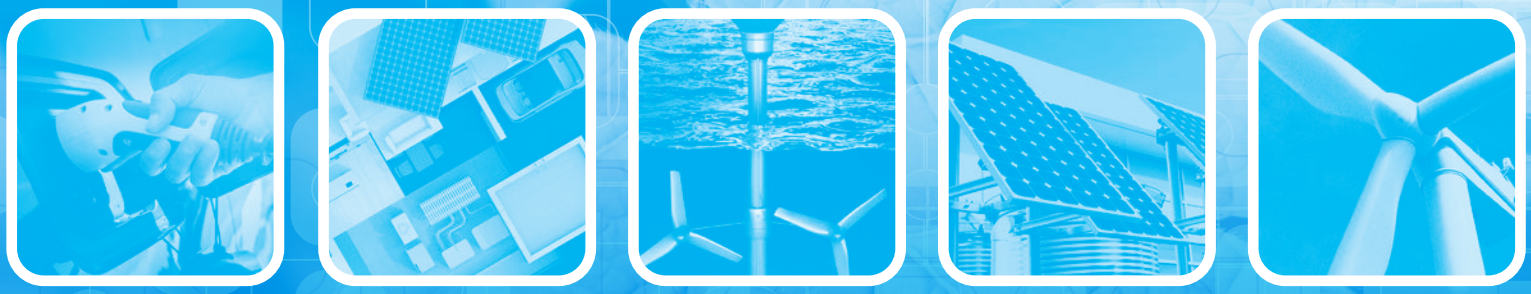
Accelerating Canada's Clean Growth Economy:

Cleantech Adoption Strategies for a Low Carbon World

September 2016



deepcentre
Centre for Digital Entrepreneurship
+ Economic Performance

About the Clean Growth Economy Project

At the COP21 meetings in Paris in December 2015, the Government of Canada announced ambitious new targets for reducing greenhouse gas emissions and called on the Canadian business community to help lead the way toward an economy driven by clean growth. As part of its mandate to investigate how Canada can leverage cleantech innovation to stimulate economic growth and create jobs, Canada's Department of Innovation, Science and Economic Development (ISED) commissioned the DEEP Centre to undertake a cross-sector survey of clean technology adoption practices and provide an analysis of measures that could accelerate Canada's progress towards a low-carbon economy. Between May and July 2016, 72 companies from a diverse range of sectors supplied detailed data about their investments in clean technology and responded to a series of questions about the economic and environmental benefits of adoption and the barriers and challenges that could inhibit further investment. In a series of one-to-one interviews with the DEEP Centre, numerous executives also shared their views on policy measures that would facilitate cleantech innovation and adoption in their industries.

We hope the resulting report will help policymakers and other stakeholders to:

1. Understand cleantech adoption practices across the economy, including plans for future investment and the perceived economic and environment benefits associated with clean technologies.

2. Recognize and address some of the barriers and obstacles that are inhibiting investments in clean technologies by Canadian companies.

3. Learn from best practice case studies that will highlight the value creation associated with smart investments in clean technology, particularly those instances where adoption is driving domestic investments in innovation and supporting the growth of cleantech SMEs.

4. Create actionable recommendations for business executives, cleantech entrepreneurs and policymakers that will help accelerate cleantech adoption across sectors and promote partnerships that will stimulate the creation of global cleantech champions in Canada.

Delivering on these objectives will help ensure that governments, corporate leaders, entrepreneurs, investors and other stakeholders are equipped with the knowledge required to promote faster and broader adoption of clean technologies, and to maximize the innovation, growth and shared prosperity that emerges from greater corporate engagement with the Canadian cleantech sector.

About the Clean Growth Economy Project

The DEEP Centre would like to thank ISED for funding this research and all of the companies and executives who took the time to participate in the study. The DEEP Centre would also like to thank Natural Resources Canada and the following industry associations for their assistance with outreach for the survey: The Business Council of Canada, Canada Mining Innovation Council Canadian Electricity Association, Canadian Gas Association, Canada's Oil Sands Innovation Alliance, FPInnovations, the Forest Products Association of Canada, the Mining Association of Canada and the Prospectors & Developers Association of Canada.

About the DEEP Centre

The Centre for Digital Entrepreneurship and Economic Performance (DEEP Centre) is an economic policy think-tank based in Waterloo, Ontario. Founded in 2012 as a non-partisan research firm, the DEEP Centre's work shapes how jurisdictions build fertile environments for launching, nurturing and scaling companies that will thrive in an increasingly connected world. The DEEP Centre provides objective research and advice on the changing drivers of success in the global economy and the critical interconnections between technology, entrepreneurship and long-run economic performance. Its research and advisory services have helped policymakers and private companies around the world identify and implement powerful new policies, programs and services to foster innovation, growth and employment in their jurisdictions.

- In 2016, the DEEP Centre published a ground-breaking report on Accelerating Canada's Clean Growth Economy which tracks adoption of clean technologies across the economy and identifies strategies for boosting growth and innovation in the cleantech sector.
- In 2015, the DEEP Centre conducted the first nationwide evaluation of Canada's network of business accelerators and incubators, which led to the formulation of new federal government initiatives for supporting the creation of high-impact firms in Canada.
- In 2014, the DEEP Centre worked with the Markle Foundation's Economic Future Initiative to identify strategies for increasing the productivity and global engagement of U.S.-based services firms using digital technologies.
- In 2013, the DEEP Centre produced an influential report on the evolution of Canada's Billion Dollar Firms, which includes a five-part analysis of the growth and performance of Canada's largest firms and their contributions to employment, innovation and export activity.

To find about more about the DEEP Centre's work, visit: http://www.deepcentre.com

About the Author

Anthony D. Williams is co-founder and president of the Centre for Digital Entrepreneurship and Economic Performance (DEEP Centre) and co-author (with Don Tapscott) of the groundbreaking bestseller *Wikinomics* and its follow-up *Macrowikino*mics: *New Solutions for a Connected Planet.*

Anthony is an expert advisor to the Markle Foundation's Initiative for *America's Economic Future,* a senior fellow for innovation with the Lisbon Council in Brussels and chief advisor to Brazil's Free Education Project, a national strategy to equip 2 million young Brazilians with the skills required for a 21st Century workforce.

Anthony was recently executive editor for the Global Solutions Network at the Martin Prosperity Institute, a committee member of the National Research Council's Committee on Science for the EPA's Future, a visiting fellow with the Munk School of Global Affairs at the University of Toronto and Program Chair for the 18th World Congress on Information Technology in Montreal. His work on technology and innovation has been featured in publications such as the Huffington Post, Harvard Business Review and the Globe and Mail.

Research Team

Warren Clarke is a senior research associate at the Centre for Digital Entrepreneurship and Economic Performance and a postdoctoral fellow in the Department of Political Science at McMaster University. Warren's research includes a strong focus on the politics of intellectual property rights and the evolving role of the state in the economy. His work has appeared in a variety of publications including World Economics, Global Society, and Policy Options. He holds a PhD from the Balsillie School of International Affairs, Wilfrid Laurier University.

Kirill Savine is the DEEP Centre's data guru. He holds a degree in Economics and Finance from Wilfrid Laurier University. He has previously worked with the Laurier Centre for Economic Research and Policy Analysis where he contributed to various economic policy publications and published periodic labour market newsletters. Kirill's interests include economic policy research and computational finance methods for investing.

Luke Dotto is a research associate with the Centre for Digital Entrepreneurship and Economic Performance in Waterloo. He holds a Masters of International Public Policy from the Balsillie School of International Affairs, and a Bachelor of Arts in Political Science from Wilfrid Laurier University.

Table of Contents

Table of Contents

1. Accelerating Canada's Clean Growth Economy

As the world grapples with the necessity of moving toward a low-carbon future, leading countries – including Canada – are adopting multi-sector strategies for promoting environmentally sustainable sources of growth and long-term prosperity. The magnitude of the challenge is hard to overstate. Merely continuing with 'business as usual' scenarios will see global average temperatures climb to 3.8°C to 4.7°C above pre-industrial levels, with profoundly negative ramifications for human health and the environment, including threats to food and energy security, massive disruption of ecosystems, a continued increase in severe weather events and rising sea levels that could jeopardize coastal cities.[1]

"The shift to an economy fuelled by clean growth will strengthen and diversify Canada's economy, create new jobs and improve our quality of life, just as innovations in steam power, electricity and computing have done before."

Avoiding these dire consequences requires a 40-70% reduction in emissions below 2010 levels,[2] which in turn means significant efforts to reindustrialize sectors as transportation, resource extraction, power generation, forestry, construction and agriculture around low-carbon solutions. Some of the changes include boosting the adoption of electric vehicles and improving transportation efficiency; adopting smart grid technologies and shifting power generation to renewable energy sources; massively increasing the efficiency commercial buildings and running corporate facilities using clean energy sources; and making dramatic improvements in the energy efficiency of products, including the processes to make them.[3]

While reindustrialization will require a decades-long effort, there is a significant upside if Canada marshals the public and private leadership required to accelerate the country's transition to an economy driven by clean growth. As noted in the Vancouver Declaration, the shift to an economy fuelled by clean growth will strengthen and diversify Canada's economy, create new jobs and improve our quality of life, just as innovations in steam power, electricity and computing have done before.[4] Achieving the transition to a low-carbon economy, however, will require a vigorous and sustained commitment by all stakeholders to leverage technology and innovation in pursuit of low-carbon solutions. Indeed, the development and adoption of clean technologies by Canadian businesses will be among the most important drivers of improved environmental performance in the Canadian economy and of new economic opportunities and jobs for Canadians.

Although Canada's weak track record on technology adoption provides reason for concern, there are numerous reasons to be enthusiastic about the economic and environmental potential of a low-carbon economy in Canada. While environmental protection has traditionally been cast as a significant cost to business, a growing number of companies see the low-carbon economy as a rich source of vibrant new business opportunities, including opportunities for innovative, green products,

1 Turn Down the Heat: Why a 4 Degree Centigrade Warmer World Must be Avoided, " Report for The World Bank by the Potsdam Institute for Climate Impact Research and Climate Analytics, Washington, DC, November, 2012
2 Climate Change 2014 Synthesis Report, (Geneva: IPPC, 2014). https://www.ipcc.ch/pdf/assessment-report/ar5/syr/AR5_SYR_FINAL_SPM.pdf
3 Intergovernmental Panel on Climate Change, Climate Change 2014: Impacts, Adaptation, and Vulnerability, Summary for Policymakers, March 31, 2014, pages 1-12
4 Vancouver Declaration on Clean Growth and Climate Change, March 3, 2016. http://www.scics.gc.ca/english/conferences.asp?a=viewdocument&id=2401

for renewable and clean energy, for smart and efficient materials, for reusing and recycling, for new transportation and housing options, and for conserving water and other resources. Moreover, there is growing evidence that cleantech adoption can help companies reduce operating costs, increase productivity, improve public relations and boost employee engagement.

The growth of new cleantech companies in Canada provides another reason for optimism. The global shift towards renewable energy and cleaner, more efficient production methods is accelerating (averaging year-over-year growth of roughly 8 percent[5]) with businesses in just about every sector seeking to confront challenges such as resource scarcity, energy security and climate change. Estimates suggest the global market for clean technologies has surpassed $1-trillion and could triple in the next decade.[6]

"Greater corporate engagement in the clean technology ecosystem can catalyze growth and innovation, providing an injection of new thinking and productivity into mature businesses while offering clean tech firms an opportunity to scale."

With cleantech innovation activities on the rise in innovation hubs and post-secondary institutions across the country, the creation of partnerships with large industrial adopters holds the potential to give Canadian commercialization efforts the kick-start they need to press on into international markets. Greater investment in low-carbon solutions by large companies will expand the number of opportunities for domestic cleantech suppliers to demonstrate and scale-up their technologies. Strong domestic adoption partnerships, in turn, will serve as a launching pad for exporting Canadian cleantech solutions to a large and rapidly growing global market.

In short, efforts to accelerate the adoption of clean technologies by corporate Canada present a win-win scenario with significant environmental and economic benefits. Greater corporate engagement in the clean technology ecosystem can catalyze growth and innovation, providing an injection of new thinking and productivity into mature businesses while offering cleantech firms an opportunity to scale. Such synergistic relationships will be vital to ensuring that Canada not only delivers on its promise to reduce its carbon footprint, but also seizes this historic moment to become a leader in generating jobs and prosperity from the clean growth industries of future.

A Cleantech Reality Check

While the promise is tantalizing, there are some tough business realities that could encumber Canada's progress towards a clean growth economy. To begin with, competition for cleantech market share is heating up. In the last five years, for example, China has caught up to the EU on per capita investment in clean energy and overtaken the EU on renewable energy build rates, R&D spending, power transmission grids and electric vehicles.[7] And, in a new 5-year plan published in

5 Analytica Advisors, "2015 Canadian Clean Technology Industry Report."
6 National Round Table on the Environment and the Economy, "Framing the Future: Embracing the Low-Carbon Economy." Climate Prosperity Report No. 06, 2012.
7 Shinwei Ng, Nick Mabey, Jonathan Gaventa, "Pulling Ahead On Clean Technology China's 13th Five Year Plan Challenges Europe's Low Carbon Competitiveness," E3G Briefing Paper, March 2016.

1. Accelerating Canada's Clean Growth Economy

March 2016, China announced that it plans to more than double its wind energy capacity, nearly triple its solar capacity, and increase electric vehicles by a factor of 10—a pace of cleantech deployment that far outstrips any other country.[8]

Growing markets will lower clean technology costs and create new opportunities for Canadian firms. However, Canada will lose out in the global cleantech innovation race if our domestic adoption of clean technology fails to keep pace with key international competitors. Indeed, there are already signs of trouble. The Canadian cleantech sector, which saw revenue growth stall in 2014, has been losing global market share as international competitors have been ramping up.[9] In an open letter sent to Prime Minister Trudeau, the BC Cleantech CEO Alliance highlighted that Canada has been the third greatest loser of market share since 2008 while facing increasingly intense competition from the United States, China, Germany, Singapore, and Israel.[10]

The situation is indicative of a deeper problem in commercializing and adopting technology in Canada. Across most domains of technology, Canada is widely considered to be strong in the science and R&D aspects of the innovation cycle, but weak when it comes to taking those ideas to market.[11] Canada's weaknesses in commercialization are mainly attributed to insufficient access to risk capital, a dearth of sophisticated management talent and a domestic market that provides inadequate opportunities for developers of innovative new technologies to market their products and services.[12] With respect to adoption, the internal market in Canada is not just small; it is also predominantly populated with firms that are late or reluctant adopters of new technologies. Unfortunately, Canada's cleantech adoption record does not offer an exception to this rule.

Compounding this problem is the fact that clean technologies are often costly when compared with existing alternatives in large part because they are new and have yet to reap the benefits of being produced at scale.[13] Additionally, because they are new, the benefits of many technologies are unproven in the field. Understandably, no business will make a significant investment in an unproven technology. And yet, demonstrating the efficacy of a new technology often requires a large industrial partner, which puts cleantech entrepreneurs in a catch 22.

When asked about the challenges associated with cleantech adoption, executives frequently note that clean technologies compete for internal capital and management attention with other investment priorities that hold the potential to boost business growth and productivity. More broadly, many of Canada's highest-emitting

8 Ibid.
9 Ibid.
10 BC Cleantech CEO Alliance, Letter to Prime Minister Trudeau, February 29 2016
11 DEEP Centre "Canada's Innovation Performance: A Scorecard," March 2015. http://deepcentre.com/wordpress/wp-content/uploads/2015/03/DEEP-Centre-Canadas-Innovation-Performance-March-2015.pdf
12 DEEP Centre "A Lynchpin in Canada's Economic Future: Accelerating Growth and Innovation with a World-Class Business Acceleration Ecosystem," October 2015. http://deepcentre.com/wordpress/wp-content/uploads/2015/10/DEEP-Centre-BABI-5-Capstone-Accelerating-Growth-and-Innovation-September-20151.pdf
13 OECD, "Climate Change Mitigation: What Do We Do?" (Paris: OECD, 2008). http://www.oecd.org/env/cc/41751042.pdf

1. Accelerating Canada's Clean Growth Economy

firms are typically in conservative, low-margin, commodity-based businesses where innovation cycles are slow and access to investment capital is highly constrained. Thus the prevailing approach to clean technology adoption in sectors such as transportation, power generation, heavy manufacturing, forestry, mining, oil and gas is focused on opportunities for reducing costs and incremental investments with short-term payoffs.

While the need to make responsible and profitable investment decisions is understandable, short-term strategies and conservatism is at odds with the increasingly evident need for more radical reinvention around low-carbon solutions. Indeed, a strictly cost optimizing, short-term approach to clean technologies is unlikely to deliver either the emissions reductions or the future competitiveness that Canada needs.[14]

"A strictly cost optimizing, short-term approach to clean technologies is unlikely to deliver either the emissions reductions or the future competitiveness that Canada needs."

These adoption challenges, however, will be speedbumps rather than showstoppers if the public and private sectors can work together to address the barriers that are inhibiting the uptake of clean technologies. Indeed, there are significant green shoots of cleantech leadership activity that, if more broadly adopted, hold promise for the Canadian economy as a whole. Industry collaborations such as Evok Innovations, the Canada's Oil Sands Innovation Alliance, the Carbon Impact Initiative, and FPInnovations are knitting together the need to enable traditional industries with cleantech innovation with the need to empower entrepreneurs to commercialize and scale-up powerful new solutions. When coupled with a price on carbon and improvements in Canada's regulatory framework, industry-led innovation partnerships with cleantech SMEs provide the combination of talent, capital and expertise required to tackle complex environmental problems while generating high-quality jobs and prosperity across the country.

