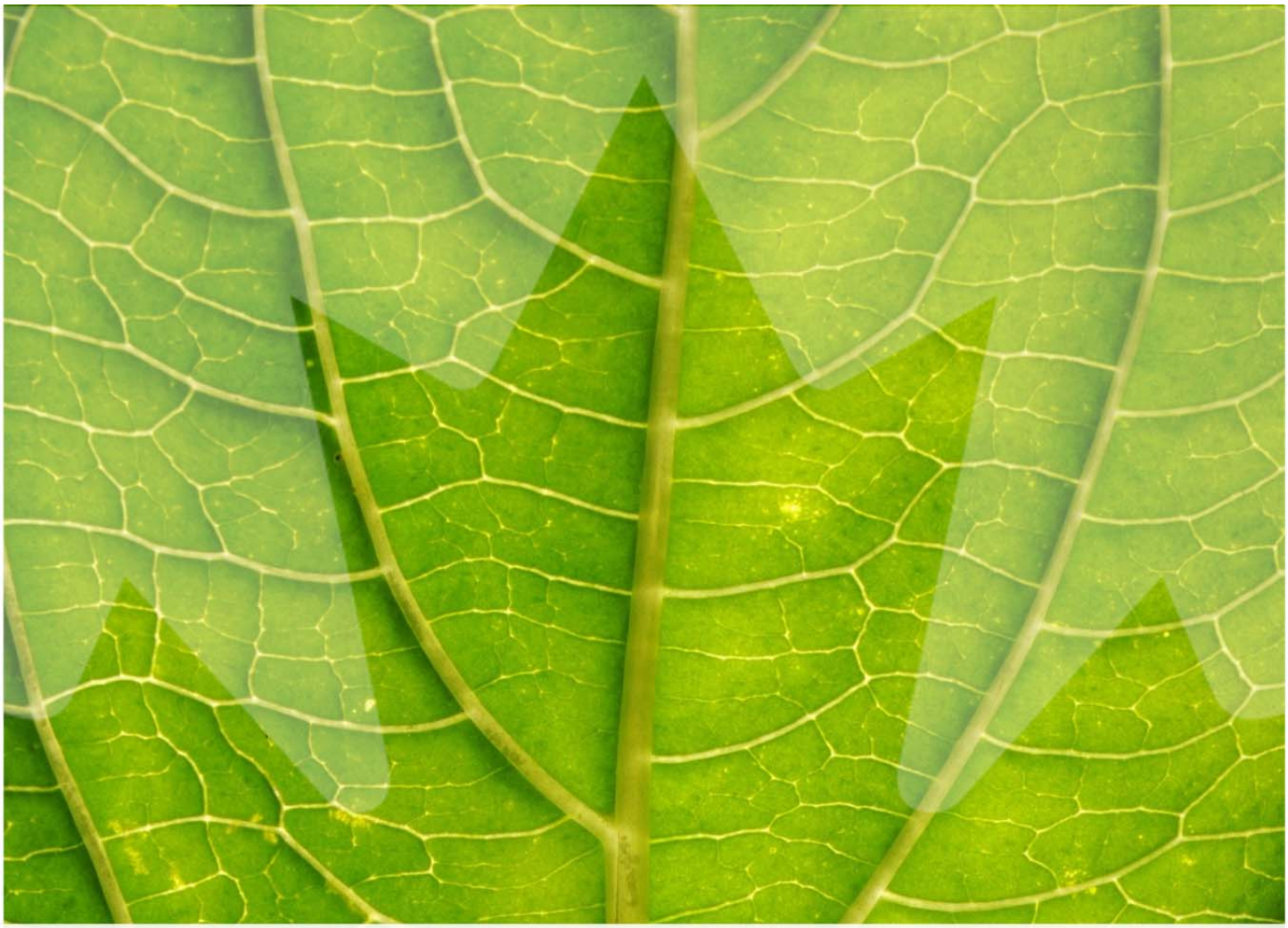


Interim Report

Of the Federal/Provincial/Territorial **Working Group on Clean Technology, Innovation and Jobs**

June 2016

EXECUTIVE SUMMARY

On March 3, 2016, First Ministers signed the Vancouver Declaration on Clean Growth and Climate Change and created several working groups to advance work in this area. This report constitutes the Interim Report of the Working Group on Clean Technology, Innovation and Jobs (the Working Group) to Ministers of Innovation and Economic Development.

The mandate of the Working Group is to:

> *Provide a report 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* [while considering] *a range of policy tools to bring new and emerging technologies 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.*

Since our Working Group's formation, we have met weekly, engaged with National Indigenous Organizations, undertaken detailed reviews of known literature and compiled national, provincial and territorial data to build a common understanding of clean technology activities and challenges across Canadian jurisdictions.

This report provides a summary of these assessments and is intended to be the basis upon which we will consult with stakeholders and develop a final report. In undertaking our work, we have used a broad interpretation of our mandate to include the development, commercialization and adoption of clean technologies and clean growth practices across all sectors of the economy.

A guiding factor in our Working Group discussions and activities is an understanding that climate change is one of the greatest long-term challenges facing the world today. Tackling climate change requires a serious and sustained global response – economies around the world must transform how they use and produce energy. A dramatic and transformative step change in global innovation and adoption of clean technologies will be essential to meet this challenge.

Canada produces approximately two percent of global GHG emissions and thus it must look beyond its borders and develop a strong export focus to maximize economic benefits and the country's contribution to addressing climate change. Canada already has significant clean technology capacity and the potential to be a world leader in this area, providing made-in-Canada solutions to this global challenge.

Clean technologies provide the pathway for emissions mitigation and more sustainable growth of all areas of the economy, including transportation, natural resources development, manufacturing, construction, utilities and others. Canada's strong industrial base and natural resource endowments can serve as a catalyst for new, sustainable clean growth, but Canada must act quickly and decisively to seize these opportunities to participate in and grow the global market.

OUR WORK TO DATE HAS LED US TO THE FOLLOWING CORE FINDINGS:

- There is significant opportunity to better stimulate economic growth and job creation, and improve environmental outcomes across all sectors in Canada by driving clean technology innovation.

- This will require accelerating not only the development of new clean technologies but also the commercialization and export of these technologies to increase Canada's presence in the large and rapidly growing global market for solutions to address climate change and other environmental challenges.

- Improving the adoption of clean technology products and processes and clean growth practices by Canadian businesses, utilities, communities and consumers will be particularly important in that it will drive domestic environmental benefits as well as improve the ability of Canadian clean technology developers to commercialize new technologies.

- There is strong potential to improve environmental, economic and social outcomes for remote and Indigenous communities by providing better access to clean, affordable and secure supplies of energy, food and water without increasing costs for essential goods and services.

- Canada is well positioned to achieve these outcomes by leveraging regional strengths, shining a light on clean growth leaders across the country, and coordinating actions by governments, industry and stakeholders.

OUR ANALYSIS HAS LED US TO THE FOLLOWING INITIAL OBSERVATIONS REGARDING THE SITUATION ACROSS THE COUNTRY:

- There is significant economic activity in clean technology development across all sectors of the economy, but given different industrial foundations, resources and opportunities, there are important regional differences in the nature and structure of clean technology activities across Canada. Some jurisdictions also face specific economic, geographic and demographic constraints (such as higher dependence on natural resources, distance from major centres and small populations). Understanding the nature of these differences and taking advantage of the opportunities they create is essential to building a strong Canadian approach and strategy.

- Notwithstanding these differences, there is also a high degree of consistency across jurisdictions as to where the greatest opportunities for clean technology development and adoption are: transportation; extractive industries (oil and gas, mining); buildings and energy efficiency; bio-technology, agriculture and forestry; power generation; smart grids and energy storage; and water/wastewater. These areas of opportunity align closely with the economic sectors that are the largest sources of GHG emissions in Canada.

- There are also common challenges to the growth and use of clean technology products and processes, including access to capital, regulatory barriers, a lack of awareness, and gaps in skills.

- There is already a wide array of government programming to support clean technology innovation, commercialization and adoption at the federal, provincial and territorial level. Many of these programs, however, focus on general business support, while programs focused exclusively on clean technologies are less common. There also exists a variety of environmental regulations, fiscal policies, and GHG emissions reduction or environmental strategies that could benefit from greater coordination and complementarity across the country.

BASED ON THESE OBSERVATIONS, AND OUR WORK TO IDENTIFY BEST PRACTICES, THE FOLLOWING AREAS DESERVE GREATER EXAMINATION:

- Building Early-Stage Clean Technology Innovation: Successful research, development and demonstration (RD&D) systems are often targeted and coordinated across multiple actors.

- Accelerating Commercialization and Commercial Capacity: Effective models for commercialization integrate and leverage private sector resources to provide stable, long-term financing, with clearly defined exit mechanisms.

- Fostering Adoption: Consistent and clear environmental regulations and policies create market incentives for business and consumers to pull clean technologies into the market. Government adoption of clean technologies (e.g., through procurement programs) also facilitates clean technology providers to attain market readiness.

- Strengthening Collaboration and Metrics for Success: Cooperation, among all levels of government, Indigenous communities and stakeholders and through international research efforts helps drive clean technology innovation.

LOOKING FORWARD, THE WORKING GROUP WILL FOCUS OUR INQUIRY IN THESE FOUR AREAS, AND CONSIDER A NUMBER OF RESEARCH QUESTIONS, INCLUDING:

Building Early-Stage Clean Technology Innovation:

- *What are the appropriate vehicles to drive greater clean technology development, including investments in new disruptive technologies, to achieve the level of GHG reductions required to meet longer term targets for decarbonization of the economy?*
- *How can increased RD&D activities in clean technologies be jointly encouraged by governments and the private sector and used to leverage international cooperation?*
- *What comprehensive approaches can be established to ensure clean technology innovation aligns existing and planned innovation programs with broader program and policy objectives?*
- *Should mission-oriented strategies be developed to drive innovation for new clean technology solutions?*

Accelerating Commercialization and Commercial Capacity:

- *How can clean technology investments be facilitated jointly by governments and the private sector to grow stronger and more adaptable clean growth firms?*
- *How can there be better access to the right types of business financing to support new ventures and export growth to ensure new and innovative products make it through commercialization and compete globally? What can be done to help Canadian companies tap into international financing?*
- *What can be done to help Canadians transition into clean technology and clean growth jobs?*
- *How can firms be supported in their efforts to embed their clean technology solutions in global value chains to generate exports that will create jobs and growth for Canada while helping to reduce global GHGs?*

Fostering Adoption:

- *What are the barriers to greater adoption of clean technologies and clean growth practices in Canada?*
- *Could environmental regulations and assessment processes help provide greater market certainty and a stronger impetus for industry, utilities, communities and consumers to innovate, adopt and adapt clean technology solutions?*
- *How can governments, utilities and crown corporations and agencies leverage their purchasing power to support clean technology adoption?*
- *How can planned infrastructure expenditures be leveraged to promote clean technology innovation, development and widespread adoption?*
- *What factors would enable Indigenous communities to accelerate the adoption clean technologies and grow clean technology businesses?*

Strengthening Collaboration and Metrics for Success:

- *How could statistical agencies and other stakeholders collaborate to fill data gaps?*
- *In what ways could all orders of government coordinate activities to achieve economies of scale in their efforts to promote clean technology development and adoption to create jobs and greater economic benefits for all Canadians?*
- *What are the institutional structures that need to be put in place to ensure continued and effective collaboration in this area?*
- *What can be done to increase open availability of existing data that may facilitate innovation related to clean growth?*

To develop options for ministerial consideration by August 2016, the Working Group plans to investigate these questions over the next three months with the benefit of input from all interested stakeholders, including the public. A portal has been established to receive and discuss ideas for a pan-Canadian Framework on Climate Change and Clean Growth at the following address: www.letstalkclimateaction.ca.

INTRODUCTION

The March 2016 *Vancouver Declaration* commits First Ministers to work together on the development of a Pan-Canadian Framework on Clean Growth and Climate Change. To this end, First Ministers directed the creation of working groups in four areas:

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

Each of these working groups is to prepare a report, by September 2016, which lays out options for action that can be considered by Federal/Provincial/Territorial Ministers. Ministers will review these reports and provide their recommendations to First Ministers.

The Working Group on Clean Technology, Innovation and Jobs (the Working Group) has been mandated to develop a report 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. This Working Group has been directed to consider 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. Its work is being overseen by Ministers of Innovation and Economic Development.
In this context, the Working Group is examining the state of the development, commercialization and adoption of clean technologies and clean growth practices in Canada.

This document is the Working Group's Interim Report to Ministers. It reflects the work and discussions undertaken by the Working Group from April to May 2016 and is intended to set the context and outline core issues that will be addressed in the group's Final Report in September 2016.

CHAPTER 1

WHAT PROBLEM ARE WE TRYING TO ADDRESS?

1.1 SETTING THE CONTEXT

1.1.1 CLIMATE CHANGE, CLEAN TECHNOLOGY AND CLEAN GROWTH

Climate change is one of the greatest long-term challenges facing the world today. The science is clear and unambiguous: urgent global action is needed to avoid the negative effects of climate change. This will require transformation on an unprecedented scale, especially for how energy is produced and used. Innovation and technology will play a central role in the transition to a low carbon economy, and has the potential to spur clean growth, generate new products for export, and create well-paying jobs.

The impacts of climate change are already being felt around the globe. 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. Canada is expected to experience greater swings in temperature and precipitation, experiencing 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, and changes in wildlife and vegetation that are already have an impact on traditional ways of life.

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 (IPCC), reports that without additional efforts to reduce GHG emissions, global temperature increase by the end of the century could be as high as 3.7°C to 4.8°C compared to pre-industrial levels. While the cost of inaction will be greater than the cost of action to tackle climate change,[1] achieving the depth of cuts in GHG emissions 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, over 190 countries, including Canada, adopted the Paris Agreement in December 2015, committing to enhance their collective efforts to avoid dangerous climate change by limiting global temperature increase to less than 2°C and ideally no more than 1.5°C. Both incremental and radical innovations are needed to decarbonize the global energy system.[2]

As part of the Paris Agreement, Canada has committed to reduce its GHG emissions by 30% below its 2005 level by 2030, which is equivalent to a reduction of 291 million (M) tonnes below business-as-usual GHG projections. Canada is not currently on track to achieve this target. Canadian GHG emissions in 2014 were 732 M tonnes, representing 1.6% of global emissions[3], and the latest projections indicate without further action to reduce GHGs, Canada's GHG emissions will increase to 815 M tonnes by 2030. Energy-related emissions account for the majority of Canadian GHG emissions, at 86%, including 26 % for oil and gas, 23% for transportation, 14% for industrial sectors (other than oil and gas), 12% for fuel use in buildings, and 11% for electricity. Non-energy related sources of GHG emissions account for 19% of Canadian emissions, including 10% for agriculture and 4% for waste management.

There is widespread consensus that innovation and global adoption of low-carbon technologies are essential to achieving needed reductions in GHG emissions. The current pace of technology development and adoption, however, is all part of the problem: a step change in global technology advancement is required to transform the way in which the world produces and consumes energy. Achieving this transformative change, perhaps with new, disruptive technology, will

[1] The Economist Intelligence Unit, (2015), *The Cost of Inaction: Recognising the Value at Risk from Climate Change;* Paul Krugman, (2014), Errors and Emissions: Could Fighting Global Warming be Cheap and Free?, *The New York Times.*
[2] International Energy Agency, (2015), *Energy Technology Perspectives 2015,* p. 13.
[3] Environment and Climate Change Canada, (2016), *National Inventory Report 1990-2014: Greenhouse Gas Sources and Sinks in Canada*, Part 1, p. 18.

require vision and action by governments, industry, and the public. It will require long-term, predictable policy frameworks sending clear signals and certainty to markets, and it must draw on our nation's inventiveness and ability to create new products, services and processes. Canada has the potential to play a key global role in this area, leading the way with companies that innovate, commercialize and successfully perform in domestic and global markets.

