

CIGI Papers No.117 – January 2017

Generating Growth from Innovation for the Low-carbon Economy

Exploring
Safeguards in
Finance and
Regulation

Céline Bak



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CIGI Masthead

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Table of Contents

vi	About the Author
vii	About the Global Economy Program
vii	Acronyms and Abbreviations
1	Executive Summary
1	The Paris Agreement: Translating Commitments into Plans
2	Illustration: The Case of MemPore Corporation
4	Policy Integration Essential for Mission Innovation
6	At the Crossroad of Climate Change, Innovation and Sustainable Finance
11	The Need to Safeguard Innovation for the Public Good
13	National and Global Contexts
14	Policy Recommendations
15	Summary of Policy Recommendations
15	Problem Sets and Policy Recommendations
19	Appendix
22	Works Cited

About the Author

Céline Bak is a CIGI senior fellow with CIGI's Global Economy Program. At CIGI, she serves as the co-chair of the Think Tank 20 (T20) taskforce on climate policy and finance. This taskforce will feed into the G20 Secretariat under the German presidency on carbon pricing, sustainable infrastructure and sustainable finance. To the T20 taskforce, she brings her expertise on barriers to scaling-up both solutions to climate change and firms that will enable the scale-up of the low carbon economy and sustainable growth.

In her capacity as an innovation practitioner, Céline sits as a director of Emissions Reduction Alberta, Green Centre Canada and chairs the Core Evaluation Team for Genome Canada's Genomic Applications Partnership Program, all of which are focused on translating innovation into the private sector for environmental benefit and economic impact. Through her role as president of Analytica Advisors, Céline provides strategic vision for clean technology industry leaders.

As an expert on innovation and the low-carbon economy, Céline has appeared on five occasions as a witness before Parliament, and is frequently sought out by major Canadian media outlets to discuss sustainable finance, climate change and the low-carbon economy in Canada. Within Global Affairs Canada, she was the chair of the Private Sector Advisory Group and served Senior Industry Advisory — Sustainable Technologies.

Prior to her role at Analytica Advisors, Céline advised investors in innovation-based firms and held executive roles at Bridgewater Systems, served as director of professional services for Europe, the Middle East and Africa at AMDOCS, and was principal at the Toronto and Madrid offices of A.T. Kearney, a consulting firm. Céline holds a master's of business administration from the University of Bath and a bachelor of commerce degree from the University of Guelph. She has worked in 25 countries and travels extensively, speaking about sustainability and innovation at prestigious events around the world.

About the Global Economy Program

Addressing limitations in the ways nations tackle shared economic challenges, the Global Economy Program at CIGI strives to inform and guide policy debates through world-leading research and sustained stakeholder engagement.

With experts from academia, national agencies, international institutions and the private sector, the Global Economy Program supports research in the following areas: management of severe sovereign debt crises; central banking and international financial regulation; China's role in the global economy; governance and policies of the Bretton Woods institutions; the Group of Twenty; global, plurilateral and regional trade agreements; and financing sustainable development. Each year, the Global Economy Program hosts, co-hosts and participates in many events worldwide, working with trusted international partners, which allows the program to disseminate policy recommendations to an international audience of policy makers.

Through its research, collaboration and publications, the Global Economy Program informs decision makers, fosters dialogue and debate on policy-relevant ideas and strengthens multilateral responses to the most pressing international governance issues.

