



**WORKING GROUP ON  
CLEAN TECHNOLOGY,  
INNOVATION AND JOBS**

**FINAL REPORT**  
September 2016

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## ABBREVIATIONS

|                 |   |
|-----------------|---|
| AFI             | Aboriginal Financial Institutions                                     |
| ARENA           | Australian Renewable Energy Agency (Australia)                        |
| ARPA-E          | Advanced Research Projects Agency-Energy (United States)              |
| BCIP            | Build in Canada Innovation Program                                    |
| BDC             | Business Development Bank of Canada                                   |
| CCEMC           | Climate Change and Emissions Management Corporation                   |
| CO <sub>2</sub> | carbon dioxide  |
| COSIA           | Canada's Oil Sands Innovation Alliance                                |
| CVCA            | Canadian Venture Capital & Private Equity Association                 |
| ECCC            | Environment and Climate Change Canada                                 |
| ECN             | Energy Research Centre of the Netherlands                             |
| EDC             | Export Development Canada   |
| EOR             | enhanced oil recovery   |
| FPT             | federal-provincial-territorial  |
| GAC             | Global Affairs Canada   |
| GCII            | Global Cleantech Innovation Index                                     |
| GDP             | gross domestic product  |
| GHG             | greenhouse gas  |
| ICT             | information and communication technologies                            |
| IEA             | International Energy Agency   |
| INAC            | Indigenous and Northern Affairs Canada                                |
| IRAP            | Industrial Research Assistance Program                                |
| ISED            | Innovation, Science and Economic Development Canada                   |
| kWh             | kilowatt hour   |
| LCEGS           | low carbon environment goods and services                             |
| LCICG           | Low Carbon Innovation Co-ordination Group (United Kingdom)            |
| MUSH            | municipalities, universities, schools and hospitals                   |
| NAICS           | North American Industry Classification System                         |
| NCE             | Networks of Centres of Excellence                                     |
| NIOs            | National Indigenous Organizations                                     |
| NRCan           | Natural Resources Canada  |
| OECD            | Organisation for Economic Co-operation and Development                |
| PSPC            | Public Services and Procurement Canada                                |
| RDAs            | Regional Development Agencies   |
| R&D             | research and development  |
| RD&D            | research, development and demonstration                               |
| SBIR            | Small Business Innovation and Research Program (United States)        |
| SmartICE        | Sea-ice Monitoring and Real-Time Information for Coastal Environments |
| SMEs            | small and medium-sized enterprises                                    |
| SR&ED           | Scientific Research & Experimental Development                        |
| STEM            | science, technology, engineering and mathematics                      |
| SDTC            | Sustainable Development Technology Canada                             |
| VPP             | virtual power plants  |

# EXECUTIVE SUMMARY

## Overview

On March 3, 2016, Canada's First Ministers signed the Vancouver Declaration on Clean Growth and Climate Change, and established four working groups to develop options to support the development of a Pan-Canadian Framework on Clean Growth and Climate Change. This is the final report of the Working Group on Clean Technology, Innovation and Jobs (the Working Group). First Ministers directed the Working Group to report to Ministers of Innovation and Economic Development with options on how to stimulate economic growth, create jobs, and drive innovation across all sectors to transition to a low-carbon economy, leveraging regional strengths.

As requested, the Working Group considered policy tools required to bring new and emerging technology and innovations to market, as well as to sustain a competitive economy, reduce greenhouse gas (GHG) emissions, encourage growth and investment, and increase exports of clean technologies, services and expertise. Solutions and actions aimed at achieving pan-Canadian objectives have to take regional approaches into account because economic strengths, resource endowments, needs and challenges vary by region.

The Working Group process involved active participation from all jurisdictions in Canada; from April to September 2016 over 20 in-person Working Group meetings or teleconferences were held. The Working Group sought input from a broad base of Canadians and clean technology, innovation and growth experts from industry, academia, think tanks, financial institutions and government departments. As of mid-September, over 700 public submissions were received through Environment and Climate Change Canada's Let's Talk Climate Action portal. A roundtable involved over 50 national stakeholder organizations from Canada's transportation, natural resources, construction, agriculture, energy and public utilities sectors. Working Group members participated in regional and provincial roundtables and drew on the knowledge that had been gathered by previous consultations in some jurisdictions. A further, important feature of the process was regular communication with National Indigenous Organizations (NIOs), representing Canada's First Nations, Métis and Inuit peoples, to obtain their valuable input.

The Working Group supplemented these consultations with its own analysis of available literature on clean technology, focusing on best practices and experiences in Canada and abroad. This work has culminated in a series of 34 options for consideration by Ministers.

The Working Group was unanimous in its assessment that climate change has the potential to threaten Canada's ecosystems, communities and economy. In response, an integrated, economy-wide approach to create jobs and drive innovation across all industrial sectors is required to grow Canada's economy, achieve stated GHG emission targets and improve Canada's overall environmental performance.

At the same time, taking action on climate change and environmental challenges could also capture new and emerging economic opportunities and ensure the future sustainability of Canada's industries and communities. The global demand for clean technologies is significant and increasing. In 2012, the global market size for clean technologies, broadly defined and produced by all industry sectors, was estimated to be approximately \$5.8 trillion, and growing at a rate of over 3% per year. To effectively compete in this global marketplace and capitalize on the current and future economic opportunity, Canada needs a step change in its investment and approach to clean technology development, commercialization and adoption.

Canada also has the potential to strengthen its performance in clean technology innovation. The World Wildlife Fund's Global Cleantech Innovation Index (GCII) ranks Canada 18<sup>th</sup> out of 40 countries on the clean technology-specific drivers of innovation, lagging behind the United States, United Kingdom and

Australia. Other countries, such as South Korea and China, are expanding their clean technology exports. The window of opportunity exists for Canada to create the conditions for new clean technology investment and exports and seize growing global markets for clean technology goods, services and processes.

While the need to mobilize clean technology innovation, commercialization and adoption is commonly recognized, differences in emphasis and priorities across Canada reflect the unique strengths, skills, resources and economic structure of individual provinces, territories and regions.

To address its mandate to develop options on stimulating economic growth while reducing GHG emissions, the Working Group focused its work on the following four core themes:

- Building and strengthening early-stage clean technology innovation and research, development and demonstration (RD&D);
- Accelerating clean technology commercialization and growing Canada's commercial capacity in clean technology;
- Fostering greater clean technology adoption within Canada; and
- Strengthening and sustaining collaboration in support of clean technology and clean growth, and creating metrics for success.

## Building Early-Stage Innovation

To become a leader in the development and deployment of clean technologies, Canada needs a strong pipeline of innovative ideas. There is value in seeking to coordinate and focus future government investments and activities in clean technology RD&D in areas that would most effectively help Canada to meet its climate change goals and also create economic opportunities and expand global market opportunities.

Efforts to coordinate and focus this work must go beyond governments and involve industry, stakeholders, academia and Indigenous Peoples. Collaboration of all participants in the innovation process are essential to this goal. Developing clean technology roadmaps could encourage greater alignment of research priorities while focusing government RD&D on key priorities. Canada must leverage its domestic strengths, which vary by region, in this process. Developing international partnerships around these priorities would create new economic opportunities, build areas of shared expertise and foster stronger bilateral relations.

New initiatives are needed to strengthen Canada's position as a leader in the development and commercialization of disruptive or "breakthrough" technologies. Well-defined "mission specific" approaches that target areas of highest impact and potential, and "grand challenges" with ambitious targets for economic and environmental benefits could spur innovative clean technology concepts.

## Accelerating Commercialization and Growth

Commercialization of clean technologies and building of commercial capacity are essential to meet Canada's economic and environmental goals. Given Canada's small domestic market, Canadian firms must look to highly competitive international markets to achieve scale. Building globally competitive clean technologies requires globally competitive talent, unhindered access to capital and resources to demonstrate the commercial viability of products, and strong international networks that facilitate the cross-border flow of clean technology goods and services. At present, there are many gaps in financing, skills development, commercial capacity and export development.

Canadian clean technology producers and researchers are currently confronted by a myriad of programs and services, at the federal, provincial and territorial level. Streamlining and integrating access to support programs and services is a priority for companies and essential to building commercial capacity in this area.

Compared with other technology areas, clean technologies face unique challenges and often take longer to get to market, making access to “patient capital” more important to successful commercialization. While federal and provincial governments already have a range of supports in place, key needs exist in terms of accessing venture capital, as well as working capital and support for first, large-scale commercial projects and deployments.

Further development of clean technologies could create new opportunities in Canada’s traditional resource sectors and new employment opportunities. Strengthening support for core science, technology, engineering and mathematics (STEM) skills, as well as business leadership and technical skills, is important to accessing these opportunities, as is expeditious immigration of highly qualified personnel.

Indigenous Peoples have the potential to be agents of change in the transition to a low-carbon economy. Governments must strengthen skills, as well as commercial and community capacity, to take advantage of this opportunity.

Building stronger companies and commercial capacity in all of Canada’s regions is essential to taking advantage of new market opportunities. Support for new technology start-ups, through incubators and accelerators, is important to this effort.

A strong, focused Canadian clean technology export strategy is needed to position Canada in growing and emerging global markets. As part of this effort, there is value in Canada seeking to take on a stronger, leadership role in the development and implementation of international standards for clean technology.

## **Fostering Adoption**

Canada’s performance on clean technology adoption by industry has significant room for improvement. Even among Canadian companies that regularly adopt advanced technologies, clean technologies are the least likely to be adopted. Effective adoption of Canadian clean technologies is needed to achieve Canada’s climate change goals, build a climate-resilient infrastructure and create a strong Canadian first market when heading to global markets.

There is significant potential for Canadian governments to “lead by example” as early adopters of clean technology. Government could play an essential role as a first or “reference customer” for Canadian clean technology goods, services and processes. A consistent theme in stakeholder advice to the Working Group was that having a “first sale” in Canada would boost firms’ chances of securing sales abroad.

Beyond direct federal and provincial government operations, other bodies, such as municipalities and publicly regulated utilities, could become significant markets for and adopters of clean technology.

Done effectively, the adoption of clean technology could be a mechanism for improving environmental circumstances and creating economic opportunity in northern, remote, and Indigenous communities. Effective engagement and collaboration with Indigenous Peoples is essential to this effort.

Encouraging dialogue between regulators and industry could improve certainty in clean technology development and allow for more effective and responsible regulation. Certification programs for clean technology could also help build consumer and business confidence in new technologies.

## **Strengthening Collaboration and Metrics for Success**

An effective approach to clean technology development, commercialization and adoption in Canada requires coherent, collaborative and focused policy and program approaches. This is true within individual governments, as well as between Canadian jurisdictions. A successful collaborative approach between governments should take into account regional strategies and jurisdictional responsibilities.

The Working Group process has proved to be an effective one for intergovernmental dialogue and engagement. There is value in building on this process and creating a mechanism for sustained and routine intergovernmental dialogue on clean technology and clean growth. Such a mechanism would eliminate duplication of efforts and identify gaps in support for clean technology development. Making this issue a regular item of discussion at future meetings of Ministers of Innovation and Economic Development, and setting a clear vision and direction for it, would be helpful. Engaging Indigenous Peoples, industry and stakeholders as a routine component of this process would be important.

Data on Canada's clean technology capacity and potential are remarkably inadequate. Building better data, and clear metrics for tracing the impact of government activities, would properly focus these activities and ensure that they achieve intended, meaningful results.

## Options

Building upon these findings and observations, the Working Group offered the following options for the consideration of Ministers:

### Building Early-Stage Innovation

#### Clean Technology Research, Development and Demonstration (RD&D)

1. **Coordinate and focus government investments and activities in clean technology RD&D to maximize Canada's progress towards specific goals**, through a process that:
  - » Identifies priority areas through collaboration with experts from government departments and labs, Indigenous Peoples, industry, academia and other stakeholders; and
  - » Prioritizes objectives based on regional strengths and the potential to reduce GHG emissions and other negative environmental impacts, meet community and social needs, and expand economic opportunities and jobs for Canadians.
2. **Strengthen clean technology RD&D support through existing organizations** by:
  - » Increasing the focus on, and allocating specific funding for, clean technology development through federal and provincial granting councils, research councils and labs;
  - » Recapitalizing Sustainable Development Technology Canada's SD Tech Fund and similar provincial/territorial programs; and
  - » Enhancing the coordination between these programs and reducing gaps, with particular attention to small demonstration project funding.
3. **Facilitate stronger networks** through a greater focus on clean technologies in broader initiatives that support centres of excellence, communities of interest, and partnerships among researchers, entrepreneurs and industry, with the goals of advancing and demonstrating emerging technologies and supporting commercialization in key opportunity areas.
4. **Strengthen Canada's participation in international clean technology RD&D activities** and position Canada as a leader in this area. This would build on Canada's Mission Innovation objectives and require improved collaboration between Canadian researchers/companies and strategic international partners.
5. **Direct government funding agencies and labs to enhance collaboration with Indigenous Peoples** on clean technology and clean growth RD&D, and encourage industry and academia to responsibly integrate traditional knowledge in a way that creates new opportunities for Indigenous communities, and conforms to ethical standards for research with Indigenous Peoples.



## Breakthrough Research and Development

6. **Create a breakthrough technology development initiative** that would advance high-risk clean technology research in areas that have the potential to radically reduce GHG emissions and other pollutants. This should draw upon international best practices from models such as the advanced research projects agencies in the United States, and this could utilize world-leading technology experts to define project priorities, and employ a design that encourages a regular renewal of ideas and researchers.
7. **Create “Grand Challenge” initiatives** that encourage new “mission-oriented” research to address specific identified clean technology and environmental performance issues. Drawing on best practices from models such as the XPRIZE Foundation, competitive calls for proposals would focus on specific, desired outcomes that build upon research capacities, issues and strengths. An early “Grand Challenge” area could be to identify and develop, in partnership with Indigenous Peoples and northern regions, cost-competitive and sustainable local clean energy systems that would reduce the reliance of northern and remote communities on diesel generation and heating.

## Accelerating Commercialization and Growth

### Access to Financing

8. **Create a “no-wrong door” approach to accessing government programs** so that clients, including Indigenous businesses, can access the full suite of federal-provincial-territorial (FPT) clean technology programming, regardless of their initial point of entry. Priorities include: funding programs and agencies coordinating their client engagement and ensuring a seamless handoff of clients as they advance through the innovation spectrum, drawing on the lessons learned through efforts such as the Government of Canada’s Accelerated Growth Service pilot; and reducing duplication (e.g., through joint application processes and shared due diligence) and gaps between programs.
9. **Promote greater availability of venture capital for clean technology development** through specific, coordinated federal and provincial measures, including:
  - » A new initiative that draws upon lessons learned and experience from other venture capital support programs and has a specific clean technology focus, longer investment time horizons and tailored incentives to encourage private-sector investment in more capital-intensive technologies, including by strategic corporate investors; and
  - » Business Development Bank of Canada (BDC) and Export Development Canada (EDC) expanding support for early and late-stage private sector-led funds focused on clean technology, and increasing direct investment in high-potential clean technology producers.
10. **Establish initiatives to increase the availability of working and growth capital** to meet the needs of later-stage clean technology providers, including through the expanded support of BDC and EDC in this area, together with tailored management advisory services.
11. **Create new instruments that leverage and mobilize private-sector investment in large commercial-scale demonstration and deployment projects**, by providing direct contributions and other forms of support (e.g., loan guarantees) to help address perceived risks associated with these projects. This could include expanding support of BDC and EDC, as well as leveraging provincial support where available, and drawing from international practices including the U.S. Department of Energy’s Loan Guarantee Program.
12. Work with Ministers of Finance, as well as industry, stakeholders and the financial community, to **identify and evaluate other patient capital tools** and ensure that an appropriate regulatory environment exists to support new mechanisms of social enterprise, including crowdfunding, green bonds, green banks, as well as the use of YieldCos and other methods for pooling and securitizing clean technology assets.

13. **Refer to Ministers of Finance for their consideration stakeholder proposals relating to the use of tax policy** to encourage clean technology development and commercialization (e.g., angel investor tax credits, flow-through shares, etc.).

### Skills and Jobs

14. Work with Ministers of Immigration to **expedite immigration of highly qualified personnel** needed to make Canada a global leader in welcoming international talent and expand clean growth capacity.
15. Work with Labour Markets, Employment and Skills Ministers to **create clean growth talent plans** that ensure Canada has the right talent to support job creation and the transition to a low-carbon economy, including for under-represented labour market groups. Priority areas include:
- » Strengthening skills in Science, Technology, Engineering and Mathematics (STEM), and associated trades;
  - » Building stronger business leadership and management skills to lead companies to rapidly grow and export clean technologies; and
  - » Supporting the development of skills needed for the adoption, installation and maintenance of clean technologies, including in Indigenous communities.
16. **Recognizing the potential for Indigenous Peoples to be agents of change in the transition to a low-carbon economy, work with other relevant Ministers** including those responsible for Indigenous affairs and Indigenous organizations to:
- » Develop initiatives to strengthen skills and entrepreneurial and community-based capacity in clean technologies;
  - » Facilitate mentorship both within and among communities, benefitting from the experience of communities that have implemented clean technologies; and
  - » Ensure Indigenous businesses have needed, effective access to capital to support innovation and development.

### Commercial Capacity

17. **Direct FPT economic development departments and agencies to collaborate and develop strategies** to further strengthen access to capital, talent and markets for companies developing and providing clean technology products, services and solutions, including Indigenous businesses.
18. **Strengthen support for clean technology start-ups and entrepreneurs through incubators and accelerators**, ensuring that they benefit from strong regional linkages and can take full advantage of regional research and business capacity. This could include increasing BDC's convertible notes program for early-stage clean technology developers in high-performing accelerators.

### Exports

19. Work with Ministers responsible for trade promotion to **strengthen clean technology export initiatives**. Priorities in this area are:
- » Building Trade Commissioner knowledge of Canadian clean technology opportunities;
  - » Engaging in trade missions focused on clean technology, including industry-led missions;
  - » Gathering better market intelligence, addressing key market access barriers and improving export marketing and branding; and
  - » Strengthening export financing mechanisms, such as through EDC.

20. Direct the Standards Council of Canada to **take a leadership role in international standards-setting processes for new clean technologies**, and ensure that Canada's clean technology capacity shapes future international standards.

## Fostering Adoption

### Governments Leading By Example

21. Work in collaboration with Ministers of Treasury Board, Government Operations and Public Services to **develop an action plan for greening the operations of government departments, agencies and entities** that would:
- » Include consideration of a target of carbon neutral governments by 2030;
  - » Set targets for the reduction of other environmental impacts;
  - » Include set-asides, as appropriate, that direct a proportion of procurement budgets for clean technology goods and services; and
  - » Incorporate lifecycle assessment into procurement practices where appropriate.
22. **Create a first deployment program** that allows governments to seek new clean technology solutions to meet operational needs. Building on existing programs, including the federal Build in Canada Innovation Program, this could involve directing a portion of government procurement budgets to support the development of new innovations that would provide solutions to departmental challenges, and ensure successful technologies transition to general government procurement processes. The U.S. Small Business Innovation and Research Program is a potential model. These approaches could also be extended to facilitate linkages between large company end-users and small company providers, and promote scale-up of these solutions.
23. Work with Ministers responsible for municipal and urban affairs and, where appropriate, Ministers of Infrastructure to **encourage municipalities to increase procurement and adoption of clean technologies** and urban planning processes that support clean growth.
24. Work with Energy Ministers to establish regulatory frameworks that **encourage more rapid development, demonstration and adoption of clean technologies by publicly regulated utilities**. Priorities include:
- » Improved inter-utility and regional (including Canada-U.S.) collaboration on the development of infrastructure that supports clean technology adoption; and
  - » Strengthened collaboration between utilities and Indigenous communities in the deployment of clean technology solutions.

### Northern, Remote, and Indigenous Communities

25. In collaboration with other relevant Ministers, including those responsible for Indigenous affairs, **support northern, remote, and Indigenous communities in adopting clean technologies** in a way that improves economic outcomes and supports energy, food and water security. Specific priorities in this regard include:
- » Reducing reliance on diesel fuel and heating oils;
  - » Ensuring that communities have the capacity to adopt and adapt clean technologies; and
  - » Developing business models that support community ownership and operation of clean technology deployments.

### Consumer and Industry Adoption

26. Work with Environment and Finance Ministers to **support the implementation of industry-specific GHG mitigation measures that encourage clean technology adoption and development in Canada**, leverage Canadian

strengths and create jobs for Canadians. Priorities in this regard are the options proposed by the Working Group on Specific Mitigation Opportunities, particularly those related to transportation, the built environment and building codes, electricity and extractive industries.

27. **Encourage and support a new working relationship between regulators and industry** that encourages early dialogue and guidance on evolving and new clean technologies, includes mechanisms to validate their performance and safety, and promotes performance-based regulations that are not overly prescriptive.
28. **Promote the development of purpose-built lending products to foster small and medium-sized enterprise adoption of clean technologies**, including energy efficiency and renewable energy installations. Repayment terms could be based on the energy savings generated through the implementation of these technologies.
29. **Ensure that Canada has visible and effective certification programs** to ensure consumer and business confidence and support green procurement.

## Strengthening Collaboration and Metrics for Success

### Collaboration

30. **Create federal, provincial, territorial, and regional Clean Growth Innovation Hubs** to improve intra- and intergovernmental policy and program coordination and sharing of data and best practices, and to act as a key mechanism for engagement with Indigenous Peoples, industry, other stakeholders and international partners. These hubs could coordinate the implementation of options identified in this report, including the process of identifying and tracking progress on priority technology areas (option 2), ensuring a no-wrong door approach to client management (option 9), the development of regional economic development strategies (option 18) and the development of a pan-Canadian data strategy (option 33).
31. **Sustain intergovernmental momentum and action on clean technology and clean growth** by:
  - » Making clean technology and clean growth a standing agenda item for future meetings of Ministers of Innovation and Economic Development;
  - » Establishing an FPT working group at the officials level to support Ministers in the design and implementation of the Pan-Canadian Framework on Clean Growth and Climate Change and facilitate ongoing collaboration; and
  - » Continuing coordination with other FPT ministerial tables and departments, including those responsible for energy and the environment, to ensure policy, program and regulatory alignment.

### Data and Metrics

32. **Establish quantitative and qualitative metrics to effectively track and assess the performance of government investments** related to clean technology in terms of the economic, environmental and social impacts.
33. **Establish a Pan-Canadian data strategy** to improve the public availability of information on clean technology activity in Canada, including on labour markets, to support and inform performance metrics and public- and private-sector decision-making and foster innovation.

### Vision Statement

34. **Develop a Pan-Canadian vision statement on clean technology and clean growth** that commits to improved program and policy collaboration and coordination across jurisdictions and institutions, affirms this area is a priority for all jurisdictions, emphasizes a whole-of-government approach to clean technology development and deployment, sets out goals and objectives and results measurement for clean technology and clean growth in Canada, recognizes cross-cutting opportunities and differences, and reflects the important contribution from Indigenous Peoples in this area.

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# **CHAPTER 1**

## **THE WORKING GROUP'S MANDATE AND APPROACH**







# CHAPTER 1 THE WORKING GROUP'S MANDATE AND APPROACH

## 1.1 Mandate

On March 3, 2016, First Ministers signed the Vancouver Declaration and committed to jointly developing a Pan-Canadian Framework on Clean Growth and Climate Change. First Ministers created four working groups to develop reports with options for action in the following areas:

- Clean Technology, Innovation and Jobs
- Carbon Pricing Mechanisms
- Specific Mitigation Opportunities
- Adaptation and Climate Resilience

The resulting options would be considered in a Pan-Canadian Framework. Federal, provincial and territorial Ministers would consider the working groups' reports and provide their recommendations to First Ministers.

This document is the Final Report to Ministers of Innovation and Economic Development of the Working Group on Clean Technology, Innovation, and Jobs ("the Working Group"). The Working Group's mandate was to develop options on how to stimulate economic growth, create jobs and drive innovation across all sectors to transition to a low-carbon economy, leveraging regional strengths. Ministers of Innovation and Economic Development oversaw this work, which included consideration of a range of policy tools to:

- Bring new and emerging technology and innovations to market;
- Sustain a competitive economy;
- Reduce greenhouse gas (GHG) emissions;
- Encourage growth and investment; and
- Increase exports of clean technologies, services and expertise.

This report reflects the work and discussions of the Working Group from April to September 2016; during this period it held over 20 in-person meetings or teleconferences.

## 1.2 Methodology and Consultations

To develop its options for action, the Working Group initially gathered input from Working Group members across the country (see **Appendix A** for a list of members) and established a working definition of "clean technology" to inform its investigations and analysis. It then reviewed and assessed relevant domestic and international literature, data and other evidence including international best practices to identify those that would be most applicable in a Canadian context. Next, it developed a framework for approaching and fulfilling its mandate. Finally, and most importantly, it conducted an extensive consultation process across the country, using a variety of vehicles and techniques, to hear the views and suggestions of a wide range of stakeholders. The Working Group also met regularly, by phone or in person, with designated representatives of National Indigenous Organizations (NIOs).

### Defining and Measuring Clean Technology Activities

The first task of the Working Group was to develop a working definition of "clean technology." Members agreed that clean technology is not a single industry sector. Rather, it includes services, processes, products

and activities that span all sectors of the economy, including activities that are generally understood to be clean technology (such as clean energy, emission-reducing technologies) and other technologies that directly reduce environmental impacts; and the many supporting technologies that also reduce energy use and/or support energy efficiency (e.g., new lightweight materials and smart grid and sensing technologies).

This broad scope makes it difficult to quantify the specific scale and extent of clean technology activity in Canada. The Working Group relied on two main domestic data sources: recent surveys from Analytica Advisors and older surveys from Statistics Canada (with the most recent from 2004). Both sources define and measure clean technologies, products and services in a different manner than the Working Group. However, despite their limitations, they are useful as early indicators of the size and scope of clean technology activity, and are useful in understanding emerging trends and the challenges and opportunities facing producers and adopters. One thing is clear: clean technology is growing in Canada.

### **Consulting with Stakeholders and National Indigenous Organizations**

To identify challenges and opportunities, along with concrete options for action that would result in real and positive environmental and economic change, the Working Group sought input from a broad base of Canadians and clean technology, innovation and growth experts from industry, academia, think tanks, financial institutions and government departments.

Obtaining the input of Indigenous Peoples was a priority for the Working Group. Partnering with Indigenous Peoples to reduce emissions and other harmful pollutants brings mutual benefits for Indigenous communities and other jurisdictions, and is essential for meeting Canada's overall clean growth objectives. The Vancouver Declaration committed to “work collaboratively with Indigenous Peoples across the country” and to “advance efforts to eliminate the dependency on diesel in northern, remote, and Indigenous communities – and use renewable, clean energy as a replacement.” To reflect perspectives from Canada's First Nations, Métis and Inuit peoples, and their unique clean growth needs and opportunities, the Working Group held three in-person meetings with NIOs as well as weekly telephone calls during the consultation process.

The Working Group recognized the importance of including traditional industry sectors in its consultation activities. It sought input from industry associations representing natural resources, energy, manufacturing, forestry, agriculture and aquaculture, transportation and construction. As the largest emitters of GHGs, clean technology is critical to their current business practices, from adopters working to improve their competitiveness and reducing their GHG emissions intensity, to developers seeking to commercialize and export products and services to global markets. Understanding the barriers and hurdles they face is essential to developing, commercializing and adopting appropriate and effective new clean technology solutions.

In June 2016, a national industry roundtable in Toronto involved about 50 representatives from the transportation, natural resources, construction, agriculture, energy and public utilities sectors. Representatives from NIOs participated in this event to hear directly from industry. Many Working Group members also held provincial or regional roundtables to solicit input from local experts and private-sector stakeholders. British Columbia, Alberta and Ontario held specific consultation sessions while New Brunswick, Nova Scotia, Prince Edward Island and Newfoundland and Labrador collectively held a regional roundtable, as did Yukon, Northwest Territories and Nunavut in the North. Quebec, Manitoba and Saskatchewan informed the Working Group of discussions and observations recently completed in their jurisdictions that were relevant to the Working Group's activities. Quebec, for example, recently held consultations related to its Climate Change Action Plan, Energy Policy and development of its cap and trade system.

A number of Working Group members attended special ad hoc sessions with large stakeholder groups. British Columbia organized two sessions: one with the Canadian Cleantech CEO Alliance and the other with stakeholders from industry and academia. The MaRS Discovery Centre, one of the world's largest urban innovation hubs, organized and hosted three sessions with clean technology chief executive officers, financing professionals and policy experts. The sessions focused on clean technology financing issues and other related issues that clean technology producers face as they grow.

Collectively, these sessions created an opportunity for industry and government officials to discuss new economic, environmental and social opportunities for Canadian households and firms as a result of the growth in clean technologies and the shift to a low-carbon economy. Where needed, the Working Group followed up with bilateral meetings with individual stakeholders and industry associations to clarify or expand suggestions, seek additional feedback and verify the core messages.

The Working Group received over 700 submissions, from individuals, companies and associations, via Environment and Climate Change Canada's (ECCC) interactive web portal, Let's Talk Climate Action. As of mid-September 2016, the portal received over 3,400 submissions in total. The Working Group reviewed submissions to identify common themes and concerns and uncover new and innovative ideas for action.

The Working Group also sought to tap into the expertise located within the federal government. Ten federal government departments completed information questionnaires and participated in bilateral discussions on analysis and specific options for action. These included Natural Resources Canada (NRCan), ECCC, Transport Canada, Indigenous and Northern Affairs Canada (INAC), Public Services and Procurement Canada (PSPC), Global Affairs Canada (GAC), Infrastructure Canada, Innovation, Science and Economic Development (ISED) Canada, Agriculture Canada and Fisheries and Oceans Canada. Provinces and territories conducted similar exercises in their own jurisdictions.