Addressing climate change will require a decades-long commitment to develop and deploy low-carbon technologies around the world, as there is no silver bullet that can deliver the scale of GHG emissions reductions required. 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.

1.1.2 UNDERSTANDING CANADA'S ENVIRONMENTAL PERFORMANCE METRICS

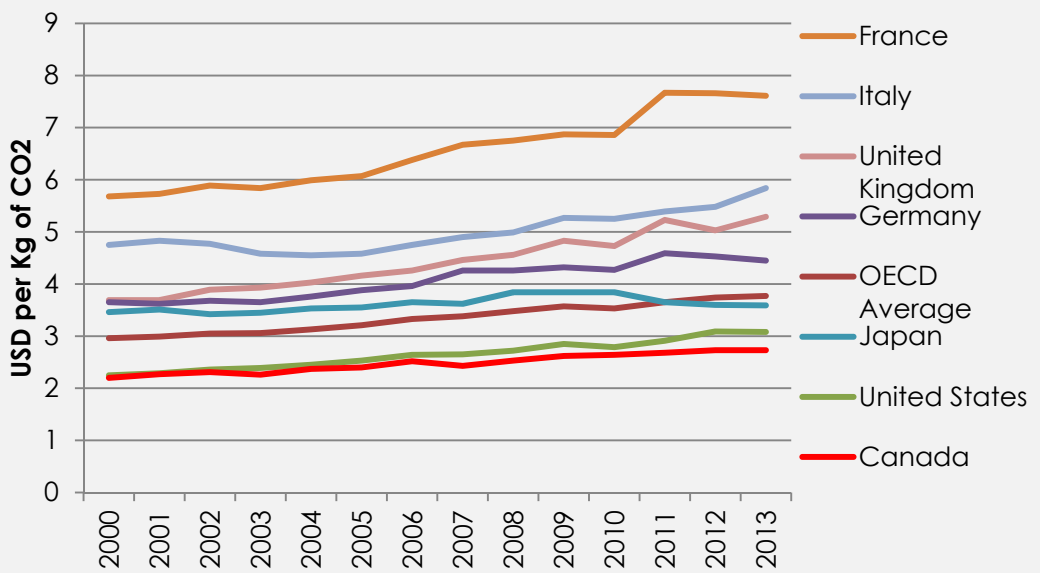
Understanding Canada's environmental performance is essential to understanding the challenges and opportunities that face Canada's clean technology sector and the potential for clean economic growth.

Overall, Canada's environmental performance on GHG emissions, air quality, water use and waste treatment, and energy usage compares poorly to its OECD peers. In almost all areas, Canada is near or at the bottom of OECD rankings for developed countries.

Our environmental performance can be partly attributed to a number of structural factors (e.g., a large geographic landmass, natural resource endowments, a low population density, and a highly variable climate), but it also reflects a lack of adoption of clean technologies, and that the rate of deployment of clean technologies is being outpaced by growth in emissions.

FIGURE 1

$C0_2$ PRODUCTIVITY (GDP GENERATED PER KG CARBON)



Source : OECD Green Growth Database

CANADA'S ENVIRONMENTAL PERFORMANCE

5TH HIGHEST
GHG emissions in 2013, among OECD countries

3RD WORST
CO_2 productivity (GDP per KG of carbon) in 2013, among OECD countries

63%
Of Canadians exposed to air pollution levels above the WHO guideline

11TH WORST
Water productivity (value generated per cubic metre of water withdrawal), among OECD countries

7TH HIGHGEST
Percentage of waste sent to landfill (71%) among OECD countries

3RD WORST
Energy productivity (GDP per energy supply), among OECD counties

A SUMMARY OF CANADA'S ENVIRONMENTAL PERFORMANCE IS AS FOLLOWS:

- *Greenhouse Gas Emissions:* Overall, Canadian emissions were 5th highest in the OECD in 2013. Canadian GHG emissions have remained relatively flat from 2003 to 2013, while overall emissions in the OECD have declined by 5% and overall emissions in the United States (U.S.) have declined by 9% during the same time period.[4]

- *Carbon Intensiveness:* In terms of CO_2 productivity, in 2013 Canada was ranked 3rd worst at 2.7 (GDP per KG of carbon); much worse than the OECD average of 3.8. However, Canada's CO_2 productivity has been improving slightly since 2003.[5]

- *Air Emissions:* Criteria air contaminant emission LEVELS (particulates, volatile organic compounds, sulfur oxides, and nitrous oxides) are at or near the bottom of the OECD (in both emissions per unit of GDP as well as per capita emissions).[6] In terms of air quality in 2013, 63% of Canada's population was exposed to levels above the WHO guideline.[7] Canadian performance is similar to the U.S.; most countries with a high population density perform worse on this metric.

- *Water Use and Treatment:* Canadian water productivity (value generated per cubic metre of water withdrawal) is $35 USD per cubic metre and ranks 11th worst in the OECD.[8] Water usage across different industrial sectors is difficult to compare internationally as each country has different water profiles. Canada only uses 1% of its available fresh water supply[9] (reflecting its abundance), however, per capita usage is high at 1,015 cubic metres.[10]

- *Waste Treatment:* Canada recycles or composts only about 25% of its municipal waste. Leading countries have composting and recycling rates above 40%, with Germany leading the way at 64%. As well, Canada landfills 71% of its municipal waste, which is the 7th highest in the OECD. Some countries, such as Sweden and Germany, landfill less than 1% of their municipal waste.[11]

- *Energy Use and Productivity:* Canadian energy productivity fares poorly among OECD countries, ranking third worst in terms of GDP per Total Primary Energy Supply (TPES), and second worst in terms of energy consumption per capita. As Well, in 2014 Canada's renewable energy supply was 18% of total energy supply placing Canada as the 12th best in the OECD, Canada, however, ranked 5th in terms of percentage of renewables in the electricity supply, at 62% of generation in 2014.[12]

[4] OECD, (2016), *Green Growth Indicators*.
[5] *Ibid.*
[6] *Ibid.*
[7] World Bank, (2016), *Data*.
[8] OECD, *Green Growth Indicators.*
[9] World Bank, *Data.*
[10] OECD, *Green Growth Indicators.*
[11] *Ibid.*
[12] *Ibid.*

1.2 UNDERSTANDING CHALLENGES AND OPPORTUNITIES

Clean technologies, while often focused in the area of renewable energy, are found in all sectors of the economy. Clean technologies are those that mitigate environmental impacts on air, water and land. Similarly, clean growth aims to increase living standards with a reduced environmental impact through the use of clean technologies and sustainable development practices.

Globally, the clean technology market is expanding rapidly as many countries strive to curb the growth of harmful emissions and further degradation of their environments. Canada's development of clean technologies and associated exports and jobs has improved, but has not kept pace with global growth. Analytica Advisors (2016) reports that the global exports of manufactured environmental goods market doubled between 2005 and 2014, and is now worth over $1 trillion dollars. In that time, Canada's global market share fell from 2.0% to 1.3%.[13]

1.2.1 EARLY-STAGE INNOVATION

Canada has a highly educated population and a strong research and development infrastructure. The *Global Cleantech Innovation Index 2014* ranks Canada tenth out of 40 countries in terms of emerging clean technology, and early-stage progress of clean technology companies.[14]

That said, early research and development activities in Canada are dependent on the public sector. Total gross domestic expenditures on Research and Development (R&D) (GERD) measured 1.61% of GDP in 2014,[15] while business enterprise R&D (BERD) measured 0.80%.[16] Each of these metrics has fallen over the past decade while Canada's OECD peers have shown improvements.

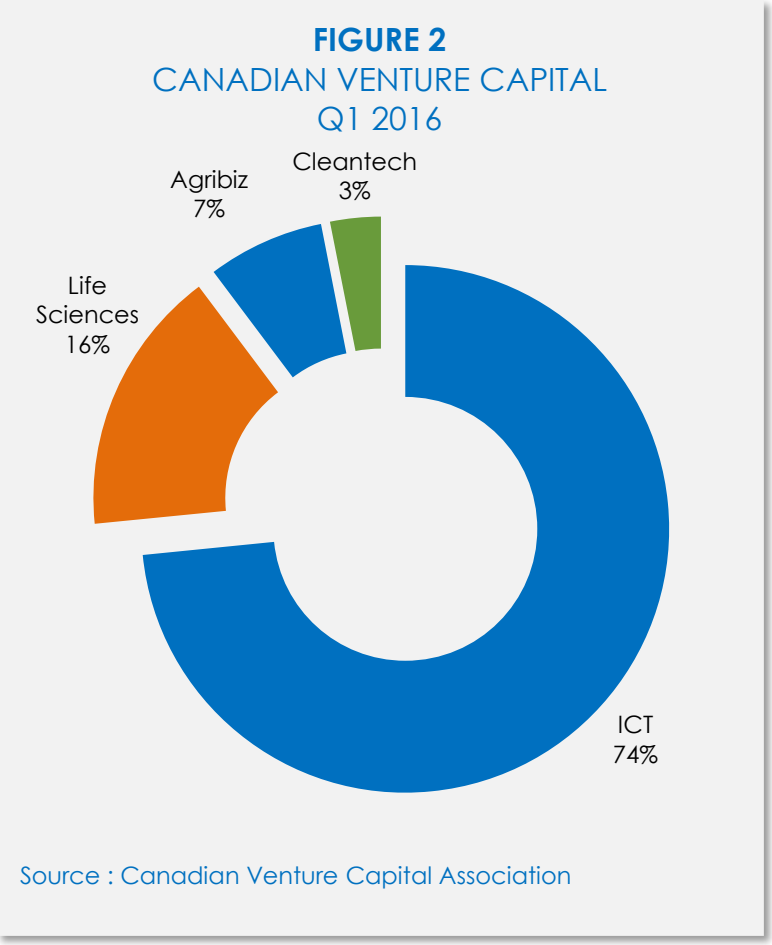
The Council of Canadian Academies notes that low BERD in Canada stems from factors that lower R&D incentives: in the integrated North American economy, many Canadian companies find easy success in being an upstream supplier to the larger firms in the US that dominate value chains.[17] The drop in BERD is also tied to the downsizing of leading R&D firms during this period (e.g., Nortel, Blackberry).

Canada leverages its innovation strengths to generate clean technology inventions, but like R&D measures, Canada is falling behind its OECD peers. Between 2010 and 2013, Canada ranked tenth in the world for terms of patents in climate change mitigation technologies; between 2000 and 2003, Canada placed fourth in the world, behind only Japan, U.S. and France. Since 2003, Denmark, Great Britain, China, Taiwan, Germany, and Korea have all surpassed Canada.[18]

1.2.2 COMMERCIALIZATION/COMMERCIAL CAPACITY

Compared to its peer nations, Canada performs only moderately well when it comes to commercializing clean technology inventions. These problems are generally linked to issues such as access to capital, successful competition in international markets, and trouble attracting and developing the appropriate skill mix and talent.

[13] Analytica Advisors, (2016), *Synopsis: 2016 Canadian Clean Technology Industry Report*.
[14] Michele Parad, *The Global Cleantech Innovation Index 2014*, World Wildlife Fund & Cleantech Group, p. 23.
[15] OECD, (2016), *Main Science and Technology Indicators Volume 2015 Issue 2*, OECD Publishing, p. 21.
[16] *Ibid*., p. 43.
[17] Council of Canadian Academies, (2013), *Paradox Lost: Explaining Canada's Research Strength and Innovation Weakness*.
[18] OECD, (2015). *OECD Science, Technology and Industry Scorecard 2015*, OECD Publishing, p. 233.



Accessing Capital

Researchers observed a lack of successful commercialization in Canada despite substantial support from numerous government initiatives.[19] Canada's relatively poor performance is often cited as linked to a scarcity of private funding, a poorly performing venture capital market and lack of coordinated leadership among institutions operating at the federal, provincial, territorial, and municipal levels.[20]

Pittis (2014) argues that Canadian financial institutions (along with other large institutional investors) have demonstrated a relative lack of willingness to invest in clean technology due to a combination of market risks and high capital costs, characteristic of many innovative clean technologies.[21]

Regarding Venture Capital (VC), OECD data ranks Canada 3rd in the word in terms of total venture capital funds available compared to GDP, however notes individual deal size is small. Canada's sector is small, compared to other countries. Canada's total VC market is growing overall (from 2014-2015 total VC grew 12% in terms of deal value and 24% in terms of number of deals), however, VC for clean technology companies is declining in terms of the number of deals, value of deals and overall investment.[22]

International Market Development

Analytica estimates that Canada's export market share was 1.3% in 2014 (19th of the top 24 clean technology exporters), as measured in terms of merchandise goods. Canada's global position has slipped moderately: in 2005, Canada's clean technology market share was 2.0% and Canada ranked as 14th best.[23] Data for clean technology services exports are limited. To compare, Canada's total export market share in 2014 was 2.6% for merchandise and 1.7% for services.[24]

Competition in international markets requires investments in relationship-building and market intelligence that frequently exceed the resource capacity of most small and medium-sized enterprises (SMEs).[25] Researchers note there are often poor relationships between SMEs and large firms in Canada. This means that many SMEs face an additional challenge in breaking into international markets, as large firms often serve as critical vehicles for SME access. Absent this relationship, SMEs face difficulties in meeting the resource demands necessary to develop relationships in a foreign market, meet the suite of demands of foreign customers, and manage risks associated with operating in a foreign country.[26]

Access to Talent/Capacity

[19] Natural Resources Canada, (2013), *Energy Innovation Roundtables: Discussion Paper*.
[20] McKinsey & Co., (2012), "Opportunities for Canadian Energy Technologies in Global Markets," [PowerPoint Slides], Study Commissioned by Natural Resources Canada.
[21] Don Pittis, (2014, Dec. 9), "Stock Market Trouble has Silver Lining for Banks," *CBC News*.
[22] Canadian Venture Capital Association, (2015), "2015 Canadian Venture Capital Market Overview," [PowerPoint Slides].
[23] Analytica Advisors, (2016), *Synopsis*.
[24] Global Affairs Canada, (2016), *Canada's State of Trade: Trade and Investment Update 2015*.
[25] Global Affairs Canada, (2013), *Canada-China Economic Complementarities Study*. ISED defines an SME as a firm with between 5 to 499 employees.
[26] *Ibid*.

Clean technology firms (and SMEs in general) often identify a shortage of skills or talent. Companies identify "staff who could bridge the gap between environmental expertise and business savvy" as in persistently high demand,[27] and there are skills shortages in the area of sales, marketing and business development.[28]

With its diverse, highly-educated workforce, Canada is fundamentally well situated in terms of its innovative human capital. The country has a strong talent base in science, technology, engineering and mathematics (STEM), although recent trends show a decrease in the number of STEM students.[29] As well, in general, researchers note that Canada has a weaker entrepreneurial culture, and often high-skilled labourers are drawn to the U.S job market. Despite this, Canadian clean technology jobs are growing, most recently in 2014 at a rate of 11.4% (nearly four times the rate of the Canadian economy during the same period).[30]

1.2.3 ADOPTION

Many of the challenges to the development, commercialization and adoption of clean technologies point to the lack of a clear policy or regulatory environment. The development of clean technology products and services requires clear and consistent long-term market signals, regulations, and policies to drive change in the cost structure and to codify public support for low-carbon products and services.[31]

Regulations and policies can guide the behaviour of supply-side innovators and entrepreneurs and can also influence demand-side activity by instilling confidence in investors and guiding the decisions of consumers. Michael Porter hypothesizes that environmental regulations and policies can spur innovation by pointing firms towards technological improvements and resource efficiency gains.[32] Finding the right balance, however, is important, as stringent or overly restrictive regulations may create undue burdens on firms looking to adopt new technologies.

