clusters across the country. Many of these Centres and clusters include a low-carbon focus within them. Examples include the following:

// Greencentre Canada: This Kingston, Ontario-based CECR works to commercialize chemistry research with the potential to make products and processes more sustainable.[29]

// Centre of Excellence in Energy Efficiency: This Shawinigan, Québec-based CECR works to support the commercialization of new energy efficiency and renewable energy innovations.[30]

// Fuel Cell and Hydrogen Technologies Cluster: This Vancouver, British Columbia-based technology cluster groups much of Canada's expertise in this field and is home to many fuel cell companies and research organizations, including the NRC's Institute for Fuel Cell Innovation.[31]

WESTERN CANADA

Western Canada has diverse low-carbon resources and opportunities that vary substantially by province; however, several common themes emerged in stakeholder discussions.[i] There was an emphasis on building on strengths. Much of western Canada's economic well-being centres on resource-based industries whether that is agricultural resources, hydro power, oil and gas, or mineral extraction and mining. This expertise was seen as a strong asset and as a platform for research and innovation. In particular, energy-sector expertise and experience were seen as key strengths in developing low-carbon energy resources. Western Canada was noted as being replete with low-carbon energy resources including hydropower, biomass, solar (Alberta and Saskatchewan were noted by one participant as receiving more solar energy than either Texas or Germany), wind (on- and off-shore), geothermal resources, and uranium. A significant portion of electricity generated in Manitoba and British Columbia is already low-carbon. Western Canada's significant expertise in drilling, large project staging, and operating in harsh environments were noted as having direct application with respect to geothermal resource development. As is often the case, sources of great challenge (e.g., fossil fuel resources, transportation, etc.) also represent great opportunity. Energy efficiency was noted as a resource that remains to be fully tapped (see **Box 3** for an example of recent efforts). Participants noted a need for greater inter-regional co-operation on a number of fronts, but particularly focused on the need for additional electricity infrastructure to allow for increased longitudinal transmission. Western Canada was highlighted as having both a significant interest and an existing advantage in the pursuit of the commercialization of CCS technologies. Two additional noted strengths were western Canada's entrepreneurial spirit, and its experience through B.C. and Alberta with the implementation of carbon pricing programs. The need for a transition to a low-carbon economy was balanced by recognition of the existing (and emerging) economic base, and the need to reconcile these two realities (see **Box 4**).

i In addition to the themes outlined here and discussed in more detail in Appendix 6.2, the Canada West Foundation published a report on the Western Canadian low-carbon economy round tables entitled, "Cautious Optimism: Western Perspectives on a Low-Carbon Economy" (Canada West Foundation and National Round Table on the Environment and the Economy 2012).

BOX 3

ENERGY EFFICIENCY IN WESTERN CANADA — WASTE HEAT RECOVERY

Waste heat recovery (WHR) is an energy efficiency measure which captures excess heat from engines, turbines or processes, and concentrates or converts what would be "waste heat energy" into a useful form of energy such as heating or cooling capacity or electricity. In Western Canada, WHR is particularly prominent in its use to improve the energy efficiency of the natural gas turbines employed to compress natural gas for transportation through pipelines.[32] Currently, there are four WHR units operating on the Alliance Pipeline system in Saskatchewan, each with a capacity of 5 MW. A fifth facility — the Whitecourt Recovered Energy Project — with a capacity of 14 MW will be introduced in Alberta. It is expected to yield GHG emissions reductions on the order of 70 Mt per year.[33] An innovative application of WHR will employ waste heat from transport trailer diesel engines to run auxiliary power units (APUs) with the capability to provide heating, cooling or 10 hours of hotel load power (e.g., refrigerator, coffee pot, television, cell phone charger, etc.) for the truck's sleeper cab without any fuel consumption.[34]

BOX 4

ALBERTA, THE ENERGY SECTOR, AND LOW-CARBON GROWTH

"If a low-carbon growth strategy is going to work for Canada, it has to work for the West." That was a key message from participants at the NRT and Canada West Foundation stakeholder sessions in Alberta and Saskatchewan in the fall of 2011. It's clear to see why: the West, Alberta and Saskatchewan in particular, has become a major engine of economic growth for Canada, with carbon-intensive industries such as oil and gas extraction central to this growth.

The high-carbon make-up of western Canada's economic activities however, was not seen as an impediment to a successful transition to a low-carbon economy, but rather as an opportunity. For example, participants from our convening session in Calgary stressed the significant gains in low-carbon innovation and investment to be made by Alberta's energy sector, given the right market signals. A large corporate presence, a high concentration of energy-savvy financiers, significant project management experience, and significant depth and breadth of technical expertise are all factors that position Alberta and its energy sector as potentially significant contributors to the low-carbon transition. The pioneering spirit of western Canada was a recurring theme in western discussions, exemplified by Alberta's early action on setting up a carbon pricing mechanism with a fund to stimulate industry-focused low-carbon innovation to go with it, and Alberta and Saskatchewan's leading efforts in carbon capture and storage.

What we heard in western Canada, and in Calgary most strongly, was both the desire and need for an energy strategy for Canada that embeds low-carbon considerations, lays out expectations, goals and actions, and becomes the basis for private-sector planning for the future.

ONTARIO

The low-carbon economy stakeholder discussion in Ontario reflected the significant influence of the provincial government's *Green Energy and Green Economy Act* (GEA) on all aspects of energy supply, technology and innovation in the province. Ontario's existing strength as a predominantly low-carbon provider of electricity was noted, but was balanced by the recognition of a need for more significant dispatchable power capacity, particularly given the success of the feed-in-tariff program at encouraging the development of intermittent energy resources (e.g., wind, solar). The opportunity for biomass to contribute to filling this gap was emphasized. Ontario's strength as the centre of Canada's nuclear industry was also noted. While the nuclear industry presents significant opportunity in the long run (particularly with the development of next-generation reactors), Canada's nuclear industry needs to re-establish itself on the world stage if it is to remain viable. Ontario's financial sector expertise also has the potential to be brought to bear to address the financing challenges of the low-carbon transition. This presents a win-win opportunity for both the financial sector and Canada's low-carbon innovators. Ontario's potential for exporting "intellectual capital" was also highlighted. A number of low-carbon and renewable energy technology companies in Ontario have been successful in developing and exporting new and innovative adaptations of existing technology. Innovative off-grid energy technology is also needed in many aboriginal communities, which offer an ideal testing environment and partnership opportunities with longer-term potential for sales into international markets facilitated by domestic demonstration. Related to this is Ontario's emerging strength in smart-grid and energy-storage technologies. It was also suggested that increased awareness, education and literacy around energy and emissions would in itself yield efficiencies and reductions in electricity consumption. One example is the potential of the "virtual world," the "gamifying" of energy efficiency and the development of new technology solutions. Focusing on Ontario's manufacturing industries the automobile manufacturing sector was noted as having potential to contribute to anticipated North American demand for low-carbon vehicles (see Box 5). It was further noted that the top twelve industrial GHG emitters in Ontario produce 80% of the province's industrial emissions. Given this concentration of emissions, the waste CO_2 can be considered as a resource if innovative approaches allow for its capture and use in, for example, biomass-based fuels.

BOX 5

LOW-CARBON VEHICLES

NRT's modelling has demonstrated that anticipated growth in efficient vehicles greatly exceeds growth in all other LCGS sectors. At present, road transportation is a substantial contributor to national GHG emissions (at nearly 20%), having grown almost 40% since 1990.[35] Electric vehicles offer significant opportunities to not only mitigate much of the ground transportation GHG emissions, but also improve grid performance, integrate renewables, and use surplus electricity production in times of low demand (e.g., at night). By tuning Canada's already established automobile manufacturing sector to this expected growth, Canada has the potential to realize significant economic gains and achieve multiple low-carbon objectives simultaneously.

QUÉBEC

Québec has significant existing low-carbon energy resources with substantial remaining opportunity in the form of hydropower, wind, solar and biomass resources. Uranium resources and tidal power are also highlighted in the Plan Nord as having potential in Québec's north. Recent work undertaken for Écotech Québec highlighted significant potential for technology development related to hydropower, energy efficiency, biomass, and residual materials management. The identification of opportunity related to residual materials management was unique to Québec. Québec's legislative framework for residual materials management[m] provides a strong base for increasing energy recovery from non-recyclable residual materials not present to the same degree in most other Canadian jurisdictions. It was also noted that Québec has a competitive advantage in manufacturing certain products due to their energy intensity and the ability to employ low-cost, low-carbon electricity in their manufacturing (e.g., aluminum). More broadly, due to Québec's low-carbon electricity, most manufactured products compare favourably to their competition with respect to carbon footprint. This presents an advantage and opportunity for Québec's manufacturing industry. Given Québec's existing transportation equipment manufacturing base, well-developed supply chains and depth of expertise, there is significant potential for Québec to develop and manufacture low-carbon large-scale transportation equipment e.g., electric buses. Several projects are currently underway including a collaborative initiative between universities and research centers in partnership with government and leading firms to develop and test new low-carbon aircraft concepts. It was also noted that with the historic presence and strength of the forest products industry in Québec, there is significant potential for the reorientation of sector activities toward the production of low-carbon products. In particular a forest biorefinery project was highlighted, the focus of which is to support the development and demonstration of new products derived from forest biomass. Québec's strong information and communications technology (ICT) sector offers a strong base for the development of new ICT products and systems that foster reduced energy consumption. Lastly, transportation was highlighted as one of Québec's most significant GHG challenges, with road transportation accounting for one third of all GHG emissions in the province. With its existing low-carbon electricity supply and substantial remaining untapped capacity, Québec presents an ideal context for the testing and deployment of electric vehicles and related infrastructure.

ATLANTIC CANADA

While their distribution across the region is not even, Atlantic Canada is home to a diversity of low-carbon energy resources. Unique to Atlantic Canada was the focus on the *"salt water hinterland."* Marine resource development is a driving force behind Atlantic Canada's current economic success stories, and has the potential to play a similar role in the low-carbon context. In addition to the potential development of ocean (wave and tidal) and wind energy resources, the development of associated marine/ocean technologies (e.g., remote sensing technologies) represents a significant long-term economic opportunity. It was noted that technology development associated with marine oil and gas exploration are expected

m An Act to amend the Environment Quality Act as regards residual materials management and to amend the Regulation respecting compensation for municipal services provided to recover and reclaim residual materials.

to generate significant low-carbon spinoff benefits. While there is global competition and Atlantic Canada is a relatively small player, as one participant put it, Atlantic Canada is "no further behind than anyone else" in the development of marine energy technologies and expertise. In addition, experience in developing and regulating offshore resources and expertise in developing technologies for use in offshore exploration and development position Atlantic Canada (and in particular, Newfoundland and Labrador) well as a launch pad for the development of Arctic offshore resources. To the degree that carbon reduction technologies (e.g., CCS) become viable, this resource has greater potential in a future low-carbon context. Discussion of low-carbon opportunities also highlighted opportunities related to regional co-operation particularly with respect to the development of hydropower (e.g., Lower Churchill Falls[n]) and related interprovincial transmission lines. As a source of dispatchable power, these potential generating assets were noted as being key to the further development of intermittent renewable power sources such as wind. Newfoundland and Labrador's remote communities and mining sites were also highlighted as providing ideal conditions for the piloting of off-grid low-carbon technologies. Many of these sites currently use diesel generators, and connection to the grid is prohibitively expensive. Nalcor, Newfoundland and Labrador's energy crown corporation, is already piloting a project in the remote island community of Ramea with the objective of using wind generation with hydrogen storage as the primary backup (Ramea Wind-Hydrogen-Diesel Project[o]) integrated with secondary diesel backup generation. Participants emphasized Atlantic Canada's innovative capacity focusing on the combined strength evident in its high quality educational and research institutions, a strong supportive start-up environment, and an exceptional quality of life that provides an edge over other jurisdictions in the competition for skilled labour. Lastly, it was also suggested that Atlantic Canada serves as an excellent test bed for small-scale modelling whether for regulatory processes or pilot projects, and that this presents an opportunity for Atlantic Canada to undertake projects that might not otherwise be pioneered in this region.

2.5 CONCLUSIONS

Our analysis demonstrates the growing importance of LCGS sectors both globally and domestically. The scale of the market opportunity is considerable, and makes a case for why Canada's public and private sectors should make strong efforts to understand the global low-carbon transition and benefit from it. Canada's regional opportunities are significant and diverse including both low-carbon resources and the capacity to deliver added value low-carbon products and services. Common threads include an emphasis on innovation, energy efficiency, and inter-regional grid connectivity as well as the expanded development of more localized renewable energy resources. Later sections of this report discuss actions that are needed to position Canadian firms to succeed and meet the market needs.

n This includes the proposed Muskrat Falls and Gull Island generating stations.

o For more information see: Natural Resources Canada 2009a, and Nalcor Energy 2010.

RISKS IN DELAYING


Media
Mining
Oil
Gas
Property
Retailers
Tobaccos
Transport
Real Estate
Travel
Leisure
Tech Software
Tech Hardware
Utilities
Government Securities
Aerospace & Defence
Automobiles
Banks
Beverages
Chemicals
Construction
Electricals
Electricity
Engineering
Industrials
Gas
Pharmaceuticals
Property
Retailers
Support Services

3.0 // RISKS IN DELAYING CANADA'S LOW-CARBON TRANSITION

3.1 // COMPETITIVENESS, MARKET ACCESS, AND TRADE RISKS

3.2 // EMISSIONS LOCK-IN RISKS

3.3 // CONCLUSIONS

3.0 RISKS IN DELAYING CANADA'S LOW-CARBON TRANSITION

Along with opportunities come risks. Delaying Canada's transition to a low-carbon economy could limit firms' access to international markets, compromise Canada's reputation abroad, and impose economic costs associated with the lock-in of high-emitting infrastructure and equipment.

In the previous chapter, we discussed the growing global and domestic demand for low-carbon goods and services (LCGS) and the opportunity that exists for Canadian firms to meet this demand. Our analysis of global and domestic spending on LCGS out to 2050 pegs the size of the potential opportunity at $70–$149 billion. It also highlights hydro, CCS, nuclear, and efficient industrial processes as areas of current strength with strong growth potential in the long term. We show just how much promoting current and developing new LCGS sectors matters to Canada's low-carbon transition. But that's only part of the story: Canada and the rest of the world must inevitably cut carbon emissions across traditional sectors of the economy.

With growth in the fossil fuel industry on the horizon, moving to a low-carbon economy presents a formidable challenge. Canada is well positioned to be a significant global supplier of oil in the years to come and to benefit economically from selling its crude to fast-growing economies. The International Energy Agency estimates a 36% rise in global energy demand between now and 2035, much of it in the form of fossil fuels.[36] The National Energy Board's forecast to 2035 includes record growth in Canadian oil and gas supplies and expansion in unconventional sources of oil in particular.[37]

Yet the economic risks of delaying action and of not preparing and planning for the global low-carbon transition are too great to ignore. This chapter explores two key economic risks for Canada: market access and competitiveness risks posed by the continued carbon intensity of trade and changing expectation of consumers, and risks from investment decisions on equipment and infrastructure that "lock-in" emissions for decades.

3.1 COMPETITIVENESS, MARKET ACCESS, AND TRADE RISKS

As nations take action to reduce their carbon emissions and as markets for low-carbon goods and services expand, the carbon intensity of imports and carbon risk of business ventures so too gain profile. Nations with stringent climate policies could well implement trade measures to protect domestic sectors from being outcompeted by sectors in jurisdictions without comparable climate policies. These measures pose direct risks to high-carbon exporters by imposing additional costs upon entry or by limiting demand for high-carbon goods outright. Border carbon adjustments (BCAs), low-carbon fuel standards and product carbon-footprinting are examples of measures jurisdictions are either contemplating or enacting.[a]

Several sectors in Canada could be exposed to such competitiveness and market-access risks in a global low-carbon economy. In the short term, border penalties against Canadian goods based on production and transport emissions are conceivable.[b] In the NRT's 2011 analysis of Canada–U.S. climate policy choices, *Parallel Paths*, we assess competitiveness risks (including border carbon adjustments) as *moderate* under Canada's current policy trajectory (i.e., "harmonize on targets"). Energy-intensive sectors like petrochemical manufacturing and iron and steel mills manufacturing could be vulnerable. Overall, $67 billion per year of Canadian exports to the U.S. (roughly 26% of exports to the U.S. in 2009) would be covered by a hypothetical U.S. scheme similar to those previously proposed.[c] Designing measures like BCAs to be both effective and legal under provisions of the World Trade Organization (WTO) is not without challenges, limiting their applicability in practice. However, there is no legal consensus on the potential for BCAs to be able to survive dispute settlement in the WTO.[38] Furthermore, WTO obligations don't always prevent countries from implementing controversial measures. One reason for this is the significant lag time that tends to transpire between implementation and any final resolution under the WTO's Dispute Settlement Mechanism.[d] Ultimately, Canada would be gambling were it to count on WTO challenges to mitigate the risk of economic impacts associated with the potential application of BCAs.

California and the EU are implementing low-carbon fuel standards (LCFS), which penalize petroleum-based fuels that are energy intensive in the production phase. Because of its effectiveness in cutting carbon emissions from transportation, the U.S. has seen repeated calls for adopting a national LCFS. Absent commercial-scale CCS, application of such a standard would clearly hinder Canada's export of oil sands–based crude oil to the U.S., overwhelmingly the largest customer. While the legality of LCFSs under international trade law (as a standard they would be covered by the provisions of the Technical Barriers to Trade Agreement) has yet to be tested and is therefore uncertain, forthcoming research suggests that LCFS would be considered legal.[39]

a The discussion in this section draws primarily from a research report prepared for the NRT by the International Institute for Sustainable Development (Cosbey, Stiebert, and Dion 2012), available upon request.

b For a comprehensive treatment of BCAs, please refer to work by the OECD (Wooders, Cosbey, and Stephenson 2009).

c This figure is likely understated as the actual GHG intensities of a number of Canadian manufacturing sectors are thought to be higher than calculated where there are significant numbers of facilities producing GHG emissions below the 50,000 tonne mandatory reporting limit.

d Although the dispute settlement process, including appeals, is mandated to take roughly 14 months, in fact it can be stretched up to two years by members trying to postpone compliance. If we add the 15-month compliance period to this, and assume bad faith compliance, the reality is that WTO-illegal measures can easily be in place for three years or more before they are finally brought into line with members' obligations. In some cases this will be enough time to accomplish the objectives for which the measures were designed.

Short-term trade measures are one thing, but long-term risks of a high-carbon economy are also apparent; a key one pertains to reputation. A country's reputation is like its brand and is important to its ability to sell goods globally. The combination of a perceived image of Canada lagging on climate policy and promotion of labelling schemes that help consumers manage embodied emissions associated with their consumption is particularly powerful. Such an image may also leave Canadian products exposed to consumer actions like boycotts. Modern campaigners are sophisticated enough to try, for example, to track Canadian oil sands products through the supply chain to the retail level, and to urge consumers not to buy. In a sector with such homogeneous products as retail-level gasoline, such actions might be significant.[e]

A negative view of Canada also has implications for Canadian firms' ability to invest abroad and for public acceptance of high-emitting activities here at home. Just as Canada seeks to screen foreign direct investment that it doesn't want,[f] foreign policy makers could feel pressure to do the same to Canadian firms that bid on projects and concessions in foreign countries. An added dimension of this risk is the increasing challenges to development that Canada's natural resource sectors are facing from local communities and interested parties across the country and abroad (e.g., the 2011 protests in New Brunswick concerning exploratory testing for shale gas, protests in Washington and elsewhere in 2012 concerning the Keystone XL pipeline in particular and Canadian oil sands development more broadly, the protests in 2012 concerning the proposed Northern Gateway Pipeline, and protests in 2012 around metal mining in Ontario's "Ring of Fire"). At a basic level, the manner in which Canada is perceived abroad can affect Canadians' perception of their industries, which can in turn influence a company or sector's social licence to operate. A plan that spells out the goals and targets needed for Canada's low-carbon transition and actions to show for it would help alleviate concerns on all sides.

Finally, the economy's high-carbon intensity relative to others' and reliance on high-carbon exports will, in the long term, affect Canada's trading position. So-called green stimulus spending that occurred in 2008 in several parts of the world signalled confidence in the higher growth potential of low-carbon economic activity relative to growth in traditional sectors.[40] Although not all players will benefit from a first-mover advantage, the value of strategically assessing and seizing niches in a nascent low-carbon economy is unequivocal. Conversely, allowing an economy to centre its trade on high-carbon exports *in the absence of a long-term transition plan* can lead to long-term stagnation and economic malaise. Reduced carbon-competitiveness — the relative carbon intensity of one's economy or a specific product as compared to that of one's peers — can ultimately result in a decrease in the terms of trade for affected products (i.e., decline in the relative value of the product traded resulting from decreased demand). In the context of multinational branch plants, the lack of a supportive policy environment can also make the capital investment required to improve one's competitive position internationally difficult to acquire.

e Supported by campaigning by ForestEthics, an environmental advocacy group, 16 large companies in the U.S. and one city have publicly announced their intention to limit or avoid the use of carbon-intensive transportation fuels (ForestEthics 2012).

f The failed Chinese takeover bid for Noranda and the controversy over competing foreign bids for Canada's Potash Corporation are examples of this dynamic at work.

3.2 EMISSIONS LOCK-IN RISKS

The NRT has consistently concluded that delay in government action to meaningfully cut emissions is costly.[41] Here, we quantify the implications of delay in sending strong, economy-wide policy signals to guide investment and technology choices toward low-carbon goals: the economic risk of emissions lock-in. G8 countries, including Canada, have acknowledged the importance of limiting global warming to no more than 2° Celsius over pre-industrial temperatures, and have agreed that "urgent action" should be taken to meet this long-term objective.[42] For Canada, this corresponds to a 65% reduction in emissions from 2005 levels by 2050.[g]

The emissions profile from infrastructure or equipment currently in place or under construction is, essentially, "locked-in" for the future: avoiding these emissions involves refurbishments, significant retrofits, slowing or stopping operations — all actions that impose substantial costs on businesses, potentially compromising their competitiveness. For example, once a coal-fired power generation facility has been commissioned, it is in place for a minimum of 30 years.[h] Undertaking significant retrofits or refurbishing the facility to meet new GHG emissions standards before this time would 1) typically cost more than it would have to have incorporated the new performance objectives in the original design and 2) present costs to the proprietor that were not factored into the initial business case for the facility. Every year of delay in implementing "loud, long, and legal" climate policy represents a wasted opportunity to take advantage of natural cycles of infrastructure and equipment renewal, making it more difficult and expensive to meet emissions reduction targets.

FOR A REMINDER OF THE SCENARIOS USED IN THIS REPORT, SEE CHAPTER 1, SECTION 1.3

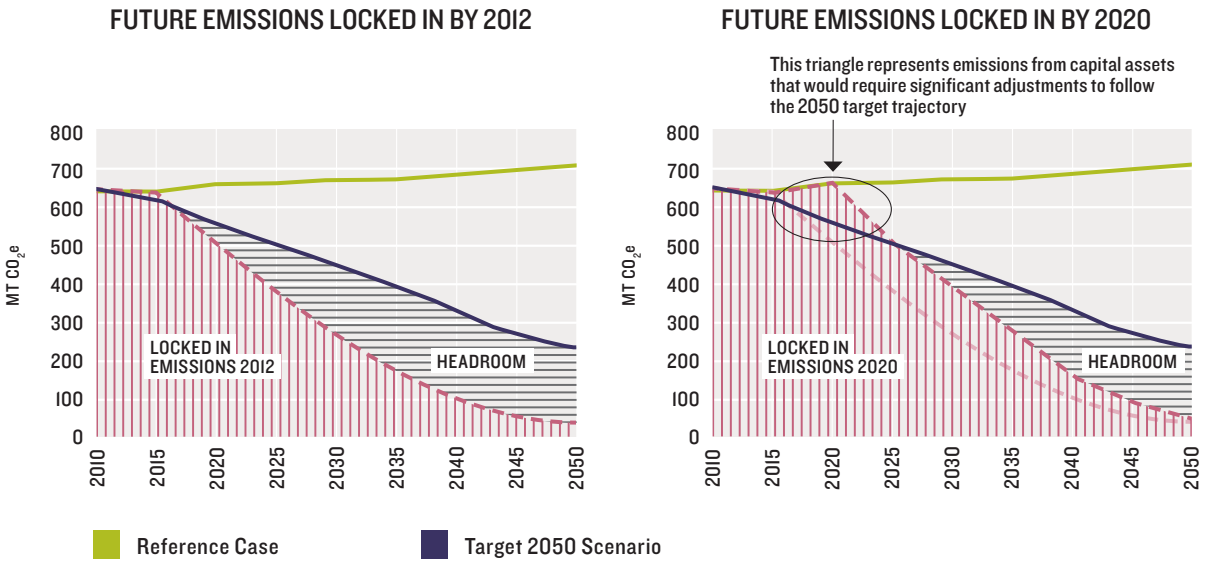
We used the well-known CIMS energy-economy simulation model to quantify the emissions stemming from locked-in infrastructure and equipment in buildings, transportation, electricity, manufacturing, and oil and gas sectors.[i] Based on the **REFERENCE CASE**, we quantified the emissions from locked-in infrastructure and equipment out to 2050, taking into account their average lifespans. We considered two cases of infrastructure lock-in. The first case looks at emissions from Canada's stock of infrastructure and equipment in place and under construction as of 2012 (see **Figure 7**). The second case looks at the 2012 stock plus infrastructure and equipment built and installed between 2012 and 2020 (see **Figure 8**). Neither case assumes additional climate policies beyond what's included in the Reference Case (all significant existing and proposed federal and provincial/territorial abatement measures).

g Under Canada's *Turning the Corner* policy statement, the federal government committed to GHG reductions of 60-70% below 2006 levels. This was considered consistent with achieving deep GHG emissions reductions. In Getting to 2050, the NRT chose a reduction target of 65% to represent this commitment. Consistent with the government's treatment of base year for its 2020 targets, for the purpose of this report we have changed the base year to 2005. Several OECD nations (e.g., the U.K. and Japan) have adopted policy pathways aimed at achieving reductions of 80% below 1990 levels by 2050 (OECD 2011e). The long-term U.S. commitment under Copenhagen is 83% below 2005 levels. The UNDP's 2008 Human Development Report notes that developed nations will need to reduce their emissions by at least 80% by 2050 (United Nations Environment Programme 2007).

h Under the *Reduction of Carbon Dioxide Emissions from Coal-Fired Generation of Electricity Regulations*, useful life is determined as the later of 45 years from the unit's commissioning date or the end of their purchase power agreement (Government of Canada 2011a).

i The consultant's report, Investment and Lock-in Analysis for Canada by Navius Research Inc. (Navius Research Inc. 2012), is available upon request.

FIGURE 7 & 8



Sectors included buildings, transportation, electricity, manufacturing industry, and oil and gas. "Buildings" captures heating and cooling equipment but not the shells, which can last much longer than this equipment.

SOURCE: NAVIUS RESEARCH INC. 2012

The infrastructure and equipment in place today and by 2020 could be responsible for 40% to 56% of Canada's emissions by 2030, with their share of emissions declining to between 4% and 7% by 2050. **Figure 7** and **Figure 8** show the emission profiles of the Canadian stock of infrastructure and equipment in 2012 and 2020, based on the Reference Case. The relative share of emissions from 2012 and 2020 stocks of infrastructure and equipment declines as these assets reach the end of their useful lives. A comparison of both figures shows the additional locked-in emissions that result from the eight-year modelled delay in policy implementation. Infrastructure and equipment in the oil and gas sector is the longest lived, comprising about 47 per cent of locked-in emissions by 2030 but 71% by 2050 (locked-in emissions 2012 case). Emissions from 2012 and 2020 transport and building stocks are close to zero by 2050.

We also compared the emissions profiles from locked-in infrastructure and equipment in 2012 and 2020 to an emissions profile that would allow Canada to cut cumulative emissions[j] by 65% from 2005 levels in 2050. This is what we found:

// Delaying implementation of strong climate policy to 2020 could require retrofits or premature retirement of infrastructure and equipment until at least 2025, if Canada is to meet the 2050 target. The triangular area identified above the Target 2050 scenario in **Figure 8** represents emissions from capital assets that would have to undergo significant retrofitting, refurbishment, or slow or cease operations (i.e., premature retirement) in order for the country to maintain an emissions trajectory consistent with the Target 2050 scenario (i.e., these represent avoidable economic costs associated with delayed action).

j Cumulative emissions reduction is the scientific metric by which climate change mitigation is measured. Whereas annual targets speak to the emissions level at a specific point in time, cumulative emissions reduction considers the total GHG emissions over a given period. Consideration of cumulative emissions allows for direct comparison of costs and policy effectiveness.

// Policy delay compromises Canada's ability to cut emissions cost-effectively. The cost per tonne of cumulative abatement under the Target 2050 scenario is just under $56. Our analysis indicates that delaying clear policy signals until 2020 raises the cost of abatement to $71 per tonne. Canada would need to invest $2.9 billion per year between 2020 and 2050 to achieve cumulative emissions cuts comparable to the Target 2050 scenario to make up for the eight-year delay in policy action — a total additional investment of roughly $87 billion over this period.

// Emissions resulting from locked-in infrastructure and equipment leave little headroom to grow the economy and meet the 2050 target. **Figure 8** shows the potential for locked-in emissions pertaining to the 2020 stock of infrastructure and equipment to limit options to reduce emissions across the economy through 2050 without costly retrofits or premature asset retirement. Had the appropriate signals been in place, less emissions-intensive technology would have been employed, allowing more room for emissions associated with economic expansion.

The emissions lock-in risk could be greater than what we have shown here, for two reasons. First, our analysis excludes the potential for factors like the shape, size, and density of Canada's cities; the lack of regulatory frameworks; and the path dependency created by existing land uses to further constrain the long-term emissions profile. For example, the existence of natural gas infrastructure paves the way for continued use of natural gas for space and water heating, despite the option to replace this equipment with new zero-emission technology prior to the end of a building shell's lifespan. Second, some equipment and infrastructure applications can be maintained to run for much longer than their average lifespan. For example, it is possible that with appropriate overhauls, coal plants in existence today could be maintained to operate to 2050.

3.3 CONCLUSIONS

Canada needs to move now. The significant opportunity in moving to embrace a low-carbon future for the country discussed in Chapter 2 and the economic risk of delaying action discussed in this chapter provide compelling reasons to act. Canadians can adjust the pace as they move forward, but they cannot let the perfect be the enemy of the good. Policy-makers need to expect to iterate, to not get it right the first time round, and need to build in flexibility. Canada cannot afford to wait for the "optimal" system/approach to arrive — it never will. Canada can build on the pioneering work undertaken by world leaders, addressing key gaps in existing approaches, and contributing to the state of knowledge. The approach will be uniquely Canadian and will need to evolve over time, but it needs to start now.

Innovation is essential. Our earlier assertion concerning continued market demand for oil sands crude likely depends heavily on the successful commercialization and deployment of carbon capture and storage (CCS) technology. Innovation is crucial to the long-term success and economic resiliency of Canada's current economic base and is also fundamental to the development of LCGS, which have the potential to contribute significantly to the economy in the long term.

Canada will need to be strategic. Many players have moved and are moving to secure a place in the clean technology and clean energy space. Much of this is low-carbon. In looking to support the transition to a low-carbon economy, Canada needs to identify those areas where it has both existing strength and the potential to build upon that strength.

Although Canada can continue to benefit from the extraction and sale of unconventional crude and other energy-intensive resources, Canadians should not take them for granted. A transition plan — a low-carbon growth plan — is required for the long term.

CREATING A FOUNDATION

FOR LOW-CARBON GROWTH

// CHAPTER 4.0

4.0 // CREATING A FOUNDATION FOR LOW-CARBON GROWTH

4.0 CREATING A FOUNDATION FOR LOW-CARBON GROWTH

Canada needs a low-carbon growth plan to guide a strategic transition toward a low-carbon economy. An effective plan will augment Canada's policies related to innovation, investment, trade, and labour markets and skills to support the transition and ensure appropriate governance mechanisms are in place.

Low-carbon growth is central to greening the global economy, recognized the world over as critical to sustainable development. In a green economy, wealth and jobs derive from public and private investments that reduce carbon emissions and pollution, enhance energy and resource efficiency, and prevent the loss of biodiversity and ecosystems. Low-carbon growth, then, implies economic growth in the context of both the reduction of GHG emissions and the enhancement of energy efficiency.

Gathering knowledge about where Canada is today is an important step toward articulating what actions and focus are needed to enable low-carbon growth in Canada into the future. This chapter first summarizes commonalities and differences across international low-carbon growth plans and defines the key elements required for a Canadian plan. It goes on to acknowledge the importance of underlying "essential conditions" in shaping Canada's success and then provides an overview of each key element and assesses Canada's low-carbon-preparedness with respect to each.

4.1 KEY ELEMENTS IN LOW-CARBON PLANNING

A low-carbon growth plan (LCGP) charts a path toward a prosperous low-carbon economy. Maintaining economic growth while addressing climate change is a central feature of existing plans around the world. Many link a country's economic competitiveness to environmental objectives like developing clean energy capacity, improving energy efficiency, and reducing the carbon-intensity of specific sectors. Drivers for undertaking comprehensive planning range from energy security, sustainable development, and competitiveness, to economic development and the establishment of an analytical basis for discussions around burden sharing in the context of common but differentiated responsibility. The framing and reach of LCGPs differs among countries (e.g., a "green growth strategy" for South Korea or a "low-carbon transition plan" for the U.K.), but all seek to build on existing competitive advantage through economy-wide improvements in the energy and emissions intensity of the economy. **Table 6** lists a number of countries that have issued low-carbon growth plans.