In addition, several federal Crown corporations made substantial contributions to the Working Group's understanding of the complexities of clean technology project and program financing. In particular, the Business Development Bank of Canada (BDC), Export Development Canada (EDC) and Sustainable Development Technology Canada (SDTC) provided core information on emerging investment opportunities, existing government financial support programs and current programming gaps.

## 1.3 Framework and Report Organization

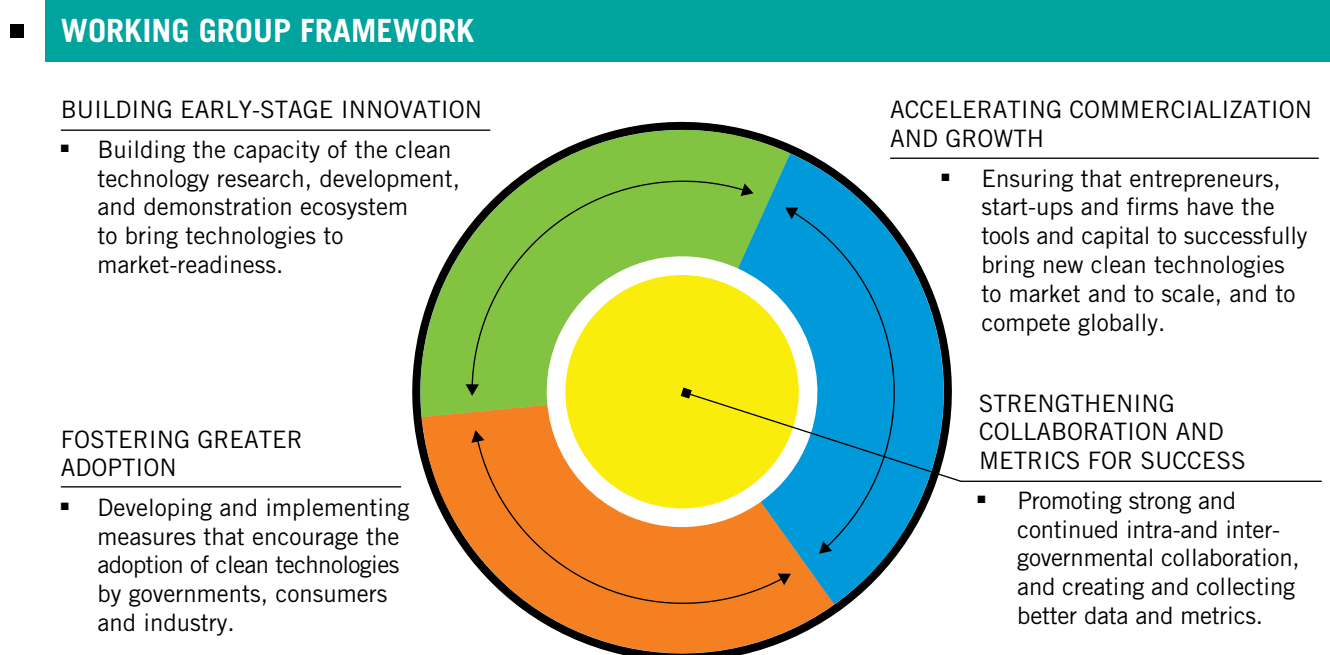
The Working Group developed a framework to structure its deliberations, research and analysis, consultation process, development of options for action, and, ultimately, the organization of this report. The framework is based on the "innovation continuum" (National Science Foundation, 2010), which broadly describes the stages through which a new technology must pass, from idea generation to competitive market. **Figure 1.1** depicts this continuum graphically. For practical purposes, and to appreciate challenges and opportunities at each key point or milestone in the innovation process, the Working Group segmented this continuum into several core components. This allowed it to develop more targeted options to improve Canadian industry performance in key areas.

Notwithstanding this segmentation, the Working Group strongly believes that innovation should be seen as an integrated and cohesive process; success is needed at all stages for new technologies to evolve from mere ideas to market success. The Working Group also recognizes that collaboration and effective engagement is essential to innovation and relevant to all stages of the innovation continuum. As a result, the Working Group's activities, discussions and analysis focused on the following four themes:

- *Building Early-Stage Innovation*: building the capacity of the clean technology research, development, and demonstration (RD&D) ecosystem to bring technologies to market-readiness.

- *Accelerating Commercialization and Growth*: ensuring that entrepreneurs, start-ups and firms have the tools and capital to successfully bring new clean technologies to market and to scale, and to compete globally.
- *Fostering Greater Adoption*: developing and implementing measures that encourage the adoption of clean technologies by governments, consumers and industry since positive impacts on the economy and the environment can only be realized if technologies are actually used.
- *Strengthening Collaboration and Metrics for Success*: promoting strong and sustained intra- and intergovernmental collaboration to better support clean technology and clean growth, and creating and collecting better data and metrics that demonstrate the effectiveness and success of private- and public-sector initiatives supporting clean technology innovation, commercialization and adoption.

**Figure 1.1**



Chapters 3 through 6 explore these areas in detail by reviewing and analyzing available domestic and international literature and data, the views and proposals of stakeholders and NIOs, and the most relevant international best practices for the Canadian context. Synthesizing the evidence for the most pressing issues in each area, the Working Group examined Canada's performance, identified the challenges and opportunities and, most importantly, proposed a suite of concrete options for action. It also identified the expected timeframe required for these actions to have an impact on Canada's economic and environmental performance and, where applicable, their alignment with Canada's international commitments on climate change for 2030.

The ultimate goal of the proposed options for action is to link and coordinate research and development (R&D) efforts across the innovation continuum, to ensure that developers and researchers are working on the same problems for which end-users and markets are demanding solutions. Better coordination can create the conditions for greater commercialization, which allows firms to grow and become globally competitive.

## **CHAPTER 2**

### **SETTING THE STAGE**





## CHAPTER 2 SETTING THE STAGE

By addressing gaps and fostering coordination, well-developed solutions can reach markets and begin to reverse the negative drivers of climate change and environmental degradation.

### 2.1 The Link between Clean Technology, Clean Growth and Climate Change

Ocean and air temperatures are increasing, sea levels are rising, snow cover is declining, precipitation patterns are shifting, and extreme weather events are occurring more frequently as greenhouse gas (GHG) emissions continue to rise. As a result, Canada is expected to experience greater swings in temperature and precipitation, and more heat waves, flooding and coastal erosion due to storm surges. Northern areas are the most significantly affected, facing reduced ice conditions, unstable and thawing permafrost, land and water contamination, and changes in wildlife and vegetation that are already affecting the traditional ways of life of Indigenous Peoples.

Climate change has significant implications for economies, communities and ecosystems, from posing risks to human health and food and energy security, to affecting infrastructure and the sustainability of natural resource sectors. The Intergovernmental Panel on Climate Change reports that without additional efforts to reduce GHG emissions, global temperatures by the end of the century could be as much as 3.7°C to 4.8°C higher than pre-industrial levels. While the cost of inaction would be greater than that of action (Economic Intelligence Unit, 2015; Krugman, 2014), achieving the GHG emissions cuts necessary to limit temperature increases will, in part, depend on the development, deployment, availability and adoption of clean technologies.

Tackling climate change requires a serious and sustained global response. To this end, more than 190 countries, including Canada, adopted the Paris Agreement in December 2015. This committed them to enhance their collective efforts to avoid dangerous climate change by limiting global temperature increase to less than 2°C and, ideally, to no more than 1.5°C.

As part of the Paris Agreement, Canada committed to reduce its GHG emissions by 30% below its 2005 level by 2030 — a reduction of 291 million tonnes below business-as-usual GHG projections. Canada is *not* currently on track to achieve this target. In 2014, Canada's GHG emissions were at 732 million tonnes, representing 1.6% of global emissions, and the latest data project an increase to 815 million tonnes by 2030 if no further action is taken. The largest emitting sectors are oil and gas (26%), transportation (23%), other industrial sectors (10%), fuel use in buildings (12%), electricity (11%) and agriculture (10%) (Environment and Climate Change Canada, 2016).

There is widespread consensus on the critical role of innovation and global adoption of low-carbon technologies in achieving needed reductions in GHG emissions. Decarbonizing the global energy system requires both incremental and radical innovations (International Energy Agency, 2015). However, the current modest pace of technology development and adoption is part of the problem. A step change in global technology advancement is needed to transform how the world produces and consumes energy — a transformation that requires a shared vision along with government, industry and public action. Long-term, predictable policy frameworks must send clear signals and certainty to markets and Canada should draw on its inventiveness and ability to create new products, services and processes. Canada has the potential to play a key global role in this area.

Addressing climate change requires a decades-long commitment to develop and deploy low-carbon technologies around the world. A portfolio of technologies is needed, including proven technologies available today and

new technologies not yet developed. This represents a tremendous opportunity for Canadian companies to innovate, prosper and lead the way.

Drawing from their relationship with the environment, faced by a lack of energy, food and water security, and given the reliance of many remote communities on diesel as an energy source, Indigenous Peoples are motivated to be agents of change towards a low-carbon economy. Traditional knowledge can support efforts to address climate change and manage complex ecosystems. Indigenous Peoples can be key actors in monitoring climate change impacts and adaptations, help drive cultural and behavioural change towards clean growth, and form part of the clean growth workforce of the future.

## **2.2 The Global Clean Technology Market**

At the 21<sup>st</sup> session of the Conference of the Parties (COP 21) to the United Nations Framework Convention on Climate Change, countries made unprecedented commitments to address climate change via emissions reduction targets, environmental initiatives and funding commitments. Under Mission Innovation, for example, 21 partners, including Canada, committed to accelerate global clean energy innovation through increased public- and private-sector investment, as well as sharing of information and expertise.

Given these global commitments and new initiatives, the future demand for clean technology is expected to be significant and increasing. In 2012, the global market for clean technologies, broadly defined, was estimated to be approximately \$5.8 trillion, and growing at a rate of over 3% per year (United Kingdom Department of Business, Innovation & Skills, 2013). Countries around the world are mobilizing sizeable resources around this opportunity to support the competitiveness of their firms and secure local economic benefits from the transition to a low-carbon economy. The time is right now for Canada to set in place a comprehensive and effective strategy to meet this competitive challenge and export unique technologies and expertise to new and growing markets.

## **2.3 Canada's Clean Technology Performance**

It is important to understand Canada's overall environmental performance against this backdrop of global economic opportunity. This context helps clarify the challenges and opportunities that face Canada's clean technology innovators as well as the potential for clean economic growth.

Overall, Canada's environmental performance compares poorly with its Organisation for Economic Co-operation and Development (OECD) peers on GHG emissions, air quality, water use, waste treatment and energy use. In almost all areas, Canada is near or at the bottom of OECD rankings for developed countries. This can be partly attributed to structural factors such as a large geographic landmass, natural resource endowments, a low population density and a highly variable climate. However, it also reflects the lack of adoption of clean technologies and the growth rate of emissions.



## Box 2.1 Canada's Environmental Performance: Selected Highlights

- *GHG emissions:* Canada's overall emissions were fifth highest in the OECD in 2013, and remained relatively flat from 2003 to 2013. In contrast, overall emissions in the OECD declined by 5% over the same period and by 9% in the United States (OECD, 2016a).
- *Carbon intensiveness:* In 2013, Canada was ranked third worst in the OECD in carbon dioxide (CO<sub>2</sub>) productivity, at 2.7 gross domestic product (GDP) per kg of carbon, compared with the OECD average of 3.8. However, Canada's CO<sub>2</sub> productivity has been improving slightly since 2003 (OECD, 2016a).
- *Air emissions:* Canada's criteria air contaminant emission levels (particulates, volatile organic compounds, sulfur oxides and nitrous oxides) are at or near the bottom of the OECD rankings (in both emissions per unit of GDP and per capita emissions) (OECD, 2016a). In 2013, 63% of Canada's population was exposed to air quality levels above the World Health Organization guideline (World Bank, 2016). Canadian performance is similar to that of the United States; most countries with a high population density perform poorly on this measure.
- *Water use and treatment:* Canada ranks 11<sup>th</sup> worst in the OECD on water productivity (value generated per cubic metre of water withdrawal) at US\$35 per cubic metre (OECD, 2016a). Water usage of industrial sectors is difficult to compare internationally as countries have different water profiles. Canada only uses 1% of its available freshwater supply (World Bank, 2016), reflecting its abundance; however, annual per capita usage is high at 1,015 cubic metres (OECD, 2016a).
- *Waste treatment:* Canada recycles or composts only about 25% of its municipal waste. Leading countries, such as Germany (64%), have composting and recycling rates above 40%. As well, Canada landfills 71% of its municipal waste, which is the seventh highest share in the OECD. Some countries, such as Sweden and Germany, landfill less than 1% of their municipal waste (OECD, 2016a).
- *Energy use and productivity:* Canadian energy productivity fares poorly among OECD countries, ranking third worst in GDP per Total Primary Energy Supply (TPES), and second worst in energy consumption per capita. In 2014, Canada's renewable energy supply was 18% of total energy supply, the 12<sup>th</sup> best in the OECD, but Canada ranked 5<sup>th</sup> in percentage of renewables in the electricity supply (62% of generation) (OECD, 2016a).

It is more difficult to specifically assess Canada's clean technology performance and activities because clean technologies span many other sectors of the economy and there is a lack of agreement on their definition. Therefore, robust and up-to-date data are not widely available.

Analytica Advisors surveys companies that self-identify as "clean technology companies". The synopsis of its latest report (Analytica Advisors, 2016; 2014 data) presents the following findings:

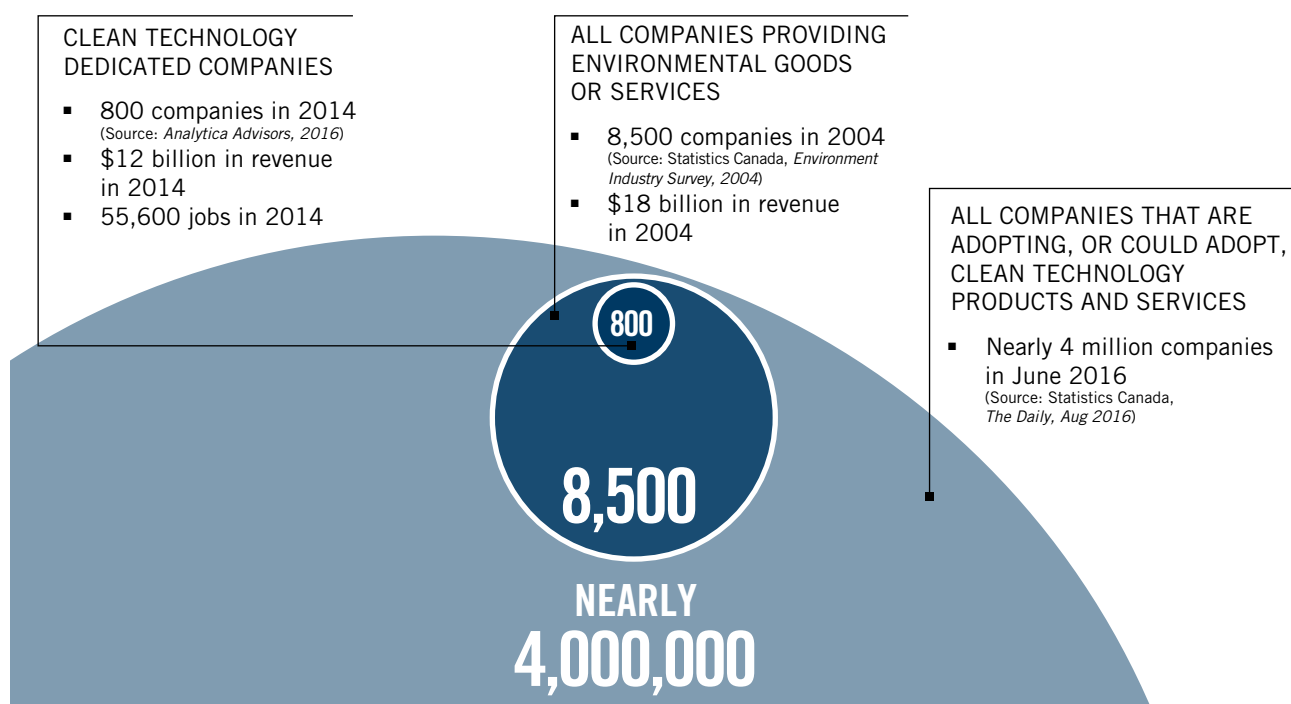
- *Clean technology activities are growing:* Over 770 companies directly employ 55,600 people. From 2012 to 2014, the compound annual growth rate of employment of sampled firms was 3%, but estimated revenue fell slightly from \$11.7 billion in 2013 to \$11.6 billion in 2014. Analytica Advisors attributes this to a lack of capital and weak global markets (although methodological differences between the survey years may also be a factor).
- *Canadian clean technology companies are export-focused:* Export revenues were approximately \$6.6 billion (57% of total revenues) in 2014, with 87% of all clean technology companies exporting and 23% of all industry revenue coming from non-U.S. markets. In 2013, surveyed companies reported \$5.8 billion in export revenues (based on GAC estimate that all environmental goods and services exports totalled \$125 billion).

- *Canadian clean technology companies invest heavily in R&D:* Surveyed companies invested over \$1.2 billion in 2014 and spent \$7.6 billion cumulatively from 2008 to 2014.
- *Clean technology is more than just clean energy:* Analytica Advisors' broad taxonomy covers an upstream sector that includes clean power generation; a downstream sector that includes smart grid, green building, transportation and others; and the water and agricultural sectors.

Statistics Canada's *Environment Industry Survey, 2004* (2007) collected data on environmental goods and services spanning the entire economy and captured firms that do not typically self-identify as clean technology. The survey reveals a broad level of clean technology economic activity, with clean technologies and services developed and adopted across all sectors of the economy. In 2004, Canadian firms earned \$18.5 billion from the sale of environmental goods and services, and export revenues reached \$1.5 billion, representing a much smaller share of overall revenues (8.1%) than the Analytica Advisors sample.

**Figure 2.1**

## ■ THE CLEAN TECHNOLOGY/CLEAN GROWTH UNIVERSE

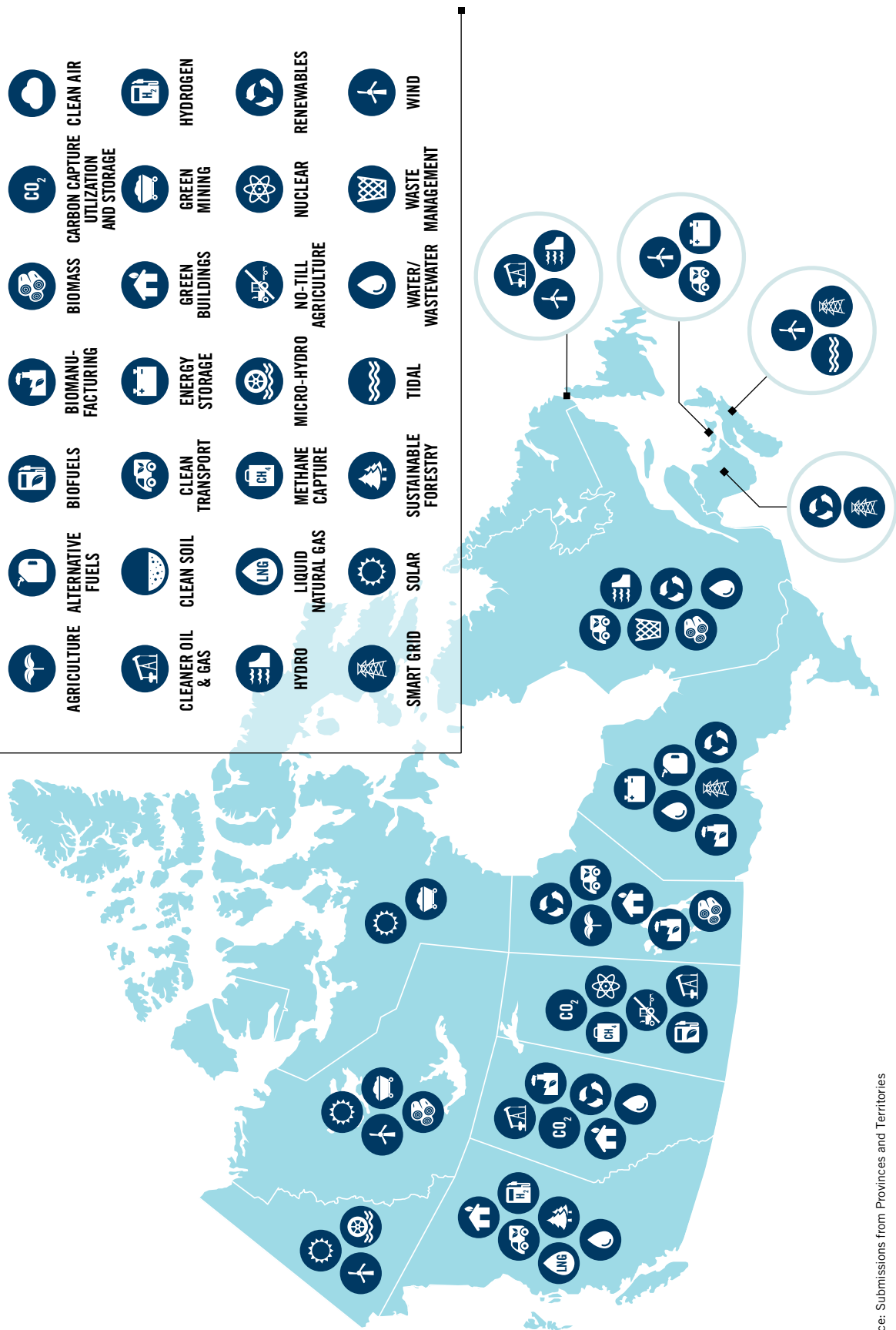


## 2.4 The Canadian Clean Technology Landscape

Opportunities for the adoption and deployment of clean technologies span the entire country (see **Figure 2.2**). Each province and territory has a unique mix of natural resource endowments and industries, including heavy emitting industries. Economic opportunities also vary by region. As a result, provinces and territories have taken context-specific approaches to supporting clean technology development. While there is generally wide coverage of program interventions across technology development, commercialization and adoption, these programs are typically broad in nature and not tailored to the imperatives of clean technology or climate change. **Appendix B** of this report provides a detailed description of provincial and territorial programs.

Figure 2.2

## EXAMPLES OF CLEAN TECHNOLOGY ACTIVITIES ACROSS CANADA



Source: Submissions from Provinces and Territories



## **CHAPTER 3**

### **BUILDING EARLY-STAGE INNOVATION**





## CHAPTER 3 BUILDING EARLY-STAGE INNOVATION

During the early innovation stages, researchers and developers advance innovative ideas to the point where they are ready to be demonstrated in a commercial capacity. For the purpose of this chapter, early-stage innovation includes activities that span the earliest conceptual phase through to commercial readiness. Notably, there is some overlap with the issues and options discussed in Chapter 4, which focuses more directly on company growth and commercialization challenges.

This chapter addresses both incremental and high-risk R&D activities. Generally guided by clear technical challenges, incremental R&D focuses on improving existing technologies or processes, typically with short timelines to market. In contrast, high-risk R&D can potentially lead to technological breakthroughs, but is often associated with longer development timelines. Although high-risk R&D can occur across the innovation continuum, it tends to be focused in areas with greater technical uncertainty that can challenge incumbent technologies or processes.

Canada performs strongly on measures of general R&D performance. The WWF and Cleantech Group's Global Cleantech Innovation Index (GCII) ranks Canada as 3<sup>rd</sup> out of 40 countries on general innovation drivers, and the 2016 WIPO/INSEAD Global Innovation Index places Canada 15<sup>th</sup> out of 128 countries. Both indices suggest that Canada performs well on general innovation. However, when examining clean technology specifically, Canada's performance is average. For example, Canada is 18<sup>th</sup> out of 40 countries in the GCII on clean technology-specific innovation drivers (an index of friendly government policies, public R&D spending, development of national clean technology infrastructure, and availability of clean technology clusters) and 10<sup>th</sup> on emerging clean technology innovation. This second metric straddles the line between early-stage innovation and commercialization, and considers clean technology patents, data on venture capital availability and ranking of global clean technology companies. Taken together, these data point to a foundation of government support in general innovation (see **Box 3.1**), but a need for targeted measures in clean technology RD&D to address specific gaps, as suggested by the data.

In this chapter, the Working Group analyzes Canada's performance in clean technology R&D and early-stage innovation in two main areas and proposes options for action in each:

- The clean technology RD&D ecosystem, including issues around alignment and how to better focus funds and priorities for clean technology and climate change imperatives; and
- High-risk, high reward research, which can potentially lead to technological breakthroughs but is not adequately supported by the public or private sector.

### Box 3.1 Government Support for Clean Technology R&D in Canada

Support is currently delivered through:

- Various federal and provincial tax incentive programs for R&D activities, such as the federal Scientific Research and Experimental Development (SR&ED) program, which provides a general 15% tax credit for eligible R&D expenditures (as well as a 35% refundable tax credit for small and medium-sized firms);
- Academic grants provided by federal, provincial and territorial departments and agencies, most notably the Natural Sciences and Engineering Research Council (NSERC);
- Federal, provincial and territorial labs and research and technology organizations, which typically perform applied research and collaborate with industry and academic partners to bring made-in-Canada ideas to the market;
- Networks of Centres of Excellence (NCEs), which provide targeted resources and expertise to research networks operating in areas of strategic importance to Canada, including the environment and natural resources (e.g., Green Aviation Research and Development Network and BioFuelNet directly address clean technology objectives);
- SDTC, which receives funding from the Government of Canada but operates at arm's length to fund pre-commercial clean technology demonstration projects and bring economically viable technologies with measurable environmental benefits to market; and
- Regional Development Agencies (RDAs), which also directly fund clean technology R&D projects.

## 3.1 The Clean Technology RD&D Ecosystem

### 3.1.1 The Issues

Although a number of federal, provincial and territorial initiatives currently support clean technology RD&D in Canada, the Working Group found a lack of overall alignment between them and relatively few initiatives that focus specifically and/or significantly on clean technologies. This section assesses the performance of existing initiatives and examines new models of organization and alignment that can generate better clean technology RD&D outcomes.

### 3.1.2 Analysis

In general, RD&D activity and investment in clean technologies are driven by environmental regulations, the overall policy environment and broader market conditions, such as energy prices. Stakeholders assert that:

- Regulatory uncertainty and a lack of flexibility can present barriers to investing in innovation and identifying suitable pilot projects; and
- Government policies and support mechanisms for clean technology should be clear and stable over longer terms (e.g., 10–15 years).

### Focus, Alignment and Collaboration

The Working Group identified a lack of focus and alignment in Canada's RD&D ecosystem for clean technology. Stakeholders supported this finding and attributed the inefficient and insufficient allocation of resources to it. Greater collaboration across governments, the private sector and academia will be needed to achieve agreed-upon pan-Canadian goals.

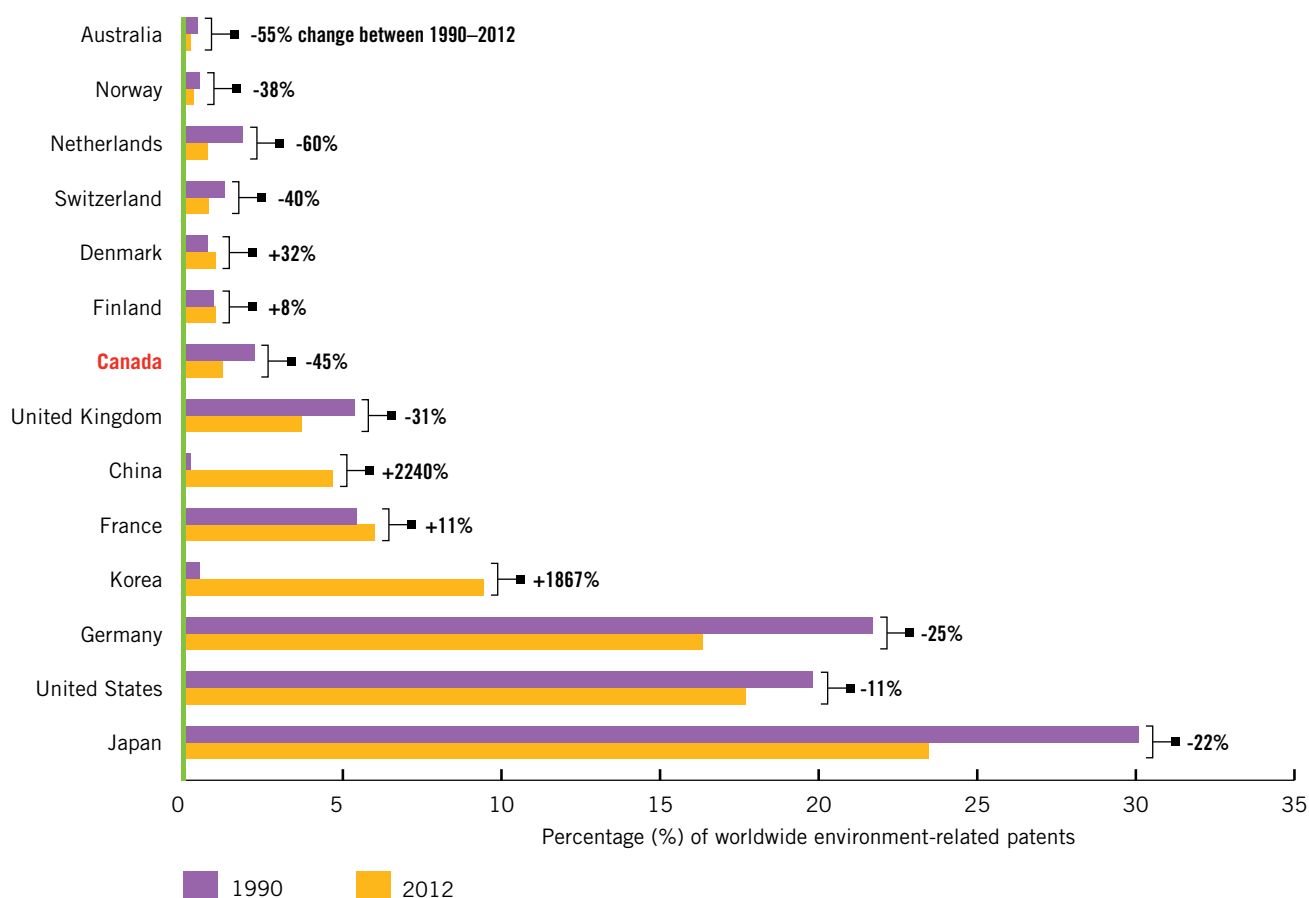


Working Group analysis and stakeholder submissions revealed that government programs at all levels are often misaligned, as are government initiatives and those of industry and academia. Overlapping or uncomplementary research priorities lead to technologies that do not match market needs; thus they struggle to gain commercial applicability. Communication and alignment need to occur throughout the innovation continuum: academic and government researchers must communicate their work to industry and industry must communicate technological needs to researchers. For example, stakeholders mentioned the importance of transferring technology and expertise from academic labs in universities to commercial development in start-ups or established companies.