A lack of demand for clean technology products and services results in fewer being pulled through to markets. In a 2014 survey of advanced technology adoption, Statistics Canada reported that advanced green technologies (as defined in the survey) were the least adopted by Canadian businesses (9% vs. 29.2% - 43.3% for other advanced technologies).[33] Stakeholders, in particularly SMEs, identify the need for better technology adoption if Canada is to reap the benefits of R&D investments. Researchers note that lack of domestic support, particularly through government procurement and technology adoption by capital-intensive Canadian firms,[34] challenges a firm's ability to demonstrate its technologies. This hinders export growth, as international customers expect domestic references before making procurement decisions.[35] With the tenth largest GDP in the world, Canada has numerous opportunities to take-up more clean technologies domestically.

Government procurement policies for pre-commercial or early commercial technologies at the federal, provincial and municipal levels are referenced in numerous reports as critical in facilitating the government's role as first adopter of clean technologies. Furthermore, these policies were identified as a means to de-risk innovation, and improve access to global markets.[36]

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[27] ECO Canada, (2012), *The Green Jobs Map: Tracking Employment through Canada's Green Economy,* p. 9.
[28] Delphi Group, (2016), *GLOBE Canada Clean Tech Innovation Workshop Report*, p. 11; Analytica Advisors, (2015), *2015 Canadian Clean Technology Industry Report,* Ottawa, ON, p. 67.
[29] *Ibid.*
[30] Analytica Advisors, (2016), *Synopsis*.
[31] Natural Resources Canada, (2014), *Energy Innovation Roundtables Report*, p. 11.
[32] Environment and Climate Change Canada, (n.d.), *Environmental Policy and Innovation*, p. 6.
[33] Statistics Canada, (2015), "Survey of Advanced Technology, 2014,"*The Daily*. The largest adopter of green technologies was found to be the utilities sector (25% adoption rate), followed by mining, oil and gas (16.1%), manufacturing (15.2%), and transportation and warehousing (14.8%). The most widely adopted green technologies were those related to waste management (including recycling, waste-to-energy, waste-reduction technologies, and hazardous and solid waste management). These types of green waste technologies were adopted by 5.6% of respondents.
[34] Natural Resources Canada, (2014), *Energy Innovation*, p. 9-12.
[35] National Roundtable on the Environment and the Economy, (2012), *Framing the Future: Embracing the Low-Carbon Economy,* Climate Prosperity Report No. 06, p. 72; Global Affairs Canada, (2013), *Canada-China*.
[36] Natural Resources Canada, (2014), *Energy Innovation*, p. 9-12.

1.3 NORTHERN AND INDIGENOUS COMMUNITIES

The Canadian north is both vast in size and small in population, and is experiencing some of the most rapid and intense climate changes on the planet. Average annual temperatures in many northern communities have already increased by two to three degrees Celsius over the last fifty years. This is above the targeted global average committed to at the Conference of the Parties 2015 (COP 21) in Paris.

In Canada, there are approximately 200,000 people in 257 communities that depend on diesel generators for their electricity.[37] Canada's northern and remote communities continue to rely largely on diesel as a source of energy to meet their electricity, heating and transportation needs. This reliance creates local environmental challenges due to high emissions of criteria air contaminants. It also is expensive, given the need to transport fuel to remote communities by way of ice roads, ferry, or air. Simultaneously, the melting permafrost and changing ice conditions are affecting infrastructure foundations and making transportation systems less reliable. In the face of these rapid changes, northern and Indigenous communities are often further challenged to meet their housing needs and face additional limits to their capacity for economic growth and development.

The small market size of northern communities also means that it is less economically viable to develop technology suited to sub-Arctic and Arctic conditions, and has discouraged local businesses from servicing new technologies. This is particularly true in remote communities, where capacity and human resource challenges are common. All this means there are even higher costs for constructing, operating and maintaining northern energy projects.

The adoption of clean technologies, particularly in the north, has the potential to improve environmental, economic and social outcomes for Indigenous Peoples. This could be done (and is being done) through deploying renewable energy technologies, particularly solar, tidal, run of river hydro, wind, biomass and geothermal, to replace diesel fuel use. This could increase grid capacities, enabling housing stock to be expanded, improving the quality of life and facilitating economic growth. To do this, it will be important that the people who live in northern and Indigenous communities are able to be job ready and educated to take advantage of the related and potential job opportunities created by innovation and the growth of clean technology activities.

[37] MaRS Advanced Energy Centre, (2015), *Enabling a Clean Energy Future for Canada's Remote Communities*, p. 1.

CHAPTER 2

WHERE ARE WE NOW: NATIONALLY, AND IN EACH PROVINCE AND TERRITORY?

2.1 NATIONAL CLEAN TECHNOLOGY ECONOMIC PERSPECTIVES

Available data on the scope and scale of clean technology economic activity is limited. It is important to note that available sources define and measure clean technologies, products and services differently. These disparate approaches reflect the fact that there is no single, standardized North American industry classification for clean technology. Statistics related to clean technology vary by source and differences exist in how clean technology itself is defined. More work will be needed to validate baseline numbers.

Analytica Advisors

Analytica surveys companies that self-identify as "clean technology companies", and its sample consists of pure-play companies (i.e., exclusively clean technology), renewable energy producers, energy efficiency applications (e.g., manufacturing processes, buildings, transport, etc.), and waste, remediation, and recycling applications. According to the synopsis of the latest report[38] (2014 data):

CLEAN TECHNOLOGY FIRMS, 2014
(Analytica Advisors)

775 companies

55,600 employees

$11.6 B revenues

$6.6 B exports

$1.2 B R&D

- *Clean technology is growing*: Over 775 companies directly employ 55,600 people. From 2012 to 2014, the compound annual growth rate (CAGR) of employment among these sampled firms grew by 3%. Revenue was estimated to be $11.6 billion (B) in 2014, down from $11.7 B in 2013. Analytica attributes this to a lack of capital and weak global markets (although methodological differences between the survey years may also be a factor).

- *Clean technology companies are export-focused:* Export revenues for Canada's clean technology companies in 2014 were approximately $6.6 B (57% of total revenues), with 87% of all companies exporting. 23% of all industry revenue came from non-U.S. markets. In 2013, surveyed companies reported $5.8 B in export revenues.[39]

- *Clean technology companies invest heavily in R&D:* The surveyed companies invested over $1.2 B in 2014, and have spent $7.6 B cumulatively from 2008 to 2014.

- *Clean technology is more than just clean energy*: Analytica's broad taxonomy covers an upstream sector which includes clean power generation; a downstream sector which includes smart grid, green building, transportation, and others; as well as water and agricultural sectors.

TSX (Toronto Stock Exchange)

The TSX recently began to track clean technology companies in Canada. As of March 2016, it tracked 110 companies with $18.3 B in gross revenues, and $4.3 B in capital expenditures. The TSX exchange and the TSX Venture exchange are home to more clean technology and renewable energy companies than any other exchange in the world (110 companies with a total market capitalization of $31 B).[40]

Statistics Canada, *Survey of Environmental Goods and Services*

Another measure of domestic clean technology is outlined in Statistics Canada's *Environment Industry Survey* (2004).[41] This survey collected data on environmental goods and services spanning the entire economy, and captured firms that do not typically self-identify as clean technology (or do not exclusively focus on clean technology but have a clean technology product or service line or business). According to this survey, in 2004, Canadian firms earned $18.5 B from the sale of environment goods and services, and export revenues reached $1.5 B, but represented a much smaller percentage of overall revenues (8.1%) compared to the Analytica sample.

[38] Analytica Advisors, (2016), *Synopsis*.
[39] Based on data from the Global Trade Atlas and Global Affairs Canada, the report estimated that total exports of all environmental goods and services totalled $12.5 B
[40] TMX Group Limited, (2016), "Clean Technology."
[41] Statistics Canada, (2007), *Environment Industry: Business Sector*, Environment Accounts and Statistics Division, Catalogue No. 16F0008XIE.

Despite the age of the data, the *Environment Industry Survey* reveals a level of economic activity that is much broader than captured by Analytica. Besides their differing methodological approaches, the two surveys also reveal inconsistencies in conceptualizing and defining clean technology. Whereas Analytica takes a more traditional, vertical view of clean technology (i.e. distinct sectors, grouped in vertical supply chains), Statistics Canada's view is more horizontal, with clean technologies and services being developed and adopted across all sectors of the economy.

2.2 A PAN-CANADIAN PERSPECTIVE

2.2.1 SIMILARITIES, DIFFERENCES AND UNIFYING THEMES

A central and early observation of the Working Group is that there are important characteristics, nuances, outright differences and opportunities when one considers the cross-Canada clean technology landscape.

Each province and territory has a unique mix of natural resource endowments, and the industrial mix and economic opportunities vary in each region of the country. The combination of emitting industries thus differs on a regional basis (as seen in Figure 3 below) and jurisdictions in all parts of the country have taken context-specific approaches to supporting the development of clean technology.

Key observations that can be drawn from this work are as follows:

- The Working Group identified a number of sectors as areas of opportunity, and these typically aligned with top GHG emitting sectors.
- 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.
- While the development of clean technologies is focused in a number of major hubs, opportunities for the adoption and deployment of clean technologies span the country.

FIGURE 3
LEADING CLEAN TECHNOLOGY ACTIVITIES ACROSS CANADA

2.2.2 KEY REGULATIONS AND PROGRAMS SUPPORT CLEAN TECHNOLOGY DEVELOPMENT

Strategies and initiatives provinces and territories are taking to address the challenge in clean technology development, commercialization, and adoption are summarized in Table 1.

TABLE 1

EXAMPLES OF KEY REGULATIONS AND PROGRAMS SUPPORTING CLEAN TECHNOLOGY			
Province	**Early-Stage Innovation**	**Commercialization**	**Adoption**
BC	• *#BCTECH Strategy* –including *BC Tech Fund* • *Innovative Clean Energy Fund* – in collaboration with SDTC, NRCan and the NRC • *BC Innovation Council's Industry and innovation Group* • Evok Innovations	• *BC Green Economy* – includes support for job growth innovation and environmental sustainability • *Export Services* – clean technology sector is a priority sector. Collaborates with the federal *Trade Commissioner Service* • *BC Renaissance Capital Fund* • *BC Innovative Clean Energy Fund*	• *BC Climate Leadership Plan* – will be released in 2016 • *Clean Energy Act* • *BC Carbon Tax* • *Carbon Neutral Government* program • *Energy Efficiency Program* • *Clean Energy Vehicle Program* • First Nations Clean Energy Business Fund
AB	• *Alberta Innovates – Bio Solutions' Bio Future* program • *Water Innovation Program* • *CCEMC Grand Challenge for CO_2 Utilization* • *Alberta Enterprise Corporation fund of funds including EnerTech Capital*	• *International Technology Partnerships* programs with Germany and France • *Climate Change and Emissions Management Corporation (CCEMC) and Alberta Innovates -Energy and Environment Solutions* focus on demonstration and scale-up • *Investor Tax Credit* for venture capital in clean technology	• *Climate Leadership Plan* • *Alberta Specified Gas Emitters Regulation*
YK	• Government support for academic research centres, particularly *Yukon Research Centre* and the Cold Climate Innovation project	• *Yukon Housing Corporation* – support for skills development and building of energy efficient construction • Commercial incentives for improving energy efficiency in commercial buildings	• Government is investigating possibility of providing biomass heat to government buildings • *Green Procurement Policy* • *Good Energy Rebate Program*
SK	• *Saskatchewan Petroleum Research Incentive* and *Enhanced Oil Recovery Royalty* • *Agriculture Development Fund*	• *Go-Green Fund*	• SaskPower commercial-scale CCS project

EXAMPLES OF KEY REGULATIONS AND PROGRAMS SUPPORTING CLEAN TECHNOLOGY			
Province	**Early-Stage Innovation**	**Commercialization**	**Adoption**
MB	• Assent Works • Vehicle Technology Centre • Red River College (Sustainable Building Infrastructure and Transportation Research)	• Commercializaton Support for Business Program • North Forge • Manitoba Technology Accelerator • Innovate Manitoba • TechFutures Program	• *Green Energy Equipment Tax Credit* • *Manitoba Hydro PowerSmart* programs • *GHG Emissions Tax* on coal and pet coke • *Biomass Incentive* • *Nutrient Management Tax Credit* • *Geothermal Energy Incentive Program* • *Biofuels Mandates*
NWT	N/A	• *Gas Tax Fund* used to finance clean technology projects • *Industry, Tourism and Investment's Support for Entrepreneurs and Economic Development*	• *Energy Action Plan* • *Biomass Strategy* • *Solar Strategy* • *GHG Strategy* • *Forest Industry Biomass Initiative* • *Alternative Energy Technologies Program* • *Large Vehicle Control Regulations*
ON	• *Best in Science* environmental research projects • Ontario Research Fund • Ontario Network of Entrepreneurs (including Ontario Centres of Excellence, MaRS, Regional Innovation Centres). • Green Investment Fund	• *Green Investment Fund* • *Ontario Development Fund* • Ontario Network of Entrepreneurs (including Ontario Centres of Excellence, MaRS, Regional Innovation Centres). • Water Technology Acceleration Project (WaterTAP) • Bloom Centre for Sustainability (Bloom) • GreenCentre Canada (GCC) • MaRS Advanced Energy Centre • Centre for Research and Innovation in the Bioeconomy (CRIBE) • Southern Ontario Water Consortium • Bioindustrial Innovation Canada (BIC) • Plus several risk capital and other financial supports (e.g. Investment Accelerator Fund, Northleaf Venture Catalyst Fund)	• *Green Energy Act* • *Western Climate Initiative* • *Climate Change Mitigation and Low Carbon Economy Act* • *Climate Change Action Plan* • *Partnerships for Growth Act* • *Feed-in Tariff (FIT)* • *Smart Grid Fund* • *Mandated Leadership in Energy and Environmental Design green building standards for government facilities* • *Cap and Trade Program (to start in 2016-17)* • *Green Bonds* • *Waste-Free Ontario Act* • *Green Focus on Innovation and Technology (GreenFIT)* • *Walkerton Clean Water Centre.* • *Green Investment Fund*