TABLE 6

EXAMPLE OF COUNTRIES WITH LOW-CARBON GROWTH PLANS

DEVELOPED COUNTRIES	EMERGING ECONOMIES	DEVELOPING ECONOMIES
Australia	Brazil	Bangladesh
Japan	China	Costa Rica
South Korea	Mexico	Guyana
The United Kingdom	South Africa	Indonesia

Plans tend to include detail on GHG reduction pathways and associated costs but are less precise on requirements to enable the low-carbon transition and are variable in setting targets and timelines. Although it is too soon to evaluate the effectiveness of existing plans or any implementation barriers and challenges, the lack of attention to the following elements is noteworthy:

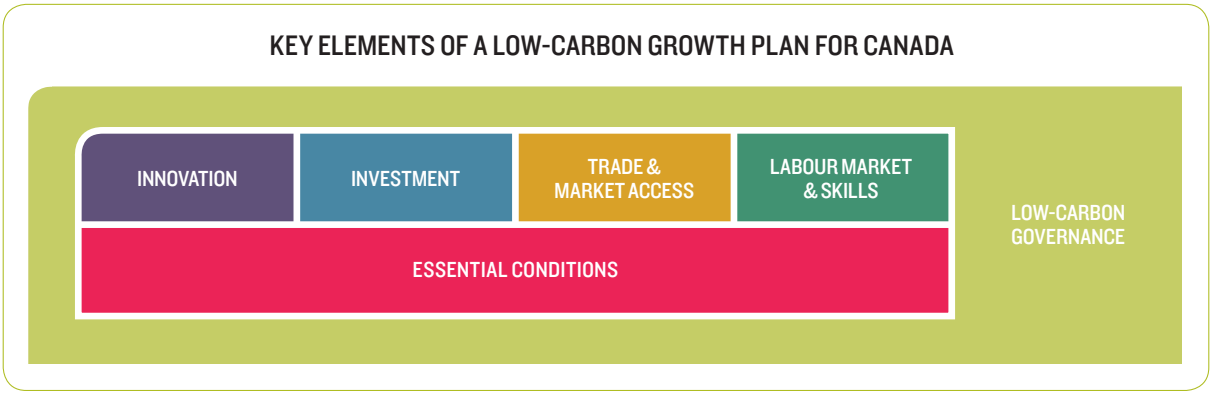
- comparisons of carbon-intensity between a nation and its trading partners or competitors;
- leading indicators of performance such as levels of spending on research and development (R&D), targeted education spending, and levels of low-carbon infrastructure investment; and
- analysis of economic dependence on carbon with particular reference to large economic sectors that may be carbon-intensive.

This report builds on earlier NRT publications that address the need for widespread carbon-pricing policy to drive domestic reductions in GHG emissions. Because of the world's dependence on fossil fuels, ceasing production of Canada's fossil-fuel energy supplies is not an option that is feasible or desirable in the short to medium term. The challenge for Canada is to define a long-term path that will transition Canada from the current carbon- and energy-intensive economies of today to a future that involves sustainable resource use and substantially lower GHG emissions. Canada's federal, provincial, and territorial energy ministers recognize the onset of a transition to a lower-carbon economy.[43] Recent discussions on pan-Canadian collaboration with respect to Canada's energy future have covered the need to diversify Canada's energy sources and the importance of long-term transition to a low-carbon economy.

The NRT sees a need for a more comprehensive low-carbon growth plan for Canada to guide a strategic transition. Through our research and stakeholder consultations we have concluded that a low-carbon growth plan for Canada should include the following elements: innovation, investment, trade and market access, labour markets and skills, and governance (**Figure 9**). Each of these elements can create value through supporting a reduction in the emissions intensity of the Canadian economy and through capitalizing on opportunities to respond to shifts in international demand for LCGS.

We conducted an in-depth analysis of each of these elements to understand the current state of play globally and within Canada and to identify strengths and weaknesses and policy gaps for each. A more fulsome analysis is presented in Appendix 6.4, but we present the highlights of our analysis below.

FIGURE 9



4.2 INNOVATION

Innovation is "the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations."[44] Innovation is in itself a process encompassing basic and applied research, development and demonstration, commercialization and market development, and market entry.

Overall, the strengths and weaknesses of Canada's innovation system sum up as follows. The country focuses most on and succeeds at basic science and research and adapting (already) commercial products to meet industry requirements. Canada is less effective than its OECD peers in product demonstration and in the transition to commercial scale and market development, owing to challenges in accessing risk capital, the limited size of the internal market, and fragmentation among key players.[45,46]

Innovation is key to supporting a low-carbon transition. It can close the gap between the low-carbon technologies of today and the low-cost, high-performance — *breakthrough* — technologies that are needed for the future. In today's global economy, Canadian firms are up against counterparts facing lower labour costs[47] and, to an extent, greater access to capital and policy certainty. Rather than trying to compete on

"last generation" technology by cutting input costs, a focus on innovation can enable the rise of Canada's LCGS sectors in global low-carbon value chains. Innovation is also the only way to enhance environmental performance of traditional industries despite increased use of natural resources, including energy.

Canada's $2 billion cleantech industry,[48] of which LCGS sectors form a substantial portion, is mostly made up of young and small firms. This emerging industry posted double-digit growth rates through the global financial downturn and is expected to achieve $10 billion in revenue by its twentieth-year milestone.[49] Canada's cleantech SMEs are a strong source of Canadian low-carbon innovation and represent a key national strength. Cleantech SMEs have benefited from government support through the Scientific Research and Experimental Development tax-credit program, the Industrial Research Assistance Program, and Sustainable Development Technology Canada's Tech Fund.[50] Other federal R&D programs, however, present high barriers to entry for SMEs; streamlining administration and approvals for federal R&D programs would increase their attractiveness. Cleantech SMEs see the need for enhanced domestic adoption of their innovations for Canada to benefit from public and private R&D investments.[51] If unaddressed, the lack of domestic adoption and support could hinder export growth. For innovative clean technologies, international customers expect domestic references before making procurement decisions.[52]

For low-carbon innovators (largely SMEs), overcoming the "valley of death" or bridging the commercialization gap (the intermediary stage between early-stage research funding and full-project financing, in which innovators attempt to achieve proof of concept to attract venture capital) is a particular financial challenge worth noting. It is one of the most common challenges in the clean technology sector (particularly where projects face high technology risk and are capital intensive), and one that is not unique to Canada. Sustainable Development Technology Canada (SDTC) has played a significant role in assisting emerging Canadian cleantech companies through the valley of death; however, challenges remain. Discussions with stakeholders identified the lack of broader support for demonstration projects as a significant barrier in moving innovative ideas from concept to commercialization, and accessing international markets and developing relationships with larger, established firms (e.g., the Global or Fortune 1000) were noted as presenting further challenges.

In discussions with stakeholders, technological innovation was noted consistently as a significant opportunity related to Canada's highly skilled labour force, strong education institutional capacity, and strong record with respect to research and development. While it was noted that Canada cannot compete on basic economic inputs (e.g., labour, resources, cost of capital), it has the capacity to develop and globally market intellectual capital. Specific examples of emerging and next generation technologies discussed during NRT's convening sessions are CCS (expertise and intellectual property), carbon precipitation technologies, algae-based biofuels, and advanced solar technologies. Stakeholders emphasized that Canada's potential contribution to reducing global GHG emissions is not limited to its domestic mitigation potential but extends globally through the potential development and deployment of disruptive technologies.

4.3 INVESTMENT

Innovation, whether low carbon or otherwise, is closely related to investment. Investment in each phase of the innovation process plays a key role in enabling growth and ensuring that Canadian firms remain competitive in a global low-carbon economy.[a] Canada's total private R&D expenditures were estimated at $16.3 billion in 2009, of which $8.5 billion (52%) were in manufacturing, $6.9 billion in services (42%), and only $0.9 billion (6%) in all other industries combined.[55] Canada's energy-intensive primary industries account for 4% of private R&D spending. Insufficient information was available to identify the low-carbon component of private R&D investments.

Economy-wide investment in non-residential structures, machinery, and equipment (i.e., commercial products) provides a measure of the degree to which Canadian businesses are renewing capital assets and updating (and possibly adapting) technology to remain competitive. In Canada, such investment has averaged $234 billion annually over the past decade, 81% of which has been private investment.[56] Spending on machinery and equipment alone accounts for an average of approximately $137 billion (58% of spending) per year.[57]

A transformation of the one envisioned for a global low-carbon economy hinges on mobilizing financial capital and delivering it where it is needed. At stake is the development of LCGS and their economic, profitable, and complete deployment domestically and globally — as well as the related environmental benefits. Public investment in clean energy has been a key driver of recent LCGS growth. The emphasis on low-carbon spending was first evident as a response to the global recession through "green stimulus" funding, signalling that a green economy was a source of future growth.

Based on a review of federal and provincial programs that include a significant low-carbon focus in their funding allocation criteria, we estimate that public and private investments prompted by these programs amount to approximately $5.7 billion per year.[58,b] These investments are predominantly targeted at commercial products including machinery and equipment. Comparing this figure with the previously noted $137 billion annual investment in machinery and equipment suggests that Canadian low-carbon spending as a proportion of overall capital renewal is modest, in the range of 5%.

Additional analysis of government-led low-carbon investment suggests that the majority of government programs target products that are already established commercially with only CCS demonstrating significant R&D and product-development spending allocations. While the investments considered represent only a subset of the low-carbon investments being made, they are explicitly programs where government and industry have partnered to address the challenge of reducing GHG emissions. The clear message is that innovation-oriented low-carbon spending is under-represented.

a The discussion in this section draws primarily from a research report prepared for the NRT by the Conference Board of Canada (Conference Board of Canada 2011b), available upon request.

b This represents a low-end estimate that is considered to be representative of the scale of investment, but not precise. Data gaps for some programs were noted and partnering funding was not consistently available.

Venture capital activity in Canada appears healthy: as recently as 2011, Canada ranked fourth behind the U.S., China, and the U.K. in terms of investments in cleantech.[59] Much of the venture capital investment activity in cleantech takes place in Ontario with the province accounting for 48% of total Canadian investment since 2005.[60] Growing and maintaining investor confidence in Canada's LCGS markets is key to the low-carbon transition. Public investment, regulatory stringency, and a climate regime characterized by transparency, longevity, and certainty stand out as factors with the potential to do just that.[61]

4.4 TRADE AND MARKET ACCESS

As a small, open economy, Canada relies on trade for economic growth and prosperity.[62] Although Canada's dependence on trade may be less than it once was,[63] trade remains a significant contributor to national GDP, and Canada's further integration into global value chains is critical to its future prosperity.

In a global economy, success in low-carbon competitiveness includes the efficient flow of low-carbon goods and services across geopolitical boundaries. As nations take action to reduce their GHG emissions and markets for low-carbon goods and services expand, the carbon intensity of imports and carbon risk of business ventures are gaining profile. Canada's trade is heavily weighted toward emissions-intensive industries and products. Emissions-intensive sectors — that is, sectors exceeding 0.5 kt CO_2e / $GDP — accounted for 44% of Canada's exports in 2010. With steady growth in oil and gas extraction, mining, and primary metals manufacturing,[c] the emissions intensity of Canada's exports is on an increasing trajectory.[d]

Currently low-carbon goods represent less than 1% of Canadian merchandise exports and approximately 1.6% of merchandise imports.[e] Canada is failing to capitalize fully on the opportunity to sell its low-carbon services in global markets.[64] Analysis of 45 climate-friendly commodity groups shows an overall negative trade balance of $3 billion for Canada.[65] Adjusting for inflation, Canada's exports of low-carbon technologies declined on average by 2% annually between 2002 and 2008.[66] Over the same period, the global low-carbon market experienced 10% annual compound growth.[67]

Looking to the future, Canada is well positioned to benefit from the relative size and growth trajectories of its trading partners' LCGS markets. While by far, the United States is Canada's main import and export market, a trend in diversification is apparent, with growing trade flows with China and the U.K.[68] Six of Canada's top ten export markets are also countries with the largest LCGS markets, and these countries represent 49% of the global low-carbon market.[f] Furthermore, analysis of Canada's likely trading partners

c Energy-intensive resource-sector exports figure prominently in Canada's trade profile. The last decade saw a steady and strong resurgence of resource-based exports including energy, metal ores, and processed metals.[c] Analysis of trade data indicates that together, these high-growth sectors accounted for approximately 39% of total exports in 2011, doubling their 2002 share (Industry Canada 2012).

d NRT analysis of DFAIT trade data (Industry Canada 2012).

e Internal report prepared by the Conference Board of Canada for the NRT (Conference Board of Canada 2011b). Because the provision of low-carbon goods and services tends to be highly integrated, we can draw conclusions on low-carbon services based on data on exports in low-carbon goods.

f Based on export market ranking in Canada's State of Trade and analysis of these nations' low-carbon market value based on the report Low Carbon and Environmental Goods and Services: An Industry Analysis — Update for 2008/09 (Innovas Solutions Ltd. 2010).

in 2040 undertaken by DFAIT[g] projects growth in trade with nations that represent a larger portion of the world low-carbon market than today, and for which low-carbon market growth rates are high. Ensuring open access to these expanding global low-carbon markets is key to the success of Canada's LCGS sectors.

4.5 LABOUR MARKET AND SKILLS

Canada continues to struggle with higher levels of unemployment due to the recent recession, with a national unemployment rate of 7.4%, as of February 2012, up from the pre-recession low of 5.9% two years ago.[69] The situation is highly variable across regions and industries, with the lowest unemployment rates in Alberta and the highest rates in Newfoundland and Labrador, and service-based industries and resource industries experiencing employment growth while employment is falling particularly in the manufacturing and utilities sectors.[70]

The global low-carbon transition will, in the long term, influence the structure of the Canadian economy, irrespective of domestic policy. Industries will evolve — some will shrink, some may disappear, others will grow, and new and innovative industries will emerge. Such shifts will undoubtedly alter Canadian livelihoods. The extent to which and pace at which the economy and its component industries reduce their carbon intensity, and Canada's capacity to reap the economic rewards of aiding global low-carbon efforts, influence and are influenced by the country's collective human capital.

Canada would benefit from better labour market data and information related to the low-carbon economy to understand its current footing and future trends. Analysis commissioned by the NRT to estimate the present and potential future size of Canada's low-carbon economy estimates that Canada's LCGS sectors directly employed in the range of 42,000 people in 2010. The years 2008 to 2010 saw exceptional annual employment growth rates in cleantech at 11%.[71] As Canada's economy reduces its carbon intensity, the electricity sector will see substantial employment growth. NRT's own analysis suggests that even in the absence of additional policy, direct employment in LCGS sectors will grow to 91,000 by 2050.

A low-carbon economy will require talents and skills to match. Current general unemployment rates and labour shortages in particular sectors hint at a potential mismatch in Canada's labour market and are a reminder of the importance of preventing such structural imbalance. Labour shortages are especially prevalent in resource sectors, and while much of the attention has been focused on the acute labour shortages in the oil sands industry, labour shortage concerns exist broadly across the energy and resource sectors. LCGS industries, a large proportion of which involve energy production, transfer, and end-use, are also exposed to this risk, and representatives of many LCGS industries have either experienced or anticipate a lack of skilled labour to meet their needs.[72]

g For their publication *Canada's State of Trade — Trade and Investment Update 2011*, the Department of Foreign Affairs and International Trade undertook to project Canada's top merchandise export markets in 2040. They employed an in-house gravity model along with a GDP forecast provided by IHS Global Insight.

4.6 GOVERNANCE

Governance "determines who has power, who makes decisions, how other players make their voice heard, and how account is rendered."[73] Governance looks beyond government as a single actor; in fact, it includes a wide range of involvement from governments, civil society, different sectors, and business communities. Canadian federalism presents unique governance challenges. The federal government has regulatory control of interprovincial trade and international trade and commerce; other areas offer decentralization and delegation of authority to the provinces, as with energy and natural resources. Yet other areas, such as the environment, are a shared responsibility. Divisions of power make tackling far-reaching policy issues a challenge in practice.

Governance shapes a nation's response to and management of the global transition to a low-carbon economy. A transformative shift in policy direction and objectives, such as that required for countries to prosper in a low-carbon transition, requires vision and leadership above all else.[74] Without exception, political leadership was necessary to propose, endorse, and embed the low-carbon growth plans where they exist.

Canada as a whole does not have a coherent climate change strategy or a low-carbon growth plan. The failure to bridge regional interests and perspectives over the past 20 years has resulted in a patchwork of uncoordinated federal and provincial actions to reduce emissions. Four key contributing factors are apparent: disparity in regional economic interests, a commitment to equitable burden sharing, a lack of institutional intergovernmental relations capacity, and a polarized or unengaged public.

The market implications of gaps in leadership and coordination are significant. Simply put, key sectors of the Canadian economy lack the policy certainty or support to prioritize low-carbon investments. Instead, investors, firms, and households may postpone investment decisions or choose conventional options with known payoffs.

In NRT convening sessions, stakeholders across the country identified inter-regional co-operation as an opportunity to increase the supply of low-carbon electricity, the availability of hydro-based energy storage, and/or bolstering the reliability of the regional electricity system. Interprovincial and inter-regional collaboration was also noted with respect to trade policy and the harmonization of standards. It was also suggested that inter-regional co-operation with respect to technology development could benefit all parties — for example, harnessing the innovative capacity in central and eastern Canada to contribute to the work already being done in western Canada to find solutions for sustainable oil sands development.

Stakeholders also saw increasing awareness of and education about energy and emissions as a strategy to change: the manner in which resources are used, the political environment for decision making, and the willingness to pursue new opportunities.

4.7 ECONOMIC COMPETITIVENESS

Trends and conditions shaping Canada's national competitiveness matter. Analysis by the World Economic Forum (WEF) for the *Global Competitiveness Index (GCI)* ranks Canada twelfth overall out of 142 economies, moving down from tenth place in 2010–2011 and ninth place in 2009-2010.[75] Ahead of Canada are Switzerland, Singapore, Sweden, Finland, the United States, Germany, the Netherlands, Denmark, Japan, the United Kingdom, and Hong Kong. Although Canada has some clear areas of strength — for example, Canada ranked fifth and sixth overall for labour market efficiency and health and primary education, respectively — Canada has two areas of notably mediocre performance[h]: macroeconomic environment and business sophistication. While many of Canada's peers (e.g., U.S., UK, France) were similarly poorly ranked for macroeconomic environment indicators, Canada stands out (along with Australia) as having lower overall business sophistication.

Our macroeconomic environment influences the attractiveness of the Canadian economy for investment and is a fundamental prerequisite to growth — low-carbon or otherwise. Key additional enabling conditions[i] include the presence of appropriate price signals[j] and an efficient but robust regulatory framework.[k] Factors like the nature of Canada's competitive advantage and value-chain breadth affect business sophistication, hindering or enabling how the country competes on a low-carbon basis. Canada was ranked low for both these categories. In the first case, the low ranking (71) results from the relative emphasis on natural resources and primary commodities in the economy.[76] Trade and market access are also critical in terms of both influencing the country's economic focus and fostering growth given the relatively small size of the Canadian market.

Recognizing that traditional competitiveness metrics are insufficient to assess the implications of the manner in which countries respond to the opportunities and costs inherent in the global low-carbon transition,[77] they are still an important part of the picture.

4.8 CONCLUSIONS

Innovation, investment, trade and market access, labour markets and skills, and governance are all key elements of effective low-carbon planning. Our analysis reveals that Canada has strengths in each of these areas upon which it should capitalize. It also identified weaknesses that should be addressed. The importance of the macroeconomic environment and overall economic competitiveness was also established. We build on these findings in our final chapter to identify priorities for action going forward and to set out the essential conditions for low-carbon growth.

h Identified indicators where Canada ranks below twentieth place. In macroeconomic environment, Canada ranked forty-ninth and in business sophistication Canada ranked twenty-fourth.

i These are consistent with the framework conditions for green growth put forward by the OECD in its 2011 publication "Towards Green Growth," which include policies that seek synergies between economic growth and conservation of natural capital, policies that reward innovations that limit or create efficiencies in natural resource use, and policies that penalize pollution and inefficient uses of natural resources.

j zThis includes pricing of pollution and natural resource use.

k Regulatory coherence and a focus on outcomes are two key elements (OECD 2011c).

HARNESSING CANADA'S

LOW-CARBON OPPORTUNITY

// CHAPTER 5.0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5.0 // HARNESSING CANADA'S LOW-CARBON OPPORTUNITY

5.1 // THE NRT'S VISION FOR A LOW-CARBON CANADA

5.2 // ESSENTIAL CONDITIONS FOR LOW-CARBON GROWTH

5.3 // KEY ACTIONS

5.4 // THE GOVERNANCE TO MAKE IT HAPPEN

5.5 // CONCLUSIONS

5.0 HARNESSING CANADA'S LOW-CARBON OPPORTUNITY

A successful transition to a low-carbon economy will be underpinned by policy certainty, a price on carbon, a level playing field, and efficient regulations that complement market-based measures to reduce GHG emissions. This final chapter sets out the NRT's framework for low-carbon growth, including our vision for 2050, key low-carbon growth objectives, and essential conditions for success.

The NRT's *Measuring Up* report concluded that Canada is not yet well positioned to compete in a carbon-constrained world.[78] Despite a strongly growing cleantech sector,[79] Canada currently faces challenges in low-carbon innovation particularly with respect to commercialization. While strength is evident in Canada's cleantech venture capital investment record,[80] overall low-carbon investment and investor confidence is low.[81] Though clear exceptions exist, Canadian companies are failing to fully capitalize on the opportunity to supply growing global demand for LCGS, in part due to the significant effort required to access international low-carbon markets.[82] LCGS sectors also face the potential for labour shortages as demand for skilled labour is high across the Canadian economy and innovative talent is highly sought after the world over.[83]

But what will it take to put Canada firmly on a path to low-carbon growth? Our research and convening show that vision combined with leadership and the collaboration to achieve it is critical. Above all else, there needs to be a conscious decision that low-carbon development is a desirable goal for Canada and that governments should bring to bear the policy tools needed to realize it. Strong communication of this decision is essential. Private sector support for and engagement with this process is crucial. A focus on accelerating innovation and investment in low-carbon infrastructure and technology, enhancing LCGS market access, and boosting Canada's capacity and understanding of low-carbon skills and labour requirements is also key. Political and corporate leaders must recognize that successful realization of this long-term goal will require action in the short term accompanied by regular re-evaluation of the path forward — in short, a plan.

This chapter presents the NRT's contribution to the development of a low-carbon growth plan for Canada. Here, we offer a low-carbon vision for the country and discuss the strategies, actions, and governance required to achieve it.

5.1 THE NRT'S VISION FOR A LOW-CARBON CANADA

The NRT's vision of what a low-carbon economy could look like for Canada recognizes the country's realities and strengths in both contributing to global efforts to arrest the speed and scale of climate change and taking advantage of the economic opportunities that lie ahead. The vision we propose is as follows:

IN 2050, CANADA

// has diverse, clean, and sustainable energy and electricity systems;

// continues to be a nation of abundant natural resources that are developed in a responsible, respectful, and sustainable manner;

// is a global marketer of low-carbon energy resources, technology, and expertise, and is seen as a responsible trading partner and energy producer;

// has become renowned for its innovation, particularly in the cleantech sector, and is a country where ideas and collaboration flourish within its academic institutes and in its private sector;

// employs coordinated and collaborative approaches to governance that continue to support and prioritize its low-carbon economy; and

// has a diverse, skilled labour pool that supports its low-carbon economy and responds to growing demands for skills and technologies.

The vision we propose could well be incomplete, not having benefited from the direct input of regional discussions. However, it's a starting point for considering what is desirable and possible, and what actions need to be taken to get there. The following sections present our view of the critical elements of a framework for low-carbon growth. Combining a competitive economic context with collaborative and coordinated approaches to governance, as well as measures to stimulate innovation, mobilize investment, enhance access to LCGS markets, and foster talent and skills development, will position Canada to prosper through the low-carbon transition.

5.2 ESSENTIAL CONDITIONS FOR LOW-CARBON GROWTH

A competitive economic context is prerequisite to a nation's low-carbon success. When it comes to competitiveness, Canada has had mixed performance in the past compared to its peers. However, recent budgets tabled and actions taken by both the federal and provincial governments are set to address the weaknesses highlighted in the *Global Competitiveness Index*[84] (i.e., government budget balance, gross national savings, and general government debt). This same global index notes Canada's institutions, goods market efficiency, labour market efficiency, and financial market development as strengths of the country's economic framework conditions.

Canada should make use of market forces to foster low-carbon growth. Economic analysis has consistently demonstrated that market-based mechanisms are typically most effective and efficient in guiding investment decisions as they drive private-sector action while minimizing intrusion by government. Low-carbon growth requires a reorientation of the economy over the long term to take into consideration existing externalities. While progressing on this front, Canada needs to make certain that any measures taken by governments do not introduce unnecessary administrative or compliance burden so as to ensure effective use of government resources and continued competitiveness on the part of Canadian companies. Our analysis builds on the work of the OECD[85] and identifies four *essential conditions* related to Canada's economic framework that need to be addressed to efficiently advance low-carbon growth: 1) providing policy certainty, 2) appropriately pricing pollution and natural-resource use, 3) establishing a level playing field for energy investments, and, 4) ensuring regulatory coherence and a focus on outcomes.

Long-term certainty around climate, energy, and innovation policy must be established. Policy certainty is fundamental to providing the private sector and individual Canadians with the signals they need to make decisions that factor in the global low-carbon transition. A lack of policy certainty is the single most significant barrier to investment in low-carbon innovation and, more broadly, interest in finding solutions to other investment challenges critical to the low-carbon transition.[a] While the literature focuses significantly on certainty with respect to climate policy, the principle applies to all significant related areas of policy development. Not only does Canada need "investment-grade climate change policy,"[86] but it also needs investment-grade energy and innovation policy. Policies that reflect transparency and longevity and that engender certainty can help materialize the required low-carbon investments.[87]

Transparency speaks to the clarity and predictability of laws, regulations, and policies. Government credibility relates to this, and hinges on how laws, regulations, and policies are developed and interpreted.[88] Clear communication of meaningful information, advanced notification, and prior consultation with respect to regulatory and policy changes, and consistent administration and application of laws and regulations all influence government credibility. Transparency with respect to how governments implement and change rules and regulations dealing with investment is a critical determinant in investment decisions.

a A report commissioned by three major international investor climate change networks identifies policy risk as "*the* major risk in low-carbon investments in the energy sector." This is because while significant progress has been made, many low-carbon power generation technologies are not cost-competitive with conventional generation sources (i.e., they have not reached grid parity). This problem is compounded by subsidies and support provided to the fossil-fuel industry (Institutional Investors Group on Climate Change et al. 2011).

Long-term commitment periods for policy are vital to establishing predictability and certainty for business decisions. The time frame to achieve policy goals and targets should match the expected time frame required for investments to generate an appropriate return. In the case of investments in low-carbon energy, a return period between 15 and 25 years is not uncommon.[89] Investor confidence takes time to develop but can be undermined very quickly. Negative investor experience can spill over to other regions — for example, Spain's cuts to feed-in tariff levels for existing projects in 2011 damaged investor confidence internationally.[90]

Certainty requires both transparency and long-term time frames, but speaks more fundamentally to both government commitment and performance. It requires clear commitment by the political leadership and a coherent long-term vision for growth, as well as actual delivery on the vision.

To induce low-carbon activity across the economy, market prices need to account for the full cost of production and resource use. Market mechanisms to internalize the social and environmental cost of pollution and capture the long-term costs of transforming natural capital into other forms of capital are among the most cost-effective and efficient policy instruments.[91] A price on carbon is fundamental to achieving the required efficiency gains and innovative drive to support low-carbon growth.[92]

A level playing field is required. Subsidies that encourage pollution or the over-extraction of resources ultimately place a drain on the public purse and need to be discontinued. Fossil fuel subsidies often work counter to and are ultimately incoherent with the introduction of a carbon price.[93] Consistent with commitments of the G-20[94] in 2009 and Asia-Pacific Economic Cooperation[95] (APEC) in 2011, and building on the federal commitment in Budget 2012,[96] federal and provincial governments should *"phase out inefficient fossil fuel subsidies that encourage wasteful consumption."* Research by the International Institute for Sustainable Development's (IISD) Global Subsidies Initiative estimated Canada's federal and provincial subsidy[b] support for upstream oil activities in 2008 at $2.8 billion, with the federal share accounting for half.[97] The research found non-conventional production followed by exploration (new drilling) as disproportionately benefitting from these subsidies. It concluded that subsidies to the oil and gas sector resulted in only a slight positive benefit to the economy, and that they stimulated exports but were not critical to the growth of the sector (the sector is projected to be about twice as large in 2020 as in 2005 with or without subsidies). Impacts on total employment were found to be negligible, and government balances were found to be lower, even with higher corporate taxes and royalty payments. It was further suggested that continued subsidization of this rapidly expanding sector risks long-term growth in subsidy obligations. Federal action to adjust subsidies focuses on aligning support for oil sands development with support for conventional oil and gas by 2016.[c] The playing field for low-carbon energy resources (e.g., renewable electricity, biofuels) remains uneven, relative to fossil energy sources.[98]

b For the purpose of their work, IISD employed the definition of subsidy from the WTO's Agreement on Subsidies and Countervailing Measures (ASCM).

c The federal government has implemented a phase-out of the accelerated capital cost allowance (ACCA) for general investment in oil sands projects; however, this will only take effect in 2015 with approximately 90% of oil sands facilities benefitting from this subsidy. The regular 25% ACCA rate will remain applicable to all oil sands projects, and additional subsidies for intangible oil sands costs as well as broader exploration and development subsidies, totalling in the range of $700 million annually, remain. For a comprehensive analysis, please see *Fossil Fuels – At What Cost?* (Sawyer and Stiebert 2010).

Efficient, effective, and outcome-oriented regulations are required. In addition, regulatory frameworks should support both economic prosperity and positive environmental outcomes. Regulations are sometimes necessary complements to market-based mechanisms. This is the case for reducing GHG emissions from buildings (e.g., energy efficiency standards in building codes) and transportation (e.g., Canada's *Passenger Automobile and Light Truck Greenhouse Gas Emission Regulations*). Efficient regulatory approaches focus on outcomes and provide flexibility in attaining the performance objective, ultimately reducing compliance costs and spurring innovation,[99] thereby ensuring the ongoing competitiveness of Canadian businesses.

In addition, coherence across environmental and economic regulations and policies is important. Interdepartmental policy coherence within federal and provincial governments, interprovincial coherence with respect to policy and regulatory frameworks, and federal-provincial policy and regulatory coherence are all necessary. For example, clear and consistent grid-connection standards across Canada could facilitate increased penetration of small-scale renewable generation capacity, and provincial waste management regulations could interfere with provincial plans to make use of biofuels derived from waste. The adoption of a systems perspective is necessary to tackle an issue as multi-faceted and complex as low-carbon growth. Such a perspective would consider the implications of all policy and regulatory initiatives on GHG emissions, innovation, low-carbon investment and economic growth. The expanded use of regulatory impact assessments to broadly include GHG emissions implications would assist this process.

5.3 KEY ACTIONS

STIMULATING INNOVATION

Innovation is one of the most important enablers of a low-carbon economy. Two trends in particular speak to the necessity for innovation in the low-carbon context: (1) intensified global competition and (2) continued and accelerated degradation of global ecosystems. As international competition increases, greater product/service differentiation will occur, and carbon intensity is already emerging as an important performance metric. The global economy is growing to meet the increased needs of an expanding population, and there is a need for less resource-intensive and environmentally damaging methods of production to permit the continuation of economic growth. Innovation is essential to driving this change.

Just as Canada needs to reframe the traditional model of economic growth and prosperity to integrate a low-carbon focus, it needs to do the same for innovation policy. Although businesses implement innovations, governments shape the environment within which innovation occurs.[100] Our research and stakeholder discussions indicate the need to sharpen the focus of Canada's innovation agenda: an innovation agenda that is aimed at developing a stronger, more prevalent clean technology, or more specifically, LCGS sector,

absolutely necessary if Canada is to advance toward a low-carbon economy. While innovation writ large is broadly a federal and provincial priority, low-carbon or cleantech innovation is only evident as a clear strategic priority for a limited number of provinces.[d] Setting an innovation policy agenda that is closely tied with clean and/or low-carbon technology will go a long way toward stimulating innovation. We see the following actions as priorities:

// To spur private sector innovation, governments must signal their commitment to achieving low-carbon objectives. Signals can take many forms, but could include policy instruments such as clean energy targets, standards for cleaner fuels, and more stringent energy efficiency requirements in building codes. With clear, sustained signals from government, investors would be more confident in supporting innovative ideas that move low-carbon technologies out of the labs and into the market.