Many government agencies and departments currently determine their own clean technology research priorities (IEA, 2016). Overall support for R&D in Canada also may be spread too thin. For instance, the 2016 Global Innovation Index shows that Canada performs well (in top 10) on inputs to innovation, such as institutions, human capital and research, infrastructure and market sophistication. However, its overall innovation efficiency (ranked 57<sup>th</sup>) is poor as innovation inputs do not always translate into strong innovation outputs (ranked 23<sup>rd</sup>), such as knowledge creation and knowledge impact. On clean technology outputs in particular, Canada is falling behind. **Figure 3.1** shows that Canada's share of worldwide environment-related technology patents fell by 45% from 1990 to 2012, as countries such as China, South Korea, Denmark and Finland greatly accelerated their R&D efforts in this area (OECD, 2016a).

**Figure 3.1**

### DEVELOPMENT OF ENVIRONMENT-RELATED TECHNOLOGY PATENTS (AS A % WORLDWIDE)



Source: OECD, *Green Growth Indicators*, 2016

Stakeholders proposed various options to better align and focus the Canadian RD&D ecosystem. Prioritizing objectives can focus public and private research activities on high-impact areas of Canadian strength, giving investors certainty, and galvanizing researchers into action towards common goals. Such prioritization should take into account the different resource endowments and industrial specializations across regions (Mazzucato et al., 2015). Focusing the research community on challenges and opportunities identified by industry experts is critical if innovations are to target real problems with real markets. This is particularly important in clean technology, given that policy uncertainty can present barriers to investing in innovation.

Roadmaps can also be used to strengthen linkages between economic sectors (i.e., bring together clean technology developers and end-users). Other jurisdictions have used roadmaps to build a consistent and comprehensive view that guides research priorities. For example, to accelerate and focus international R&D efforts in areas of high impact, ministers from Group of 8 countries recently tasked the International Energy Agency (IEA) with developing clean technology roadmaps. These roadmaps identify priority actions for government, industry and other relevant stakeholders to advance certain clean technologies.

Comparative studies and data confirm that Canada has one of the most generous R&D support regimes in the world (OECD, 2016b). Some stakeholders and commentators have noted, however that government support for private-sector innovation in Canada focuses heavily on indirect measures (e.g., tax credits) rather than on direct program support, which many international competitors favour (OECD, 2015; Review of Federal Support to Research and Development, 2011). Although indirect R&D incentives are generally non-discriminatory and market-led, direct support may be better suited to targeting specific priorities and addressing market failures, such as combatting climate change and stimulating early-stage innovation (Drummond et al., 2015).

### Sustainable Development Technology Canada

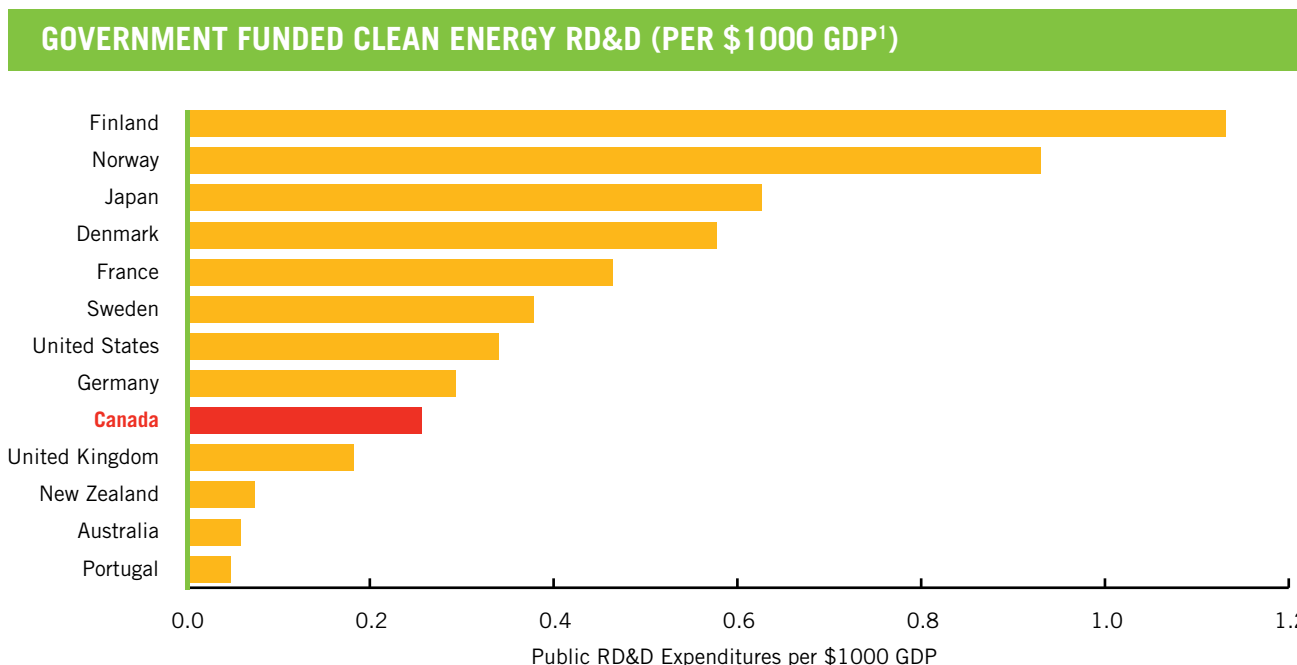
SDTC, an arm's-length organization that is part of the Innovation Science and Economic Development Portfolio, provides funding support to companies across Canada to develop and demonstrate innovative new clean technologies that promote sustainable development, including those that address environmental issues related to air, water, soil and climate change.

Since inception in 2001, SDTC has allocated \$928 million to 320 projects and leveraged over \$2.45 billion from other project partners, with over 80% coming from the private sector. By the end of 2015, SDTC reported that 73 completed projects had led to market-ready technologies, generating an estimated 6.3 MT of CO<sub>2</sub>e annual emissions reductions, \$1.4 billion in annual revenue and more than 9,200 direct and indirect jobs in 2015.

SDTC also forges partnerships to support the continued de-risking of clean technology, particularly to reduce barriers for entrepreneurs. SDTC has launched joint funding opportunities in collaboration with Alberta-based Climate Change and Emissions Management Corporation (CCEMC) and Alberta Innovates - Energy and Environment Solutions (AI-EES). SDTC partners with the Ontario Centres of Excellence to enhance Ontario's Greenhouse Gas Innovation Initiative.

Currently, Canada delivers much of its direct R&D support to business through the National Research Council's Industrial Research Assistance Program (IRAP), SDTC and NRCan, as well as industry consortia and cross-sector collaborative research networks under the NCEs. Non-financial R&D government support provided by unique facilities and expertise of federal and provincial research organizations and laboratories are important, as these are not cost-effective for the private sector to create and maintain. Canada, however, lags leading countries such as Finland, Denmark and Japan in government-funded clean technology R&D (including energy efficiency, renewable energies, transmission, etc.) in private-sector, academia, and government labs as a percentage of GDP (see **Figure 3.2**) (IEA, 2016b).

Figure 3.2



Source: R&D database underlying *IEA (2016a)*, summing over all government RD&D categories except 'fossil fuels'.

1 including energy efficiency, renewable energies, nuclear, fuel cells and transmission

Researchers and innovative firms in Canada find it difficult to navigate and access the appropriate government support programs for clean technology R&D due to the large number of actors, programs and policies. Stakeholders perceived administrative processes for accessing R&D support as burdensome for many firms, particularly small and medium-sized enterprises (SMEs), with some hiring external consultants to help with these processes. This issue could be addressed by multiple programs leveraging a single point of entry or by consolidating the number of programs.

Federal, provincial and territorial collaboration on research priorities and policies could be achieved through alignment of collective outcomes across technologies and technology platforms. This could be done in such a way that enables provinces and territories to meet their goals while contributing to pan-Canadian goals. Program delivery alignment could then help improve accessibility, and help technology developers negotiate public support through different stages of development. As well, stakeholders identified difficulties in accessing program support for small clean technology pilot and demonstration projects (under \$1 million).

International counterparts highlight mechanisms that align and focus early-stage innovation. Some countries use a centralized approach. For example, Finland sets innovation priorities centrally via a Research and Innovation Council, chaired by the Prime Minister. This enables the coordination of R&D and associated funding agencies and programs, and has led to notable advancements including in information and communication technologies (ICT), green mining and forestry. However, while a centralized approach is compatible with Finland's unitary state structure, it poses challenges for a federal system like that of Canada.

Germany's Fraunhofer Society suggests that public support for networks should be outcome-oriented and competitive, with clear exits established for poor performing networks. The Fraunhofer model involves a coordinated network of specialized research institutes, which are funded based on a small proportion

of public funds and a greater, leveraged proportion of private-sector contracts and commissions (Review of Federal Support to Research and Development, 2011). Notable Fraunhofer projects include the MP3 compression algorithm and developments in solar cells.

Stakeholders noted that industry-led consortia and publicly supported NCEs in Canada have played a large role in advancing the development of technologies that address common challenges. Industry-led consortia are an effective mechanism to organize relevant industry actors to identify sector-wide challenges, pool resources, collaborate on R&D and work with the wider innovation ecosystem (i.e., SMEs, academia and government) to develop solutions to common challenges. Further supporting and strengthening such networks could accelerate development efforts. Where networks or consortia do not exist, governments could play a convening or facilitating role to bring relevant actors together to establish communities of interest, particularly in areas such as electric vehicles and fleets; electricity and associated technologies; built infrastructure; resource extractive industries; clean and advanced manufacturing; sustainable forestry, agriculture and fisheries; water technologies and related services; cold climate research; and platform technologies that cut across sectors.

The Netherlands is a good example of a country with coordinated research programming that effectively aligns the research community with a consortium-based “pre-competitive” problem-solving approach involving industry, academia and regulators. To support its ambitious energy targets and clean technology goals, the Netherlands has created numerous organizations, initiatives and programs that bring relevant parties together to stimulate engagement and cooperation and increase efficiencies. One example is the Energy Research Centre of the Netherlands (ECN), which is responsible for developing new and innovative technologies and conducting pioneering sustainable energy management research. ECN streamlines and coordinates European energy research programs within the Europe Energy Research Alliance, a consortium of nine other European research organizations that harmonize research programs. The government has contributed €30 million to this initiative, with a goal of securing €4 million from the business sector.

Along with government, industry and academia, utilities are key actors in early-stage innovation and demonstration. Stakeholders suggested that internal researchers at utilities (electrical, water and gas) should be supported and encouraged to collaborate with university researchers, government labs and private-sector innovators to verify and de-risk solutions through funding and more flexible regulations. Utilities could be inspired to take on additional risk, including allowing regulated utilities to invest in demonstration of promising innovations.

Ultimately, governments can help establish pan-Canadian research priorities and direct support to move the needle in certain strategic areas of shared importance. In selecting priority technology areas, national and regional strengths are important considerations along with targeting domestic environmental challenges and the opportunities presented by international markets. Priority technology areas could be identified in collaboration with relevant industry actors and focus on industry challenges, where there is a market appetite for change. Stakeholders pointed to policy barriers, such as domestic and international intellectual property regimes, standards and regulations (discussed further in Chapter 5), and improved data and metrics (Chapter 6). These policy conditions can greatly affect the potential of new technology innovations. Program and funding certainty over the long term (10–15 years) is also needed to allow sufficient time for R&D to materialize into concrete innovations that achieve the goals set out in those strategic areas.

As convenors, governments are uniquely positioned to drive greater research collaboration and efforts around shared objectives. This would help focus and align innovation activities and funding for increased probability of success.

## International Collaboration

Despite being party to several international initiatives such as Mission Innovation, which commits to doubling spending on clean energy R&D, Canada should collaborate more internationally to leverage necessary resources and expertise. Canada currently partners with other countries to align objectives and pool resources to meet global climate change targets and drive clean technology development. For instance, Canada is seeking opportunities to expand collaboration with international partners through a Memorandum of Understanding Concerning Climate Change and Energy Collaboration (Canada, the United States, and Mexico) and a Joint Declaration on Canada-China Clean Technology Cooperation.

Canada's associate membership in the pan-European EUREKA research network also gives its researchers and businesses access to international expertise, resources, markets and global value chains. In 2014–2015, EUREKA-Canada opportunities led to 22 new collaborative projects with international partners in information communications technologies, manufacturing, transportation, materials and medical technologies, with a combined value of approximately \$30 million (NRC, 2015).

## Partnerships with Indigenous Peoples

There are many opportunities for government partnerships with Indigenous Peoples and the responsible use of traditional knowledge to further the development of clean technologies. NIOs proposed that federal, provincial and territorial governments and Indigenous organizations work together to set a clean technology research agenda that aligns federal, provincial, territorial and Indigenous requirements. As well, partnerships and leverage opportunities must be encouraged to build the Canadian North as a centre of innovation testing and exporter of proven innovative ideas due to its unique climate and geographic features.

Stakeholders also suggested that, as well as leveraging the traditional knowledge of Indigenous Peoples in innovation processes, public- and private-sector and Indigenous communities must participate and communicate clearly at each stage of a clean technology project, from idea to design to implementation. This approach has worked effectively in the past. For example, traditional knowledge on Inuit hunting practices was captured as information for new maps for a global positioning system. This project created new partnerships and innovative thinking for both researchers and local Indigenous Peoples.

The Working Group proposes to continue to partner with Indigenous Peoples in these ways.

## 3.2 Breakthrough R&D

### 3.2.1 The Issues

Sustained support over long periods for high-risk, early-stage R&D activities is critical for the development of high-impact, breakthrough clean technologies that will help Canada meet its ambitious long-term climate change targets at a reasonable cost. However, neither the public nor the private sector adequately supports this type of research.

The Working Group explored this issue by examining:

- Canada's performance in supporting early-stage clean technology innovation activities;
- Novel program models that could enhance support for high-risk, high-impact technologies, especially in leveraging private-sector efforts; and
- Coordinating mechanisms such as "missions" that could focus the priorities and capacity of numerous research programs and actors to meet ambitious clean technology innovation and climate change goals.

### British Columbia: Carbon Engineering

Since August 2015, Carbon Engineering Ltd. has been operating the world's largest direct air capture demonstration plant in Squamish, B.C. The pilot-scale plant is removing and purifying 1 tonne of CO<sub>2</sub> per day from ambient air; future, full-scale plants will potentially capture one million tonnes of CO<sub>2</sub> per year. The demonstration plant was the result of six years of R&D and two years of plant design, engineering and construction. Since 2014, SDTC has provided \$3 million towards the demonstration plant.

Thanks to a strong clean technology innovation ecosystem, B.C. is starting to gain global recognition as a leader in carbon capture and conversion. B.C. is helping to move this technology towards commercial readiness. Since 2015, B.C.'s Innovative Clean Energy Fund has provided over \$4 million to Carbon Engineering to design and build a fuel synthesis demonstration plant in Squamish.

As Carbon Engineering ramps up activities for its fuel synthesis demonstration, a growing consortium of parties has evolved to promote educational and employment opportunities in Squamish, including the University of British Columbia, Squamish First Nation, the District of Squamish, Carbon Engineering and Newport Beach Development. The consortium aims to establish an education, research and innovation hub to bring together First Nations, a world-class university, next generation innovators and venture capital.

### 3.2.2 Analysis

The Working Group and the stakeholders it consulted agree that further support of high-risk, early-stage research is essential due to its potential to lead to breakthrough technologies and its current underinvestment by the private sector.

These technologies are inherently high risk, are less well understood, face high barriers of entry and longer development timelines, and involve environmental and knowledge externalities, leading to underinvestment by the private sector (Mazzucato et al., 2015; Gates, 2015; Drummond et al., 2015). For example, since markets do not adequately account for environmental costs, the private sector has little incentive to alter its behaviour and adopt or invest in clean technologies that reduce emissions. Knowledge spillovers relate to the “public good” nature of knowledge; this means that “potentially innovative private firms and individuals may not have incentives to provide the socially optimal level of research activity” (Popp, 2016; Drummond et al., 2015). An analysis of patent data across OECD countries suggests that new patents related to clean technology R&D tend to generate knowledge spillover benefits that are greater than those related to fossil fuel technologies and comparable to robotics, information technology and nanotechnologies (Dechezlepretre et al., 2013). While broad-based innovation policies are important, targeted support is particularly effective for technologies that address externalities, to allocate resources in a way that supports the most socially optimal outcomes.

However, evidence highlights the importance of delivering this support not only through government labs and academia, as traditionally done, but also through innovative private companies working on cutting-edge technologies (Mazzacuto et al., 2015). Direct support can help incent increased innovation activity in higher-risk, high-impact technologies, especially due to the lower probability of crowding out private investment (Gaddy et al., 2016; Gates, 2015; Drummond et al., 2015). Research undertaken by academic and government labs and direct funding for innovation could be aligned to challenges identified by industry.

Stakeholders also suggested that, due to the unpredictable nature and high-risk profile of cutting-edge R&D, public programs that support potential breakthrough technologies should be flexible, decentralized and tied to increasingly focused milestones at successive stages as ideas come together. This view is consistent with international best practices. For example, direct government support for high-risk, high-impact technologies

in leading peer countries is beginning to bear fruit; an example of this is the U.S. Department of Energy's Advanced Research Projects Agency-Energy (ARPA-E).

ARPA-E's success demonstrates that a decentralized, nimble approach to research support at the program and project level may be most effective in maximizing resources and impact due to the difficulty in knowing which technologies will succeed. The U.S. Congress gives ARPA-E considerable freedom, allowing it to grant discretion to leading experts in defining and targeting program themes. Projects must be high-potential, high-impact energy projects that could significantly advance how energy is generated, stored, distributed and used. Failures should be tolerated, but priority setting should be bottom-up, reassessed regularly, and with specific technical targets laid out in each stage of the research process (Haley, 2016). Importantly, at the beginning of the process, each project team is assigned milestones, which the team must meet to continue receiving support. This prevents funding for unsuccessful technologies from becoming a long-term burden for taxpayers, while ensuring that long-term support continues to be available for breakthrough technologies (Global Commission on the Economy and Climate, 2014). ARPA-E combines elements of competition and decentralization within an overarching mission-based approach at a technology-specific level. As of 2016, ARPA-E has funded 475 projects at US\$1.3 billion, attracting US\$1.25 billion in follow-on funding from the private sector thus far (ARPA-E, 2016).

Stakeholders consistently raised the importance of broader ambitious "mission-oriented goals" at both the program and whole-of-government level (e.g., U.S. lunar landing effort in the 1960s). These could manifest as broad missions that guide several government programs (e.g., the mission to increase energy efficiency) or the targeting of specific technical challenges at the program level. These programs must be "solution agnostic", so as not to limit the scope of innovation when the path forward is unclear. In areas where technical challenges are clearer, outlining strategic objectives at a high level, would encourage collaboration and alignment with an overarching strategy and help drive Canadian priorities that include clean technology solutions.

International best practices also suggest that mission-oriented approaches, such as "grand challenges", are an effective way to focus both public and private research efforts to achieve ambitious concrete and clearly defined goals. For example, the U.S. XPRIZE Foundation designs and manages public competitions that encourage technological developments that benefit humanity, form new industries or revitalize markets. XPRIZE competitions, which target "unsolvable" problems, typically offer a cash reward to the team that best meets a specific technical challenge. Highly ambitious goals, open competition and clear definition of technical challenges without being overly prescriptive are key to the XPRIZE model. Competitions like XPRIZE advance technologies by pushing the limit of what is currently possible. One US\$20 million competition, sponsored by Canada's Oil Sands Innovation Alliance and NRG, focuses on advancing breakthrough technologies that would convert CO<sub>2</sub> into useful products and services.

In general, early-stage support for breakthrough technology research and development should be linked with later-stage supports for commercialization and scale, and ensure that ground-breaking innovations are able to reach markets.

### Yukon: Innovation Prize

The Government of Yukon funds an annual contest, open to all Yukon residents and businesses, to stimulate interest and engagement in developing and commercializing local products and services that address northern issues and opportunities. The theme was energy efficiency in building construction in 2015, and food security and northern agriculture in 2016.

The \$70,000 received by the winners is used to support the commercialization of the innovation.

The first winner, who proposed an energy-efficient radon gas mitigation system, has partnered with a manufacturer in the South to bring his solution to market next year. The 2016 winner, a passive energy greenhouse designed to extend Yukon's growing season from four to eight months, is using the funds to build a prototype unit.

## 3.3 Action Plan

To become a leader in the development and deployment of clean technologies, Canada should have a strong pipeline of innovative clean technology ideas. In this respect, Canada's clean technology RD&D ecosystem drives efforts to meet environmental and economic objectives. Measures to strengthen this ecosystem and focus efforts would have an impact on Canada's economic and GHG reduction performance over the medium to long term, as investments and RD&D support are aligned to better support the advancement of clean technologies in key areas.

Breakthrough technologies play a particularly important role in achieving the reductions in GHG emissions required to meaningfully address climate change in Canada and globally. Measures to support early-stage, higher-risk technologies could be expected to have an impact over the longer term, as breakthrough technologies with the potential to change the way we live, work and consume energy are effectively advanced along the innovation continuum.

The Working Group proposes the following options for action to Ministers:

### Clean Technology Research, Development and Demonstration

- **Coordinate and focus government investments and activities in clean technology RD&D to maximize Canada's progress towards specific goals**, through a process that:
  - » Identifies priority areas through collaboration with experts from government departments and labs, Indigenous Peoples, industry, academia, and other stakeholders; and
  - » Prioritizes objectives based on regional strengths and the potential to reduce GHG emissions and other negative environmental impacts, meet community and social needs, and expand economic opportunities and jobs for Canadians.
- **Strengthen clean technology RD&D support through existing organizations** by:
  - » Increasing the focus on, and allocating specific funding for, clean technology development through federal and provincial granting councils, research councils and labs;
  - » Recapitalizing Sustainable Development Technology Canada's SD Tech Fund and similar provincial/territorial programs; and
  - » Enhancing the coordination between these programs and reducing gaps, with particular attention to small demonstration project funding.
- **Facilitate stronger networks** through a greater focus on clean technologies in broader initiatives that support centres of excellence, communities of interest, and partnerships among researchers, entrepreneurs,



and industry, with the goals of advancing and demonstrating emerging technologies and supporting commercialization in key opportunity areas.

- **Strengthen Canada's participation in international clean technology RD&D activities** and position Canada as a leader in this area. This would build on Canada's *Mission Innovation* objectives and require improved collaboration between Canadian researchers/companies and strategic international partners.
- **Direct government funding agencies and labs to enhance collaboration with Indigenous Peoples** on clean technology and clean growth RD&D, and encourage industry and academia to responsibly integrate traditional knowledge in a way that creates new opportunities for Indigenous communities, and conforms to ethical standards for research with Indigenous Peoples.

## Breakthrough Research and Development

- **Create a breakthrough technology development initiative** that would advance high-risk clean technology research in areas that have the potential to radically reduce GHG emissions and other pollutants. This should draw upon international best practices from models such as the advanced research projects agencies in the United States, and this could utilize world-leading technology experts to define project priorities, and employ a design that encourages a regular renewal of ideas and researchers.
- **Create "Grand Challenge" initiatives** that encourage new "mission-oriented" research to address specific identified clean technology and environmental performance issues. Drawing on best practices from models such as the XPRIZE Foundation, competitive calls for proposals would focus on specific, desired outcomes that build research capacities, issues and strengths. An early "Grand Challenge" area could be to identify and develop, in partnership with Indigenous Peoples and northern regions, cost-competitive and sustainable local clean energy systems that would reduce the reliance of northern and remote communities on diesel generation and heating.



## **CHAPTER 4**

# **ACCELERATING COMMERCIALIZATION AND GROWTH**





## CHAPTER 4 ACCELERATING COMMERCIALIZATION AND GROWTH

The commercialization of even the most promising innovations from RD&D processes is onerous. Canadian clean technology producers face a number of challenges in bringing innovative solutions to market, particularly in attracting the requisite capital and talent to achieve scale and compete both domestically and internationally. Canada's ability to rapidly commercialize clean technologies and build private-sector capacity is essential to maximizing its global market share, generating economic growth and jobs, and meeting climate change commitments. Government support for commercialization is delivered in a variety of ways by a number of organizations (see **Box 4.1**).

Similar to clean technology innovation, Canada's performance in transitioning clean inventions into successful commercial products is average. The GCII ranks Canada 14<sup>th</sup> out of 40 countries for commercialization of clean technologies. The index considers variables such as clean technology manufacturing value-added, clean technology revenues, renewable energy consumption, late-stage private investment and activities of publicly traded clean technology companies. The economic consequences of this underperformance are grave. For example, Analytica Advisors (2016) reports that between 2002 and 2014, Canada's global market share decreased by 41%, which means that Canada is becoming less competitive.

This chapter analyzes Canada's performance on clean technology commercialization and proposes options for action in four key areas:

- Increasing financial support for clean technologies and facilitating their access to private capital;
- Ensuring companies and investors have the required skills for success and the broader labour force is equipped with clean technology skills to support a low-carbon economy, through education, training and immigration;
- Building stronger companies, including through developing regional collaborative strategies to support clean technology development, and further supporting incubators and accelerators; and
- Providing Canadian firms with the information, expertise, financing and networking tools they need to access and succeed in international markets.

### Box 4.1 Government Support for Clean Technology Commercialization in Canada

Support is currently delivered through the following vehicles:

- IRAP's Concierge service provides SMEs with a free, single access point for information on funding, expertise, facilities and global opportunities.
- Federal Crown corporations and agencies, including BDC and EDC, offer financial support for companies at the stages of commercial deployment through to export development. Provinces and territories provide project-based financing support through similar arms-length mechanisms.
- The Centres of Excellence for Commercialization and Research program, administered by the three granting councils under the NCE framework, supports industry partners in advancing research and facilitating commercialization through access to financing, mentorship, research expertise and facilities.
- The Venture Capital Action Plan and the Industrial, Clean and Energy Technology Venture Fund, administered by BDC, provide federal support for venture capital. Provinces and territories also provide support through mechanisms such as Crown corporations and investment tax credits.
- Federal RDAs provide small clean technology producers with access to intelligence on clean technologies and innovation, facilitate relationships with major stakeholders like research facilities, industry and Indigenous organizations, and support a range of policy and investment tools that reflect regional market contexts. Provinces and territories have local business development agencies that often work in tandem with the RDAs.
- Some federal, provincial and territorial programs focus on the commercialization of technologies in specific sectors, including natural resources. Further details on these programs can be found in **Appendix B**.
- Global Affairs Canada develops export promotion strategies and, via the Trade Commissioner Service (TCS), helps firms compete in international markets through the Canadian Technology Accelerators program. Provinces and territories also devise export strategies and offer similar services through their own trade and investment representatives.

## 4.1 Access to Financing

### 4.1.1 The Issues

In response to a 2015 Cleantech Canada survey commissioned by CCEMC, 37% of Canadian clean technology producers cited lack of financing as their top challenge in developing new clean technologies. Clean technology projects and producers often do not have adequate access to capital, and multiple financing gaps exist at various stages in the commercialization process. The unique characteristics of many clean technologies — high risk, capital intensity and long timeframes — do not align with traditional investment models. Addressing these financing gaps and facilitating adequate access to capital is a critical challenge for Canada. Success would lead to improved commercialization of clean technologies and growth of globally competitive clean technology producers.

## 4.1.2 Analysis

### “No-Wrong Door”

A myriad of programs currently exist among federal, provincial and territorial governments with the aim of facilitating firms’ access to financing. Stakeholders noted an overall lack of coordination among these financing supports, such that clean technology producers find it difficult to navigate the network of government programs and policies that offer support at the commercialization stage. Several called for a “one stop” help desk where experts would direct them to the appropriate mechanisms. Federal, provincial and territorial departments and officials also acknowledge this particular challenge.

Several help desk initiatives currently guide companies to the government support they need to commercialize their technologies. At the federal level, the Accelerated Growth Service pilot and IRAP’s Concierge service provide advice to firms looking to innovate and accelerate their growth. Several provincial and territorial equivalents also operate to this effect. The level of comprehensiveness and engagement of these programs varies. Some provide information materials on government programming, such as guidebooks, and others offer more active client service models in which companies interact with a single point of contact who oversees their progress from program to program and facilitates information sharing between programs so as to reduce due diligence and other administrative burdens.

The Working Group considered this latter, more active approach to be an appropriate mechanism for supporting clean technology development. Given the nascent, complex nature of many clean technologies, developers face unique challenges in accessing the financing they need to commercialize their technologies (described in greater detail below). Governments could actively guide companies to the public support mechanisms that would help them demonstrate their technologies’ commercial viability. Using a “no-wrong door” approach, which emphasizes coordinating government support, is a central theme of the Working Group’s analysis in Chapter 6. In this regard, alignment between the “no-wrong door” mechanism and clean growth innovation hubs could be considered.