Key Findings and Recommendations

As part of its mandate to investigate how Canada can leverage cleantech innovation to stimulate economic growth and create jobs, Canada's Department of Innovation, Science and Economic Development (ISED) commissioned the DEEP Centre to undertake a cross-sector survey of clean technology adoption practices and provide an analysis of measures that could accelerate Canada's progress towards a low-carbon economy. Between May and July 2016, 72 companies from a diverse range of carbon-intensive sectors supplied detailed data about their investments in clean technology and responded to a series of questions about the economic and environmental benefits of adoption and the barriers and challenges that could inhibit further investment. In a series of one-to-one interviews with the DEEP Centre, numerous executives also shared their views on policy measures that would facilitate cleantech innovation and adoption in their industries.

14 "Backgrounder," Federal-Provincial Working Group on Clean Technology, Innovation and Jobs, July 2016.

1. Accelerating Canada's Clean Growth Economy

The following summary of key findings highlights some of the main insights from this research:

"While 43% of firms in Canada have adopted advanced logistics technologies, less than 10% have adopted clean technologies."

- **Canadian firms as a whole are late or reluctant adopters of clean technologies.** In a 2014 survey of 12,000 enterprises in Canada, Statistics Canada found the rate of cleantech adoption to be by far the lowest among the four classes of technology it tracked, which also included business intelligence, logistics, design and fabrication technologies. While 43% of firms in Canada adopted advanced logistics technologies, less than 10% have adopted clean technologies. The adoption rate among Canada's large enterprises is somewhat higher at 15% for companies with 250 employees or more. Within industrial sectors such as power generation and resource extraction cleantech adoption rates among large enterprises range between 20% and 40%. Nevertheless, the results indicate that a significant majority of firms (including those in the highest-emitting sectors) have made little to no investment in clean technologies.

- **Early adopters of clean technologies in Canada are focused on efficiency measures that reduce operating costs and cite high implementation costs as a barrier to future investment.** Across the sample, energy efficiency investments were found to be the most common with 81% of companies surveyed reporting projects in this area. The focus on energy efficiency is consistent with the finding that the principal motivation for making investments in clean technologies is a desire to lower operating costs. The most frequently cited environmental benefits of cleantech adoption, on the other hand, include lower GHG emissions (83%) and increased energy efficiency (71%). In characterizing the economic benefits, firms cited reduced input costs, greater production efficiency, greater employee engagement, and new revenue creation as significant outcomes. Higher than expected costs associated with cleantech solutions was identified as the number one implementation challenge by participating firms. Nearly three-quarters (74%) of the sample indicated that the high cost and capital-intensity of cleantech solutions is also the primary barrier to future investment.

- **Challenging economics and slow innovation cycles hamper cleantech adoption in traditional industries.** While Canada's traditional industries (agriculture, construction, fisheries, forestry, mining and oil and gas) face the most acute pressure to reinvent themselves for a low-carbon world, their pathway to clean growth is encumbered by significant obstacles. In interviews with executives, many companies cite capital constraints, low commodity prices, slow innovation cycles and intense margin pressures as barriers to cleantech adoption. Numerous

executive also noted that framing a business case for adoption that will satisfy internal rate of return requirements is particularly challenging in an environment in which cleantech projects compete for internal capital with other proven technologies that can boost company performance. However, as the case studies demonstrate, challenging economics and slow innovation cycles are not an excuse for complacency. On the contrary, they set the stage for industries to come together in creative new ways and for leaders to step up their efforts to differentiate their companies from the competition.

- **Canada's adoption leaders see cleantech as an opportunity to reinvent and reinvigorate traditional industries such as transportation, forestry and construction.** The forest product industry, for example, is responding to the long-term secular decline in pulp and paper with major investments in the creation of new forest-based bio-products—products like nanocrystal cellulose with the potential to transform the sector into an innovative 21st century player in the emerging bio-economy. Leading players in Canada's construction industry are piloting "net zero emissions" buildings which use technologies and materials that maximize the conservation of energy and produce as much energy as possible on site. While indicative of the kind investments that will help ailing industries diversify their products lines and tap new sources of growth, these sectors still face significant challenges in building new market opportunities and value chains around cleantech offerings. Access to world-class science, support for technology adoption and regulatory frameworks that ratchet up performance standards are among the tools and incentives these sectors need to spring forward into a low-carbon world.

- **Collaboration and open innovation are helping Canadian companies overcome tough adoption hurdles.** Sharing responsibility for research and innovation with competitors and collaborating with a broader ecosystem of contributors is new territory for firms accustomed to more conventional approaches to technology acquisition and R&D. However, a number of collaborative industry-led initiatives show how collaboration is often faster, more efficient and less risky than pursuing a proprietary approach. Collaboration and open innovation also expands the pool of talent that can participate in solving problems which produces a diversity of thought that can lead to breakthrough results. While industry networks and consortia are increasingly common in Canada, so too are partnerships with postsecondary institutions that offer firms access to tremendous technical and academic experience and a research and experimentation infrastructure that would be too costly to create from scratch.

1. Accelerating Canada's Clean Growth Economy

- **Anchor customer relationships with cleantech firms can give rise to powerful synergies that will enhance the competitiveness of both traditional and emerging industries.** The emergence of mutually beneficial relationships between cleantech firms and large adopters is perhaps the most auspicious finding of this research. As previous DEEP Centre research has shown, Canadian entrepreneurs cite the ability to access to the supply chains of anchor customers (including both government and large firms in Canada) as one of the most important vehicles for growing their firms. Having a domestic "reference customer" is not just a source revenue, it's often a prerequisite for expansion into international markets. Entrepreneurs have also referenced the value mentoring systems that connect new entrepreneurs to experienced business executives who can provide advice at key pivot points, shape product development and help mold vital management competencies.

"A cleaner and more engaged corporate community in Canada can generate increased revenue for cleantech SMEs, create opportunities for SMEs to refine their offerings and provide better access to growth capital, channel relationships and global value chains."

Three of the four case studies featured in the study showcase a variety of efforts by large Canadian firms to engage more deeply cleantech firms and innovation hubs across Canada. The case studies demonstrate how a cleaner and more engaged corporate community in Canada can generate increased revenue for cleantech SMEs, create opportunities for SMEs to refine their offerings and provide better access to growth capital, channel relationships and global value chains. At the same time, they demonstrate the extent to which these partnerships can infuse greater creativity and new momentum into the efforts of large firms to grapple with the economic and environmental challenges facing their industries.

Given these findings, which measures hold the greatest promise for helping Canadian companies adapt to the realities of a low-carbon world? Drawing on the survey research, case studies and interviews with executives, we identified fifteen recommendations for accelerating Canada's transition to a clean growth economy. These include a list of ten strategies for increasing the adoption of clean technologies and five actions large, capital-intensive firms in Canada can take to help strengthen the capacity of the cleantech sector to successfully commercialize world-class solutions for a low-carbon economy.

Among the recommendations for boosting the adoption of clean technologies are the following actions:

- **De-risk clean technology adoption** through industry-led pilot projects that test and verify the performance of new technologies in partnership with cleantech SMEs.
- **Expand the domestic market for clean technologies** through public procurement and funding for large-scale demonstration projects.

1. Accelerating Canada's Clean Growth Economy

- **Create industry consortia to lower the cost and increase the pace of innovation,** using collaborative, cross-sector initiatives to pool the knowledge and investments required to move quickly and decisively in preparing for a global low carbon economy.
- **Establish vertically-focused and industry-supported cleantech acceleration models** to build a pipeline of new innovation opportunities and help position industries such as forest products, mining, fisheries and agriculture as world leaders in sustainability.
- **Use strategic regulations as a driver for cleantech innovation and adoption** with consistent, national approaches to carbon-pricing and other performance-based regimes that drive continuous improvement in environmental performance.

Our list of industry-led capacity building measures for cleantech sector includes the following actions:

- **Identify high-impact problems for cleantech innovators to solve** by launching industry innovation challenges and communicating industry pain points to post-secondary institutions and cleantech accelerators.
- **Provide flexible capital to cleantech start-ups and SMEs** using industry-backed investment and acceleration models to structure win-win partnerships between cleantech innovators and large adopters.
- **Create opportunities to test, refine and scale-up new products and services** with pilot projects and partnerships run through industry consortia that will share pilot project results with a larger community of potential customers.
- **Build cleantech management capacity** by making executives available to mentor cleantech companies using structured capacity-building programs such as Quebec's MACH initiative in the aerospace industry.
- **Broker international market opportunities** by opening up access to global supply chains and helping cleantech SMEs forge stronger international ties.

1. Accelerating Canada's Clean Growth Economy

Taken together, these and other actions recommended in the report can deliver the step change in clean technology adoption that Canada needs. Implementation of these measures will not only help ensure Canada meet its climate change commitments, it will also put Canada's high-emitting industries on a pathway to reinvention around low-carbon solutions and create new opportunities for the emerging cleantech sector to commercialize and scale-up powerful new solutions.

Organization of the Report

The remainder of the report is organized as follows:

Survey of Cleantech Adoption in Canada. Section 2 of the report reviews the findings of Statistics Canada's 2014 Survey of Advanced Technology and provides an overview of the results from our 2016 Clean Technology Adoption Survey. The latter survey builds a broad understanding of current adoption practices in Canada, offering insights into why and how companies are making cleantech investments, the challenges firms are encountering, and the perceived barriers to future investment.

Case Studies. Section 3 of the report describes four domestic case studies of exemplary practices in cleantech innovation and adoption. The case studies highlight the value creation associated with smart investments in clean technology and illuminate how leading companies are overcoming the key challenges of transitioning to a low carbon economy. Several of the case studies also highlight instances where large Canadian firms, or consortia of firms, are providing cleantech SMEs with access to capital, opportunities to refine their offerings and facilitated entry into international markets.

Strategies for a Clean Growth Economy. Section 4 of the report summarizes our analysis with a focus on defining strategies for accelerating Canada's transition to an economy driven by clean growth. The analysis is divided into two parts. Part one provides strategic options for increasing the adoption of clean technologies by Canadian firms. The options discussed include actions that can be taken by the private sector and policy options that could be implemented by the federal and provincial levels of government. Part two provides strategic options for boosting growth and innovation in Canada's cleantech sector. While other works have focused on the role of government, our focus is on how corporate Canada can boost the cleantech sector's capacity to commercialize solutions for a low-carbon world.

Conclusions and Recommendations. Section 5 of the report includes an overview of our conclusions and a brief summary of the key recommendations.

2. Survey of Clean Technology Adoption in Canada

As acknowledged in the Vancouver Declaration, Canada's capacity to transition to a low-carbon economy depends, in large part, on a vigorous and sustained commitment by Canada's business community to leverage technology and innovation in pursuit of low-carbon solutions.[15] Indeed, the development and adoption of clean technologies by Canadian businesses will be among the most important drivers of improved environmental performance in the Canadian economy and of new economic opportunities and jobs for Canadians.

To date, however, there has been very little empirical data collected about the cleantech adoption practices of Canadian firms, with the notable exception of Statistics Canada's Survey of Advanced Technology. Last conducted in 2014, the periodic survey of 12,000 enterprises in Canada tracks the adoption of advanced technologies by small, medium and large enterprises (defined by employment), including four distinct classes of technology: business intelligence, logistics, design and fabrication, and clean technologies (although Statistics Canada uses the nomenclature 'green technology').[16] The following findings provide valuable context for interpreting the findings of our survey of clean technology adoption in Canada (see Table 1 for a detailed breakdown of the Statistics Canada data):

- **Canadian firms as a whole are late or reluctant adopters of clean technologies.** In fact, clean technology adoption was the lowest among the four classes of technologies tracked by Statistics Canada. Nearly half (43.3%) of all firms in Canada adopted advanced logistics technologies, while 38.4% adopted advanced design and fabrication technologies and 29.2% adopted business intelligence technologies. Clean technologies, on the other hand, were adopted by only 9.9% of firms in Canada.

- **As in other areas of advanced technology, cleantech adoption in Canada is highly concentrated among large enterprises.** Not surprisingly, larger enterprises are the most active adopters of advanced technologies. Specifically, 90.6% of large enterprises reported using three or more advanced technologies, a higher rate than that of medium-sized enterprises (76.4%) and small enterprises (56.4%). Although the rates of cleantech adoption are lower than those found in the other categories, the same firm size adoption pattern holds. Among all sectors, 15.4% of large firms adopted air or emissions technologies, 9.8% adopted energy technologies, 12.6% adopted water technologies and 17% adopted waster technologies.

15 Vancouver Declaration on Clean Growth and Climate Change, March 3, 2016. http://www.scics.gc.ca/english/conferences.asp?a=viewdocument&id=2401

16 Statistics Canada, Survey of Advanced Technology, 2014. See the following for a more comprehensive review of the survey findings: http://www.statcan.gc.ca/daily-quotidien/151211/dq151211b-eng.htm

2. Survey of Clean Technology Adoption in Canada

- **The utilities sector reported the highest overall rate of adoption of clean technologies,** with a quarter of all enterprises within this sector reporting the adoption of at least one advanced green technology. Mining, quarrying, and oil and gas extraction (16.1%), manufacturing (15.2%) and transportation and warehousing (14.8%) all reported similar clean technology adoption rates. Again, the adoption rates by large firms are significantly higher in these sectors. For example, roughly 40% of large utilities and resource extraction firms have adopted technologies to treat or conserve water, while technologies for reducing air pollution and GHG emissions have been adopted by 24% of large resource firms, 33% of large utilities, 23% of large manufacturers and 20% of large transportation and warehousing firms.

- **Waste management technologies were the most widely adopted clean technologies.** These include reduce, reuse, and recycle technologies, waste-to-energy technologies, waste-reduction technologies, hazardous-waste management and solid-waste management. In 2014, these types of clean technologies were adopted by 5.6% of all enterprises in Canada. Air, water and energy technologies were second, third and fourth respectively.

Table 1: **Statistics Canada Survey of Advanced Technology Adoption**

Air or Emission Technologies	All Firms	Large Firms (250 +)	Medium Firms (100-249)	Small Firms (10-99)
Forestry and Logging	5.7		13.6	5.6
Mining, Quarrying, and Oil & Gas Extraction	8.7	24.2	12	7
Utilities	14.2	33.4	30.1	9.3
Manufacturing	8.4	23.4	13	7.1
Wholesale Trade	2.4	4.9	7.3	2.1
Retail Trade	2.5	8.9	6.5	2.2
Transportation and Warehousing	12.2	19.9	15.2	11.8
Professional, Scientific and Technical Services	0.7	2.3	0	0.6
All Sectors	**4.6**	**15.4**	**9.2**	**4**

CONTINUED ON NEXT PAGE

2. Survey of Clean Technology Adoption in Canada

ENERGY TECHNOLOGIES				
Forestry and Logging	1.3		13.6	1.1
Mining, Quarrying, and Oil & Gas Extraction	5.9	22.2	6	4.4
Utilities	11.7	29.5	18.4	7.8
Manufacturing	3.6	15	6.9	2.6
Wholesale Trade	1.6	3.1	11.1	1
Retail Trade	3.2	4.4	3.5	3.1
Transportation and Warehousing	3.2	7.4	6.2	2.9
Professional, Scientific and Technical Services	0.8	2.5	0	0.8
All Sectors	**2.7**	**9.8**	**5.8**	**2**
WATER TECHNOLOGIES				
Forestry and Logging	0.2		13.6	0
Mining, Quarrying, and Oil & Gas Extraction	10.9	40.2	17.9	7.7
Utilities	13	41.4	5.9	8.5
Manufacturing	5.6	21.1	11.2	4.1
Wholesale Trade	2.6	1.1	7.5	2.4
Retail Trade	1.7	5.3	0	1.8
Transportation and Warehousing	2.6	2.6	1.4	2.7
Professional, Scientific and Technical Services	2.2	1.3	1	2.3
All Sectors	**3.1**	**12.6**	**5.7**	**2.6**
WASTE TECHNOLOGIES				
Forestry and Logging	1.9		13.6	1.7
Mining, Quarrying, and Oil & Gas Extraction	10	21	13	8.7
Utilities	10.9	35.1	5.9	6.9
Manufacturing	9.6	24.1	12.5	8.5
Wholesale Trade	3.9	10.7	11.5	3.3
Retail Trade	4.8	20.2	4.4	4.6
Transportation and Warehousing	4.8	6.3	3.2	4.8
Professional, Scientific and Technical Services	3.5	1.7	0.3	3.7
All Sectors	5.6	17	8	5.1

Source: Statistics Canada, Survey of Advanced Technology, 2014.[17]

17 Statistics Canada, Survey of Advanced Technology, 2014.

2. Survey of Clean Technology Adoption in Canada

Objectives of the Clean Technology Adoption Survey

While valuable for the breadth of its sample and for the comparison it provides across classes of technology, the Statistics Canada survey nevertheless leaves many questions unanswered. The survey, for example, does not probe the specific rationales that underlie firm-level decisions to invest or not invest in clean technology solutions. The broad aggregate data that is available can provide little insight into the factors that drive clean technology investment by early adopter firms or the benefits associated with adoption. Similarly, while existing data points to the late or reluctant adoption of clean technologies by Canadian firms, it is unable to explain existing barriers to investment and associated challenges with sourcing and implementation.

"The survey findings point to the importance of helping companies find creative ways to build a stronger business case for clean technology investments, by both clarifying and enhancing the potential benefits and working collaboratively at the product development stage to manage and contain associated costs."