// Policies that provide both "supply-push" and "demand-pull" will be necessary. An example of a demand-pull policy instrument is a feed-in tariff (FIT) program. An example of supply-push policy instrument is a tax credit for certain types of R&D. Canadian LCGS innovators could use more "push" in the form of organizations such as SDTC that provide both direct funding for demonstration projects and technical assistance and support. The need for additional organizations of this type is unclear, but long-term and expanded funding to existing organizations could go a long way in addressing unmet needs. The need for additional "pull" to increase demand for innovation is also apparent.[101] In providing direct funding to support low-carbon innovation, Canada should be focused and seek to identify and support key strategic market niches. China, Korea, and others have created huge barriers to entry in the solar and wind markets through support to their respective manufacturers and exporters. Rather than attempting to compete head-to-head in these well-developed sectors, Canada should be investing in less developed and strategically important sectors such as CCS, and building on its existing manufacturing base and expertise in such areas as clean automobile manufacturing where there is a clear strategic benefit going forward.[e] Building on existing strengths in Canada's resource base and areas of expertise, positions the country well to compete.

// Governments need to review and streamline innovation funding frameworks within which innovation occurs. Some in the innovation field have noted that overly burdensome regulations and policies often drive innovators to other countries to take their ideas to pilot or full scale.[102] They have also noted that government support is frequently scattered under numerous federal and provincial programs with access requiring significant investment of time, effort, and resources. This presents a particular challenge for SMEs that form the majority of low-carbon innovators in Canada. It may be possible to address some of the noted challenges by reviewing policy and regulatory frameworks related to innovation and financing low-carbon technologies to ensure that they are efficient and yet robust enough to support development of the sector.

d Some provinces such as Québec, Ontario, and British Columbia are taking a lead in this realm with the introduction of legislation and programs that are clearly supportive of and aimed at developing robust, prosperous, cleantech sectors.

e SDTC in particular has established a strong track record of screening projects and financing those with strong potential and manageable risk profiles.

// Establishing innovation clusters could help narrow current gaps between innovators, particularly SMEs, potential users of the innovation, and investors. Although innovation clusters[f] are in their infancy in Canada, there is a need to quickly develop and support them to address these two key challenges, facilitate the exposure of their ideas and innovations to a global audience, and bring in the expertise and resources needed to attain the next level of development.

MOBILIZING INVESTMENT

The low-carbon transition requires investment in innovation across the full spectrum from technology research and development to demonstration and ultimately deployment. Investment in the physical infrastructure that supports the uptake of innovative products and processes is also critical. The scale of this investment — the investment required to drive the low-carbon transition such that it prevents dangerous climate change[g] — is sizeable. The International Energy Agency estimates that an incremental annual investment of $158 billion in the decade from 2011 to 2020 and $1.1 trillion annually by 2035 will be required to achieve a global emissions pathway with a reasonable chance of limiting global average temperature rise to 2°C over pre-industrial levels.[103]

FOR A REMINDER OF THE SCENARIOS USED IN THIS REPORT, SEE CHAPTER I, SECTION I.3

Canada needs to significantly step up its low-carbon investment with a focus on electricity infrastructure and the oil and gas sector. We estimate that for Canada to reduce GHG emissions by 65% below 2005 levels in 2050, annual investment on the order of $13 to $17 billion (Target 2050 and Lock-in SCENARIOS, respectively) could be necessary in addition to that already anticipated under existing and proposed policy measures.[h] **Table 7** presents the forecasted investment requirements by scenario and sector (additional analysis concerning estimated investment required under a simulated regulatory approach is presented in **Box 6**). Roughly 85% of these annual amounts (i.e., between $11 and $15 billion) will need to be allocated to the electricity sector. For context, between 2000 and 2010, annual investments in the electric power sector averaged $12 billion.[104] This means that Canada would need to roughly double the investment rate for the foreseeable future to meet the specified emissions reductions. Incremental investments modelled for the oil and gas sector are also noteworthy, amounting to $1.6 to $1.7 billion per year (or a 4–5% increase over current levels). This investment is largely focused on CCS. Additional investment in energy efficiency improvements, alternatively fuelled equipment, and building-shell retrofits in the commercial sector average between $360 and $560 million per year. Switching from road transportation to rail freight results in reduced investment requirements between $1.0 and $1.1 billion; however, the changes to investment in freight transport embody some additional uncertainty due to the infrastructure requirements of expanded rail service. Overall, the extra private sector investment amounts to an increase of between 5% and 8% per year over current levels, focused largely in the electricity and oil and gas sectors.

f Innovation clusters (also called innovation ecosystems) consist of interactions between business, universities, and government in a manner that provides the necessary ingredients to foster innovation (University of Alberta 2011), and "support and sustain the creation and growth of new ventures" (Council of Canadian Academies 2009). Several clusters supporting cleantech innovation exist in Canada, including MaRS and Écotech Québec.

g See Hansen 2006 and Metz et al. 2007 for discussions on what constitutes dangerous climate change and why.

h The discussion of future low-carbon investment requirements in Canada draws from a research report prepared for the NRT by Navius Research Inc. (Navius Research Inc. 2012), available upon request.

TABLE 7

INCREMENTAL AVERAGE ANNUAL LOW-CARBON INVESTMENT REQUIREMENTS BY SCENARIO

	TARGET 2050	S&L TARGETS	DELAY	LOCK-IN
SCENARIO DURATION	(35 YEARS)	(35 YEARS)	(30 YEARS)	(30 YEARS)
COMMERCIAL BUILDINGS	$0.3B	$0.4B	$0.4B	$0.5B
FREIGHT TRANSPORT	-$1.0B	-$1.0B	-$1.1B	-$1.0B
ELECTRICITY GENERATION	$10.8B	$10.9B	$12.4B	$15.4B
MANUFACTURING INDUSTRY	$0.8B	$0.7B	$0.9B	$1.3B
OIL AND GAS	$1.7B	$1.7B	$1.5B	$1.6B
AVG. ANNUAL CHANGE IN INVESTMENT	$12.8B	$12.6B	$14.2B	$17.9B

Source: Navius Research Inc. 2012
Note: totals may not sum due to rounding

Patient and risk-tolerant capital needs to be made available to Canadian LCGS entrepreneurs to allow them to succeed. One of the most significant challenges to innovators, particularly SMEs, is a lack of access to risk capital — in some cases the barrier is venture capital, in others it is an issue of significant project financing required for full-scale developments. Related to this is the challenge of time required for an innovative idea to come to maturity; it typically takes between 10 and 15 years[i] to reach commercial maturity which means that the availability of patient, risk-tolerant capital will be a key driver to the LCGS industry's success. Government policies must help de-risk the financing of new innovative technologies and ideas to significantly improve commercialization of low-carbon technologies. While the Canadian government continues to fund innovation and has recently placed greater emphasis on early-stage risk capital[105], additional funding geared specifically toward LCGS would be helpful.

i In its analysis for the 2010 SDTC Cleantech Growth and Go-To-Market Report, the Russell Mitchell Group presents a benchmark for the maturation timeline for high-growth technology-based companies. The authors suggest that high-growth technology-based companies achieve revenues of $100 million within 10 years of start-up. Based on survey results, they estimate that Canadian cleantech companies take between 10 and 15 years to reach this revenue benchmark (Sustainable Development Technology Canada and Russell Mitchell Group 2010).

BOX 6

BEST-IN-CLASS REGULATORY SCENARIO

In addition to the four scenarios exploring the investment and emissions implications of short- and long-term GHG emission targets and implementation timing, the NRT undertook new modelling to assess the abatement performance and investment requirements for a simulated "Best-in-Class" (BIC) GHG performance standard regulatory approach. We undertook a review of technologies and processes to identify the appropriate options by sector and region. This highlighted two facts: 1) best-in-class technologies in one sector affect those in other sectors and 2) differences in fuel options and other factors mean that best-in-class technologies may not be identical across regions of Canada. In particular, the presence of substantial hydro resources in some provinces represented a significant distinction from those with fossil resources.

To implement the BIC scenario, we conducted a simulation in which capital stock currently in place is permitted to operate until it reaches the end of its natural lifespan, at which time new stock is required to meet best-in-class emission performance standards. A notable risk of this scenario — as with any technology-specific regulation — is the possibility of requiring investment in equipment that is significantly more costly than alternatives, thus driving abatement that is not least cost. Additionally, such an approach to climate policy lacks the capacity to drive innovation beyond the best-in-class technologies specified.

Implementation of this scenario assumed that performance standards were implemented for those assets reaching the end of their useful life starting in 2012. We found the following:

// A BIC regulatory approach can achieve significant long-term emissions reductions. The modelled scenario achieved GHG reductions of 15% and 61% below 2005 levels in 2020 and 2050, respectively. Annual emissions abatement in 2050 is estimated at 445 MT as compared with 475 MT for the Target 2050 scenario. The BIC scenario also achieved similar cumulative abatement to that of the Target 2050 scenario (9.5 vs. 9.2 GT CO_2e).

// The change in overall cumulative investment is substantially lower compared with other scenarios because more expensive retrofits do not occur (they are not induced by carbon pricing as in the other scenarios) and because reduced electrification results in reduced electricity generation expansion.

// The manufacturing sector absorbs a significantly higher proportion of abatement costs. In the BIC scenario, more oil and gas investment occurs without guidance from a strong carbon price such that the investment is more evenly spread between manufacturing and oil and gas sectors. Abatement from some other sectors is precluded.

// The BIC scenario is less cost-effective than the Target 2050 or S&L Targets scenarios; however, at close to $62, the cost per tonne of cumulative abatement remains noticeably below that associated with either scenario involving delayed policy implementation.

TABLE 8 CHANGES IN ANNUAL FIRM INVESTMENT IN THE BIC SCENARIO

	BIC
SCENARIO DURATION	(35 YEARS)
COMMERCIAL BUILDINGS	N/A
FREIGHT TRANSPORT	N/A
ELECTRICITY GENERATION	$9.9B
MANUFACTURING INDUSTRY	$2.1B
OIL AND GAS	$1.5B
AVG. ANNUAL CHANGE IN INVESTMENT	$13.5B

NOTE: TOTALS MAY NOT SUM DUE TO ROUNDING
SOURCE: NAVIUS RESEARCH INC. 2012

Beyond putting in place the *essential conditions* for low-carbon growth and establishing policy certainty through clear economic signals in particular, action is required on the part of both governments and the private sector to succeed in meeting the necessary scale and pace of investment. We have identified two key areas for action:

Governments and financial institutions need to work together to substantially increase access to capital. The substantial investment required to finance the low-carbon transition requires deploying a combination of public- and private-sector capital at greater levels than today. While the public sector's continued role is critical, particularly in investing in areas of significant provincial, regional, or national interest, or R&D where the spinoff benefits are large, private-sector sources of capital will need to play an increasingly prominent role going forward. For this to occur, a greater diversity of sources of capital is required than is available today. This involves reaching out and creating ways for those who currently are not investing in low carbon — including untapped sources of capital such as institutional investors (e.g., pension and insurance funds) and even individual investors to do so.

To increase access to these alternative sources of capital, financial institutions need to develop and popularize new vehicles for low-carbon investment. Secondary markets for low-carbon project finance debt packaged as "green bonds" could provide banks with the ability to make additional loans and create a promising growth area.[106] For broad adoption, green bonds (and other low-carbon securities) would need to adhere to standards that provide investors with certainty about the underlying investments.[107] Leases for energy-efficient equipment also have significant potential. In addition to requiring no up-front costs from the purchaser, leases provide the opportunity for aggregation of projects into larger quantities more suitable for debt financing through partnerships with utilities or banks.[108]

New approaches to financing are also required to reduce transaction costs due to project size and due diligence requirements. Low-carbon infrastructure and technology investments tend to be fragmented and unstructured, consisting of a large number of small projects requiring individual financing rather than a small number of large, more structured projects.[109] At the same time, requirements for due diligence — regulatory, technical, commercial and financial — tend to be similar, leading to comparatively high transaction costs. This frequently renders the projects unsuitable for financing by large corporate and investment banks despite the potential benefit from their in-house expertise. The development of tools and products that aggregate both the risk and the financing requirements into larger, more structured transactions could lower overall transaction costs and provide an entry point for larger financial institutions.

Banks and other financial institutions need to strengthen their capacity to perform risk assessments of low-carbon technologies and projects.[110] Low-carbon technologies tend to be complex and relatively speaking, immature, leading investors to attach greater risk to LCGS investments.[111] Many low-carbon investments

also have long-term horizons with respect to payback periods and investors require the financial return on their investments to be guaranteed over this time frame. In addition, revenue streams for low-carbon technologies are typically more complex to estimate than traditional technologies, compounding the risk attached to them. For example, the intermittent nature of many renewable energy sources increases the uncertainty associated with the revenue stream. To better understand these added dimensions of investment risk and to facilitate the development of customized investment vehicles structured to mitigate such risks, banks and other financial institutions need to increase their advisory capacity on technical, regulatory, commercial, and financial aspects of low-carbon technologies and projects.[112] Developing capacity to fairly assess the risk of these investments is of particular importance with respect to attracting investment by institutional investors such as pension and insurance funds, which tend to have low levels of risk tolerance.[113,114]

Governments need to be open to providing incentives to encourage low-carbon investment. Incentives could balance the risk-reward ratios for low-carbon investment. Where perceived risk is high, balancing risk-reward ratios is necessary to improve the financial attractiveness of investments and to generate the desired levels of private sector investment.[115,116] In some instances (for example with renewable energy technologies where grid parity has not yet been attained), support may be required for the development or introduction of emerging low-carbon technologies. Direct subsidies (e.g., feed-in tariffs) are often used in the absence of stability and clarity with respect to carbon markets.[117] Other methods by which public funds are used to leverage private investment in low-carbon technologies include capital gains tax credits (direct equity or funds), tax-equity/debt schemes, and matching participation in venture capital equity investments. Such use of public funds can make sense where public spinoff benefits (e.g., from early stage R&D) are expected or where long-term benefits of initial investments are significant (e.g., increased deployment of renewable electricity technologies [RETs] brings them closer to grid parity) and would not be otherwise valued in private decisions (i.e., where there are specific market failures). Such incentives should be subject to regular review, keeping in mind requirements for long-term policy certainty and the principle of providing a level playing field across all technologies.

Incentives could also address barriers to low-carbon investments by Canadian households. High up-front costs can be a major barrier to consumer purchases of renewable micro-generation, electric vehicles, or low-carbon buildings, despite net savings over the lifetime of these technologies.[118] Reducing up-front costs through low-interest loans, leases, or special mortgage arrangements would encourage purchasing decisions with carbon impacts in mind. Several of these programs are in existence in North America, but in Canada, the coverage of these programs is incomplete, and the strength of existing programs can be increased.

ENHANCING ACCESS TO LCGS MARKETS

Trade is and will continue to be critical to Canada's prosperity. Trade related to Canada's traditional, resource-oriented economic base and to low-carbon goods and services are both important. Ensuring access to key LCGS markets will support the growth of the low-carbon industrial base. Undertaking targeted activities, strengthening the international brand and, removing sector-specific barriers to trade are key strategies to pursue on a priority basis. A final priority lies in reducing the carbon intensity of the resource-oriented component of Canada's economy; its continued success and access to global markets is at stake if Canada doesn't act on this priority.

The federal and provincial governments should step up their roles in facilitating Canadian access to global LCGS markets. Canadian companies already target international markets disproportionately to the domestic one for two reasons: the small size of the domestic market and the absence of domestic signals to stimulate LCGS uptake. Access to global LCGS markets is currently inhibited by limited opportunity for domestic demonstration and by gaps among innovators, investors, and potential users of new products or processes. Governments need to make it easier for Canadian companies to tap into the growing global demand for LCGS. Key actions are as follows:

// Engage in international diplomacy to build the broad conditions necessary for investment and trade in Canadian LCGS. Canada should continue to actively participate in bilateral and international efforts to build capacity and remove barriers to investment in other countries. Tackling regulatory, policy, and technical barriers to the adoption of low-carbon energy applications in developing countries, in particular, not only encourages the flow of investment toward low-carbon energy provision but also opens up markets for countries that supply LCGS.[119]

// Proactively participate in the formulation of standards and labels of critical importance to Canadian exports. Canada should, for example, work to get a low-carbon fuel standard taken up by ISO for consistent application across states. Efforts to get hydropower recognized by U.S. federal and state governments as eligible for satisfying renewable portfolio standards requirements would position Canada's electricity sector to benefit from access to premium rates for electricity exports.

// Convene stakeholders in LCGS innovation and promote LCGS sectors internationally. Governments can act as conveners to close the gaps between innovators, investors and users of innovative technology, particularly when it comes to SMEs. SMEs are leading low-carbon innovation in Canada. Our discussions with stakeholders suggest that their chances of success in global markets would greatly improve by connecting to and collaborating with large corporations that provide access to resources and expertise to help with commercialization. Governments are well situated to foster these strategic collaborations. Internationally, an expanded trade promotion and convening role by the Canadian government would support growth of Canada's LCGS sectors. Such a role would involve linking up the strengths of Canada's innovation with emerging international demand and potential sources of international finance. Benefits to Canadian innovators include reduced

time, effort, and expense to gauge international interest and potential partnerships, which is important given the limited opportunity for domestic demonstration.[j] Indirect government endorsement of Canadian LCGS innovations would also benefit Canadian companies. Though not a standard requirement in dealing with most industrialized economies, government backing can be critical to sealing a deal in some emerging economies. The kind of government support described here will require the federal government to maintain a comprehensive global awareness of technology and innovation needs, as well as an in-depth and current understanding of solutions being developed within Canadian LCGS sectors.

// Put in place domestic procurement policies and technology verification programs. Canada's small market and low risk tolerance when it comes to technology adoption means Canadian entrepreneurs often seek out international markets to prove the viability of their products and services before ever entering the domestic market. The added effort and expense by Canadian entrepreneurs to go international is incurred despite the noted preference of international purchasers for domestic demonstration. Domestic low-carbon technology testing, evaluation, and validation through government procurement and the development of a rigorous and internationally recognized low-carbon technology verification program (e.g., the U.S. EPA's Environmental Technology Verification program) would provide significant support to Canadian firms.

The federal government needs to strengthen Canada's international "brand," particularly on climate policy. Canada's brand is a form of currency in itself, influencing the ability of Canadian firms to trade and invest internationally, and affecting the inflow of foreign direct investment (FDI). Canada's domestic and international climate policy positions and the communication of those positions on the international stage shape perceptions of Canada on a host of other issues and topics. The reality is that Canada is currently subject to substantial international criticism over climate policy and fossil resource development.[k] This has the potential to jeopardize trade and investment related to Canada's current heavily resource-oriented economic base as markets begin to discriminate and investors begin to hedge against climate-related risks.

Improvements to Canada's brand will come from actions that elaborate and demonstrate the country's commitment to reduce GHG emissions and build capacity to engage domestically and internationally on climate change policy. This could include building effective and realistic pricing of carbon to meet current and future goals; developing and communicating clear, transparent, and realistic plans to meet Canada's internationally-pledged target for 2020; and establishing a clear GHG reduction target for 2050. Canada should also seek opportunities to build on its strengths in the financial sector and its commitment to providing "fast start financing" (under the Copenhagen Accord and Cancun Agreements) as a contribution to the United Nations Framework Convention on Climate Change's (UNFCCC) Green Climate Fund. Canada should continue contributing to bilateral and regional initiatives, such as the multi-lateral commitment tackling short-lived climate pollutants.[l]

j A similar concept for broader science and technology R&D collaboration already exists in the form of ISTP (International Science and Technology Partnerships) Canada which is intended to stimulate early-stage partnership development, facilitate the creation of partnerships between Canadian companies and research organizations and their international counterparts, and invest in cooperative R&D projects with high commercial potential (International Science and Technology Partnerships Canada Inc. 2009).

k For example, see Carrington and Vaughan 2011; Conway-Smith 2011.

l For more detail, see: United Nations Environment Programme 2012b.

Federal and provincial governments should remove sector-specific barriers to trade. Where illegitimate trade barriers exist and Canada has a long-term interest in maintaining the viability of a strong sector, the federal government should consider measures available to it under international trade law. For example, the U.S. recently enacted countervailing duties to address alleged "dumping" of solar PV equipment by Chinese manufacturers. Where interprovincial barriers to trade exist, provinces should collaborate to remove them. For example, domestic content requirements in Québec and Ontario disadvantage firms in other Canadian provinces that could sell into their markets. Content requirements could be framed so as to broadly benefit Canadian production as opposed to targeting exclusively in-province production, though it should be noted that Ontario's domestic content requirements are currently being appealed internationally through the WTO. Specific interprovincial barriers include a regulatory vacuum on ownership of geothermal resources and the lack of key infrastructure such as interprovincial transmission capacity.

Governments should support the development of low-carbon thermal energy and electricity sources to limit the "carbon exposure" of key sectors. Of particular concern are Canada's energy-intensive trade-exposed (EITE) sectors. Addressing the carbon exposure of these sectors represents an opportunity for domestic LCGS innovation. However, government support for LCGS innovation, such as we discussed above, combined with flexible and adaptive regulatory and environmental approval frameworks (and in particular, provincial frameworks) are necessary. Regulators tend to be inherently risk-averse, and new technologies, new approaches, and new fuels can present evaluation challenges. New proposals and approval applications in heavy industry also frequently generate substantial interest from local community members, presenting a need for significant communications efforts and community engagement. Governments can actively promote positive innovation by developing approval frameworks that encourage demonstration projects and the generation of data required for technology verification and further development.

FOSTERING TALENT AND SKILLS DEVELOPMENT

Our collective talent can be a driver of a low-carbon transition, but a lack of preparation can be a barrier. A low-carbon transition will cause a shift in demand for certain occupations, may result in the emergence of new occupations, and may require existing occupations to take on new skillsets. However, issues of labour shortages and skills gaps can curtail growth and cause structural unemployment. Globally, the International Labour Organization (ILO) states that present shortages are already hindering a global low-carbon transition.[120]

Federal and provincial governments must increase their knowledge of the human resource requirements of LCGS sectors and of economy-wide changes to employment resulting from a low-carbon transition. Canada's ability to prepare for the low-carbon transition is currently hindered by gaps in knowledge, including the absence of official statistics on skills requirements and employment levels in LCGS sectors and related occupations. Without such understanding, developing, coordinating and deploying training and employment programs to facilitate low-carbon growth is difficult for all labour market actors.

ECO Canada, an industry-led environmental-careers organization, reports that there is a need for better information on the skills and employment needs of Canada's growing green economy.[121] Governments must lay the groundwork by generating employment and economic statistics for current and emerging LCGS sectors.

Federal and provincial governments need to collaborate on the design and implementation of a coordinated jobs policy that explicitly addresses LCGS sector needs in the context of broader economic development objectives and competing demands for human resources. Energy and climate policies must be linked with job creation and skills development strategies. There is sufficient information to move forward and encourage training for skills Canada knows will be in demand. Other major industrialized nations, as well as many emerging economies, have moved forward with aggressive low-carbon growth plans, many of which are linked to job creation and skills strategies.[122] Coherence between these two priorities is the key to a successful transition, as the ILO noted in its foundational report comparing 21 such strategies.[123] The lack of such a strategy risks losing economic and employment opportunities associated with the low-carbon economy. Science, technology, engineering, and math — the so-called STEM skills — form the core skillsets upon which many more detailed occupations are formed. These skillsets have been in high demand in the past, are presently, and will continue to be in the future. These skills are also essential in building a leading-edge, innovative low-carbon economy. The most recent C-Suite Survey[m] acknowledges that the hardest jobs to fill are those that require STEM skills.[124] Skills for efficient and low-carbon buildings will also be in very high demand. Governments should ensure that the scale of training for low-carbon trades exists, is accessible, and meets high standards.

5.4 THE GOVERNANCE TO MAKE IT HAPPEN

In addition to the broader essential economic conditions for low-carbon growth and specific actions required to position Canada on a low-carbon growth trajectory, strong governance is foundational to effectively advancing the low-carbon agenda. The NRT identifies fives ways in which governance will contribute to successful development and implementation of the NRT's low-carbon growth framework: vision and commitment, coordination, private sector engagement, engagement with Canadians, and the development of a mechanism for the ongoing assessment of progress and provision of advice.

Canada's federal and provincial governments need to articulate a clear coordinated vision and demonstrate sustained commitment to the transition to a low-carbon economy. The development of low-carbon growth plans internationally has taken place under different contexts and with different motivating factors, depending on the state of the public discourse on climate change, the understanding of related risks and opportunities, and government priorities. For example, in the U.K., the low-carbon growth plan set in place by the government leadership was necessitated by public demand. At the time of its implementation, the agenda was broadly endorsed and doubt with respect to climate change science was not a substantive issue.[125] In the case of the Republic of South Korea, the president championed the initiative announcing a

m The C-Suite Survey is a quarterly opinion survey commissioned by *Business News Network* and *The Global and Mail*. It is aimed at chief executive, chief financial, and chief operating officers of Canada's largest 1000 companies. (The Gandalf Group 2011).

"low-carbon, green growth" plan in a 2008 national address commemorating South Korea's independence.[126] No matter the impetus, successful implementation requires political commitment from all orders of government, commitment and follow-through on the part of central agencies, and in a federation such as Canada, a coordinated federal-provincial approach. The NRT has articulated an initial vision that will require further refinement based on broad consultation.

Federal and provincial governments need to increase the effectiveness of coordination within and across departments as well as between levels of government. While facilitated when leadership clearly promotes a low-carbon transition, effective coordination requires improved communication within and across relevant government departments to better align objectives and efforts and achieve results. Departmental accountability mechanisms also greatly facilitate coordination. Improved communications across governments leads to streamlined responsibilities and greater policy coherence.

Improving interdepartmental dialogue to tackle the crosscutting issue of low-carbon growth requires both organizational specialization and the adoption of a holistic approach. For example, the United Kingdom created the Department of Energy and Climate Change (DECC) in 2008 to address tensions arising from the sometimes conflicting policy mandates of climate change and energy departments and to balance environmental and economic objectives. To develop the LCGP, DECC adopted the model used for other issue areas: create a core group of 10–12 people to lead and coordinate strategy development and consult across government to gain diverse policy and technical input. This approach builds buy-in from all departments involved. In the U.K.'s case, the legally binding commitment to meet emission reduction targets across government and related carbon budgeting exercises has helped ensure policy coherence.[127] British Columbia's Climate Action Secretariat (CAS) provides an example of a successful Canadian approach. The CAS "drives change to achieve B.C.'s GHG emission reduction targets by coordinating climate action activities across government and with stakeholders".[128] While housed in the Ministry of Environment, the CAS works across the provincial government to support integration of climate change considerations into planning and operations, from both mitigation and adaptation perspectives.[129] Whether by using existing mechanisms, reorganizing, and/or developing new mechanisms, integration across both federal and provincial governments will be necessary to achieve a successful low-carbon transition in Canada.

Increased inter-governmental coordination is also required to maximize low-carbon outcomes and minimize policy and program overlap. Given the diversity of interests, resources, and opportunities across Canada's provinces, regional representation in any discussion of a national low-carbon strategy is critical. Furthermore, stimulating low-carbon growth will require action at all levels of government on a diversity of files. Minimizing jurisdictional fragmentation and increasing alignment of policies will increase efficiency and improve overall cost-effectiveness. Where expertise is more concentrated within a given level of government, greater coordination would also provide the opportunity for more effective delegation to the party best equipped to address the issue. Intragovernmental coordination is an important related issue. Climate

policy, a component of low-carbon growth, has historically resided in environment departments. However, given the broad, crosscutting implications of low-carbon growth and the intersection of energy, environmental, and economic considerations, a new approach and new champions may be required.

The participation of municipalities will be critical in meeting federal and provincial GHG mitigation targets, a key aspect of low-carbon growth. The Federation of Canadian Municipalities published a discussion paper in January 2012 entitled *Building Canada's Green Economy: The Municipal Role*, demonstrating that municipalities are on board and acting already to implement low-carbon solutions.[130] Greater collaboration with municipalities stemming from more coordinated federal-provincial action would be beneficial. The importance of aligning national policies with local and regional policies and practices such as land-use planning to ensure that climate change is fully integrated into development plans is broadly recognized.[131]

The private sector needs to step up and engage proactively with governments concerning its vision for the low-carbon economy and the optimal path to achieve it. The necessity of the direct involvement of the private sector in low-carbon planning was a recurring message throughout the NRT's discussions across Canada. In our conversations, private-sector representatives broadly acknowledged that the transition to a low-carbon economy is inevitable. While concern was raised about the implications for more carbon-intensive operations, there was also recognition that most issues could be addressed provided the existence of open, frank dialogue on objectives, impacts and options, and the presence of all implicated parties at the table. It is particularly important for sector leaders to be engaged in such dialogue. Within most if not all sectors, leading companies are innovating and planning for low-carbon growth. It is essential that these voices are present at the table to avoid descent to the lowest common denominator.

Governments need to more actively engage Canadians with respect to climate policy, Canada's energy context, and low-carbon growth. Building Canada's energy and emissions literacy will enhance individuals' capacity to contribute to conservation efforts, and increase understanding on the part of citizens with respect to both the need for and opportunity in the low-carbon transition. Information and tools are already available to enhance energy and emissions education and awareness in the form of national programs (e.g., Canada's Centre for Energy and SEEDS Energy Literacy Series), provincial programs (e.g., New Brunswick's Climate Change Public Education and Outreach Hub and Climate Change Education Saskatchewan), and municipal initiatives (e.g., the City of Vancouver's Climate Protection Program).[n] Enhancing Canada's existing efforts in a broad-based manner and expanding the discussion to incorporate low-carbon growth considerations could lead to a better informed public discussion on this issue of national importance. The multi-stakeholder public interest model being pioneered through QUEST presents significant potential for advancing both knowledge and public dialogue and ultimately generating more sustainable approaches to community development (see **Box 7**). Public awareness and understanding of and dialogue about the opportunities as well as the trade-offs involved as the world moves to a low-carbon economy are key to long-term policy development.

n For more sources see Climate Change Education.org 2011.

BOX 7

QUEST[132]

Quality Urban Energy Systems of Tomorrow (QUEST) is a non-profit that offers education and research on integrated energy systems to promote deployments of these systems in Canadian communities. QUEST, which brings together diverse stakeholders, is supported financially by a broad selection of public and private sector players. Incorporated in 2011 after a number of years in formation, the collaborative approach pioneered through QUEST holds promise for increasing engagement by decision makers and advancing both knowledge and implementation of solutions.

Specifically, governments need to engage in conversation with Canadians on the price of electricity. Given the substantial additional investment required in the electricity system over the next forty years both to cut emissions and for the sector to remain in compliance with regulations, a rise in electricity prices over this time frame is likely. In some cases, Canadians do not currently pay the full price of the electricity they use.[133] Although social equality can be a consideration in setting energy prices (particularly where electricity meets heating needs), the broad subsidization of consumer pricing simply conveys the wrong market signals. Alternative and more directed social policy targeting affordability issues should replace current, broad-based approaches. Low-cost electricity has historically been a key economic advantage in many regions in Canada, but electricity prices paid by industry have risen in most areas in recent years,[o] eliminating or greatly reducing this advantage. Electricity prices continue to be a key cost consideration for many manufacturers and industry players. Policies or programs aimed at enhancing industrial or manufacturing competitiveness should consider the long-term value of full-cost pricing and where necessary, governments should identify alternatives to price subsidization to mitigate significant cost increases that compromise competitiveness.

Lastly, establishing an impartial, credible mechanism to both monitor Canada's performance with respect to its low-carbon objectives and provide unbiased advice to governments regarding the path forward would greatly help Canada achieve low-carbon growth. An independent, non-partisan entity can bring together disparate views and shed objective light on the path forward. In contrast, entities within or close to government can suffer from partisan views lacking in perspective and departmental advice can be influenced by perceived, and often shorter-term, government priorities. International precedence for such a mechanism exists. In Germany, the German Advisory Council on the Environment and the German Advisory Council on Global Change provide independent, scientific advice to government. The U.K. Committee on Climate Change (CCC) is a permanent independent group that provides advice to the central government and the devolved administrations on progress toward a low-carbon economy and reports annually to Parliament. The CCC plays an important integration role across departments and among levels of government in the U.K.[134]

o The average industrial electricity price in Canada increased by 5.1% from 2010 to 2011 (Canadian Electricity Association 2012).

5.5 CONCLUSIONS

Moving toward a green economy is one of the most important issues for the twenty-first century.[135] A green economy is, of necessity, a low-carbon economy. Much of the world is already moving to reduce the carbon intensity of economic growth and, in this way, transitioning to a *low-carbon* economy. While the Rio+20 Conference in June 2012 did not culminate in substantive agreements or new commitments on the part of nation states concerning the path toward a global green and in particular low-carbon economy, it did highlight the role of domestic and local action in effecting this transition and of the potential opportunity for countries that strategically take early action to transition.[136] While there are components of a low-carbon economy policy discussion developing in parts of Canada, such as the continuing pan-Canadian energy dialogue, there is no cohesive, collaborative, and comprehensive national approach to this issue.

Canada needs a low-carbon growth plan that builds on strengths, involves all governments, engages the private sector, and focuses on market mechanisms. The development of a low-carbon growth plan needs to be a comprehensive, inclusive, and transparent process. In Canada, this will demand open dialogue and regional input from all corners of the country. It will require strategic foresight necessitating truly pan-Canadian thinking that transcends parochial interests while giving due consideration to regional issues and concerns. This report is a starting point to get the country moving forward. The NRT has laid out a framework for low-carbon growth containing what we believe are the critical areas to be addressed and outlining necessary foundational considerations. We have offered the beginnings of a pan-Canadian vision for a low-carbon economy, and have identified actions we believe to be fundamental to stimulating low-carbon growth. These ideas are meant to lay the foundation for future work. Firstly, it is imperative to ensure that Canada has the right policy context, and so it should start with the essential conditions for low-carbon growth: creating certainty around climate, energy, and innovation policy; implementing a clear, strong, and long-term price signal on carbon emissions; establishing a more level playing field by eliminating inefficient subsidies supporting fossil fuels; and ensuring that policy and regulatory approaches are outcome-oriented, adaptive, and responsive to changing economic and environmental realities.