### Venture Capital

Generally, Canada boasts a strong venture capital ecosystem. OECD data (2016b) rank Canada third in the world in terms of total venture capital funds available based on GDP, and the Canadian Venture Capital & Private Equity Association (CVCA) (2016) observes that from 2014 to 2015, total venture capital grew by 12% in terms of deal value and by 24% in terms of number of deals. The CVCA data also show that clean technologies receive only a small proportion of this financing. In the first quarter of 2016, only 3% of venture capital in Canada went to clean technologies. Stakeholders suggested that of this 3%, the majority of deals went to ICT-related clean technologies, which have characteristics that align with traditional venture capital investment models. However, a large proportion of clean technologies do not align with these investment models. They possess unique characteristics that require flexible, alternative investment models that can provide more capital, adopt higher-risk levels and assume longer-term investment positions. Stakeholders noted that where traditional investment models do not align with these characteristics, additional and tailored venture capital support is needed for the commercialization of clean technologies.

A body of research substantiates these stakeholder views. For example, Mazzucato and Semieniuk (2015) and Gaddy et al. (2016) find that the high-risk and high-capital requirements of clean technologies, combined with a history of low and slow payout performance (compared with other technology areas like health sciences and software),<sup>1</sup> have had significant and negative impacts on investors’ willingness to invest. The financial crisis and stricter banking regulations have also dampened the investment climate for clean

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1 According to the Working Group’s definition, clean technologies can be software-based.

technologies. Investors have tightened their appetite for risk and reduced the length of time they are willing to tie up capital in investments (Mazzucato & Semieniuk, 2015; OECD, 2012; Gaddy et al., 2016).

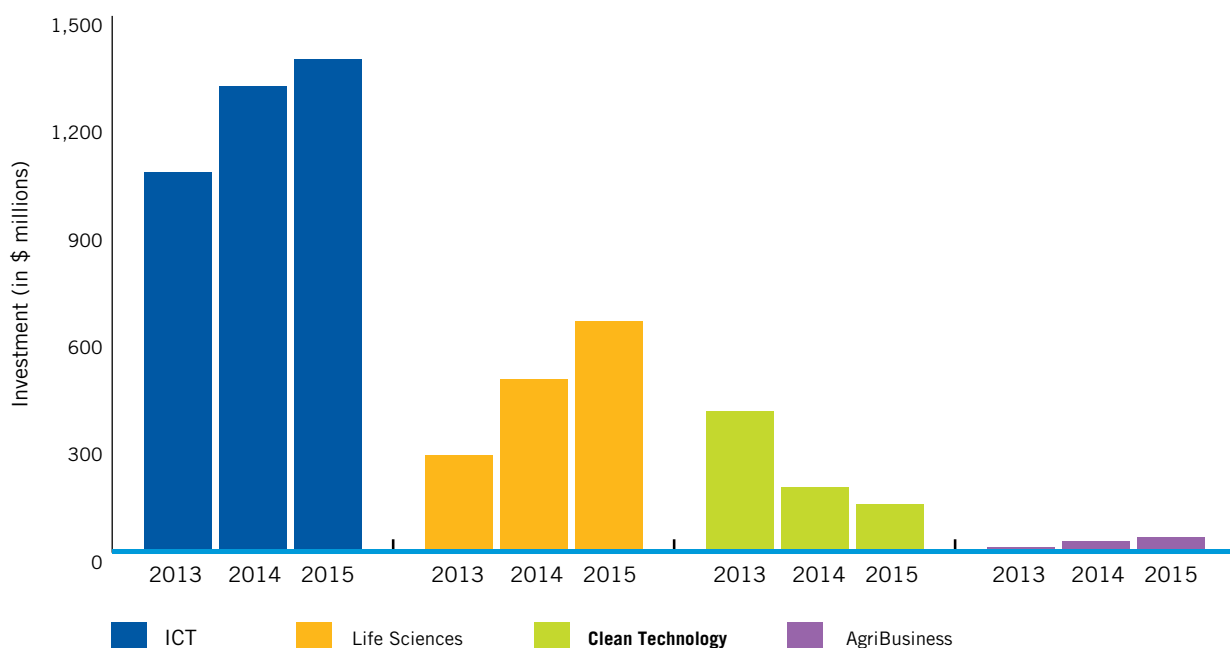
Haldane (2016) argues that the “short-termism” that has emerged among investors poses barriers for longer-term clean technology investments. A survey of Canadian clean technology investments by the Cleantech Group (2016) demonstrates this trend, showing investors withdrawing from early-stage investment and shifting to later, growth-stage financing. This is cause for concern, as sustaining a strong pipeline of early-stage clean technologies acts as an important foundation for continued innovation and successful commercialization of clean technologies.

The UN Framework Convention on Climate Change Technology Executive Committee (2015) highlights the roles of blended finance (co-investments made by the public and private sectors) and concessional finance (loans with flexible conditions) in targeting risk and knowledge gaps that deter private investors. Through blended finance, the public-sector support can play a number of roles, including as providers of first-loss capital or underwriters of the risks associated with clean technology development. These arrangements can reduce the cost of capital and draw private investors into the earlier financing stages. The Cleantech Group (2015) indicates that public financing programs can influence private-sector investment models and lead to the longer time horizons and higher risk tolerances required for clean technology.

At the federal level, BDC and EDC deliver financing support. The Venture Capital Action Plan, administered by BDC, distributes funds directly to venture capital investors and through a “fund of funds” model that aggregates multiple venture capital funds into a larger investment portfolio. Some provinces and territories encourage private investments through direct spending and indirect measures, such as investment tax credits.

**Figure 4.1**

#### ■ VENTURE CAPITAL ACROSS SECTORS IN CANADA (2013-2015)



Source: CVCA, *Canadian Capital Market Overview*, 2015



Overall, the Working Group found evidence that greater public support is needed to encourage and leverage early-stage and venture capital investments from the private sector. Several mechanisms already exist to deliver such support at the federal, provincial and territorial levels. However, additional support with a specific focus on clean technology could be beneficial, such as through a dedicated clean technology fund.

### **Nova Scotia: Building Clean Technology Start-Ups**

In 2011, the Province of Nova Scotia created a specialized venture capital fund to support high-potential start-ups and early-stage companies in the clean technology sector. Managed by Crown corporation Innovacorp, the Clean Technology Fund is designed with the flexibility to address financing needs at different stages of clean technology development, from proof-of-concept to pilot-scale validation to commercial-scale demonstration with partners.

Innovacorp has made equity investments in 12 early-stage clean technology companies and provided acceleration funding to over a dozen start-ups, many of them university spin-outs, to help them become “investment-ready”. Companies supported by the Fund are targeting sectors including construction, agriculture, smart grid, biorefining, water treatment and oil & gas. Innovacorp’s funding has leveraged \$1.44 of private investment and \$1.64 in funding from the Atlantic Canada Opportunities Agency, IRAP and SDTC for every dollar invested.

Key considerations include Nova Scotia’s strong base of early-stage innovation in clean technology, particularly in smart energy, ocean technologies and bioresources with high potential for regional collaboration. Access to acceleration support, incubation facilities and expert mentors is vital to helping start-ups become “investable” and reach critical early milestones. Finally, there is a growing need for patient, deep-pocket funding to finance capital-intensive demonstration and first commercial stages critical for market entry.

### **Working Capital**

After seed and early-stage financing, availability of working and growth capital is an important driver of firm growth. Stakeholders suggested that further later-stage financing is needed for firms to expand or restructure operations around competitive clean technologies. Many firms seek working capital to grow their businesses into globally competitive companies. The Working Group notes that Indigenous businesses, including those focused on clean technologies, are uniquely challenged in this regard. This is in part due to their often more remote locations and the difficulties in leveraging capital against property assets on-reserve.

Many of the trends that influence investment in early-stage clean technology development also are in play at the later stages. Investors are currently quick to write off investments that do not achieve scale within three to five years (Gaddy et al., 2016). Clean technologies are poorly suited to short-term investment models because they are often illiquid, expensive to scale and subject to intense market competition with thin profit margins. They often involve complicated exits where the sale price is unlikely to offer the outsize returns that investors seek.

According to the Cleantech Group (2015), growth investment funds lack sufficient resources to finance the expansion phase of clean technology companies. This echoes stakeholder feedback that Canadian funds are currently undersized (\$100 million or less) since around \$300 to \$350 million is often needed to support the commercialization of innovative technologies. Stakeholders linked this issue to a late-stage financing gap where clean technologies require extended support (relative to some other technologies) to achieve net positive cash flow; however, current funds do not have the resources or the risk appetite to support them.

The U.S. Department of Energy's Loan Guarantee Program is an example of a successful program that supports company growth by providing partial risk coverage of loan losses to encourage commercial banks and other lenders to offer financing. Tesla is one company that has successfully grown its business through participation in the program. The company has since repaid its loan with interest. Overall, the program and portfolio of loans have returned funding to the taxpayer.

The climbing rate of Canadian growth-stage venture capital deals was an important trend in 2012–2015 (Cleantech Group, 2016). While this growth could potentially point to improvement in Canada's commercialization performance, further data are necessary to properly understand it. At the same time, stakeholders suggested that there is demand for additional growth-stage financing. Until more concrete evidence emerges that demonstrates the private sector's capacity to meet the demand for clean technology growth capital among Canadian companies, the Working Group believes that public-private cooperation is important to provide additional funds and promote sustained financing through longer investment cycles. Strengthening the growth-stage prospects of clean technology producers is an important step in developing internationally competitive Canadian clean technologies.

Many existing agencies already deliver public working capital financing, such as BDC and provincial and territorial equivalents. While noting all these existing efforts, the Working Group concluded that further focus and larger funds could be allocated to clean technology producers given their strategic importance to the economy and the environment.

### **Project Financing**

Clean technology producers find it challenging to access project financing for first-of-a-kind or early commercial deployments. According to stakeholders, improved access to financing is required for large projects (more than \$100 million) that deploy non-mature technologies. Deterrents to investors include long payout periods (15-20 years), poor collateral (single purpose and highly specialized assets with little resale value), and the need for multiple investors, which requires some parties to take subordinated, riskier investment positions. While long-term, patient capital is often found in large institutional investors, such as pension funds and sovereign wealth funds, individual clean technology projects tend to be too high risk and, in some instances, too small for these larger funds to consider. Stakeholders suggested that EDC and BDC should specifically design complementary clean technology project loan guarantee, equity and debt programs to finance commercial clean technology projects.

Other analyses identified by the Working Group confirm that project financing is a crucial mechanism for clean technologies due to their capital intensiveness; they further confirm that lack of access is a common problem. Kaminker and Stewart (2012) attribute institutional investor hesitancy about clean technologies to a lack of information, expertise and supportive regulations. They also point to the general absence of suitable investment vehicles with the characteristics needed to manage the risks specific to clean technology projects. New, unproven and capital-intensive clean technologies are too large for venture capital funds, but too high risk for banks and project finance (Mazzucato & Semieniuk, 2016). Institutional investors tend to focus on less risky investments due to a lack of appetite for technology risk in project financing (Ghosh & Nanada, 2010). Stakeholders noted that clean technology projects tend to pose significant liquidity challenges, with highly specialized, single purpose assets whose value is difficult to establish. This further adds to a project's risk and therefore to the costs of financing.

The evidence underscores the need for governments to play a role in supporting clean technology project financing, particularly as underwriters to lower the cost of capital and address risks that are deterring private investors. Additionally, through other co-investment mechanisms (e.g., concessional financing or the assumption of subordinated debt positions), governments can facilitate projects' access to patient capital at an affordable cost.

The Working Group found that further support is needed in this area. Successful early commercial deployments are a critical ingredient in the commercialization of Canadian clean technologies and growing Canadian companies. Addressing clean technologies' project financing gaps is an important challenge for which government support has significant potential for impact.

### **Other Patient Capital Tools and Tax Incentives**

Stakeholders highlighted a number of other financing tools that have the potential to support commercialization of clean technologies, including mechanisms that mitigate the high risk of clean technologies by pooling together clean technology projects (e.g., through YieldCos or investment trusts), green bonds and investment tax incentives. New and evolving forms of investment, such as social and crowdfunding, may also become relevant in this area in the future. A number of provincial and territorial initiatives related to these and other financing mechanisms are currently underway.

In the area of investment tax incentives, stakeholders expressed a need to level the playing field of tax credits for clean technology producers, for example through extended eligibility for flow-through shares and accelerated capital cost allowances, which they argued currently favour traditional sectors of the economy. Stakeholders also mentioned angel investor tax credits and extending SR&ED eligibility to include commercialization activities as potential ways to support further investment in clean technologies.

The Working Group notes the potential value of these financing tools in supporting the commercialization of clean technologies and encourages their further consideration.

## **4.2 Skills and Jobs**

### **4.2.1 The Issues**

The Working Group identified several challenges related to skills and jobs for clean technology commercialization. First, clean technology firms face skills gaps in business and commercial competencies. Second, it is often difficult for firms to attract personnel, domestically and from abroad, with particular science, technology, engineering and mathematics (STEM) skills despite Canada's strong base in STEM. Third, the broader labour force needs to be better armed with the clean technology skills and experience necessary to adapt to and succeed in a low-carbon economy. This is of particular relevance in northern, remote, and Indigenous communities, where skills development and capacity building are important for the adoption of clean technologies.

### **4.2.2 Analysis**

Stakeholders identified skills gaps among clean technology entrepreneurs in many commercial competencies, including sales, marketing, business development, product management and financial management, particularly among the executive suites of SMEs. They also proposed that Canada should establish a skills training and jobs development plan to support the transition to a low-carbon economy. This strategy should seek to provide Canadian workers with the skills and labour market information that they need to seize clean growth opportunities.

The research rounds out stakeholder views. For example, the Canadian Clean Technology Industry Report (Analytica Advisors, 2016) observes that clean technology development is a driver of high-skill, high-wage, knowledge-based jobs. In 2014, engineers accounted for 20% of the employees of the companies surveyed. Business development, management, sales, marketing and capital-raising are the skills gaps identified by surveyed companies in this report, similar to those raised by stakeholders and highlighted for many sectors

of the economy in other reports surveyed by the Working Group. The integration of clean technologies in traditional sectors is often constrained by a lack of receptor capacity at facilities (i.e., employees with the skills, experience and professional networks necessary to support the installation and operation of innovative technologies) (DEEP Centre, 2016).

While many of these skills challenges apply beyond clean technologies, stakeholders also pointed to a skills challenge unique to clean technologies: limited investor expertise in Canada. Fostering a class of investors with clean technology expertise, experience and a large network, with the ability to evaluate and identify high-potential clean technology producers and projects for investment and act as mentors in the development of internationally competitive firms, is critical. The Working Group highlighted this as a key skills priority.

According to stakeholders, firms face increasing barriers in attracting international talent to fill Canadian clean technology skills gaps as global competition for talent grows. Slow and administratively burdensome immigration processes make recruitment difficult. Stakeholders suggested creating a public/private-sector working group to develop recommendations to streamline the immigration process (e.g., establishing a fast-track immigration approval process for executive talent, adding clean technology competencies to the list of eligible criteria for expedited immigration processes and facilitating greater communication between industry and immigration representatives).

There are immediate opportunities, in the Working Group's view, in implementing the policy measures available for addressing Canada's clean technology skills challenge. For example, expedited immigration processes, such as the federal Start-up Visa program, Express Entry Program and Provincial Nominee Program, could be aligned with identified skills gaps for Canadian clean technology firms. More broadly, however, the design of government programs and policies, from incubators and research institutions to government procurement plans and regulations, should strive to foster the development of skills and competencies that are important to the commercialization of clean technologies.

ECO Canada (2010) suggests that the green economy mainly influences the labour force through the adaptation or reallocation of jobs. In this regard, the labour force transition associated with the development and diffusion of clean technologies would focus on diversification and broadening of existing skills among existing professions, rather than the emergence of distinctly new skill sets and professions. ECO Canada's *Green Jobs Map* (2012), a survey of the country's green jobs, makes three key observations:

- Demand for green employment is strongly driven by established environmental industries such as environmental protection, renewable energy, energy efficiency, green building and eco-tourism.
- Green jobs require integration of environmental expertise into business planning and development.
- Careers in the low-carbon economy are widespread and highly transferable since many feature competencies in high demand in non-clean technology work.

This suggests that Canada does not have to reinvent the wheel when it comes to approaches to education and training around clean technologies. Rather, labour force adjustment to the low-carbon economy is an issue of continued education and an opportunity for high-quality jobs for all Canadians.

Developing and attracting world-class talent is an important component of Canada's plan to meet its climate change objectives and drives the competitiveness of Canadian clean technology firms. There is a need for collaboration, among industry, post-secondary institutions and training facilities, and across jurisdictions, that leverages existing programs in support of communicating sector-specific skills requirements to educators, trainers, employers and workers. This noted, the impetus to develop and attract talent is not unique to clean technology. Several other federal initiatives to address skills development are underway, including the Innovation Agenda and the ongoing review of Canadian immigration policies, along with

provincial and territorial measures. Collaboration across these initiatives is important going forward so that provincial and territorial considerations are incorporated into federal skills strategies.

Finally, NIOs noted the importance of addressing skills training and job opportunities in northern, remote, and Indigenous communities, as well as for other under-represented groups. They saw the need to strengthen skills related to the low carbon economy, develop the entrepreneurial and community-based capacity, and facilitate mentorships among communities. BDC and INAC offer services and financial support specifically designed to meet Indigenous business needs. For example, INAC provides funding and other supports to the National Aboriginal Capital Corporations Association and a network of Aboriginal Financial Institutions (AFIs) dedicated to stimulating economic growth for Aboriginal businesses owned by First Nation, Métis and Inuit people. The program provides a non-repayable contribution to help entrepreneurs build equity as well as enhance the network's financial sustainability and capacity.

BDC has a team of specialists that deal exclusively with Indigenous entrepreneurs and provide them with targeted financing and advice. In addition to conventional lending, activities and initiatives specific to Indigenous entrepreneurs starting or expanding their businesses include a micro credit program that combines financing with management training and ongoing mentorship, and a growth capital loan program with an option to donate some of the interest to a charity or community organization. BDC also has direct arrangements with several AFIs.

#### 20/20 Catalysts Program

The 20/20 Catalysts Program is an example of how Indigenous communities are already forming partnerships to mentor and share skills related to clean technology and clean growth. The program connects First Nations, Métis and Inuit Catalysts to a network of Indigenous and non-Indigenous clean energy project mentors and coaching specialists involved in clean energy project development, including solar, wind, hydro, biomass and geothermal. It demonstrates how mentor-mentee relationships that promote knowledge sharing can amplify the readiness of Indigenous communities to drive change towards clean technology business and economic development.

## 4.3 Commercial Capacity

### 4.3.1 The Issues

The Government of Canada's RDAs and Canada's network of incubators and accelerators are key support mechanisms for firm growth in the pre-commercial phases of development. RDAs and business support organizations support local and regional ecosystems and help entrepreneurs and start-ups scale their companies through the provision of working space, education, mentorship and access to capital and networks, sometimes in return for equity or fees.

Building commercial capacity for Canada's clean technology entrepreneurs and start-ups is an important component in the commercialization of Canadian clean technologies. The Working Group identified barriers to access to capital, networks and markets, which are critical success factors.

### 4.3.2 Analysis

Stakeholders proposed that more public funding for clean technology-focused incubators and accelerators is needed to address the funding and business support gaps for clean technology start-ups. Mentorships and connections (to capital and to customers) should be priority areas. Better focus and alignment to meet clean technology and climate change objectives are also needed to achieve critical mass.

A 2015 study found that the top 20 incubators and accelerators in Canada attracted \$1.7 billion in follow-on investment and helped create more than 10,000 jobs (DEEP Centre, 2015). International initiatives also highlight the value of incubators and accelerators, as well as the sharing of best practices and supporting critical mass. For example, the U.S. Department of Energy's National Incubator Initiative for Clean Energy, launched in 2014, established a national consortium of more than 19 incubators (called Incubatenergy) to support coordination and capacity building. The program also funded five regional incubators to scale early-stage clean technology companies and develop best practices for incubators. Companies supported by Incubatenergy have collectively received more than US\$1 billion in follow-on funding, generated US\$330 million in revenue, and employed almost 3,000 people (Incubatenergy, 2016).

Canada has around 140 incubators and accelerators of varying sizes, specializations and ownership structures (e.g., public, private, non-profit). While most of these are sector-agnostic (with large ICT focuses), a few business support organizations have a clear clean technology/natural resource focus, including the Centre of Excellence in Energy Efficiency, Foresight Cleantech Accelerator, Innovate Calgary (Kinetica), Ecofuel, IamXconnect, MaRS Cleantech, WaterTAP and Innovacorp.

According to a study of Canada's network of business support organizations, clean technology-focused incubators and accelerators tend to have a more difficult time attracting funding due to the often longer lifecycles and revenue generation points of the technologies. This has resulted in lower follow-on investment and job creation statistics, compared with sector-agnostic or traditional ICT-focused business support organizations (DEEP Centre, 2015). Similar to project financing, public funding can address this gap by directly targeting clean technology-focused accelerators and incubators to support the commercial capacity of Canadian entrepreneurs and firms.

The critical "translation" role of incubators and accelerators needs to be strengthened and regional activities across the country linked (similar to the U.S. Incubatenergy network) and leveraged to maximize synergies without creating regional competition. Since incubators and accelerators are still relatively new models in Canada, current work by ISED to develop a performance measurement framework for them could help inform further government support and target investments to the most effective areas (Department of Finance, 2016). Additionally, due to the important role of RDAs and provincial and territorial economic development agencies in these local innovation ecosystems, greater collaboration could reinforce regional strengths and opportunities.

## Ontario: MaRS Cleantech

MaRS Cleantech works closely with entrepreneurs and investors to create solutions in energy, water, agri-tech, advanced materials and manufacturing, and smart cities. The industry looks to MaRS Cleantech to assist with company growth and the removal of complex technology adoption barriers. The team supports high-impact businesses by connecting innovators with potential partners, customers, investors, talent and capital.

MaRS Cleantech comprises three main entities: Venture Services and its network of advisors; the Advanced Energy Centre, whose team facilitates collaborative problem-solving and exports; and ArcTern Ventures, a \$50 million, privately backed venture fund. It is also supported by MaRS Data Catalyst, which provides detailed data on the Canadian entrepreneurial ecosystem, helping innovators make informed decisions about the products, solutions and services they create. Together, they build globally competitive companies and drive innovation in the clean technology sector.

## 4.4 Exports

### 4.4.1 The Issues

Global export opportunities are valuable not only for generating economic benefits, but also because Canada should look beyond its borders to address climate change. Canada produces 1.6% of global GHG emissions. Canadian clean technology firms, however, require further support to export products, understand international markets and pursue international demonstrations and deployments. Competition in international markets requires investment in relationship-building and market intelligence that frequently exceeds the resource capacity of many SMEs.

### 4.4 Analysis

Due to the size of the domestic market, to achieve scale Canadian clean technology firms often rely on exports and integration into global value chains. According to Analytica Advisors (2016), the majority of Canadian clean technology firms are export-focused, with 87% of them already exporting products or services. However, Canada's share of global environmental goods exports has slipped in recent years, from 2.2% in 2005 to 1.3% in 2014 (Analytica Advisors, 2016), and has failed to keep pace with global market growth.

## Clean Technology Priority Markets for Canada

In 2014, China, the United States and the European Union were the most active global traders of clean technologies in terms of both exports and imports (Analytica Advisors, 2016). In the same year, according to data from Global Affairs Canada (GAC), Canada's *merchandise exports* in clean technologies were \$14.2 billion, with 74.6% going to the U.S., 8.5% going to the European Union, and 2.7% going to China.

Due to its proximity, market size and shared cultural and business practices, the United States remains Canada's largest customer for most export categories, including clean technologies. In June 2016, leaders from Canada, the United States and Mexico announced a range of initiatives to advance cooperation on clean technology RD&D.

China is the world's top investor in clean technologies. The Chinese government's strategy to deploy clean technology across its economy has provided clean technology producers with a burgeoning market. In February 2016, Canada and China signed a Joint Declaration on Clean Technology Cooperation.

The EU market offers many opportunities across the full spectrum of trade, investment and innovation for Canadian clean technology solutions, with many attractive incentives offered in various EU countries.

Canadian clean technology firms, many of which are SMEs, often do not get the requisite support to fully take advantage of international opportunities. Stakeholders emphasized that SMEs do not have sufficient resources to identify and understand international market opportunities, develop international business relationships and respond to the demands of global customers.

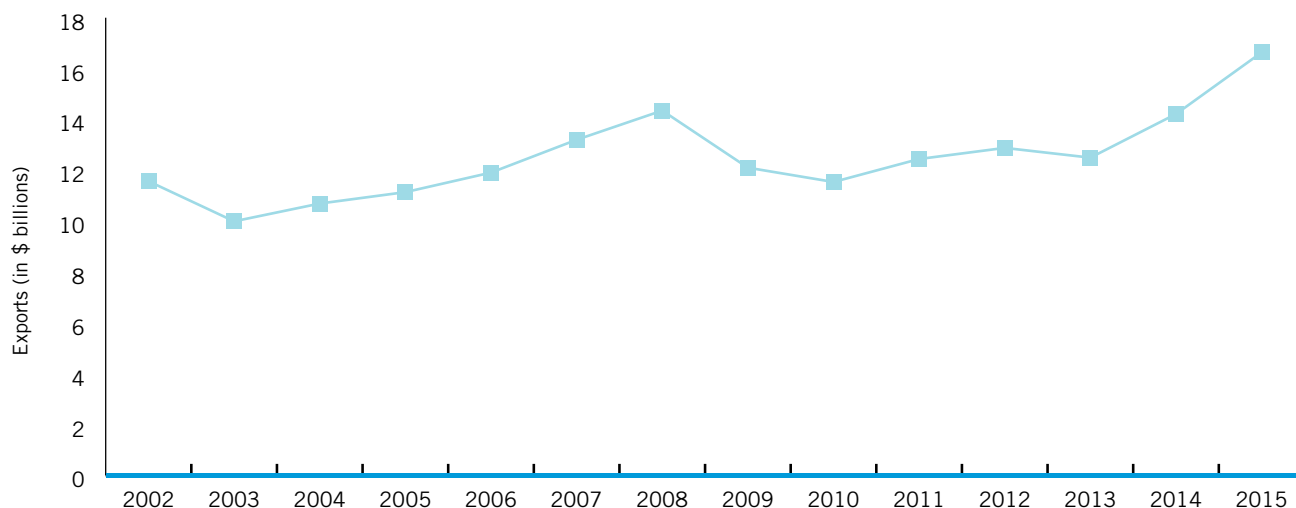
Research in this area suggests an absence of strong relationships between SMEs and larger firms, which can often serve as a critical vehicle for SME access to international markets. Due to the absence of these relationships, SMEs need additional support to access global markets and value chains. The OECD (2009) identifies financial, informational, network and managerial capacity barriers as the core challenges faced by firms competing in international markets. This categorization aligns with the challenges encountered by Canadian stakeholders including the resource demands associated with identifying opportunities and developing relationships in foreign markets, responding to the suite of demands of foreign customers, and managing risks associated with operating in a foreign country.

Government engagement could help firms export by mobilizing public resources around a number of these challenges. Governments could also facilitate strategic partnerships between small and medium clean technology producers and larger Canadian and international firms with established global networks and the ability to act as anchor customers for their products, allowing SMEs to establish themselves in foreign markets. Building government capacity to further international cooperation, identify opportunities and boost engagement with international financial institutions around clean technologies could strengthen Canada's clean technology export performance (GAC, 2013; NRCan, 2014).