Acronyms and Abbreviations

BERD	business expenditure in research and development
CMHC	Canada Mortgage and Housing Corporation
CO₂	carbon dioxide
COP21	twenty-first session of the Conference of the Parties
EPC	engineering procurement and construction
GHG	greenhouse gas
ITMOs	internationally transferred mitigation outcomes
Mt	megatonnes
OECD	Organisation for Economic Co-operation and Development
ppm	parts per million
R&D	research and development
SDTC	Sustainable Development Technology Canada
SMEs	small and medium-sized enterprises
UNFCCC	United Nations Framework Convention on Climate Change

Executive Summary

On October 5, 2016, the Paris Agreement, agreed to at the twenty-first session of the Conference of the Parties (COP21) to the United Nations Framework Convention on Climate Change (UNFCCC), cleared the final hurdle with 55 countries — representing 55 percent of global emissions — ratifying their commitment. Canada’s Parliament voted to support the climate change agreement following Cabinet’s decision to ratify the accord. On November 4, the Paris Agreement came into force and on December 9, all but two Canadian provinces signed onto the Pan-Canadian Framework on Clean Growth and Climate Change as the plan to meet Canada’s commitment to a 30 percent reduction in greenhouse gas (GHG) emissions from 2005 levels by 2030.

The Paris Agreement heralded a new level of engagement on energy innovation with COP21’s “Mission Innovation” — a commitment, by 21 member countries, to doubling the investment in energy innovation by 2020. Public investment in innovations related to energy and to carbon and business environment enablers that reduce barriers to the emergence of new firms have resulted in the creation of many firms whose business models are founded on innovation and whose markets are global, but whose customers and competitors are much larger incumbents.

At the same time, economic researchers such as Thomas Piketty (2014) have concluded that economies and industries are both increasingly concentrated, with fewer and fewer firms representing a greater share of economic activity. In Canada, the concentration of industries appears to be associated with low levels of investment in innovation and, consequently, low productivity. This low innovation equilibrium creates structural impediments to the growth of new firms. For example, emerging innovative firms with solutions to reduce CO₂ emissions are not consulted in standard setting, environmental regulation and approval processes, whether domestically or in multilateral processes such as the UNFCCC. The private sector roles in these processes are dominated by large incumbents. Such structural barriers reduce the rate at which innovations are considered in regulatory formulation and, as such, will slow progress toward both growth goals and Paris Agreement goals.

Innovation policy makers must consider how public investments in innovation are translated into markets with ensuing spillover benefits to the environment and the economy. Within the policy framework of stringency, predictability, flexibility and subsidiarity, policies to safeguard the spillover benefits of publicly funded innovation should address market failures and asymmetries in the status of innovative firms vis-à-vis regulators and standards agencies, as well as public and private sector markets. Policies to finance these safeguards should be financed through the prompt unwinding of fossil fuel subsidies embedded in both fiscal policies and public finance.

Four interrelated policies are proposed as solutions to the challenges of stimulating low-carbon growth through the scale-up of new firms where decoupling economic growth from GHG emissions growth is the policy goal: the Innovative Carbon Emissions Mitigation Fund; the Sustainable Finance Performance Warranty Program; the Best Global Regulations for Low-carbon Economy Program and the Sustainable Infrastructure Program.

The Paris Agreement: Translating Commitments into Plans

The Paris Agreement commits its 197 signatories to keep global warming “well below” 2°C above pre-industrial levels. On November 4, 2016, the Paris Agreement went into force, 30 days after the country-level ratification by 55 signatories representing 55 percent of global emissions. The process of ratification was thrust into the spotlight by the joint announcement of US President Barack Obama and Chinese President Xi Jinping on September 3, 2016, in the presence of UN Secretary-General Ban Ki-moon. President Obama spoke of the United States’, and China’s ratifications as leading by example and President Xi committed China to unwaveringly pursuing sustainable development. President-elect Donald Trump campaigned with the promise to rescind the United States’ ratification of the Paris Agreement. Bearing in mind the likelihood of future US actions under the Trump presidency,

as of December 12, 2016, 117 of the 197 parties that signed have ratified their adherence to the treaty, including all 10 of the largest global emitters.

Under the Paris Agreement, Canada committed to reducing annual CO₂ emissions to 524 megatonnes (Mt) by 2030. This represents a 30 percent reduction from 2005 levels. As of 2014, Canada's predicted emissions for 2030 are 291 Mt *in excess* of the 2030 Paris Agreement target. On its current trajectory, Canada will miss its 2030 target by 55 percent.¹ The goal of the Pan-Canadian Framework on Clean Growth and Climate Change, agreed to on December 9 by all but two Canadian provinces, is to reverse this trend and establish a plan for Canada to achieve its Paris Agreement commitment.