These gaps in available data highlight the need to develop a better and more granular understanding of clean technology adoption in Canada. Crafting a coherent strategy to accelerate the transition towards a clean growth economy requires a better understanding of the types of clean technologies in which Canadian companies are investing; why and how companies are making these investments; and what challenges firms are facing. In service of these objectives, and in consultation with Canada's Department for Innovation, Science and Economic Development (ISED), the DEEP Centre designed and administered a fifteen question survey intended to illuminate broader trends in cleantech adoption practices in Canada and gather insights related to the benefits and challenges associated with sourcing and implementing clean technologies.

The survey findings – which focused particularly on early-adopter companies – highlight the central role played by cost-related factors in driving clean technology investment decisions. Among surveyed firms, a desire to reduce operating costs was identified as the most important motivating factor underlying investments in clean technology. At the same time, cost concerns were overwhelmingly identified as the most important barrier to clean technology investment. Taken together, these findings point to the importance of helping companies find creative ways to build a stronger business case for clean technology investments, by both clarifying and enhancing the potential benefits and working collaboratively at the product development stage to manage and contain associated costs.

Survey Sample and Questions

The population of firms targeted for the survey includes both Canadian-owned businesses and, to a lesser extent, foreign multinationals with significant operations in Canada. We targeted early adopters of clean technologies because our objective was to learn more about where and how companies are sourcing clean technologies and the benefits and the challenges associated with implementation. It is worth noting that our findings, which suggest relatively high rates of adoption, are not directly comparable to the Statistics Canada study given our explicit focus on a

population of firms known to have made some investments in clean technologies. By focusing on early adopters, however, our survey helps illuminate the factors that are driving clean technology investment, and the barriers that firms wishing to invest in this area continue to face.

Among the early adopters, our primary target group included large Canadian firms with annual revenues of $1billion or more in high-emitting sectors including construction, forestry, manufacturing, mining, oil and gas, transportation and utilities. In addition, the DEEP Centre worked with NRCAN, ISED and a number of industry associations to identify small and medium-sized adopters of clean technologies in the same target sectors. For the purposes of this survey, companies with $99 million in annual revenues or less were characterized as small firms. Companies with revenues of $100 - 999 million were characterized as medium-sized firms. Companies with annual revenues between $1 and 50 billion were characterized as large firms.

A total of 72 companies completed the survey between May and July 2016. The final sample includes a representative mix of small (33%), medium (25%) and large firms (42%) operating in a range of industries, with the bulk of participants engaged in manufacturing, power generation and mining, quarrying and oil and gas extraction. The actual distribution of firms is depicted in Tables 1 and 2.

Table 2: **Survey Respondents by Firm Size**

Annual Revenues	Number/Percentage of Respondents	
$0 - 9 million	15	21%
$10 - 49 million	5	7%
$50 - 99 million	4	6%
TOTAL SMALL FIRMS	**24**	**33%**
$100 - 249 million	10	14%
$250 - 499 million	6	8%
$500 - 999 million	2	3%
TOTAL MEDIUM FIRMS	**18**	**25%**
$1 - 2 billion	8	11%
$2 - 5 billion	9	13%
$5 - 10 billion	3	4%
$10 - 20 billion	5	7%
$20 - 50 billion	5	7%
TOTAL LARGE FIRMS	**30**	**42%**
Grand Total	**72**	**100%**

2. Survey of Clean Technology Adoption in Canada

Table 3: **Survey Respondents by Sector**

Sector	Percentage of Respondents
Manufacturing	34%
Mining, Quarrying, or Oil and Gas Extraction	17%
Utilities	13%
Other	8%
Professional, Scientific and/or Technical Services	7%
Transportation and Warehousing	6%
Agriculture, Forestry, Fishing or Hunting	6%
Construction	4%
Finance/Insurance	3%
Wholesale Trade	1%
Retail Trade	1%
Grand Total	**100%**

The questions posed to these companies included:

- Which technology areas has your company invested in over the past five years and what was the approximate value of those investments?
- How has your firm invested in clean technology (i.e., in-house development, technology licensing, partnerships with universities or SMEs, etc.) and where is the technology being sourced?
- Why did your company invest in clean technology and what economic and environmental benefits have been observed as a result?
- Has your firm encountered any challenges in sourcing and implementing clean technologies?
- What barriers, if any, are preventing your company from investing (or further investing) in clean technologies?
- Are there any government initiatives that would help facilitate greater adoption of clean technologies by your firm?

2. Survey of Clean Technology Adoption in Canada

Definitions and Limitations

For the purpose of this study, clean technologies are considered to be any process, product, or service that uses energy or other resources more efficiently compared to conventional technologies or services, and/or reduces environmental impacts. These include, but are not limited to, technologies related to renewable energy and fuels, energy efficiency, waste water management, emissions reduction, eco products and materials, and waste reduction, re-use and recycling.

As we began this survey process, however, it became clear from the feedback we received from participants that the centralized collection of data on cleantech investments was not necessarily commonplace. For large, complex companies, investments in cleantech solutions are frequently spread across multiple operating divisions and geographies, with no central mechanism for tracking investments across the company. The broad definition of clean technologies also proved problematic for some. While many companies have energy efficiency managers to track energy conservation efforts, for example, these individuals usually have limited visibility into investments in cleantech solutions designed to reduce waste and air pollution or remediate land and water resources. In some cases, the effort to extract comprehensive data about cleantech investments, and the related challenges and benefits, was significant and we are very appreciative for the investment of time and resources many of the participating companies made to complete the survey.

Survey Findings

As noted, our survey of clean technology adoption was designed to focus on a population of early adopters of clean technologies and to hone in on why and how companies are making these investments, the challenges firms are encountering, and the perceived barriers to future cleantech investment. Our key findings include the following observations:

- Across all firms in the sample, investments in energy efficiency are the most common with 81% of companies surveyed reporting investments in this area.
- A majority of firms (69%) are developing cleantech solutions in-house, with approximately half of the sample opting to purchase or license solutions and/or partner with cleantech SMEs or post-secondary institutions.
- Lowering operating costs is the principal motivation for most investments in clean technologies, while other factors included societal concerns about environmental sustainability and the opportunity for new revenue creation.

2. Survey of Clean Technology Adoption in Canada

- The most frequently cited environmental benefits of cleantech adoption are lower GHG emissions (83%) and increased energy efficiency (71%). In characterizing the economic benefits, firms cited reduced input costs, greater production efficiency, greater employee engagement, and new revenue creation as significant outcomes.

- Higher than expected costs associated with cleantech solutions was identified as the number one implementation challenge by participating firms. Nearly three-quarters (74%) of the sample indicated that the high costs of cleantech solutions is also the primary barrier to future investment.

These findings are described in detail below.

Clean Technology Investments Over the Past Five Years

Table 3 shows that 81% of participating companies have invested in energy efficiency enhancing technologies and processes over the past five years. Other key areas of investment include technologies to reduce water consumption and/or treat water (54%), renewable energy (51%) advanced materials and production processes with environmental benefits (49%) and technologies to reduce air pollution and greenhouse gas emissions (47%).

Table 4: **Cleantech Investments over the Past 5 Years**

Cleantech Investment Category	Percentage of Respondents
Energy Efficiency	81%
Water Consumption and/or Water Treatment	54%
Renewable Energy	51%
Advanced Materials and/or Production Processes that Achieve Environmental Benefits	49%
Air Purification and/or Emissions Reduction	47%
Waste Management Technologies	38%
Air, Water or Land Remediation Technologies	31%
Other	17%

Source: DEEP Centre, Clean Technology Adoption Survey, 2016.[18]

18 DEEP Centre, Clean Technology Adoption Survey, Conducted May to July 2016. Sample size = 72.

2. Survey of Clean Technology Adoption in Canada

Approach to Cleantech Adoption

Table 4 indicates that Canadian companies are using a variety of approaches to develop and adopt clean technologies, with a majority (69%) choosing to develop solutions in-house. Just over half of the sample have purchased or licensed solutions from a supplier (53%), while 54% of respondents have partnered with start-ups and post-secondary institutions to develop and adopt clean technologies. Parsing the sample by firm size reveals that small firms are significantly less likely purchase or license solutions from a supplier and tended to develop solutions in-house or partner with research organizations. Large firms, on the other hand, were more likely to either purchase or license solutions or develop them in-house.

Table 5: **Approach to Cleantech Development and Adoption**

Approach to Cleantech Adoption	Percentage of Respondents
In-House Development of New Solutions	69%
Investment and/or Partnership with Start-Ups Universities or Research Organizations	54%
Purchase or Licensing from Technology Supplier	53%

Source: DEEP Centre, Clean Technology Adoption Survey, 2016.[19]

Firms were also asked where they sourced their technologies. Just over half (51%) source their cleantech solutions both in Canada and abroad. Over a third (39%) of companies sourced their technologies solely from within Canada. Only 8% indicated that they sourced cleantech solutions exclusively from outside of Canada.

Reasons for Investing in Cleantech

Table 5 shows that firms' principal motivations for investing in clean technologies are a desire to reduce operating costs (76%) and as a means of responding to societal concerns about environmental sustainability (75%). However, 58% of the sample saw cleantech investments as means to generate new sources of revenue and company growth, and this was especially true for smaller firms in the sample. Investments by larger firms were most strongly motivated by potential costs savings and by a need to meet social expectations that companies implement environmentally sustainable business practices.

19 DEEP Centre, Clean Technology Adoption Survey, Conducted May to July 2016. Sample size = 72.

Table 6: **Reasons for Investing in Clean Technologies**

Reasons for Cleantech Adoption	Percentage of Respondents
Potential for Cost Savings	76%
Concern about Environmental Sustainability	75%
Potential for New Revenue Creation and/or Growth	58%
Concern about Changing Regulatory Environment	46%
Requests from Customers and/or Shareholders	43%
Other	21%

Source: DEEP Centre, Clean Technology Adoption Survey, 2016. [20]

Environmental and Economic Benefits of Adoption

Companies were asked to identify the environmental and economic benefits associated with their cleantech investments to date. Table 6 shows that a strong majority are seeing reduced GHG emissions (83%) and reduced energy consumption (71%). Half of sample have reduced other air pollutants, while just under half have reduced waste (46%) and water consumption (42%). Numerous respondents noted that their reductions in GHG emissions and other air pollutants were measured as net reductions in intensity rather than absolute volumes.

Table 7: **Environmental Benefits of Adopting Clean Technologies**

Environment Benefits of Cleantech Adoption	Percentage of Respondents
Reduced GHG Emissions	83%
Reduced Energy Consumption	71%
Reduced Other Air Emissions	51%
Reduced Waste	46%
Reduced Water Consumption	42%
Other (please specify)	22%
Reduced Land Use	21%
Water Pollution Remediation	10%
Land Pollution Remediation	6%

Source: DEEP Centre, Clean Technology Adoption Survey, 2016. [21]

20 DEEP Centre, Clean Technology Adoption Survey, Conducted May to July 2016. Sample size = 72.
21 DEEP Centre, Clean Technology Adoption Survey, Conducted May to July 2016. Sample size = 72.

2. Survey of Clean Technology Adoption in Canada

In characterizing the economic benefits of cleantech adoption, reduced input costs was the most common benefit and there was relative parity between the next 3 benefits, including increased production efficiency (46%), greater employee engagement (46%) and the creation of new products and services (44%). However, small firms (63%) were more likely to cite new products and services as the primary economic benefit, while large firms cite greater employee engagement (61%) and increased production efficiency (57%).

Table 8: **Economic Benefits of Adopting Clean Technologies**

Economic Benefits of Cleantech Adoption	Percentage of Respondents
Reduced Input Costs	54%
Increased Production Efficiency	46%
Greater Employee Engagement	46%
Creation of New Products/Services	44%
Improved Customer Response	31%
Other	21%

Source: DEEP Centre, Clean Technology Adoption Survey, 2016. [22]

Challenges in Sourcing or Implementing Clean Technologies

Companies were asked to provide a ranking of the challenges they had encountered in sourcing and implementing clean technologies. Higher than expected costs associated with implementing cleantech solutions was identified as the number one challenge by 39% of the sample. Other notable implementation challenges include difficulties integrating clean technologies into existing business processes (ranked #2 by 26% of the sample) and difficulties with implementation due to a lack of in-house skills (ranked #3 by 22% of the sample).

There are some noteworthy differences in the key challenges identified by the various sectors represented in the sample. Firms in the construction and transportation sectors, for example, cited a lack of acceptance of new technologies by management as the primary implementation challenge. Firms in the forestry sector, on the other hand, rank difficulty identifying suppliers of relevant clean technologies as the number one challenge.

22 DEEP Centre, Clean Technology Adoption Survey, Conducted May to July 2016. Sample size = 72.

Table 9A: **Implementation Challenges**

Difficulty Identifying Suppliers	
1	17%
2	8%
3	13%
4	10%
5	14%
N/A	28%
[blank]	10%
Total	**100%**

Source: DEEP Centre, Clean Technology Adoption Survey, 2016. [23]

Table 9B: **Implementation Challenges**

Difficulty Implementing Technologies Due to Lack of Skills/Training	
1	4%
2	18%
3	22%
4	17%
5	4%
N/A	28%
[blank]	7%
Total	**100%**

Source: DEEP Centre, Clean Technology Adoption Survey, 2016. [23]

Table 9C: **Implementation Challenges**

Difficulty Integrating Technologies Into Existing Business Processes	
1	13%
2	26%
3	17%
4	8%
5	3%
N/A	22%
[blank]	11%
Total	**100%**

Source: DEEP Centre, Clean Technology Adoption Survey, 2016. [23]

23 DEEP Centre, Clean Technology Adoption Survey, Conducted May to July 2016. Sample size = 72.

Table 9D: **Implementation Challenges**

Lack of Uptake/Acceptance of New Technologies Among Management		
1	15%	
2	15%	
3	15%	
4	8%	
5	11%	
N/A	29%	
[blank]	7%	
Total		

Source: DEEP Centre, Clean Technology Adoption Survey, 2016. [23]

Table 9E: **Implementation Challenges**

Higher Than Expected Costs		
1	39%	
2	12%	
3	4%	
4	18%	
5	7%	
N/A	19%	
[blank]	1%	
Total		

Source: DEEP Centre, Clean Technology Adoption Survey, 2016. [23]

Barriers to Investing in Cleantech

In describing the barriers to making further investments in clean technologies there is a very clear consensus, with nearly three-quarters (74%) of the sample indicating that the high costs of cleantech solutions is the number one obstacle to adoption. Other factors included a perception that clean technologies have no direct relevance to their business (33%), a perceived lack of regulatory pressure for adoption (31%) and a lack of knowledge about potential solutions (29%).

23 DEEP Centre, Clean Technology Adoption Survey, Conducted May to July 2016. Sample size = 72.

2. Survey of Clean Technology Adoption in Canada

Table 10: **Barriers to Cleantech Investment**

Barriers to Cleantech Adoption	Percentage of Respondents
Cost of Technology	74%
Lack of Direct Relevance to Business Model	33%
Lack of Regulatory Pressure	31%
Lack of Knowledge about Potential Technologies	29%
Other (please specify)	28%
Regulatory Constraints	19%
Lack of Implementation Skills	14%
Difficulty Identifying Suppliers	10%

Source: DEEP Centre, Clean Technology Adoption Survey, 2016. [24]

High costs and the "lack of convincing business case" for adoption figure most prominently in firms' perceptions of cleantech investment barriers. In the commentary on this question, for example, there were repeated references to the perceived lack of cost-effective solutions. Respondents frequently cited the difficulties justifying investments in clean technologies with low or long-term rates of return, particularly when such investments compete for internal capital with other technologies and measures with the potential to reduce costs, improve productivity and increase profitability. The results suggest that lowering the cost of clean technologies and helping companies frame a compelling business case for cleantech investment will be among the most important factors in driving up the adoption rate. The case studies featured in the next section highlight some novel strategies for addressing these issues and we return to the "business case" challenge in our recommendations for accelerating clean technology adoption.

24 DEEP Centre, Clean Technology Adoption Survey, Conducted May to July 2016. Sample size = 72.

3. Case Studies

The patterns of adoption activity in Canada highlighted by the survey results are just one element of a more complex and intriguing picture of the emerging ecosystem for cleantech innovation in Canada. The qualitative case study research conducted for the study allows for a more thorough probing of the strategies Canadian firms are deploying to make the transition to a clean growth economy. The four case studies selected for analysis highlight a variety of models for addressing environmental challenges and advancing cleantech innovation in three different industries: oil and gas extraction, forest products and construction.[25] The case studies include:

- **Canada's Oil Sands Innovation Alliance (COSIA),** an alliance of 13 oil sands producers focused on accelerating the pace of the industry's improvement in environmental performance through collaborative action and innovation. The case study demonstrates the value of pooling financial and intellectual capital to address fundamental innovation challenges that are shared across the member community.

- **Evok Innovations,** a cleantech investment fund seeking to increase the scale, diversity and quality of early-stage innovations focused on addressing some of the most pressing environmental and economic challenges facing the energy sector. The case study highlights a new approach to corporate venture capital in which the BC Cleantech CEO Alliance has joined forces with two leading energy companies to accelerate the commercialization of impactful energy solutions by connecting cleantech entrepreneurs with flexible capital, mentors and industry partners.

- **Domtar Corp,** one of the largest paper manufacturers in the world, whose cleantech initiatives are indicative of the efforts Canada's embattled forest sector is undertaking to reinvent itself as an innovative 21st century player in the emerging bio-economy. The case study documents Domtar's efforts to reach outside of the company, and often its own sector, to find partners and funding for path-breaking innovation projects that will lead to the discovery and commercialization of new forest-based bio products.