Figure 4.2

## CANADA'S GLOBAL ENVIRONMENTAL GOODS EXPORTS (2002–2015)



Source: *Global Trade Atlas, 2016*

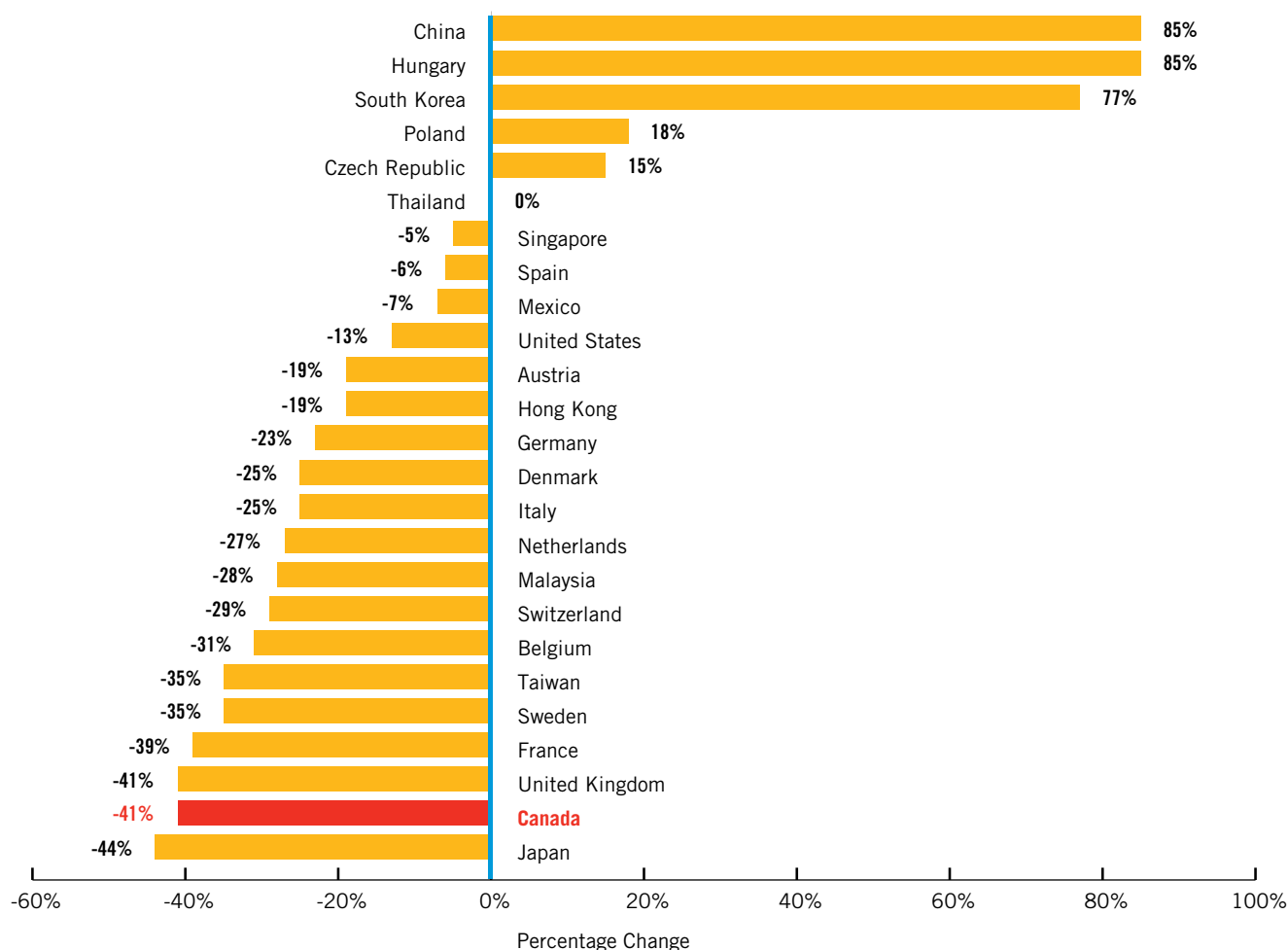
Stakeholders observed barriers for firms in deploying and demonstrating abroad. Financing risks and a lack of reference demonstration projects in Canada prevent them from launching international commercial-scale projects. Stakeholders proposed that government support would help clean technology producers secure first-commercial deployments in international markets and that support for feasibility studies and joint ventures could accelerate and clarify entry points into new markets. Stakeholders also pointed out opportunities to leverage the large sums of international climate financing committed by countries towards climate change mitigation and adaptation projects and programs.

Stakeholders, as well as provincial officials, drew attention to the need for better awareness of trade promotion services and more collaboration on them by federal, provincial and territorial governments.

Finally, stakeholders posited that Canadian clean technology entrepreneurs could gain significant competitive advantages through shaping new clean technology-related international standards. By embedding Canadian innovations, technologies, products and services into the international standards-setting process, firms could assert their influence in the global marketplace. This would drive competitiveness and global demand for made-in-Canada innovations. Similarly, conforming to international standards is critical for Canadian firms looking to gain access to global markets and value chains. Standards bodies that produce these rules include the Institute of Electrical and Electronics Engineers, the International Organization for Standardization (ISO) and CSA Group. Governments largely act as facilitators or coordinators in standards setting, rather than as developers (as for regulations). The Standards Council of Canada, a federal Crown corporation, promotes efficient and effective standardization in Canada and represents Canadian interests in international forums on standards. Stakeholders, however, perceived the need for greater capacity in the involvement of Canadian clean technology producers in international standards setting.

Figure 4.3

### CHANGE IN GLOBAL MARKET SHARE, ENVIRONMENTAL GOODS EXPORTS (2002–2014)



Source: *Global Trade Atlas*, 2016

The Working Group identified and considered two other federal initiatives that are currently underway to develop the export prospects of Canadian companies more broadly. First, GAC's proposed Trade and Investment Strategy aims to outline actions to bolster government support for exports across all sectors of the economy. The Working Group suggests that this strategy should consider the importance of clean technologies and exports in securing Canada's future economic prosperity. GAC is also developing the Progressive Trade Policy Agenda, which will lay out Canada's objectives for future negotiation of trade policy commitments with other countries. The Working Group affirms that the objectives could consider promotion of environmental goods and services, as well as the negotiation of ambitious environmental commitments in Canada's future trade agreements.

Various provincial and territorial initiatives also contribute to the promotion of Canadian clean technology exports. The Working Group found that the myriad of government initiatives that target clean technology export promotion would benefit from a coordinated strategy to support Canadian clean technology producers in accessing and competing in international markets.

## Prince Edward Island: Island Water Technology

Island Water Technology, a start-up, focuses on waste water treatment systems for rural and hard to service regions of the world. Its cost-effective waste solutions work better than existing septic systems at a fraction of the price. The decentralized solutions use solar energy as their main power source and are built in a shipping container package for easy transport and quick setup and operation. These temporary or permanent solutions to environmental challenges can be applied for military use, northern regions or catastrophic events.

Support for the company's R&D and growth came from NRC R&D support programs, a federal \$500,000 conditionally repayable loan, \$250,000 in seed funding from Innovacorp and additional support from Innovation PEI.

## 4.5 Action Plan

The commercialization of clean technologies and building of commercial capacity are essential to meet Canada's economic and environmental goals. Innovative clean technologies have the potential to reduce emissions in both domestic and international markets, with significant associated economic benefits. Given Canada's small domestic market, Canadian firms must look to highly competitive international markets to achieve scale. Building globally competitive clean technologies requires globally competitive talent, unhindered access to the capital and resources that firms need to demonstrate their products' commercial viability, and strong international networks that facilitate the cross-border flow of clean technology goods and services. However, many gaps exist in these areas of financing, skills development, commercial capacity and export development.

The Working Group expects measures targeted at reducing financing gaps to have an immediate impact on innovators' access to capital to develop, demonstrate and commercialize their technologies. The greatest economic and GHG reduction impact of these measures would likely occur in the medium term as companies gain market traction, scale up and export their technologies.

Labour market measures, particularly in immigration, could be expected to have an immediate impact in supporting the talent requirements of Canadian firms for commercial capacity. Similar to financing access measures, those that target regional capacity and incubators and accelerators could have an immediate impact in supporting innovators, but achieve their greatest economic and GHG reduction impacts in the medium to long term as entrepreneurs and start-ups move to commercialize their technologies.

For measures to increase Canadian clean technology exports, impacts would likely be felt in the short term as market-ready Canadian technologies are exported in greater numbers. Over the medium to long term, exports would expand alongside growing demand for clean technologies and Canada's clean technology capacity.

Finally, the Working Group expects measures targeted at developing skills and building the capacity of Indigenous Peoples to have an impact over the medium to long term.

The Working Group proposes the following options for action to Ministers:

### Access to Financing

- **Create a “no-wrong door” approach to accessing government programs** so that clients, including Indigenous businesses, can access the full suite of federal-provincial-territorial (FPT) clean technology programming, regardless of their initial point of entry. Priorities include: funding programs and agencies coordinating their client engagement and ensuring a seamless handoff of clients as they advance through the innovation

spectrum, drawing on the lessons learned through efforts such as the Government of Canada's Accelerated Growth Service pilot; and reducing duplication (e.g., through joint application processes and shared due diligence) and gaps between programs.

- **Promote greater availability of venture capital for clean technology development** through specific, coordinated federal and provincial measures, including:
  - » A new initiative that draws upon lessons learned and experience from other venture capital support programs and has a specific clean technology focus, longer investment time horizons, and tailored incentives to encourage private-sector investment in more capital-intensive technologies, including by strategic corporate investors; and
  - » Business Development Bank of Canada and Export Development Canada expanding support for early and late-stage private sector-led funds focused on clean technology, and increasing direct investment in high-potential clean technology producers.
- **Establish initiatives to increase the availability of working and growth capital** to meet the needs of later-stage clean technology providers, including through the expanded support of BDC and EDC in this area, together with tailored management advisory services.
- **Create new instruments that leverage and mobilize private-sector investment in large commercial-scale demonstration and deployment projects**, by providing direct contributions and other forms of support (e.g., loan guarantees) to help address perceived risks associated with these projects. This could include expanding support of BDC and EDC, as well as leveraging provincial support where available, and drawing from international practices including the U.S. Department of Energy's Loan Guarantee Program.
- Work with Ministers of Finance, as well as industry, stakeholders and the financial community, to **identify and evaluate other patient capital tools** and ensure that an appropriate regulatory environment exists to support new mechanisms of social enterprise, including crowd funding, green bonds, green banks, as well as the use of YieldCos and other methods for pooling and securitizing clean technology assets.
- **Refer to Ministers of Finance for their consideration stakeholder proposals relating to the use of tax policy** to encourage clean technology development and commercialization (e.g., angel investor tax credits, flow-through shares, etc.).

## Skills and Jobs

- Work with Ministers of Immigration to **expedite immigration of highly qualified personnel** needed to make Canada a global leader in welcoming international talent and expand clean growth capacity.
- Work with Labour Markets, Employment and Skills Ministers to **create a clean growth talent plan** that ensures Canada has the right talent to support job creation and the transition to a low-carbon economy, including for under-represented labour market groups. Priority areas include:
  - » Strengthening skills in Science, Technology, Engineering and Mathematics (STEM), and associated trades;
  - » Building stronger business leadership and management skills to lead companies to rapidly grow and export clean technologies; and
  - » Supporting the development of skills needed for the adoption, installation and maintenance of clean technologies, including in Indigenous communities.
- **Recognizing the potential for Indigenous Peoples to be agents of change in the transition to a low-carbon economy**, work with other relevant Ministers including those responsible for Indigenous affairs, and Indigenous organizations to:
  - » Develop initiatives to strengthen skills and entrepreneurial and community-based capacity in clean technologies;

- » Facilitate mentorship both within and among communities, benefitting from the experience of communities that have implemented clean technologies; and
- » Ensure Indigenous businesses have needed, effective access to capital to support innovation and development.

## Commercial Capacity

- **Direct FPT economic development departments and agencies to collaborate and develop strategies** to further strengthen access to capital, talent and markets for companies developing and providing clean technology products, services and solutions, including Indigenous businesses.
- **Strengthen support for clean technology start-ups and entrepreneurs through incubators and accelerators**, ensuring that they benefit from strong regional linkages and can take full advantage of regional research and business capacity. This could include increasing BDC's convertible notes program for early-stage clean technology developers in high-performing accelerators.

## Exports

- Work with Ministers responsible for trade promotion to **strengthen clean technology export initiatives**. Priorities in this area are:
  - » Building Trade Commissioner knowledge of Canadian clean technology opportunities;
  - » Engaging in trade missions focused on clean technology, including industry-led missions;
  - » Gathering better market intelligence, addressing key market access barriers and improving export marketing and branding; and
  - » Strengthening export financing mechanisms, such as through EDC.
- Direct the Standards Council of Canada to **take a leadership role in international standards-setting processes for new clean technologies**, and ensure that Canada's clean technology capacity shapes future international standards.



## **CHAPTER 5**

# **FOSTERING GREATER ADOPTION**







## CHAPTER 5 FOSTERING GREATER ADOPTION

Government policies can help support the advancement of clean technologies along the innovation continuum from ideation to final products and services (*supply-push*). In addition, policies that incentivize the adoption of clean technologies by governments, industry and consumers (*demand-pull*) are also critical (e.g., targeted government procurement programs, carbon pricing mechanisms, regulations, standards and certifications).

By stimulating demand for clean technologies, government policies can directly generate incentives for the private sector to invest in innovation and, critically, support the mass diffusion of these technologies to help meet Canada's ambitious climate change goals (CCA, 2015; Comette et al., 2015; Action Canada, 2014). These measures also produce domestic testing grounds for Canadian entrepreneurs and firms to develop and improve new clean technologies, demonstrate them to potential customers and produce solutions at greater scale and efficiency, which allows them to scale successfully (Global Commission on the Economy and Climate, 2014). Adopters of clean technology are also critical innovators, working with technology suppliers to integrate new clean technologies into their operations, which could require significant modification, and taking on technical and financial risk.

Effective domestic adoption of clean technologies can also create a strong Canadian "first market" when firms look to global markets. There is a critical feedback loop between demand and supply-side policies in supporting clean technology innovation (Goldman Sachs, 2015). Poor domestic adoption of clean technologies can negatively affect investment in innovation.

Canada's performance on clean technology adoption by industry is poor, with much room to improve. According to Statistics Canada's 2014 *Survey of Advanced Technology Adoption*, only 9.9% of Canadian firms have adopted clean technologies, making it the least adopted distinct class of advanced technologies (the other classes were business intelligence, logistics and design and fabrication), with SMEs the worst performers. In contrast, 43.3% of firms surveyed have adopted advanced logistics technologies. This low level of clean technology adoption is also partly reflected in Canada's poor performance on environmental indicators, such as low CO<sub>2</sub> productivity and high overall GHG emissions. Canada ranks 25<sup>th</sup> out of 128 countries on environmental performance on the 2016 Global Innovation Index, performing particularly poorly on energy efficiency (94<sup>th</sup>) and ISO 14001 environmental management certificates (54<sup>th</sup>).

Current tools such as environmental regulations, carbon pricing mechanisms and codes and standards (e.g., building codes) encourage investment in clean technologies in Canada. In addition, government procurement programs could set aside a portion of regular procurement spending for clean technologies. Similarly, innovation procurement programs allow governments to procure earlier-stage technologies (versus commercially available products) and work with firms to demonstrate and adapt technologies to government infrastructure and operations. Any examination of adoption issues should include a discussion of the unique challenges faced by northern, remote, and Indigenous communities. Clean technologies offer many advantages and opportunities to these communities, such as reducing GHG emissions, lowering expensive fuel costs and increasing self-sufficiency and economic capacity.

In this chapter, the Working Group examines Canada's performance on clean technology adoption in three key areas and proposes options for action for each:

- Expanding the leadership role of governments through procurement;
- Supporting adoption by northern, remote, and Indigenous communities; and
- Catalyzing consumer and industry adoption through direct policy levers and support of certification and technical standards.

## 5.1 Governments Leading by Example

### 5.1.1 The Issues

Each year, federal, provincial and territorial governments and municipalities in Canada procure more than \$200 billion in goods and services (Swick, 2014). The public sector controls large spending in transit and infrastructure, hospitals, schools, universities and other areas. Governments can also influence the procurement priorities of these public institutions as well as those of utilities. Collectively, public-sector procurement has enormous potential to drive clean technology growth in Canada, while also directly supporting environmental goals. However, current government procurement programs do not sufficiently target clean technologies and there is room for expansion of governments' roles as first adopters of clean technologies.

### 5.1.2 Analysis

International organizations, such as the OECD (2011a) and International Institute for Sustainable Development (2012), emphasize public procurement as a “key policy tool” for governments to influence shifts in the economy towards strategic environmental objectives. Governments can:

- Directly create demand and catalyze activity in clean technology innovation and help companies to bridge the pre-commercial gap for their products and services;
- De-risk clean technologies by acting as a lead adopter, showcasing technologies in real-world situations, which can contribute to the unlocking of private capital; and
- Help technologies achieve critical mass and allow companies to achieve scale and become more efficient, by serving as anchor customers (OECD, 2011a).

The rationale for employing public procurement as a clean technology innovation policy tool is further strengthened by its positive impacts on environmental sustainability, an additional public policy goal (CCA, 2015; Drummond et al., 2015; Dunsy Energy Consulting, 2015).

However, many stakeholders, including clean technology producers, cite the lack of domestic market support in Canada, particularly through public procurement, as a significant barrier to growth. The absence of these domestic sources of demand hinders the export potential of Canadian clean technologies (Action Canada, 2014). International customers expect domestic references and are unwilling to take on first-commercial deployment risks. Many competitor countries, such as Australia, Germany, Netherlands, United Kingdom and the United States, have established procurement programs to support innovation (OECD, 2011a). There is a major opportunity for enhanced government procurement of clean technologies to expand the domestic market for clean technologies in Canada.

An examination of international practices reveals three main ways to support innovation through public procurement. Governments can:

- Incorporate innovation-related criteria and environmental criteria to tender specifications to buy technologies off-the-shelf in general government procurement;
- Strategically create demand for specific technologies or services that do not yet exist, but are close to market or can be developed in a reasonable time, by predefining functional requirements; and
- Directly purchase R&D services from the private sector to supplement their own work and support decision-making.

The third area targets the pre-commercialization gap that many firms face by supplying risk capital in early-stage technologies. In some cases, there is an explicit guarantee that governments will purchase technologies after successful development (OECD, 2011a).

Notwithstanding the above, public procurement in Canada is currently not oriented to support innovation goals. It is primarily conducted on the basis of lowest initial cost rather than lifecycle cost accounting or innovation-related criteria, which may more appropriately capture the full social and environmental costs and associated economic benefits. In addition, traditional procurement is biased against SMEs due to the inherent risk profile of many novel technologies. In contrast, Germany, a world leader in renewable energy, uses the criterion of “best available technology” in green public procurement to support innovative German companies in environmental sectors (OECD, 2011a).

### Newfoundland and Labrador: SmartICE

Arctic climate change is causing landfast sea ice to be thinner, form later and break up earlier than before, resulting in increasingly dangerous over-ice travel. As the majority of residents in Arctic communities use sea ice to access country foods and maintain cultural and family activities, increased risk or fear of travelling on the ice has severe repercussions for food security and physical and mental health. At the same time, changes in sea-ice conditions are creating longer shipping seasons, which is beneficial for natural resource economics and the demand for winter shipping.

SmartICE (Sea-ice Monitoring And Real-Time Information for Coastal Environments), a community-academic-government-industry partnership, is developing an integrated, near-real-time monitoring and dissemination system to inform decisions about coastal sea-ice travel and shipping, thereby improving safety and adapting to the impacts of climate change. SmartICE has created technologies and data products for providing sea-ice information services in the pilot communities of Nain (Nunatsiavut) and Pond Inlet (Nunavut). In response to increasing community demand and commercial opportunities, SmartICE is preparing to expand across the Arctic through the establishment of a northern social enterprise.

Establishing ambitious emissions targets for government operations and incorporating criteria to support innovative clean technologies during bid processes can reduce emissions and provide a significant proving ground and anchor customer for made-in-Canada clean technologies. Stakeholders also suggested avoiding overly prescriptive criteria in tenders. Procurement processes can better respond to innovative new technologies by focusing on necessary outcomes, rather than narrowly defining eligible types of solutions and technologies.

Infrastructure investments are key mechanisms for governments to procure clean technologies directly because infrastructure investment cycles are generally decades-long and emissions can be locked in (Drummond et al., 2015.). Governments can create the right investment conditions through urban planning and investing in projects to encourage alternative vehicle deployments and further integrate renewables into the electricity grid.

The U.S. Small Business Innovation Research (SBIR) program offers valuable lessons on the pre-commercialization and demonstration side. This competitive, awards-based program provides a conduit for federal agencies to procure earlier-stage research, which allows small businesses to develop and test their products in a live environment. SBIR tenders projects via a competitive selection process, clearly defines benchmarks and exit mechanisms for poor performers, and hands off successful projects to general, later-stage procurement programs to improve chances of commercial success (Review of Federal Support to Research and Development, 2011). To date, SBIR has awarded over US\$40 billion to research-intensive small businesses and has drawn on and grown the expertise of 450,000 engineers and scientists. Similar programs have been created in the United Kingdom, Australia, Netherlands and Canada.

In Canada, PSPC administers the Build in Canada Innovation Program (BCIP). Inspired by SBIR, the program supports small Canadian companies in developing innovative technologies and services.

Stakeholders proposed increasing the funding specifically targeted at clean technologies and developing flexible program criteria that include new clean technology firms. In addition, they observed that many projects successfully procured by BCIP are not handed off to general procurement programs; as a result, they fail to realize commercial success. The SBIR/BCIP model could be extended beyond the public sector to link innovative projects with large firms seeking similar solutions. Research indicates that projects have higher chances of success when working closely with large domestic and multinational companies that can provide integration into global value chains, market validation and mentorship (DEEP Centre, 2016).

Public-sector institutions represent further opportunities to increase the adoption of clean technologies through procurement. Municipalities, universities, schools and hospitals (MUSH) are all large owners of real property and infrastructure, and large energy consumers and waste generators. They also operate in close proximity to the Canadian public and are well suited to implementing local clean technologies (People Power Planet, 2016). Accordingly, the Federation of Canadian Municipalities administers a \$550 million program for clean technology projects in MUSH, offering loans and grants to improve environmental performance. Stakeholders, however, noted the need for a more comprehensive and pan-Canadian approach to MUSH procurement.

Utilities are also large adopters of advanced technologies. The sector reported the highest rate of advanced technology adoption in Statistics Canada's *2014 Survey of Advanced Technology*, with 74% using at least one advanced technology. The same survey indicated 26% of utilities adopted "green" technologies, a rate that was the highest of any of the sectors surveyed. Utilities also strongly support clean technology R&D and can act as demonstration grounds for new technologies. However, the innovation activity of utilities may be inadvertently constrained by stringent regulations (CCA, 2015). This may lead to lower levels of adoption and less incentive to pursue internal R&D projects or collaborate with external projects (Concentric Energy Advisors, 2014). Stakeholders pointed to examples of promising technologies and projects that utilities were slow to adopt or reluctant to offer facilities for demonstration purposes.

### New Brunswick: Power Shift Atlantic

PowerShift Atlantic (PSA), launched in 2010 and completed in 2015, demonstrated one of the world's first fully grid-integrated virtual power plants (VPP) designed to allow for more effective integration of wind power. Unlike typical demand response services, the VPP used load and wind forecasting and aggregation capabilities to perform near real-time load shifting of commercial and residential loads and provide new ancillary services to the grid. The end-uses targeted had storage capacity such as electric hot water heaters and electric thermal storage heating. NB Power and a consortium (including University of New Brunswick) conducted the project, which was funded by NRCan through the Clean Energy Fund.

The project involved more than 1,400 residential and commercial customers with approximately 17.3 megawatts at full capacity. By remotely shifting and combining customer loads in minute-to-minute cycles, PSA demonstrated ways to optimize wind generation without requiring changes to customer behaviour or consumption. Its solution became known as the Intelligent Load Management (ILM) system, representing a transformation from "Generation following Load" to "Load following Generation".

This initiative helped shape NB Power's long-term vision of sustainable electricity and identified the importance of developing a new partnership with customers as part of a more sustainable future. PSA became the catalyst for NB Power's 10-year ongoing partnership with Siemens to develop smart grid infrastructure to help reduce shift and demand.

PSA received several awards and recognition including Climate and Energy Action and Canadian Wind Energy Association awards in 2012, a Peak Load Management Alliance award in 2014, and a Smart Grid Canada Innovation award and the Greentech Media Award in 2015.

Most importantly, as the centres of energy generation and managers of consumer relationships, utilities can further encourage energy conservation and thus consumer adoption of clean technologies, as well as using clean technologies to produce energy more efficiently and cheaply for consumers. In particular, some stakeholders raised the merits of rate-based financing models where consumers contribute a portion of their power/water/gas rate to an innovation fund that would be used to develop and demonstrate clean technologies and potentially lower rates in the long run.

Overall, governments, utilities and Crown corporations have considerable capacity to lead as strong adopters of clean technologies by fully accounting for environmental, social and economic externalities in the procurement process. Effective public procurement can also help achieve climate change targets by reducing emissions from government operations and by supporting the development and commercialization of products and services that have low lifecycle GHG emissions.

## **5.2 Northern, Remote, and Indigenous Communities**

### **5.2.1 The Issues**

Northern, remote, and Indigenous communities face many challenges related to food, water and energy security, as well as immense infrastructure deficits, high costs of living and generally limited access to economic opportunities. The Working Group recognizes that these challenges cannot be addressed in isolation. For example, implementing solutions to a single issue like electricity security could have a negative impact or create new challenges related to food security or increased costs and access to other energy services (e.g., transportation or heating). Adoption of clean technologies can potentially offer opportunities to address these issues but, to maximize the benefits, local capacity and skills should be developed further.

### **5.2.2 Analysis**

Continued efforts to adopt renewable energy and energy efficiency models in northern, remote, and Indigenous communities should feature complementary federal and territorial strategies and involve Indigenous and industry partners throughout the entire process. All partners must understand the unique challenges and opportunities of the communities. Indigenous communities face particular economic challenges including inadequate access to capital and low on-reserve investment. As a result, it is more difficult to provide financial independence and employment opportunities to community members, or quality community services and infrastructure, including clean technologies (CCA, 2014). Constraints in water, food and energy security pose simultaneous challenges and opportunities for Indigenous communities. Clean technologies can address these challenges, but can also be constrained by a lack of supporting infrastructure or resources.

Reducing the dependency of northern, remote, and Indigenous communities on diesel fuel for electricity generation and heating should be a primary objective for governments. Reduced dependency could improve energy security, generate new revenue, create well-paying jobs, improve health outcomes and greatly lower the cost of living and negative environmental impacts. For instance, around 300 communities in Canada (of which 170 are Indigenous), with about 200,000 people, are not connected to centralized electrical grids and rely on diesel and other fossil fuels as their main or back-up source of power generation and heating (AANDC and NRCAN, 2011). This translates into a lower standard of living and high energy costs including costs for transporting the fuel, maintaining or replacing diesel generators, higher electricity rates and subsidies.

## Nunavut: Home Energy Audits and Retrofits

Established through Nunavut's Energy Strategy, Ikummatiit, the Buildings and Equipment Initiative, has successfully increased energy-efficiency levels and fostered adoption of green technologies.

The Government of Nunavut, in partnership with the Arctic Energy Alliance, is currently running a series of energy audits for homeowners in several regions across Nunavut. The aim is to profile the existing energy-efficiency levels in the built environment and identify ways in which privately owned buildings can become more energy efficient. These recommendations are shared with owners, leading to retrofits that include the adoption of green technologies and ultimately ongoing energy cost savings. The most common green technologies adopted by homeowners are high-efficiency light bulbs, low flow water fixtures, ENERGY STAR® qualified windows, and vapour barriers and weather stripping. For a relatively small investment, a homeowner in Rankin Inlet can achieve cost savings of up to \$1,700 per year and GHG reductions of up to 8T per year.

The *Draft Technical Report and Business Case for the Connection of Remote First Nation Communities in Northwest Ontario* (2014) states that diesel generation costs to remote communities are 3 to 10 times higher than the provincial average and the fuel required is expected to increase by approximately 450% over the next 40 years. In that same period, the transmission connection of the affected Indigenous communities would result in around \$1 billion in savings, a 30 to 40% reduction. In 2013, the total estimated cost of diesel generation to these communities was \$90 million per year. Clean technologies such as microgrid and small-scale solar, hydro or biomass installations can also address these challenges.

Reducing the dependency on diesel is not without its challenges. The wide variety of regulatory regimes and operational landscapes across jurisdictions makes it difficult for project proponents to finance and implement clean technology solutions. For example, participants in the China Creek and Okikendawt hydro projects point to the need for provincial funding support and difficulties in navigating the appropriate regulations to get that support (Henderson, 2013). Stakeholders described the multitude of federal and provincial grants and programs that support alternative energy development, all with different application processes, timelines and requirements. This makes access to funding complicated and onerous to navigate.

Many procurement and funding programs also do not adequately capture the environmental and socio-economic benefits or lower lifecycle costs associated with diesel alternatives, which dampens the business case for investing in these solutions. Additional complicating factors include perceived technology risk with regard to reliability and operational challenges related to technology deployment in these regions, such as extreme weather and remoteness (MaRS, 2015). At the same time, clean growth and clean technologies present many opportunities to these communities for mutual benefit. For instance, their unique geographic characteristics and climate can make them testing grounds to pilot new clean technology solutions for export in the global market, particularly for microgrid technologies. The global remote microgrids market is currently worth \$2.4 billion and is expected to grow to \$10 billion annually by 2024 (MaRS, 2015).

The design, implementation, management and maintenance work related to the adoption of clean technologies could also present highly skilled work opportunities for community residents. More efficient, reliable and cost-effective sources of energy would reduce a key barrier for many businesses looking to invest in these communities (GE, 2011). However, according to stakeholders, success in these areas requires building local capacity through support for job training, energy literacy, mentorship, sharing of best practices and greater funding for projects. Governments could support adoption of clean technologies to prevent their acquisition and implementation being too costly for communities.

Indigenous communities can lead the way on community-owned and co-operative business models for clean energy projects. Research indicates that clean technology projects can involve meaningful participation and ownership from Indigenous Peoples (Henderson, 2013). While some Canadian communities support such innovative models, government funding policies and regulations should continue to encourage these types of innovation.

Finally, as northerners continue to look for ways to reduce the cost of living, diesel consumption and associated GHG emissions, the Working Group notes that traditional technologies such as root cellars could be explored and traditional southern practices such as greenhouse agriculture could also be adapted.

### Northwest Territories: Independent Solar Power Production Project

As the first independent solar power producer in the Northwest Territories, Lutsel K'e Dene First Nation is at the cutting edge of the clean energy transition. Lutsel K'e is a fly-in Dene First Nations community of approximately 350 people located on the east arm of Great Slave Lake. Its reliance on imported diesel fuel to produce electricity was expensive (\$0.61/kWh residential; \$0.52/kWh commercial), emissions intensive, and left the community dependent on fossil fuels and vulnerable to price and supply changes. The new solar power system produces 39MWh of electricity annually, representing 20% of the electrical load. It runs year round with November to January the lowest production months, and spring and summer the most productive time due to sunlight reflection from snow.

Lutsel K'e owns and operates the solar PV system as an independent power producer and provides ongoing stable revenue from the sale of the electricity to the community. Involvement of the entire Lutsel K'e community has led to pride of ownership. Four community members completed the five-day solar training course, of which two chose to work on the installation. The Lutsel K'e community was nationally recognized in 2015 with CanSIA's Game Changer award.