EXAMPLES OF KEY REGULATIONS AND PROGRAMS SUPPORTING CLEAN TECHNOLOGY			
Province	**Early-Stage Innovation**	**Commercialization**	**Adoption**
QC	• *Technoclimat* • *Créativité Québec* • *Passeport Innovation*	• *Ecoperformance* • *PSPDT (support for electric taxi demonstration projects)*	• Cap and Trade Program with California (and soon Ontario) • *Stratégie gouvernementale de développement durable 2015-2020* • *Plan d'action sur les changements climatiques 2013-2020* • *Politique énergétique* • *Plan d'action en électrification du transport* • *Politique de gestion des matières résiduelles* • *Programme de biométhanisation et compostage* • *Programme Prime-Vert* • *Biodiesel Tax Credit* • *Programme Écocamionnage* • *PETMAF (energy efficiency in air, train, boat transportation)* • *Créativité Québec* • *The Green municipal fund, and other programs help municipalities to adopt greener technologies and practices and more efficient public transports.*
NU	N/A	N/A	N/A
NB	• *NBIF's Research Innovation Fund* • *NB Innovation Foundation's Industry Innovation Voucher* • *NBIF's Research Innovation Fund*	• NBIF's VC Fund • Build Ventures Fund • NBIF Start-Up Fund	• *Energy Efficiency Program (incentive for heat pumps)* • NB Power's LORESS (Locally Owned Renewable Energy Small Scale) Program • GNB Technology Adoption Program for Industry • Environmental Trust Fund grants
PEI	• *Pilot and Discovery Fund* • *Ignition Fund* • *Innovation and Development Labour Rebate* • *Growing Forward 2* (Department of Agriculture and Forestry in collaboration with Agriculture and Agri-Food Canada)	• *Development and Commercialization Fund* • *Marketing Support Assistance*	• *Heat Pump Rebate* • *Equipment upgrade Rebate* • *Building Envelope Upgrade Rebate* • *Home Energy Low-income Program* • *Commercial Energy Audit Program* • Expanding use of biomass heating in public buildings

EXAMPLES OF KEY REGULATIONS AND PROGRAMS SUPPORTING CLEAN TECHNOLOGY			
Province	**Early-Stage Innovation**	**Commercialization**	**Adoption**
NS	• Innovacorp: Clean Technology Innovation Fund, Productivity and Innovation Vouchers, Early-stage Commercialization Fund (grant funding for innovation) • Offshore Energy Research Association Fund (grant funding for Tidal research) • Department of Energy Innovation Fund (grant funding for Electricity system innovation) • Department of Natural Resources Innovation Hub (grant funding for biorefinery development)	• Innovacorp: Clean Technology Investment Fund (equity investments in clean technology start-ups) • Nova Scotia Business Inc. (grant funding for export development; employee rebate program)	• Environmental Goals and Sustainable Prosperity Act • Nova Scotia Climate Change Action Plan: GHG caps on electricity system • Renewable Energy Regulations: legislated target for minimum renewable generation on electricity grid • Feed-in-tariffs for community-owned renewables and for Tidal Energy demonstration projects • Efficiency Nova Scotia: efficiency retrofits and incentives financed by rate payers / electricity rates
NL	• Research & Development Corporation NL (Programs Including: *LeverageR&D; CollaborativeR&D; EmployR&D*; R&D Vouchers; and R&D Proof of Concept)	• *Regional Development Fund* • *Business Investment Fund* • *Venture Newfoundland and Labrador* • *Build Ventures* • *Aquaculture Capital Equity Program* • *Aquaculture Working Capital Loan Guarantee Program*	• *Climate Change Action Plan* • *Energy Efficiency Action Plan* • *Greening Government Action Plan* • *Build Better Buildings policy* • *Growing our Renewable and Sustainable Forest Economy* • *Sustainable Aquaculture Strategy* • *Ocean Technology Strategy* • *Green Procurement Initiative* • *TakeCHARGE* – rebates to offset cost of energy efficiency products and services • *Biogas Electricity Generation Pilot Program* • *Renewable Energy Credits*

Early-Stage Innovation

One of the more common approaches to supporting clean technology development is the use of provincial/territorial Scientific Research & Experimental Development (SR&ED) programs to provide tax credits on eligible R&D expenses. These programs operate in tandem with the federal SR&ED program and offer stacked support. These SR&ED programs typically give an additional 4.5% - 30% tax credit on eligible expenditures. Quebec and Alberta administer their SR&ED programs independently.

Unlike the SR&ED programs, direct programming in support of clean technology R&D is less coordinated. Most provinces and territories have broad innovation bodies that support R&D in many areas, including clean technology – Alberta Innovates and the Climate Change and Emissions Management Fund, Ontario Research Fund, the New Brunswick Innovation Foundation (NBIF), Innovacorp Nova Scotia First Fund, the Newfoundland and Labrador R&D Corporation, BC Innovation Council Industry and Innovation Group, and the Yukon Research Centre are all good examples here.

The federal government has direct programs across multiple departments, some of which specifically target clean technology and some with a broader mandate for R&D support. Examples are: the Forestry Innovation Program and ecoENERGY Innovation Initiative at Natural Resources Canada; the Clean Marine and Clean Rail programs at Transport Canada; and the Discovery and Innovation Grants through the National Sciences and Engineering Research Council. The federal government also operates a number of labs including CanmetENERGY at NRCan and several at the National Research Council and Environment and Climate Change Canada.

As well, some of the provinces and territories have targeted programs, including those focused on climate and clean technology issues such as Alberta's Climate Change and Emissions Management Corporation (CCEMC), Saskatchewan's Petroleum Research Initiative, New Brunswick's Locally Owned Renewable Energy Small Scale (LORESS) Program, Quebec's Fonds vert (Green fund) and Technoclimat program, Nova Scotia's Fundy Ocean Research Centre for Energy (FORCE) to harness tidal energy, the Northwest Territories' Geological Survey, and the Ontario Green Investment Fund.

Commercialization/Commercial Capacity

The bulk of initiatives supporting commercialization are direct programs. Similar to development activities, most provinces and territories offer broad business support/funds and these programs are often under the same roof as innovation and R&D supports. Good examples of broad commercialization programs include Innovation PEI, BC Innovation Council's Venture Acceleration Program, the Ontario Network of Entrepreneurs (ONE), Créativité Quebec, New Brunswick's Innovation Voucher Fund, Nova Scotia's Innovacorp, and Newfoundland/ Labrador's Regional Development Fund.

Federal programs tend to focus largely on demonstration (Agriculture and Agri-food Canada's Agriculture Adaptation Program, Natural Resource Canada's ecoENERGY Innovation Initiative) and pre-commercialization (Sustainable Development Technology Canada's (SDTC) Sustainable Development Tech Fund, Transport Canada's ecoTECHNOLOGY for Vehicles program). NRCan's Investments in Forest Industry Transformation supports commercialization.

Some provinces and territories have developed or supported venture capital funds for clean technologies in their provinces and territories. For example, ArcTern Ventures works in partnership with the MaRS Discovery District in Toronto to provide early-stage capital to companies developing next generation clean technology breakthroughs. In 2011 Nova Scotia put $24 M into a Clean Technology Fund, under Innovacorp management, to make equity investments in Nova Scotia-based early-stage clean technology companies. The Maritime Provinces collaborated in the creation of the Atlantic regional Venture Capital fund in 2013, creating a $65 M fund managed by Build Ventures and focused on early-stage technology firms including clean technology. Newfoundland and Labrador joined the fund recently with a $10m contribution, and also invested $10 M in Venture Newfoundland and Labrador.

Federally, the Business Development Bank of Canada's mandate for Venture Capital Action Plan includes clean technologies, and it aims to improve access to financing in high growth sectors. Additionally, both Global Affairs Canada's CanExport program and Export Development Canada (EDC) provide financial services that support commercialization and international market penetration. The EDC Cleantech Underwriting Framework specifically addresses the risk parameters of clean technology companies, allowing EDC to facilitate access to risk capital for clean technologies.
Larger clean technology initiatives (i.e., transportation and infrastructure) have dedicated funds in various provinces and territories. Ontario raised $750 M in January 2016 by issuing Green Bonds to fund transit and other infrastructure projects in the province. In the same manner, Quebec dedicates the major part of its Green Fund to public transit improvements and infrastructure (Quebec's Green Fund is financed mainly by the revenues of the carbon market).

Manitoba and Ontario referenced coordination among various commercialization supports as a pathway to ensure that entrepreneurs and SMEs take advantage of all the programs available. For example, Manitoba introduced the North Forge concierge-type service which streams together complementary services for entrepreneurs. In Quebec, Entreprise Québec is a front line service by which all SMEs can receive information about all the governmental programs and services available

to them. Ontario has several networks in place (e.g., the Ontario Network of Entrepreneurs, WaterTAP, etc.) and has listed development of a similar concierge program as a short-term priority.

Indirect support for commercialization includes the recently announced Alberta Investor Tax Credit (AITC). The AITC will offer a 30% tax credit over two years to investors that provide venture capital to Alberta companies active in clean technologies, among other sectors. New Brunswick recently made its Small Business Investor Tax Credit (SBITC) the most generous in the country with a 50% credit to investors in innovative start-ups, and plans to tighten the focus to strategic industries like clean technology in the near future.

Some jurisdictions also are attempting to update procurement processes and leverage the governments' purchasing power to support innovation. Ontario's GreenFIT strategy is designed to allow the government to create opportunities for new green technology companies. The strategy enables the government to act as a reference customer, validating technologies and helping companies bring innovative and sustainable technologies to market. It also helps the government to adopt alternative technologies and solutions.

Adoption

The federal government has typically taken a sector-by-sector approach to limiting GHGs. For example, Canada's vehicle emissions regulations, renewable fuel standards, information and benchmarking tools for buildings, efficiency labelling programs (e.g., ENERGY STAR), and coal-fired electricity generation regulations that are aligned with U.S. standards.[42] Provinces and territories have set standards as well, such as in Nova Scotia where 2009 regulations imposed a diminishing cap on GHG emissions from the electricity sector (55% below 2010 levels by 2030) and in Alberta where large emitters are regulated under the *Specified Gas Emitters Regulation*.[43]

Several provinces and territories have moved beyond sector-by-sector GHG regulations and have implemented, or plan to implement, carbon prices or cap-and-trade systems. British Columbia's revenue-neutral carbon tax has been in place since 2008, along with its supporting legislative framework – *Clean Energy Act* and *Carbon Tax Act*. Alberta, in 2017 will introduce a carbon levy and rebate system for transportation and heating fuels which will complement existing measures related to large emitters. Quebec joined California in 2013 in the creation of what is now the main cap-and-trade system in North America (under the *Western Climate Initiative* guidelines for the linking of jurisdictional cap-and-trade regulations into one North-American carbon market), and Ontario plans to join this initiative in 2016. Revenues from carbon pricing mechanisms or auctioned allocation credits can be used to support the development of clean technologies.[44] However, it should be noted that there are sometimes legal implications which may restrict how this revenue can be invested.

Other environmental regulations, including water quality/protection, soil quality, waste, and other airborne emissions are set by various levels of government (municipal, provincial, federal) and can help drive the development and adoption of clean technologies. For example, Ontario introduced the *Water Opportunities Act* in 2010, and through that *Act* established the Water Technology Acceleration Project (WaterTAP). This has helped the province secure its position as a North American leader in water technologies, driving innovation, expanding exports, and creating a competitive Ontario advantage in clean water technology. Similarly, Ontario's *Green Energy Act* and its Feed-In-Tariff program have been pivotal to the growth of renewable manufacturing and energy generation in the province.

[42] Environment and Climate Change Canada, (2014), "Canada Continues to Align Greenhouse Gas Emissions Measures with the United States," News Release.
[43] Emitters of 100,000 tonnes of GHGs per year are required to reduce emissions intensity by 15% (20% after Jan. 1, 2017).
[44] See Canada's Ecofiscal Commission's 2016 report, *Choose Wisely,* for options regarding carbon revenue recycling.

Environment for Success

Within the provinces and territories, work is underway to build collaboration among organizations such as governments, Indigenous groups, think tanks, or non-governmental organizations. Several similarities to their approaches are:

- Most jurisdictions typically consult widely while constructing climate change strategies and regulations (e.g., Declaration of the Premiers at the Sommet de Quebec, 2015), including with private sector organizations and Indigenous communities.

- Provincial programs typically collaborate with the private sector and/or academia to create expert consortia to support the development of specific technology programs.

- Provinces and territories have been successful in leveraging private sector financing for clean technology development and commercialization (see examples pointed to above: British Columbia's Evok, Alberta's CCEMC, the NRG CCEMC/COSIA Carbon XPrize, and Ontario's MaRS Discovery District).

- There are examples of programmatic collaboration between provinces such as the recently announced research initiative MOU between Ontario's Centres of Excellence and Alberta's CCEMC.

- Canada is home to several research institutes that bring together academia, government, and the private sector to create new clean technology solutions for Canada and the world (e.g., the Wind Energy Institute of Canada in Prince Edward Island, the Wood Innovation Design Centre in British Columbia and the Prairie Agricultural Machinery Institute and the Mitsubishi-Hitachi-SaskPower Carbon Capture Test Facility in Saskatchewan, to name a few).

Collaboration is also enhanced within international forums such as the Climate Group States and Regions Alliance, the Climate Summit of the Americas conference hosted by Ontario this past July, the Global Climate Leadership "Under 2 MOU". The federal government's participation in Mission Innovation with 19 other countries should increase investment and enhance collaboration to accelerate clean energy innovation.

Program funding is often shared between the Granting Councils (Natural Sciences and Engineering Research Council (NSERC), Social Sciences and Humanities Research Council, and Canadian Institutes for Health Research), the Regional Development Agencies (RDAs) and provincial economic ministries. For example, Newfoundland and Labrador noted collaboration between the Granting Councils and local post-secondary institutions for funding; Alberta listed cooperation between National Research Council's Industrial Research Assistance Program and Alberta Innovates; Nova Scotia noted collaboration between Innovacorp and Atlantic Canada Opportunities Agency (ACOA); and Yukon noted collaboration between the Cold Climate Innovation Research Centre, CanNor and NSERC.

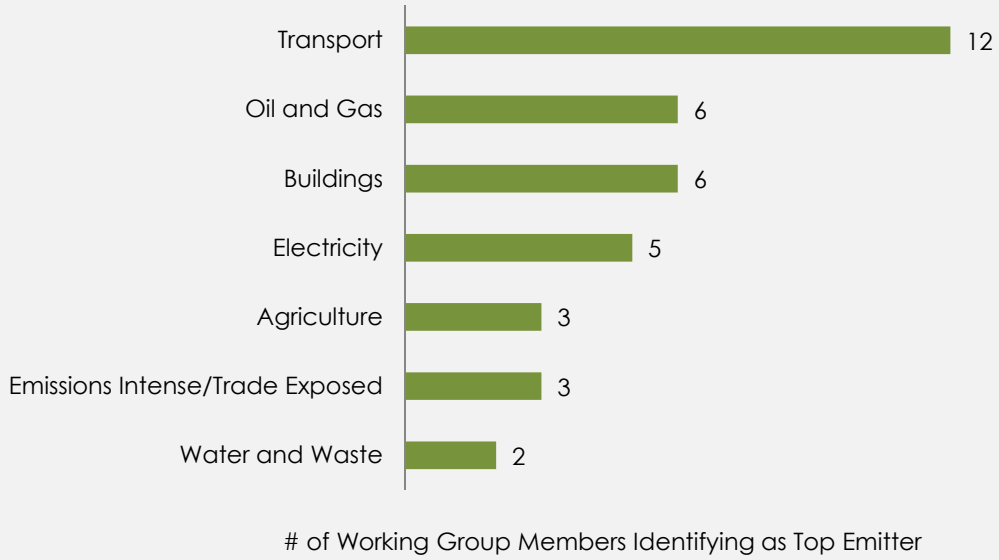
Of the many clean technology commitments made in Budget 2016, two examples aimed directly at collaboration are: a doubling of annual RDA support for clean technology activities to $100 M per year and $2.24 B over five years to Indigenous communities to support green infrastructure, wastewater and waste management. The Working Group noted some challenges in accessing federal funds, namely off-reserve Indigenous communities do not qualify for funds earmarked for on-reserve communities. Additionally, SMEs (particularly from smaller provinces and territories) have a much harder time applying for and receiving federal funds due to business scale (i.e., programs are geared towards a particular size of business) or reporting requirements.