Nine months earlier, on March 3, 2016, Canadian federal and provincial leaders met to begin the process of translating Canada's Paris Agreement commitments into plans. In the Vancouver Declaration, they agreed to an approach that balanced federal and provincial jurisdictions. The framework planning process took the form of formal federal-provincial/territorial consultations structured under four working groups: Carbon Pricing Mechanisms; Specific Mitigation Opportunities; Adaptation and Climate Resilience; and Clean Technology Innovation and Jobs.

This last working group, Clean Technology Innovation and Jobs, provided a report with options on how to stimulate economic growth, create jobs and drive innovation across all sectors to transition to a low-carbon economy, leveraging regional strengths. The plan for this working group was delivered to ministers of innovation and economic development.

Based on a cohort of 800 innovative firms in the clean technology sector, roughly two-thirds of Canada's clean technology firms could be viewed as "climate-tech," that is to say, the solutions they provide are part of reducing the use of fossil fuels through:

- alternative forms of energy for electricity, heating and transportation;
- energy efficiency;
- high-performance materials as enablers of low carbon solutions; and
- conversion of carbon into value-added products.

These clean technology companies, which include both privately held and publicly listed firms, were founded to both deliver investor and lender returns, and address climate change.

Many climate-tech firms have been in operation for 10 or more years and are ready to scale up. However, as described below, safeguarding these investments in clean innovation is not a given. Where markets do exist, the price of fossil fuels — which innovations compete against for markets and capital — is volatile and in the future may be subject to downward pressure, making it difficult for low-carbon solutions to be taken up in the market. Negative carbon prices in the form of fiscal and public finance subsidies to fossil fuel industries make market entry even more challenging.

As countries translate Paris Agreement commitments into domestic regulations, more than 40 jurisdictions have implemented carbon-pricing mechanisms, and many are implementing complementary regulations targeting methane and other emissions from coal-fired electricity plants. New research, however, points to deep gaps between climate policy, innovation policy and economic policy. Aligning these through market mechanisms specifically targeted to innovation can help lay the foundation to scale up new firms that provide solutions to climate change, while creating employment opportunities that can replace the jobs that are core to economies today as the transition is made to the low-carbon economy.

Illustration: The Case of MemPore Corporation

On October 3, 2016, the federal government announced Canada's Pan-Canadian Pricing on Carbon Pollution, which stipulated a minimum price on carbon for all jurisdictions starting at \$10 in 2018 and rising to \$50 in 2022.² This important step in Canada's climate policy has taken years of patient work at various levels of jurisdiction. So it is with innovative firms that provide solutions to climate change. These firms are often the product of decades of public

1 See www.ec.gc.ca/indicateurs-indicateurs/default.asp?lang=en&n=CCED3397-1.

2 Unless otherwise noted, all figures are in Canadian dollars.

investment in people and in companies, but even with carbon pricing, the slow pace of reform to the structural and market advantages afforded to incumbent industries make it unlikely they will be still standing and creating jobs when the economic playing field is finally levelled.

MemPore Corporation (MemPore),³ a clean technology firm under the leadership of founder Oleh Kutowy and president Alastair Samson, illustrates the challenges faced by innovations to address climate change, and the path from brown to green finance. MemPore has developed a technology that uses nano-filtration membranes to purify used lubricating oil. The MemPore system would reduce GHG emissions significantly (71 percent) over conventional reclamation (re-refining and burning) processes at an estimated cost of \$71 per metric tonne of CO₂ and produce a final product that can be returned to users. In addition, rescuing this base oil reduces the need to refine an equivalent amount of oil and the CO₂ released during extraction. Users are currently prepared to pay a current market price of \$129 per metric tonne of CO₂ equivalent for the recycled base oil. This means that, from a carbon perspective, the market price for the recycled lubricant is nearly twice the cost of producing it.