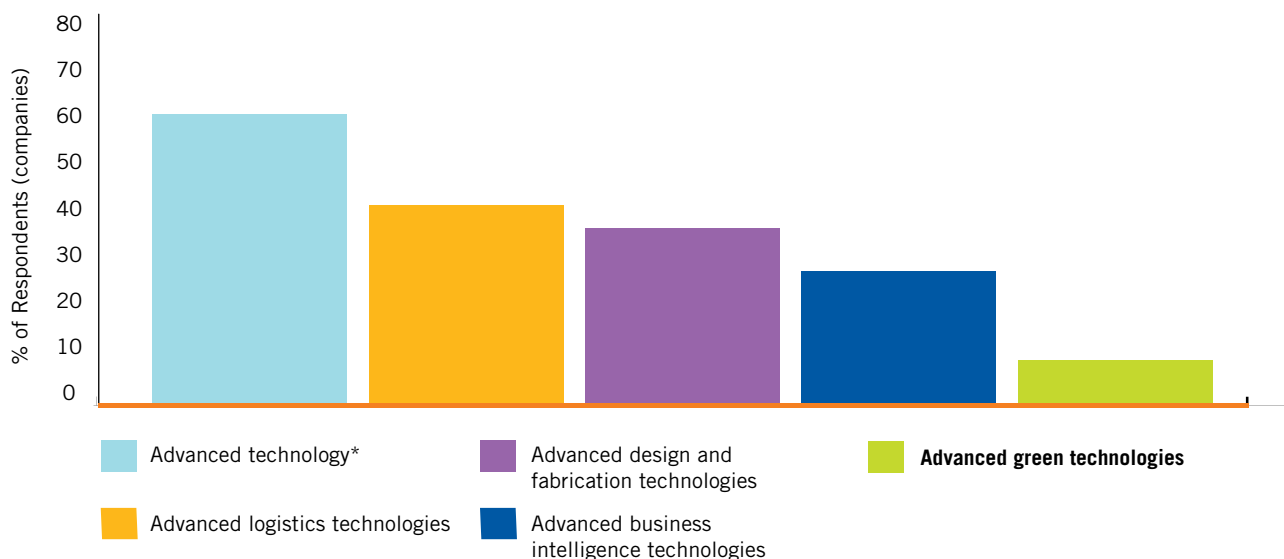
## 5.3 Consumer and Industry Adoption

### 5.3.1 The Issues

Due to the externalities inherent in environmental and social goods, markets have not yet adequately accounted for the benefits of clean technologies. This reduces the likelihood of adoption by consumers and firms, especially by SMEs. **Figure 5.1** illustrates this trend, and shows the poorer adoption rate of clean technologies compared with other advanced technologies.

Figure 5.1

### ADOPTION RATE BY TECHNOLOGY IN CANADA



\* The company adopted at least one advanced technology

Source: Statistics Canada, *Survey of Advanced Technology, 2015*

Government regulations and pricing mechanisms are two policy levers that can be applied to account for these externalities, adjust incentives and stimulate demand for clean solutions — creating the right conditions for mass adoption of clean technologies. The Working Group examined these policy levers in the context of supporting clean technology development and the growth of clean technology firms, while recognizing that two other working groups have the mandate to develop options in these particular areas. The options proposed by the Working Group on Specific Mitigation Opportunities (the Mitigation Working Group) focus on priority areas that could support the adoption of clean technologies, including transportation, electricity, the built environment and extractive industries (see **Box 5.1**). The Working Group therefore acknowledged the importance of continuing to work closely with the Mitigation Working Group and Environment and Finance Ministers in the implementation of these measures.



### Box 5.1 Mitigation Opportunities

Various options for action proposed by the Mitigation Working Group are relevant to this Working Group's analysis and to setting the broader policy context to foster clean technology growth.

The options proposed for the transportation and electricity sectors would support economic growth and clean technologies. Infrastructure investments, including investing in electric vehicle infrastructure and upgrading electricity transmissions systems to support higher electricity use in electric vehicles, coupled with further incentives to purchase zero emissions vehicles and financial support for non-emitting electricity generation, could strengthen market conditions for clean technologies. If implemented, this could lead to supply chains that support electric vehicle manufacturing and foster the development of renewable energy industries.

The Mitigation Working Group's proposed options for reducing reliance on diesel in northern, remote, and Indigenous communities are consistent with the options proposed in this chapter, and encourage clean technology adoption by promoting the deployment of renewable electricity and heating solutions. In turn, this could generate local jobs, create economic opportunities tied to support and training for the operation of clean technologies, and ultimately lower energy costs, which could ease economic and social constraints.

The building codes and incentives proposed for residential and commercial buildings would drive the adoption of clean technology and create jobs, in the skilled trades for the installation of technologies and in engineering for the design of new retrofits. However, in implementing building code measures, Indigenous culture and the unique environmental circumstances of remote and northern communities should be key considerations. Indigenous communities face housing challenges and need to build new, highly efficient homes that reflect cultural values, such as enabling extended families to live together or in close proximity, as well as designs that are circular, modular and portable.

Finally, mitigation options proposed for all industrial sectors could be a key mechanism to encourage and accelerate the adoption of clean technology in the extractive industries. They would heighten stringency for emissions and pollutants and drive large industries to seek out new clean technology solutions. Extractive industries represent a significant portion of the Canadian economy and are large potential adopters. Further, the innovation and adoption of technologies by large Canadian industries could bolster their competitiveness in an international market that increasingly prioritizes clean growth. Among these options, special consideration should be given to clear regulations designed to be performance-based and not technology prescriptive.

Certifications, labelling and awareness can also drive demand for clean technologies and promote adoption and innovation by consumers and industry, but the government plays a supporting role in these measures. Certifications are procedures by which a third party gives written assurance that a product, process or service meets certain performance, qualification or quality standards. Certified products, processes or services coupled with labelling and awareness can have powerful signalling effects for consumer and industry adopters.

### 5.3.2 Analysis

#### Regulatory Frameworks

Stakeholders, including both clean technology solution providers and adopters, strongly agreed on the importance of clear, predictable and credible policy incentives to stimulate and support the development and diffusion of clean technologies. Such measures can directly influence the demand for innovative, clean technologies (OECD, 2011a). For example, a recent C.D. Howe report suggests that demand-side innovation policies are critical to achieving clean technology goals (Popp, 2016).

#### Quebec: Cap and Trade System

The Quebec cap and trade system is the cornerstone of an integrated sustainable development approach aimed at building a low-carbon green economy. Its most innovative aspect is that instead of relying on traditional standards and regulations, it is a flexible mechanism that, by introducing a carbon cost in business decision-making, facilitates the implementation of more sustainable practices and cleaner technologies. Additional market flexibility was achieved by linking to the cap and trade system of California in 2013.

Industrial facilities and consumers in Quebec now take into account the cost of carbon in every aspect of their decision-making processes. This changes the investment decisions for clean technologies by increasing their payback, thereby fostering increased adoption. The result is that every industrial installation covered is meeting its compliance obligations (at December 2014, the end of the first compliance period).

The internalization of the carbon price into the price of gasoline at the pump sends a clear signal that carbon emissions represent a real cost to society. Revenues from the cap and trade system help finance rebates for the purchase of electric vehicles and investment in the supporting infrastructure. As a result, Quebec now has one of the highest adoption rates of low emission cars in North America. The international City Mobility program has chosen the Province and the city of Montreal as its North American partner, with the aim of accelerating adoption of the efficient, clean and highly connected urban transit systems that are needed for the 21<sup>st</sup> century.

(Quebec's system is one example of a carbon pricing mechanism in Canada. Other provinces have successfully adopted other approaches.)

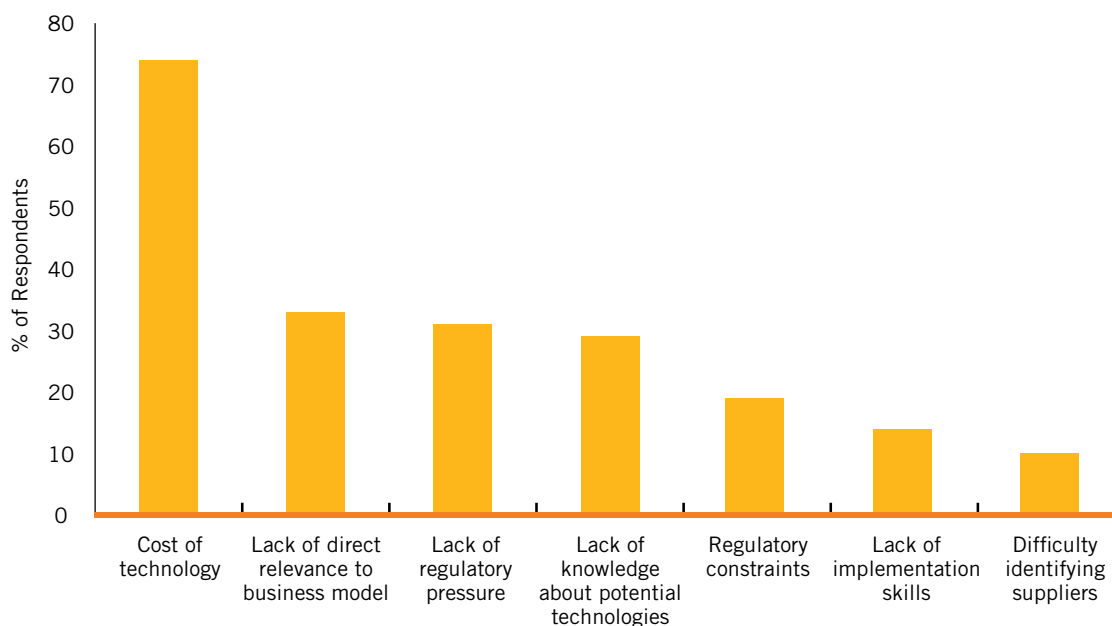
Generally, targeted policy interventions that address environmental externalities and take the social costs of environmental damage into account can provide clear signals for both Canadian consumers and industry to adopt clean technologies (Global Commission on the Economy and Climate, 2014; Drummond et al., 2015). This signals broad support for clean technology solutions and ultimately provides a domestic “first market” for Canadian innovators to pilot and develop their technologies and businesses before entering international markets, thereby accelerating commercialization.

Clean technology adopters posited that well-targeted policy interventions could create a more level playing field between early adopters and their competitors (who are not investing in new clean technologies), and even prod their customers towards cleaner solutions (DEEP, 2016). For clean technology providers, on the other hand, the first adoption of their technologies by a large reference customer is critical to accessing new markets and building confidence in their technologies in the eyes of other potential customers, particularly those in foreign countries.

A recent survey of companies reveals that the high cost of clean technology solutions is the primary barrier to future investment (DEEP, 2016). This could partly be addressed by incentives such as funding or loan programs, better performing clean technologies and/or demand-oriented policies.

**Figure 5.2**

## ■ BARRIERS TO CLEAN TECHNOLOGY ADOPTION IN CANADA



Source: DEEP Centre, *Accelerating Canada's Transition to a Clean Growth Economy*, 2016

At the same time, stakeholders called for transparent, stable regulatory frameworks to increase consumer and business confidence in investment in the development and adoption of clean technologies (Global Commission on the Economy and Climate, 2014). They also pointed to the importance of flexibility and consistency across jurisdictions. Flexibility ensures that the best, most cost-effective technology solutions are used to comply with regulations, particularly as new technologies emerge. Consistency reduces duplication and complexity, and thus compliance costs. Finally, stakeholders advocated for striking the right balance between regulation and innovation. Overly stringent or prescriptive regulations that have not been updated to take other alternatives into account can create undue economic burdens on firms and decrease their international competitiveness, especially if a rival jurisdiction has not implemented equivalent regulations. On the other hand, a policy instrument that is insufficiently stringent may not induce the optimal level of innovation (OECD, 2011a).

One mechanism for addressing such regulatory challenges is creating a safe space for businesses to test their innovative products without being fully subject to regulations and consequences. For example, the U.K. Financial Conduct Authority implemented a “regulatory sandbox” for financial technologies in early 2016. The sandbox allows new firms access to a limited portion of financial infrastructure to test their innovation in a live environment. Before the sandbox, firms had to obtain a full banking license before demonstrating their technology. Although no results are available so far, it is clear that easing barriers for demonstration allows newer technologies to reach the adoption stage quicker. Moreover, closer industry collaboration enables regulators to more nimbly update frameworks.

## Certification, Labelling and Awareness

Effective domestic certification, labelling and awareness can inform consumers and industry looking to adopt clean technologies (e.g., ENERGY STAR for energy-efficient products). By signalling that Canadian products and services meet certain qualifications whether technical, environmental, or other, certifications can help to de-risk clean technologies for industry and increase consumer confidence in purchasing new clean technologies.

The U.K. Carbon Trust Product Footprint Certification is a good example of well-functioning certifications. It has certified and communicated the GHG footprint of more than 25,000 products. U.K. consumers and businesses have increasingly expressed a preference for products and services that display this label. The Trust leverages knowledge gained from the certification process (on manufacturing processes, supply chains, logistics, etc.) to provide business and policy advice. The Trust not only improves firms' environmental performance, but also creates other efficiencies in firms' processes, enhances their reputation among consumers and stakeholders, and helps them comply with regulations (Carbon Trust, 2016).

On the domestic front, Canada's leadership in establishing forest certification has improved its competitive advantage and reputation in forestry and led to clear environmental benefits (NRCan, 2016). Wood and paper products labelled with those certifications positively influence business and consumer purchase decisions. Other countries are now beginning to certify their forests using the same standards as those established in Canada (Forest Stewardship Council, 2016).

## 5.4 Action Plan

In general, public policies targeted at increasing the domestic demand for clean technologies are critical in supporting the development of clean technologies. Without such domestic market support, many Canadian clean technology innovations would fail to commercialize and achieve scale, hindering export opportunities and domestic jobs and industries. The Working Group expects measures to increase public adoption of clean technologies to have an immediate impact on Canada's GHG performance, as well as in supporting Canadian companies with market-ready technologies. Greening infrastructure initiatives are likely to have short-term impacts in the construction phase but important GHG impacts over the longer term, as those investments further facilitate clean technology adoption.

Measures to support the adoption of clean technologies in northern, remote, and Indigenous communities, and reduce the dependency on diesel fuel for electricity and heating, could be expected to have a positive impact over the shorter to medium term, as opportunities for economic growth and better quality of life are expanded.

The Working Group expects measures targeted at increasing aggregate demand for clean technologies to have an immediate impact, as greater domestic adoption supports market-ready Canadian technologies. This would likely further de-risk technologies for international markets, allow innovators to achieve production scale, and directly lead to improved domestic environmental performance. Over the longer term, opportunities could be provided to innovators to test and refine earlier-stage technologies domestically before they are ready for mass adoption. In all cases, policy measures to spur demand for clean technologies would send a broad signal to all actors to increase activity along the entire innovation continuum.

The Working Group proposes the following options for action to Ministers:

### Governments Leading By Example

- Work in collaboration with Ministers of Treasury Board, Government Operations and Public Services to **develop an action plan for greening the operations of government departments, agencies and entities** that would:
  - » Include consideration of a target of carbon neutral governments by 2030;
  - » Set targets for the reduction of other environmental impacts;
  - » Include set-asides, as appropriate, that direct a proportion of procurement budgets for clean technology goods and services; and
  - » Incorporate lifecycle assessment into procurement practices where appropriate.
- **Create a first deployment program** that allows governments to seek new clean technology solutions to meet operational needs. Building on existing programs including the federal Build in Canada Innovation Program, this could involve directing a portion of government procurement budgets to support the development of new innovations that would provide solutions to departmental challenges, and streamlining the general government process for technologies that are successfully demonstrated. The U.S. Small Business Innovation and Research Program is a potential model. These approaches could also be extended to facilitate linkages between large company end-users and small company providers, and promote scale-up of these solutions.
- Work with Ministers responsible for municipal and urban affairs and, where appropriate, Ministers of Infrastructure to **encourage municipalities to increase procurement and adoption of clean technologies** and urban planning processes that support clean growth.
- Work with Energy Ministers to establish regulatory frameworks that **encourage more rapid development, demonstration and adoption of clean technologies by publicly regulated utilities**. Priorities include:
  - » Improved inter-utility and regional (including Canada-U.S.) collaboration on the development of infrastructure that supports clean technology adoption; and
  - » Strengthened collaboration between utilities and Indigenous communities in the deployment of clean technology solutions.

### Northern, Remote, and Indigenous Communities

- In collaboration with other relevant Ministers, including those responsible for Indigenous affairs, **support northern, remote, and Indigenous communities in adopting clean technologies** in a way that improves economic outcomes and supports energy, food and water security. Specific priorities in this regard include:
  - » Reducing reliance on diesel fuel and heating oils;
  - » Ensuring that communities have the capacity to adopt and adapt clean technologies; and
  - » Developing business models that support community ownership and operation of clean technology deployments.

### Consumer and Industry Adoption

- Work with Environment and Finance Ministers to **support the implementation of industry-specific GHG mitigation measures that encourage clean technology adoption and development in Canada**, leverage Canadian strengths and create jobs for Canadians. Priorities in this regard are the options proposed by the Working Group on Specific Mitigation Opportunities, particularly those related to transportation, the built environment and building codes, electricity and extractive industries.

- **Encourage and support a new working relationship between regulators and industry** that encourages early dialogue and guidance on evolving and new clean technologies, includes mechanisms to validate their performance and safety, and promotes performance-based regulations that are not overly prescriptive.
- **Promote the development of purpose-built lending products to foster small and medium-sized enterprises adoption of clean technologies**, including energy efficiency and renewable energy installations. Repayment terms could be based on the energy savings generated through the implementation of these technologies.
- **Ensure that Canada has visible and effective certification programs** to ensure consumer and business confidence and support green procurement.

## **CHAPTER 6**

# **STRENGTHENING COLLABORATION AND METRICS FOR SUCCESS**







## CHAPTER 6 STRENGTHENING COLLABORATION AND METRICS FOR SUCCESS

While previous chapters have examined initiatives required to support the early-stage innovation, commercialization and adoption of Canadian clean technologies, this chapter focuses on the importance of coordination and collaboration across these initiatives. It also addresses the need for stronger data and metrics to inform policy-maker and stakeholder decisions, while tracking progress along clearly defined metrics for success. As previously noted, the Vancouver Declaration on Clean Growth and Climate Change outlined the need for enhanced cooperation between governments and collaboration with Indigenous Peoples to promote clean economic growth and to create jobs. In this regard, the role of collaborative mechanisms that align intra- and intergovernmental decision-making in support of clean technology innovation is critical.

At the federal level, numerous departments and agencies deliver programs and services related to clean growth and clean technology innovation, including ISED, NRCan, GAC, ECCC, Infrastructure Canada, Transport Canada and PSPC. Provinces and territories also continue to be more active in clean technology innovation, increasing their policy interventions and ramping up investments (see **Appendix B**). The Working Group notes the broad consensus among stakeholders on the lack of collaboration in federal, provincial and territorial initiatives. Through duplication of efforts in some areas and gaps in support in others, the failure to collaborate leads to inefficient use of government resources and poses barriers to clean growth and clean technology innovation.

In addition to collaborative efforts to promote clean technology innovation and development, a strong evidence base is needed to support and track clean technology activity. While the Working Group acknowledges the existence of many sources of information and data, collectively they do not present a comprehensive overview of clean technology innovation and development activity and performance across Canada. Strong and granular data, developed in cooperation with all orders of government and in collaboration with industry, should underpin policy-maker decisions, guide government initiatives along the innovation continuum, and facilitate private-sector investment decisions.

### 6.1 Collaboration

#### 6.1.1 The Issues

As countries around the globe continue to accelerate clean growth activities, a concerted pan-Canada effort, driven by an ambitious vision, is required to launch Canada as a global leader in clean technology innovation. As described in earlier chapters, numerous federal, provincial, territorial and municipal programs currently support the RD&D, commercialization and adoption of clean technologies. Coordination of these efforts would lead to more effective use of government resources and comprehensive coverage of the support required by Canadian clean technology producers.

## Saskatchewan: International Collaboration on Carbon Capture and Sequestration

Because of its existing electrical generation and transmission infrastructure and abundance of low-cost coal, Saskatchewan developed a cluster of capabilities around carbon capture and storage (CCS). Tremendous international and national collaboration resulted in the first implementation of CCS on a commercial coal-fired power station.

The International Energy Agency (IEA) initially established a project to evaluate the potential for geological sequestration of CO<sub>2</sub>. Researchers and oil companies monitored the results over 12 years, demonstrating the viability of enhanced oil recovery (EOR) and that the CO<sub>2</sub> remained sequestered. A second project, Aquistore, evaluated the potential for CO<sub>2</sub> injection into deep saline aquifers. IEA, the U.S. Department of Energy, SDTC, SaskPower, the Province of Saskatchewan and other international partners shared the funding of both projects, which were managed by Saskatchewan's Petroleum Technology Research Centre.

SaskPower then embarked on a carbon capture development project for its boundary dam coal-fired electricity facility. It refurbished a 150 megawatt electrical generation unit and installed carbon capture technology, with captured CO<sub>2</sub> sold for EOR. The federal government contributed \$240 million to the \$1.5 billion project and collaboration with Shell Canada and others helped solve technical challenges. The plant now captures 800 kT annually.

Research and collaboration continues. For example, Mitsubishi-Hitachi Power Systems and SaskPower operate a centre for testing new carbon capture technologies. BHP Billiton and SaskPower have established the Carbon Capture Knowledge Centre for continued international collaboration. The University of Regina hosts three additional institutes to continue CCS research.

### 6.1.2 Analysis

The Working Group affirmed that strategic collaboration is critical, across orders of government, with Indigenous Peoples, and between the public and private sectors as well as academia. Stakeholders highlighted a lack of policy and programming coordination, which has led to the duplication of efforts, gaps in coverage, limited information sharing and navigational challenges for project proponents and other stakeholders in Canada. Previous chapters have detailed many of these gaps, redundancies and challenges and governments have previously prescribed programs or policies to address them. The alignment of and continued collaboration on the development of these policies and programs is important to establish shared pan-Canadian objectives, focused strategies and regulatory and market certainty. Regular interdepartmental and intergovernmental dialogue, as well as routine engagement of Indigenous Peoples, industry and stakeholders, is essential. A useful starting point in this process would be for governments to establish a clear, unified vision for clean technology and clean growth in Canada.

When different orders of government and key actors align objectives and pool resources, they can leverage each other's funding, policies, programs and expertise to achieve common objectives. This can also lead to fewer areas of overlap, more effective targeting of resources, streamlined decision-making and better access for stakeholders. The Working Group proposed that a federal coordinating mechanism that coordinates collaboration of all actors could effectively support the innovation, commercialization and adoption of clean technologies, while allowing for flexibility to target policies in differing circumstances and contexts across industries and jurisdictions.

## Manitoba: Composites Innovation Centre

Since inception in 2003, the Composites Innovation Centre (CIC), based in Winnipeg, has been bringing the best minds together globally to overcome technology barriers and create new business opportunities. The focus is on the sustainable commercialization of natural fibres and fillers from agricultural biomass to develop bioproducts that replace energy intensive materials for improved environmental outcomes.

CIC, especially with its close links to industry through direct engagement in over 490 projects, has successfully built the composites and bioproducts industry in Manitoba and Western Canada. This has created more than 860 jobs and 53 new capabilities in industry, and led to the transfer of 136 technologies. Industry requirements have driven CIC's leading capabilities globally in areas of design, analysis, process development, prototype manufacturing, testing and business development within the biomaterials, ground vehicles, aerospace and industrial sectors. Through networks, CIC connects to industry and research organizations across Canada and in the United States, Australia, China and Europe. Its current capability and experience can support the continued development and commercialization of materials and technologies focused on industry and government priorities, especially clean technology.

Finland, the United Kingdom and Australia are strong examples of countries laying out comprehensive national policy strategies and establishing national coordinating mechanisms around clean technology innovation and development.

In 2012, the Finnish government launched its Strategic Programme for Cleantech to make Finland a “global superpower” in clean technology innovation by 2020. The strategy's goals are to double Finland's clean technology revenues from 2012 to 2018, create more than 40 new high-growth companies annually, and generate 40,000 jobs by 2020 (Finnish Ministry of Employment and the Economy, 2014). As mentioned previously, the government sets innovation priorities centrally via its Research and Innovation Council, chaired by the Prime Minister. More than one-third of its public R&D investment is targeted at clean technology. The 2014 GCII ranks Finland second in the world, with strong scores on all clean technology innovation indicators. Finland is one of the largest outperformers on clean technology-specific innovation drivers.

The U.K. government coordinates its low-carbon innovation activities to prioritize support and maximize impact through the Low Carbon Innovation Co-ordination Group (LCICG). LCICG brings together key public-sector organizations supporting clean technology innovation to pool resources to offer combined support, provide brokering and knowledge-exchange services, develop a shared toolkit of metrics to assess the impact of public spending, and conduct Technology Innovation Needs Assessments to inform program planning. Core members include the Department of Business, Innovation and Skills, the Department of Environment and Climate Change, and the Energy Technologies Institute. Although the LCICG has faced some resource challenges and concerns about transparency and membership, stakeholders are supportive of its mandate and role. A 2014 House of Commons study on the government's support for low-carbon innovation concluded that “the LCICG is the key tool for delivering the Government's low carbon objectives, but there is a mismatch between the resources allocated by the Government and its level of ambition” (UK House of Commons, 2014).

In 2012, Australia created the Australian Renewable Energy Agency (ARENA) to consolidate its federal clean energy programs under the Australian Centre for Renewable Energy, the Department of Resources, Energy and Tourism, and the Australian Solar Institute. Since then, ARENA has committed over A\$1.1 billion to more than 230 renewable energy projects and studies (ARENA, 2015). In 2013–2014, Australia ranked third in absolute terms and first as a percentage of GDP among IEA members on renewable energy R&D spending (Swann, 2016).

This report makes many references to the economic opportunities linked to the projected growth of the global clean technology marketplace. While other countries are actively pursuing the competitive edge, Canada should substantially bolster its own strategic prospects.

### **Canada's Oil Sands Innovation Alliance (COSIA)**

COSIA is an alliance of oil sands producers with the shared goal of accelerating the pace of improvement in environmental performance in Canada's oil sands through collaborative action and innovation. Participating companies develop and share the most innovative approaches and best thinking on four environmental priority areas: tailings, water, land and GHGs. To date, COSIA members have shared 814 distinct technologies and innovations that cost almost \$1.3 billion to develop.

Sharing is done in a manner that values and protects corporate technologies and intellectual property, but, at the same, enables members to accelerate the pace of environmental performance improvements in their operations.

In addition to its 13 member companies, COSIA works with 39 associate members that range from SMEs and academic institutes to multinational corporations and government agencies. Many have joined to ensure that their strategic planning efforts are aligned with industry priorities, allowing them to effectively use their innovation budgets and capacities in both the short and long terms.

## **6.2 Data and Metrics**

### **6.2.1 The Issues**

Decisions made by entrepreneurs, investors, consumers, Indigenous communities and governments are driven by information. Governments can help support effective decision-making by developing stronger and more detailed data on clean technology innovation, commercialization, investments, trade, skills, jobs and adoption. Current data gaps limit a full understanding of the evolving clean technology landscape in Canada. Available data are largely provided by the private sector and address only a subset of clean technologies because of inconsistencies in defining the scope of clean technology and tracking clean technology activities, which tend to be embedded in multiple traditional industry sectors and technology solutions. It is often difficult to isolate clean technology products and services.

With a more robust data set, the use of new and evolving information tools, such as open data, big data and advanced analytics, could promote smart, data-driven decision-making by translating data into new ideas and solutions with significant economic impacts. Filling information gaps allows policy-makers to explore potential barriers to innovation, commercialization and adoption, and to address the challenges of clean technology development.

### **6.2.2 Analysis**

In 2012, the National Round Table on the Environment and the Economy suggested that better labour market data and information on the low-carbon economy would help Canada better understand its performance and predict future trends.

Stakeholders pointed to the lack of clean technology-specific, company-level data and the need to develop more consistent, integrated and open data to promote informed decision-making among clean technology actors. In particular, they expressed frustration at the limitations of the North American Industry Classification System (NAICS) in measuring clean technology activities. National-level data currently rely on the NAICS data, which, while useful for broad comparisons and identifying trends, are limited in their

ability to isolate clean technology goods and services that are integrated into traditional industries. NAICS classifications often do not account for clean technologies developed by companies that do not self-identify as clean technology focused.

Stakeholders also noted the need for more developed labour market data and better quantitative and qualitative statistics that capture the environmental and social impacts of clean technologies. Under current conditions, they highlight the difficulty and inaccuracy of cross-jurisdictional benchmarking, their inability to access necessary information to identify the factors that enable or impede clean technology company success, and the incomplete understanding of the broader economic, social and environmental impacts of clean technology activity in Canada. High-quality information is needed to inform public- and private-sector activity around clean technology innovation, education, training, labour adjustment and industrial development.

As part of the federal clean technology priorities in Canada, Budget 2016 provided \$2.1 million over two years to NRCan to enhance clean technology data, in collaboration with Statistics Canada and ISED (Department of Finance). The funding is to develop a statistical framework that regularly publishes information on the economic contributions of clean technologies and helps the government track progress towards clean technology objectives. The program is anchored in:

- Developing a new Clean Tech Satellite Account (CTSA) that integrates existing socio-economic information from multiple sources and, for the first time, provides a set of indicators (e.g., GDP, income, employment) specifically for clean technology industries; and
- Redesigning the Survey of Environmental Goods and Services (SEGS) to include a broader range of companies that develop and manufacture goods and services defined as “clean technology”, including those that do not typically self-identify as clean technology-related (i.e., do not exclusively focus on clean technology products or services but have a clean tech product line or service as part of their broader operations).

The data development program also includes funding to measure the growing importance of clean technology in resource development, such as energy production and the potential displacement of fossil fuels over time. This work is complemented by a renewable energy scoping study, which will improve understanding of the Canadian energy market and clean technology supply and demand — a clear focus of climate change and clean innovation.