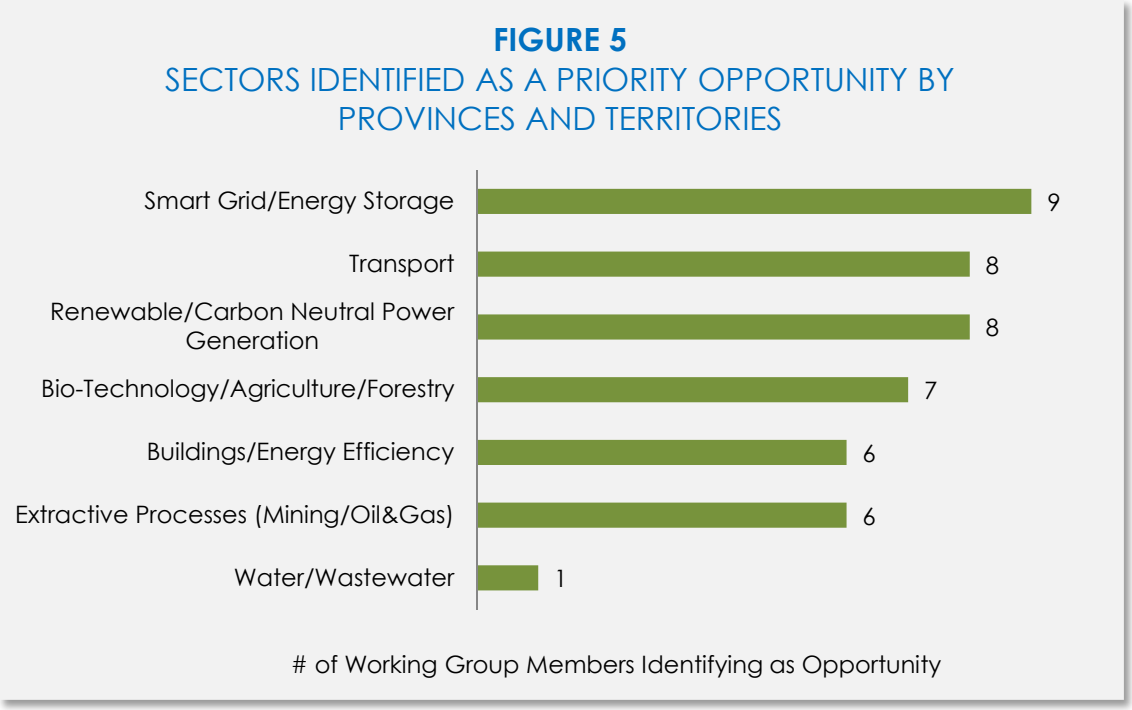
2.2.3 IDENTIFIED SECTORS OF OPPORTUNITY AND AREAS OF STRENGTH

Clean technology activities are often a reflection of the natural resources and economic endowments found in a given 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. Figure 4 (below) tallies the top emitting sectors in each province and territory to highlight the relative influence of each sector. The Working Group identified the following sectors as important for clean technology development (see Figure 5):

FIGURE 4

COMMON HIGH-EMISSIONS SECTORS ACROSS PROVINCES AND TERRITORIES





Transportation

Most Working Group members identified transportation as a priority for clean technology deployment. Canada's vast geography makes transportation an important opportunity for clean technology, as well as a large source of emissions. Of Canada's total emissions in 2014, transportation produced 23%.[45] Working Group members that identified transportation as a key clean technology sector include Yukon, Quebec, Manitoba, British Columbia, Northwest Territories, Prince Edward Island, Nova Scotia and Ontario. In Canada, transportation-related clean technology firms invested $195 M in R&D 2014.[46]

- *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 fueling infrastructure; and Ballard Power Systems develops hydrogen fuel cells.

- *Quebec*: EcoTuned Technologies electrifies old government fleet vehicles; and TM4 Electrodynamic Systems develop electric powertrain solutions. A Quebec Electric Bus Consortium also groups NovaBus, Bathieum Canada, TM4, Giro, René Matériaux Composites and Précicad.

- *Ontario*: Magna International develops lightweight technologies and auto parts. Hydrogenics develops fuel cells.

Extractive (Mining and Oil and Gas)

Working Group members that identified extractive industries as a key clean technology sector include Alberta, Saskatchewan, Northwest Territories, Ontario, Yukon, and Newfoundland and Labrador. Analytica Advisors (2014) estimates

[45] Environment and Climate Change Canada, (2016), *National Inventory Report* p. 23.
[46] Analytica Advisors, (2016), *Canadian Clean Technology*.

that revenues in the clean technology extractive sector were $309 M in 2014. Purely clean technology companies in this sector employed 1,400 people and made $122 M in R&D investments in 2014.[47]

- *Alberta*: Shell Canada's Quest Carbon Capture and Storage Project captures emissions from the oil sands with a total projected 10 year investment valued at $1.35 B ($865 M from Alberta and federal governments and $485 M 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 vs. convention steam-based processes.

- *Saskatchewan*: Cenovus (light oil) and Husky (heavy oil) are leaders in enhanced oil recovery methodologies that sequester captured CO_2.

- *Newfoundland and Labrador:* Oil Filtration Solutions Inc. provides a micron oil bypass filtration system that reduces the amount of wastewater in oil extraction.

- *Yukon*: GroundTruth Exploration, a mining exploration company that developed a low-impact and 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

Working Group members that identified green building as a key clean technology sector include British Columbia, Manitoba, Quebec, Nova Scotia, New Brunswick, and Ontario. Analytica Advisors (2016) estimates that revenues in the clean technology green building and energy efficiency sector were $1.51 B in 2013. Green buildings firms employed 7,200 people and invested $98 M in R&D 2014.[48]

- *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 is providing 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. Atis Technologies is an engineering firm specializing in energy management and efficiency in industrial food processing sector.

- *Nova Scotia*: CarbonCure retrofits concrete plants with technology that recycles waste carbon dioxide to make affordable, greener and more durable concrete products.

- *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.

[47] *Ibid.*
[48] *Ibid.*

Bio-Technology/Agriculture/Forestry

Working Group members that identified these sectors as a key clean technology sectors include Saskatchewan, Prince Edward Island, Alberta, Quebec, New Brunswick, Nova Scotia, and Manitoba. Analytica Advisors (2016) estimates revenues in the clean technology agricultural sector were $62 M in 2014, along with 700 jobs and $24 M invested in R&D.[49] Biorefinery products generated $343 M in 2014, along with 1,600 jobs and a $146 M R&D investment.[50]

- *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 260M litres of ethanol per year from 700 thousand tonnes of non-food quality grains.
- *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:* Larvatria offers the livestock food industry a renewable and competitive alternative to fishmeal and oil supplements.
- *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.

Renewable/Carbon-Neutral Power Generation

Finding greener ways to produce power was highlighted by most Working Group members as an important sector for clean technologies. This includes 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 their choices on how best to decarbonize their electricity grids. Analytica Advisors (2016) estimates revenues in the clean technology power generation sector to be $3.8 B in 2014, coupled with 13,200 jobs, and $183 M in R&D investments.[51]

- *Prince Edward Island*: The Wind Energy Institute of Canada provides facilities and supports for wind RD&D.
- *Newfoundland and Labrador*: Grey Island Energy developed ocean wave power generation system called "SeaWEED."
- *British Columbia*: General Fusion Inc. develops magnetized target fusion; and Endurance Wind Power manufactures and distributes wind turbines.
- *Northwest Territories*: The Northwest Territories Power Corporation (NTPC) 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 Center 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 22MW of tidal energy to 2020.

[49] *Ibid.*
[50] *Ibid.*
[51] *Ibid.*

- *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 have identified small modular reactors (SMRs) for electrical generation and other applications as an opportunity.

- *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.

Smart Grid/Energy Storage

Nine provinces and territories identified energy efficiency and smart grid technology as important for clean technology development. Energy efficiency improvements present cost-cutting opportunities and help to reduce energy use. Analytica Analytica Advisors (2016) estimates that the infrastructure and smart grid sector generated $698 M in revenues in 2014 while employing 3,300 people. R&D investment in the sector was $122 M.[52]

- *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. Neurio 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.

Water/ Wastewater

There are more issues and pressures on global water resources that 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%.[53]

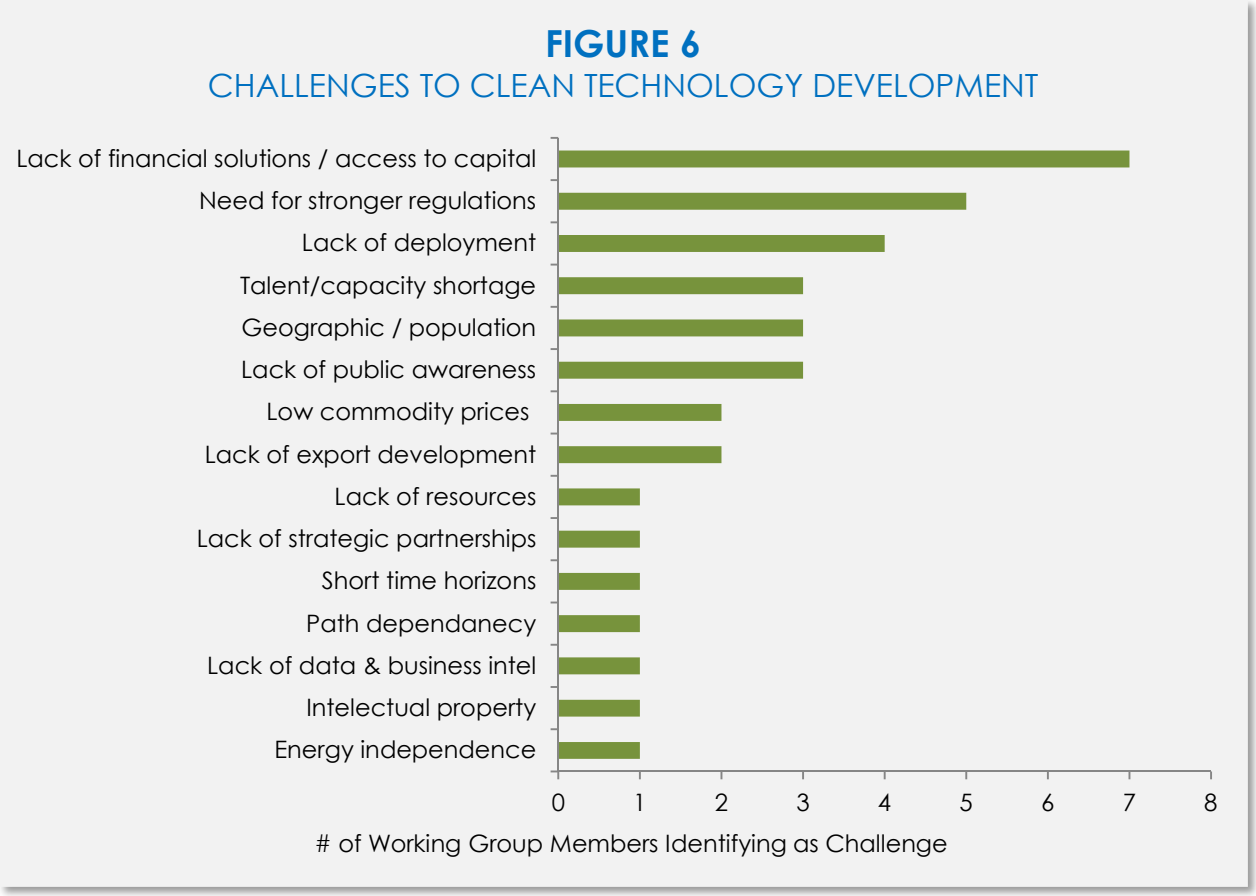
These growing needs have seeded a global market for water technology that is expected to grow to over $1 trillion by 2020. Canadian water companies should be poised to provide the innovative solutions to these problems.

- *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 being employed to help California to improve and optimize their water and wastewater systems for future drought events.

[52] *Ibid.*
[53] USA Today, (2013), "U.N. Chief Warns of Growing Water Scarcity."

2.2.4 CHALLENGES TO CLEAN TECHNOLOGY DEVELOPMENT

Figure 6 below lists the most commonly identified challenges to regional clean technology development by provinces and territories



Finance

The most cited barrier to developing clean technologies was access to capital. British Columbia, Quebec and Manitoba see capital challenges at all levels of the innovation ecosystem: R&D, commercialization, sales, and business development. Ontario expressed a specific concern with overcoming the commercialization valley of death.

In the Ontario context, many clean technology companies face difficulty securing financing at critical stages of technology and business development which makes it difficult to address the high cost associated with demonstrating and commercialization near-market technologies.

Alberta and Prince Edward Island identified the early and risky nature of clean technology companies as a characteristic that inhibits access to debt financing from investors (angels, venture capital and financial institutions). National Indigenous Organization representatives identified access to financing and innovative community ownership models as important enables to adopting clean technologies.

Regulations
Working Group members commonly identified regulatory challenges as an impediment to clean technology development. A number of themes emerged, including:

- Collaborative policy approaches
- Regulatory burden
- Long-term regulatory certainty

The prairie provinces (Alberta, Saskatchewan and Manitoba) suggested now is an opportunity for the provinces to collaborate with the federal government to establish a policy environment that makes clean technologies more cost competitive and set standards for a new low-carbon economy. Saskatchewan pointed to the success of federal regulations regarding coal-fired emissions in directing SaskPower to become a leader in carbon capture and storage.

Ontario, Prince Edward Island, Quebec and Alberta highlighted the regulatory burden faced by companies that operate with emerging technologies. These include environmental approvals and certifications. Ontario has taken steps to minimize this regulatory burden with the Innovative Technology Verification Permission (ITVP) program. Through ITVP, the Ministry of Environment and Climate Change supports clean technology innovation leaders by fast-tracking permissions for implementation. This will also create a pathway to allow consistent incorporation of existing and future technology verifications into the decision-making process.

Ontario also pointed to concern from stakeholders about regulatory certainty as far as future carbon and electricity prices and the details of the cap-and-trade system (e.g., number of free allowances) are concerned.

Adoption (including Procurement)
Several Working Members identified adoption as a challenge, including:

- British Columbia noted the lack of adoption by local markets makes it difficult to demonstrate clean technologies for larger international applications.
- Ontario and Prince Edward Island suggested existing government procurement policies are geared towards low-cost sourcing and should be reoriented to emphasize the uptake of clean technologies. This will assist with the uptake of cleaner technologies as well as locally-sourced products.
- Alberta pointed to low commodity prices and path dependency on the part of firms as a barrier to the expansion of the biofuel market in Canada. For example, Canada ships more than a M metric tonnes of wood pellets per year to the EU because there is little interest for them in Canada.

Public Awareness
The lack of adoption is potentially related to a lack of information about clean technologies in the Canadian economy. In reference to the previous example, Alberta noted that domestic demand for Canadian wood pellets is beginning to grow as businesses recognize the importance of the triple-bottom line (financial, social and environmental) to their consumers.