Secondly, it is imperative that Canada get the governance "right" to enable a transition to low carbon. Together with the essential conditions, strong governance provides the underlying support for the critical actions. Of all the governance considerations, it is imperative that federal and provincial governments show leadership and demonstrate their strong commitment to the transition toward a low-carbon economy through the articulation of a clear, coordinated and collaborative vision for Canada. This would be further enhanced by the development of a national strategy that builds upon the many regional strengths and opportunities across the country. To support the vision and strategy, implementation will require more effective coordination and integration within and across departments in both federal and provincial governments, active engagement on the part of the private sector, broader engagement with Canadians, and the establishment of a mechanism for assessing performance and providing ongoing advice.

All our ideas in this chapter merit consideration in developing a low-carbon growth plan for Canada. However, we are suggesting here that a few are critical for getting started on a low-carbon growth strategy now. The criteria against which we considered these top priorities are few and simple: implementation of the action must have broad and significant impacts in realizing a transition to a low-carbon economy; must be achievable in the near term; and should generate benefits beyond those associated strictly with the transition to a low-carbon economy.

Of all our key components of a low-carbon strategy, the most important and necessary is the establishment of **long-term certainty on climate, energy, and innovation policies**. For many years now the NRT has advised governments of the critical need for policy certainty on climate change. Through this most recent work, we are now concluding that in order to move to a low-carbon economy this must be complemented with policy certainty on a pan-Canadian energy strategy and an innovation policy that is focused on low-carbon and clean technology. Long-term certainty must be established to send the right signals to the private sector that Canadian governments are serious about the transition to a low-carbon economy. It will give the necessary certainty to move the private sector, including the financial sector, to act.

Figuring out the investment and financing aspects of a low-carbon transition will be among the most challenging components; they are also, in our view, some of the most important pieces to figure out in the short term. In particular, **it will be imperative that governments and financial institutions work together to substantially increase access to capital**, one of the most notable barriers to supporting clean technology innovation and SMEs in Canada. While governments will need to establish the correct signals, there is a clear private sector imperative both with respect to meeting the significant investment requirements and in establishing the mechanisms for tapping larger more diversified pools of capital.

Given the forecasted growth in global LCGS markets and the relatively limited size of Canada's domestic market, the opportunity in the global transition to a low-carbon economy lies primarily in the potential for Canadian companies to supply a portion of the anticipated growth in global demand. Canadian firms need to be strong players in international markets. There is an important role for federal and provincial governments to improve and facilitate increased access to global markets for trade and investment in LCGS. **In particular governments can reduce barriers to commercialization by facilitating international collaboration between firms and between innovators and investors. They can further strengthen domestic innovation capacity and international competitiveness by implementing procurement, demonstration and verification programs.**

Finally, there is an important public engagement aspect to the low-carbon transition. Many stakeholders identified further electrification of the economy as an important element of the transition. Canada has some of the lowest electricity rates in the world, but with the need for full-cost pricing of new and existing supplies, the price of electricity will rise. Therefore, **there is a need for governments to engage Canadians in a conversation with respect to the real price of electricity, and why this price will likely need to increase over time.** Without this understanding Canadians are not likely to be supportive of reducing GHG emissions and ultimately unlikely to support the transition to a low-carbon economy. Politicians look to their constituents for guidance on policy direction. Therefore, the low-carbon dialogue must occur throughout all sectors and levels of Canadian society.

Figure 10 presents a graphical overview of the priorities laid out in this document — NRT's framework for low-carbon growth. It encompasses the vision, essential conditions, required governance context, and actions to move toward a low-carbon economy.

FIGURE 10

A LOW-CARBON GROWTH FRAMEWORK FOR CANADA

VISION FOR 2050

- Our energy and electricity systems are diverse, clean, and sustainable.
- We develop our vast natural resources responsibly, respectfully, and sustainably.
- Our firms are reputable global exporters of low-carbon energy, technology, and expertise.
- We are an innovation nation, and our successes in bringing low-carbon ideas to market are globally renowned.
- Canadians in all regions benefit from the growing demand for low-carbon jobs.
- Canadians expect federal and provincial decision makers to support and prioritize the low-carbon economy.

OBJECTIVES	STIMULATE INNOVATION	MOBILIZE INVESTMENT	ENHANCE MARKET ACCESS	FOSTER TALENT AND SKILLS DEVELOPMENT
KEY ACTIONS	Establish a low-carbon innovation policy agenda	Proactively engage key capital market players (institutional investors, pension, and insurance fund managers) to increase low-carbon investment streams	Strengthen domestic innovation capacity and international competitiveness by implementing procurement, demonstration, and verification programs	Compile and report statistics on employment levels and contributions to regional economies of current and emerging low-carbon goods and service sectors
	Provide both supply-push and demand-pull signals	Establish public-private partnerships to finance energy efficiency and renewable energy applications	Reduce barriers to commercialization by facilitating international collaboration between firms and between innovators and investors	
	Review and streamline funding and regulatory frameworks	Aggregate low-carbon infrastructure and technology applications for financing to reduce transaction costs	Engage in international diplomacy to remove barriers to investment and to build emerging and developing economies' capacity to absorb innovations	
	Support low-carbon innovation clusters: reduce barriers to commercialization by facilitating collaboration between firms and between innovators and investors	Build analytical capacity of financial sector for risk assessment of low-carbon assets and developments	Actively participate in formulation of international standards and labels	Link low-carbon innovation, energy, and climate policies with job creation and skills development strategies
		Create and promote financial products for low-carbon purchases and investments by Canadian households	Expand trade promotion role to match international needs with Canadian low-carbon goods and services	
		Provide financial incentives to balance risk-reward ratio for low-carbon investment by private sector	Improve Canada's international brand on climate policy	
		Prioritize investment in electricity infrastructure and oil and gas sector	Promote and prioritize low-carbon thermal energy and electricity sources to limit "carbon exposure" of key sectors	
			Remove sector-specific, interprovincial barriers to trade	
ESSENTIAL CONDITIONS	A unified, long-term price on carbon Outcome-based, adaptive regulatory regimes that integrate economic and environmental costs and benefits A level playing field for fossil and non-fossil energy sources Transparent and long-term climate, energy, and innovation policy			

LOW-CARBON GOVERNANCE

- Articulate clear, coordinated national vision of a low-carboneconomy, short-, mid-, and long-term targets
- Engage Canadians to shape agenda that meets vision
- Prioritize dialogue on the full cost of electricity
- Private sector participates and provides leadership with respect to low-carbon vision and path forward
- Coordinate and integrate low-carbon efforts within and across government departments
- Establish impartial credible mechanism to monitor national progress and provide unbiased advice

APPENDICES

// CHAPTER 6.0


Collection nationale
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SORTIE

6.0 // APPENDICES

6.1 CANADA'S LCGS SECTORS

Canada's low-carbon opportunities are as significant and diverse as its geography. The distribution of low-carbon energy resources and of LCGS opportunities across Canada varies by region, and even within regions.

The types of low-carbon energy resources available, and the broader nature of the regional economies, can have significant influence over what opportunities are viable, and can influence regional priorities for development. Despite this significant variation in regional economies and natural resource endowments, a number of opportunities were identified consistently across Canada. In addition, a number of opportunities were highlighted as being of national significance. The following LCGS sector-specific overviews are informed by both our research and these discussions and provide a high-level qualitative characterization of the opportunity as a function of Canada's perceived strengths.[a]

RENEWABLE ELECTRICITY GENERATION[b]

There is significant opportunity in the further exploration and development of renewable electricity sources. These can be used to power Canada's added-value economy, and the electricity and/or technology (and intellectual property) can be exported in its own right. Renewable electricity sources noted across Canada include biomass, hydropower, solar, onshore and offshore wind, wave and tidal, and geothermal power.

// **BIOMASS:**[c] Canada has large biomass resources and the bioenergy industry is well positioned to claim a significant portion of the international bioenergy market. Installed thermal and electrical capacity from biomass was approximately 5,050 MW in 2008.[137] The electrical capacity of this biomass was approximately 1,400 MW. This generation includes independent power producers and industry — particularly the pulp and paper sector. British Columbia and Ontario have aggressive plans to increase biomass power generation within their provinces. The Ontario Power Authority currently has 54 MW of bioenergy capacity generated by biomass and landfill waste under contract, with an additional 125 MW of bioenergy under development.[138] BC Hydro has a number of initiatives underway to procure bioenergy from projects that use wood fibre and other biomass fuel sources.

a Some LCGS sectors consider aspects that were not included in the quantitative analysis.

b Much of this material references work undertaken by Delphi Group and EnviroEconomics (Delphi Group and EnviroEconomics 2012) as well as Stiebert Consulting (Stiebert 2012) in the quantification of Canada's low-carbon opportunity.

c The biomass subsector has been delineated to include only biomass used for the production or cogeneration of electricity in large utility sized projects. This definition excludes the use of biomass to produce biofuels for transport and to substitute existing fuels such as heating oil for small end uses; such uses are included in the Biofuels subsector described later.

As a subset of biomass, biogas was highlighted as an opportunity that has seen significant penetration in Europe, but is currently significantly underdeveloped in Canada. Biogas can, at large scale, be used to generate electricity or can be used for direct heating applications on a smaller scale.

// HYDROPOWER: Hydropower is the leading source of electricity in Canada, providing for approximately 60% of the national electricity generation. Canada is currently the second-largest hydro producer in the world, producing close to 12% of the world's total hydroelectric output, with a depth of experience going back over 125 years. In addition, 65% of electricity exports from Canada are hydropower. Canada's total hydroelectric installed capacity exceeded 69,000 MW in 2009. It is estimated that about 2,000 MW of this installed capacity is small hydro facilities.[139] Significant potential for future investment in hydropower remains and there are an estimated 23 GW of future hydro developments currently under review by electric utilities.[140] Recent estimates suggest that Canada could develop about 29 GW of hydropower over the next 20 years.[141]

// SOLAR: While starting from a small base, recent expansion in Canada's total PV power installed capacity has been rapid. In 2009, installed capacity reached 95 MW up from under 33 MW at the end of 2008 and the grid-connected market accounted for 87% of the market as compared to only 33%.[142] This significant growth was mostly spurred by Ontario's feed-in tariff (FIT) program. Forecasted solar PV growth in Ontario is expected to continue to be very rapid with the Ontario Power Authority anticipating over 2,000 MW being installed by 2015[143] as a result of the FIT program. Despite this rapid regional growth, the Canadian solar PV industry, sized at 350 companies, is small and has limited R&D and capital investments when compared with the U.S. or on a global scale. The Canadian industry does nonetheless appear to be well positioned to participate in global supply chains for PV components (e.g., PV system controllers, solar collectors, photovoltaic cells, etc.). In a 2010 report, the Conference Board of Canada highlighted Canada's small revealed comparative advantage in PV system controllers (second largest global low-carbon trade category by value) and noted several other product categories for which Canada did not have a revealed advantage, but nonetheless exports more than $100 million annually.[145] Global trade in these product categories was also noted as growing by more than 10% annually. Interestingly, while Germany has the highest level of solar PV installations of any market in the world, with current installed capacity of 9.6 GW — roughly 145 times Canada's current capacity[146] — Canada's solar resources are considerably stronger than those of Germany — an indication of the potential.

// **WIND:** Despite almost 4,000 MW of installed wind energy capacity at the end of 2010 less than 1% of Canada's electricity comes from wind. According to the Canadian Wind Energy Association (CanWEA) wind energy could satisfy 20% of domestic electricity demand by 2025. Achieving this vision could generate $80 billion of investment, create 52,000 full-time jobs, add 55,000 MW of generating capacity, and reduce Canada's annual greenhouse gas emissions by 17 Mt.[147] Regional growth would be expected to vary significantly across Canada. As an example, a study in Québec projected that by 2015, the wind energy industry could develop 4,000 MW of generating capacity, resulting in $10 billion in new investment, more than 5,000 jobs, and significant economic benefits for regions hosting wind power facilities. With regard to trade, Canada is a leader in the manufacturing of small turbines, and has four manufacturers in the small 30–100 kW range and seven manufacturers in the <30 kW range. These small-scale wind manufacturers captured 15% of the global market and exports accounted for 86% of their 2009 sales.

// **WAVE AND TIDAL:** The wave and tidal subsector includes all manner of ocean energy projects that harness the power of ocean waves and tidal flows. Currently there are only a few operational ocean energy systems in the world, but significant development is underway. Canada has substantial wave and tidal energy resources not only because of its extensive coastline, but also because the energy density of waves tends to be the highest between 30 and 60 degrees latitude, and because it has areas with some of the highest tidal stream energy levels in the world. Canada's only commercially operational ocean energy system is the 18 MW Annapolis Royal Tidal Plant in the Bay of Fundy. The Bay of Fundy between New Brunswick and Nova Scotia is the most promising location in Canada for tidal energy, and could potentially produce as much as 30,000 MW of energy. On a national scale, wave, tidal, and in-stream energy sources could contribute generating capacity of 75 MW by 2016, 250 MW by 2020, and 2,000 MW by 2030.[148] There have been no new large-scale installations since the Bay of Fundy project; however, there is renewed activity in Canada, and many active companies. For example, in 2010 a collaboration between Minas Basin Pulp and Power, Nova Scotia Power, Alstom, the Nova Scotia government, OpenHydro, and Marine Current Turbines, made a commitment to install four 20 MW 34.5 kV off-shore cables to pilot tidal array power plants.

// **GEOTHERMAL:** The Geothermal subsector includes all projects that generate power from the use of super-heated water or steam from the earth's interior. There is currently no domestic geothermal power production in Canada and only a small number of companies are active in Canada. The potential for geothermal energy in Canada has been estimated to be over 5,000 MW of power production from shallow geothermal resources.[149] Most of this potential is believed to be in western and northern Canada. Approximately five geothermal power projects in Canada are under some stage of development in British Columbia and Alberta. Geothermal energy was highlighted in NRT's dialogues where several participants noted that the exploration and drilling expertise in Canada is the best in the world as a result of the oil and gas exploration and production sector, and that this expertise should be brought to bear on this resource.

// OFF-GRID RENEWABLE ELECTRICITY TECHNOLOGIES: As a particular niche within the renewable electricity technology category, off-grid renewable electricity and distributed generation technologies have significant potential in international markets given the number of regions worldwide that are currently bereft of large centralized energy infrastructure. Canada's remote communities, many of which are aboriginal communities located in Canada's north, provide an ideal opportunity for exploring the deployment of off-grid renewable electricity technologies (RETs) and the integration of RETs with existing conventional electricity supply. Frequently, costs associated with connection to the centralized grid are prohibitive. Conventional off-grid electricity generation, often using diesel generators, is also expensive to operate and subject to increasing price-risk. These elevated costs create conditions in which the deployment of off-grid RETs has the potential to be cost-competitive. Furthermore, many aboriginal communities have additional concerns such as the environmental footprint of their community and energy security, which make pursuing such opportunities attractive.[d] Canada's strength in small-scale wind turbine design and manufacturing is an example of alignment between an existing strength, domestic need, and international opportunity.

// LOW-CARBON ELECTRICITY GENERATION (NON-RENEWABLE): In addition to renewable electricity supplies, Canada is home to significant expertise and resources associated with nuclear energy, a critical low-carbon electricity source, and carbon capture and storage, a technology with the potential to increase low-carbon electricity generation, particularly in the West. As highlighted most recently in the International Energy Agency's 2011 World Energy Outlook, these two low-carbon electricity sources are critical to easing the transition to a low-carbon world.

// NUCLEAR ENERGY: Nuclear energy includes the implementation of nuclear power,[e] as well as refurbishments of nuclear power plants. Canada operates 17 nuclear reactors at five sites in Québec, Ontario, and New Brunswick. These reactors contribute approximately 15% of Canada's total electricity generation, including 55% in Ontario. All of the commissioned reactors are based on Canada's CANDU technology that uses Pressurized Heavy Water Reactors. The last domestic CANDU reactor was completed in 1993; however, Atomic Energy of Canada Limited (AECL) sold and built 11 CANDU reactors outside of Canada between 1971 and 2007.

Canada's nuclear sector is a $6.4 billion per year industry generating $1.4 billion in federal and provincial revenues from taxes, and providing 66,000 direct and indirect jobs. Canada's nuclear sector represents 150 firms, generates $1.2 billion per year in exports, and provides over 50% of the global supply of medical isotopes that find use in over 50,000 procedures per day.[150] In addition, Canada is the world's second-largest uranium producer and exporter.

d For examples, see (Aboriginal Affairs and Northern Development Canada 2004) or (Weis and Cobb 2008).

e Other components of the nuclear sector such as uranium mining and nuclear medicine are excluded.

Canada's nuclear industry has seen a decline in recent years; however, there remains significant capacity and Canada has been a world leader in nuclear technology for over 60 years.[151] While several nuclear power plants are undergoing upgrades in Canada, no new generation has been approved.[f] CANDU Energy Inc. (formerly AECL) is currently awaiting a decision with respect to its proposal for constructing an Enhanced CANDU 6 reactor at Ontario's Darlington facility. Securing this project is seen as pivotal in terms of the potential for winning new international projects. Given the positive international reputation of Canada's CANDU technology for safety, performance and reliability, and the competitive advantages of CANDU technology over other technologies,[g] there is significant potential for next generation CANDU reactor technology to be sold on international markets. This would also bring opportunities for Canadian companies to provide ongoing related services.

// **CARBON CAPTURE AND STORAGE:** The CCS subsector includes all components of carbon sequestration including capture from power plants or industrial sources, transportation to the storage site, enhanced oil or gas recovery sites, and geological storage in deep saline formations, depleted oil and gas fields, or un-minable coal. Carbon capture and storage (CCS) offers a significant opportunity for Canada to exploit its substantial natural fossil fuel endowments in a manner that respects its international commitment to reducing GHG emissions. As the global economy becomes more carbon-constrained, CCS also has the potential to assure the ongoing viability of this commodity as a source of prosperity for Canada. Expertise and intellectual capital developed around CCS is also expected to offer opportunities in global markets. In 2011, Canada was ranked third in the world (behind the U.S. and Europe) in terms of the number of CCS projects and fourth in the world in terms of the volume of CO_2 potentially stored. The recent cancellation of the Project Pioneer demonstration project has highlighted the importance of a supportive market-oriented policy context in achieving domestic commercial success.

BIOFUELS

The biofuels LCGS subsector includes the use of biofuels for transport and to substitute existing fuels such as heating oil for small end-uses.[h] With abundant biomass resources in Canada, the biofuel industry is well positioned to claim a significant portion of the international bioenergy market, and Canada is currently among the leading nations in the development of bio-fuel technologies, equipment, and services. Canadian firms have gained expertise in the design, construction and operation of large-scale production plants for bioethanol, biodiesel, and biogas products. From an R&D perspective, Canadian firms are leading the way in the development of second-generation biofuels, using distinct feedstock, such as wheat stalks, wood chips (also pine beetle affected wood mass), and municipal waste.

f Specifically within Ontario, units at the Darlington and Bruce sites will be modernized and the province has noted that it will need two new nuclear units at Darlington. Ontario is also investing in refurbishment in the extension of the Pickering B station until 2020. Outside of Ontario, several provinces are currently considering nuclear reactors for electricity generation and for heat/steam generation.

g Canada's CANDU technology has competitive advantages over other technologies resulting from its ability to use thorium as an alternative to uranium as fuel, and its ability to reuse uranium recycled from light water reactor fuel used in other reactors.

h The biofuels subsector excludes the use of biomass for large heat and power applications.

The major driver in Canada of biofuels investment is the renewable fuel standard in Canada that requires 5% renewable content in gasoline by 2010 and 2% renewable content in diesel and home heating oil by 2012. It was estimated that Canada would need to produce a total of 3.1 billion litres of biofuel to meet this regulation. As of the end of 2010, there were more than 28 biofuel plants operating in Canada, producing more than two billion litres of biofuels. The domestic and international potential for biofuels for transportation is significant. While some regions in Canada will look to electrification of their transportation systems, this may make less sense for other regions with more limited access to low-carbon electricity sources. Biofuels offer significant potential as a low-carbon alternative fuel.[i]

ENERGY EFFICIENCY, DEMAND-SIDE MANAGEMENT (DSM), AND LOW-CARBON FUEL SWITCHING

Energy efficiency, demand-side management (DSM), and low-carbon fuel switching continue to offer significant cost-saving and GHG reduction potential to the Canadian economy. While it was broadly suggested in our consultations that the energy efficiency and DSM potential was spread across a number of activity areas including industry and manufacturing, energy efficiency in existing and new residential and commercial buildings was highlighted as being substantial and easily served by existing technology. It was also noted that there was a particular opportunity for building energy efficiency gains in areas subject to rapid expansion and growth in the building stock (e.g., Saskatchewan, Newfoundland and Labrador).

// **LOW-EMITTING AND EFFICIENT INDUSTRIAL AND MANUFACTURING PROCESSES:** The industrial processes subsector includes LCGS that are deployed in a vast array of industries and manufacturing. Ultimately these LCGS contribute to emission reductions either through energy efficiency, changing processes to become less emission intensive, or through fuel switching to renewable energy supplies. This LCGS subsector is essential to the continued competitiveness of many of Canada's resource sectors and requires significant innovation to identify new approaches and technologies that can reduce the carbon intensity of the processing and manufacturing that forms a significant part of the Canadian economy.

// **LOW-CARBON BUILDINGS:** Right across Canada, the ability to reduce carbon emissions through both new green buildings and green retrofits is a real opportunity that Canada can and must act upon.[j] This opportunity presents itself both on the commercial as well as the residential sides. Canada's commercial building sector is a significant energy user and producer of carbon emissions. It accounts for 14% of end-use energy consumption and 11% of the country's carbon emissions. Energy efficient technologies exist that could reduce costs to businesses and consumers while reducing the environmental impact of this major economic sector. The opportunity in the residential building sector provides a similar opportunity especially for new construction within cities that are planning for significant growth, infill, and urban intensification.

i This is particularly true as second-generation biofuel feedstocks and technologies become available. Second generation biofuels generally come from inedible sources (e.g., switchgrass, agricultural and forestry residues, etc.) whereas first generation biofuels are often derived from edible sources (e.g., sugarcane, vegetable oil, grains, etc.).

j In 2009 the NRT and Sustainable Development Technology Canada (SDTC) jointly investigated the opportunities within commercial building and provided policy advice to help governments make policy choices enabling the commercial building sector to deploy technologies necessary to achieve substantial energy efficiency gains. See: Geared for Change (National Round Table on the Environment and the Economy 2009b).

The estimated incremental capital investment in Canada for new green construction in 2009 represents approximately $950 million in total construction costs.[152] Total residential and commercial construction costs exceed $110 billion per year.[153] Green retrofits to buildings are not counted in this total of new construction. However, between 2007 and 2009, the EcoEnergy Retrofit Program delivered approximately $100 million in grants to 99,863 residential property owners.[154] Investment in more efficient buildings is expected to continue beyond these current trends, with investment increasing over seven times between now and 2050. Growth could climb from current levels of about $1.5 billion to over $9.7 billion in 2050.[155]

// LOW-CARBON TRANSPORTATION: Low-carbon transportation encompasses efficient or low-carbon vehicle technology including both passenger and freight technologies ranging from personal vehicles to natural gas engines for trucks and heavy vehicles, to advanced rail technologies and advanced aviation materials. In addition to the benefits to the Canadian economy derived from the increased resource efficiency, some regions may benefit through their participation in global manufacturing supply chains for transportation equipment. The Canadian automotive industry is a major contributor to the Canadian economy, employing over half a million people. The industry produces light-duty vehicles, heavy-duty vehicles, and a wide range of parts, components, and vehicle systems, a large portion of which is slated for export. The current on-road vehicle market in Canada is significant.[156]

Our analysis estimates a Canadian market (total spending) for efficient vehicles at approximately $1.6 billion in 2010. Going forward, there appears to be a considerable opportunity specifically in two types of next generation electric vehicles being developed, both of which can offer substantially lower GHG emissions. These are Plug-In Hybrid Electric Vehicles (PHEVs) that are powered by both re-chargeable batteries as well as by a normal internal combustion engine, and a new generation of pure electric vehicles (EVs) that have only an electric motor. Relative to its size in the global economy, Canada currently has a significant share of companies that are involved in manufacturing electric vehicles or components. However, to date, no mass production PHEVs or EVs are being assembled in Canada.

IHS Global Insight forecasted that the global production of pure EVs would be more than 60,000 in 2011, and growing to more than 150,000 in 2015.[157] Major automakers have announced over 50 new electric vehicle models will be launched over the next three to five years; most of these will be PHEVs but many automakers are planning to offer pure EVs as well.

Given the rapid turnover rate in vehicle investment as compared to other sectors, vehicles are expected to be one of the highest growth areas in international investment. This will also likely be true for domestic deployment rates of efficient vehicles. Our forecast indicates that investment could increase almost 15 times between now and 2050, from about $1.6 billion currently to over $24.2 billion in 2050.[158]

// LAND-USE PLANNING: Land-use planning was highlighted in a number of jurisdictions as presenting significant opportunity, particularly in the context of rapid growth and urbanization. Advance planning using a systems perspective and anticipating levels of growth provides the opportunity to develop communities that are less energy and resource intensive, requiring less energy for transportation, water treatment/distribution, etc., and which are ultimately less costly to maintain and inhabit. This opportunity is less achievable in areas with significant existing development and infrastructure.

6.2 METHODOLOGY FOR ESTIMATING LCGS MARKET SIZE AND GROWTH POTENTIAL

GLOBAL:

1 // Sourced data from IEA's World Energy Outlook 2011.

2 // Extended forecast from 2035 to 2050 using additional data from IEA's Energy Technology Perspectives 2010.

3 // Supplementary forecast information for efficient vehicles was used to estimate total low-carbon investment from additional investment relative to the current IEA's World Energy Outlook 2011 scenario. Additional information included short-term forecasts for efficient vehicles and investment costs from J.D. Power and Associates.[159]

DOMESTIC:

1 // Reviewed literature to estimate current domestic LCGS investment and economic activity for wind, solar, biomass, hydro, nuclear, biofuels, carbon capture and storage (CCS), and efficient vehicles.

2 // Used CIMS model to estimate current LCGS investment for geothermal, buildings and industrial processes; CIMS is an economy-environment model that estimates investment in technologies based on equilibrium in the markets for energy, goods and services.

3 // Forecasted future spending for all LCGS sectors using CIMS model.

4 // Apportioned total investment of each LCGS sector into different capital components, drawing from project implementation costs identified through economic reviews.

5 // Related (mapped) each capital component to the corresponding North American Industry Classification System (NAICS) Codes of the highest possible resolution, or using trade information on individual product/service codes (HS codes) where possible.

6 // Extracted Statistics Canada data on employment, trade, GDP and output for identified six-digit NAICS sectors and forecasted future NAICS economic activity using Informetrica forecasts.

7 // Compared market size of each LCGS sector to market size of NAICS parent sectors to determine a*pportionment ratios* for spending, employment, trade and GDP.

8 // Applied *apportionment ratios* to break-out Statistics Canada data for each LCGS sector from the NAICS parent sectors, thereby specifying the spending in each NAICS sector.

9 // Developed multipliers from Statistics Canada data to relate total spending to employment, trade and GDP for all relevant NAICS sectors.

10 // Applied identified multipliers to spending identified for each NAICS sector to quantify employment, trade, GDP and output based on forecast future spending from CIMS model.

11 // Applied additional Statistics Canada multipliers to estimate indirect and induced effects of LCGS on the economy.

KEY LIMITATIONS:

1 // The CIMS Model is a domestic model, independent of and unresponsive to the level of global investments. As a result estimated LCGS investment and trade is related only to the assumed policy scenario in Canada and is not affected by the global demand for LCGS. Given the strong international focus of the Canadian clean technology industry, this may result in an underestimation of the growth in LCGS sectors particularly under the Reference Case. The CIMS model has no capacity to measure the effect of international demand on the development of Canadian LCGS sectors or compare its influence to that of domestic policy.

2 // Whereas characterization of technology for some LCGS sectors such as solar and wind energy is fairly straightforward, and statistics concerning production and trade exist and are for the most part accessible, characterization of other LCGS sectors — including efficient industrial processes, low-carbon buildings and efficient vehicles (low-carbon transportation) — is more complex. For these sectors, individual technology components may be considered low-carbon or not, depending on the manner or context in which they are used. An added complication is the evolutionary aspect of these sectors, For example, what is "efficient" or "low-carbon" now, may be standard or inefficient in 10 years. No authoritative definition for these sectors has been published and as a result, NRT's characterization may be different from that used by the IEA or other organizations. This makes direct comparison with other estimates difficult.

3 // The CIMS model draws from a database of known technologies as well as technologies that are anticipated to become commercially viable within the study period. It does not consider breakthrough technologies that may result from innovation — by their very nature these are impossible to predict. Were major breakthroughs to occur, it would likely lower the estimated overall low-carbon investment. On the other hand, if costs for presently non-commercial technologies (e.g., CCS) were found to be higher than anticipated, the overall investment in low-carbon technologies could be higher.

4 // The CIMS model assumes capital and operating costs related to different technologies and employs declining cost functions over time to capture the technology "learning curve." Estimation of costs and development of declining cost functions for markets that are evolving rapidly — e.g., solar energy — presents a challenge. As a result, some sectors with rapidly evolving cost structures may be under-represented.

5 // The apportionment of LCGS apparent domestic demand to NAICS is an indirect method of estimating the output, trade, GDP and employment of the LCGS sector. Actual production of LCGS is likely to have a different profile than the other goods and services that are also included within the NAICS sector and it is likely that there are many additional smaller NAICS sectors contributing to the LCGS than identified in the analysis. This introduces uncertainty with respect to the estimates.

6 // While every effort has been made to align the global and domestic forecasts, the global LCGS forecast has many inherent assumptions including economic growth, technology costs, energy prices and country policies that *may be* different from Canada's projected baseline. For this reason, our use of comparative analysis in this regard is limited, and readers should employ caution in directly comparing outputs from domestic and global scenarios.

6.3 REGIONAL STAKEHOLDER ENGAGEMENT: DETAILED REGIONAL OPPORTUNITIES

The following summaries of regional opportunities were developed based on a series of stakeholder convening sessions held by the NRT together with its regional partners in November and December 2011. The statements herein reflect the views of the participants about the low-carbon strengths and opportunities in their respective regions.

Western Canada

Western Canada's low-carbon opportunities vary provincially; however, when looked at in aggregate, common themes emerge. As is often the case, sources of great challenge (e.g., fossil-fuel resources, transportation, etc.) also represent great opportunity. Western Canada has a number of strengths on which its low-carbon opportunities can be built:

// LOW-CARBON ENERGY RESOURCES: western Canada is replete with low-carbon energy resources including hydropower, biomass, solar, wind (on- and off-shore), geothermal power, and uranium. A significant portion of electricity generated in Manitoba and British Columbia is already low-carbon.

// ENERGY EXPERTISE: as the centre of Canada's oil and gas extraction industry, western Canada has a large capital base which provides a strong platform for research and innovation. For the same reason, western Canada has strong energy sector and related expertise including project financing capacity and broader energy markets expertise.

// INNOVATION ENVIRONMENT: the presence of many energy sector head offices in Calgary and the large number of energy exploration and production start-ups provides an ideal environment for starting up innovative energy-related endeavours.

// ENTREPRENEURIAL SPIRIT: western Canada is home to an entrepreneurial spirit not typically seen elsewhere in Canada.

Key low-carbon opportunities identified in western Canada include the following:

// FURTHER DEVELOPMENT OF LOW-CARBON ENERGY RESOURCES: biomass, passive solar and waste-to-energy were noted as particularly viable low-carbon energy sources for Manitoba, along with further development of its hydropower resources. One participant noted that Alberta and Saskatchewan received more solar energy than either Texas or Germany.[k] In fact, Alberta is noted as having some of the best solar resources in the country with its average solar resource measuring between 1,100 and 1,400 kilowatt hours of electricity per kilowatt of installed photovoltaic (PV) capacity per year.[160] Comparatively, Germany receives on average less than 1,000 kWh/kW/year.[161] Significant wind capacity (on- and off-shore), biomass, biofuels and non-biofuel low-carbon fuels were noted in British Columbia. Geothermal energy was noted in both Alberta and British Columbia as having significant potential. It is clear that there is extensive opportunity for low-carbon energy resource development across Canada's west.

// GEOTHERMAL RESOURCE DEVELOPMENT: due to western Canada's significant experience in oil and gas and the broader energy and resource sectors, Canada has significant expertise in exploration, extraction and production, including drilling, large project staging and operating in harsh environments. This experience is directly applicable to the development of deep geothermal energy resources and is marketable the world over.