- **The Carbon Impact Initiative,** a cross-sector industry consortium working on low-carbon solutions for transforming the construction sector and supporting Canada's international obligations to meet its climate change targets. The case study reveals how a sector experiencing stagnating levels of productivity and innovation can rally around the need to respond to the new priorities society and the environment are placing on urban buildings and infrastructure.

25 The case studies documented in the report represent only fraction of the potential use cases that could impart valuable lessons for public and private sector leaders. As part of the survey, participating firms were asked if they would like to have their clean technology investments, projects or partnerships highlighted as a best practice in this report. Well over half (40 of the 72) of participating firms contributed projects for consideration.

3. Case Studies

Canada's Oil Sands Innovation Alliance (COSIA)

Of all of the sectors surveyed for this report, the environmental challenges facing Canada's energy sector are arguably the most acute and the most daunting. The environmental impacts of oil sands extraction, in particular, are the subject of intense national and international scrutiny and debate. After tens of billions of dollars of investment in rapidly expanding oil sands production over several decades, increasing greenhouse gas emissions are a major concern. So too are other known impacts, including intensive water use, the creation of tailings ponds and hundreds of square kilometers of strip-mining and drilling in the boreal forest.

"Industry leaders increasingly recognize that their ongoing role in satisfying the global energy demands of the future depends, in no small way, on the capacity Canada's energy sector to harness technological innovation to significantly lower its carbon intensity."

Industry leaders increasingly recognize that their ongoing role in satisfying the global energy demands of the future depends, in no small way, on the capacity Canada's energy sector to harness technological innovation to significantly lower its carbon intensity. Indeed, it's this very objective that spurred thirteen of the largest energy firms operating in Alberta's oil sands to join forces in pursuing a bold new approach to developing and adopting new technologies that will accelerate progress in addressing the industry's most vexing environmental challenges.

The Canada's Oil Sands Innovation Alliance (COSIA) is an alliance of 13 member companies which, combined, conduct more than 90% of oil sands production in Canada. This includes; BP Canada, Canadian Natural Resources Limited, Cenovus Energy Inc., ConocoPhillips Canada Resources Corp., Devon Canada Corporation, Imperial Oil, Nexen, Shell Canada Energy, Statoil Canada Ltd., Suncor Energy Inc., Syncrude Energy Inc., Total E&P Canada Ltd., and Teck Resources Limited. Established in 2012 COSIA brings oil sands companies together to cooperate in areas of research and development to expedite the pace of innovation by establishing binding legal agreements regarding the sharing of technologies and intellectual property between member companies. According to COSIA, member companies have shared 814 distinct technologies and innovations which cost more than $1.3 billion to develop.

At the time COSIA was established, it was among the first agreement of its kind anywhere in the world. Never before had an entire sector decided to cooperate rather than compete on the development of technologies with the potential to reshape the industry itself. However, two factors made collaboration an economic and environmental imperative.

First, COSIA member companies recognized that stakeholders were judging the industry's environmental performance collectively rather than individually. Just as a damaging environmental incident at one oil sands facility could cast suspicion on the sector as a whole, one company's investments in improving environmental performance – no matter how ambitious – could not insulate it from the environmental failures of others. In other words, the industry's poor reputation could only be repaired cooperatively.

3. Case Studies

Second, oil sands executives agreed that the scope and complexity of the challenges merited an investment of talent and resources that went well beyond the capabilities of a single company. Collaboration – both across the sector and with other stakeholders – could tap into greater ingenuity and deliver results faster and more cost effectively. Indeed, the rationale and resolve to collaborate around finding new efficiencies and breakthrough environmental technologies has strengthened in the wake of an economic environment that is much more challenging than it was at the outset in 2012.

With this collaborative structure in place, COSIA member companies have cast a wide net in search of solutions in four priority areas: water, land, tailings, and greenhouse gases. Within each of these priority areas, COSIA has established a series of joint venture agreements declaring what participating member companies want to accomplish (e.g. reducing water consumption by half) and specific performance objectives with time-bound metrics to measure improvements and progress.

To stimulate innovation, COSIA is holding innovation summits and conferences, establishing partnerships with academics, companies, governments, innovation funders and cleantech communities, and is even co-sponsoring a $20-million XPRIZE competition in which teams from around the world are competing to develop breakthrough technologies that convert CO2 into usable energy products.

Perhaps most interesting, however, is how COSIA manages the intellectual property its members develop together. COSIA's approach is premised on equitable contributions and equitable ownership rights. To achieve this, COSIA assigns a monetary value to all of the funding, time, and intellectual property contributed by member companies. Contributions are calculated and compared using a formula that weighs the size of each company's oil sands production, thus ensuring the largest producers are required to spend the largest amounts. According to Dan Wicklum, CEO of COSIA, this structure creates a "race to innovate" as companies work to keep up each other's innovation efforts.[26]

Some of COSIA's earliest successes have been achieved in addressing the industry's use of freshwater. In 2012 COSIA set two specific performance goals: to reduce freshwater use for in situ operations by 50 percent by 2022 and to reduce the net water use intensity from the Athabasca River and its tributaries in mining operations by 30 per cent by 2022. Just three years later COSIA announced that they had already achieved a 30 per cent reduction in water use intensity from the Athabasca River and they had reduced fresh water use intensity from in situ operations by 36 per cent.[27]

26 Interview with Dan Wicklum, conducted May 17, 2016.
27 "All About COSIA", COSIA, May 6, 2016.

3. Case Studies

COSIA has also enjoyed success in its efforts to transform tailings from waste into a resource that speeds land and water reclamation. Following significant investments in tailings technology Syncrude opened a $1.9 billion centrifuge to process tailings, which are waste products produced in the process of surface mining oil sands. The centrifuge spins the tailings, separating water from solid material. The water is recycled, and the solid material is used to reclaim disturbed land back into a functioning ecosystem. Syncrude subsequently shared their centrifuge intellectual property with other COSIA members. Shell Canada then adopted the Syncrude technology at its Jackpine site which meant they were able to start treating tailings using a proven technology much quicker and less expensively than otherwise would have been possible.[28]

"When global oil prices are low, innovation becomes more important. There is often a direct correlation between cutting costs and environmental performance. Becoming more efficient improves performance and decreases costs."

-- Dan Wicklum, CEO, COSIA

To speed the rate at which mined oil sands sites are returned to boreal forest, COSIA is funding two Biodiversity Conservation Chairs at the University of Alberta, while Cenovus has shared its technology for the SkyStrat airborne drilling rig (essentially a flying drilling rig) which eliminates the need to build new roads through the forest to access remote drilling locations. To reduce greenhouse gas emissions, COSIA is investing in the creation of molten carbonite fuel cells to generate electricity from captured carbon dioxide waste, and, in addition to the XPRIZE competition, it has also funded a pilot-project scale biorefinery to convert carbon dioxide into biofuel and biomass products.

These are only a select few examples of more than 242 projects currently being developed, tested, and implemented by COSIA member companies. Collectively, the industry collaboration model deployed by COSIA illustrates some important lessons for public and private sector leaders seeking to accelerate the development and adoption of clean technologies.

With the right structure for leadership and collaboration, challenging economics can be the seed of invention. For Canada's energy sector, plummeting oil prices have forced some companies to scale back R&D spending, but according to Wicklum the pressure to cut costs has led to a doubling down on the COSIA concept. "When global oil prices are low, innovation becomes more important," says Wicklum, who argues that, "there is often a direct correlation between cutting costs and environmental performance. Becoming more efficient improves performance and decreases costs."[29] Indeed, high oil prices arguably created a climate in which oil sands companies could afford not to innovate because their comparatively high cost production remained competitive. But only the most efficient producers will survive a prolonged drop in prices, a reality which helps shore up the business case for making joint investments in technologies that can deliver new efficiencies.

28 Interview with Dan Wicklum, conducted May 17, 2016.
29 Ibid.

3. Case Studies

"Open IP not only spreads the costs and risks of development, it expands the pool of talent that can participate in solving problems which produces a diversity of thought that, in turn, can lead to breakthrough results."

Sharing intellectual property paves the way for developing cost effective cleantech solutions. COSIA successes demonstrate that sharing responsibility for research and innovation is faster, more efficient and less risky than each firm going it alone. In fact, open IP not only spreads the costs and risks of development, it expands the pool of talent that can participate in solving problems which produces a diversity of thought that, in turn, can lead to breakthrough results. The Syncrude centrifuge and Cenovus SkyStrat drilling rig are two examples of how COSIA enables companies to share IP and expertise, which markedly accelerates the development and adoption of new technologies and technology improvements. However, such collaboration requires both leadership and an effective coordinating function to manage group interactions. Many of the projects that have been brought under the COSIA umbrella were proprietary technologies which would not have been shared with competitors in the absence of the work that COSIA performs to broker agreements between the member companies on what constitutes an equitable contribution to technology development. That COSIA has achieved such successes while involving an entire industry should not be discounted. Collaboration becomes more difficult as the number and diversity of participants grows. COSIA has achieved its successes by managing competing interests and ensuring that both costs and benefits are distributed as equitably as possible within the alliance.

COSIA's innovation concierge role provides a shared entry point for cleantech SMEs and efficient global technology scanning for members. Wicklum points out, for example, that an emerging cleantech firm can pilot its technologies with one alliance member and the results will be shared across all 13 members, which could potentially speed the path to successful commercialization. More broadly, COSIA scans the globe for promising technologies and thus provides its members with greater visibility into the ecosystem of cleantech capability in Canada and internationally. To that end, COSIA has signed agreements with a series of domestic and international innovation hubs that will act as intermediaries in screening ideas on behalf of its members and in helping to convey industry needs to researchers and entrepreneurs through a series of webinars and face-to-face events designed to drill down on particular innovation objectives. By clearly articulating and communicating innovation priorities to 3rd parties (including SMEs), and by providing a simple mechanism where 3rd parties can have their technologies assessed by all oil sands companies, good ideas are identified quickly, leading to quicker testing and potential adoption and diffusion across the whole oil sands sector.

3. Case Studies

Evok Innovations

The global shift towards renewable energy and cleaner, more efficient production methods is accelerating (averaging year-over-year growth of roughly 8 percent[30]) with businesses in just about every sector seeking to confront challenges such as resource scarcity, energy security and climate change. The good news for Canadian cleantech entrepreneurs is that the global market for clean technologies has surpassed $1-trillion and, up until 2014, growth in the clean technology sector in Canada has outpaced almost all other sectors. The bad news is that the Canadian cleantech sector saw revenue growth stall in 2014. In fact, the sector has been losing global market share as international competitors have been ramping up.[31] In an open letter sent to Prime Minister Trudeau, the BC Cleantech CEO Alliance highlighted that Canada has been the third greatest loser of market share since 2008 while facing increasingly intense competition from the United States, China, Germany, Singapore, and Israel.[32]

Among the Canadian industry's key challenges is a general reluctance by the investment community to fund capital-intensive clean-tech start-ups, and the slump in the oil and gas sector, which represents a key customer base for Canadian cleantech companies. Evok Innovations – a trilateral cleantech cross-sector partnership between Cenovus Energy, Suncor Energy and the BC Cleantech CEO Alliance –was created to address these gaps and thereby increase the scale, diversity and quality of early-stage cleantech ventures in Canada—ventures that can not only serve the domestic oil and gas industry, but compete head-to-head in international markets as well. At the same time, Evok Innovations is helping some of Canada's largest energy firms embrace a broader diversity of new innovations with greater speed and agility.

Launched in January of 2016 in Vancouver and headed by Silicon Valley veteran Marty Reed, Evok is a $100-million entrepreneur-led innovation fund that was created to expedite the development and commercialization of cleantech solutions to key issues facing the oil and gas industry. Evok is presently funded exclusively by its industry partners, Cenovus and Suncor, who have each committed up to $50-million for 10 years.

Evok has identified four key issue areas affecting the oil and gas sector: greenhouse gas emissions, water use, the harmful effects on marine and land ecosystems, and the need to deliver products with lower environmental impacts at lower costs. As a first step, Evok and its partners identified a series of pain points and technological gaps in the value chain to help focus the fund's investments. The next step was to make investments in new companies that can bring technologies to market that will alleviate those pain points. Reed, who is set to announce Evok's first round

30 Analytica Advisors, 2015 Canadian Clean Technology Industry Report
31 Ibid.
32 BC Cleantech CEO Alliance, Letter to Prime Minister Trudeau, February 29 2016

of deals in the Fall of 2016, says the investments will be spread across a mixture of what he describes as "low-hanging fruit" (e.g. technologies to boost industrial efficiencies, including predictive analytics and big data applications) and transformational technologies with the potential to radically reshape the energy sector.

Jonathan Rhone, a serial cleantech entrepreneur, CEO of Axine Water Technologies and co-founder of Evok Innovations, is keen to stress that there is much more to Evok than simply making investments in promising technologies and early stage companies. A fundamental success factor, according to Rhone, will be helping cleantech entrepreneurs access more opportunities to market their technologies and, in particular, to win that all-important first customer.[33] As Rhone knows from experience, the oil and gas sector in Canada is large, complex and difficult for new early stage companies to penetrate. The industry's sheer scale creates barriers to entry that can be nearly insurmountable for early stage entrepreneurs seeking to market new innovations to large energy firms. Scalability becomes perhaps the greatest barrier to entry and many innovators simply take their ideas to other sectors where the barriers are not so high. With Evok, entrepreneurs not only gain a visible and accessible entry point into the global energy value chain, in Cenovus and Suncor they also have two motivated customers who can help them better understand industry needs and give them feedback on unit economics, time to market and product performance specifications.

"The real value behind Evok is the conversations and the learning we have had together with tech entrepreneurs and oil and gas executives to figure out how we can work together and how each other's worlds work."

-- Jonathan Rhone, CEO, Axine Water Technologies

Rhone argues that this ongoing dialogue between cleantech entrepreneurs and the large integrated energy firms will be a vital driver of success going forward. "The real value behind Evok is the conversations and the learning we have had together with tech entrepreneurs and oil and gas executives to figure out how we can work together and how each other's worlds work,"[34] says Rhone. Judy Fairburn, Executive Vice President of Business Innovation at Cenovus and Evok co-founder agrees and says there are weekly calls between Cenovus and Evok and, perhaps more importantly, between the entrepreneurs working on new solutions and the technology and operations managers at Cenovus who will be responsible for implementation.

Perhaps the greatest challenge for Evok, however, will be helping its portfolio companies achieve the kind of scale required to make their solutions commercially relevant and internationally competitive. Both Rhone and Reed point out that Canada is a tough environment in which to reach scale. Rhone, who advises cleantech start-ups to seek out customers in the United States as early as possible, says, "Canadian corporations tend not to be early adopters, they are fast followers or late adopters, and in many cases they are laggards and the last to adopt technologies."[35] While Cenovus and Suncor are breaking the mould, they alone can't solve the scalability challenges facing cleantech entrepreneurs. Cenovus and Suncor

33 Interview with Jonathan Rhone conducted June 16, 2016.
34 Ibid.
35 Ibid.

are sensitive to the importance of scale and understand that for a technology to be commercially relevant it has to be adopted widely across the industry. That's one reason why Evok and its partners are not asking for exclusive rights to the technologies accelerated by their fund.

While it is still in the early stages, Evok Innovations is currently the only fund of its kind in Canada and there are a number of early lessons for the cleantech ecosystem.

Corporate-backed accelerators are the 2.0 model for corporate venture funds. A number of large Canadian firms have tried their hand at corporate venturing but enjoyed mixed success. As Marty Reed explains, "massive corporations are not very good at this type of work. You don't take a football player and put him on a baseball field."[36] Fairburn calls Evok "a 2.0 model for corporate venture capital" and observes that blending the experiences and competencies of the respective partners is a key differentiator in this new model. While Cenovus and Suncor provide capital, industry knowledge and opportunities for implementation, seasoned cleantech entrepreneurs are managing the business acceleration process and bring both deep domain expertise and an acute understanding of how cleantech start-ups can overcome the product development, marketing and sales challenges they face. Both Cenovus and Suncor have also been careful not to impose heavy-handed restrictions on the companies that receive funding from Evok. "We're in a collaboration economy," says Fairburn. "You can't put entrepreneurs in handcuffs or you won't get the best entrepreneurs coming to you."[37]

"At Evok we are knitting together the need to enable traditional industries with cleantech innovation and the need to empower entrepreneurs to commercialize and scale-up powerful new solutions."

-- Judy Fairburn, Executive Vice President of Business Innovation, Cenovus

Evok creates win-win scenarios for all stakeholders involved in commercializing and adopting cleantech solutions. Suncor and Cenovus gain access to a more diverse talent pool and much greater agility in their efforts to address economic and environmental challenges. And although neither Cenovus nor Suncor retains any exclusive rights to the technologies that are developed, Fairburn says being a partner in Evok provides early access to the pipeline of promising ideas and thus has the potential to dramatically speed up the rate at which Cenovus can make the transition to a zero-emissions model. Entrepreneurs, on the other hand, get access to all of the traditional elements of a classic business acceleration model (e.g., access to capital, product development support, mentorship and a peer network), but they get something else too: a clear pathway to implementation and big step forward in achieving scale by virtue of the fact that Cenovus and Suncor are large and willing adopters of high-impact solutions. Fairburn sums up the value exchange well: "At Evok we are knitting together the need to enable traditional industries with cleantech innovation and the need to empower entrepreneurs to commercialize and scale-up powerful new solutions."[38]

36 Interview with Marty Reed, conducted June 22, 2016.
37 Interview with Judy Fairburn, conducted July 7, 2016.
38 Ibid.

While Evok is bringing the two worlds of big industry and entrepreneurship closer together there is room for complementary partners, including government. Marty Reed is seeking a handful of additional industry partners, but there is space within the model for both government and the investment community to become syndicate partners as well. According to Reed, the fund will continue to place bets on transformative technologies and give its corporate partners an opportunity to be early investors and adopters. Bringing additional public and private investors into the fold, however, has the potential to mobilize the kind of large-scale funding required to build demonstration projects or construct "first-of-its-kind" manufacturing plants. Sharing the risk of building out new cleantech capabilities at an industrial scale would not only boost the global competitiveness of the cleantech sector, it would also accelerate technology adoption in Canada's resource intensive industries. The end result would be a cleaner and more competitive natural resources sector with all of the environmental and economic benefits such a shift entails.