Quebec, Manitoba, British Columbia and Ontario all pointed to a general lack of awareness (businesses, governments and citizens) about the urgency to act on the climate change problem and the benefits of improving our environmental performance. This includes a lack of information concerning clean technology opportunities for businesses and consumers and, related to this, a lack of urgency to adopt clean technologies.

Demographic and Geographic Challenges

The Northwest Territories and Newfoundland and Labrador face geographic challenges due to their northern location and/or low level of population density. These circumstances can limit opportunities for business and technology development. For example, the long distances between communities in Northwest Territories make the electrification of those communities through an electrical grid cost prohibitive. For this reason, many Northwest Territories communities rely on diesel fuel and heating oil.

Newfoundland and Labrador expressed a similar challenge with respect to its diesel-powered communities. In addition to energy security, National Indigenous Organization representatives identified challenges related to food security. Innovative clean technologies could provide solutions for independent, localized access and production of food and services.

Newfoundland and Labrador also pointed to its ageing population as a challenge for business innovation. Prince Edward Island's small population and small geography also limits opportunities for business and technology development.

Talent

Some regions are challenged by the limited talent pool in some areas, particularly with respect to sales and export development and experience with scaling up small firms. Newfoundland and Labrador, Northwest Territories and British Columbia all pointed to this problem. The Northwest Territories also highlighted its lack of a university facility in the territory, along with low literacy levels, which leads to problems accessing training for clean technology-related skills.

Export Capacity

British Columbia, Alberta, Northwest Territories, Manitoba, Ontario, Quebec, and Prince Edward Island identified clean technology export development as an important challenge for Canadian clean technology companies. Many Canadian clean technology companies are SMEs and lack the resources required to: identify international market opportunities for their solutions; foster and develop international business relationships; and respond to the demands of customers across the globe. Working Group members specifically referred to the challenge of building the scale and capacity of Canadian clean technology firms with export-ready and near export-ready technologies to access and compete in international markets.

2.3 REMOTE/INDIGENOUS PERSPECTIVE

Working Group members highlighted opportunities for clean technology adoption also exist in remote and Indigenous communities. A number of success stories already exist:

- *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 their 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 $1M towards installing wind turbines to reduce reliance on diesel generation in communities of Burwash Landing and Destruction Bay.
- *Saskatchewan*: Saskatchewan Research Council has supported Cowasis First Nation to develop a wind turbine-battery storage demonstration project. SaskPower power purchase agreements with Meadow Lake Tribal Council for biomass power. Negotiations are also underway for the purchase of additional solar power generation.
- *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 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 provided 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 Mawiomi (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.

These examples demonstrate that clean technology opportunities in many remote and Indigenous communities revolve around electrification using renewable energy technologies, to reduce the dependence on diesel fuel power generation. In 2015, a Pan-Canadian Task Force on Reducing Diesel Use in Off-Grid Communities was established and includes partners in six provinces and territories. This Task Force is linked to the Canadian Energy Strategy.

CHAPTER 3

WHERE DO WE WANT TO GO?

3.1 INTRODUCTION

As per the Vancouver Declaration, Canada is to become an economic and environmental leader in the global clean growth economy. This will involve:

- Greater development, commercialization and adoption of clean technologies by Canadian industry, consumers and communities from coast to coast to coast. By examining demonstrated best practices at home and internationally, Canada can learn important lessons.

- Significantly expanding Canadian clean technology product and service revenues, exports and jobs, in all sectors of the economy, building on regional and industry strengths. This will include the development of new disruptive technologies that will be required to meet global climate change targets in 2030 and beyond.

3.2 DISRUPTIVE CLEAN TECHNOLOGIES

For continued success in a dynamic and rapidly changing clean growth economy, Canadian business leaders, policymakers and stakeholders will need to look ahead at future clean technology trends and possibilities, continually innovate and bring new ideas, goods, services and processes to market.

Collaborative international efforts are now underway to develop new disruptive clean technologies. In 2015, leaders from 20 countries, including Canada, launched Mission Innovation with the goal to double their governments' research and development in transformational clean energy technology over five years. Similarly, the Breakthrough Energy Coalition has 28 investors from 10 countries committed to invest patient capital in early-stage technology development to support Mission Innovation efforts.

The Working Group noted of some of the international examples of longer term disruptive and transformative energy technologies, for example: solar chemical (creating hydrogen directly from sunlight); flow batteries and energy storage; solar paint; nuclear fission and fusion; free-air capture technology; high-voltage DC grid; carbon capture, sequestration and utilization; bio-technology; tidal and wave energy generation; and high-altitude wind power. Each of these technologies, if successfully developed and widely adopted, has the potential to dramatically affect regional or global environmental performance.

3.3 CURRENT STRATEGIES AND OBJECTIVES

The Working Group found that Canada's federal, provincial and territorial governments are setting new strategies and goals, creating opportunities to align and collaborate on efforts to develop clean technology solutions. Most jurisdictions have already taken steps to help position themselves to succeed in clean technology industries and the transition to a low carbon economy.

Drawing on Working Group member submissions regarding provincial and territorial policy objectives, a picture emerges as to how Canadian jurisdictions envision success in innovation and the development of clean technologies. Notably, many of these objectives align with the issues identified by researchers as areas of lagging performance for Canada, while also giving consideration to the regionally-specific geographic, demographic and economic circumstances highlighted in Chapter 2.

3.3.1 SHORT-TERM (TO 2030)

Research and Development (R&D)
Leading up to 2030, provinces and territories generally emphasize the need to bolster efforts to strengthen clean technology R&D. For some jurisdictions this involves addressing weak levels of investment and performance, while for others, it means maintaining current efforts and seeking new areas of competitive advantage.

Many jurisdictions highlighted R&D targeted towards finding solutions linked to regionally specific opportunities. This includes those that stem from natural resource endowments, or geographic and demographic circumstances. For example, Saskatchewan is focused on technologies for emissions free oil and gas production and Nova Scotia on demonstrating tidal energy extraction from the Bay of Fundy, while British Columbia, the Yukon, Manitoba, the Northwest Territories, Quebec and Newfoundland and Labrador focus on displacing diesel energy generation in rural, remote and Indigenous communities. Additionally, provinces and territories expressed interest in short-term efforts to facilitate the development of high-growth technologies and those that create a competitive advantage.

Financing/Commercialization
Addressing the challenge of accessing high risk capital was highlighted by Working Group members, and was linked to the need to build strong networks of angel/venture capital investors and accelerators. Support for late-stage commercialization of technologies in sub-sectors with high-growth potential, including through demonstration opportunities, was also highlighted.

Programs/Incentives
Most Working Group members emphasized the need for consistency and predictability for clean technology companies and investors when developing programs and incentives to support the adoption of Canadian clean technologies. Procurement, in particular, was identified as an area of government policy that could support clean technology demonstration and adoption.

Export Development
Several Working Group members noted the importance of integration into global supply chains and emerging markets. International market intelligence and matching services for Canadian clean technology products and services, as well as linking SMEs to multinational enterprises (MNE), were featured as important steps towards integration and scaling of Canadian clean technologies in international markets. Additionally, facilitating companies' ability to locate and use government export services was highlighted.

Promoting Awareness and Understanding (domestically and internationally)
Working Group members highlighted promoting awareness and understanding as important for clean technology development. There exists a domestic and an international angle in this regard. Domestically, there is a need for the Canadian public and domestic businesses and institutions to better understand the importance of clean technology development and adoption. This includes celebrating and promoting successful Canadian clean technology products, processes and services. Internationally, the promotion of Canadian clean technologies through trade missions, and by leveraging international government networks can also promote awareness and adoption of Canadian clean technology solutions.

Skills Issues
Several Working Group members cited skills and employment objectives linked to the transition to a low-carbon economy. These include retraining and mobilizing talent from sectors of the economy that face contraction, to sectors of the economy that could experience growth. They also include efforts to attract and develop a world class labour force. The

need for collaboration among industry, post-secondary institutions, training facilities, and across jurisdictions was emphasized.

The Working Group also determined that Canada has some unique clean technology skills initiatives already in place. The United Nations Association of Canada is hoping to help develop domestic talent for the low-carbon economy with Canada Green Corps. Canada Green Corps offers 150 six-month paid internships for un- or under-employed youth in Canada. The internships are with organizations that are, or want to be, incorporating some aspect of environmental sustainability in their operations. Apart from developing skills for the green economy, interns discuss the work of the Canada Green Corps and the importance of acting on climate change with local schools, faith groups, and community centers, and at public events. Interns are placed in one of eight cities – Vancouver, Calgary, Edmonton, Ottawa, Montreal, Toronto, Halifax, and Yellowknife. Similarly, ECO Canada runs the Environmental Youth Corps (EYC) Internship Program which gives employers in science, technology, engineering, or mathematics a 50% wage subsidy[54] for new full-time environmental jobs. The EYC is funded through Environment and Climate Change Canada's Science Horizons Program.[55]

3.3.2 LONG-TERM (TO 2050)

For the medium-to-long-term, Working Group members noted the need to develop clean technology clusters, centres of excellence, and federal government-led, mission-oriented R&D as important conditions for success to compete in clean technology markets. Working Group members see the need to establish dedicated clean technology commercialization supports, particularly incubators and accelerators to address the challenges in bringing Canadian clean technologies to market. Finally, the Working Group identified focused research on clean technology export market diversification, and identification of strategic international opportunities to adopt Canadian technologies for medium-to-long-term success.

GHG Programs and Targets

Most provinces and territories have adopted climate change targets or are in the process of developing comprehensive climate change plans. Typically, provinces and territories have specific targets for 2020, 2030 and 2050. Some provinces have more specific targets or limits on emissions on key sectors, such as Alberta's limit of 100MT on emissions from the oil sands and Nova Scotia declining caps on GHGs from electricity generation.

These targets are well aligned with the broader Canadian targets of a 17% reduction below 2005 levels by 2020 and 30% by 2030. These broad targets at the provincial/territorial and federal levels serve to provide the goals and framework within which policies and programs have been developed to meet short-term commitments, and will be developed to meet medium- and long-term commitments. High level and long-term goals signal to industry the types of policies to expect in the longer term and the broad types of innovation and technology that will be required to meet those commitments.

Energy Programs and Targets

The Working Group found that energy strategies have been developed in many provinces and territories. These tend to reflect individual provincial and territorial circumstances, such as their current energy generating mix and the specific challenges associated with their energy systems. Many Working Group members reported having set either renewable energy targets as a percentage of their generation capacity or as specific capacity targets.

Those reliant on coal fired-generation have either, like Ontario, phased out coal-fired electricity entirely, or are developing plans to phase it out or adopt carbon capture, storage and utilization, such as Alberta, Saskatchewan[56] and Nova Scotia. Many provinces and territories have programs or plans to help remote and Indigenous communities to reduce their reliance on diesel generation either through grid integration where possible or through the integration of renewable energy (micro

[54] Up to a maximum $15,000.
[55] ECO Canada, (2016), "EYC Internship Program."
[56] Saskatchewan has committed to improve its use of renewable energy from 25% to 50% by 2030 and believes it can achieve emissions free electrical generation by 2050 through a combination of small modular nuclear reactors and carbon capture and storage.

hydro, wind, solar) and energy storage. Some provinces have a form of energy efficiency goals typically targeted at residential consumers and programs and incentives to help achieve those goals. A few have smart grid targets and Ontario has a target of meeting 10% of its peak demand in 2020 from demand response.

Transportation, Procurement, Buildings

There is less alignment on goals and policies related to the transportation sector, buildings or government procurement. Although there are a few current policies, the targets or goals in these areas are not as well defined. For instance, provinces and territories may have goals related to reducing emission from the transportation sector or increasing the electrification of the sector.

British Columbia has a stated vision that 5% of light duty vehicles purchases in the province will be clean energy vehicles in 2020 and thereafter. Some provinces have identified green procurement initiatives or goals for improving the efficiency or renewable energy used in their government buildings. For example, Nova Scotia's strategy for buildings is focused on reducing the current high proportion (more than 50%) of buildings that use furnace oil for space heat and hot water. Quebec and Ontario already have some programs where they use procurement and public markets to encourage the use of green technologies and demonstration projects in their sustainable development and climate actions strategies.

Clean Technology Strategy

Most provinces and territories have aspirational goals for developing clean technology industries. This may be specific to certain provincial strengths or be broad based across the provincial/territorial economy. These goals often center on growing clean technology companies supporting the development of green jobs.

Some of these efforts range from increasing collaboration and understanding of clean technology across government departments, to multi-government initiatives such as Quebec and Ontario working together on economic development with an emphasis on clean technology. Additionally, Quebec and Alberta have stated the goal of becoming a waste-free society through improved waste management and, for example, by deriving value from waste streams for energy. Nova Scotia has staged goals for generating clean tidal electricity from the Bay of Fundy.

3.4 BEST PRACTICES

Other countries also promote clean growth and are developing and implementing new approaches to improve their environmental performance. The Working Group has identified several of these international best practices that may provide insights for possible new Canadian government initiatives. The practices outlined in the following section reflect the policy interventions of leading countries performing well among their peers in innovating, commercializing and adopting technology.

3.4.1 EARLY-STAGE CLEAN TECHNOLOGY INNOVATION

Many governments struggle with the issue on how to select projects for funding, and the type of funding mechanism to be employed. They often focus efforts on areas in which returns are greatest, or in which the private sector underinvests.

Mission-Oriented Approaches

Mission-oriented approaches, where technology pathways and projects are centrally selected, offer potentially large payoffs and have been successful in the past (e.g. the U.S. lunar landing effort in the 1960s). Mowery (2009) argues mission-oriented approaches are best when the way forward is relatively clear, as the presence of uncertainty in centralized decision making can stifle innovation.

Research indicates that mission-oriented RD&D funding programs are well suited for direct funding and allow for innovation programs to tackle specific challenges. Addressing specific challenges rather than broader issues tends to be more effective at advancing technologies along the innovation chain.
An example of a well-functioning mission-oriented system with direct funding is:

- *Germany:* Provides a modest amount of support to businesses primarily through direct incentives rather than though tax incentives. A great deal of support is directed to research institutions such as the Fraunhofer Society and the Helmholtz Association and others from both the federal and state level of government. These public research institutions perform basic and mission-oriented applied research, often under contract from industry. Green innovation remains a major German strength. The Framework Programme Research for Sustainable Development (FONA) (2010-15) focuses, in part, on climate, energy and sustainable resource management.

Centralized, Coordinated Approach

Another best practice identified through Working Group analysis is the value of a centralized approach for innovation systems, granting governments the ability to ensure programing is aligned between different funding agencies and performers and programs. A centralized system also lends itself to aligning innovation with broader policy objectives, and is usually reinforced with direct funding (as opposed to indirect which is more difficult to align to specific policy objectives).

Examples of well-functioning centralized systems include:

- *Finland:* The Finnish innovation system is highly centralized, via the Research and Innovation Council, chaired by the Prime Minister.[57] This allows for co-ordination of R&D and that funding agencies, programs and performers research aligned in their efforts. There are two primary agencies for funding development in Finland: the Academy of Finland that funds academic and research institutions[58] and Tekes, which funds business R&D.[59] Tekes has several programs that focus on clean innovation and sustainable growth, notably the green mining programs that strives to make Finland a global leader in sustainable mining by 2020.[60] Through this centralized model and by funding industry directly, Finland has been successful in advancing technology development in a number of areas including ICT (Nokia), green mining and forestry.