To put the scale of the opportunity in context, the potential within Canada if 50 percent of used lubricant was recycled rather than burned is for 1 Mt of CO₂ emissions reductions per annum, excluding the emissions associated with producing new lubricants from fossil fuels. In 2014, CO₂ emissions from oil sands was 68 Mt. Furthermore, in a post-carbon economy, the MemPore system could also be used to purify liquids from sources other than hydrocarbons, thereby saving the energy needed to produce lubricants from bio-based sources. Even without a price on carbon, MemPore's solution passes the test of both short-term and long-term cost-effectiveness.

The path to the current stalled position has all the hallmarks of potential success, and yet, 10 years after the company was founded to commercialize this technology, its solution is not being deployed. Why is this?

In the case of MemPore, when Kutowy left the National Research Council, Canada's national

research organization, and started MemPore, he first set about fine-tuning his research on filtration membranes into a system that is commercially robust. To do this, he applied his research to engineer and construct an integrated small-scale prototype system comprised of a pre-treatment system and a filtration unit (based on the membrane technology), both patented, which produced good-quality Group II base oil — a lubricant used in many industrial processes. For his part, Alastair Samson brought to the endeavour decades of success starting and growing new companies in industrial settings in both North America and the United Kingdom.

Once the technical issues were ironed out in the small-scale prototype system, Kutowy and Samson spent several years looking for investors for a large-scale prototype system to test the technology at scale in the intended commercial environment. To help reduce the cost to private investors of a large prototype system, they prepared an application to Sustainable Development Technology Canada (SDTC), which is a Canadian arm's-length foundation that provides grants to reduce what private sector investors must invest to validate carbon-reducing and environmental technologies at large prototype scale within intended commercial environments. SDTC provides what the Green Finance Study Group calls "strategic policy signals" (G20 Green Finance Study Group 2016), by channelling public money into demonstration projects to de-risk private sector investment.

Following detailed technical due diligence by SDTC, a \$0.5 million grant was pre-approved to build a large-scale prototype, subject only to obtaining matching funding from a private sector partner. After three years, several potential investors and industry partners were identified, but all claimed that they could not take the risk of investing in MemPore until the first demonstration plant had been built and was operational. With negative carbon prices, and as there are no regulations or standards requiring solutions to the problem MemPore addresses, the firm has not been able to attract investors. This is the situation that many innovative firms find themselves in: investors are looking for regulatory and market certainty before they invest in new innovations. The result is that society does not benefit from solutions that have been developed through publicly funded research, and that are necessary for the orderly unwinding of the global hydrocarbon

³ The author has no relationship, financial or otherwise, with MemPore Corporation.

economy. Increasing investments in energy innovation will make it even more important to address the market and regulatory barriers that today prevent start-up firms from scaling up into solution providers and sizable employers.

Policy Integration Essential for Mission Innovation

Forged by private and public sector cooperation, Mission Innovation was announced at COP21 in Paris as a commitment to doubling, by 2020, the investment in energy innovation by participating countries. Mission Innovation heralds a new period of active private-public sector engagement on energy, climate and innovation policy.

The launch of Mission Innovation was made by Bill Gates with US President Barack Obama, French President François Hollande and Indian Prime Minister Narendra Modi on the first day of COP21. Mission Innovation's state-level participants pledged to double investments in clean energy research by 2020, with the goal of shoring up research budgets that, in real terms, have fallen to half of what they were at the end of the 1970s. On December 12, 2016, Gates announced that he would chair Breakthrough Energy Ventures, a US\$1 billion fund with a 20-year investment horizon focused on clean energy technologies. This followed the announcement one year earlier at COP21 in Paris of the Breakthrough Energy Coalition (Delaney 2016).