Domtar Corporation

The economic and environmental challenges facing the forest products sector in Canada are not unlike those facing the other natural resource intensive sectors surveyed for this report. On the environmental front, Canada's forestry and forest products sector has gained international recognition for its advances in sustainable forestry practices and for its effort to lower its carbon intensity. However, much work remains to be done in pursuit of Canada's ambitious climate change commitments made at COP21 in Paris. On May 2, 2016, the forest products industry pledged to do its part by reducing its annual CO2 emissions by 30 megatonnes by 2030 — the equivalent of more than 13% of the Canadian government's emissions target.[39] Among the advances that will be required to succeed are forest management practices that can maximize carbon storage in the forest and spur the growth of trees, the development of forest-based bio products that can displace materials made from fossil fuels, and further efficiencies at mill sites.

On the economic front, the $20-billion-a-year forest products industry is in a long-term secular decline and under acute pressure to reinvent itself. While the sector still provides some 230,000 direct jobs and represents 1.2% of Canada's GDP, the industry's contributions to GDP declined steadily from 2005 to 2009 before stabilizing in 2010 thanks largely to a U.S.-led rebound in demand for solid wood products.[40] The decline has resulted in significant industry-wide pulp and paper capacity removal or repurposing and, in many cases, total facility closures. Indeed, a 2013 report by the DEEP Centre found that Canada has lost six billion-dollar forestry products companies since 2003 as a result of industry-wide consolidation and retrenchment.[41]

39 http://www.fpac.ca/forest-products-industry-launches-30-by-30-climate-change-challenge/
40 Natural Resources Canada, retrieved July 25, 2016, http://www.nrcan.gc.ca/node/16556.
41 DEEP Centre, "Canada's Billion Dollar Firms: Contributions, Challenges and Opportunities," July 2014. http://deepcentre.com/wordpress/wp-content/uploads/2014/07/DEEP-Centre-Canadas-Billion-Dollar-Firms-July-2014_ENG.pdf

3. Case Studies

The chief factor underlying this long-term malaise is the rise of an increasingly digital world that requires far fewer paper products—particularly products like newsprint that have long been critical to the Canadian pulp and paper subsector. The industry also faces competition from lower-cost producers in emerging markets and the need to upgrade an aging infrastructure built for a centuries-old industry.

This maelstrom of combined challenges has Canadian producers taking dramatic steps to carve out a win-win scenario—a scenario where they generate significant new revenue streams from environmentally-beneficial products and materials derived from one of Canada's most abundant resources. Domtar Corp, one of the largest paper manufacturers in the world, is indicative of the efforts Canada's embattled forest sector is undertaking to reinvent itself as an innovative 21st century player in the emerging bio-economy.

"Domtar Corp, one of the largest paper manufacturers in the world, is indicative of the efforts Canada's embattled forest sector is undertaking to reinvent itself as an innovative 21st century player in the emerging bio-economy."

After more than a century operating in Canada, Domtar runs 13 pulp and paper mills in Canada and the United States, employs nearly 10,000 people and generates $5-billion in revenue annually. Despite a comparatively healthy balance sheet, the company—like the broader forest products sector—operates on very thin profit margins and has trouble attracting private sector capital. After years of cutbacks, the company has also shed most of its internal R&D capacity—a trend mirrored by forest product companies around the world.

Thin margins, lightweight R&D capacity and limited access to capital are hardly a recipe for producing game-changing innovations in a commodity-based industry. Yet, for Domtar's pulp and paper division, innovation is not a choice but rather a matter of survival. Interestingly, virtually all of its current reinvention efforts are linked either to environmental improvements in its own operations or to the development of new products that will have environmental benefits for other sectors. Domtar believes that many of its existing facilities can be repurposed to develop new value-added fibre-based products like bio-fuels, bio-chemicals, organic acids, and biodegradable plastics. Existing facilities would, in effect, become integrated bio-refineries, allowing the company to produce a portfolio of products that maximizes overall value from the wood feedstock, including the energy required to manufacture the products produced there.

But, how can a company with tight constraints on capital, having downsized its R&D capacity, accomplish such a thorough and far-reaching transformation? According to Bruno Marcoccia, Domtar's head of research and development, the solution has been to reach outside of the company, and often its own sector, to find partners and funding for path-breaking innovation projects. Marcoccia refers to this process as "open innovation" whereby Domtar develops collaborative partnerships with government agencies, with universities, colleges, and research institutions, and

with end users. "We need to innovate and we need to change our products," says Marcoccia, "so the only sensible way out of that box is open innovation where you're dealing with a broader subset of experience and skills. Internal innovation didn't work, it was unaffordable, so we looked outside and realized we can get a lot more done and there's a lot more leveraging opportunities."[42] Domtar has had notably successful collaborations with the NRCan's Pulp and Paper Green Transformation program and the Investments in Forest Industry Transformation program, the Natural Sciences and Engineering Research Council of Canada, and over a dozen Canadian universities and colleges.

The flagship example of Domtar's new innovation strategy is their joint investment with FPInnovations (a Canadian not-for-profit organization specializing in forestry innovation research and technology transfer) in the CelluForce facility in Windsor, Quebec. CelluForce is the first facility in the world to manufacture wood-derived nanocrystal cellulose, a nanomaterial made from wood fibres that is lightweight, non-toxic, renewable, and eight times stronger than stainless steel. The potential commercial uses for this proprietary product span the aerospace, automotive, chemical and textile industries. The versatile material could even be deployed as a bio-composite for bone replacements and tooth repair. Given the risks attached to the technology (it has yet to be manufactured at an industrial scale), the joint venture between Domtar and FPInnovations would not have been feasible without financial support from the NRCan IFIT program and the Quebec provincial government.

The CelluForce facility in Quebec is but one of a number of facilities that Domtar has built through public partnerships that are producing first-of-its-kind bio products. Domtar's response to secular decline, and its strategy for repurposing many of its facilities to produce new forest-based bio products, highlights some of the potential opportunities for industries facing similar declines, and potential government responses.

Open innovation can lower R&D costs for sectors facing tight constraints on capital. Partnering with governmental agencies and postsecondary institutions is an excellent way for companies to make progress despite having limited access to R&D budgets and private capital. Moreover, an open innovation strategy connects companies with a much broader base of skilled practitioners than would have been possible if that strategy had been internalized. Research and postsecondary institutions have access to tremendous technical and academic experience and a research and experimentation infrastructure that would be too costly to create from scratch. Continued government support for targeted funding programs is critical to bringing companies together with the broader innovation infrastructure at Canadian research labs, universities and colleges.

42 Interview with Bruno Marcoccia, conducted July 7, 2016.

"We don't conduct 75% of our R&D in Canada for sentimental reasons. We do it because what we find is that strategic innovation in Canada provides us with better access to a robust innovation system and a rich array of resources, including people and research facilities, and better access to infrastructure, public policy and sponsorship programs."

-- Bruno Marcoccia, Director of Research and Development, Domtar Inc.

Canada's innovation ecosystem—including its diverse supports for R&D investment—is a key enabler of clean tech innovation and an important source of a competitive advantage for Domtar. While only 25% of Domtar's manufacturing capacity in based in Canada, the company conducts more than 75% of its research and development here. In fact, Domtar makes extensive use of both provincial and federal programs for activities across the innovation spectrum, ranging all the way from fundamental research at universities through to proof of concept and commercial development and demonstration projects. And, in contrast to much commentary, Domtar describes Canada's public supports for innovation (broadly defined) as considerably more effective for its purposes than those provided in the United States. "We don't [conduct 75% of our R&D in Canada] for sentimental reasons," says Marcoccia. "We do it because what we find is that strategic innovation in Canada provides us with better access to a robust innovation system and a rich array of resources, including people and research facilities, and better access to infrastructure, public policy and sponsorship programs."[43] Many of the investments Domtar makes are in early-stage proof-of-concept technologies and the discovery of new forest-based bio products that it hopes to commercialize. The initial investments in such discovery projects are usually relatively minor, often in the tens of thousands of dollars. Marcoccia notes that Canada has an abundance of programs to help fund projects of this size and, furthermore, that the speed and ease at which these programs come to funding decisions not only allows Domtar to take projects from inception to completion very quickly, but also to conduct many more projects than would be possible in the United States. For example, Domtar has utilized the NSERC Engage program repeatedly to connect with professors at Canadian universities with whom it can collaborate on small projects with funding of only $25,000. For a company seeking to reinvent itself by launching a portfolio of exploratory bets, this sort of micro financing for innovation could, in fact, hold the key to its long-term survival.

Carbon Impact Initiative

Our urban environment lies at the nexus of a number climate change related challenges. Although they cover less than 2 per cent of the Earth's surface, UN-Habitat estimates that cities consume 78 per cent of the world's energy and produce more than 60 per cent of all carbon dioxide.[44] At the same time, cities are uniquely vulnerable to the impacts of climate change. Over 80% of Canadians live in urban centres today and the large metropolitan areas surrounding cities like Montreal, Toronto and Vancouver will continue to grow, even as the density of cities increases. Many cities in Canada depend on infrastructure, like water and sewage systems, roads, bridges, and power plants, that is aging and in need of repair or replacement. Rising sea levels, storm surges, heat waves, and extreme weather events will compound these issues, stressing or even overwhelming these essential services.

43 Ibid.
44 http://unhabitat.org/urban-themes/climate-change/

3. Case Studies

The choices Canada makes in responding to growing urbanization and the need to expand and renew urban infrastructure will have a major bearing on our resilience to climate change. Public and private decisions regarding the design and regulation of transportation infrastructure and the built environment will also determine, to a large extent, how successful we are in reducing greenhouse gas emissions. Going forward, buildings will need to be much more efficient and utilize low-carbon materials; the energy cities draw will need to come from clean and renewable sources; and the transportation systems that move people and goods from A to B will need to harness the latest technologies to limit the use of fossil fuels and maximize efficiency.

"Net Zero Energy buildings will dramatically lower greenhouse gas emissions with technologies and materials that maximize the conservation of energy, produce as much energy as possible on site and only draw additional energy from local renewable sources when required."

The Carbon Impact Initiative is a good example of private sector leadership in responding to the new priorities society and the environment are placing on urban buildings and infrastructure. Spearheaded by EllisDon—one of Canada's largest construction companies—the newly formed industry-led consortium involves six other companies that are working together to develop industry solution with the potential to transform the construction sector while simultaneously supporting Canada's international obligations to meet its climate change targets. The other founding partners include BASF Canada, Enbridge Gas, Cricket Energy, WSP Group, the Cement Association of Canada and Cisco Systems.[45]

The action items announced in the Carbon Impact Initiative's action plan include a pilot project to design, build and operate a number of large-scale commercial buildings that produce net zero emissions; a commitment to developing a "Carbon Accounting Modeling Tool" allowing construction services companies to track greenhouse gas emissions and impacts in the field from project start to finish; and a promise to work with technology incubators and innovation hubs across Canada to test the performance of new technologies in the built environment and encourage the adoption of clean technology innovations by verifying their performance in the field. The partners in the Initiative will also review their own financing and investment strategies and create new funding models to support the adoption of new technologies such as a grants and loans database that clients can access for funding.

A priority for EllisDon is what the industry describes as "Net Zero Energy" buildings. According to the United Nations Environment Programme (UNEP), the construction, operations and ongoing maintenance of urban buildings alone generates 40% of the carbon emissions into our atmosphere.[46] Net Zero Energy buildings would dramatically lower these emissions with technologies and materials that maximize the conservation of energy, produce as much energy as possible on site and only draw additional energy from local renewable sources when required. Getting to the point where a significant proportion of the built environment will produce net

45 http://www.lowcarbonagenda.ellisdon.com/lowcarbon.html
46 "Buildings and Climate Change," Sustainable Buildings and Climate Change Initiative, UNEP, 2009. http://www.unep.org/sbci/pdfs/SBCI-BCCSummary.pdf

zero energy, however, will require a massive, multi-stakeholder effort. For example: building codes will need to require higher standards; innovative lifecycle financing models will need to incent building owners to pursue sustainable, low-carbon approaches; construction companies will need to invent and incorporate greener building materials; building operators will need to harness smart building technologies that deliver comprehensive analytics and automatically conserve the use of resources like water and energy.

Some of these changes will take years to work their way through Canadian institutions and firms. In the meantime, Net Zero Energy pilot projects led by the Carbon Impact Initiative can demonstrate how new approaches can dramatically lower carbon output during building construction and operation. As part of the process, Initiative members will be working with cleantech innovators to test and verify the performance of new technologies, materials and processes that can improve the environmental performance of large, commercial buildings. For example, digital sensors, intelligent machines, mobile devices, and new software applications that increase efficiency will be applied across the design, build and operational phases of building construction and maintenance. Clean technologies, including green construction materials and renewable energy technologies, will also be incorporated. According to industry leaders, building confidence that new products, materials and processes will perform to industry expectations is vital to encouraging the broader adoption of these technologies into buildings and infrastructure.

The Carbon Impact Initiative shows what stands to be accomplished through collaboration when traditional industries work together with emerging cleantech suppliers to develop and adopt sustainable, low carbon solutions. While the Initiative is in the early stages and will need to be judged on its results rather than its promises, there are lessons for other sectors and for the Government of Canada.

Industries with long technology lifecycles struggle with cleantech innovation and adoption. As compared to industries such as software and consumer electronics, innovation cycles in the construction sector are sclerotic and the industry as a whole has been slow to adopt new technologies. The waves of digital upheaval and disruption seen in other sectors have largely bypassed what construction insiders describe as a conservative industry that is reticent to adopt unproven methods. As a result, industry productivity has stagnated over the past 40 years—or in some cases, even declined.[47] A challenge for the sector, as the Carbon Impact Initiative points out, is the expected service lifespan for the materials and technologies integrated into buildings.[48] Whereas the underlying technologies in consumer electronics and automotives are replaced every two to five years, buildings and infrastructure are built to last decades. Cost is a factor as well, particularly when new materials and technologies can cost multiples of the established options. A

47 "What's the future of the construction industry?" World Economic Forum, April 4, 2016. https://www.weforum.org/agenda/2016/04/building-in-the-fourth-industrial-revolution/

48 The Carbon Impact Initiative: An Industry-Led Action Plan in Support of Canada's International Climate Change Commitments, EllisDon, June 15, 2016.

number of the strategies being deployed by the Initiative are designed to address both the supply and demand side of these challenges. The commitment to engage with cleantech incubators and innovation hubs, for example, will see companies such as EllisDon working directly with cleantech firms to minimize costs, verify performance and develop robust market entry strategies for new technologies. New carbon accounting and project financing models, on the other, will also help on the demand side by allowing end users to factor the full lifecycle savings from new technologies into the upfront cost of acquiring them.

"There is a short time frame, starting now, to get in front of opportunities, or we risk falling behind the pace of change. If federal and provincial governments are committing Canada to participate in international emission reduction targets, industry will bear the brunt of the responsibility to meet them."

-- Andrew Bowerbank, Global Director of Sustainable Building Services, EllisDon

If the government sets the direction for the economy, then private companies can act as the engine that helps get to that destination. Indeed, having set firm and ambitious targets at COP21 in Paris, EllisDon's global director of sustainable building services, Andrew Bowerbank, suggests that it is imperative that "industry leaders understand the magnitude this commitment and what will be expected of us." "There is a short time frame, starting now," he continues, "to get in front of opportunities, or we risk falling behind the pace of change. If federal and provincial governments are committing Canada to participate in international emission reduction targets, industry will bear the brunt of the responsibility to meet them."[49] In addition to setting direction, however, governments will also need to give slow-moving moving sectors like construction an additional nudge along the path to a clean growth economy. Improved regulatory frameworks (including green building standards), a price on carbon and supports for technology development and adoption are among the tools and incentives the sector needs to move forward. With a policy framework in place, the Carbon Impact Initiative shows that some of the largest and most bankable companies in Canada can come together and reach a consensus on what must be done to move Canada toward a low carbon economy.

Cross sector collaborations are uniquely positioned to break down sector silos and offer leadership on complex problems like adapting our urban environments to address climate change. Although the Carbon Impact Initiative is focused on transforming the building construction sector, the collaboration brings policymakers and regulators together companies with specialties ranging from energy distribution to information technology to engineering services. In this sense, the Carbon Impact Initiative differs from COSIA, given the latter's vertical focus on addressing the environmental challenges of the oil sands industry. One model is not better than the other, but only a cross-sector approach can bring together the diverse competencies required to make headway on complex and interdependent issues like renewing urban infrastructure and building greener cities.

49 Andrew Bowerbank, "Shifting markets towards a low-carbon economy," The Carbon Impact Initiative: An Industry-Led Action Plan In Support of Canada's International Climate Change Commitments, EllisDon, June 15, 2016.