- *Norway*: The innovation system is highly coordinated through the Research Council of Norway (RCN) that also links to demonstration and commercialization entity Enova. This degree of coordinated R&D is unique in the international context. RCN's approach also includes a diverse range of government, academic and industry experts when developing research agendas that often span five to ten years. This time horizon is important as it provides the time and strategic direction for a research program to achieve results. Also important is the SkatteFUNN, a tax incentive that support business R&D; however it is granted on a project basis with added incentives for collaboration between R&D institutions and academia.[61]

Targeting Performance

The Working Group found examples of countries that targeted specific technologies. A risk associated with this approach. pre-determining technological paths may crowd out other, more sustainable and economically competitive options. At the same time, targeting performance (for innovation programs) has benefits from an environmental perspective, allowing policymakers to target the projects that will lead to the largest reductions in GHGs. This approach, however, tends to limit projects to those that are closest to market, risking leaving out newer, emerging technologies.[62]

[57] Government of Finland, (n.d.), "Research and Innovation Council," Ministry of Education and Culture.
[58] Academy of Finland, (2016), "About Us."
[59] Tekes, (n.d.), "Results and Impact."
[60] Tekes, (n.d.), "Tekes Programmes."
[61] The Research Council of Norway, (2015), *Report on Science & Technology Indicators for Norway,* Oslo, p. 37 & 64.
[62] OECD & The World Bank, (2014), *Making Innovation Policy Work: Learning from Experimentation,* OECD Publishing, p. 201.

- *Israel*: Clean technology and green innovation is one of Israel's key priority areas and they have set up several tailored programs. The NewTech Program focuses on clean water and clean energy innovation in order to address Israel's limited natural resources "by supporting academia and research, encouraging implementation in the local market, and by helping Israeli companies succeed in the international arena."[63]

Competitive Tenders and Collaboration

Opening R&D tenders to competition is another accepted best practice. Generally, well-crafted clean technology innovation supports should not favor incumbents, but encourage new entrants; should be flexible, embracing "trial and error"; and provide exit mechanisms for when a technology fails in the marketplace.[64]

Competitive Markets

Last, supporting clean technology innovation and R&D is about general competition policy, as much as supporting R&D: policy action should facilitate the entry, growth and exit of new firms; ensure fair competition (especially as key markets such as energy have high entry barriers); and encourage the growth of small, entrepreneurial firms by reducing or supporting costs, and reducing their administrative burden.[65]

3.4.2 COMMERCIALIZATION AND COMMERCIAL CAPACITY

Clean technology companies require a variety of financing mechanisms to grant them the capital they need to scale up and demonstrate their effectiveness and become market ready. Governments have a role to play by teaming up with central banks, institutional investors, and others to accelerate the participation of long-term finance in clean technology, or by directly investing themselves.[66]In encouraging private sector participation, governments can promote the development of innovative financial mechanisms by altering financial regulations.[67]

Examples of best practices include:

Leveraging Private Sector Financing

Promoting risk-sharing schemes with the private sector such as public-private partnerships is one such option. As an example, Murray (1999) finds that that the best option for raising early-stage venture capital funding is to provide mechanisms for public co-investment with private partners.[68] Other mechanisms include those that pool together clean technology assets such as Green Bonds.

Stable Funding & Exit Mechanism

Public financial instruments and programs should be designed with stable funding sources over a long time horizon; are tailored so they don't crowd out other sources of finance; are transparent; and, have off-ramps.[69] Creating a stable funding environment can take on several forms, from directly funding small businesses to creating incentives for private capital to flow to specific high risk investments.

Examples of successful funding and exit mechanisms include:

- *Australia*: The Clean Energy Finance Corporation (CEFC) serves as an important mechanism to finance clean energy companies and projects. CEFC takes a commercial approach to financing while looking to increase the availability of financing from the private sector through direct investments and strategic partnerships.[70]

[63] Israel NewTech, (n.d.), "National Sustainable Energy and Water Program."
[64] OECD, (2011), *Towards Green Growth*, OECD Green Growth Studies, OECD Publishing, p. 47.
[65] *Ibid.*
[66] Green Growth Best Practices (2014), *Green Growth in Practice : Lessons from Country Experiences*, Green Growth Institute
[67] *Ibid.*
[68] OECD Making Innovation Policy Work
[69] Green Growth Best Practices (2014), *Green Growth in Practice : Lessons from Country Experiences*, Green Growth Institute
[70] Clean Energy Finance Corporation, (2016), "About the CEFC."

- *Germany*: There is a number of programs that focus on growing young firms and supporting clean technology. There is a tax incentive for holding companies to invest venture capital into young technology companies. Support for SMEs is provided directly through the ZIM program that primarily funds R&D but also provides support for market launch.[71] The CLIENT project helps to establish international partnerships in environmental and climate protection technologies and to trigger the development of lead markets.[72]

Incubator Programs

Incubator programs assist companies achieve viability. They also provide support and advice to SMEs. As well, they provide direct funding to companies to enable them to reach the stage were private equity will intervene to continue the businesses growth or by providing incentives for private equity to invest in high risk investments.
Examples of successful incubator programs include:

- *Finland:* Business entrepreneurship in Finland is strong, boasting top five performances in the OECD in terms of Venture capital per GDP and patenting firm's less than five years old. Two programs that support this are Enterprise Finland,an online advisory service for SMEs, and the Vigo Accelerator programme, which has raised approximately USD 80 M in capital for promising start-up firms in clean technology, ICT, mobile and life sciences.[73]

- *United States:* President Obama launched the Startup America Initiative to support entrepreneurs in growing their businesses including in the clean technology field. This initiative helps businesses in five separate areas: : 1) unlocking access to capital; 2) connecting mentors; 3) reducing barriers; 4) accelerating innovation; and 5) unleashing market opportunities.[74]

- *Israel*: Its venture capital record ranking is near the top of the OECD in terms of venture capital per dollar of GDP.[75] This strong support is supplemented through government programs such as the Technological Incubators programs whose primary goal are to transform innovative ideas & technologies to viable companies that can then raise additional private equity funding. The incubators program positioned itself as the primary manufacturer of startups in Israel today, establishing 70-80 new startups every year[76] (approximately 15% of companies in the program are clean technology focused).

Investment Intermediaries

For direct investment in commercialization and scale-up, governments can make direct use of the budget, or utilize public intermediaries such as green funds or banks. However, some point to concerns that such intermediaries are too disconnected from the budget process, and result in an overall dilution of accountability and transparency.
Programs that specifically spur demand for products and services and help to buy down some of the initial adoption risk for consumers can be successful at enabling companies to reach commercialization. These types of programs can also serve to reduce energy consumption and costs while reducing environmental impacts. These programs also can be funded using innovative mechanisms that do not necessarily rely on public funds such as additional charges on electricity bills.

Examples of investment intermediaries include:

- *United States:* Connecticut developed the world's first state-level green bank in 2011 and is experimenting with innovative loan repayment mechanisms for household adoption projects where repayment is made "on-bill" (i.e., tacked onto electricity bill and property tax payments).[77] In 2013, the Connecticut Green Bank attracted $180 M

[71] Government of Germany, (n.d.), "ZIM Overview," Federal Ministry of Economic Affairs and Energy.
[72] OECD, (2012), *OECD Science, Technology and Industry Outlook,* OECD Publishing, p. 296-299.
[73] *Ibid.,*, p. 288-291.
[74] The White House, (n.d.), "Startup America."
[75] *Ibid.,*, p. 324-327.
[76] Technological Incubators Program, (2010), "About Us."
[77] The Climate Group, (2014), *Age of Experiments: How States and Regions are Developing the Next Generation of Climate and Energy Policies*, p. 5-7. BC funded its Innovative Clean Energy Fund from an on-bill levy.

USD in private capital with $20 M USD in public funds: a 9:1 private-public investment ratio. The Bank estimates that the capital it raised through the Bank helped created over 1,200 jobs.[78]

- *Norway*: Through Enova SF organizations, Norway is developing markets for efficient and environmentally friendly energy solutions. This is funded through a charge on electricity bills. The goal of the organization is to improve energy efficiency and increase the amount of renewable energy. A key principle is solutions should be market-based and is accomplished by stimulating the demand for forward looking energy solutions to force the supply chain into development, innovation, competence increase, and quality control. This method enables multiple solutions to be implemented in more areas and at a lower price.[79]

- *Ontario-Quebec*: Ontario has also signed an memorandum of understanding (MOU) with Quebec to implement the Ontario – Quebec joint work plan on Economic Development through Climate Change Innovation. This will provide opportunities for collaboration and to learn from what Quebec is doing to grow its clean technology sector and how cap and trade revenues are being spent.

3.4.3 CLEAN TECHNOLOGY ADOPTION

Countries with ambitious and long-term goals that address resource security, climate change and other environmental concerns create market certainty for clean technology firms to develop solutions. These ambitious goals also have to be supported with concrete action for achieving those goals such as environmental regulations, pollutant pricing or energy taxes. Research to date indicates it is important that governments set clear, long-term policy signals, set ambitious environmental regulations, address market failures, lower barriers to investment, promote collaborative dialogue among investors, and encourage key investors, such as institutional investors.[80]

<u>Consistent/Clear Regulatory Environment</u>
Among the important conditions for creating a market for clean technologies is a stable, well defined regulatory environment. Goals such as ambitious emissions reductions targets or renewable portfolio standards are also crucial and need to be supported by a regulatory framework such as an emissions trading system or a carbon tax.
Examples of consistent/ clean regulatory environments include:

- *European Union (EU):* The EU is a leader in fostering an enabling environment for clean technology development and adoption, setting clear goals and environmental targets. In 2007 (legislated in 2009) the EU set its 20-20-20 objectives of achieving 20% reductions in GHG emissions, 20% of their energy from renewables and a 20% improvement in energy efficiency by 2020. One of the primary goals of the 2020 objectives was to "create jobs, advance green growth and make Europe more competitive." This was followed up with more ambitious objectives for 2030 (enacted in 2014) and a goal of transitioning to a low carbon economy by 2050. These ambitious goals are supported by policy actions such as the implementation of the EU – Emissions Trading Systems (EU-ETS) covering 45% of GHG emissions and specific policies implemented in member countries.[81]

- *Finland:* Adopted an ambitious target of reaching 38% renewables in their primary energy supply by 2020; and has also implemented an energy tax (taking into account energy content, CO2 emissions and local/particle emissions).[82] The stated goal of Finland's energy tax is to improve efficiency, reduce emissions, and foster solutions.[83]

[78] *Ibid.*
[79] Enova, (n.d.), "Our History and Mission."
[80] OECD, (2011), *Towards Green Growth*.
[81] European Commission, (2016), "2020 Climate & Energy Package."
[82] International Energy Agency, (2013), *Energy Policies of IEA Countries: Finland 2013 Review*, p. 11.
[83] *Ibid.*, p. 24.

- *Germany:* Implemented policies to pull clean technology into the market are coordinated by the *Energiewende* or "Energy Concept", which is a detailed long-term strategy for an environmentally sound, reliable and affordable energy supply system by 2050. It has ambitious targets and incentives related to energy efficiency and renewable energy adoption.[84] Its detailed and coherent roadmap gives great certainty to inventors and investors. In addition, Germany adopted Ecological tax reforms in 1999 with the goal of mitigating GHG emissions, creating jobs and bosting innovation.[85]

- *United States*: Has a number of programs to pull innovations into the marketplace, including clean energy standards, tax incentives such as the investment tax credit, the production tax credit, both directed at renewable energy and doubling energy productivity by 2030.[86] There is also action at the state level, including renewable portfolio standards for state electricity systems. This is led by California, who typically has more aggressive standards for reducing emissions and integrating renewables than national standards.

- *Norway:* Despite being a fossil fuel producer and exporter, Norway has aggressive targets related to climate change. Norway aims to reduce emissions 30% below 1990 levels by 2020 and to carbon neutral by 2050. Norway put a carbon tax on fossil fuels and on gas and oil production in 1991, which lead to the development of commercial carbon capture and storage facilities. Norway generally has high taxes on energy and also imposes a tax on sulphur emissions.[87] Although Norway is not an EU member, it is often aligned with EU policies and directives (particularly environmental) including the EU-ETS.[88]

Procurement

Government procurement policies can be instrumental at multiple stages in the innovation-commercialization process, particularly for near-market or market-ready products. Programs that target pre-commercial technologies are important as they strengthen domestic innovation capacity by acting as first adopters of new technologies. As well, programs that target early-commercial technologies serve as a critical component of the commercialization process and can act as a launching point for international market penetration of successful clean technologies.[89]

A number of researchers have found procurement policies to be effective in stimulating clean technology investment. Edler (2007) determined procurement led to increased and more diverse innovation than R&D subsidies. Fraunhofer (2005) argues that focusing public demand through procurement creates clear incentives for suppliers and reduces their level of commercial risk. In addition, businesses that win procurement contracts are able to enjoy reputational effects that increase their commercial viability.[90]

Best practices for implementing public procurement policies include: a clear legal and policy framework; an assessment technology life-cycle costs; inclusion of environmental standards in the design, selection and award of projects; multidisciplinary procurement teams; raising awareness of buyers to clean technologies; and monitoring and measuring the environmental and economic impacts.[91]

However, governments face challenges when implementing green procurement programs : the public sector may be subjective in its decisions, leading to distortions in the competition process; procurement may be captured by vested interests (e.g. by state-owned enterprises); and risks and opportunities costs of selecting a given project may not be properly captured. An OECD survey found that the majority of countries don't explicitly consider these factors when using procurement to support socioeconomic objectives.[92]

[84] International Energy Agency, (2013), *Energy Policies of IEA Countries: Germany 2013 Review*, p. 9-10.
[85] *Ibid.,* p. 28.
[86] OECD, (2012), *OECD Science*, p. 404-407.
[87] International Energy Agency, (2011), *Energy Policies of IEA Countries: Norway 2011 Review*, p. 23.
[88] European Commission, (n.d.), "The EU Emissions Trading System (EU ETS)."
[89] Natural Resources Canada, (2014), *Energy Innovation*; National Roundtable on the Environment and the Economy, (2012), *Framing the Future*.
[90] See OECD & The World Bank, (2014), *Making Innovation*, p. 211.
[91] OECD, (2015), *Aligning Policies for a Low Carbon Economy*, OECD Publishing.
[92] OECD & The World Bank, (2014), *Making Innovation*, p. 208-209.

Consumer Behaviour

Other roles for government in creating an investment environment include setting consumer policies and standards. Ensuring the quality and reliability of information available to consumers via trustmarks or third party certification, supporting the development of product comparison tools (e.g., ENERGY STAR, EnerGuide labels, R2000 for homes), strengthening knowledge and education and generally raising awareness all can potentially increase the uptake of clean technology products. Likewise, government can convene clean technology stakeholders and act as a catalyst for the development of clean technology industry standards.[93]

3.4.4 ENVIRONMENT FOR SUCCESS

Intergovernmental Collaboration

When different orders of government align their objectives and pool resources it can serve as a powerful signal to affect change. This enables governments to leverage each other's funding and programs to achieve common objectives. Examples of intergovernmental collaboration include:

- Alberta's Climate Change and Emissions Management Corporation (CCEMC) and SDTC signed an MOU and held a joint call for proposals for funding for GHG-reducing technology (with $20M from each organization). The joint funding process allows applicants to access higher funding than if they applied to either organization individually, and pools administrative resources and knowledge. In addition to collaborating with CCEMC, SDTC collaborates with the Quebec Technoclimat program.