// CARBON CAPTURE AND STORAGE TECHNOLOGY (CCS): offers a significant opportunity for western Canada to exploit its substantial natural fossil-fuel endowments in a manner that is substantially less carbon-intensive than current extraction methods. As the global economy becomes more carbon-constrained, CCS also has the potential to assure the ongoing viability of this commodity as a source of prosperity for Canada. Expertise and intellectual capital developed around CCS is also expected to offer opportunities in global markets. In 2011, Canada was ranked third in the world (behind the U.S. and Europe) in terms of the number of CCS projects and fourth in the world in terms of the volume of CO_2 potentially stored.

k This claim is supported by documentation elsewhere including a July 2011 submission by CanSIA to the government of Saskatchewan which claims that Saskatchewan's solar potential is *"significantly superior to Germany's — the country with over 50% of the world's operating solar technology"* (Canadian Solar Energy Industries Association 2011b).

// ENERGY EFFICIENCY: there remains significant opportunity to improve energy efficiency, both at the community level with respect to transportation and urban planning, and in buildings. It was noted that governments have significant sway in setting direction — for example, they could decide tomorrow that capital projects should target energy efficiency, and efforts would follow. Furthermore, it was noted that while even more efficient technologies will no-doubt be invented, significant progress can be made using existing technology and knowledge. It was further noted that significant opportunity is presented in the context of urban growth (such as is being experienced in some parts of Alberta and Saskatchewan), both for putting in place high-efficiency buildings and for planning the growth in such a manner as to maximize efficiency and enable more efficient transportation options (e.g., urban transit).

// ELECTRIFICATION: the potential for using electricity to displace fossil fuels where there is significant low-carbon electricity potential was noted. One specific example noted in Manitoba was the potential for using electricity (hydropower) to power oil and gas extraction operations in the province rather than diesel. This concept has broader application in the residential and commercial sectors in the context of a significant shift toward a low-carbon economy and has been identified as a necessary measure for deep carbon reductions in previous NRT work.[162]

// TRANSPORTATION: was noted as providing opportunities on a number of fronts — from improved vehicular efficiency to fuel substitution (e.g., biofuels) and/or electrification, to reduced transportation requirements as a function of urban design. It was put forward that 61% of oil is consumed for transportation purposes.[l] In addition to the fuel-switching (biofuels and non-biofuel low-carbon fuels) and electrification potential around personal transportation, the use of natural gas engines for heavy-duty trucking and the opportunity for increased long-haul freight fuel efficiency resulting from the standardization of load limitations between Canadian provinces and with U.S. states were noted as specific freight-related opportunities.

// INNOVATION: western Canada is host to significant low-carbon innovative potential, and the focus of that innovation should be "building on our strengths." As the centre of the oil and gas industry in western Canada, Calgary was put forward as having the potential to host the creation of an energy cluster with the opportunity to become a centre of energy technology innovation, exporting expertise and intellectual capital across the world. Innovation was also highlighted in discussions in Saskatoon both with respect to nuclear energy and agriculture. The University of Saskatchewan is host to the Canadian Centre for Nuclear Studies. The centre encompasses six research clusters: innovation; northern development; nuclear medicine and health; mineral research and environmental science; neutron, radiation and nuclear science and engineering; and, nuclear, hydrogen and novel fuel energy.[163] Agricultural innovation both with respect to new varieties that reduce the overall energy inputs for crops, and specific development of biodiesel feedstocks, was also noted in Saskatchewan. Discussions in British Columbia highlighted the presence of an emerging clean technology cluster with a strong focus on low-carbon technologies and the potential for this sector to provide continued growth and prosperity to the province.[m]

l According to Statistics Canada's publication *Energy supply and demand, by fuel type,* in 2009 transportation accounted for 64% of total end use of net supply excluding producer consumption, or 73% of energy use final demand (Statistics Canada 2009a).

m The *Cleantech Report Card for British Columbia*, produced by KPMG on behalf of the B.C. Cleantech Alliance identifies 63% of cleantech survey respondents as developing energy-related technologies (KPMG 2011).

// NETWORK EFFICIENCIES: it was noted that increased connectivity between provincial electricity transmission networks, allowing increased east-west/west-east flow of electricity could provide greater opportunities for Canadian jurisdictions to benefit from excess low-carbon electricity from their neighbours. In particular, it was noted that Alberta's electricity grid is an island, and that increased connectivity with British Columbia could assist in providing much-needed hydro-based storage capacity as well as providing the possibility for interprovincial flow of Canadian low-carbon electricity. It was suggested that an east-west grid is required to allow Canada to benefit more broadly from its own natural low-carbon advantage.

Ontario

Several strengths upon which Ontario's low-carbon opportunities depend were noted:

// LOW-CARBON ENERGY RESOURCES: a significant fraction of Ontario's current electricity generating capacity is already low-carbon (in 2011, electricity generation supplied was 56.9% nuclear, 22.2% hydro, 2.6% wind, 14.7% natural gas, 2.7% coal and 0.8% other — greater than 80% low-carbon) . In addition, Ontario was noted as having strong biomass energy potential.

// FINANCIAL RESOURCES & EXPERTISE: Ontario has significant pools of capital that can, in the right environment (i.e., in a supportive context), be brought to bear for the commercialization of low-carbon technology. As a major financial centre in Canada, Ontario also has significant banking expertise which can be employed to address the barriers currently slowing access to these resources.

// INNOVATION CAPACITY: Ontario hosts a highly educated workforce and intellectual thought-leaders with strong post-secondary and research institutions. It is also host to a high concentration of innovation clusters and supporting organizations.

// STRONG LOW-CARBON REGULATORY ENVIRONMENT: while it has its supporters and detractors, the Green Energy and Green Economy Act was noted as providing a strong regulatory framework in support of low-carbon electricity and renewable energy technologies. The Integrated Power System Plan (IPSP), which provides a mid-term supply-side outlook, was also cited as strengthening the regulatory and planning framework for Ontario's electricity system.

// NUCLEAR EXPERTISE: Ontario is the centre of Canada's nuclear industry and home to significant sector-specific expertise. This provides a strong base for the potential development of advanced nuclear reactor designs.

Key low-carbon opportunities identified in Ontario include the following:

// BIOMASS FOR POWER GENERATION: biomass for electricity generation was noted as a significant opportunity for Ontario in that it would make use of existing renewable resources (forestry and agricultural biomass resources), use existing transmission infrastructure, and provide instantaneously dispatchable power capable of balancing the introduction of other renewable energy technologies that are subject to variability (e.g., wind), significantly reducing the need for backup / peaking natural gas-fired electricity generation capacity.

// ENHANCED GEOTHERMAL: enhanced geothermal was noted as a significant opportunity for Canada. It was noted that while the technology remains in its early stages and needs to be de-risked to fund further R&D and commercialization, the resource potential across Canada is significant.

// BIOGAS: was noted as an "energy orphan," not being included in the provisions of Ontario's *Green Energy and Green Economy Act*, but having significant potential particularly for agricultural and food processing facilities. Another participant noted that biogas is a proven technology and that Germany produces large quantities of biogas and expects it to ultimately represent a significant portion of its total energy supply.[n] The potential in Ontario remains largely untapped due to regulatory hurdles and disincentives (e.g., it does not meet the requirements for inclusion in the feed-in tariff program, and is disadvantaged by consumer price indexing). This potential includes the displacement of propane in rural Ontarian communities through the use of combined heat and power (CHP) generation technology.

// NEXT GENERATION NUCLEAR POWER: in addition to being home to three nuclear power generating stations (Pickering, Darlington, and Bruce), Ontario is home to Canada's nuclear industry housing a large portion of Canada's nuclear power expertise including academic training and research centres, applied research facilities and laboratories, fuel processing, manufacturing and conversion service companies and related manufacturing facilities. While there remains some uncertainty around the plans of CANDU Energy (wholly owned subsidiary of SNC-Lavalin Group Inc.) to pursue the development of new CANDU reactor designs since their acquisition of AECL's commercial division in 2011, Ontario has significant supporting expertise, supply chains and infrastructure that positions it well to pursue this work. Discussion is ongoing around the development of four new reactors at Ontario Power Generation's Darlington site.

// EXPORT OF "INTELLECTUAL CAPITAL": it was noted that there are a number of low-carbon and renewable energy technology companies in Ontario and that these companies are successful primarily in developing new technologies and innovative adaptations of existing technology — intellectual capital. Due to relatively low uptake in Canadian and North American markets (Ontario being an exception with the introduction

n Biogas is used extensively in a number of European countries for heat and combined heat and power generation. The European Biomass Association suggests that by 2020, biogas could provide more than 1/3 of Europe's natural gas production or around 10% of the European consumption, and that the overall potential for biogas could reach between 15% and 25% of total bioenergy in Europe (European Biomass Association (AEBIOM).

of its generous feed-in tariff), these companies frequently target international markets. In addition, they tend to outsource the majority of manufacturing to jurisdictions with lower-cost economic inputs. It was noted that where Ontario excels and where it should focus, is on the development and export of intellectual capital.

// **OFF-GRID RETS:** it was noted that investment in power supply for aboriginal communities represents an ideal opportunity for exploring the deployment of off-grid renewable energy technologies. Many aboriginal communities are self-contained and remote, and are currently under-serviced or serviced by diesel generators which are carbon-intense, operationally expensive, and subject to price-volatility. Development of technologies for such off-grid, remote application has worldwide applicability. It was further noted that a number of Aboriginal organizations have access to capital and are actively making investments.

// **ENERGY EFFICIENCY:** was noted as a significant opportunity that continues to exist despite years of efforts. The energy efficiency discussion primarily focused on building energy efficiency. Specific examples included:

- // Less than 1% of new commercial buildings are LEED or BOMA Best certified;
- // The National Energy Code of Canada for Buildings requires a maximum energy usage of 38 kWh/ft^2/year while participants suggested Canada could easily achieve 20 kWh/ft^2/year;
- // Ground-source heat pump (GSHP) technology is highly underused; and
- // Phantom load was estimated as representing between 12 and 15% of electricity costs.

// **TRANSPORTATION:** given the concentration of Ontario's population in major urban centres, more efficient mass transportation and urban planning represent significant opportunities for GHG emissions reductions. It was noted that transportation and buildings are the big two emissions reduction opportunities in Ontario once coal-fired electricity is phased-out (2014).

// **AWARENESS & EDUCATION:** it was suggested that increased awareness, education and literacy around energy and emissions would in itself yield efficiencies and reductions in consumption. One example is the potential of the "virtual world," the "gamifying" of energy efficiency and the development of new technology solutions. This potential is premised on the development of smart-grid infrastructure in Ontario that would permit the increased use of information and communications technology (ICT) in managing household and business energy profiles.

// WASTE CO_2: a participant noted that the top twelve GHG emitters in Ontario produce 80% of the emissions. It was further suggested that innovative processes and approaches could substantially reduce emissions from industrial and manufacturing facilities. There is a need to turn problems into opportunities. How can Canada use waste CO_2 to benefit society? In addition to sourcing renewable energy technologies for electricity generation, there is significant opportunity for using low-carbon fuels in Ontario's industrial and manufacturing sector. Innovations on this front include the use of biomass-based fuels and the development of carbon absorption technologies which create useful products from the waste CO_2 stream.

// LOW-CARBON / ZERO-EMISSION VEHICLE MANUFACTURING: Ontario is home to an established automobile manufacturing industry with integrated North American supply chains, existing talent pool and infrastructure. It was noted that this opportunity remains mostly latent as Ontario has yet to become home to any low-carbon vehicle manufacturing lines.

Québec

Québec is noted to have a number of low-carbon strengths on which it can build:

// LOW-CARBON ENERGY RESOURCES: Québec's electricity supply is already completely low-carbon with hydropower, wind and nuclear making up 97%, 1% and 2% of its supply, respectively.[165] Electricity accounts for approximately 38% of Québec's overall energy consumption. There is strong potential for increased wind and solar as well as potential for geothermal power generation. Uranium resources and tidal power are also highlighted in the Plan Nord as having potential in Québec's north.

// PEOPLE / INNOVATION CAPACITY: Québec has significant innovative capacity. Home to strong research institutions, Québec has a highly educated workforce with a focus on manufacturing and information and communications technology. It is also host to a nascent cleantech cluster.

// PUBLIC SUPPORT: it was noted that a recent survey indicates that 80% of the Québec population is in favour of provincial energy independence and supports measures to reduce dependence on fossil fuels. Expenditures on imported petroleum products currently costs Québec in the range of $20 billion per year.[166]

Key low-carbon opportunities identified in Québec include the following:

// FURTHER DEVELOPMENT OF LOW-CARBON ENERGY RESOURCES: it was noted that Québec has significant remaining hydropower, wind and biomass resources. Also, Québec's regulatory framework for the management of residual materials provides significant opportunity for energy recovery from residual materials.[167]

// ENERGY TECHNOLOGY DEVELOPMENT: a recent report on Québec's cleantech sector highlighted significant potential for Québec in technology development related to hydropower, energy efficiency, biomass and residual materials.

// LOW-CARBON MANUFACTURING: Québec has a competitive advantage in manufacturing certain products due to their energy intensity and the ability to employ low-cost, low-carbon electricity in their manufacturing (e.g., aluminum). More broadly, due to Québec's low-carbon electricity, most manufactured products compare favourably to their competition with respect to carbon footprint. This presents an advantage and opportunity for Québec's manufacturing industry to position itself.

// TRANSPORTATION EQUIPMENT MANUFACTURING: given Québec's existing transportation equipment manufacturing base, well-developed supply chains and depth of expertise, there is significant potential for Québec to develop and manufacture low-carbon large-scale transportation equipment e.g., electric buses. Several projects are currently underway including a collaboration between universities and research centers in partnership with government and leading firms to develop and test new low-carbon aircraft concepts.

// LOW-CARBON FOREST PRODUCTS: it was noted that with the historic presence and strength of the forest products industry in Québec, there is significant potential for the reorientation of sector activities toward the production of low-carbon products. In particular a forest biorefinery project was noted, the focus of which is to support the development and demonstration of new products derived from forest biomass.

// LOW-CARBON INFORMATION AND COMMUNICATIONS TECHNOLOGY (ICT): Québec's strong information and communications technology sector offers a strong base for the development of new ICT products and/or systems that foster reduced energy consumption.

// ENERGY EFFICIENCY: there remains significant opportunity for improving energy efficiency in Québec's building sector. It was noted that the low cost of electricity in Québec has historically made capturing these opportunities more challenging.

// TRANSPORTATION: transportation (road, air, marine, railway, off-road) is Québec's most significant GHG challenge accounting for 44% of provincial GHG emissions. Road transportation alone accounts for more than 70% of transportation-related emissions or 33% of all GHG emissions. This also represents a significant opportunity for reducing emissions through increased vehicular efficiency, more extensive use of mass transportation / transit options, and community development and re-development using more energy efficient urban designs that promote alternative transportation options over the use of personal vehicles. In addition, due to the low-carbon nature of its electricity supply, Québec presents an ideal context for the deployment of electric vehicles.

Atlantic Canada

Discussions in Atlantic Canada highlighted several key strengths that underlie its low-carbon opportunities:

// LOW-CARBON ENERGY RESOURCES: while their distribution across the region is not even, Atlantic Canada is home to abundant and diverse low-carbon energy resources including hydropower, on- and off-shore wind, marine (wave and tidal) and biomass.

// PROXIMITY TO NORTHEASTERN U.S. MARKETS: Atlantic Canada's proximity to the New England states has historically provided its firms with access to a much larger market into which to sell its goods and services. While recent natural gas prices have reduced the viability of the New England states as an export market for low-carbon electricity in the near term, this market proximity was consistently cited as an advantage of the region.

// INNOVATION CAPACITY: Atlantic Canada's high-quality education system and numerous educational and research facilities produce a highly educated and talented labour force and represent significant innovative capacity. There are a several examples of programs / approaches to furthering the development of innovative technology which speak to this strength (e.g., FORCE) as well as a large number of post-secondary institutions relative to the population.

// START-UP ENVIRONMENT: the business environment for start-ups was noted as excellent in Atlantic Canada, being very supportive and collaborative.

// QUALITY OF LIFE: in the competition for talented labour, Atlantic Canada was noted as having an advantage, providing a high quality of life (including short commutes) at relatively low-cost.

Key low-carbon opportunities identified in Atlantic Canada include the following:

// FURTHER DEVELOPMENT OF LOW-CARBON ENERGY RESOURCES: Atlantic Canada has significant low-carbon energy resources at its disposal; however, it currently has one of the most carbon-intensive electricity supplies in Canada due to a significant historical reliance on coal and oil-fired electricity generation in Nova Scotia, New Brunswick and Prince Edward Island.[168] The further development of Atlantic Canada's low-carbon energy resources has the potential to significantly reduce the carbon-intensity of electricity production in the region. In particular, the proposed development of the Lower Churchill Falls hydro-power generating stations (Muskrat Falls and Gull Island) has the potential to contribute a combined capacity of 3,074 MW to Atlantic Canada's electricity system, and would include provision for transmission capacity between Labrador and Newfoundland and also between Newfoundland and Nova Scotia, and

through Nova Scotia to New Brunswick and P.E.I. Atlantic Canada is also home to significant additional smaller scale hydropower resources, on-shore and off-shore wind resources, and in the long term, significant wave and tidal energy capacity.

// OCEAN TECHNOLOGIES AND THE "SALT WATER HINTERLAND": marine resource development (offshore oil, gas, wind, tidal and wave energy) and the development of associated marine/ocean technologies (e.g., remote sensing technologies) represent a significant long-term economic opportunity. While some of these resources are high-carbon, the spinoff technology and expertise can be employed in the pursuit of low-carbon opportunities. It was noted that the rest of Canada has expanded in terms of land mass post confederation and that this expansion into the "hinterland" has provided significant resource opportunities; however, Atlantic Canada has not expanded, and its hinterland is the ocean. While there is global competition and Atlantic Canada is a relatively small player, as one participant put it, Atlantic Canada is "no further behind than anyone else" in the development of marine energy technologies and expertise. In addition, experience in developing and regulating offshore resources and expertise in developing technologies for use in offshore exploration and development, position Atlantic Canada (and in particular, Newfoundland and Labrador) well as a launch-pad for the development of Arctic offshore resources. To the degree that carbon reduction technologies (e.g., CCS) become viable, this resource has greater potential in a future low-carbon context.

// OFF-GRID RETS: Newfoundland and Labrador's remote communities and mining sites provide ideal conditions for the piloting of off-grid low-carbon technologies. Many of these sites currently use diesel generators and connection to the grid is prohibitively expensive. Nalcor, Newfoundland and Labrador's energy crown corporation, is already piloting a project in the remote island community of Ramea with the ultimate objective of using wind generation with hydrogen storage as the primary backup (Ramea Wind-Hydrogen-Diesel Project)[o] integrated with secondary diesel backup generation.

// TRANSPORTATION: represents a significant opportunity for reducing carbon emissions but also presents significant challenges. Atlantic Canada's population is widely distributed with lower population concentration in urban centres than typical in the rest of Canada. This provides less opportunity for public transit solutions, and results in long trucking distances to supply the dispersed population. Several possible options were put forward in different consultation sessions including increased rail penetration (Nova Scotia), the potential of natural gas as a transition fuel for freight (Nova Scotia), and, fleet electrification (Newfoundland and Labrador was proposed as an "ideal test-bed" due to the significant hydropower capacity). Some participants noted that interprovincial collaboration on a regional transportation system could reduce the carbon-intensity of transportation in Atlantic Canada. It was further noted that regional supply chains are typically not well understood and that regionally coordinated efforts at optimizing supply chains could reduce the associated carbon footprint.

o For more information see Nalcor Energy 2010; Natural Resources Canada 2009a.

// ENERGY EFFICIENCY AND LOW-CARBON FUEL SWITCHING: there was consistent agreement across all convening sessions that there remains significant opportunity for energy efficiency improvements particularly in the residential and commercial sectors (building energy efficiency). Atlantic Canada has higher rates of fuel oil use for heating than the rest of Canada and it was suggested that there is significant potential for the increased use of natural gas for residential and commercial applications. It was noted that there is significant opportunity in the context of Newfoundland and Labrador's high growth rates to build energy-efficient structures. It was also noted that industrial energy efficiency assists with building resiliency for energy-intensive and trade-exposed sectors that have a significant presence in some parts of Atlantic Canada (e.g., oil and gas, mining, cement manufacturing).

// NETWORK EFFICIENCIES: as well as discussing the need to better link the Atlantic Canadian electricity supply network, participants across Atlantic Canada suggested that Canada should consider further developing east-west transmission corridors — in particular for hydroelectricity — rather than expanding existing north-south transmission capacity. They noted that power from the Lower Churchill Falls development would be instantaneously dispatchable, making it an excellent balance to other renewable energy development in the region. Significant co-operation and collaboraton is required from all Atlantic Provinces to fully realize the potential of this project. It was also noted that existing inter-regional processes such as the Atlantic Energy Gateway have proven almost as valuable in terms of their process as in their end result(s).

// TEST-BED: it was suggested that Atlantic Canada serves as an excellent test bed for small-scale modelling whether for regulatory processes or pilot projects, and that this presents an opportunity for Atlantic Canada to undertake projects that might not otherwise be pioneered in this region.

6.4 CANADA'S PREPAREDNESS FOR LOW-CARBON GROWTH: DETAILED STATE-OF-PLAY

Energy and emissions

A low-carbon economy is one that functions at a low carbon intensity — emitting low levels of GHGs per unit of GDP.[169] What does this involve? For Canada and the rest of the world, achieving low carbon intensities across the economy inevitably involves cuts in energy-related emissions in targeted industrial sectors. Most developed countries and an increasing number of emerging and developing economies are working toward lowering their carbon emissions, either in absolute or relative terms, by improving energy efficiency and replacing GHG-intensive energy systems with ones that have lower or no net emissions. Achieving low carbon intensities also involves promoting current and developing new low-carbon goods and services (LCGS) sectors, such as those discussed in Chapter 2.

The transformation of Canada's energy systems will need to be a central component of a low-carbon growth plan for three reasons. First, many of the energy systems across Canada, as well as energy exports, are carbon-intensive and present risks and costs to parts of Canada's economy in a low-carbon future. Second, energy activities contribute significantly to the economy. Third, diverse energy resources combined with technological innovation and a strong skills base are comparative strengths to be harnessed.

PROFILE IN BRIEF

Canada's energy sector is a significant contributor to economic well-being. The energy sector accounted for 6.7% of Canada's GDP and 81% of Canada's total GHG emissions in 2010.[170] The oil and gas service sector, which supports the oil and gas production sector, is a key contributor in its own right, accounting for 4.8% of Canada's GDP in 2006.[171] The energy sector directly employed approximately 264,000 Canadians and was responsible for over one fifth of all new capital investment in the country in 2010.[172]

But the emissions profile that goes with it presents challenges to meeting environmental goals. Canada's total GHG emissions in 2010 amounted to 692 Mt, representing about 2% of global GHG emissions or 20.3 tonnes per person (amongst the highest in the world).[173] Between 1990 and 2010 total emissions in Canada grew 17%, while in the shorter-term, since 2005, total emissions have decreased 6%.[174] From 1990 to 2010, energy-related GHG emissions grew by 95 Mt CO_2e. This represents about 92% of the total increase in GHG emissions over that period.[175]

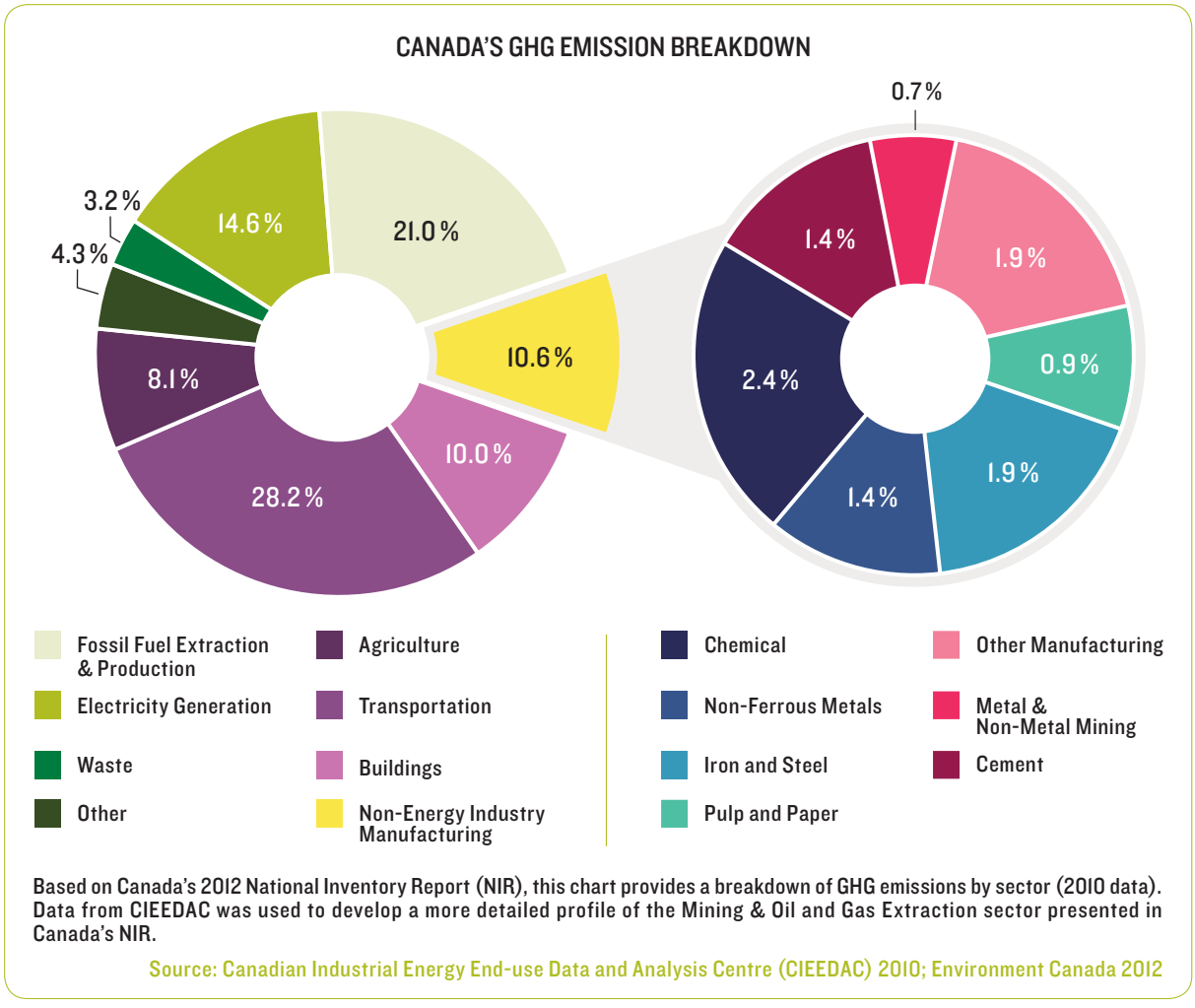
The energy sector is comprised of stationary combustion[p] emissions, transportation emissions, and fugitive sources of emissions. Stationary combustion alone represents almost half of Canada's total emissions. Its growth is attributable to an increase in fuel consumed by mining and oil and gas extraction which leaped from about 7 Mt CO_2e in 1990 to 38 Mt CO_2e in 2010. Another key emissions source in Canada is transportation. Emissions from the transportation sector in Canada increased 30% from 1990 to 2010 in part because of "a shift from light-duty gasoline vehicles such as cars to trucks, minivans, sport-utility vehicles; increased vehicle usage overall; and greater use of heavy-duty diesel vehicles."[176] Fugitive sources denote the intentional and unintentional releases of GHG emissions from coal mining and oil and natural gas exploration, production, transportation, and distribution. Emissions from fugitive sources increased 40%[q] since 1990 due primarily to growth in oil and gas extraction.[177]

p Emissions from fuel combustion (e.g., for energy and heat production, manufacturing, construction etc.).

q Based on NRT analysis of National Inventory Report data (Environment Canada 2012).

Regional emissions profiles — both sources and emissions levels — and related economic interests differ markedly and have precluded a comprehensive approach to climate policy to date. On an absolute basis, the majority of emissions in Canada in 2010 originated from just two provinces — Alberta (233 Mt) and Ontario (171 Mt).[178] Alberta is the largest energy producer in the country and generates a significant portion of its electricity from thermal sources (55% coal and 35% natural gas in 2011).[179] In 2010 Alberta's electricity and heat generation, fossil-fuel production & refining, and mining and oil & gas extraction accounted for 48.1 Mt, 32.0 Mt, and 29.8 Mt, respectively.[180] Its population, energy consumption and transportation emissions make Ontario the second highest emitter in Canada.[181] In Ontario in 2010, transportation accounted for 60.7 Mt, and manufacturing industries contributed 15.3 Mt, followed closely by electricity and heat generation with 19.8 Mt.[182]

FIGURE II



Based on Canada's 2012 National Inventory Report (NIR), this chart provides a breakdown of GHG emissions by sector (2010 data). Data from CIEEDAC was used to develop a more detailed profile of the Mining & Oil and Gas Extraction sector presented in Canada's NIR.

Source: Canadian Industrial Energy End-use Data and Analysis Centre (CIEEDAC) 2010; Environment Canada 2012

In 2010, as a signatory to the Copenhagen Accord, Canada committed to reducing its GHG emission to a level of 607 Mt[183] by 2020 — 17% below the level in 2005. As the NRT has shown in its 2012 report *Reality Check: The State of Climate Progress in Canada*, "Canada will not achieve its 2020 GHG emissions reduction target unless significant new, additional measures are taken." According to original modelling by the NRT, Canada is on track to achieve just under half of the emissions required to meet its 2020 target, with a remaining 117 Mt gap to close.[184] In addition to the federal 2020 target of 607 Mt, each of the provinces has its own target. However, with the exception of Saskatchewan and Nova Scotia, most provinces are not currently in a position to achieve their own targets for 2020 based on existing and proposed federal and provincial policies.[185]

LOW-CARBON PREPAREDNESS

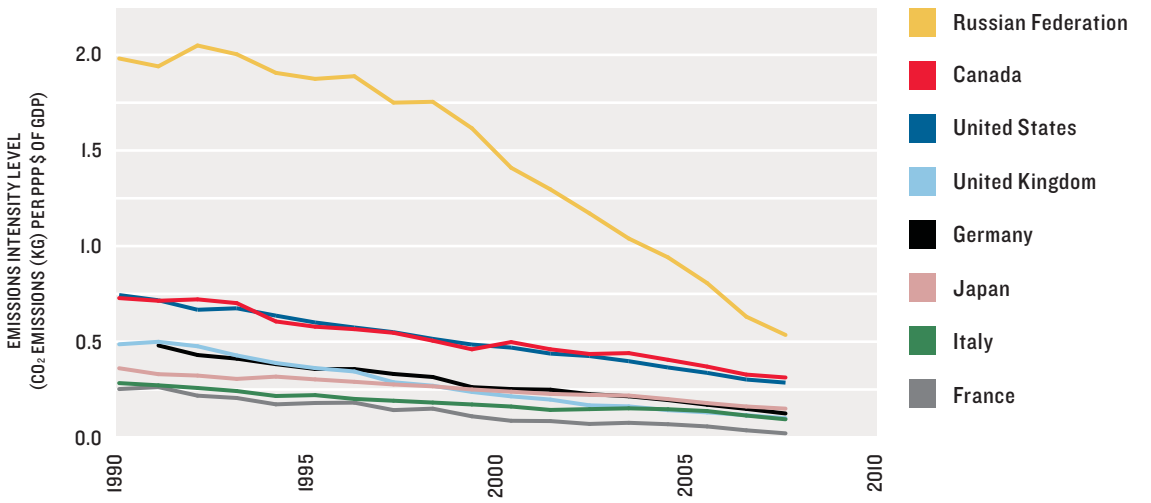
Because of the world's dependence on fossil fuels, ceasing production of Canada's fossil-fuel energy supplies is not a feasible or desirable option in the short to medium term. The challenge for Canada is to define a long-term path that will transition the country from the current carbon- and energy-intensive economies of today, to a future that involves sustainable resource use and substantially lower GHG emissions. Canada's federal, provincial, and territorial Energy Ministers recognize the onset of a transition to a lower-carbon economy.[186] Recent discussions on pan-Canadian collaboration with respect to Canada's energy future have covered the need to diversify Canada's energy sources and the importance of long-term transition to a low-carbon economy.

When it comes to energy and emissions, our assessment focused on four indicators of Canada's low-carbon preparedness: (1) emissions intensity of the economy, (2) industrial emissions intensity, (3) diversification of energy sources, and (4) technology and infrastructure deployment to facilitate the decarbonization of energy systems.

Despite improvements over the past two decades, Canada is one of the most emissions-intensive economies of the G8 (**Figure 12**) and rests in the middle of the pack among the G20.[187] From 1990 to 2007, all G8 countries decreased emissions intensities by over 40% with the rate of intensity reduction being fairly consistent over this period for most countries. Canada's emissions intensity declined faster between 2000 and 2007 than between 1990 and 2000. Overall, the pace of change of emissions intensity in Canada was on average slightly lower than that of its peers. While recent analysis suggests that Canada's was one of only a few national economies to reduce its GHG intensity in 2010 as the global economy climbed out of recession, Canada's overall emissions grew by 2.6%.[r] Canada is also squarely in the middle of the pack compared with the emerging economies (Brazil, China, India, and the Russian Federation) and countries of strategic importance (e.g., Australia, Belgium, Mexico, Netherlands, Norway, and the Republic of South Korea). A number of this broader group, and in particular, Australia and Mexico are making significant headway in reducing the carbon-intensity of their economies.

r Analysis by PwC (PricewaterhouseCoopers LLP 2011) suggests that in 2010 Canada reduced the carbon-intensity of its economy by 0.4% as compared with most G8 countries which posted overall increases (albeit small). In 2010, for the first time in 10 years, the GHG intensity of the global economy increased. This increase (0.6%) was almost as large as the annual average decrease experienced over the last 10 years (0.7%). Despite Canada's positive relative performance, its overall emissions grew by 2.6%.