4. Strategies for a Clean Growth Economy

The Intergovernmental Panel on Climate Change (IPCC) has reported that global carbon dioxide emissions must be reduced by 40 to 70% below 2010 levels by 2050 in order to cap the rise in average temperatures at 2°C or less.[50] To achieve this will require the development and application of a broad range of low-carbon technologies at a scale and rate far greater than current efforts. Some of the changes include dramatic improvements in the energy efficiency of products, including the processes to make them; shifting to renewable and recyclable materials; increasing transportation efficiency and the adoption of electric vehicles; and running commercial buildings and corporate facilities using clean energy sources. According to the IPCC and the OECD, the bulk of this low-carbon re-industrialization must occur within the next two decades—much faster than previous industrial transformations such as the transition to steam power and electricity.[51]

"While growing markets will lower clean technology costs and create new opportunities for Canadian firms, Canada will lose out in the global cleantech innovation race if our domestic adoption of clean technology fails to keep pace with key international competitors."

The transition to a global clean growth economy is generating increasingly fierce competition for leadership of the $1-trillion cleantech market—a market which is expected to expand rapidly as countries ramp up efforts to reduce their reliance on fossil fuels and adjust to the impacts of climate change. The clear signals of China's green intent, for example, are indicative of a growing innovation race: it wants to lead the world in developing new cleantech industries and is beginning to tackle its domestic energy dilemma with the same gusto and muscle that transformed its agrarian economy into a global manufacturing powerhouse overnight. In the last five years China has caught up to the EU on per capita investment in clean energy and overtaken the EU on renewable energy build rates, R&D spending, power transmission grids and electric vehicles.[52] In a new 5-year plan published in March 2016, China announced that it plans to more than double its wind energy capacity, nearly triple its solar capacity, and increase electric vehicles by a factor of 10—a pace of cleantech deployment that far outstrips any other country.[53]

While growing markets will lower clean technology costs and create new opportunities for Canadian firms, Canada will lose out in the global cleantech innovation race if our domestic adoption of clean technology fails to keep pace with key international competitors. The survey results for this study suggest that a handful of Canadian cleantech adoption leaders are emerging. However, the broader Statistics Canada analysis of domestic cleantech investment reveals that overall pace of adoption is far below what's required to meet Canada's international obligations, let alone position Canada as a leader in the low carbon economy of the future.

Our analysis of strategic options for accelerating Canada's transition to a clean growth economy is divided into two complementary parts:

50 Climate Change 2014 Synthesis Report, (Geneva: IPPC, 2014). https://www.ipcc.ch/pdf/assessment-report/ar5/syr/AR5_SYR_FINAL_SPM.pdf
51 OECD Environmental Outlook to 2050 (Paris: OECD, 2011). https://www.oecd.org/env/cc/49082173.pdf
52 Shinwei Ng, Nick Mabey, Jonathan Gaventa, "Pulling Ahead On Clean Technology China's 13th Five Year Plan Challenges Europe's Low Carbon Competitiveness," E3G Briefing Paper, March 2016.
53 Ibid.

4. Strategies for a Clean Growth Economy

- **Strategic options for increasing the adoption of clean technologies.** First, we focus on what Canada can do to foster the demand side for cleantech innovation. The recommendations include a list of ten actions that private and public sector leaders can take to increase the adoption of clean technologies.

- **Strategic options for boosting growth and innovation in the cleantech sector.** The second section provides options for strengthening the commercialization capacity of Canada's cleantech sector. Our focus is on actions Corporate Canada can take, and thus complements other works which focus principally on the enabling role of government.

"We need to recognize that advancements in new technologies are changing our industry at a rapid pace. We also need to be part of the change by investing in cleantech development, incubating new ideas and methodologies, and hiring industry innovators,"

-- Geoff Smith, CEO of EllisDon

Accelerating the Adoption of Clean Technologies

While Canada is not leading the world in cleantech adoption, a growing number Canada's corporate champions are striving to address the environmental and economic challenges in front of them. "We need to recognize that advancements in new technologies are changing our industry at a rapid pace," says Geoff Smith, CEO of EllisDon.[54] "We need to be part of the change by investing in cleantech development, incubating new ideas and methodologies, and hiring industry innovators," he says.[55] Suncor and Cenovus recruited a Silicon Valley entrepreneur to lead Evok Innovations because they wanted someone who, in Judy Fairburn's words, "would accelerate our path forward in addressing our economic and environmental challenges because he understands disruptive technologies and sees the exponential pace of change in other parts of the energy sector."[56] Fairburn thinks many industries are underestimating the pace of change and she encourages her peers to think long and hard about whether their firm is going to be the next Kodak. "When you've got big hardware," says Fairburn, "changes aren't made overnight."[57]

Acknowledgement of the problem may be the first step toward a solution. However, given the pace of change—and the ambitions of international players such as China—key sectors such as resource extraction, power generation, manufacturing, transportation, construction and agriculture will need to redouble their cleantech innovation efforts in the years ahead. In light of the challenges and obstacles identified in the survey and case study research, these industries will also need support to make the necessary adjustments.

What specifically should Canada do to accelerate the adoption of clean technologies and hasten the transition to a clean growth economy? The recommendations discussed below are aimed at addressing the primary obstacles to investment in clean technologies, namely the high costs and perceived risks associated with adopting new technologies.

54 Geoff Smith quoted in: The Carbon Impact Initiative: An Industry-Led Action Plan in Support of Canada's International Climate Change Commitments, EllisDon, June 15, 2016.
55 Ibid.
56 Op. cit., Fairburn.
57 Op. cit., Fairburn

4. Strategies for a Clean Growth Economy

1. **De-Risk Clean Technology Adoption**

   Given Canada's reputation for risk aversion, it is perhaps not surprising that the most common refrain from executives who participated in the study is that clean technologies need "de-risking." To be fair, deployments of cleantech solutions are often capital-intensive, requiring large sums of human and financial capital to achieve even a single deployment. Large adopters are understandably weary of shouldering these costs on their own, particularly when the benefits of a given technology have not been demonstrated at an industrial scale. Calls for assistance in de-risking such deployments are not unreasonable given analogous efforts in China, across Europe and at the state-level in the United States. Executives at cleantech firms and large adopters alike suggest that support can come in several forms, ranging from efforts of industry consortia to share the costs piloting new technologies to new government-backed financing mechanisms that would share the risk of large scale demonstration projects and building out manufacturing capacity.

   In the realm of industry-led solutions, the Carbon Impact Initiative's Net Zero Energy building pilot projects will test and verify the performance of new technologies, materials and processes that can improve the environmental performance of large, commercial buildings. Such demonstrations will build confidence that new products, materials and processes will perform to industry expectations and thus encourage the broader adoption of these technologies into buildings and infrastructure. Other innovations include COSIA's shared product testing process whereby the results of pilot projects conducted with one alliance member are shared across all 13 members, which could increase the speed at which high-impact solutions are widely adopted.

2. **Expand the Market Through Public Procurement and Funding for Demonstration Projects**

   Government can also play a significant role in de-risking technology adoption through public procurement and by helping to fund large-scale demonstration projects. Acquiring the large investments to demonstrate the viability of clean technologies and build first-of-its-kind manufacturing facilities to produce them has been the Achilles heel of the cleantech sector. Banks and institutional investors have deemed such investments too risky, thus largely depriving the sector of the debt financing it needs to overcome a crucial commercialization hurdle. The Canada Cleantech Alliance has issued a number of recommendations aimed at closing this financing gap, which include bolstering federal

funds for the Sustainable Development Technology Canada (SDTC) and creating a loan guarantee program that would guarantee a portion of project debt and reduce the risk for banks.[58] Sharing the risk of building out new cleantech capabilities at an industrial scale would accelerate technology adoption by eliminating product performance uncertainties for early adopters. It would also boost the global competitiveness of Canada's cleantech sector by matching similar funding opportunities in countries such as Switzerland and the United States.

The provincial and federal levels of government can further expand the domestic market for clean technologies by becoming early adoption partners themselves. As the Canada Cleantech Alliance notes, Canada's federal, provincial and territorial governments own and operate one of the nation's largest networks of buildings, transportation fleets, ports and other infrastructure that will require retooling to meet greenhouse gas reduction goals.[59] Publicly procuring clean technologies would not only hasten progress towards meeting Canada's climate goals, it would also strengthen the business case for private sector adoption by demonstrating the potential of such technologies at scale.

"44 per cent of the companies surveyed for this study are positioning their investments in clean technology as an opportunity to launch new product lines and win new markets in a low-carbon economy."

3. **Reposition Cleantech Investments as an Opportunity to Reinvent Traditional Industries**

There is a tendency across corporate Canada to view clean technology as an investment in reducing operating costs and making incremental improvements in environmental performance—investments that will only be made once the ROI has been proven. However, 44 per cent of the companies surveyed for this study are positioning their investments in clean technology as an opportunity to launch new product lines and win new markets in a low-carbon economy.[60] In other words, these firms are positioning their investments in cleantech as an exercise in fundamentally redefining their companies.

In this sense, Domtar's investments in emerging technologies and new product development are a good example of the broader forest products sector's efforts to generate greater economic value from a much broader range of products and processes than traditional milling and pulping. Collectively, the sector has the potential to diversify its product lines, contribute to revolutionary environmental advances and significantly increase its overall productivity by generating additional revenue streams from each log harvested.

58 Canada Cleantech Alliance for a Sustainable and Prosperous Future, "Submission to the Federal-Provincial Territorial Working Group on Clean Technology Innovation and Jobs." June 10, 2016.
59 Ibid.
60 DEEP Centre, Clean Technology Adoption Survey, Conducted May to July 2016. Sample size = 72.

The Carbon Impact Initiative heralds a similar potential for its founding partners in the construction sector. As net-zero emissions buildings and infrastructure become the way of the future, companies like EllisDon have an opportunity to offer complementary products and services in clean energy technologies and smart building automation solutions. Ultimately, the company's leadership in the Carbon Impact Initiative could help it entirely redefine what it means to be a full service construction company. As Geoff Smith put it, "Our [low carbon agenda] refers to our changing role in the world, and our growing determination to lead change, rather than merely anticipate it."[61]

4. **Build New Market Opportunities and Value Chains Around Cleantech Offerings**

For traditional industries, one of the greatest challenges in seizing new opportunities in a low-carbon economy will be building the value chains required to tap new markets. As Domtar has learned, doing the lab work to discover revolutionary materials like nanocrystalline cellulose is only a half-step towards realizing new market opportunities. The other half is developing a market for the specialty fibres, materials and bio-fuels the forest products industry sees as its future. Essentially, companies like Domtar face the challenge of creating whole new markets from scratch. Domtar's clientele has historically been banks, schools, newspapers and the paper-intensive offices of the past. Its customers of the future might be robotics companies, the aerospace sector, or manufacturers of fibre optics. The company's capacity to transition from one value chain to another will be the differentiator between success and failure.

Is there an opportunity here for governments to act as a broker in establishing new markets and new value chain relationships? Bruno Marcoccia of Domtar suggests that stronger incentives for cleantech adoption would be helpful given that most of the new products the industry is working on have environmental benefits, particularly those that act as substitutes for fossil fuel precursors. Even more helpful, according to Marcoccia, "would be to have end users and potential customers at the table when we are developing a new product."[62] And it is here that companies like Domtar—and others across Canada—can learn from the kind of work COSIA and Evok Innovations are doing to foster value chain relationships that will accelerate the commercialization and adoption of clean technologies.

61 Op. cit., Smith.
62 Interview with Bruno Marcoccia, conducted July 7, 2016.

5. **Set an Ambitious Clean Growth Mandate with Executive Leadership**

Companies on a pathway to reinvention need an executive mandate from the very top. Indeed, even if a company's goal is to achieve incremental improvements in environmental performance, a commitment to action from executive leaders is required to ensure that financial resources and top talent are dedicated to achieving environmental objectives. Successful technology adoption starts with leadership at the top," says Judy Fairburn of Cenovus. "You need to set an enterprise goal—an affordable zero emissions goal—and you need to have leaders at the very top stand behind the goal."[63] Initiatives like NRG COSIA Carbon XPRIZE, Evok Innovations and the Carbon Impact Initiative represent pretty fundamental shifts in industry norms and behaviour—none of which would have happened without Geoff Smith at EllisDon, Steve Williams at Suncor or Brian Ferguson at Cenovus making such initiatives a priority. Fairburn insists that companies also need granular performance goals and must reward their employees for achieving them, just as they do in other parts of their business. "You need performance metrics towards zero emissions or you won't have people motivated to get to that goal," says Fairburn.[64]

6. **Use Industry Consortia to Lower the Cost and Increase the Pace of Innovation**

With higher than expected costs an overriding factor shaping cleantech investment decisions, industry collaborations such the Carbon Impact Initiative and COSIA can pool the knowledge and investments required to move quickly and decisively in preparing for the new economic and environmental realities that a global low carbon economy will bring. "Whenever there is a fear around adoption, or a fear around something new, it is a lot easier for leaders of companies to band together," says Jonathan Rhone of Axine Water Technologies.[65] In fact, the 2016 Global Innovation Barometer suggests the appetite for such collaborations is on the rise in Canada. Conducted by General Electric, the survey found that 75% of Canadian executives are open to sharing revenue streams and revenue losses from collaborative activities, and 86% responded that collaborative activities have helped increase revenues for their companies, a 25% increase from 2015, and a 37% increase from 2014.[66] The widespread support for collaboration bodes well for cleantech adoption, which often requires companies to step out of their comfort zones and make investments in costly technologies with long-term horizons. However, if collaborative innovation models can work well in the oil patch or in the construction sector, then other

63 Op. cit., Fairburn.
64 Ibid
65 Interview with Jonathan Rhone conducted June 16, 2016.
66 GE Global Innovation Barometer 2016, http://www.gereports.com/innovation-barometer-2016/

industries in Canada should feel emboldened to follow suit. Indeed, when market conditions are tough, collaborative industry ventures make even more sense.

7. **Create Vertically-Focused and Industry-Supported Cleantech Acceleration Models**

Porting industry-backed investment and acceleration models like Evok Innovations to other natural resource sectors could help position industries such as forest products, mining, fisheries and agriculture as world leaders in cleantech innovation and sustainability. For sectors where the pace of innovation has traditionally been slow and incremental, a structured process for engaging with early-stage start-ups can provide exposure to breakthrough ideas and build a pipeline of new innovation opportunities that would otherwise be difficult for companies to replicate internally. For cleantech firms, business acceleration partnerships with large adopters can give entrepreneurs access to the deep domain expertise required to build a scalable solution that meet validated industry needs. For example, cleantech entrepreneurs can work directly with the engineering and operations teams at large companies to optimize product performance and minimize costs during the product development phase.

"Porting industry-backed investment and acceleration models like Evok Innovations to other natural resource sectors could help position industries such as forest products, mining, fisheries and agriculture as world leaders in cleantech innovation and sustainability."

While growing in Canada, corporate partnerships with innovation hubs and business accelerators are comparatively nascent when measured against the partnership activities present in countries such as Germany, the United Kingdom and the United States.[67] Indeed, many top international firms are either highly engaged in a variety of third-party accelerators and venture capital funds or running their own accelerators as an extension of their corporate innovation strategies. Leading innovation hubs such as Communitech and MaRS now host resident innovation teams from a number of Canada's largest firms and offer these corporate partners customized programming and curated access to their networks of supported firms. However, the focus of these engagements is largely confined to digital technologies and life sciences, with Evok Innovations the only cleantech investment fund in Canada with substantive participation from the energy sector.

While commodity-based industries cite tight margins, capital constraints and slow product cycles as obstacles to innovation, vertically-focused business accelerators backed by industry partners represent a relatively low-cost option for placing a variety of small bets on technologies and entrepreneurs that can unleash new opportunities

67 DEEP Centre, "Global Best Practices in Business Acceleration: Charting the Evolution and Performance of the World's Leading Accelerators." http://deepcentre.com/wordpress/wp-content/uploads/2015/10/DEEP-Centre-BABI-4-Global-Best-Practices-in-Acceleration-September-20151.pdf

for achieving enhanced growth and competitiveness. Evok co-founder Jonathan Rhone suggests starting point for replicating the Evok Innovations model in other industries is for leading firms in these sectors to agree to put some money on the table to fix a shared set of industry pain points. "If the leadership of these sectors thinks innovation is important—and is prepared to invest to find technologies to positively disrupt their businesses while improving environmental performance, efficiency and cost—then the Evok model provides a powerful mechanism for accelerating the development and adoption of impactful solutions," says Rhone.[68]

"The growing importance of open innovation is reflected in the fact that 54% percent of survey respondents indicated that third parties, (including SMEs and postsecondary institutions) play an important or very important role in cleantech innovation, research and development."

8. **Tap External Talent and Resources Through Open Innovation**

Partnering with governmental agencies and postsecondary institutions is a smart and efficient way for companies to accelerate cleantech innovation, particularly for companies with limited access to internal R&D capacity. By opening up the innovation process, companies can connect with a much broader base of skilled practitioners and leverage research and experimentation infrastructures at postsecondary institutions that would be too costly to create from scratch. The growing importance of open innovation is reflected in the fact that 54% percent of survey respondents contacted for this study indicated that third parties, (including SMEs and postsecondary institutions) play an important or very important role in cleantech innovation, research and development.[69]

Succeeding with open innovation, however, means engaging with a diverse innovation ecosystem and working hard to become an attractive collaborator. It's a challenge that "old-economy" firms like Domtar face: making themselves appealing partners for the world's smartest minds—the kind of talent coveted by innovation-hungry companies around the globe. "The way we make ourselves the preferred enabler is by being quick and ready to engage: we are open to discussions with all types of technology providers and in many cases start-up companies," says Domtar's Bruno Marcoccia. "We also are quick to make decisions on projects, and we have a reputation for effective innovation leadership and project execution."[70]

According to Marcoccia, the innovation funding programs at NSERC and NRCAN provide a perfect complement to Domtar's collaborative approach to cleantech innovation. Domtar's strategy for maximizing engagement with the research community is to place a portfolio of small bets before committing serious resources. Programs like NSERC

68 Op. cit., Rhone.
69 DEEP Centre, Clean Technology Adoption Survey, Conducted May to July 2016. Sample size = 72.
70 Op. cit., Marcoccia.