The United Kingdom and United States provide two examples of best practices in clean technology data frameworks. The Low Carbon Environmental Good and Services (LCEGS) framework developed by the U.K. Department for Business Innovation and Skills uses a broad definition of low-carbon goods and services that encompass both supply chain and value chain activities (2,800 activity headings) under 24 subsectors and 119 sub-subsectors divided into three broad categories: Environmental, Renewable Energy and Low Carbon (2013). This methodology accounts for companies that do not solely provide LCEGS, but derive at least 20% of their sales from LCEGS or are large companies with significant LCEGS business lines. The collection of LCEGS data relies on private-sector, academic, public and market research sources, as well as national statistics.

Similarly, the U.S. Bureau of Labor Statistics publishes detailed economic statistics on industry employment in green goods and services (Chadwick et al., 2013). To provide some disaggregation from traditional labour statistics, the statistics are based on a detailed analysis of the potential green goods and services linked to each NAICS industry code.

Beyond strengthening the breadth and depth of data sets on Canadian clean technology activities, stakeholders see opportunities in big data and analytics with the potential to mobilize data, turning

information into new ideas and solutions for the development of innovative Canadian clean technologies. In this regard, the emphasis is on the importance of integrated, open-access information systems that facilitate the sharing of relevant data between governments, industry, academia, not-for-profits and Indigenous communities. To mobilize a strong national data network that is representative across industries and jurisdictions, and facilitates collaboration between governments, the private sector and academia, government support is required, with federal leadership acting as a convener.

In Germany, for example, the federal government has attempted to introduce greater transparency and accountability into its funding policies. In 2015, it introduced EnArgus, a central online information system led by the Fraunhofer FIT (German Ministry for Economic Affairs and Energy, 2014). The portal makes public 45 years of government funding for energy research, providing extensive details on more than 12,000 ongoing and completed projects. The public has also had access to a map of German energy research since 2013. These initiatives give German clean energy stakeholders access to information to make informed decisions on clean energy research.

Applied collectively, these elements could help governments progress towards clean technology and climate change objectives and address many of the concerns raised in the Working Group process. Making data more available would support evidence-based decision-making by governments, the private sector and Indigenous communities. Going forward, efforts should continue to broaden data collection and enhance alternative data sources to measure the evolving clean technology landscape.

## **6.3 Action Plan**

The Working Group process itself has been a valuable foundation for intergovernmental collaboration on the development of clean technologies, as well as a useful mechanism for engagement with NIOs. It has also established a productive dialogue with the private sector and academia. Stakeholders are now more aware of shared pan-Canadian clean technology objectives and of important regional considerations. To meet its commitments to reduce GHG emissions and capitalize on the global clean technology market opportunity, Canada should sustain these efforts.

The Working Group believes that measures to improve collaboration would start having an impact on Canada's economic and environmental performance over the short term as clean technology innovation program and service delivery are improved for innovators looking to access the public support they need to be successful. However, the greatest impact would likely be over the longer term as better collaboration results in greater alignment and focus of resources and improved support for advancing technologies in areas of Canadian strength.

Canada should also take steps to improve evidence-based decision-making around clean technology. Efforts are required to develop clean technology-specific data that effectively track the activities of researchers, developers, investors and adopters in Canada.

Measures to support the development and availability of data on clean technology would likely have an impact over the short to medium term as public- and private-sector decision-makers are empowered with better information to act, measure and evaluate.

An early step that could facilitate greater data availability and collaboration, and provide impetus for many of the other options the Working Group is proposing, is a pan-Canadian vision that affirms clean technology as a shared priority for all jurisdictions. This vision statement could emphasize whole-of-government action to support clean technologies, and could pursue ambitious goals and objectives for clean technology growth in Canada.

The Working Group proposes the following options for action to Ministers:

## Collaboration

- **Create federal and provincial/territorial/regional Clean Growth Innovation Hubs** to improve intra- and intergovernmental policy and program coordination and sharing of data and best practices, and to act as a key mechanism for engagement with Indigenous Peoples, industry, other stakeholders and international partners. These hubs could coordinate the implementation of options identified in this report, including the process of identifying and tracking progress on priority technology areas, ensuring a no-wrong-door approach to client management, the development of regional economic development strategies and the development of a pan-Canadian data strategy.
- **Sustain intergovernmental momentum and action on clean technology and clean growth** by:
  - » Making clean technology and clean growth a standing agenda item for future meetings of Ministers of Innovation and Economic Development;
  - » Establishing an FPT working group at the officials level to support Ministers in the design and implementation of the Pan-Canadian Framework on Clean Growth and Climate Change and facilitate ongoing collaboration; and
  - » Continuing coordination with other FPT ministerial tables and departments, including those responsible for energy and the environment, to ensure policy, program and regulatory alignment.

## Data and Metrics

- **Establish quantitative and qualitative metrics to effectively track and assess the performance of government investments** related to clean technology in terms of the economic, environmental and social impacts.
- **Establish a pan-Canadian data strategy** to improve the public availability of information on clean technology activity in Canada, including on labour markets, to support and inform performance metrics and public- and private-sector decision-making, and foster innovation.

## Vision Statement

- **Develop a pan-Canadian vision statement on clean technology and clean growth** that commits to improved program and policy collaboration and coordination across jurisdictions and institutions, affirms this area is a priority for all jurisdictions, emphasizes a whole-of-government approach to clean technology development and deployment, sets out goals and objectives and results measurement for clean technology and clean growth in Canada, recognizes cross-cutting opportunities and differences, and reflects the important contribution from Indigenous Peoples in this area.





## **CHAPTER 7**

### **CONCLUSION**





## CHAPTER 7 CONCLUSION

To address its mandate to develop options on how to stimulate economic growth, create jobs, and drive innovation across all sectors in Canada to transition to a low-carbon economy, leveraging regional strengths, the Working Group has considered a wide range of policy tools in four main areas:

- Building and strengthening early-stage clean technology innovation and R&D;
- Accelerating the commercialization of clean technologies and growing Canada's commercial capacity in clean technology and clean growth;
- Fostering greater clean technology adoption within Canada; and
- Strengthening and sustaining intergovernmental collaboration in support of clean technology and clean growth, and creating metrics for success.

Although Canada performs well on *general* innovation drivers (i.e., for all technologies), its performance on *clean technology* innovation specifically is average, with room for improvement. The GCII ranks Canada 3<sup>rd</sup> out of 40 countries on general innovation drivers but only 18<sup>th</sup> on clean technology innovation drivers. On commercialization of clean technologies, Canada's performance is also average, ranking 15<sup>th</sup> out of 40 countries in the GCII.

Canada performs relatively poorly on clean technology adoption by industry. Only 9.9% of Canadian firms have adopted clean technologies, making it the least adopted distinct class of advanced technologies. SMEs are the worst performers on this measure. In contrast, 43.3% of firms have adopted advanced logistics technologies. This low level of clean technology adoption is also partly reflected in Canada's poor performance on environmental indicators, such as low CO<sub>2</sub> productivity and high overall GHG emissions.

This chapter presents and synthesizes the Working Group's analysis and findings from the previous chapters, identifies cross-cutting themes and provides an overview of options for concrete action. In its research and deliberations, the Working Group relied heavily on the views of stakeholders and NIOs gathered during its extensive consultation process.

### 7.1 Main Findings

#### Building Early-Stage Innovation

To become a leader in the development and deployment of clean technologies, Canada needs a strong pipeline of innovative ideas. In this respect, Canada's clean technology RD&D ecosystem drives efforts to meet environmental and economic objectives. While existing initiatives do support technology RD&D and continue to build areas of regional expertise and strength, increased coordination and alignment of initiatives are needed going forward. Efforts to coordinate and focus this work should go beyond governments and involve industry, academia, other stakeholders and Indigenous Peoples.

Developing clean technology roadmaps could encourage greater alignment of research priorities while focusing government RD&D support on key priorities. Canada should leverage its domestic strengths, which vary by region, in this process. Developing international partnerships around these priorities would create new economic opportunities, build areas of shared expertise and foster stronger bilateral relations.

New initiatives are needed to strengthen Canada's position as a leader in the development of disruptive or "breakthrough" technologies. Greater public support is therefore needed for the advancement of high-risk, early-stage R&D. Well-defined "mission objectives" that target areas of highest impact and potential and

“grand challenges” with ambitious targets for economic and environmental benefits could potentially spur innovative clean technology concepts.

### Accelerating Commercialization and Growth

Commercialization of clean technologies and building of commercial capacity are essential to meet Canada’s economic and environmental goals. Given Canada’s small domestic market, Canadian firms must look to highly competitive international markets to achieve scale. Building globally competitive clean technologies requires globally competitive talent, firms’ unhindered access to capital and resources to demonstrate the commercial viability of products, and strong international networks that facilitate the cross-border flow of clean technology goods and services. However, many gaps currently exist in financing, skills development, commercial capacity and export development.

Compared with other technology areas, clean technologies face unique challenges and often take longer to get to market, making access to “patient capital” more important to successful commercialization. Governments need to assume a leadership role in this area, using both direct and indirect measures of support to catalyze private-sector investment. While federal and provincial governments already have a range of supports in place, key needs exist in terms of accessing venture capital, as well as working capital and support for first, large-scale commercial projects/deployments. Streamlining and integrating access to government support programs and services is a priority for firms and key to building commercial capacity in this area. Firms and researchers are currently confronted and hindered by a myriad of programs and services.

Further development of clean technologies could create new opportunities in Canada’s traditional resource sectors and new employment opportunities. Strengthening support in core science skills (STEM), business leadership and technical skills is important to accessing these opportunities, as is expeditious immigration of highly qualified personnel. Governments must also work to strengthen skills in Indigenous communities, as well as commercial and community capacity, to unleash the potential of Indigenous Peoples as agents of change in the transition to a low-carbon economy.

Building stronger companies and commercial capacity in all of Canada’s regions would help take advantage of new market opportunities. Support for new technology start-ups, through incubators and accelerators, is important to this effort. Finally, a clear, focused Canadian clean technology export strategy is needed to position Canada in growing and emerging global markets. As part of this effort, Canada has the potential to take on a stronger leadership role in the development and implementation of international standards for clean technology.

### Fostering Adoption

Canada’s performance on clean technology adoption has significant room for improvement. Effective adoption of Canadian clean technologies is needed if Canada is to achieve its climate change goals, build a climate-resilient infrastructure and create a strong Canadian first market when heading to global markets.

Through prudent procurement practices, Canadian governments could “lead by example” as early adopters of clean technologies. They could also play a crucial role as a first or “reference customer” for Canadian clean technology goods, services and processes. A consistent theme in stakeholder advice to the Working Group was that obtaining a “first sale” in Canada would boost firms’ chances of securing sales abroad. Beyond direct federal and provincial government operations, other bodies, such as municipalities and publicly regulated utilities, are important markets for adopters of clean technology.

Done effectively, the adoption of clean technology could be a mechanism for improving environmental circumstances and creating economic opportunity in northern, remote, and Indigenous communities.

Effective engagement and collaboration with Indigenous Peoples would be central to this effort.

Encouraging dialogue between regulators and industry could improve certainty in clean technology development and allow for more effective and responsible regulation. Regulations need to be stable, transparent, flexible and, where possible, consistent across jurisdictions. Certification programs for clean technology could also help build consumer and business confidence in new technologies.

### **Strengthening Collaboration and Metrics for Success**

An effective approach to clean technology development, commercialization and adoption in Canada requires coherent, collaborative and focused policy and program approaches. This is true within individual governments, as well as between Canadian jurisdictions. A successful collaborative approach between governments should take into account regional strategies and jurisdictional responsibilities.

The Working Group process has proved to be an effective one for intergovernmental dialogue and engagement. There is value in building on this process and creating a mechanism for sustained and routine intergovernmental dialogue on clean technology and clean growth. Such a mechanism would eliminate duplication of efforts and identify gaps in support for clean technology development. Making this issue a regular item of discussion at future meetings of Innovation Ministers, and setting a clear vision and direction for it, would be helpful. Engaging Indigenous Peoples, industry and stakeholders as a routine component of this process would continue the productive dialogue established by the Working Group's consultations.

Data on Canada's clean technology capacity and potential are remarkably inadequate. Building better data, including firm-level and labour market data, would enable more effective decision-making by stakeholders and policy-makers. Clear metrics for tracing the impact of government activities would properly focus these activities and ensure that they achieve intended, meaningful results. Improved data collection would facilitate international benchmarking and enhanced stakeholder and policy-maker understanding of the economic and environmental impacts of the transition to a low-carbon economy, namely emissions, skills, jobs and exports.

## **7.2 Cross-Cutting Themes**

The Working Group identified a number of cross-cutting themes in the four areas of investigation. These themes are widely reflected in this report's options for action presented below.

**Focus, alignment and collaboration.** Although numerous support mechanisms currently span the clean technology innovation continuum (e.g., R&D, deployment, financing, skills, exports, public procurement), greater focus, alignment and collaboration are needed. Strengthening the approach to all clean technology activities would result in more effective allocation of resources to areas in which Canada could have the greatest impact. Facilitating access and information sharing, and improving cross-governmental and agency program delivery, would make it simpler and quicker for innovators and firms to get the support required for success. In addition, predictable and consistent regulations that are well understood by industry would facilitate investment in clean technologies.

**Pan-Canadian objectives, regional strategies.** Stronger focus, alignment and collaboration in clean technology innovation would help achieve pan-Canadian and provincial and territorial objectives, such as improved clean growth and climate performance. At the same time, solutions and actions should take account of regional approaches because economic strengths, resource endowments, needs and challenges vary by region. Such an approach would help Canadian jurisdictions to act together, leveraging local economic opportunities and areas of expertise, to address climate change objectives and improve environmental outcomes for all Canadians.

**Partnerships with Indigenous Peoples.** Many opportunities exist to partner with Indigenous Peoples to achieve mutually beneficial outcomes and objectives. For example, traditional knowledge of managing complex ecosystems could complement government, academic and industry R&D efforts. On skills, there are many opportunities to support capacity building within and across Indigenous communities through training, education and mentorship. Finally, partnering with northern, remote, and Indigenous communities to reduce their dependency on diesel fuel for electricity and heating could increase the standard of living, strengthen the economy and improve health outcomes. Alternative energy sources and clean technologies could create a number of economic opportunities for northern, remote, and Indigenous communities that are currently unavailable due to energy constraints or outdated infrastructure. These could include new business export opportunities where technology solutions adopted by one community are exported to another community facing similar energy constraints.

**Government leadership.** Given the environmental and knowledge externalities and market failures inherent to clean technology innovation, decisive government leadership at all levels is required to signal broad support for clean technologies, coordinate innovation efforts and catalyze private-sector involvement. As well, governments can act directly to address climate change and low-carbon economic goals by using their combined purchasing power to support and develop clean technologies.

Government leadership is especially critical to supporting early-stage R&D, unlocking private capital, boosting skills development, creating demand for clean technologies, and making data more available. Increased public-sector appetite for taking on greater risk, together with additional and more targeted funding in areas of high impact, could also stimulate clean technology investment and activities.

**Industry engagement.** While government action could act as a catalyst to increase the rate of success in clean technology innovation, industry should also be fully engaged in RD&D, commercialization and adoption of clean technologies. While governments can provide the right incentives and market conditions, industry should actively take advantage of new opportunities, leveraging its expertise, resources and infrastructure. In many areas, industry is at the forefront of researching new clean technologies, providing the capital and business expertise needed to grow small projects into globally competitive products and adopting new technologies that address Canada's environmental performance.

**Global orientation.** Seizing global opportunities, is essential if Canada is to achieve its economic and environmental goals. Canada represents approximately 1.6% of the global economy and GHG emissions. Improved access to international markets could meaningfully lower global emissions, as well as create jobs and grow the economy. Canada's clean technologies and solutions could be exported to the world. Conversely, Canada should look beyond its borders for sources of expertise, talent and capital and close partners in addressing climate change and developing clean technologies.

## 7.3 Action Plan

It is broadly recognized that climate change has the potential to gravely threaten Canada's ecosystems, communities and economy. Growing Canada's economy and achieving GHG emission targets requires an integrated, economy-wide approach. Taking action on climate change could also capture new and emerging economic opportunities and ensure the future sustainability of Canada's environment, industries and communities. Many countries are mobilizing and accelerating their clean technology efforts and activities, and in 2012, the global market size for clean technologies, broadly defined and produced by all industry sectors, was estimated to be approximately \$5.8 trillion, and growing at a rate of over 3% per year. To effectively compete in this global marketplace and capitalize on the current and future economic opportunity, Canada needs a step change in its investment and approach to clean technology development, commercialization and adoption.

To this end, the Working Group offers a series of options for the consideration of Ministers. The options are intended to be complementary and mutually reinforcing. One weak link in the innovation continuum could undermine the entire innovation process and lead to unrealized economic and environmental gains.

Given the urgency of climate change, these options are designed for immediate action. However, in most cases, their full impact on Canada's economic growth and GHG reduction performance is unlikely to be immediate. The Working Group has classified the impact of proposed measures as short term (before 2020), medium term (up to 2030) or long term (2050 and beyond).

The Working Group expects measures to strengthen the RD&D ecosystem to have their greatest impact over the medium to long term, as investments and RD&D support are aligned to better support the advancement of clean technologies in key areas. Measures to support breakthrough technologies would likely have an impact over the longer term, as these technologies are effectively advanced along the innovation continuum.

Measures targeted at reducing financing gaps are expected to generate important results in the short term as innovators receive the support they need to develop, demonstrate and commercialize their clean technologies. However, the greatest economic and GHG reduction impact of these measures would likely occur in the medium term as companies gain market traction, scale up and export their technologies.

Labour market measures, particularly in immigration, are expected to have an immediate impact in supporting the talent requirements of Canadian firms for commercial capacity. Similar to financing access measures, those that target regional capacity and incubators and accelerators could have an immediate impact in supporting innovators, but achieve their greatest economic and GHG reduction impacts in the medium to long term as entrepreneurs and start-ups move to commercialize their technologies.

For measures to increase Canadian clean technology exports, impacts would likely be felt in the short term as market-ready Canadian technologies are exported in greater numbers. Over the medium to long term, exports would expand alongside growing demand for clean technologies and Canada's clean technology capacity. Measures targeted at developing skills and building the capacity of Indigenous Peoples are similarly expected to have an impact over the medium to long term.

The Working Group expects measures to increase public-sector adoption of clean technologies to have an immediate impact on Canada's GHG performance, as well as in supporting Canadian companies with market-ready technologies. Greening infrastructure initiatives would likely have short-term impacts in the construction phase but important GHG impacts over the longer term.

Measures to support the adoption of clean technologies in northern, remote, and Indigenous communities, and to reduce the dependency on diesel fuel, would likely have a positive impact over the shorter to medium term, as opportunities for economic growth and better quality of life are expanded.

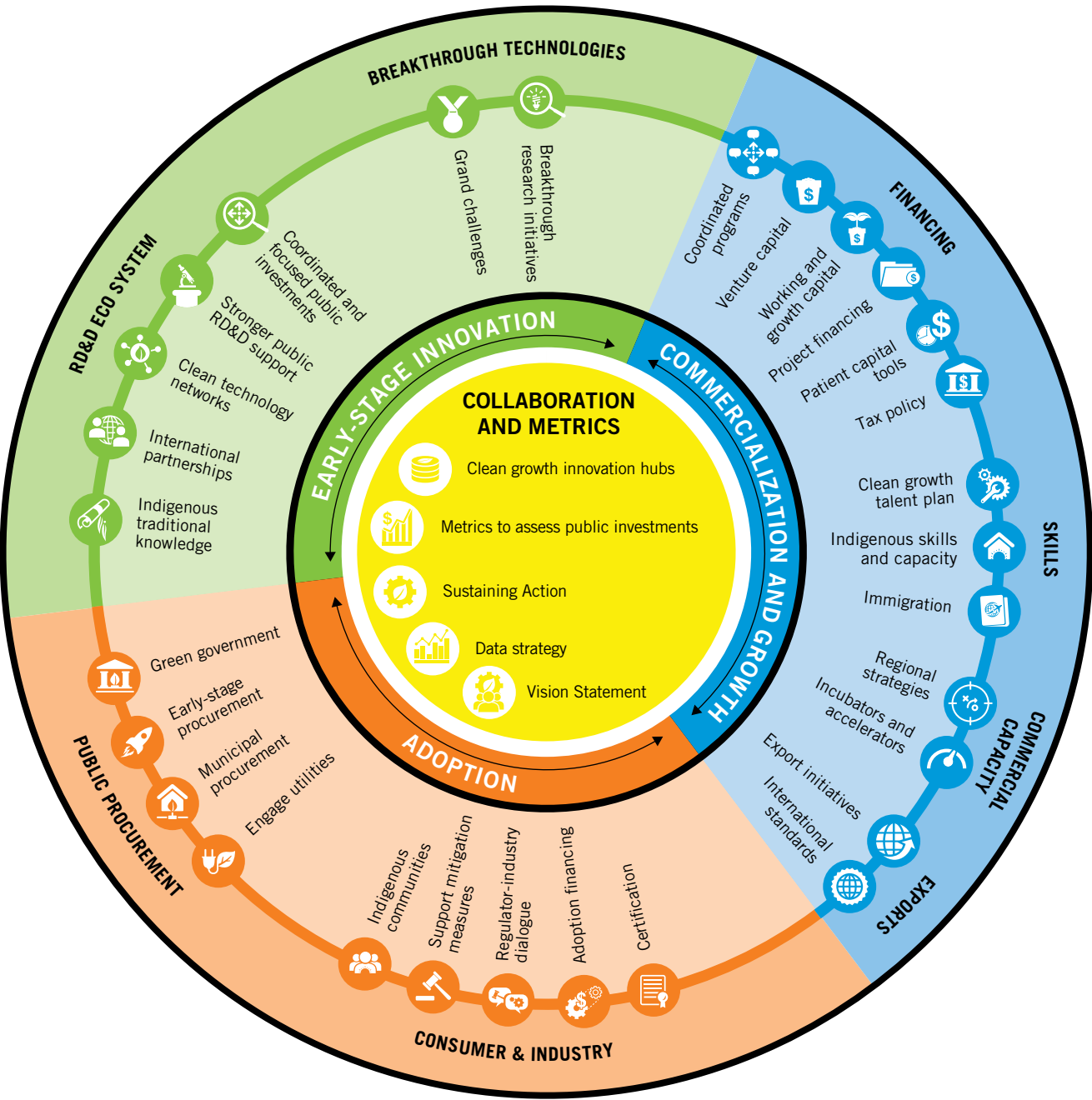
The Working Group expects measures targeted at increasing aggregate demand for clean technologies to have an immediate impact, as greater domestic adoption supports market-ready Canadian technologies. This would likely further de-risk technologies for international markets, allow innovators to achieve production scale, and directly lead to improved domestic environmental performance. Over the longer term, opportunities could be provided to innovators to test and refine earlier-stage technologies domestically before they are ready for mass adoption. In all cases, policy measures to spur demand for clean technologies would send a broad signal to all actors to increase activity along the entire innovation continuum.

Measures to improve overall collaboration would likely begin having an impact in the short term as improvements to clean technology innovation program and service delivery make it simpler for innovators to access support. However, the greatest impact is expected over the medium and longer term as better

collaboration results in greater alignment and focus of resources and improved support for advancing technologies in areas of Canadian strength. Measures to support the development and availability of data on clean technology would have an impact over the short to medium term as public- and private-sector decision-makers are empowered with better information to act, measure and evaluate.

Figure 7.1

SUMMARY OF OPTIONS



Please see action plans in chapters 3-6 for further detail.



Figure 7.2

■ EXPECTED TIME TO IMPACT (ENVIRONMENTAL AND ECONOMIC BENEFITS)

|                              | SHORT TERM 2020 | MEDIUM TERM 2030 | LONG TERM 2050                       |
|------------------------------|-----------------|------------------|--------------------------------------|
| EARLY-STAGE INNOVATION       | >               |                  | Coordinated and Focused Investments  |
|                              |                 | >                | Stronger Public RD&D Support         |
|                              |                 | >                | Clean Technology Networks            |
|                              | >               |                  | International Partnerships           |
|                              | >               |                  | Indigenous Traditional Knowledge     |
|                              |                 | >                | Breakthrough Research Initiatives    |
|                              |                 | >                | Grand Challenges                     |
| COMMERCIALIZATION AND GROWTH | >               |                  | Coordinated Programs                 |
|                              |                 | >                | Venture Capital                      |
|                              |                 | >                | Working and Growth Capital           |
|                              | >               |                  | Project Financing                    |
|                              |                 | >                | Patient Capital Tools                |
|                              | >               |                  | Tax Policy                           |
|                              |                 | >                | Clean Growth Talent Plan             |
|                              |                 | >                | Indigenous Skills and Capacity       |
|                              | >               |                  | Immigration                          |
|                              | >               |                  | Regional Strategies                  |
|                              |                 | >                | Incubators and Accelerators          |
|                              | >               |                  | Export Initiatives                   |
| ADOPTION                     |                 | >                | International Standards              |
|                              |                 | >                | Green Government                     |
|                              | >               |                  | Early-Stage Procurement              |
|                              | >               |                  | Municipal Procurement                |
|                              | >               |                  | Engage Utilities                     |
|                              | >               |                  | Indigenous Communities               |
|                              |                 | >                | Support Mitigation Measures          |
|                              |                 | >                | Regulator-Industry Dialogue          |
|                              | >               |                  | Adoption Financing                   |
| COLLABORATION AND METRICS    |                 | >                | Certification                        |
|                              | >               |                  | Clean Growth Innovation Hubs         |
|                              | >               |                  | Sustaining Action                    |
|                              | >               |                  | Metrics to Assess Public Investments |
|                              | >               |                  | Data Strategy                        |
|                              | >               |                  | Vision Statement                     |

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## APPENDIX A: WORKING GROUP MEMBERS

### CO-CHAIRS

#### FEDERAL CO-CHAIR

Andrew Noseworthy  
*Senior Advisor, Energy*  
Atlantic Canada Opportunities Agency

#### PROVINCIAL/TERRITORIAL CO-CHAIRS

##### Newfoundland and Labrador

Jackie Janes  
*Assistant Deputy Minister*  
Office of Climate Change and Energy Efficiency

##### Ontario

Bill Mantel  
*Assistant Deputy Minister*  
Research, Commercialization and  
Entrepreneurship Division

### MEMBERS

##### British Columbia

Okenge Yuma Morisho  
*Associate Deputy Minister*  
Economic Development Division  
and Major Investments Office  
Ministry of Jobs, Tourism and Skills Training  
and Responsible for Labour

##### Alberta

Justin Riemer  
*Assistant Deputy Minister*  
Science and Innovation  
Alberta Economic Development and Trade

##### Saskatchewan

David Grier  
*Chief Strategist*  
Innovation Saskatchewan

##### Manitoba

Douglas McCartney  
*Senior Executive Director*  
Science, Innovation and Business Development  
Manitoba Growth, Enterprise and Trade

##### Ontario

Tom Kaszas  
*Director*  
Environmental Innovations Branch  
Environment and Climate Change

##### Quebec

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*Assistant Deputy Minister*  
Economic Policies  
Ministry of Economy, Science and Innovation  
  
Marie-Josée Blais  
*Assistant Deputy Minister*  
Innovation Sector  
Ministry of Economy, Science and Innovation

##### New Brunswick

Eric Beaulieu  
*Assistant Deputy Minister*  
Department of Intergovernmental Affairs

##### Nova Scotia

Michael Dennis  
*Investment Manager, Clean Technology*  
Innovacorp



**Prince Edward Island**

Heather MacLeod  
*Manager of Energy Assets*  
PEI Energy Corporation

**Newfoundland and Labrador**

Doriann Coombs  
*Director of Innovation*  
Dept. of Business, Tourism, Culture and  
Rural Development

**Yukon**

Geoff Woodhouse  
*Senior Business Development Advisor*  
Department of Economic Development

**Northwest Territories**

Deborah Archibald  
*Assistant Deputy Minister*  
Mineral and Petroleum Resources  
Industry, Tourism and Investment

**Nunavut**

Bernie MacIsaac  
*Assistant Deputy Minister*  
Economic Development  
Department of Economic Development  
and Transportation

**Canada**

Chris Johnstone  
*Director General*  
Clean Technology, Innovation and Jobs  
Innovation, Science and Economic  
Development Canada

## APPENDIX B: PAN-CANADIAN CLEAN TECHNOLOGY INITIATIVES

### A Pan-Canadian Perspective

#### Similarities, Differences and Unifying Themes

Each province and territory has a unique mix of natural resource endowments, and the industrial mix and economic opportunities also vary by region. The combination of emitting industries thus differs on a regional basis and jurisdictions in all parts of the country have taken context-specific approaches to supporting the development of clean technology. The nature of programmatic interventions varies across the country. While there is generally broad coverage of interventions across development, commercialization and adoption, programs are typically broader in nature, rather than tailored specifically to the imperatives of clean technology or climate change. The development of clean technologies focuses on major hubs, but opportunities for the adoption and deployment of clean technologies span the country.

#### Key Regulations And Programs That Support Clean Technology Development

Table 1 summarizes key strategies and initiatives taken by provinces and territories to address the challenge in clean technology development, commercialization and adoption.