FIGURE 12



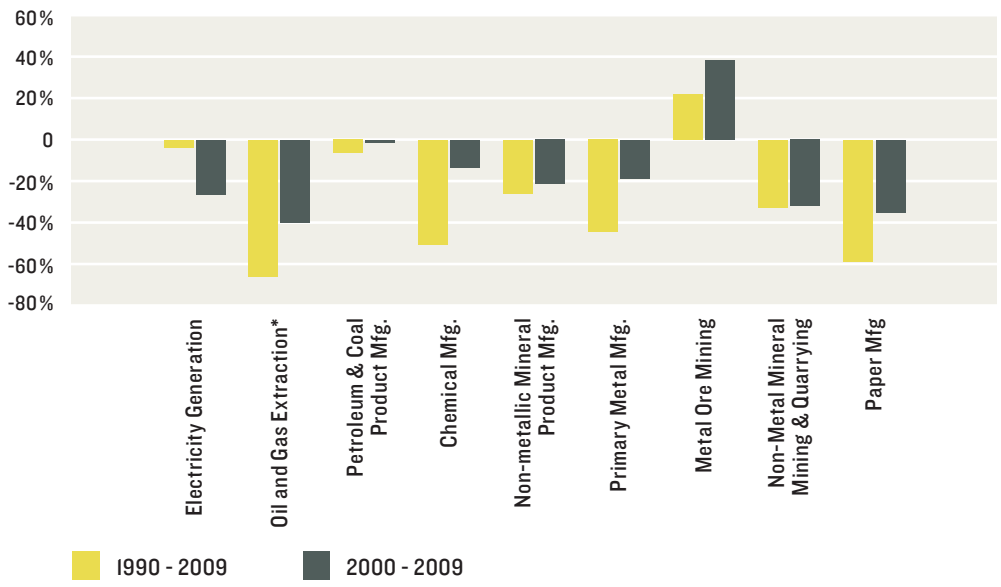
This line graph shows the decreasing emissions intensity in the G8 economies over time. It is clear that Canada's emissions intensity levels, although closely aligned with the U.S., lag behind the G8 countries. Normalized to 1990 emission levels, Canada's rate of improvement in the emissions intensity of its economy was superior to that of Japan and Italy, remaining behind the rest of the G8.

Source: World Bank 2012

Emissions and growth trends in Canada's industrial and manufacturing sectors could worsen the emissions intensity of Canada's economy in the coming years. **Figure 13** shows the rate of change in emissions intensity for Canada's nine most emissions-intensive industrial sectors over two periods.[s] Three observations are noteworthy. First, the rates of efficiency improvements relative to growth are decreasing for all but electricity generation. Second, some sectors show only marginal improvements in efficiencies (e.g., petroleum and coal products manufacturing) and one is actually worsening (metal ore mining). Third, absent technological innovations, crude oil production in Canada could well become more emissions intensive than it is today, due to enhanced crude production from in-situ oil sands development (as opposed to surface mining).[188]

s In considering Canada's industrial and manufacturing sectors and their respective carbon intensity on a per unit GDP basis. There is a clear divide at 0.5 kt CO_2e / GDP separating the top nine most emissions-intensive sectors.

FIGURE 13

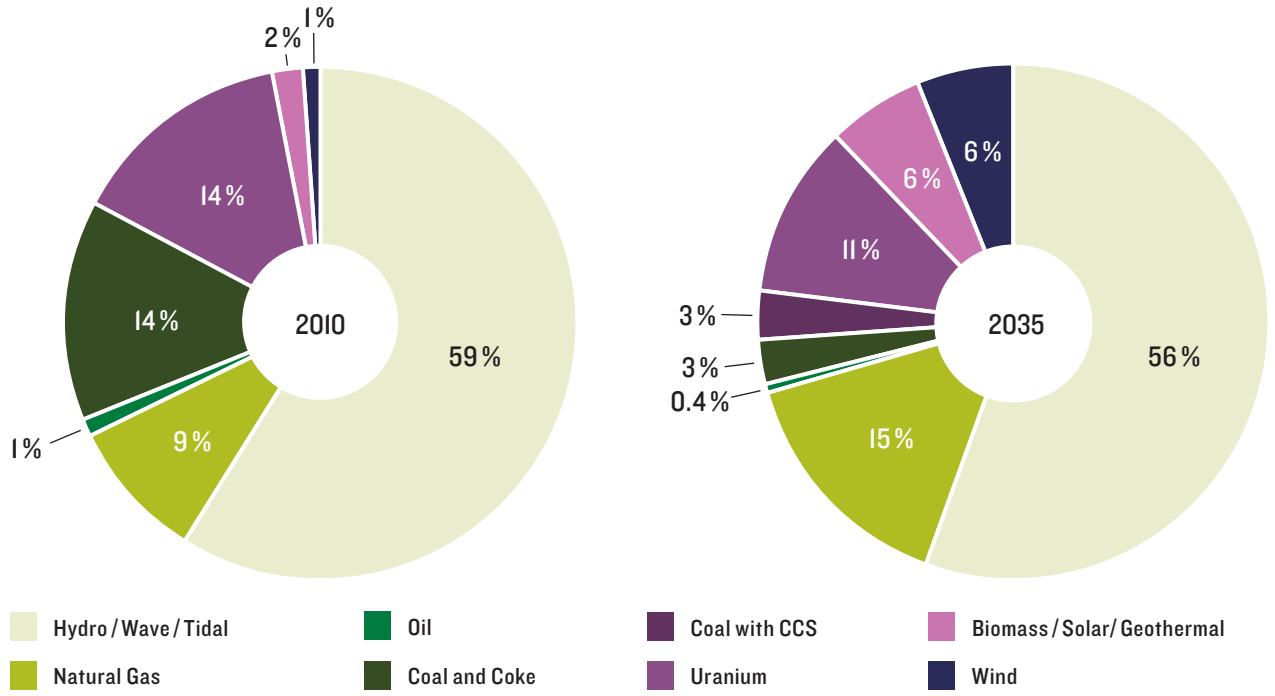


*Data for the Oil and Gas Extraction sector is only available for the 1990–2006 period and is measured in terms of tonnes CO_2e per thousand dollars of production. The numbers presented here represent the 1990–2006 and 2000–2006 periods.

Source: Canadian Industrial Energy End-use Data and Analysis Centre (CIEEDAC) 2010

Energy is Canada's comparative advantage; opportunities exist to decrease reliance on emissions-intensive energy sources by increasing renewable and low-carbon energy supplies, particularly for power generation. Canada has both abundant energy resources and significant diversity in primary energy production and electricity. Compared with the rest of the world, Canada is second in hydroelectricity production and in uranium production and export and third in natural gas exports. It is also poised to expand its renewable energy sources such as biomass, wind, solar, tidal and geothermal.[189] Three-quarters of electricity generation in Canada comes from non-emitting or low-emitting sources: hydro, wave, tidal, uranium, biomass, solar, geothermal and wind (see **Figure 14**). Projections of the Canadian electricity generation mix show continued growth in low-carbon shares, with combined shares of biomass, solar, geothermal, and wind quadrupling between 2010 and 2035.[190]

FIGURE 14



The NEB-produced chart forecasts electricity generation mix based on economic growth, relative costs of generation; government and industry efforts to curb energy-related GHG emissions; and accounts for existing provincial energy strategies. Any changes in the aforementioned variables, such as fuel prices or policy initiatives, would change the forecast results.

Source: National Energy Board 2011b

Successful reduction in the carbon-intensity of Canada's energy systems depends on the rate and extent of technology and infrastructure deployment — a process taking place unevenly across Canada with initiatives by both governments and innovative industries. Key technology areas requiring deployment include smart grids, power storage, fuel switching infrastructure, and CCS.

// Smart grids are of interest to all of Canada's provincial electricity regulators, but two provinces, Ontario and B.C., are moving forward most aggressively by deploying smart meters.[191] Smart meters are a necessary step in setting up grids conducive to growing low-carbon energy systems.[192]

// Power storage is both complementary to and an enabler of smart grids. So far, only Ontario has deployed both demonstration projects and grid-operational projects,[193] although small-scale demonstration projects are also occurring in remote areas in Ontario and, to a limited extent, in other provinces.[194]

// Fuel switching is taking place in power generation via the introduction of biomass for coal generating stations in Ontario.[195] Additional fuel switching from coal-fired electricity generation is expected across the country as a result of other provincial initiatives and the new federal coal-fired regulations. The pulp and paper industry has gained ground in substituting biomass for natural gas and the cement industry has increased its use of renewable and alternative sources.[196]

// CCS is seeing heavy investments by both Alberta and the federal government, with Alberta introducing legislation and regulation to guide the technology.[197] Canada is home to eight of the world's 75 large-scale CCS projects, but a recent project termination could imply shifts in the commercial viability of the technology under current market conditions.[198]

TABLE 9

SUMMARY OF LOW-CARBON PREPAREDNESS OF CANADA'S ENERGY SYSTEMS

STRENGTHS & OPPORTUNITIES	WEAKNESSES & CONSTRAINTS
• Abundant and diverse low-carbon and renewable energy resources • Electricity sector already low-carbon • Technological innovation (e.g., smart grids, CCS)	• High emissions intensity relative to peers and trading partners • Differences in regional energy resources • Economic reliance on carbon-intensive energy exports

Innovation

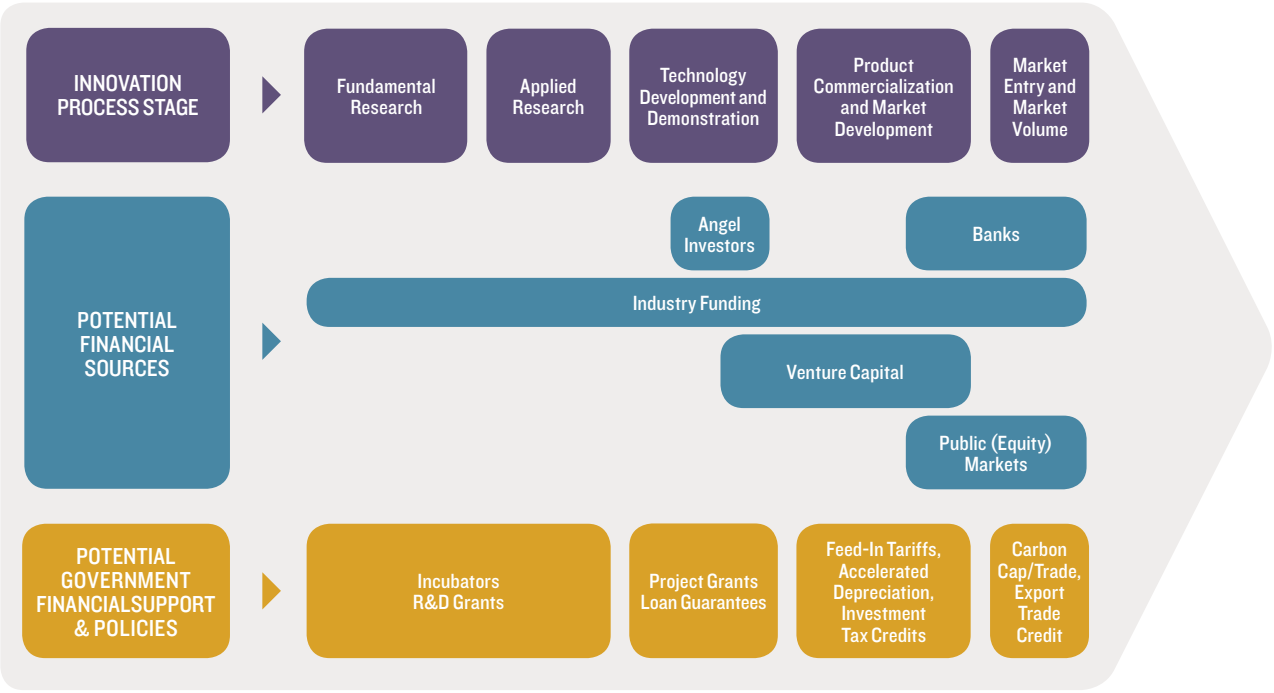
Innovation is a tool for increasing productivity and competitiveness; it is also a building block of many low-carbon growth plans (see **Box 8** for a definition). Innovation can close the gap between the low-carbon technologies of today and the low-cost, high-performance — *breakthrough* — technologies that are needed for the future. Why is accelerating low-carbon innovation key for Canada? In today's global economy, Canadian firms are up against counterparts facing lower labour costs[199] and, to an extent, greater access to capital and policy certainty. Rather than trying to compete on "last generation" technology by cutting input costs, a focus on innovation can enable the rise of Canada's low-carbon goods and services (LCGS) sector — a segment of cleantech — in global low-carbon value chains. Innovation is also the only way to enhance environmental performance of traditional industries despite increased use of natural resources, including energy.

BOX 8

WHAT IS INNOVATION?

Innovation is *"the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations."* [200] Innovation is in itself a process encompassing basic and applied research, development and demonstration, commercialization and market development, and market entry (see Figure 15):

FIGURE 15 THE INNOVATION PROCESS, ACTIVITIES, AND FUNDING



Who's part of Canada's innovation system? Basic and applied researchers, entrepreneurs, development and commercialization specialists, investors, and governments all play a role in ensuring innovation performance. Innovation is largely a private-sector activity but governments facilitate private sector innovation by putting in place enabling policy frameworks and by directly and indirectly supporting R&D and commercialization. Federal support for innovation has tended to be indirect, focusing on enabling conditions via R&D tax credits and spending on post-secondary education. Because of its broad-based nature, potential spillover effects, administrative efficiency, and public benefits, indirect support of this kind is often the focus of government intervention. Recent studies suggest it's time to recalibrate both the reliance on indirect measure to spur business innovation and the focus on subsidizing R&D.[201]

PROFILE IN BRIEF

Canada's innovation performance has been subject to discussions for decades. Economic, policy, and benchmarking studies all arrive at the basic conclusion that Canadian business innovation is underwhelming relative to that of its competitors.[202] Several explore root causes of this chronic issue and recommend ways

to narrow the gap between levels of support for business innovation and commercial success.[t] Since low-carbon innovation is a subset of innovation at large, key characteristics of Canada's innovation system are worth noting.

Overall, the strengths and weaknesses of Canada's innovation system sum up as follows. Canada focuses most on and succeeds at basic science and research, and adapting (already) commercial products to meet industry requirements. Canada is less effective than its OECD peers in product demonstration and in the transition to commercial scale and market development.[203]

Canada's performance in early stages of innovation — idea generation, basic and applied research, laboratory demonstration, and related academic support — compares well to OECD peers'.[204] Within the OECD, Canada offers the second highest level of support to R&D at 0.24% of GDP. Over 90% of R&D support is provided as tax credits (such as the long-standing Scientific Research and Experimental Development program).[205] Public investment in universities and colleges is also notable. At approximately 0.7%, Canada ranks second highest among OECD peers in higher education expenditure on R&D (HERD) as a proportion of GDP.[205] The high quality of Canada's education system overall — and specifically the high quality of math, science, and engineering education and management schools — provides a strong base for innovation in Canada. In contrast, private sector or business expenditure on R&D as a percentage of GDP is below the OECD average (see **Box 9**).

BOX 9

BUSINESS INNOVATION AND CANADA'S PRODUCTIVITY

Innovation is one of the most important drivers of productivity. It increases the development of higher-value products and results in the more efficient use of production input[209] enhancing multi-factor productivity (MFP).[u] Businesses invest in innovation when they view it as a necessary part of the business strategy, they face competitive pressures to do so, they have access to innovation financing, and they recognize domestic market opportunities.[210] In general, Canadian firms rely more on government support to motivate innovation investment than their U.S. counterparts.[211] Canadian business leaders' interest in innovation investment may be dampened by several perceptions, including the following:

// government financial support programs for innovation are not easy to understand or access, especially for small firms[212] — includes support for R& D and commercialization;[213]

// lack of available risk capital to move R&D to commercialization;[214]

// burden of governmental administrative requirements and taxation levels; and[215]

Interestingly, Canadian business leaders are 13% more risk-averse than their U.S. counterparts (based on evaluation of past business performance), despite self-perception that they are not. Furthermore, Canadian firms that self-identify as risk avoiders are less likely to invest in R&D than their U.S. counterparts.[216]

t See, for example, Council of Canadian Academies 2009; Ontario Chamber of Commerce and Mowat Centre for Policy Innovation 2012

u MFP is considered one of three principal factors that account for labour productivity growth. It is "a residual measure that captures all other factors that affect productivity. MFP reflects how effectively labour and capital are employed jointly to produce output" (Panel on Federal Support to Research and Development 2011).

But it is no secret that Canada is not reaping the economic benefits of public R&D investment as much as it could be.[217] Canada is strong in science and engineering R&D aspects of the innovation cycle but weak on taking those ideas to market.[218] Three reasons for this are apparent.[219] The first is access to risk capital (venture capital or angel investors) — the primary sources of funding for the transition from a demonstrated product to a share of the market. The creation of Sustainable Development Technology Canada (SDTC) was a federal response to bridge funding gaps preventing products' transition from demonstration to commercial success. British Columbia and Ontario have both established funds to co-invest in new technologies alongside venture capital firms. The second is actual market development. Canada has a small internal market with limited opportunities to demonstrate new technologies, inadequate government procurement and inadequate adoption of domestic technologies.[v] As well, a large percentage of innovations occur upstream from the end user. This not only runs the risk that Canadian firms will produce innovations that the market won't accept, but it also supports the tendency that firms will import technologies or machinery and adapt them.[220] The third is fragmentation among key players. A lack of efficient and targeted collaboration between Canadian universities and businesses has hindered the translation of academic knowledge into viable commercial applications.[221]

LOW-CARBON PREPAREDNESS

In its simplest form, low-carbon innovation is about bringing products, processes, or practices to market that are better, cheaper, or more resource-efficient relative to conventional counterparts while reducing or eliminating GHG emissions. Such innovation takes place within firms in traditional industry sectors and is a major focus of firms in the "clean technology" or "cleantech" sector.[w] Because over 80% of Canada's total GHG emissions stem from production, transformation, transmission, or final use of energy, low-carbon innovation tends to centre on energy.

When it comes to innovation, our assessment focused on three indicators of low-carbon preparedness: (1) market presence, (2) LCGS firms' propensity to innovate, and (3) government support for low-carbon R&D. In describing low-carbon innovation much of the research and analysis covers cleantech at large, and so our discussion below refers to cleantech and low-carbon innovation interchangeably.

Relative to its competitors, Canadian cleantech innovation is weak. Canada ranked twenty-third of 26 countries evaluated regarding the sales of clean technology products in 2008, with Germany, the United States, China and Denmark leading the pack by a considerable margin.[222] Globally, Canada ranked fourteenth in terms of the magnitude of clean technology exports and seventh in terms of imports.[223]

v Domestic technology procurement and adoption by the public sector has been identified as an urgent issue by the Canadian Clean Technology industry (Analytica Advisors 2011). A federally commissioned review of Canadian R&D found that more government support was needed on the demand side to foster Canadian business innovation (Panel on Federal Support to Research and Development 2011). They recommended increasing public sector procurement of Canadian goods, services, and technologies,by expanding existing federal initiatives such as the Canadian Innovation Commercialization Program (Public Works and Government Services Canada 2012).

w Clean technology firms focus on developing, marketing, and/or using proprietary technology to deliver products or services that reduce or eliminate negative environmental impacts and address social needs while delivering competitive performance and/or using fewer resources than conventional technologies or services (Analytica Advisors 2011).

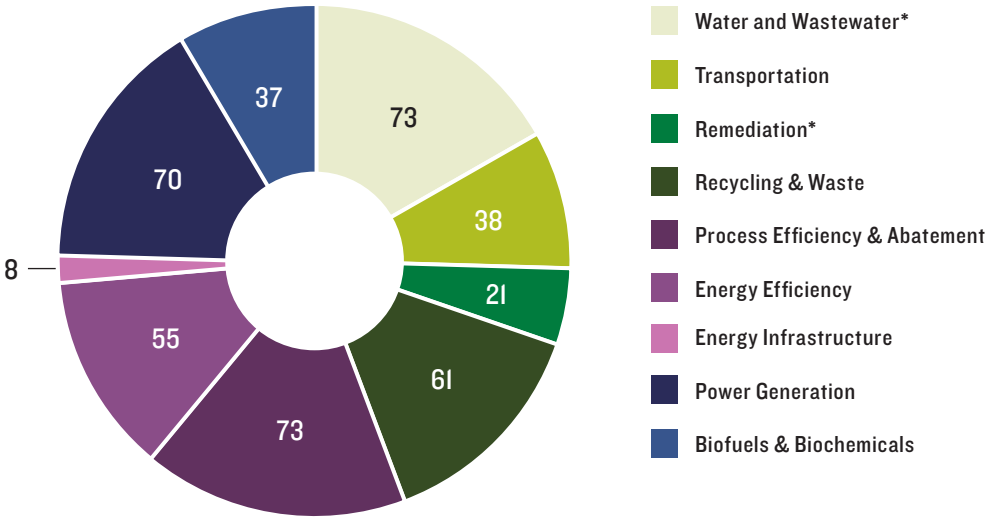
Yet Canada's cleantech industry is a viable and growing contributor to the economy. Over eight in ten firms in this industry are small and mid-sized enterprises (SMEs),[x] reflecting its relatively young (15-year) age as an industry. In 2009, these 436 firms amounted to a $2 billion industry,[y] posting double-digit growth rates through the global financial downturn. Based on current and projected growth rates, Canada's cleantech industry is on track to achieving $10 billion in revenue by its twentieth-year milestone, much like occurred with the aerospace and defence industry. A snapshot of Canada's cleantech SMEs appears in **Box 10**.

BOX 10

WHO ARE CANADA'S CLEANTECH SMEs?

As of 2009, Canada's cleantech industry was made up of 436 companies spread across the country, with 95 companies in British Columbia, 106 in the Prairies, 112 in Ontario, 95 in Québec, and 28 in Atlantic Canada. The concentration of companies generally aligned with each region's share of GDP, with the exception of Ontario and British Columbia where cleantech companies are, respectively, under- and over-represented. Cleantech companies are most active in the process efficiency and abatement, power generation, water and wastewater, recycling and waste, and energy efficiency segments (see **Figure 16**). The intellectual property these businesses are working to commercialize comes primarily from inventions by the company founder rather than intellectual property developed in academic or private institutions.

FIGURE 16 NUMBER OF CLEANTECH FIRMS BY SEGMENT



* Denotes sectors that do not provide low-carbon goods and services
Sources: Analytica Advisors 2011; Sustainable Development Technology Canada and Russell Mitchell Group 2010

x In this report SMEs refer to companies having fewer than 500 employees and less than $50 million in annual revenues (Analytica Advisors 2011).

y The information on SMEs in this section is taken from Analytica Advisors 2011.

WHO ARE CANADA'S CLEANTECH SMES? (CONT'D)

Canada's cleantech companies are 15 years old on average. They are small firms: roughly 84% of cleantech companies earned less than $5 million in revenues in 2009 and the average workforce size is 34 employees. As the industry matures, it is advancing along the innovation continuum, with 5% of firms focusing on R&D, 21% on technology development and demonstration, 27% on product commercialization and market development, and 47% on market entry and market volume. As businesses move toward commercialization and market development, 96% of companies are pursuing markets beyond national borders, aiming to compete globally.

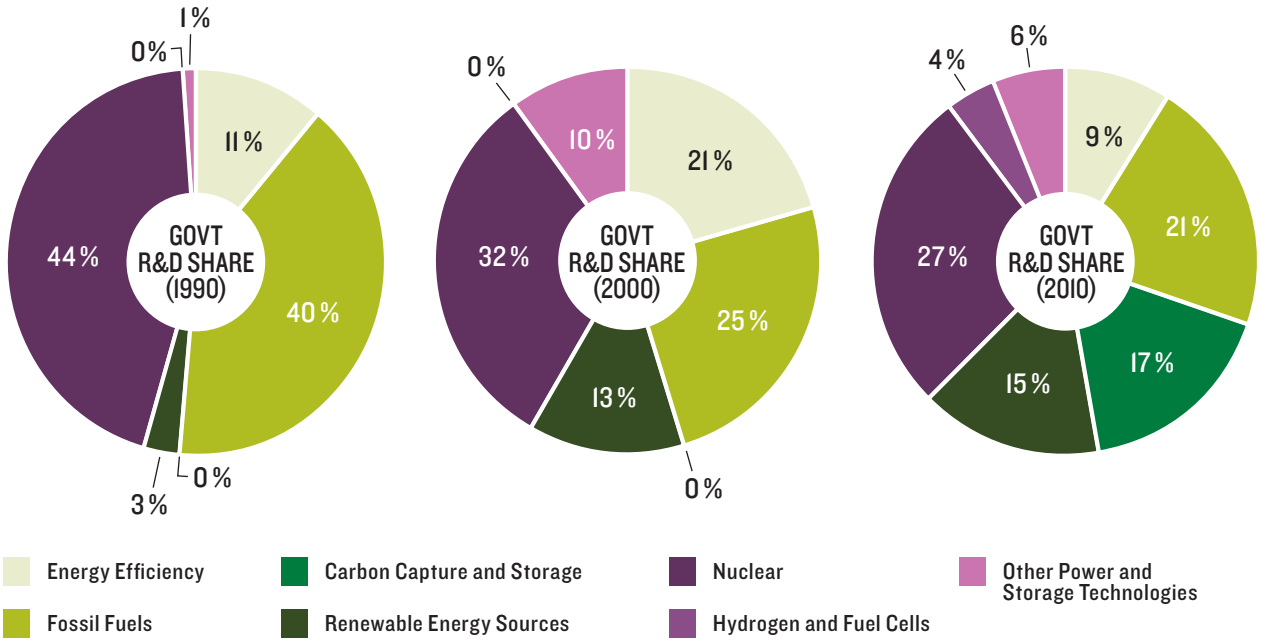
Sustainable Development Technology Canada defines a clean technology company as one *"that is predominantly engaged in the development and marketing and/or use of its proprietary technology to deliver products or services that reduce or eliminate negative environmental impacts, and address social needs; while delivering competitive performance, and/or using fewer resources than conventional technologies or services."*

Canada's cleantech industry is well positioned to become a globally competitive and innovative LCGS sector. The single greatest motivation for business innovation is competition.[224] Absent a domestic market and despite a strong dollar, Canadian cleantech SMEs have ambitions to compete globally and take advantage of growth in emerging economies. Canadian cleantech SMEs are nine times more likely to export than Canadian SMEs overall and far less reliant on export sales from the U.S.[225] By implication, they will have to innovate to survive and could well do so. Canadian clean technology SMEs invest early and generously in R&D — and this is with pre-profitability dollars and during times of recession.

Canadian governments perform and support R&D with the potential to spur low-carbon innovation that, for the most part, aligns with cleantech firms' needs. A look at three snapshots in time of Canadian governments' R&D budgets targeting energy activities shows a shift from a heavy focus on fossil fuels and nuclear to an increasing share of renewable energy sources and carbon capture and storage (**Figure 17**). When it comes to the needs of cleantech firms specifically, strengths and weaknesses of federal R&D programs are apparent. Canadian cleantech SMEs have high regard for R&D programs that are business-oriented and don't require multi-year collaborations with academia and large companies. These include the Scientific Research and Experimental Development tax-credit program, the Industrial Research Assistance Program, and Sustainable Development Technology Canada's Tech Fund.[226] The majority of federal R&D programs, however, present high barriers to entry for SMEs. Streamlining administration and approvals for federal R&D programs would increase their attractiveness to SMEs.

FIGURE 17

FOCUS OF CANADIAN GOVERNMENTS' ENERGY R&D BUDGETS



The IEA data used for the NRT's analysis is limited to government energy R&D budgets. This includes money spent on research, development, and demonstration (i.e., prototype stage) related to energy production, transportation, distribution, and use. All types of energy are included in this data. Deployment activities (i.e., business or government use of commercially available technologies, outreach, technical assistance, market development, other activities to enhance market uptake of technologies, or practices) are not included.[227]

Source: NRT analysis based on International Energy Agency (IEA) data.

A final message from Canada's cleantech SMEs was clear: enhancing domestic adoption of their innovations was necessary for Canada to benefit from public and private R&D investments.[228] If unaddressed, the lack of domestic adoption and support could hinder export growth. For innovative clean technologies, international customers expect domestic references before making procurement decisions.[229]

TABLE 10

SUMMARY OF LOW-CARBON PREPAREDNESS FOR INNOVATION

STRENGTHS & OPPORTUNITIES	WEAKNESSES & CONSTRAINTS
• Viable and growing cleantech industry • SME investments in R&D • Effectiveness of flexible and business-oriented government R&D programs in supporting cleantech innovation • Cleantech firms' investment in R&D • Cleantech firms' global orientation	• Limited cleantech innovation to date relative to international peers • Challenges accessing risk capital • Limited domestic market uptake of clean technologies

Investment

A transformation to a global low-carbon economy like the one envisioned hinges on mobilizing financial capital and delivering it where needed. At stake is the development of LCGS and their economical, profitable, and complete deployment domestically and globally — as well as the related environmental benefits. The emphasis on low-carbon spending was first evident as a response to the global recession through "green stimulus" funding, signalling that a green economy was a source of future growth. Investment and financing figure prominently in low-carbon growth plans, covering both the scale of investments required and the steps needed to unlock the necessary capital.[230]

Investment in LCGS is a leading indicator of potential shifts in the carbon or emissions intensity of an economy. LCGS investment includes public or private expenditures, or a mix of both. These expenditures may target specific LCGS segments like efficient vehicles or renewable energy, focus on infrastructure deployment, or focus on a particular stage of innovation. What follows is an overview of low-carbon investment across the globe. We next explore recent investment trends in Canada and assess their implications for the low-carbon transition.

PROFILE IN BRIEF

The world is witnessing a growing investment in low-carbon goods and services. The upward trend in world exports of "green" goods as a proportion of general merchandise exports began in 1990, posting higher growth rates than general merchandise exports overall.[231] Investments in clean energy alone show significant gains. Since 2004, global new investment in renewable energy has increased roughly five and a half times.[232] By way of rough comparison, annual investment in oil and gas increased four-fold between 2000 and 2011, not accounting for inflation.[233] Strictly comparing investments related to electricity, in 2010, $185 billion was invested in electricity generation from small- and large-scale renewables with an additional $46 billion in large-scale hydro investments (roughly $230 billion in total).[234] Combined, this exceeds the total 2010 investment in fossil-fuel plant capacity ($217 billion). Consideration of the *net investment*[z] in fossil-fuel plant capacity ($155 billion) further increases this difference. Despite the global economic slow-down, investment in LCGS is growing rapidly.

Public investment in clean energy has been a key driver of recent LCGS growth. The global financial crisis was an opportunity for nations to sustain and expand low-carbon investment via economic stimulus. Twelve members of the world's major economies committed a collective $192 billion in government stimulus related to clean energy.[235] Many devoted significant shares of their economic stimulus packages to fostering a "green recovery" with South Korea leading the way at 80%, followed by the EU at 64%, China at 38%, and Norway at 30%.[236] The green component of Canada's economic stimulus was a modest 8.3% and primarily focused on low-carbon power, including nuclear energy, energy efficiency, and research.[237]

z Net investment excludes capacity being brought on-line to replace existing capacity which is being retired.

In spite of fiscal pressures, public investment in LCGS remains strong, with investments by emerging economies poised to outstrip those of their industrialized counterparts. The U.S., despite successive budget cuts in its recent federal budgets and a downward spending trajectory, continues to invest in low-carbon energy as part of its economic recovery,[aa] and is ranked third globally in terms of attracting clean energy investment.[238] In Canada, LCGS growth continued during the recent financial crises, in part through initiatives by certain provinces (e.g., growth in solar PV capacity stemming from *Ontario's Green Energy and Green Economy Act*)[239]. The scale of investment occurring in emerging economies is remarkable. By sheer magnitude, China is unparalleled in its level of investment in renewable energy - with a total investment of $48 billion.[240] In fact, 2010 marked the first time in which renewable energy investments by developing economies exceeded that of industrialized economies ($71 billion versus $69).[241]

Private sector investment in low-carbon is also growing, more recently induced by public investment. Between 2004 and 2010, venture capital for renewable energy technology development saw an average annual growth of 36%.[242] Over the same time period, equipment manufacturing for renewable energy saw substantial annual growth as well — 45% for private equity expansion capital, and 87% in public markets.[243] According to forecasts by the World Economic Forum private investment in renewable energy and energy efficient technologies could amount to $445 billion in 2012 and $594 billion in 2020.[244]

LOW-CARBON PREPAREDNESS

Investment, whether low-carbon or otherwise, closely relates to innovation. Investment in each phase of the innovation process plays a key role in enabling growth and ensuring that Canadian firms remain competitive in a global low-carbon economy.