Engage provide the initial seed funding to discover new forest-based bio products develop early-stage proof-of-concept technologies in collaboration with the research community. "The basic idea is to operate with parallel efforts, which limit risk and exposure," says Marcoccia. "But once we identify a winning innovation, we move quickly to create platforms that we can launch major new initiatives from and build up organically from there."[71]

9. **Use Strategic Regulations as a Driver for Cleantech Innovation and Adoption**

Regulation is an important tool for creating an incentive for businesses to pull clean technologies into the market. A price on carbon – through a carbon tax of a cap-and-trade system – not only provides a financial incentive for industry adoption, the revenues from carbon pricing mechanisms or auctioned allocation credits can also be used to further the development and adoption of clean technologies. Other environmental regulations, including water quality/protection, soil quality, waste, and other airborne emissions standards are set by federal, provincial and territorial governments, as well as municipalities, and can help drive the development and adoption of clean technologies.

Interestingly, there was a consistent view among the sample of firms surveyed that Canada's regulatory frameworks are not only lagging other jurisdictions (particularly those in Europe), but failing to keep pace with the development of new technologies and failing to provide adequate incentives for investment. Some respondents were quite blunt in their assessment, indicating that a lack of regulatory pressure was a leading reason for not making further investments in clean technologies. In the energy sector, strategic regulations, like the Alberta climate policy, were described by one executive as "a stick to enable the carrot," without which it would be hard for firms to justify significant investments in the technologies and operational improvements required to reduce greenhouse gas emissions.

Leading companies, on the other hand, are concerned about being undercut by competitors who have not yet borne the cost of investing in technologies to improve environmental performance. The early adopters of technologies, in particular, would like regulatory frameworks strengthened in order to create a level playing field. In other cases, companies noted that higher regulatory standards and performance goals will be required to nudge their customers towards cleaner solutions. The Carbon Impact Initiative, for example, highlights the need

71 Ibid.

for green building standards to accelerate the adoption of renewable energy technologies and mandate the use of more efficient building materials. In construction sector, the owners of large commercial buildings, rather than the builders, must be convinced to make the upfront investments in energy-saving materials and technologies.

However, in modernizing Canada's environmental regulatory regimes, companies want regulatory solutions that are streamlined, clear, consistent and long-term. There is a strong preference for national frameworks over a patchwork of provincial approaches, and for North American frameworks where possible. There is also a preference for performance-based regimes rather than overly stringent or prescriptive regulations that mandate the use of particular technologies and/or eliminate any scope for innovation in how companies comply with regulatory expectations. Finally, companies want provinces to work together to harmonize existing rules in order to lower the cost of compliance.

"The largest internal barrier to investment is often the inability of project proponents to formulate a solid strategy to deploy capital and generate returns that meet internal rates of return (IRR) targets."

10. **Share Best Practices and Help Frame the Business Case for Cleantech Investments**

Building a business case to get executive approval for cleantech investments is another common challenge for companies, particularly those making their first investments in clean technologies. Numerous executives noted that cleantech projects typically compete for capital with long list of other projects with the potential to boost company performance. Thus the largest internal barrier to investment is often the inability of project proponents to formulate a solid strategy to deploy capital and generate returns that meet internal rates of return (IRR) targets. One respondent noted that requirements for an ROI on all capital projects of one year or less is common, which is at odds with the reality that many capital intensive clean technologies have longer term cost reduction targets.

Programs like the Canadian Industry Program for Energy Conservation (CIPEC) are recognized for providing a wide range of resources to support energy efficiency efforts, from promoting best practices and turnkey solutions to hosting networking and leadership recognition events for practitioners. CIPEC's inventory of detailed industry use cases and company case studies is especially valuable for supporting business case development. However, the program only covers energy efficiency, which represents only one domain in a broader array of cleantech opportunities that can boost the environmental performance

and competitiveness of Canadian firms. This suggests an opportunity for government and industry associations to work together to expand the array of toolkits and resources available to companies seeking to formulate cleantech investment plans for specific industries and technological applications.

Boosting Growth and Innovation in the Cleantech Sector

An encouraging finding from the study is the widespread mutual recognition of the strong interdependencies between evolution and ongoing competitiveness of Canada's traditional resource industries and the growth and international success of the emerging cleantech sector. The instances of deep engagement identified in the case studies serve different purposes and take different forms. But the mutual exchange of value is key. Large firms provide emerging cleantech firms with access to capital, mentorship and capacity building, technological expertise and assistance in entering new markets. Cleantech innovators offer large firms access to a greater diversity of ideas and greater agility in enhancing their own competitiveness in a clean growth economy.

While the case studies demonstrate promise, Canada is still in the early stages of knitting together the need to enable traditional industries with cleantech innovation with the need to commercialize and scale-up powerful new solutions. In fact, cleantech firms cite the lack of engagement with large Canadian firms as an obstacle to demonstrating their technologies which in turn hinders export growth, as international customers expect domestic references before making technology investment decisions.[72] While the energy sector has recently come to the table, more sectors need to step up with investments and partnership activities that will not only shore-up their own long-term competitiveness, but also help build the capacity of Canada's cleantech sector. To summarize some of the key insights from survey research, case studies and interviews with executives, we focus specifically on highlighting a number of key actions corporate Canada can take to advance these objectives.

11. **Identify High-Impact Problems for Cleantech Innovators to Solve**

    A large percentage of innovation in Canada occurs upstream from the end users that developers are ultimately striving to target with their technologies. This not only runs the risks that innovators will develop technologies that the market won't accept, it also reinforces the tendency for firms to import technologies or solutions from abroad. As Marty Reed of Evok Innovations put it: "In Canada we fund a scientist to invent a widget and then we struggle to figure out why that widget isn't being bought."[73] Instead, Reed says it's better to start with questions like: "Who is the customer? Why are they buying

72 National Roundtable on the Environment and the Economy, "Framing the Future: Embracing the Low-Carbon Economy," Climate Prosperity Report No. 06, p. 72.
73 Interview with Marty Reed, conducted June 22, 2016

this? And, why is what we are doing better?"[74] In other words, it is important to define the problems that need solving before investing in the science and product development required to build a solution.

Targeted collaborations between end users, universities and SMEs can reduce fragmentation, ensure that technologies in development are well adapted to the needs of the market and create more efficient pathways for commercialization. Entities such as COSIA and Evok Innovations, for example, have put a great deal of upfront effort into defining key industry needs and helping shape innovation agendas. COSIA's XPRIZE challenge, for example, provides a high-profile vehicle and a healthy financial incentive ($20 million prize purse) for innovators to contribute to developing high-impact solutions; in this case breakthrough technologies that convert CO2 into usable energy products. According to Dan Wicklum at COSIA, it is important that industry engagement in defining problems and identifying pain points should happen as early in the innovation cycle as possible.[75] COSIA's partnerships with domestic and international innovation hubs—and the webinars and face-to-face events they jointly orchestrate—are also good examples of simple measures that can be taken to convey industry innovation objectives to researchers and entrepreneurs.

"Canada needs venture funds designed for and run by people who understand cleantech. Cleantech has typically longer time frames to liquidity. It's more industrial, capital intensive, and requires different type of capital animal."

-- Marty Reed, CEO, Evok Innovations

12. **Provide Flexible Capital to Cleantech Start-Ups and SMEs**

Canada's cleantech venture capital sector is disproportionately small compared to countries such as Germany, Singapore and the United States, forcing Canadian cleantech companies to raise capital from abroad. Indeed, while 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), overall VC investment in cleantech companies is declining (including the number of deals and average value of deals).[76] Marty Reed of Evok argues that Canada specifically needs venture funds designed for and run by people who understand cleantech. "Cleantech has typically longer time frames to liquidity. It's more industrial, capital intensive, and requires different type of capital animal."[77] Cleantech companies not only need early stage equity, like series A venture capital, they also need late stage equity and access to project debt to fund demonstration projects and build manufacturing capacity when they are just going commercial.

74 Ibid.
75 Interview with Dan Wicklum, conducted May 17, 2016.
76 Canadian Venture Capital Association, "2015 Canadian Venture Capital Market Overview." http://www.cvca.ca/wp-content/uploads/2016/04/Venture-Capital-2015-Report_REV-Apr-2016.pdf
77 Op. cit., Reed.

Rocco Vita, director, emerging technology at Enbridge where he oversees investments in renewable energy across North America, agrees, noting that "it takes more dollars and more time to get cleantech start-ups to the commercialization stage."[78] Enbridge—which has made a dozen equity investments in a series of renewable energy companies, including Morgan Solar and Temporal Power—would welcome greater participation from large Canadian energy players and the investment community, both domestically and abroad. "Canada needs more hands at the table to support innovative cleantech companies," says Vita.[79]

In this sense, the investments by Cenovus and Suncor could be a sign of more to come. Indeed, if Reed is successful in bringing additional corporate partners into Evok Innovations, more investment dollars will soon follow. The advantage of mobilizing corporate engagement is that equity investments in Canada's cleantech sector can come bundled with access to expertise and opportunities for technology implementation. In other words, well-structured corporate partnerships provide a more complete package of resources to help accelerate cleantech commercialization. However, companies that choose to invest should be careful not to impose heavy-handed restrictions on how entrepreneurs bring their technologies to market. As Rhone warns, "Giving ownership of technologies to large companies constrains the ability of cleantech companies to scale, and if you don't get to scale you don't have a competitive solution."[80]

13. **Create Opportunities to Test, Refine and Scale-Up New Products and Services**

In addition to capital, emerging cleantech firms need opportunities to test, refine and scale-up their innovations. Early adoption partnerships that provide such opportunities are arguably the most important contributions large anchor companies can make in helping younger firms climb on the ladder to high-growth.

COSIA, the Carbon Impact Initiative and Evok Innovations are all structured, in their own ways, to facilitate such opportunities and help cleantech entrepreneurs overcome the large commercialization hurdles associated with developing and demonstrating their technologies at scale. Another good example is the relationship between HydroOne in Ontario and Temporal Power, a leading manufacturer of the energy storage products that are necessary for the fulfillment of the renewable energy promise. According to Aaron Lampe, Temporal's Vice President of Sales and Operations, the company is aiming to double its current

78 Interview with Rocco Vita, conducted June 23, 2016.
79 Ibid.
80 Op. cit., Rhone.

employee count of 25 and force itself out of its current 25,000 square foot location within the next 3 to 4 years.[81] This growth is largely possible because of a long-running co-development partnership with Hydro One which has seen Temporal's unproven technology become a going, and growing, concern.

The relationship started as a joint study, hosted by Ryerson University, about the potential of Temporal's flywheel technology. It progressed to a joint research project between Temporal and Hydro One, followed by testing at Temporal's facility, and now a grid-connected project. Intellectual property developed through the partnership is co-owned. Lampe describes this anchor relationship as integral to the company's growth: "without this we never would have got off the ground. [Hydro One was] willing to work with us very early in the process. This helped refine our technology and the design of our product."[82] The benefits evidently flow both ways. Lampe adds that Hydro One "was looking to modernize and saw us as a potential means of doing do. Without this relationship, our path and progress would be very different, far less advanced, and I'd imagine Hydro One would have missed out as well."[83] Lampe adds that while there are challenges for a start-up manufacturer in working with a major anchor customer like Hydro One, "what are the alternatives?" The high start-up costs for cleantech firms means dearly adoption partners who will share costs and risks associated with demonstrating new technologies are necessary to promote even short-run sustainability.

"We have tremendous technical talent in Canada with world-class engineering schools and applied science schools. But we still struggle with the entrepreneurial skills and commercialization skills to build high growth companies."

-- Jonathan Rhone, CEO, Axine Water Technologies

14. **Build Cleantech Management Capacity with Executive Mentorship Programs**

Helping to develop a larger pool of sophisticated "go-to-market" talent is another domain in which mature companies can contribute to the growth and success of Canada's cleantech sector. As in other high growth sectors, cleantech entrepreneurs face challenges recruiting the specialized management talent required to help Canada's cadre of brilliant technical founders build large, sophisticated businesses with the enterprise capabilities to serve a truly global market. "We have tremendous technical talent in Canada with world-class engineering schools and applied science schools," says Rhone. "But we still struggle with the entrepreneurial skills and commercialization skills to build high growth companies."[84]

81 Interview with Aaron Lampe, conducted July 2015.
82 Ibid.
83 Ibid.
84 Op. cit., Rhone.

Rhone's observations are consistent with the findings of numerous DEEP Centre studies in which a significant majority (60%) of company founders identified problems recruiting sophisticated management talent with "go-to-market" experience as the number one inhibitor to scaling up. Company founders interviewed for a study by the Lazaridis Institute for the Management of Technology Enterprises said Canada has a limited pool of repeat entrepreneurs and experienced executives who had seen companies scale, managed growth on an international level and could provide scale-ups much-needed management depth by putting that experience to work. Skills that are particularly hard to find include sales, marketing, business development, product management, and specialized financial skills, including CFO's with experience raising capital and structuring business models that will win in the international markets.

Given the dearth of domestic management talent, ambitious growth companies inevitably seek to build their top teams with talent from around the globe. But there again, they run into trouble. The Canada Cleantech Alliance describes the current immigration process for obtaining approval to hire and relocate top international talent as "cumbersome, time consuming, expensive and frequently unsuccessful."[85] The Alliance has called for a streamlined immigration process to make it easier to hire C-level and V-level executive talent from around the world. Business schools can play a role by ensuring that their graduates receive training in the key entrepreneurial competencies described above.

However, as Evok Innovations demonstrates, there is also a mentorship role for corporate Canada to play in strengthening the enterprise capabilities of cleantech firms. Indeed, another interesting mentorship and capacity-building model focused on small and medium sized aerospace technology firms has proven quite successful in boosting the competitiveness of Quebec's aerospace industry. In an era of globalization and consolidation, tier I and II aerospace suppliers are no longer merely providers of stock components, but are increasingly co-development and innovation partners who share in the technological, operational, and financial risks of long-term projects. Funded by a consortium of public and private groups and directed by Aéro Montréal, the MACH Initiative was launched in 2010 to facilitate development and continuous improvement in the province's aerospace supply chain.

85 Op. cit., Canada Cleantech Alliance.

Upon entry into the MACH program, participant firms are subject to a rigorous one-day audit that assesses the company's competitiveness across key business areas including challenges business process innovation, operations and product management, and marketing and strategic planning. On the basis of the findings, suppliers develop and propose improvement projects, to be co-funded with the MACH Initiative, and are subsequently paired with large firms such as CAE Inc., Pratt & Whitney and Bombardier, which play an important role as mentors to their participating suppliers.

In selecting firms to work with, these large companies signal their desire to establish a significant long-term relationship with that supplier and to take a sustained interest in their development through the production of a high-value project. Since launching its first cohort in 2011, the MACH Initiative has facilitated mentoring relationships with 60 firms, with OEMs and suppliers both having indicated their satisfaction with the program. In fact, collaboration through the MACH Initiative benefits mentor and mentored firms alike. For large OEMs, the partnership allows them to help improve the quality of their supply chain and secure innovation and ideas from their suppliers. In addition, as customers, larger firms can benefit from improved efficiencies in their suppliers' operations in the form of lower prices and improved quality. For smaller firms, the initiative allows them to help identify and finance continuous improvement projects and develop deeper relationships with large firms.

While the nuances of the MACH Initiative's funding and mentorship model would need to be adapted to the specific needs of the cleantech sector, a mentorship program pairing large industrial companies with cleantech firms could provide a complementary route to building high-quality management capabilities across the sector.

15. **Broker International Market Opportunities**

Amongst the biggest challenges facing Canadian SMEs is the ability to broaden their reach beyond Canada by building an international customer base. While internationalization is a necessary component of growth, Canadian SMEs often lack access to the global supply chains that can unlock international growth opportunities. Large firms with deep international networks can and should partner more actively with local start-ups and SMEs to help the latter forge stronger international ties. In other words, large firms can play an important role as "reference customers" and "market makers" by helping develop early traction for Canadian cleantech solutions in key export markets.

"We see ourselves as a bridge between two business communities. There's no doubt that government trade missions attempt something similar but they are unable to build the depth of credibility and legitimacy with potential buyers and supply chains that we are."

-- Denis Painchaud, CNOOC-Nexen

CNOOC-Nexen, for example, is attempting to facilitate better international engagement among SMEs through its Canada-China Business Mission program. Established in 2014, the program has been run twice so far. The first iteration, in 2014, saw 30 SMEs accompany CNOOC-Nexen staff to Beijing. The second, in 2015, saw 20 SMEs head over. The results are impressive. In 2014, 12 of 30 participating companies secured contracts or commitments. In 2015, 15 out of 20 either secured a contract or are now working on a significant contract lead.

The missions seek to match Canadian SMEs, in particular those working in Western Canada's energy industry, with growing demand for high-quality, high-value energy related services in China. The program is comprised of pre-departure training followed by an intense in-market schedule of business-to-business meetings, workshops and field visits. Included amongst these meetings are seminars on regulatory and legal issues facing foreign firms when operating in China.