Table 1

#### Examples of Key Regulations and Programs Supporting Clean Technology

| Province         | Early-Stage Innovation  | Commercialization   | Adoption  |
|------------------|---|---|---|
| British Columbia | <ul style="list-style-type: none"> <li>▪ <i>#BCTECH Strategy</i> – including <i>BC Tech Fund</i></li> <li>▪ <i>Innovative Clean Energy Fund</i> – in collaboration with SDTC, NRCan and the NRC</li> <li>▪ BC Innovation Council's Industry and innovation Group</li> <li>▪ Evok Innovations</li> </ul> | <ul style="list-style-type: none"> <li>▪ <i>BC Green Economy</i> – includes support for job growth innovation and environmental sustainability</li> <li>▪ Export Services – clean technology sector is a priority sector. Collaborates with the federal Trade Commissioner Service</li> <li>▪ <i>BC Renaissance Capital Fund</i></li> <li>▪ <i>BC Innovative Clean Energy Fund</i></li> </ul> | <ul style="list-style-type: none"> <li>▪ <i>BC Climate Leadership Plan</i></li> <li>▪ <i>Clean Energy Act</i></li> <li>▪ BC Carbon Tax</li> <li>▪ <i>Carbon Neutral Government program</i></li> <li>▪ <i>Energy Efficiency Program</i></li> <li>▪ <i>Clean Energy Vehicle Program</i></li> <li>▪ <i>First Nations Clean Energy Business Fund</i></li> <li>▪ <i>Climate Action Charter and Climate Action Revenue Incentive Program</i></li> </ul> |

## Examples of Key Regulations and Programs Supporting Clean Technology

| Province     | Early-Stage Innovation   | Commercialization  | Adoption   |
|--------------|--|--|--|
| Alberta      | <ul style="list-style-type: none"> <li>Alberta Innovates – <i>Bio Solutions' Bio Future</i> program</li> <li><i>Water Innovation Program</i></li> <li>CCEMC Grand Challenge for CO<sub>2</sub> Utilization</li> <li>Alberta Enterprise Corporation fund of funds including EnerTech Capital</li> </ul>         | <ul style="list-style-type: none"> <li><i>International Technology Partnerships</i> programs with Germany and France</li> <li>Climate Change and Emissions Management Corporation (CCEMC) and Alberta Innovates-Energy and Environment Solutions focus on demonstration and scale-up</li> <li>CCEMC and Alberta Innovates have both partnered with SDTC to develop deployable small company solutions</li> <li><i>Investor Tax Credit</i> for venture capital in clean technology</li> </ul> | <ul style="list-style-type: none"> <li><i>Climate Leadership Plan</i></li> <li><i>Alberta Specified Gas Emitters Regulation</i></li> <li>Shell Quest, Carbon Capture and Storage project</li> </ul>  |
| Yukon        | <ul style="list-style-type: none"> <li>Government support for academic research centres, particularly Yukon Research Centre and the Cold Climate Innovation project</li> </ul>   | <ul style="list-style-type: none"> <li>Yukon Housing Corporation – support for skills development and building of energy efficient construction</li> <li>Commercial incentives for improving energy efficiency in commercial buildings</li> </ul>  | <ul style="list-style-type: none"> <li>Government is investigating possibility of providing biomass heat to government buildings</li> <li><i>Green Procurement Policy</i></li> <li><i>Good Energy Rebate Program</i></li> </ul>  |
| Saskatchewan | <ul style="list-style-type: none"> <li><i>Saskatchewan Petroleum Research Incentive</i></li> <li><i>Agriculture Development Fund</i></li> <li>Fedoruk Centre for Nuclear Innovation</li> <li>Saskatchewan Research Council</li> <li>Innovation Sask's SAIF – Saskatchewan Advantage Innovation Fund</li> </ul> | <ul style="list-style-type: none"> <li>SaskPower power purchase agreements with First Nations Power Authority, MB Hydro and others to be 50% renewable by 2030</li> <li>BHP Billiton-SaskPower CCS Knowledge Centre</li> <li>Aquistore CO<sub>2</sub> injection monitoring</li> <li>Prairie Agricultural Machinery Institute</li> </ul>  | <ul style="list-style-type: none"> <li>SaskPower commercial-scale CCS project</li> <li>STEP (Saskatchewan Trade and Export Partnership)</li> </ul>   |
| Manitoba     | <ul style="list-style-type: none"> <li>Assent Works</li> <li>Vehicle Technology Centre</li> <li>Red River College (Sustainable Building Infrastructure and Transportation Research)</li> </ul>   | <ul style="list-style-type: none"> <li><i>Commercialization Support for Business Program</i></li> <li>North Forge</li> <li>Manitoba Technology Accelerator</li> <li>Innovate Manitoba</li> <li><i>TechFutures Program</i></li> </ul>   | <ul style="list-style-type: none"> <li><i>Green Energy Equipment Tax Credit</i></li> <li><i>Manitoba Hydro PowerSmart programs</i></li> <li><i>GHG Emissions Tax</i> on coal and pet coke</li> <li><i>Biomass Incentive</i></li> <li><i>Nutrient Management Tax Credit</i></li> <li><i>Geothermal Energy Incentive Program</i></li> <li>Biofuels Mandates</li> </ul> |

## Examples of Key Regulations and Programs Supporting Clean Technology

| Province              | Early-Stage Innovation   | Commercialization   | Adoption   |
|-----------------------|--|---|--|
| Northwest Territories | N/A  | <ul style="list-style-type: none"> <li>▪ <i>Gas Tax Fund</i> used to finance clean technology projects</li> <li>▪ Industry, Tourism and Investment's Support for Entrepreneurs and Economic Development</li> </ul>  | <ul style="list-style-type: none"> <li>▪ <i>Energy Action Plan</i></li> <li>▪ <i>Biomass Strategy</i></li> <li>▪ <i>Solar Strategy</i></li> <li>▪ <i>GHG Strategy</i></li> <li>▪ <i>Forest Industry Biomass Initiative</i></li> <li>▪ <i>Alternative Energy Technologies Program</i></li> <li>▪ <i>Large Vehicle Control Regulations</i></li> </ul>  |
| Ontario               | <ul style="list-style-type: none"> <li>▪ <i>Best in Science</i> environmental research projects</li> <li>▪ <i>Ontario Research Fund</i></li> <li>▪ <i>Ontario Network of Entrepreneurs</i> (including Ontario Centres of Excellence, MaRS, Regional Innovation Centres)</li> <li>▪ <i>Green Investment Fund</i></li> </ul> | <ul style="list-style-type: none"> <li>▪ <i>Green Investment Fund</i></li> <li>▪ <i>Ontario Development Fund</i></li> <li>▪ <i>Ontario Network of Entrepreneurs</i> (including Ontario Centres of Excellence, MaRS, Regional Innovation Centres)</li> <li>▪ <i>Water Technology Acceleration Project (WaterTAP)</i></li> <li>▪ Bloom Centre for Sustainability (Bloom)</li> <li>▪ GreenCentre Canada (GCC)</li> <li>▪ MaRS Advanced Energy Centre</li> <li>▪ Centre for Research and Innovation in the Bioeconomy (CRIBE)</li> <li>▪ Southern Ontario Water Consortium</li> <li>▪ Bioindustrial Innovation Canada (BIC)</li> <li>▪ Plus several risk capital and other financial supports (e.g., Investment Accelerator Fund, Northleaf Venture Catalyst Fund)</li> </ul> | <ul style="list-style-type: none"> <li>▪ <i>Green Energy Act</i></li> <li>▪ <i>Western Climate Initiative</i></li> <li>▪ <i>Climate Change Mitigation and Low Carbon Economy Act</i></li> <li>▪ <i>Climate Change Action Plan</i></li> <li>▪ <i>Partnerships for Growth Act</i></li> <li>▪ <i>Feed-in Tariff (FIT)</i></li> <li>▪ <i>Smart Grid Fund</i></li> <li>▪ <i>Mandated Leadership in Energy and Environmental Design green building standards for government facilities</i></li> <li>▪ <i>Cap and Trade Program</i> (to start in 2016–17)</li> <li>▪ <i>Green Bonds</i></li> <li>▪ <i>Waste-Free Ontario Act</i></li> <li>▪ <i>Green Focus on Innovation and Technology (GreenFIT)</i></li> <li>▪ Walkerton Clean Water Centre</li> <li>▪ <i>Green Investment Fund</i></li> </ul> |

## Examples of Key Regulations and Programs Supporting Clean Technology

| Province      | Early-Stage Innovation  | Commercialization  | Adoption  |
|---------------|---|--|---|
| Quebec        | <ul style="list-style-type: none"> <li>Fonds vert</li> <li><i>Technoclimat</i></li> <li><i>Passeport Innovation</i></li> <li><i>Fonds Cycle-C3E</i></li> <li><i>Ecofuel</i></li> <li><i>Anges Québec Capital</i></li> <li><i>Fonds de recherche du Québec Nature et Technologies</i></li> <li><i>Programme de soutien à la recherche</i></li> </ul> | <ul style="list-style-type: none"> <li>Fonds vert</li> <li><i>Ecoperformance</i></li> <li><i>Créativité Québec</i></li> <li><i>PSPDT (support for electric taxi demonstration projects)</i></li> <li><i>Fonds Cycle C3E et le Fonds Cycle Capital I et III</i></li> <li><i>Fonds Enertech Capital IV</i></li> <li>Investissement Québec</li> </ul> | <ul style="list-style-type: none"> <li><i>Cap and Trade Program</i> with California (and soon Ontario)</li> <li><i>Stratégie gouvernementale de développement durable</i></li> <li><i>Plan d'action sur les changements climatiques</i></li> <li>Politique énergétique</li> <li><i>Plan d'action en électrification du transport</i></li> <li><i>Politique de gestion des matières résiduelles</i></li> <li><i>Stratégie maritime</i></li> <li><i>Vision stratégique du développement minier</i></li> <li><i>Programme de biométhanisation et compostage</i></li> <li><i>Programme Prime-Vert</i></li> <li><i>Biodiesel Tax Credit</i></li> <li><i>Programme Écocamionnage</i></li> <li><i>PETMAF</i> (energy efficiency in air, train, boat transportation)</li> <li><i>Créativité Québec</i></li> <li><i>The Green municipal fund</i>, and other programs help municipalities to adopt greener technologies and practices and more efficient public transports</li> </ul> |
| Nunavut       | N/A   | N/A  | <ul style="list-style-type: none"> <li>Nunavut Energy Management Program</li> <li>Nunavut Energy Strategy, <i>Ikummatiit</i></li> </ul>   |
| New Brunswick | <ul style="list-style-type: none"> <li><i>NBIF's Research Innovation Fund</i></li> <li><i>NB Innovation Foundation's Industry Innovation Voucher</i></li> <li><i>NBIF's Research Innovation Fund</i></li> </ul>   | <ul style="list-style-type: none"> <li><i>NBIF's VC Fund</i></li> <li><i>Build Ventures Fund</i></li> <li><i>NBIF Start-Up Fund</i></li> </ul>   | <ul style="list-style-type: none"> <li><i>Energy Efficiency Program</i> (incentive for heat pumps)</li> <li><i>NB Power's LORESS</i> (Locally Owned Renewable Energy Small Scale) Program</li> <li><i>GNB Technology Adoption Program for Industry</i></li> <li><i>Environmental Trust Fund grants</i></li> </ul>   |

## Examples of Key Regulations and Programs Supporting Clean Technology

| Province                  | Early-Stage Innovation  | Commercialization   | Adoption   |
|---------------------------|---|---|--|
| Prince Edward Island      | <ul style="list-style-type: none"> <li>▪ <i>Pilot and Discovery Fund</i></li> <li>▪ <i>Ignition Fund</i></li> <li>▪ <i>Innovation and Development Labour Rebate</i></li> <li>▪ <i>Growing Forward 2</i> (Department of Agriculture and Forestry in collaboration with Agriculture and Agri-Food Canada)</li> </ul>  | <ul style="list-style-type: none"> <li>▪ <i>Development and Commercialization Fund</i></li> <li>▪ <i>Marketing Support Assistance</i></li> </ul>  | <ul style="list-style-type: none"> <li>▪ <i>Heat Pump Rebate</i></li> <li>▪ <i>Equipment upgrade Rebate</i></li> <li>▪ <i>Building Envelope Upgrade Rebate</i></li> <li>▪ <i>Home Energy Low-income Program</i></li> <li>▪ <i>Commercial Energy Audit Program</i></li> <li>▪ Expanding use of biomass heating in public buildings</li> </ul>   |
| Nova Scotia               | <ul style="list-style-type: none"> <li>▪ Innovacorp: <i>Clean Technology Innovation Fund, Productivity and Innovation Vouchers, Early-stage Commercialization Fund</i> (grant funding for innovation)</li> <li>▪ Innovacorp: <i>Clean Technology Accelerate Program</i> – start-up accelerator for clean tech companies</li> <li>▪ <i>Offshore Energy Research Association Fund</i> (grant funding for Tidal research)</li> <li>▪ <i>Department of Energy Innovation Fund</i> (grant funding for Electricity system innovation)</li> <li>▪ <i>Department of Natural Resources Innovation Hub</i> (grant funding for biorefinery development)</li> </ul> | <ul style="list-style-type: none"> <li>▪ Innovacorp: <i>Nova Scotia First Fund – Clean Technology Investment Fund</i> (equity investments in clean technology start-ups)</li> <li>▪ <i>Build Ventures: Regional public-private venture capital fund</i> (sector agnostic)</li> <li>▪ Nova Scotia Business Inc. (grant funding for export development; employee rebate program)</li> </ul> | <ul style="list-style-type: none"> <li>▪ <i>Environmental Goals and Sustainable Prosperity Act</i></li> <li>▪ <i>Nova Scotia Climate Change Action Plan</i>: GHG caps on electricity system</li> <li>▪ <i>Renewable Energy Regulations</i>: legislated target for minimum renewable generation on electricity grid</li> <li>▪ <i>Feed-in-tariffs for community-owned renewables and for Tidal Energy demonstration projects</i></li> <li>▪ <i>Efficiency Nova Scotia</i>: efficiency retrofits and incentives financed by rate payers/electricity rates</li> </ul>   |
| Newfoundland and Labrador | <ul style="list-style-type: none"> <li>▪ Research &amp; Development Corporation NL (Programs Including: <i>LeverageR&amp;D; CollaborativeR&amp;D; EmployR&amp;D; R&amp;D Vouchers; and R&amp;D Proof of Concept</i>)</li> </ul>   | <ul style="list-style-type: none"> <li>▪ <i>Regional Development Fund</i></li> <li>▪ <i>Business Investment Fund</i></li> <li>▪ <i>Venture Newfoundland and Labrador</i></li> <li>▪ <i>Build Ventures</i></li> <li>▪ <i>Aquaculture Capital Equity Program</i></li> <li>▪ <i>Aquaculture Working Capital Loan Guarantee Program</i></li> </ul>  | <ul style="list-style-type: none"> <li>▪ <i>Climate Change Action Plan</i></li> <li>▪ <i>Energy Efficiency Action Plan</i></li> <li>▪ <i>Greening Government Action Plan</i></li> <li>▪ <i>Market Transformation Framework</i></li> <li>▪ <i>Build Better Buildings policy</i></li> <li>▪ <i>Growing our Renewable and Sustainable Forest Economy</i></li> <li>▪ <i>Sustainable Aquaculture Strategy</i></li> <li>▪ <i>Ocean Technology Strategy</i></li> <li>▪ <i>Green Procurement Initiative</i></li> <li>▪ <i>TakeCHARGE</i> – rebates to offset cost of energy efficiency products and services</li> <li>▪ <i>Biogas Electricity Generation Pilot Program</i></li> <li>▪ <i>Renewable Energy Credits</i></li> </ul> |

## Identified Sectors Of Opportunity And Areas Of Strength

Clean technology activities are often a reflection of the natural resources and economic endowments found in a jurisdiction. That is, existing economic strengths lead to opportunities for the integration of clean technologies. Similarly, large sources of emissions present opportunities for clean technology solutions that lessen negative environmental impacts. This section surveys the sectors identified by the Working Group, and lists examples of companies in each province and territory. It is not intended to be an exhaustive list of activities; rather, it illustrates that activities take place in every region of the country.

### Overview

In general, the Working Group identified a number of sectors as high emitters:

- Transportation
- Oil and Gas
- Building
- Electricity
- Agriculture
- Heavy Industry (mining, smelting and refining, pulp and paper, iron and steel, cement, lime and gypsum, and chemicals and fertilizers)
- Water and Waste

As well, the Working Group highlighted a number of sectors as priority areas for the application of clean technology, including:

- Transportation
- Extractive Industries (Mining, Oil and Gas)
- Buildings and Energy Efficiency
- Biotechnology, Agriculture, and Forestry
- Renewable and Carbon Neutral Power Generation
- Smart Grid and Energy Storage
- Waste and Wastewater

### Transportation

Canada's vast geography makes transportation an important opportunity for clean technology, as well as a large source of emissions. In 2014 transportation produced 23% of Canada's total emissions (ECCC, 2016) and transportation-related clean technology firms invested \$195 million in R&D (Analytica Advisors, 2016).

Examples include:

- *Manitoba*: New Flyer Industries manufactures heavy-duty transit vehicles and supports electric, hybrid-electric configurations, and alternative natural gas fuels that emit less than diesel, electric trolley vehicles, and hydrogen-hybrid buses.
- *British Columbia*: Westport Innovations develops heavy-duty natural gas engines. Clean Energy Compression is a global leader in natural gas fuelling infrastructure. Ballard Power Systems develops hydrogen fuel cells.

- *Quebec*: EcoTuned Technologies electrifies old government fleet vehicles, Effenco develops heavy vehicle hybrid solutions, and TM4 Electrodynamic Systems develops electric powertrain solutions. A Quebec Electric Bus Consortium also groups NovaBus, Blue Solutions, TM4, Giro, René Matériaux Composites and Précicad. A pre-competitive research consortium INNOVée also regroups industry and academia to develop solutions for the electrification of transports.
- *Ontario*: Magna International develops lightweight technologies and auto parts. Hydrogenics develops fuel cells.

### **Extractive (Mining and Oil and Gas)**

Analytica Advisors (2014) estimates that in 2014 revenues in the clean technology extractive sector were \$309 million, and purely clean technology companies in this sector employed 1,400 people and invested \$122 million in R&D.

Examples include:

- *Alberta*: Shell Canada's Quest Carbon Capture and Storage Project captures an estimated 1 million tonnes of CO<sub>2</sub> emissions from the oil sands annually, with a total projected 10-year investment valued at \$1.35 billion (\$865 million by the Alberta and federal governments and \$485 million by industry over the 10-year project life).
- *Alberta*: N-Solv developed a purer, cleaner solvent for oil extraction resulting in an 80% reduction in GHG emissions versus convention steam-based processes.
- *Saskatchewan*: Cenovus (light oil) and Husky (heavy oil) are leaders in enhanced oil recovery methodologies that sequester captured CO<sub>2</sub>.
- *Newfoundland and Labrador*: Oil Filtration Solutions Inc. provides a micron oil bypass filtration system that reduces the amount of wastewater in oil extraction.
- *Yukon*: Mining exploration firm GroundTruth Exploration developed a low-impact, low-cost approach to mining exploration and mapping in remote/ecologically sensitive areas.
- *Ontario*: Hatch is working to dramatically reduce waste, energy and water use in mining operations and Newterra provides modular water treatment systems for mining.

### **Buildings/Energy Efficiency**

Analytica Advisors (2016) estimates that revenues in the clean technology green building and energy efficiency sector were \$1.51 billion in 2013. Green buildings firms employed 7,200 people and invested \$98 million in R&D in 2014.

Examples include:

- *British Columbia*: dPoint Technologies uses polymer energy recovery technology to limit energy loss resulting from air ventilation processes. SunCentral develops solutions to allow full-spectrum sunlight into multi-storey buildings.
- *Ontario*: EllisDon Corporation launched the Carbon Impact Initiative in partnership with five influential construction companies to reduce the carbon impact from commercial buildings. Greyter provides solutions that reuse greywater in homes. RenewAbility provides solutions that capture waste heat in hot water systems.
- *Quebec*: Airex Industries Inc. provides a suite of solutions for fossil fuel reduction and substitution, heat recirculation and recovery, and electricity consumption optimization and power sharing. Engineering firm Atis Technologies specializes in energy management and efficiency in industrial food processing.



- *Nova Scotia*: CarbonCure retrofits concrete plants with technology that recycles waste CO<sub>2</sub> to make affordable, greener and more durable concrete products. Green Power Labs provides software analytic solutions for predictive control of building energy management.
- *New Brunswick*: Shift Energy's EOS is a software solution that optimizes energy consumption within existing building systems through the process of automated Intelligent Live Recommissioning, reducing costs for large facilities like the Rogers Arena and the University Health Network in Toronto.

### **Biotechnology/Agriculture/Forestry**

Analytica Advisors (2016) estimates that in 2014 revenues in the clean technology agricultural sector were \$62 million; the sector employed 700 people and invested \$24 million in R&D. Biorefinery products generated \$343 million in 2014, along with 1,600 jobs and a \$146 million R&D investment.

Examples include:

- *Saskatchewan*: Milligan Biofuels produces biofuels from damaged grade Canola.
- *Alberta*: Growsafe develops algorithms related to cattle feeding patterns to make production more efficient and to lower emissions.
- *Manitoba/Saskatchewan*: Husky Energy has two major ethanol plants in Minnedosa, MB and Lloydminster, SK; they produce 260 million litres of ethanol per year from 700,000 tonnes of non-food quality grains.
- *Saskatchewan*: The University of Saskatchewan's Crop Development Centre has led the development and commercialization of legume crops which fix nitrogen GHG emissions to the soil.
- *New Brunswick*: Resson Aerospace technology helps reduce water and fertilizer use in commercial agriculture by using recent advances in large-scale cloud-based data processing, swarm robotics and advanced data analytics.
- *Quebec*: Larvatia offers the livestock food industry a renewable and competitive alternative to fishmeal and oil supplements. Inocucor produces sustainable biological products for the phyto-microbiome that protect our natural resources and Agrisoma produces biofuel from carinata oil.
- *Nova Scotia*: TruLeaf develops and manufactures Smart Plant Systems® that leverage multi-level vertical farming to create controlled and efficient indoor farms for produce production in urban settings and harsh environments. CelluFuel is demonstrating biorefinery technology for conversion of wood waste to renewable diesel fuel.

### **Renewable/Carbon Neutral Power Generation**

Greener ways to produce power include renewables (e.g., wind and solar) and carbon neutral generation technologies (e.g., fossil fuel plants using carbon capture and sequestration and nuclear energy). Differences in provincial and territorial populations and geographic size as well as their natural resource endowments affect choices on how best to decarbonize electricity grids. In addition, some provinces already have a significant foundation of renewable power generation. Analytica Advisors (2016) estimates that revenues in the clean technology power generation sector were \$3.8 billion in 2014; the sector employed 13,200 people and invested \$183 million in R&D.

Examples include:

- *Prince Edward Island*: The Wind Energy Institute of Canada provides facilities and supports for wind R&D.
- *Newfoundland and Labrador*: Grey Island Energy has developed an ocean wave power generation system called "SeaWEED".

- *British Columbia*: General Fusion Inc. develops magnetized target fusion. Endurance Wind Power manufactures and distributes wind turbines.
- *Northwest Territories*: The Northwest Territories Power Corporation and the GNWT have invested in a football-field-sized solar energy project in Fort Simpson, the largest solar photovoltaic installation in northern Canada.
- *Nova Scotia*: The Fundy Ocean Research Centre for Energy (FORCE), located at the site of the world's most powerful tides, is Canada's leading demonstration site for grid-connected, in-stream tidal energy and will host five projects for 22 MW of tidal energy to 2020.
- *Alberta*: The Halkirk Wind Project, owned and operated by Capital Power, has the capacity to generate 150 megawatts and is one of Alberta's largest.
- *Saskatchewan*: Produces and exports uranium for nuclear power plants and has identified small modular reactors (SMRs) for electrical generation and other applications as an opportunity for clean energy production in applications with smaller demand. SaskPower was first in the world to implement carbon capture and storage on a commercial coal-fired power plant, reducing emissions of SO<sub>2</sub> by 100% and CO<sub>2</sub> by 90%.
- *Ontario*: Silfab Solar has one of the most automated solar panel manufacturing facilities in North America. Siemens manufactures wind blades in Tillsonburg and exports to regions around the world.
- *Quebec*: Enerkem manufactures biofuels from non-recyclable waste. Terragon provides clean technology solutions that enable small remote communities to generate energy from their solid waste and sludge.

## Smart Grid/Energy Storage

Energy efficiency improvements present cost-cutting opportunities and help to reduce energy use. Analytica Advisors (2016) estimates that the infrastructure and smart grid sector generated \$698 million in revenues in 2014 while employing 3,300 people. R&D investment in the sector was \$122 million.

Examples include:

- *Northwest Territories*: The Arctic Energy Alliance provides smart meters for remote northern communities to monitor and regulate energy distribution.
- *British Columbia*: Schneider Electric provides energy management and automation. Neuro Technologies and Rainforest Automation developed a smart monitor for home energy consumption.
- *Manitoba*: Manitoba Hydro is actively researching advanced metering infrastructure to improve energy efficiency in residential and commercial buildings.
- *Ontario*: The Ontario Energy Board has adopted Demand Side Management (DSM) as a legislative requirement, and developed programs for the province based on the DSM framework. Ecobee is a smart home automation company that makes thermostats for residential and commercial use. Hydrostor has developed underwater compressed air energy storage. ElectroVaya has developed the world's greenest lithium ion battery. Temporal Power has developed a flywheel for energy storage.

- *Nova Scotia*: NS Power has contributed to reductions in oil-fired heating through consumer financing of high-efficiency heat pumps and ceramic heat storage units. Unify Energy is demonstrating energy storage for grid integration of intermittent wind generation.
- *New Brunswick*: The province is home to Siemens' Global Smart Grid Centre of Competence as well as the Smart Grid Innovation Network, a partnership between Siemens, NB Power and the University of New Brunswick to drive and support a smart grid ecosystem for innovation, technology advancement, research and development.
- *Quebec*: Hydro-Quebec research institute, Sigma Energy Storage, Pituvik Landholding and Innergex provide expertise and technologies for energy storage, particularly in northern, remote, and Indigenous communities.

## Water/Wastewater

More issues and pressures on global water resources emerge every year including severe weather events and changing climate, population growth and urbanization, emerging contaminants and aging infrastructure. UN Secretary General Ban Ki-Moon, in considering these pressures, warns that by 2030, nearly half the global population could be facing water scarcity and demand could outstrip supply by 40% (USA Today, 2013).

These growing needs have seeded a global market for water technology that is expected to grow to over \$1 trillion by 2020. Canadian water companies should be poised to provide innovative solutions to these problems.

Examples include:

- *Ontario*: Trojan Technologies is known globally as the gold standard for UV water treatment (recently adopted by Chicago and New York City). Ontario technologies from companies such as Pure Technologies, WatrHub Inc., UV Pure Technologies and Lystek are all currently employed to help California improve and optimize its water and wastewater systems for future drought events.
- *Nova Scotia*: Island Water Technology (based in PEI with R&D in Nova Scotia), which manufactures solar-powered wastewater treatment systems for remote off-grid sites, has sold a unit to the Department of National Defence (Gagetown, NB) under the BCIP.
- *Alberta*: COSIA is building a Water Technology Development Centre to be attached to Suncor Energy's Firebag oil sands facility. Lessons learned and similar projects by COSIA's industry partners and suppliers could be applied to international opportunities.

## Northern, Remote, and Indigenous perspectives

Success stories relating to clean technology adoption already exist in northern, remote, and Indigenous communities:

- *British Columbia*: The First Nations Clean Energy Business Fund promotes increased participation of Indigenous communities in the clean energy sector. The First Nations Energy Efficiency Building Project supports standards and measures for housing on-reserve, as well as economic and community development initiatives.
- *Alberta*: Saddlelake Cree Nation is creating a solar project to power its water treatment plant. Athabasca Chipewyan First Nation is using its solar pilot project to power its youth and elder lodge.
- *Yukon*: Government of Yukon is committing \$1 million to installing wind turbines to reduce reliance on diesel generation in the communities of Burwash Landing and Destruction Bay.

- *Saskatchewan*: Saskatchewan Research Council has supported Cowasis First Nation's development of a wind turbine-battery storage demonstration project. SaskPower has power purchase agreements with Meadow Lake Tribal Council for biomass power. Negotiations are also underway for the purchase of additional solar and flare gas power generation from First Nations Power Authority.
- *New Brunswick*: NB Power has reserved 40 megawatts of generation for Indigenous-owned renewable energy projects, while numerous Indigenous communities are developing wind, biomass and waste-to-energy projects.
- *Northwest Territories*: Lutsel K'e Dene First Nation, a remote community of 350 people, has worked with the Government of the Northwest Territories, Bullfrog Power, Arctic Energy Alliance and the Government of Canada's ecoENERGY for Aboriginal and Northern Communities program on the development of a 35 kW solar PV installation, which includes 144 solar panels installed. Colville Lake, located 50 kilometres above the Arctic Circle, has installed a solar/diesel/battery system that will allow the community to shut down its diesel generators for extended periods over the summer months.
- *Manitoba*: The Province provided financial assistance to Aki Energy, an Indigenous social enterprise, to increase training and installation of alternative energy and to support food self-sufficiency.
- *Ontario*: Ontario's Independent Electricity System Operator programs under the Aboriginal Energy Partnerships Program, including the Aboriginal Renewable Energy Fund and the Education and Capacity Building Fund, target the development of renewable energy projects, skills and awareness.
- *Quebec*: In December 2016, Innergex, in partnership with the Mi'gmawei Mawiommi (Micmaque Nation), will initiate service for a 150MW wind farm in the Gaspésie-Iles-de-la-Madeleine region.
- *Nova Scotia*: Provincial community feed-in-tariff policies enabled Indigenous involvement in the renewable energy sector, with seven Mi'kmaq-owned large wind COMFIT projects under construction or in operation with a combined generation capacity of 25.4 MW.
- *Newfoundland and Labrador*: The Ramea Wind-Hydrogen-Diesel Energy R&D Project on the isolated electrical system on Ramea Island uses renewable energy to reduce the communities' diesel requirements and is meant to demonstrate the potential to support other off-grid communities with renewable energy.