When it comes to low-carbon investment, our assessment focused on four indicators of preparedness: (1) LCGS investment relative to overall investment spending in Canada, (2) the nature of investment in low-carbon innovation, (3) alignment between public investment and GHG emissions abatement, and (4) investor confidence in domestic LCGS markets.[bb]

Data and information related to baseline and forecasted public and private low-carbon investments in Canada is limited. The data and information that exist preclude a comprehensive analysis. Gaps in baseline information relate to existing data collection systems, which were not designed to permit the separation of low-carbon portion from the total. Despite data and information deficiencies, some observations are possible.

aa Close to 75% of all federal U.S. "clean energy" funding over the 2009–2014 period is directed toward cleantech deployment and adoption (e.g., renewable energy). It is estimated that the U.S. government will spend in excess of $150 billion on cleantech programs in the 2009–2014 period, more than 3 times its expenditure from 2002–2008. However, significant cuts were experienced over 2011, and it is expected that cleantech spending will be reduced to half the 2011 investment in 2012 with further reductions to come. Approximately one third of the total spending over this period derives from the American Recovery and Reinvestment act of 2009 (ARRA), which, along with a number of time-limited incentive programs, is coming to an end in 2012 (Jenkins et al. 2012).

bb The discussion in this section draws primarily from a research report prepared for the NRT by the Conference Board of Canada (2011b), available upon request.

Economy-wide investment in non-residential structures, machinery and equipment (i.e., commercial products) provides a measure of the degree to which Canadian businesses are renewing capital assets and updating (and possibly adapting) technology to remain competitive. In Canada, such investment has averaged $234 billion annually over the past decade, 81% of which has been private investment.[245] Spending on machinery and equipment alone accounts for an average of approximately $137 billion (58% of spending) per year.[246]

Based on a review of federal and provincial programs that include a significant low-carbon focus in their funding allocation criteria, we estimate that public and private investments prompted by these programs amount to approximately $5.7 billion per year.[247,cc] These investments are predominantly targeted at commercial products including machinery and equipment. Comparing this figure with the previously noted $118 billion annual investment in machinery and equipment suggests that Canadian low-carbon spending as a proportion of overall capital renewal is modest, in the range of 5%. The programs we considered in developing this estimate include those available through federal granting agencies, federal research agencies, the Program for Energy Research and Development, the ecoEnergy Technology Initiative, the Clean Energy Fund, Sustainable Development Technology Canada's two funds, and 24 provincial climate change technology investment programs. Our estimates included both public and private investments that were motivated through these programs, but in many cases only partial funding data was available.[dd]

Working from this same data set we disaggregated investments by sector and innovation phase, as set out in **Figure 18**. This exercise illustrates three things. First, residential, commercial/institutional, and transportation sectors almost exclusively invest in already-commercial products and services. Second and not unexpectedly, carbon capture and storage investments focus on R&D and product development with the aim of overcoming cost and efficiency barriers and reducing technological risks related to its application. Third, product development — typically the purview of private-sector activity — is not a major focus of government-led investment programs. Overall, there is a heavy emphasis on investment in products that are already commercially established with much lower levels of investment in R&D, product development or product demonstration.

cc This represents a low-end estimate that is considered to be representative of the scale of investment, but not precise. Data gaps for some programs were noted and partnering funding was not consistently available.

dd Conference Board of Canada (2011b) provides a complete list of the programs included in this assessment.

FIGURE 18

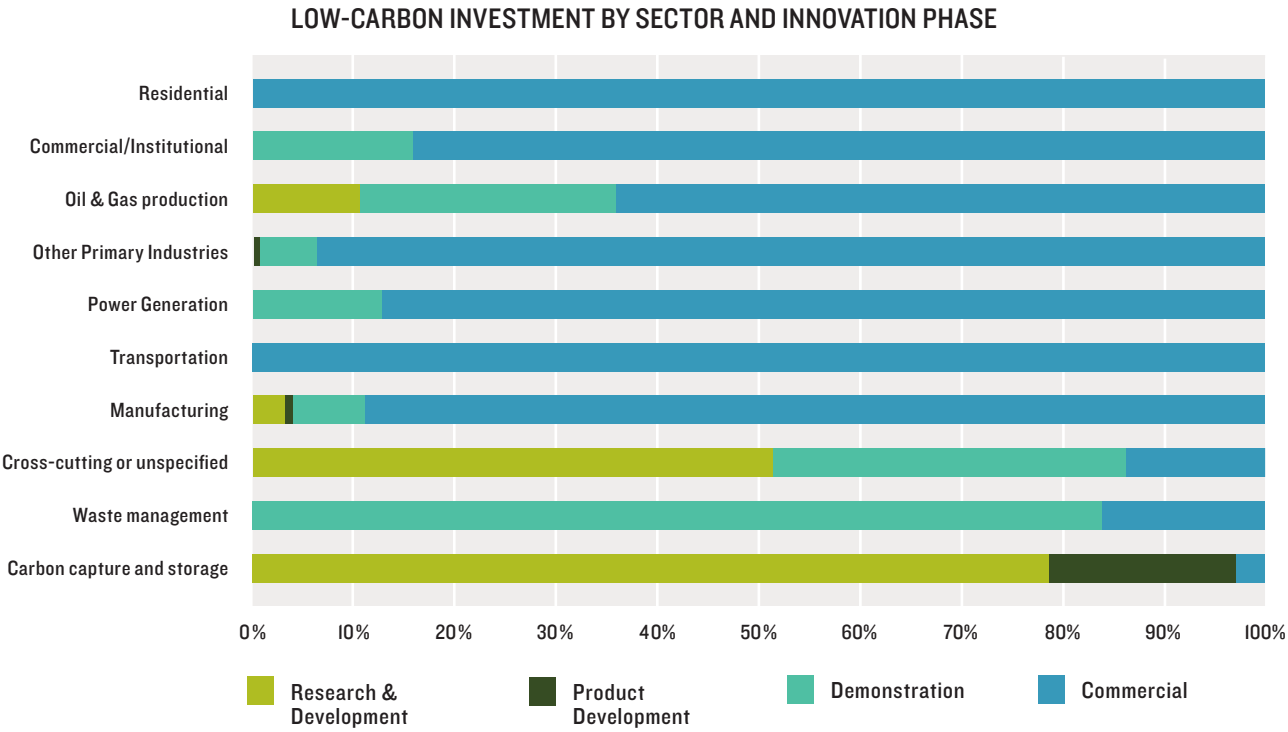
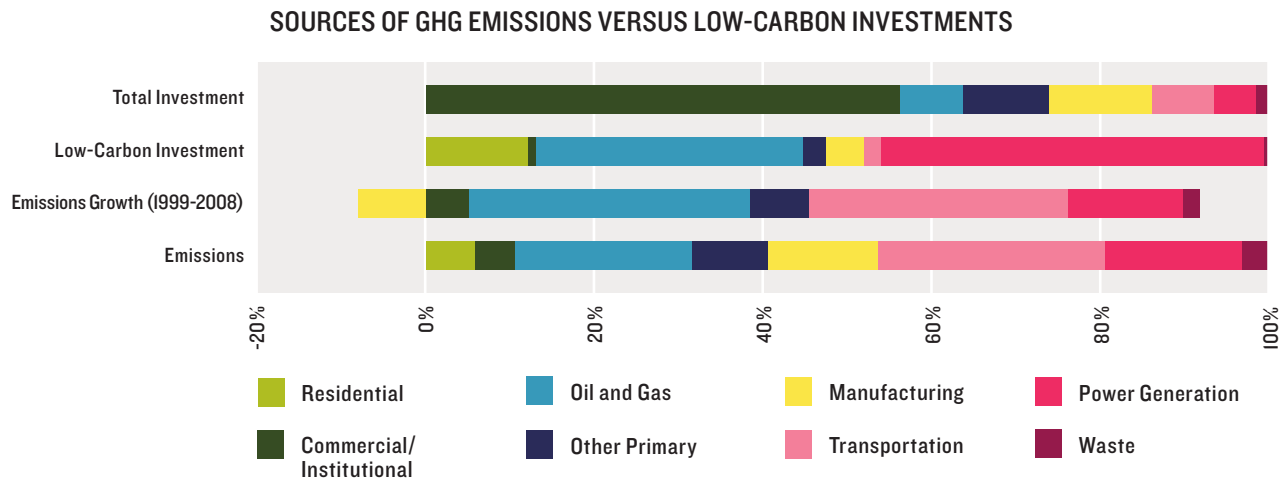


Figure 19 shows the shares of emissions and growth in emissions over the past 20 years for eight sectors, and their respective shares of total and low-carbon investment from the sample of government programs described above (excluding in-house R&D). Because available data sources do not capture investments that are made outside of those programs, what's shown below understates the total. Although simplistic, such comparisons of Canada's GHG emissions with low-carbon investments by sector can help identify whether Canada is making investments in sectors facing the greatest emissions challenge, thereby improving competitiveness for those sectors as well as other sectors that purchase their goods or use their services.

FIGURE 19



Source: Conference Board of Canada 2011b

THE ANALYSIS RAISES A FEW QUESTIONS:

Is the scale of low-carbon investments by government directed at transportation less than it should be? Several measures targeting transportation emissions are low cost, which partially accounts for the low investment levels in that sector. For example, most provinces have programs in place to encourage consumers, industry, and government departments to purchase fuel-efficient vehicles and adjust practices to reduce fuel consumption. Québec pioneered the use of speed-limiting devices for heavy-duty trucks, and other provinces are following suit. Finally, the federal government has imposed tailpipe emissions standards on new vehicles, a step that is expected to reduce GHG emissions with a relatively modest level of investment. As low-cost opportunities to reduce transportation emissions are exhausted, high-cost measures and related investments will be necessary.

What accounts for the drop in emissions from manufacturing where emissions have declined in spite of a very low level of government support as compared to other sectors? Two reasons stand out. One is regular investment in machinery and equipment that is undertaken to modernize and remain competitive, over and above any response to government initiatives. The other is the impact of capital cost allowances and investment tax credits that are not directly measured in program investments.

Is the scale of low-carbon investments by government directed at power generation more than it should be? This sector's share of low-carbon investments outweighs its share of emissions, and two factors could help explain this. First, we allocated half of investments in carbon capture and storage to power generation despite its uncertain future benefits to the sector. Second, government low-carbon investment programs have focused on small-scale renewable electricity generation technologies, primarily wind power and solar power. The low-carbon investment in this sector is even higher than shown in the figure since retail support programs (such as the FIT program in Ontario) generate investments that we don't capture in these data. Regardless of the role of electrification in the low-carbon transition, significant reinvestments in Canada's electricity infrastructure are foreseeable (see **Box 11**).

BOX 11

REINVESTING IN CANADA'S ELECTRICITY INFRASTRUCTURE

During the 1960s and 1970s, Canada invested heavily in expanding its electricity system with average yearly growth rates in capacity of 6%.[248] Growth has been much slower in recent decades: 0.5% per year during the 1990s and 2000s.[249] After an extended period of very limited investment, there is a need for Canada to upgrade existing and build new generation, transmission and distribution infrastructure — to the tune of $294 billion between 2010 and 2030.[250] Hydroelectric development will be a key growth area in the coming years, with nearly $50 billion in investments planned for this decade.[251]

Signs of investor confidence in domestic LCGS markets provide mixed messages. In the past five years, renewable energy projects in Canada have received over $16 billion of asset financing.[252] Much of the financing has gone to on-shore wind, an energy application that's attractive to investors due to its cost-competitiveness and relatively low technological risk. Venture capital activity in Canada appears healthy: as recently as 2011, Canada ranked fourth behind the U.S., China, and the U.K. in terms of investments in cleantech.[253] Much of the VC investment activity in cleantech takes place in Ontario, with investment in the province accounting for 48% of total Canadian investment since 2005.[254] Recent events suggest a drop in investor confidence, however. Despite $742 million in federal and provincial subsidies and project costs remaining within the expected range, industry partners terminated the Pioneer carbon capture and storage project in Alberta in April 2012 because "the market for carbon sales and the price of emissions reductions were insufficient to allow the project to proceed."[255] As part of its plan to "refocus strategies and activities," Ottawa-based Iogen abandoned a development project for a biofuel plant in southern Manitoba.[256] Growing and maintaining investor confidence in Canada's LCGS markets is key to the low-carbon transition (see **Box 12**). Public incentives, regulatory stringency, and a climate regime characterized by transparency, longevity, and certainty stand out as factors with the potential to do just that.[257]

BOX 12

CHALLENGES FOR LOW-CARBON VENTURES IN GAINING ACCESS TO CAPITAL

Access to capital can be a challenge both in the early stages of innovation and technology deployment and in the later stages of installing low-carbon infrastructure. In the early stages, before a technology has been proven, the government plays a large role in project financing. The Business Development Bank of Canada (BDC) offers financing and capacity building to support entrepreneurship in Canada, working primarily with small and medium-sized enterprises. Funding for low-carbon innovation is also available through Sustainable Development Technology Canada's $(2002)590 million SD Tech Fund. In 2010 the Government of Canada appointed a panel of experts to provide advice on optimizing government support for innovation. The panel concluded, "too many innovative Canadian firms that have the potential for high growth are unable to access the funding needed to realize their potential."[258] To address this difficulty, the panel recommended BDC focus more of its lending portfolio on early stage financing and be given new capital to support the development of late-stage venture capital funds for investment proposals of over $10 million.[259]

Once a low-carbon technology is proven, firms seeking access to financing for renewable energy infrastructure projects confront different challenges: project cost profiles are heavily skewed to the front end, thus increasing the costs of borrowing relative to fossil-fuel projects;[260] lending institutions may lack familiarity with some of the technologies and therefore overestimate the project risks;[261] and in instances where the business case for a project relies on public incentives or policy requirements, any change to government policy would exacerbate project funding risk.[262] The financial crisis has had a mixed impact on renewable energy financing. Even though investors are generally less willing to lend to all project types, the clean energy sector has been a key beneficiary of stimulus funding, resulting in over US$190 billion in pledges globally in 2009–2010.[263] Growth in public sector funding for the sector, through stimulus programs and government incentives for renewable energy projects (e.g., the Government of Ontario's Feed-in Tariff program), paves the way for private sector investments to follow.[264] Renewable energy is also becoming an increasingly attractive area for investors as the price differential between renewable and fossil-fuel energy falls.[265]

TABLE 11

SUMMARY OF LOW-CARBON PREPAREDNESS FOR INVESTMENT

STRENGTHS & OPPORTUNITIES	WEAKNESSES & CONSTRAINTS
• Public investment in clean energy • Economic stimulus	• Lack of sufficient price on carbon to drive investments • Reduced investor confidence across the economy • High upfront costs for renewable energy projects

Trade and market access

In a global economy, success in low-carbon competitiveness includes the efficient flow of low-carbon goods and services across geopolitical boundaries. As nations take action to reduce their GHG emissions and markets for low-carbon goods and services expand, the carbon intensity of imports and carbon risk of business ventures are gaining profile. Carbon-related trade barriers are beginning to materialize, with reputation shaping trade and investment-related decisions.

Understanding Canada's trade profile within the global context is thus essential to exploring the country's low-carbon competitiveness and the role of trade in supporting Canada's low-carbon growth. Two dimensions come into play: new opportunities to export Canadian goods and services and contribute to global low-carbon value chains, and measures to "green" the traditional economic base, particularly the energy-intensive and trade exposed (EITE) sectors that are of strategic importance to Canada.

PROFILE IN BRIEF

As a small, open economy, Canada relies on trade for economic growth and prosperity.[266] Although Canada's dependence on trade may be less than it once was,[267] trade remains a significant contributor to national GDP, and Canada's further integration into global value chains is critical to its future prosperity.

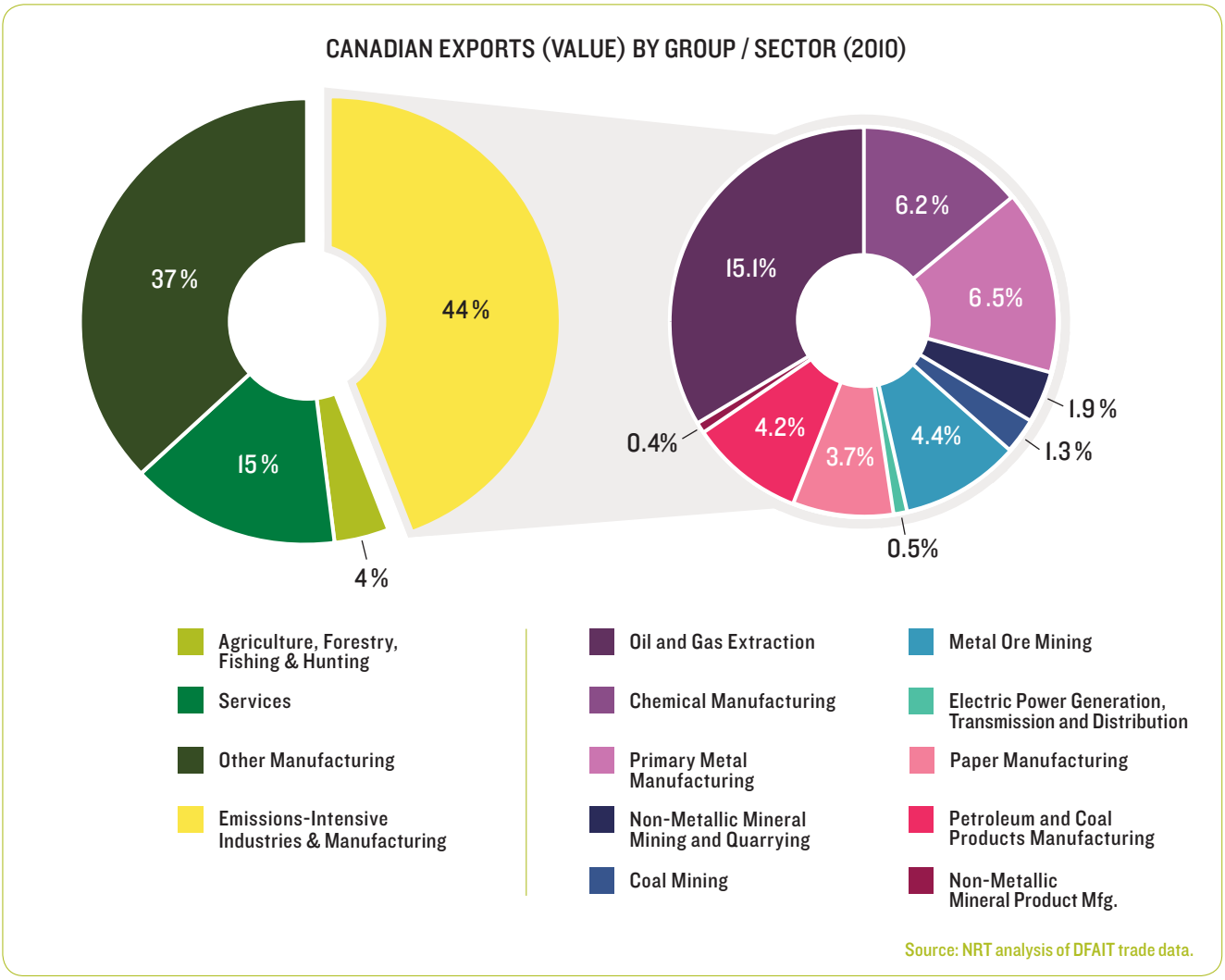
Resource-sector exports figure prominently in Canada's trade profile. Trade in resource-based products was dominant until the 1990s when manufactured goods — like industrial and agricultural machinery, transportation equipment, and consumer products — became Canada's lead exports.[268] Growth in the export of services and knowledge-intensive products characterized Canada's trade profile in the 2000s, but remain a relatively small fraction of Canada's overall trade today (15% of total exports in 2010).[269] Analysis of export data indicates a steady and strong resurgence of resource-based exports over the last decade including energy products, metal ores, and processed metals.[270] Together, these high-growth sectors accounted for approximately 38% of total exports in 2011, more than doubling their 2002 share.[ee]

Canada's trade is heavily weighted toward emissions-intensive industries and products. Emissions-intensive sectors — that is, sectors exceeding 0.5 kt CO_2e / GDP — accounted for 44% of Canada's exports in 2010 (see **Figure 20**). With the steady growth in oil and gas extraction, mining, and primary metals manufacturing, the emissions intensity of Canada's exports is on an increasing trajectory.[ff]

ee Export categories included in this calculation include: energy products, metals and metal ores, and metals and alloys (Statistics Canada 2012g).

ff NRT analysis of DFAIT trade data.

FIGURE 20



Source: NRT analysis of DFAIT trade data.

By far, the United States is Canada's main import and export market, but a trend in diversification is apparent.[gg] Trade with the U.S. accounted for 74% and 50% of Canada's goods exports and imports respectively in 2011, representing a drop in 13 percentage points compared to 2002 for both categories. And, while overall trade is growing in absolute terms, exports to the U.S. have declined 4% since 2002 and imports have risen by only 1%. Canada's export shares to China and the U.K. have more than tripled between 2002 and 2011, and import shares from China have doubled over the same period.

LOW-CARBON PREPAREDNESS

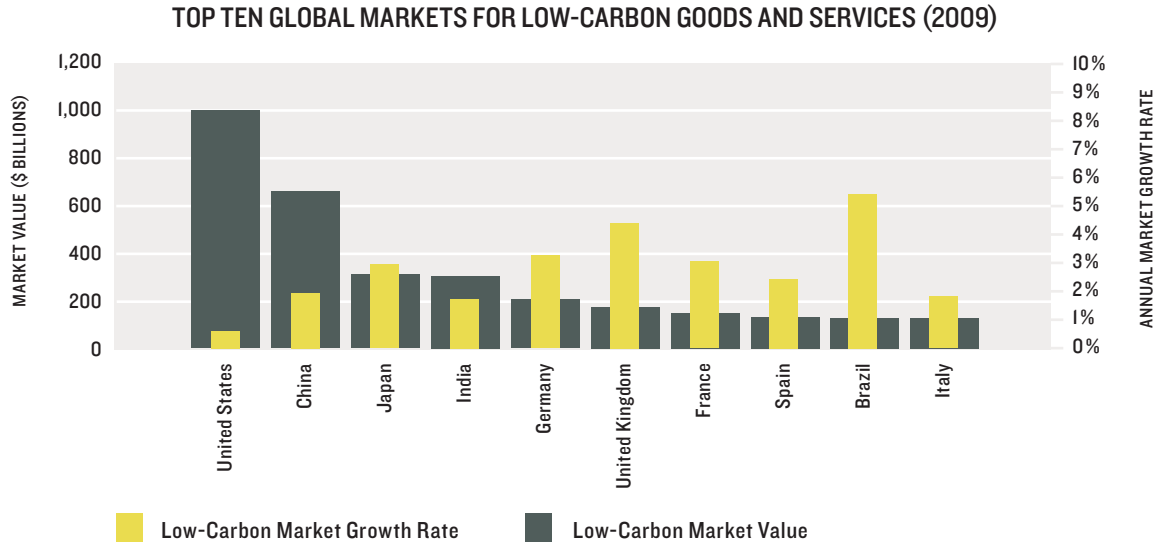
Chapter 3 discusses trade in terms of economic risk to Canada if Canada delays in reducing the emissions intensity of the economy. This section considers how trade and trade-related policy can contribute to a prosperous low-carbon Canadian economy.

gg The figures presented in this paragraph are based on NRT analysis of Industry Canada data (Industry Canada 2012).

When it comes to trade, we looked at three indictors of low-carbon preparedness: (1) Canada's trade relationship with key players in global low-carbon markets, (2) Canada's current trade in LCGS relative to overall trade, (3) use of trade-related instruments to further low-carbon growth.

Overall, Canada is well positioned to benefit from the relative size and growth trajectories of its trading partners' LCGS markets. At present, Canada's top ten export markets are the U.S., the U.K., China, Japan, Mexico, South Korea, Netherlands, Germany, France, and Hong Kong; Canada's top ten import markets are U.S., China, Mexico, Japan, Germany, the U.K., South Korea, France, Algeria, and Italy. **Figure 21** shows the ten largest countries for LCGS[hh] by market value as well as the growth rates for each country in 2009. Together, these nations represent 64% of the world low-carbon market.[271] Seven of these nations — 42% of the world low-carbon market — are OECD members, and six — 49% of the world low-carbon market — are among Canada's top 10 export markets.

FIGURE 21



Source: Innovas Solutions Ltd. 2010

Furthermore, analysis of Canada's likely trading partners in 2040 undertaken by DFAIT[ii] projects growth in trade with nations that represent a larger portion of the world low-carbon market than today, and for which low-carbon market growth rates are high (see **Table 12**).

hh This study included a broader segment of environmental goods and services in their overall categorization of "low-carbon and environmental goods and services." Despite the inclusion of this additional market component it remains one of the most comprehensive surveys of global LCGS markets.

ii For their publication Canada's State of Trade — Trade and Investment Update 2011, the Department of Foreign Affairs and International Trade undertook to project Canada's top merchandise export markets in 2040. They employed an in-house gravity model along with a GDP forecast provided by IHS Global Insight.

TABLE 12

COMPARISON OF TOP 10 LOW-CARBON MARKETS WITH CANADA'S TOP 10 EXPORT MARKETS

	TOP 10 LOW-CARBON MARKETS	CANADA'S TOP 10 EXPORT MARKETS	
		2009	(2040) PROJECTED
1	United States	United States	United States
2	China	United Kingdom	China
3	Japan	China	United Kingdom
4	India	Japan	India
5	Germany	Mexico	Mexico
6	United Kingdom	South Korea	Germany
7	France	Netherlands	France
8	Spain	Germany	Japan
9	Brazil	France	Brazil
10	Italy	Hong Kong	South Korea
SHARE OF GLOBAL LOW-CARBON MARKET (2009)	64 %	50 %	58 %

Source: NRT analysis using data from Foreign Affairs and International Trade Canada 2011a; Innovas Solutions Ltd. 2010

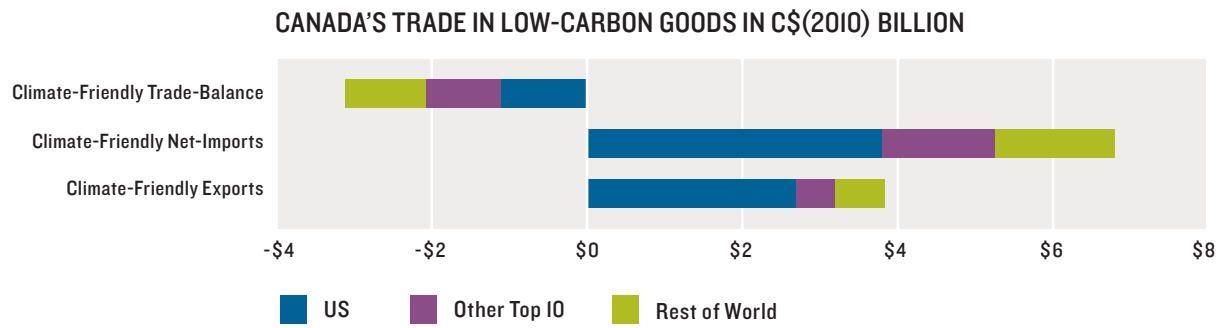
Even though Canada's trade in low-carbon goods and services comprises a small share of trade overall,[jj] low-carbon activity aligns well with the global market opportunity. Low-carbon goods represent less than 1% of Canadian merchandise exports and approximately 1.6% of merchandise imports.[272,kk] What little low-carbon trade Canada does undertake, is largely captured by the top 10 low-carbon markets shown in Table 12. The United States is Canada's largest market for 40 of the 45 commodities identified by the United Nations as "climate-friendly" and is the largest source of imports for 34 of the 45 commodities.[273] Overall, 83% of Canada's exports and 78% of imports of low-carbon goods are to the ten largest low-carbon markets.[274]

jj Analysis undertaken by the Conference Board of Canada suggests that trade numbers may understate the degree of global business in low-carbon technologies (Goldfarb 2010). Global business in some technologies, and particularly those that are difficult to transport, is likely better captured by foreign direct investment. For example, cross-border investment is more important than trade in understanding global wind energy (Kirkegaard, Hanemann, and Weischer 2009). Particularly with the rise in importance of global value chains, trade cannot be looked at in isolation but must be considered together with inwards- and outwards-bound investment.

kk Because the provision of low-carbon goods and services tends to be highly integrated, we can draw conclusions on low-carbon services based on data on exports in low-carbon goods.

Canada is failing to capitalize fully on the opportunity to sell its low-carbon services in global markets.[275] Analysis of 45 climate-friendly commodity groups shows an overall negative trade balance of $3 billion for Canada. Exports amount to roughly $3.8 billion and imports roughly $6.8 billion net of re-exports (see **Figure 22**). Canada's trade balance is positive for only 13 of the 45 climate-friendly commodities listed, and for 15 categories, net imports exceed domestic exports by a factor greater than 3:1.[276] The country's low-carbon export activity is stagnant, at best.[277] Adjusting for inflation, Canada's exports of low-carbon technologies declined by 2% annually on average over 2002 and 2008.[278] Over the same period, the global low-carbon market experienced 10% annual compound growth and, with the exception of the U.K., the top 10 global exporters of low-carbon technologies experienced annual growth in excess of 5%.[279]

FIGURE 22



Source: Conference Board of Canada 2011b

Relative to many of its trading partners, Canada makes little use of policy instruments to boost the domestic growth of low-carbon goods and services sectors and promote their export viability.[ll] Both direct (trade measures such as tariffs, subsidies and conditional subsidies) and indirect (domestic regulations, mandates or targets, and infrastructure investment) trade-related instruments exist and their application varies widely.[mm] For example, average tariff rates deployed by developing-country importers on low-carbon goods tend to be higher than their industrialized counterparts,[280] with biofuels as an exception to this pattern.[nn] Subsidies are universally applied (see **Table 13**). Conditional subsidies or support, such attaching export performance conditions to subsidies, are uncommon and WTO-illegal. Domestic content requirements are broadly applied; China (*Ride the Wind* program) and India (Phase 2 of Jawaharlal Nehru National Solar Mission) use this tool extensively. Joint venture requirements are quite common in China, but not as common elsewhere. Ontario (currently being challenged at the WTO) and Québec currently make use of domestic content conditions for their feed-in tariff programs, but performance conditions are not widely employed in Canada. Export Development Canada (EDC) does provide some export credit financing; however, this could be bolstered to provide further dedicated support for low-carbon goods and services sectors.[oo]

ll It should be noted that overall Canada's trading partners are not making extensive use of tariffs as tools of green industrial policy; however, Canada's use of such mechanisms is even more limited.

mm The discussion on trade-related policy primarily draws from an IISD report (Cosbey, Stiebert, and Dion 2012) commissioned by the NRT.

nn As an exception to this rule, on May 17th 2012, the U.S. imposed preliminary anti-dumping duties ranging from 31% to 250% on Chinese manufactured solar cells after ruling these products were sold below cost (Nicola 2012).

oo The Canadian Cleantech Coalition has developed a detailed proposal for export credit financing for the cleantech sector (Canadian Cleantech Coalition 2012).

TABLE 13

SUBSIDY TYPES APPLIED TO LOW-CARBON DEVELOPMENT

SUBSIDY TYPE	NOTABLE COUNTRY APPLICATIONS	COMMENTS
PREFERENTIAL TAX TREATMENT	India, China, U.S., 16 of 27 EU member states, others	• High degree of variability in application. • In Canada, accelerated capital cost allowance (30% per year) for which LCGS sectors may qualify.
EXPORT CREDIT	China, U.S., India	• China's substantial level of export credit is notable, amounting to more than all the G7 countries combined.[281] Many of its programs go beyond the standards set by the OECD's *Arrangement on Officially Supported Export Credits*.[pp] • Available to exporters through Export Development Canada (EDC). Adheres to OECD *Arrangement on Officially Supported Export Credits*; not considered a subsidy under trade law.
GRANTS	U.S., China, South Korea, EU, and others.	• Almost universally used; standard feature of 2009 stimulus packages. Typically target capital expenditures or investment, supporting R&D or infrastructure development.
SOFT LOANS	China, India	• Widespread use as measure to overcome financing barriers (e.g., high perceived risk by investors, high up-front capital costs relative to O&M, etc.). China is the heaviest user of this tool. The U.S. Commerce Department imposed customs tariffs on Chinese imports of solar cells in response to subsidies in May 2012. Final determination on the tariffs is expected to be made in October 2012.[282]
R&D SUPPORT	China, Germany, U.S., Sweden, many other EU states — almost universal.	• Widely used as a tool to drive innovation and create domestic sectoral capacity.
FEED-IN-TARIFFS (FIT)	Almost universal	• In place in over 60 countries as of early 2011, including 15 middle-income countries (e.g., South Africa, Malaysia) and 13 lower-income countries (e.g., India, China).[283] The only OECD countries *without* a FIT program in 2011 included Belgium, Netherlands, New Zealand, Norway, and Sweden.

Trade and trade-related policy as well as trade instruments are also of relevance to Canada's energy-intensive and trade-exposed (EITE) industries. Where other nations are establishing carbon-related trade instruments, Canada can attempt to intervene to ensure fair treatment for its sectors (e.g., this was the case with the EU low-carbon fuel standard, and may be warranted were the U.S. to actively consider a national LCFS). In addition, as Canada moves to put in place regulations or appropriate price signals on GHG emissions, consideration must be given to measures for ensuring a level playing field with international competitors that may not be subject to the same controls / signals.

pp While China is not a signatory, this agreement is widely regarded as an international standard (Cosbey, Stiebert, and Dion 2012).