While brokering international meetings and leading trade missions is normally a role reserved for governments, the fact that CNOOC-Nexen has stepped up demonstrates considerable foresight and leadership. In fact, CNOOC is well positioned to help facilitate these connections and meetings. The state-owned energy company has 29 subsidiaries that operate in a series of energy-related sectors. Moreover, CNOOC's name carries weight in boardrooms across the country. As Denis Painchaud, CNOOC-Nexen's Director of International Government Relations, describes, this means that the suppliers who are chosen to join the missions get direct access to top decision-makers. He notes, "Participating firms get instant credibility based on their CNOOC relationship. This speeds up the process of deal-making in China, where contacts and relationships matter."[86]

Participating firms attest to benefits. David Bromley, principal of David Bromley Engineering, a Calgary-based environmental technology firm participated in the first mission in 2014. His company has created a novel nanofiltration process that should help resource extraction companies reduce water consumption used in the extraction process. Bromley notes that in his previous efforts in the Chinese market, his company's size and the novelty of their technology worked against them. Now, however, with CNOOC-Nexen's support, he's been able to leverage the Canada-China Business Mission into a long-term engagement with a major Chinese oil industry company. He adds, "I would have been unable to get access to senior decision makers like I have

86 Quoted in: DEEP Centre, "Catalyzing Canadian Growth: Understanding the Role of Large Firms in Helping Small Businesses Succeed," November, 2015. http://deepcentre.com/wordpress/wp-content/uploads/2015/11/DEEPCENTRE_CATALYZING_CANADIAN_GROWTH_NOV_2015.pdf

recently without the networking and access offered by CNOOC-Nexen. It's provided a massive shortcut to get my technology adopted and into the field."[87]

While various levels of government operate international trade missions to key markets such as China, Painchaud notes that CNOOC-Nexen's model has one key advantage over such publicly-led missions. "We see ourselves as a bridge between two business communities. There's no doubt that government trade missions attempt something similar but they are unable to build the depth of credibility and legitimacy with potential buyers and supply chains that we are."[88] Given the results achieved by participating firms, this business-led international engagement model certainly merits further exploration as a model for others. Incumbent firms with a significant international presence could act as ambassadors abroad for Canadian cleantech SMEs, producing benefits for both participating SMEs as well as the large firms leading the overseas missions.

87 Ibid.
88 Ibid.

5. Conclusions and Recommendations

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. As things currently stand, Canada is not on track to achieve this target. In fact, in the business-as-usual scenario, Canada's GHG emissions will rise by 11.5% from 732 M tonnes in 2014 to 815 M tonnes by 2030.[89]

There is widespread consensus that innovation and global adoption of low-carbon technologies are essential to achieving needed reductions in GHG emissions, including proven technologies available today and new technologies not yet developed. In this respect, the slow pace of technology development and adoption in Canada is a significant problem. Canada needs a step change in clean technology adoption to reindustrialize and reinvigorate high-emitting industries around low-carbon solutions, including industries such as transportation, resource extraction, heavy industry and construction.

"Canada needs a step change in clean technology adoption to reindustrialize and reinvigorate high-emitting industries around low-carbon solutions, including industries such as transportation, resource extraction, heavy industry and construction."

The adoption of clean technologies is not just an environmental issue. While central to meeting Canada's climate change obligations, industry leaders and public policy-makers should not underestimate the degree to which the future competitiveness of Canada's core industries is at stake. As the global race for clean growth heats up, regulations everywhere will tighten and global supply chains will reconfigure around firms that can deliver efficient, low-carbon solutions.[90] The ongoing growth and international success of resource-based industries (along with sectors such as construction, manufacturing and transportation) will be increasingly linked to their capacity to reinvent their businesses accordingly.

Canada's energy sector, for example, needs to dramatically its lower carbon intensity through carbon capture and sequestration and help build out new sources of renewable energy capacity across the country. Forestry companies need to turn their conventional feedstock into wide array of new forest-based bio-products ranging from low-carbon bio-fuels through to advanced materials for construction, medicine and automotive manufacturing. Transportation companies should be at the forefront electric vehicle adoption and leading the development of intelligent automation solutions. Construction companies should champion the adoption of green building materials and clean energy solutions required to construct zero-emissions buildings.

While the case studies in section 3 highlight breakthrough innovations in development, overall progress towards realizing these innovations at scale has been slow. Indeed, the 2014 Survey of Advanced Technology reveals the extent of the adoption gap that Canada must close to secure its future prosperity and meet domestic and international obligations to address climate change and other environmental issues.

89 "Backgrounder," Federal-Provincial Working Group on Clean Technology, Innovation and Jobs, July 2016.
90 World Economic Forum, "Logistics & Supply Chain Industry Agenda Council Final Report 2010-2011," (Geneva: WEF, 2011). http://www3.weforum.org/docs/WEF_GAC_LogisticsSupplyChain_Report_2010-11.pdf

5. Conclusions and Recommendations

As discussed in section 2, the rate of cleantech adoption is by far the lowest among the four classes of technology tracked by Statistics Canada. While 43% of firms in Canada adopted advanced logistics technologies, less than 10% have adopted clean technologies. The adoption rate among Canada's large enterprises is somewhat higher at 15% of companies with 250 employees or more. Within industrial sectors such as power generation and resource extraction cleantech adoption rates among large enterprises range between 20 and 40%. Nevertheless, the results indicate that a significant majority of firms (including those in the highest-emitting sectors) have made little to no investment in clean technologies.

In highlighting the presence of significant adoption challenges, the DEEP Centre's survey of early adopters helps explain the reluctant uptake, or complete lack of uptake. The prevailing approach to clean technology adoption in Canada is focused on opportunities for reducing costs and incremental investments with short-term payoffs. According to the firms surveyed, the number one barrier to further investment is the high cost and capital-intensity of cleantech solutions. As numerous executive noted, framing a business case for adoption that will satisfy internal rate of return requirements is particularly challenging in an environment in which cleantech projects compete for internal capital with other proven technologies that can boost company performance. Compounding this problem is the fact that Canada's highest-emitting firms are typically in conservative, low-margin, commodity-based businesses where innovation cycles are slow and access to investment capital is highly constrained.

The need to prioritize responsible and profitable investment decisions is understandable. However, a strictly cost optimizing, short-term approach to clean technologies will not deliver either the emissions reductions or the future competitiveness that Canada needs. Canada's incremental approach needs an infusion of radical market disruption. As backgrounder from the Working Group on Clean Technology, Innovation and Jobs put it: "[The transition to a clean growth economy] will require both incremental improvements to existing technologies and dramatically different solutions, including disruptive technologies."[91] Our ten recommendations for accelerating adoption, discussed at length in section 4, have thus emphasized a mix measures that address concerns about costs and risks while also tackling the need for companies to reinvent themselves around low-carbon solutions. These recommendations include the following:

91 "Backgrounder," Federal-Provincial Working Group on Clean Technology, Innovation and Jobs, July 2016.

5. Conclusions and Recommendations

1. **De-risk clean technology adoption** through industry-led pilot projects to test and verify the performance of new technologies in partnership with cleantech SMEs.

2. **Expand the market for clean technologies** through public procurement and funding for large-scale demonstration projects.

3. **Reposition cleantech investments as an opportunity to reinvent traditional industries,** following, for example, the forest products industry's efforts to transition into new forest-based bio-products for the emerging bio-economy.

4. **Build new market opportunities and value chains around cleantech offerings,** as companies like EllisDon have done with its green building investments through the Carbon Impact Initiative.

5. **Set an ambitious clean growth mandate with executive leadership,** including clear objectives, company-wide metrics and performance measures for managers.

6. **Use industry consortia to lower the cost and increase the pace of innovation,** using collaborative, cross-sector initiatives to pool the knowledge and investments required to move quickly and decisively in preparing for a global low-carbon economy.

7. **Create vertically-focused and industry-supported cleantech acceleration models** to build a pipeline of new innovation opportunities and help position industries such as forest products, mining, fisheries and agriculture as world leaders in sustainability.

8. **Tap external talent and resources through open innovation** by leveraging research and experimentation infrastructures at postsecondary institutions and connecting with a much broader base of skilled practitioners, including cleantech SMEs.

9. **Use strategic regulations as a driver for cleantech innovation and adoption** with consistent, national approaches to carbon-pricing and other performance-based regimes that drive continuous improvement in environmental performance.

10. **Share best practices and help frame the business case for cleantech** investments by making toolkits and resources available to companies seeking to formulate cleantech investment plans for specific industries and technological applications.

5. Conclusions and Recommendations

The focus of this report has been on adoption and what can be done to increase the uptake of clean technologies. However, there are important implications to draw from this research which pertain to the supply side of the cleantech innovation equation. One implication is that the invention, commercialization and adoption of clean technologies needs to be seen as part of an end-to-end process by which promising Canadian cleantech firms use our domestic market as a launchpad to succeed on the international stage. A weakness in any link of the chain undermines the strength of the whole ecosystem and Canada's lagging adoption is an example of this.

"The invention, commercialization and adoption of clean technologies needs to be seen as part of an end-to-end process by which promising Canadian cleantech firms use our domestic market as a launchpad to succeed on the international stage."

Up to this point, Canada's comparatively small domestic cleantech market, with a limited number of early adopters, has put a handbrake on cleantech commercialization. Cleantech firms that aspire to grow need to be present in larger, fast growing cleantech markets in the United States, Europe and Asia. However, to do so it helps to have domestic reference customers who have already deployed or at least piloted their solutions. Fortunately, measures that increase domestic demand for cleantech innovations will also help complete this circle of invention and commercialization by expanding opportunities for cleantech entrepreneurs to demonstrate and scale their solutions.

In section 4, we identified five additional capacity-building measures large, capital-intensive firms in Canada can implement to boost growth and innovation in the cleantech sector:

11. **Identify high-impact problems for cleantech innovators** to solve by launching industry innovation challenges and engaging post-secondary institutions and cleantech accelerators in partnerships designed to communicate and address industry pain points.

12. **Provide flexible capital to cleantech start-ups and SMEs** using the Evok Innovations investment and acceleration model as a guide for how to structure corporate venture activities.

13. **Create opportunities to test, refine and scale-up new products and services** with pilot projects and partnerships run through industry consortia such as COSIA and the Carbon Impact Initiative.

14. **Build cleantech management capacity** by making executives available to mentor cleantech companies, using structured capacity-building programs like Quebec's MACH initiative as a template.

15. **Broker international market opportunities,** following the lead of companies such as CNOOC-Nexen, which has introduced over 50 Canadian SMEs to the key contacts in the Chinese market using its Canada-China Business Mission program.

5. Conclusions and Recommendations

A final observation is that Canada's success in transitioning to a clean growth economy will require collaboration on a mass scale. "Collaboration," as Jon Rhone put it, "can be Canada's secret weapon." Indeed, all parts of the ecosystem need to step up to make Canada a cleantech superpower. Among other things, this process of stepping up entails continued investment in the creation of world-class research that provides the scientific foundation for revolutionary process innovations and new products and services. It requires vertically-focused cleantech incubators and accelerators with deep market knowledge and connectivity to support the development of a thriving cleantech sector.

A thriving clean-tech sector, in turn, will need access to specialized venture capital that understands the capital-intensity and time-to-liquidity that is typical of the sector. It will also need large-scale project funding for demonstration projects and manufacturing capacity to ensure world-class science and innovation converts to industrial-scale solutions. Corporate Canada must shed its risk aversion and muster the leadership to play an active role in developing and adopting cleantech innovations, at a much greater rate than before. Stepping up also requires forward-thinking governments willing to make strategic investments and create enabling regulatory frameworks. With all of these critical components working in concert, Canada will be well-positioned to emerge as a 21st Century cleantech superpower.

Works Cited

Analytica Advisors, "2015 Canadian Clean Technology Industry Report," (Ottawa: Analytica Advisors, 2015). http://www.analytica-advisors.com/assets/file/2015%20Report%20Synopsis%20Final_wcovers.pdf

BC Cleantech CEO Alliance, Letter to Prime Minister Trudeau, February 29 2016. http://www.newswire.ca/news-releases/50-bc-cleantech-ceos-send-prime-minister-trudeau-an-open-letter-outlining-a-national-cleantech-growth-strategy-570484941.html

Bowerbank, Andrew. "Shifting markets towards a low-carbon economy," The Carbon Impact Initiative: An Industry-Led Action Plan in Support of Canada's International Climate Change Commitments, EllisDon, June 15, 2016.

Canada Cleantech Alliance for a Sustainable and Prosperous Future, "Submission to the Federal-Provincial Territorial Working Group on Clean Technology Innovation and Jobs." June 10, 2016.

http://www.evokinnovations.com/recommendations-to-pmo-10jun16-1.html

Canadian Venture Capital Association, "2015 Canadian Venture Capital Market Overview."

http://www.cvca.ca/wp-content/uploads/2016/04/Venture-Capital-2015-Report_REV-Apr-2016.pdf

DEEP Centre "Canada's Innovation Performance: A Scorecard," March 2015. http://deepcentre.com/wordpress/wp-content/uploads/2015/03/DEEP-Centre-Canadas-Innovation-Performance-March-2015.pdf

DEEP Centre, "A Lynchpin in Canada's Economic Future: Accelerating Growth and Innovation with a World-Class Business Acceleration Ecosystem," October 2015. http://deepcentre.com/wordpress/wp-content/uploads/2015/10/DEEP-Centre-BABI-5-Capstone-Accelerating-Growth-and-Innovation-September-20151.pdf

DEEP Centre, "Canada's Billion Dollar Firms: Contributions, Challenges and Opportunities," July 2014. http://deepcentre.com/wordpress/wp-content/uploads/2014/07/DEEP-Centre-Canadas-Billion-Dollar-Firms-July-2014_ENG.pdf

DEEP Centre, "Catalyzing Canadian Growth: Understanding the Role of Large Firms in Helping Small Businesses Succeed," November, 2015. http://deepcentre.com/wordpress/wp-content/uploads/2015/11/DEEPCENTRE_CATALYZING_CANADIAN_GROWTH_NOV_2015.pdf

Works Cited

DEEP Centre, "Global Best Practices in Business Acceleration: Charting the Evolution and Performance of the World's Leading Accelerators." http://deepcentre.com/wordpress/wp-content/uploads/2015/10/DEEP-Centre-BABI-4-Global-Best-Practices-in-Acceleration-September-20151.pdf

DEEP Centre, Clean Technology Adoption Survey, conducted May to July 2016.

EllisDon, The Carbon Impact Initiative: An Industry-Led Action Plan in Support of Canada's International Climate Change Commitments, June 15, 2016. http://www.lowcarbonagenda.ellisdon.com/

Federal-Provincial Working Group on Clean Technology, Innovation and Jobs, "Backgrounder," July 2016.

General Electric, "GE Global Innovation Barometer 2016," http://www.gereports.com/innovation-barometer-2016/

Government of Canada, "Vancouver Declaration on Clean Growth and Climate Change," March 3, 2016. http://www.scics.gc.ca/english/conferences.asp?a=viewdocument&id=2401

http://www.cvca.ca/wp-content/uploads/2016/04/Venture-Capital-2015-Report_REV-Apr-2016.pdf

Intergovernmental Panel on Climate Change, "Climate Change 2014 Synthesis Report," (Geneva: IPCC, 2014). https://www.ipcc.ch/pdf/assessment-report/ar5/syr/AR5_SYR_FINAL_SPM.pdf

Intergovernmental Panel on Climate Change, "Climate Change 2014: Impacts, Adaptation, and Vulnerability," (Geneva: IPCC, 2014). http://www.ipcc.ch/report/ar5/wg2/

National Round Table on the Environment and the Economy, "Framing the Future: Embracing the Low-Carbon Economy." Climate Prosperity Report No. 06, 2012. http://nrt-trn.ca/climate/climate-prosperity/global-low-carbon-transition

Ng, Shinwei, Nick Mabey, Jonathan Gaventa, "Pulling Ahead On Clean Technology China's 13th Five Year Plan Challenges Europe's Low Carbon Competitiveness," E3G Briefing Paper, March 2016. https://www.e3g.org/docs/E3G_Report_on_Chinas_13th_5_Year_Plan.pdf

OECD, "Climate Change Mitigation: What Do We Do?" (Paris: OECD, 2008). http://www.oecd.org/env/cc/41751042.pdf

Works Cited

OECD, "OECD Environmental Outlook to 2050," (Paris: OECD, 2011). *https://www.oecd.org/env/cc/49082173.pdf*

Potsdam Institute for Climate Impact Research and Climate Analytics, "Turn Down the Heat: Why a 4 Degree Centigrade Warmer World Must Be Avoided." (Washington, DC: World Bank, November, 2012). *http://documents.worldbank.org/curated/en/865571468149107611/pdf/NonAsciiFileName0.pdf*

Statistics Canada, Survey of Advanced Technology, 2014. See the following for a more comprehensive review of the survey findings: *http://www.statcan.gc.ca/daily-quotidien/151211/dq151211b-eng.htm*

United Nations Environment Programme, "Buildings and Climate Change," Sustainable Buildings and Climate Change Initiative, UNEP, 2009. *http://www.unep.org/sbci/pdfs/SBCI-BCCSummary.pdf*

World Economic Forum, "Logistics & Supply Chain Industry Agenda Council Final Report 2010-2011," (Geneva: WEF, 2011). *http://www3.weforum.org/docs/WEF_GAC_LogisticsSupplyChain_Report_2010-11.pdf*

World Economic Forum, "What's the future of the construction industry?" April 4, 2016. *https://www.weforum.org/agenda/2016/04/building-in-the-fourth-industrial-revolution/*