- The Networks of Centres of Excellence (NCE) program supports large-scale, academically-led research networks that bring together some of Canada's brightest minds in health science, natural and social sciences and engineering. Partners from industry, government (Health Canada; Innovation, Science and Economic Development Canada; and the Tri-Council Agencies) and not-for-profit organizations contribute additional expertise and contribute nearly $90 M per year of cash and support. Australia, South Africa and some EU countries have incorporated the NCE model into their own innovation ecosystems.[94] The NCE also has Business-Led Networks (BL-NCE) that allow industry partners to propose research projects led at private facilities and funded through matching requirements (at least half of the network's research costs are paid by partners). Launched in 2007, the program helps Canadian SMEs grow and capture new markets such as the Green Aviation Research and Development Network (GARDN), which produces green aviation solutions.

Facilitating Private Sector Collaboration

Government can play a role as convener of private sector and academic stakeholders. Governments could engage with stakeholders to ensure the relevance and consistency of policy objectives, but can also play a role in stimulating enhanced coordination and public governance among environment and natural resource management, energy, and investment authorities, for example.

- FPInnovations is the largest public-private forest research organization in the world, with R&D laboratories and technology transfer offices across Canada. Its membership represents a significant portion of Canada's forest industry, and is a hub of innovation that collaborates with industry, governments, and academia.

International Cooperation

Proven international cooperation strategies include: joint investment in basic research; mapping of R&D needs collaborative research in international networks; technology transfer; and scholarships and fellowships for the international mobility of research. Benefits of these strategies include economies of scale, reducing redundancies, utilizing

[93] OECD, (2011), *Fostering Innovation for Green Growth*, OECD Green Growth Studies, OECD Publishing.
[94] Government of Canada, (2015), "Networks of Centres of Excellence Program," Networks of Centres of Excellence of Canada.

complementary expertise, pooling resources for research funding, developing a common pool of knowledge, and generally strengthening technology development and diffusion.

This work is done through a number of bilateral agreements and international organizations such as the International Energy Agency (IEA) which implement agreements that help to advance energy technologies.

- *International:* The Generation IV International Forum (GIF) is a co-operative international endeavour to carry out the R&D needed to develop the next generation of nuclear energy systems with enhanced safety, security, and economics, while addressing waste and proliferation concerns. Thirteen member states, including Canada, are collaborating on six different nuclear energy systems.[95] The GIF has made steady progress in developing these systems, which are expected to be commercially deployed around mid-century, through a community of over 300 R&D managers across 8 countries.[96] In 2015, GIF extended collaboration for another ten years.

- *Canada-U.S.*: Under the *Regulatory Cooperation Council,* Natural Resources Canada and the U.S. Department of Energy have committed to align energy efficiency standards and test procedures to the extent practical and permitted by law.

Industry Cooperation

Industry cooperation in developing of technology and sharing of intellectual property can act as a catalyst for accelerating the development of technologies that improve environmental outcomes.

- *Canada*: The Canadian Oil Sands Innovation Alliance (COSIA) is a partnership of 13 member companies representing 90% of Canada's oil sands production. It is a model for developing clean innovation and devoting R&D funding to environmental challenges. To address one of the oil sands' biggest challenges – CO_2 emissions – COSIA, in partnership with NRG Energy and the X Prize Foundation, has initiated a grand challenge for breakthroughs that convert CO_2 emissions into useful products. Teams from around the world will compete to generate the highest net value products from CO_2 emissions while operating with the smallest environmental footprint. The X Prize competition offers COSIA and NRG Energy the change to leverage global private sector innovation and research talent to address environmental challenges.

- *Canada*: In support of intellectual property scale problems, the MaRS Innovation Initiative pools the intellectual property offices of its 15 Toronto-based research institutions for scale benefits and to support a team of commercialization experts with experience in a wide variety of fields.[97] In the clean technology field, MaRS helped new ventures obtain over 110 patents between 2013 and 2014.

- *Australia*: A cornerstone of the Australian innovation system is Commonwealth Scientific and Industrial Research Organization (CSIRO), a leading multidisciplinary research organization. CSIRO views collaboration and partnership with its stakeholders and clients as critical to its success. One successful program is the Cooperative Research Councils that are industry led and bring together researchers to tackle clearly articulated challenges that help to create a direct link between research and the end-users.[98]

[95] Generation IV International Forum, (2016).
[96] J. Kelly, T. Dujardin, & H. Paillere, (2013), GIF's Role in Developing the Nuclear Technologies of the Future, *NEA News,* No. 31.2.
[97] Council of Canadian Academies, (2009), *Innovation and Business Strategy: Why Canada Falls Short*, p. 138-139.
[98] CSIRO, (n.d.), "Client and Stakeholder Engagement."

CHAPTER 4

HOW DO WE GET THERE?

4.1 DEVELOPING OPTIONS FOR CHANGE

Drawing on the research to date, the Working Group found that environmental and clean technology challenges are addressed and opportunities are realized at each point along the innovation spectrum for clean economic growth – development, commercialization and adoption and diffusion. As well, Working Group members have noted that each province, territory and region in Canada has unique resources, centres of expertise, and challenges or obstacles to clean growth. Options for ministerial consideration in each of these areas will be informed by stakeholder engagement over the coming months.

4.2 BUILDING EARLY-STAGE CLEAN TECHNOLOGY INNOVATION

Evidence reviewed by the Working Group suggests that innovative clean technologies are required both to address Canada's stark environmental problems, such as access to potable water for remote communities, and to achieve many of its key environmental targets, such as GHG emissions reductions. Innovative solutions to these and other environmental and climate change challenges will require both incremental improvements to existing technologies and dramatically different solutions. Incremental innovation can result in immediate and efficient improvements, particularly in the short-term while disruptive technologies may be able to affect more substantive change over the longer term.

Clean Technology development has many of the same challenges that face other innovation efforts across *the* Canadian economy, such as strong invention potential, but low business investment in research and development. There may be, unique challenges to clean technology development that are not directly addressed through the general innovation support, both at the national and sub-national level, which may benefit from specifically tailored approaches.

In addition, Canada produces approximately two percent of global GHG emissions and the domestic market is a relatively small share of the global market. Through a review of the current economic context, Working Group members are of the view that for Canada to develop a world class clean technology economy and be a contributor in reducing global emissions, it must look beyond its own borders and develop a strong export focus. Canada has many of the strong R&D elements in place, but more will be needed to make Canada's clean technology sector globally competitive.

Questions to be addressed:

- What are the appropriate vehicles to drive greater clean technology development, including investments in new disruptive technologies, to achieve the level of GHG reductions required to meet longer term targets for decarbonization of the economy?
- How can increased RD&D activities in clean technologies be jointly encouraged by governments and the private sector and used to leverage international cooperation?
- What a comprehensive approach can be established to ensure clean technology innovation aligns existing and planned innovation programs with broader program and policy objectives?
- Should mission-oriented strategies be developed to drive innovation for new clean technology solutions?

4.3 ACCELERATING COMMERCIALIZATION AND COMMERCIAL CAPACITY

As is the case with development, the challenges in introducing new clean technology products and services to market are generally similar to those faced by other companies striving to commercialize their innovations. The Working Group notes, however, that there are a few factors that create added pressure on clean technology commercialization efforts. Most clean technology producers are SMEs, which often face a larger challenge in bringing their innovations through to market. The research reviewed by the Working Group also suggests that there are several unique financing hurdles for clean technology that need to be overcome along the way, such as the high capital intensity of demonstration projects.

As well, in comparison with other innovative technologies such as those from information and communications technology companies, clean technology companies often have higher capital costs in their commercialization phase and are long-life assets with lengthy procurement cycles (for example, 20+ years for power generation technologies).

Finally, the Canadian market is not large enough to support robust clean technology companies on its own, meaning domestic firms often rely on exports and integration into global value chains to grow their market share. This means that Canadian firms also must compete on the global marketplace in the expanding clean technology sector. Canadian clean technology companies can find opportunities for growth in helping the world reduce GHG emissions. Scaling up domestic firms and exporting technologies to countries that are grappling with resource scarcities and environmental challenges could potentially reduce technology costs in Canada.

Questions to be addressed:

- How can clean technology investments be facilitated jointly by governments and the private sector to grow stronger and more adaptable clean growth firms?
- How can there be better access to the right types of business financing to support new ventures and export growth to ensure new and innovative products make it through commercialization and compete globally? What can be done to help Canadian companies tap into international financing?
- What can be done to help Canadians transition into clean technology and clean growth jobs?
- How can firms be supported in their efforts to embed their clean technology solutions in global value chains to generate exports that will create jobs and growth for Canada while helping to reduce global GHGs?

4.4 FOSTERING CLEAN TECHNOLOGY ADOPTION

The adoption phase of the innovation spectrum is where clean technologies become economically viable, create value and high quality jobs, and where they have the strongest impact on Canada's environmental performance. Preliminary analysis by the Working Group identified significant challenges for clean technology at this stage, preventing the widespread use of these cleaner solutions and the growth of these firms. Through its initial engagement activities with industry and other experts, the Working Group has heard the challenges Canadian firms face in breaking into new markets, both at home and abroad, as well as possible solutions.

Unlike some other technology fields, however, governments have some levers that may help drive private sector demand for new clean technology solutions. Environmental regulations and policies, for example, can guide firms and households to make choices and investments that help improve environmental quality or make the economy and communities more resilient to climate change. Clear and ambitious targets, especially when backed by supporting and enforceable regulations, policies and incentives, can help overcome organizational inertia to change and drive clean technology development and adoption.

Governments can also use their procurement processes and spending powers in other areas to further support clean technology adoption and to support suppliers of new services through the difficult transition from concept to commercial-scale demonstration. The Working Group has also heard calls to set environmental targets for new infrastructure projects as they can bring new technologies into the market and can help as a reference by being the first to purchase new technologies to help establish product credibility.

Questions to be addressed

- What are the barriers to greater adoption of clean technologies and clean growth practices in Canada?
- Could environmental regulations and assessment processes be improved to help provide greater market certainty and a stronger impetus to innovate, adopt and adapt clean technology solutions by industry, utilities, communities and consumers?
- How can governments, utilities and crown corporations and agencies leverage their purchasing power to support clean technology adoption?
- How can planned infrastructure expenditures be leveraged to promote clean technology innovation, development and widespread adoption?
- What factors would enable Indigenous communities to accelerate the adoption clean technologies and grow clean technology businesses?

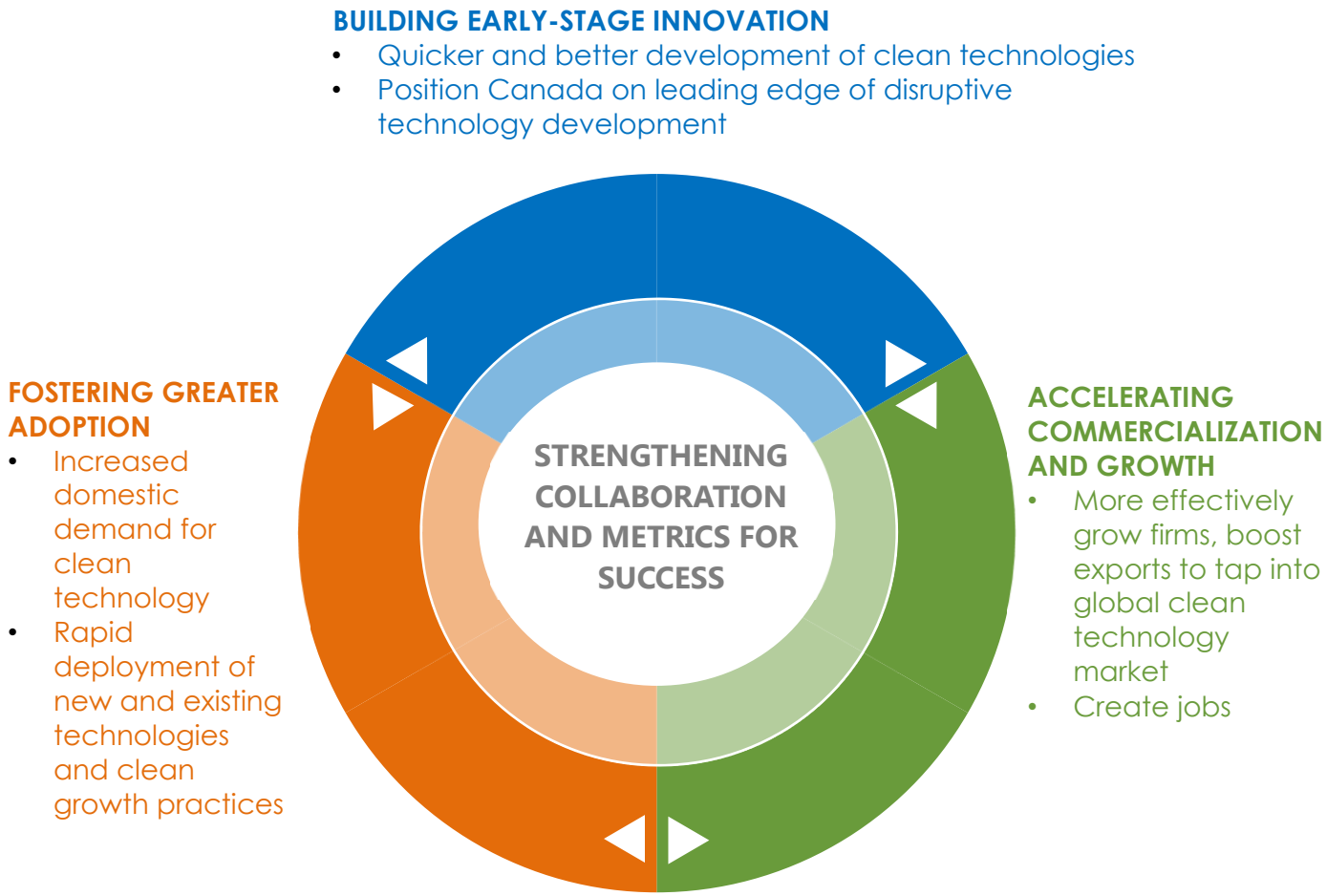
4.5 STRENGTHENING COLLABORATION AND METRICS FOR SUCCESS

Decisions for government action are rooted in evidence, both to define the type and timing of action and to measure the results and benefits of the new regulations, policies and programs. While the Working Group recognizes that much information and data are available, it is often difficult to develop a comprehensive overview of the clean technology sector as well as the corresponding demand for these products and solutions. Stronger and more detailed data, developed in cooperation across all orders of government could help guide government initiatives at each point along the Innovation spectrum.

Questions to be addressed:

- How could statistical agencies and other stakeholders collaborate to fill data gaps?
- In what ways could all orders of government coordinate activities to achieve economies of scale in their efforts to promote clean technology development and adoption to create jobs and greater economic benefits for all Canadians?
- What are the institutional structures that need to be put in place to ensure continued and effective collaboration on this area?
- What can be done to increase the open availability of existing data that may facilitate innovation related to clean growth?

FIGURE 7 – WORKING GROUP FRAMEWORK



4.6 NEXT STEPS

This Interim Report of the Working Group report outlines the key opportunities and challenges for clean technology and innovation at the national, provincial and territorial level. To further elaborate on this work and to refine options for future government action, the Working Group will:

- Conduct in-depth sectoral analysis, meeting with sectoral experts and associations;
- Continue and assess the results of previous and planned engagement activities, including submissions received through the Talk Climate Change portal and regional roundtable meetings; and
- Consult federal-provincial/territorial program delivery agents, to confirm research findings and to develop options.

ANNEX

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