TABLE 14

SUMMARY OF LOW-CARBON PREPAREDNESS FOR TRADE

STRENGTHS & OPPORTUNITIES	WEAKNESSES & CONSTRAINTS
• Solid trading position with ten largest international markets for low-carbon goods • Prominence of OECD countries in global low-carbon markets (fewer barriers to entry for Canadian firms relative to non OECD who still impose substantial trade barriers for LCGS)[284]	• Declining low-carbon technology exports • Negative trade balance for climate-friendly commodity groups • Current exports skewed toward energy-intensive industries and products

Governance

Governance shapes a nation's response to and management of the global transition to a low-carbon economy (see Box 13 for definitions). A transformative shift in policy direction and objectives — such as that required for countries to prosper in a low-carbon transition — requires vision and leadership above all else.[285] Without exception, political leadership was necessary to propose, endorse, and embed the low-carbon growth plans where they exist.

BOX 13

WHAT IS "GOOD" LOW-CARBON GOVERNANCE?

Governance "determines who has power, who makes decisions, how other players make their voice heard and how account is rendered."[286] Governance looks beyond government as a single actor; in fact, it includes a wide range of involvement from governments, civil society, different sectors and business communities.

Much like traditional notions of good governance, principles of "good' low-carbon governance include the following:[287]

// Leadership and vision

// Legitimacy

// Fairness

// Accountability

// Performance

Coordination among institutions at similar levels of organization and across jurisdictional levels is key. Mechanisms that facilitate engagement, co-operation, joint learning and information sharing all play a role.[288] Canada's federalist context combined with the need to integrate low-carbon growth across a number of policy areas makes a focus on governance solutions all the more important.

PROFILE IN BRIEF

Canadian federalism presents unique governance challenges. The federal government has regulatory control of interprovincial trade and international trade and commerce; other areas offer decentralization and delegation of authority to provinces, as with energy and natural resources. Yet other areas, such as the environment, are a shared responsibility. Divisions of power make tackling far-reaching policy issues a challenge in practice. Current structures governing energy and innovation are good illustrations of this.

Regulatory complexity and the cross-border nature of energy complicate achieving clean energy goals. The energy sector involves numerous actors and regulators. Canada's power industry encompasses Crown corporations in some provinces, privately held utilities or both private and Crown corporations in others.[289] Several provinces also include independent regulatory boards that set electricity rates and arms-length agencies that undertake long-term planning (e.g., Ontario Power Authority). The National Energy Board, as an arms-length federal agency, regulates international and interprovincial aspects of the oil, gas and electric utility industries. The nuclear sector is under federal government regulation through the Nuclear Safety Commission. Environmental regulation around energy-related developments is also a mixed-jurisdictional issue.

LOW-CARBON PREPAREDNESS

Previous NRT reports have discussed Canada's governance performance in the low-carbon transition. Key conclusions related to weaknesses in Canada's policy signals: a lack of a low-carbon growth framework; presence of medium-term GHG target but no systems to independently monitor and report on performance; and absence of a unified, national carbon price. What follows is a discussion focused on leadership and coordination.

Specifically, in assessing Canada's low-carbon preparedness relating to governance, we looked at (1) opportunities and constraints to enhance leadership to set a low-carbon vision for Canada and follow through with it and (2) the extent to which existing mechanisms facilitate coordination on low-carbon issues.

Canada as a whole does not have a coherent climate change strategy or a low-carbon growth plan. The failure to bridge regional interests and perspectives over the past 20 years has resulted in a patchwork of uncoordinated federal and provincial actions to reduce emissions. Yet federations such as the European Union and Australia have managed to develop low-carbon growth plans. Federalism aside, four key factors are apparent for Canada: disparity in regional economic interests, a commitment to equitable burden sharing, a lack of capacity in institutional intergovernmental relations, and a polarized or unengaged public.

// Regional economic interests vary widely and differences in aspirations and identities surface immediately in discussions on energy and GHG emissions. Earlier in this appendix we covered regional differences in emissions sources and profiles. Provincial jurisdiction over natural resources can further distance regional interests in cases where gains in resource developments in one region are perceived to damage another. The public dispute in April 2012 between the Premiers of Ontario and Alberta over the net costs to Ontario's manufacturing economy of Alberta's oil sands development is an example of this.[290] A renewed interest in a collaborative, pan-Canadian energy strategy represents an opportunity to orient the discussions toward low-carbon growth.[291]

// Burden sharing — internationally and domestically — while noble in intent is difficult to implement. Canada has a principle that "no region shall bear an undue portion of the cost" to meet emissions targets;[292] however, consensus on how this ought to play out in reality remains elusive. Canada's regional diversity in energy sources is a strength. This same diversity — and the diversity in the carbon intensity of the energy sources — has made discussion of climate policy and mitigation difficult due to significant variation in compliance costs across regions.

// Intergovernmental fora for discussion of environmental issues are lacking in stability and, in some cases, legitimacy. Gaps in stability refer for example to "participation rules that exclude first ministers" and processes that are "subject to change or dissolution in the face of changes in the underlying interests of actors."[293] Gaps in legitimacy become evident when actors choose to "opt out and work outside or around" existing processes.[294] The National Climate Change Process (1998–2002) is a case in point: Ontario, Alberta, and Québec opted out of several ministerial decisions and remained unengaged at high political levels.[295] Governance scholars have argued for the need to augment existing intergovernmental mechanisms in both substance and process to effectively address environmental issues.[296] Although legitimate and effective institutions for intergovernmental relations exist, they have not been used well to make progress in tackling climate change. Institutions such as the Canadian Council of Ministers of the Environment, Canadian Council of Energy Ministers, First Ministers Meetings, and the Council of the Federation are mechanisms that could be improved to facilitate Canada's low-carbon transition in a way that strengthens participation rules to guarantee appropriate decision making.

// Public opinion can help or hinder federal government leadership and, in the case of climate policy and low-carbon growth, public and media interest have inhibited political endorsement to date. Framing of low-carbon growth hasn't aligned with Canada's core interests. Due to Canada's fossil-fuel energy wealth, a low-carbon growth plan is not seen to promote either energy security or economic expansion, but rather is seen to solely promote environmental merits. Public engagement on regional and national challenges and opportunities in the global low-carbon transition is a key step to steer the country toward a low-carbon economy (see **Box 14**).

BOX 14

PUBLIC ENGAGEMENT AND LOW-CARBON GROWTH PLANNING

Public engagement is central to low-carbon growth planning. Communication, information sharing, education, and awareness building are all essential. These activities legitimize low-carbon goals by clarifying what the low-carbon economy is and what its long-term benefits could be. Engagement can occur at various levels and to various degrees, depending on the context and need. For example, South Korea's green growth plan included public hearings to present the strategy to the public.[297] Australia's low-carbon planning included significant government engagement and collaboration with the business community.[298] Although not always front and centre in low-carbon growth plans, citizen engagement also occurs and can be important to foster societal buy-in. China's climate change plan includes provisions to create campaigns for public literacy on climate change and promote sustainable actions such as reducing energy use.[299]

In Canada, several engagement mechanisms exist to bring together governments, the private sector, and academia. They include the Canadian Council for Public Private Partnerships,[300] multi-sectoral research partnerships such as that managed by the Social Sciences and Humanities Research Council for innovation solutions,[301] national consultations to build consensus on a future strategy such as for the digital economy strategy,[302] and ministerial conferences that can include relevant ministers, government officials, private sector executives, municipal authorities, NGOs, and academia. Their use in facilitating dialogues on Canada's transition to a low-carbon economy remains limited. The most promising development on this front has been the engagement of both private and not-for-profit sectors in Canada's energy ministers' dialogue on an energy strategy for the country.

Baseline deficiencies in coordination within and across government departments and ministries could stifle progress on low-carbon planning in the future. Horizontal coordination requires agreeing on objectives and co-operation mechanisms to achieve them. At a high level, departments (or even groups within a department) may be tasked with mandates that require the resolution of conflicting interests. In the absence of a "whole-of-government" sense of purpose, departments may ultimately work at cross-purposes. More commonly, "silos" exist within both federal and provincial government departments. Absent the appropriate tools to break down silos, effective communication and information sharing does not occur. This leads to inefficiencies at best and counter-productive efforts at worst. Perverse outcomes such as these are in most cases unintentional, resulting from a lack of clear leadership.

The market implications of gaps in leadership and coordination are significant. Simply put, key sectors of the Canadian economy lack the policy certainty or support to prioritize low-carbon investments. Instead, investors, firms, and households may postpone investment decisions or choose conventional options with known payoffs.

TABLE 15

SUMMARY OF LOW-CARBON PREPAREDNESS RELATING TO GOVERNANCE

STRENGTHS & OPPORTUNITIES	WEAKNESSES & CONSTRAINTS
• Experience navigating federalism to make difficult decisions on other files • Potential for increased regional co-operation	• Lack of policy certainty • Absence of low-carbon growth framework • Absence of intergovernmental framework to address the challenge • Shared jurisdiction over relevant policy areas • Regional disparities

Labour market and skills

The global low-carbon transition will, in the long term, influence the structure of the Canadian economy, irrespective of domestic policy. Industries will evolve — some will shrink, some may disappear, others will grow — and new and innovative industries will emerge. Such shifts will undoubtedly alter Canadian livelihoods. The extent to which and pace at which the economy and its component industries reduce their carbon intensity, and Canada's capacity to reap the economic rewards of aiding global low-carbon efforts, influence and are influenced by the country's collective human capital.

The labour market and skills category appears to have the least quantitative rigour across existing low-carbon growth plans. Our exploration covers the implications of the low-carbon transition on the workforce and the preparedness of the workforce to meet its labour needs.

PROFILE IN BRIEF

A low-carbon economy will require talents and skills to match. Current general unemployment rates and labour shortages in particular sectors hint at a potential mismatch in Canada's labour market and are a reminder of the importance of preventing such structural imbalance. Labour shortages are especially prevalent in resource sectors, and while much of this attention has been focused on the acute labour shortages in the oil sands industry, labour shortage concerns exist broadly across the energy and resource

sectors. LCGS industries, a large proportion of which involve energy production, transfer, and end use, are also exposed to this risk, and representatives of many LCGS industries have either experienced or anticipate a lack of skilled labour to meet their needs.[303]

So what constitutes the low-carbon economy, what industries comprise it, how many people does it employ, and what skills will be required in the future? Insufficient information exists to confidently answer these questions for a "green" economy,[304] let alone the low-carbon subset. ECO Canada, Canada's sector council[qq] for the environmental sector, attempted to define and quantify the size of the Canada's green economy in 2010. Their study results suggests it is sizeable and rapidly growing: an environmental sector comprising 682,000 workers in 2010, up from 530,000 in 2007,[rr] and a further two million Canadians spending a portion of their time at work on environmental activities.[305]

Two factors make it difficult to estimate employment within the low-carbon economy. One relates to definitions. The continued lack of a consistent definition of the scope or breadth of what constitutes "low-carbon" not only prevents accurate estimates of the size of Canada's low-carbon economy but also prevents comparisons among jurisdictions. The second is a lack of attention to baselines. The tendency exists for studies to focus more heavily on anticipated future employment, notably relating to investment decisions, than on statistics on present employment.

LOW-CARBON PREPAREDNESS

When it comes to labour markets and skills, we assessed low-carbon preparedness on four fronts: (1) current employment in LCGS sectors relative to employment overall, (2) potential growth in low-carbon employment, (3) availability of policy-relevant information, and (4) ability to retain and attract low-carbon workers.

The magnitude of current employment in the low-carbon economy is small. Analysis commissioned by the NRT to estimate the present and potential future size of Canada's low-carbon economy estimates that Canada's LCGS sectors directly employed in the range of 42,000[ss] people in 2010.[306] This estimate is largely consistent with analysis for Canadian cleantech industries, which places direct employment in cleantech at 44,000 and employment in LCGS sectors exclusively at close to 33,000.[307] Industry association studies and government reports further support these macro-estimates and suggest that they may be on the conservative side.[tt] Inclusion of indirect and induced employment effects more than doubles the contribution of the LCGS sector to employment (96,000).[308]

qq Sector councils are tasked with assessing and implementing solutions to human resource needs across employers, workers, educators, professional associations, and governments.

rr The data includes employees who spent more than half their time performing environmental work activities.

ss All employment numbers are expressed in terms of full-time equivalents (FTE).

tt CanWEA estimates that in 2011, the wind sector alone created 13,000 person-years of employment exclusive of operation and maintenance (Canadian Wind Energy Association 2012); the Government of Ontario has stated that by mid-2011, it had already created 20,000 clean energy jobs through the policies associated with the Ontario Green Energy Act, and indicates that by the end of 2012, a total of 50,000 of these jobs will be created (Ontario Ministry of Energy ND). In B.C. the Globe Foundation estimates that employment in green buildings, energy management and efficiency, clean and alternative energy, and carbon finance and investment are directly responsible for almost 70,000 jobs as of 2008 (GLOBE Foundation 2010).

Expected growth in LCGS sectors has several implications for Canada's labour markets. The years 2008 to 2010 saw exceptional annual employment growth rates in cleantech at 11%.[309] The energy sector as a whole is expected to undergo substantial transformation as it reduces its carbon intensity. At present, it alone employs 300,000 people, 100,000 of which are employed in the electricity sector.[310] As Canada's economy reduces its carbon intensity, the electricity sector will see substantial employment growth. Expert opinion and trend analysis indicates "emerging/very high growth" expectations for LCGS sectors.[311] NRT's own analysis suggests that even in the absence of additional policy, direct employment in LCGS sectors will grow to 91,000 FTE by 2050 with total employment (including indirect and induced) reaching 224,000 FTE.

Canada has the talent and educational capacity to embark on its low-carbon transition; however, the country continues to lack the information necessary to effectively plan for future low-carbon labour demand. In the NRT's report *Measuring Up*, we acknowledged that "data collection for education and skills development needs to be improved."[312] The same conclusion still holds true. The establishment of ECO Canada as an environmental sector council was a necessary start, and that organization is working to fill knowledge gaps on Canada's green labour markets. A federal working group on green jobs established by Human Resources and Skills Development Canada (HRSDC) is also a promising early step.

The fact remains that Canada's statistical capacity is not attuned to tracking growth in the low-carbon economy. Other nations also face this problem, but leaders are moving quickly to build the required knowledge foundation.[313]

Some major industrialized nations as well as many emerging economies have moved forward with aggressive low-carbon growth plans, many of which are linked to job creation and skills strategies. As noted by the International Labour Organization (ILO) in its foundational report comparing 21 such strategies, coherence between these two priorities is the key to a successful low-carbon transition.[314]

TABLE 16

SUMMARY OF LOW-CARBON PREPAREDNESS FOR LABOUR MARKET AND SKILLS

STRENGTHS & OPPORTUNITIES	WEAKNESSES & CONSTRAINTS
• Capacity of educational institutions • Emerging institutions (e.g., ECO Canada)	• Lack of reliable data on necessary skills and labour market needs

SCOPING SESSION

The NRT held a meeting to gather input on our scope, framing and analytical approach to low-carbon growth and competitiveness.

OTTAWA, ONTARIO
DECEMBER 14, 2010

Céline Bak
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Russell Mitchell Group Inc

Simon Baptist
Senior Economist
Vivid Economics

Dale Beugin
Policy Advisor
NRT

Joëlle Boutin
Research Associate
NRT

Matthew Bramley
Director, Climate Change
The Pembina Institute

Michael Cleland
Nexen Executive in Residence
Canada West Foundation

Len Coad
Director, Environment, Energy and Technology
The Conference Board of Canada

René Drolet
Director of Policy and Research
NRT

Meera Fickling
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Peterson Institute for International Economics

Isabella Kavafian
Research Associate
NRT

Marie-Josée Langlois
Secretary Trade Agreements and NAFTA Secretariat
Foreign Affairs and International Trade Canada

Alex Long
Senior Policy Advisor
NRT

David McLaughlin
President and CEO
NRT

Nadra Meigag
Administrative Assistant
NRT

Pierre Pyun
Director, Sector-A International Business Development, Investment and Innovation
Foreign Affairs and International Trade Canada

Joy Senack
Director, Strategic Integration
Natural Resources Canada

Robin Smale
Director
Vivid Economics

Paolo Utano
Sector Advisor, Infrastructure and Environment
Export Development Canada

Rick Whittaker
Vice-President Investments and Chief Technology Officer
Sustainable Development Technology Canada

Alexander Wood
Senior Director, Policy and Markets
Sustainable Prosperity

PUBLIC SECTOR CONSULTATION SESSION

The NRT held one public sector consultation session to gather the input of government representatives with respect to a low-carbon growth plan for Canada.

OTTAWA, ONTARIO
OCTOBER 6, 2011

Jill Baker
Senior Policy Advisor
NRT

Derek Baas
Principal, Corporate Research Department
Export Development Canada

Mark Berman
Director, Climate Change Research Department
Foreign Affairs and International Trade Canada

John D. Bonar
Deputy Director, North America Trade Policy
Foreign Affairs and International Trade Canada

John Cuddihy
Senior Policy Advisor
NRT

Lynda Danquah
A/Director, Trading Regimes
Environment Canada

René Drolet
Director, Policy and Research
NRT

Denise Edwards
Administrative Assistant
NRT

Stephen Entwisle
Manager, Compliance, Risk and Performance
Sustainable Development Technology Canada

Pamela Hay
Rio+20 Chief Coordinator, United Nations Division
Foreign Affairs and International Trade Canada

Pierre Pyun
Director, Clean Tech, Infrastructure and Life Sciences Practices Division, Global Business Opportunities Bureau
Foreign Affairs and International Trade Canada

Rachel Samson
Director, Current Analysis and Economic Research, Economic Analysis Directorate, Strategic Policy Branch
Environment Canada

Nicola Scahill
Policy Analyst, Strategic Transportation and Policy and Analysis
Environment Canada

Sumeet Tandon
Research Associate
NRT

REGIONAL STAKEHOLDER SESSIONS

The NRT held nine regional sessions in November and December 2011 to elicit stakeholder input on building Canada's low-carbon growth plan. Each session was jointly hosted by a regional partner: Canada West Foundation in Vancouver, Calgary, Saskatoon and Winnipeg; Mowat Centre in Toronto; Écotech Québec in Longueuil; and the Atlantic Canada Opportunities Agency in Saint John, Halifax and St. John's.

VANCOUVER, BRITISH COLUMBIA
NOVEMBER 3, 2011

Jill Baker
Senior Policy Advisor
NRT

Shawn Burns
President and CEO
Carbon Credit Corp.

John Cuddihy
Senior Policy Advisor
NRT

Roger Gibbins
President and CEO
Canada West Foundation

Sarah Goodman
VP, Business Development and Services
Tides Canada

Doug Hooper
CEO and Chair
Canadian Bioenergy Corporation

Roslyn Kunin
Director of BC Office
Canada West Foundation

Tim McEwan
President & CEO
Initiatives Prince George

Richard Prokopanko
NRT Member
Director, Government Relations
Rio Tinto Alcan Inc

Juergen Puetter
President
Blue Fuel Energy Corp.

John Richards
School of Public Policy
Simon Fraser University

Shawna Stirrett
Researcher
Canada West Foundation

Erich Schwartz
Founder and President
Greenomics

Ian Thomson
Partner
Waterfall Advisors Group

Jasper Van de Wetering
Environmental Manager
Lehigh Cement

CALGARY, ALBERTA
NOVEMBER 9, 2011

Jill Baker
Senior Policy Advisor
NRT

Rosemary Boulton
President
Kitimat LNG, Inc.

James Brown
Principal
Kaya Strategies

David Butler
Executive Director
Canadian Clean Power Coalition

Jenna Dunlop
Manager, Climate Change Policy
CAPP

John Cuddihy
Senior Policy Advisor
NRT

Gerry Ertel
Manager
Shell

Roger Gibbins
President and CEO
Canada West Foundation

Ken Hogg
Founder and President, Renewable Energy Solutions
Board Member of Alberta Energy Efficiency Alliance (AEEA)

Peter Howard
President and CEO
Canadian Energy Research Institute

Eddy Isaacs
CEO
Alberta Innovate

Brenda Kenny
President
Canadian Energy Pipeline Association

Robert Kulhawy
NRT Member
Executive Chairman
Calco Environmental Group

Lois Macklin
Manager of Foresight Research
Alberta Innovates

Peter May
Director, Sustainability
Viterra

Susan Nelson
Owner
OpenGate Properties Inc

Robert Page
TransAlta Professor of Environmental Management & Sustainability
University of Calgary

Shaun Peddie
Director, Policy
Western Economic Diversification Canada

Justin Pockar
Energy & Environment Coordinator
City of Calgary

Shawna Stirrett
Researcher
Canada West Foundation

SASKATOON, SASKATCHEWAN
NOVEMBER 2, 2011

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Enterprise Saskatchewan

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NRT

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NRT Member
Partner
McKercher LLP

Dick Carter
CEO
Crown Investments Corporation of Saskatchewan

John Cuddihy
Senior Policy Advisor
NRT

Brett Gartner
Research Fellow
Canada West Foundation

Roger Gibbins
President and CEO
Canada West Foundation

Laura Hartney
Future Growth Manager
City of Saskatoon

Lisette Mascarenhas
Senior Innovation Officer
SpringBoard West Innovations

Shawna Stirrett
Researcher
Canada West Foundation

WINNIPEG, MANITOBA
NOVEMBER 24, 2011

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NRT

James Battershill
Policy Analyst
Keystone Agricultural Producers

Norm Blagden
Vice President
Manitoba Trucking Association

Tom Carson
Director, Manitoba
Canada West Foundation

John Cuddihy
Senior Policy Advisor
NRT

John Fjeldsted
Executive Director
Manitoba Environmental Industries Association

Philip Gass
Project Manager
International Institute for Sustainable Development (IISD)

Roger Gibbins
President and CEO
Canada West Foundation

Thomas Henley
Executive Director
Natural Resources Institute
Associate Head and Associate Professor
University of Manitoba

Roslyn Kunin
Director, BC
Canada West Foundation

Ed Lohrenz
Vice President, Geo-Xergy Systems
Manitoba Geothermal Energy Alliance

Dan MacLean
President and CEO
Tundra Oil and Gas Partnership

Jane McDonald
Energy Policy Advisor
Manitoba Hydro

David McLaughlin
President and CEO
NRT

Dan McInnis
Assistant Deputy Minister
Government of Manitoba

Shawna Stirrett
Researcher
Canada West Foundation

TORONTO, ONTARIO
NOVEMBER 8, 2011

Ed Agar
Vice President Sales
Zerofootprint

Zel Artan
Eco-Social Entrepreneur

Jill Baker
Senior Policy Advisor
NRT

Michael Brooks
Chief Executive Director
Real Property Association of Canada

John Cuddihy
Senior Policy Advisor
NRT

Svetlana Diomin
Vice President, Policy
Ontario Energy Association

Denise Edwards
Administrative Assistant
NRT

Ken Elsey
President and Chief Executive Officer
Canadian Energy Efficiency Alliance

Garry Fortune
Consultant
Stanton Farms

Duncan Hawthorne
President and Chief Executive Officer
Bruce Power

Sasha Jacob
President and Chief Executive Officer
Jacob Securities

Robert Joshi
Executive Researcher in Residence, Energy Policy
Mowat Centre for Policy Innovation

Isabella Kavafian
Research Associate
NRT

Tatiana Khanberg
Energy Policy Associate
Mowat Centre for Policy Innovation

Robert Lyng
Acting Vice President, Sustainable Development
Ontario Power Generation

Dan McCarthy
Director, Energy, Environment Policy and Coordination,
Senior Vice-President, Policy and Programs
Atlantic Canada Opportunities Agency

David McLaughlin
President and CEO
NRT

Matthew Mendelsohn
Director
Mowat Centre for Policy Innovation

James Milway
Executive Director
Institute on Competitiveness and Prosperity

Tom Rand
Advisor, Cleantech and Physical Science
Venture Group
MARS

Nigel Taylor
Principal
Novus Environmental
Member, Environmental Committee
Ontario Energy Association

Martin Vroegh
Corporate Environment Manager
St. Marys Cement Inc.

Christine Wickett
Founder/Director
Seeds of Tomorrow

LONGUEUIL, QUÉBEC
NOVEMBER 23, 2011

Écotech Québec — 3e Forum des technologies propres

The NRT's Director of Policy and Research, René Drolet, moderated a panel session at Écotech Québec's 3e Forum des technologies propres entitled "The low-carbon economy or how to adapt to the winds of climate change."

Conference Chair

Denis Leclerc
President and CEO
Écotech Québec

Panelists

Philippe Bourke
PDG
Réseau national des conseils régionaux en environnement

Pierre-Luc Desgagné
Directeur principal planification stratégique
et affaires gouvernementales
Hydro Québec

Jean-Pierre Noël
Directeur principal, Énergies nouvelles
Gas Métro

Bruce Parry
Chef responsabilité sociale
Bombardier Aéronautique

Frédéric Verreault
Directeur des affaires corporatives et des communications
Chantiers Chibougamau

SAINT JOHN, NEW BRUNSWICK
NOVEMBER 29, 2011

Rob Belliveau
General Manager
Emera New Brunswick

Bill Borland
Vice President, Canadian Federal Programs
AMEC Earth Environmental

Bill Breckenridge
Director, Renewable Energy and Emerging Technologies,
Department of Energy
Government of New Brunswick

Andrew Carson
Legal Affairs & Government Relations, Irving Oil
Operations G.P.
Irving Oil

David Coon
Executive Director
Conservation Council New Brunswick Action

John Cuddihy
Senior Policy Advisor
NRT

Darwin Curtis
A/Executive Director
New Brunswick Climate Change Secretariat

Susan Farquharson
Executive Director
Canadian Rivers Institute

John Herron
President
Atlantica Centre for Energy

Paul Jordan
Community Planner
New Brunswick Climate Change Secretariat and Green
Economy Project

Isabella Kavafian
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Thomas MacDermott
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Efficiency NB

Dan McCarthy
Director, Energy and Environment Policy and Coordination
Atlantic Canada Energy Office
Atlantic Canada Opportunities Agency

David McLaughlin
President and CEO
NRT

William Stanley
Chairman
Atlantic Hydrogen Inc. (AHi)

David Rayworth
Consultant

Michael Riley
President
Riley Environment Limited

HALIFAX, NOVA SCOTIA
NOVEMBER 30, 2012

Jill Baker
Senior Policy Advisor
NRT

Elizabeth Beale
President & Chief Executive Officer
Atlantic Provinces Economic Council

Shawn Duncan
Associate Vice President
AECOM Canada

Darleen Duggan
President
Duggan International Group

John Cuddihy
Senior Policy Advisor
NRT

Denise Edwards
Administrative Assistant
NRT

Jacob Irving
President
Canadian Hydropower Association

Douglas Keefe
Executive Director
Fundy Ocean Research Centre for Energy

Lois Levine
Executive Director
Nova Scotia Research and Innovation Trust

Don McIver
Director of Research
Atlantic Institute for Market Studies

David McLaughlin
President and CEO
NRT

Ryan McLeod
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Atlantic Provinces Economic Council

Andrew Noseworthy
Senior Advisor to President – Energy
Atlantic Canada Opportunities Agency

Mark Parent
NRT Vice Chair

Steve Rankin
Director, External Relations
Maritime & Northeast Pipeline –
Spectra Energy Transmission

Jamie Thomson
Board Representative – Energy Issues Committee

Jennifer Wagner
Carbon Project Specialist
Carbon Sense Solutions Inc.

Shelley Wilcox
President and Chairman
Community Economic Development Investment Funds
Management Ltd. (CEDIF)

Peter Wright
Industry Development Officer,
Atlantic Canada Energy Office
Atlantic Canada Opportunities Agency

ST. JOHN'S, NEWFOUNDLAND AND LABRADOR
DECEMBER 2, 2011

Jill Baker
Senior Policy Advisor
NRT

Steve Bettles
Environmental Lead
Husky Energy Inc.

Harvey Brenton
Chief Executive Officer
Argentia Management Authority

Doug Cook
Chief Executive Officer
Petroleum Research Atlantic Canada

Gerald Crane
Director of Evidence
Office of Climate Change, Energy Efficiency
& Emissions Trading
Government of Newfoundland and Labrador

John Cuddihy
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NRT

Robert Dunphy
Senior Environment Advisor, Environment and Regulatory
ExxonMobil Canada Ltd.

Denise Edwards
Administrative Assistant
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Acting Director, Intergovernmental Affairs External
Relations Branch, Science and Policy Integration
Natural Resources Canada

Stephen Henley
Country Manager Canada
SubSea 7 Canada

Terry Hubele
Manager, Safety, Health, Environment and Security
ExxonMobil Canada Ltd.

Jackie Janes
ADM and Senior Policy Advisor
Office of Climate Change, Energy Efficiency &
Emissions Trading, Executive Council Government
of Newfoundland and Labrador

David King
President and Chief Executive Officer
Genesis Group Inc.

Dan McCarthy
Director
Atlantic Canada Opportunities Agency

Gerry O'Connell
Executive Director
Mining Industry NL

EXPERT STAKEHOLDER SESSIONS

During February 2012, the NRT convened experts to discuss energy, trade and innovation in the context of a low-carbon growth plan for Canada.

ENERGY // OTTAWA, ONTARIO
FEBRUARY 14, 2012

Martin Adelaar
Principal
ICF Marbek

Jill Baker
Senior Policy Advisor
NRT

Eric Beynon
Director, Strategy & Policy
IC0$_2$N

Jim Burpee
President & Chief Executive Officer
Canadian Electricity Association

Len Coad
Director, Energy, Environment and Technology Policy
The Conference Board of Canada

Paul Cobb
Senior Technical and Policy Advisor, Public Sector Services
Pembina Institute

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TRADE // OTTAWA, ONTARIO
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INNOVATION // OTTAWA, ONTARIO
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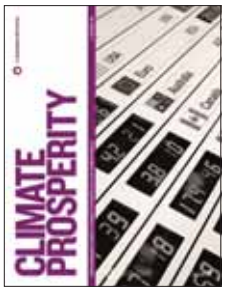
CLIMATE PROSPERITY

THE TIMELINE

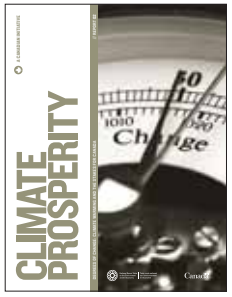
NATIONAL ROUND TABLE ON THE ENVIRONMENT AND THE ECONOMY

2010 → 2012



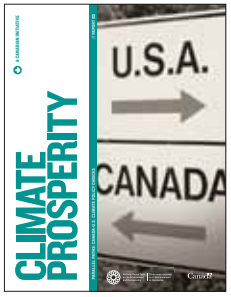
REPORT 01 //
MEASURING UP:
BENCHMARKING CANADA'S COMPETITIVENESS IN A LOW-CARBON WORLD

This report will assess Canada's capacity to be competitive in a new global low-carbon economy, by comparing us to other G8 nations in areas such as emissions and energy, skills, investment, innovation and governance.



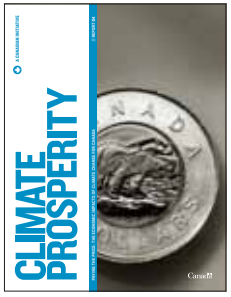
REPORT 02 //
DEGREES OF CHANGE:
CLIMATE WARMING AND THE STAKES FOR CANADA

This report will communicate the risks and benefits that a warming climate poses to Canada over the next one-hundred years in areas such as ecosystems, water resources, health, infrastructure and natural resource sectors and how adaptation can help.



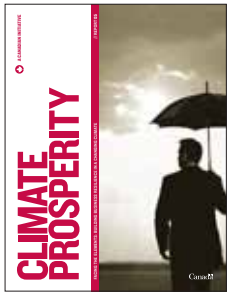
REPORT 03 //
PARALLEL PATHS:
CANADA-U.S. CLIMATE POLICY CHOICES

This report will examine Canadian climate policy choices based on potential U.S. courses of action and what this means for achieving Canadian environmental goals at the least economic cost.



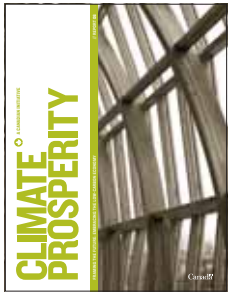
REPORT 04 //
PAYING THE PRICE:
THE ECONOMIC IMPACTS OF CLIMATE CHANGE FOR CANADA

This report will provide, for the first time, national economic costings of the impact of climate change on Canada, together with a detailed look at three key sectors.



REPORT 05 //
FACING THE ELEMENTS:
BUILDING BUSINESS RESILIENCE IN A CHANGING CLIMATE

/ CASE STUDIES
// BUSINESS PRIMER
/// ADVISORY REPORT
These three reports set out what Canadian businesses can and should do to prepare and take action to manage the risks and opportunities of a changing climate, and how governments can help.



REPORT 06 //
FRAMING THE FUTURE:
EMBRACING THE LOW-CARBON ECONOMY

Building on previous reports in the series, this report will lay the foundation for a low-carbon growth plan for Canada, putting forward a framework that will position Canada to harness the opportunities and manage the risks inherent in the global transition to a low-carbon economy.

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