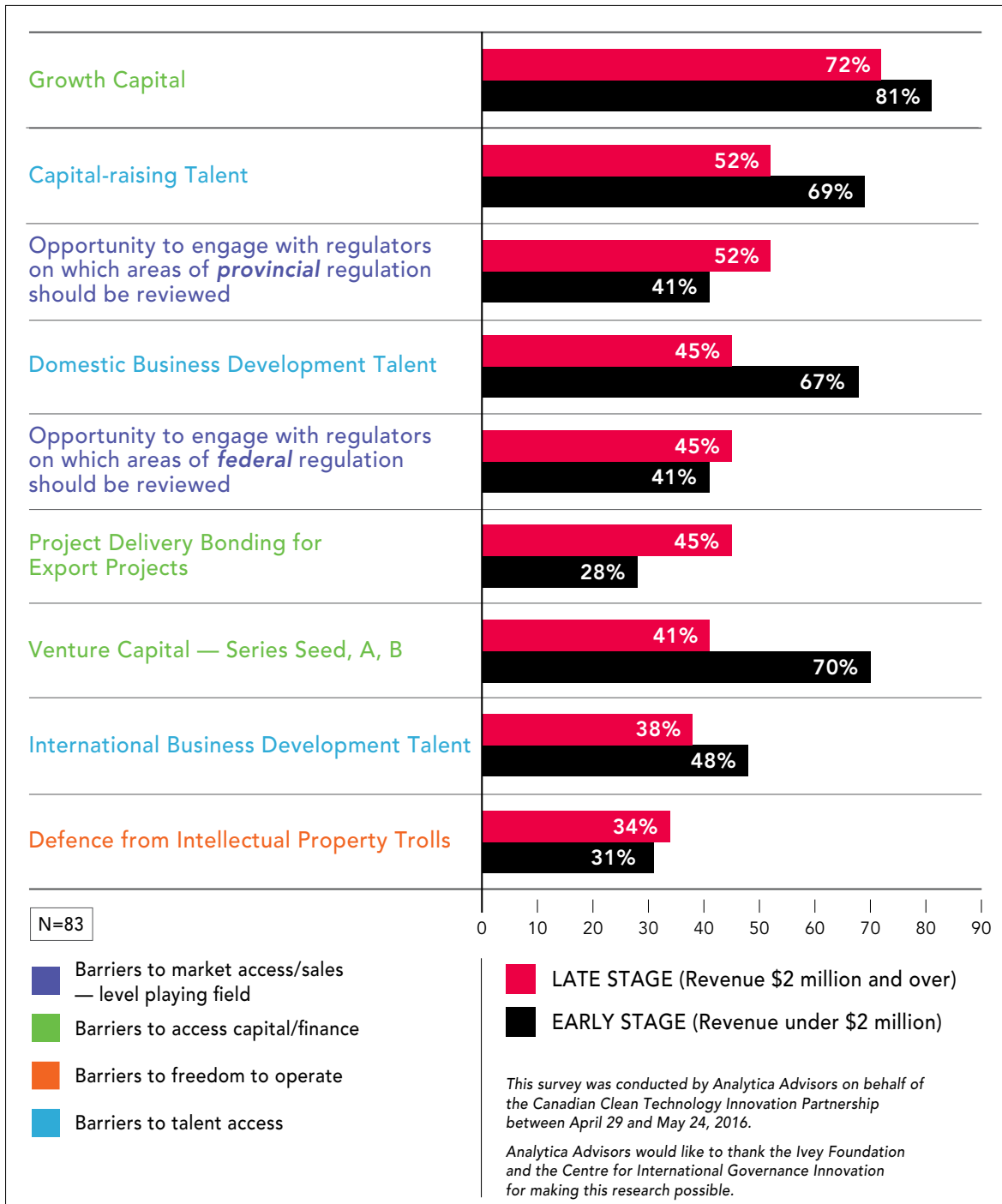
Energy innovation investments can require billions of dollars to bear fruit and, thus, reviewing the spillover benefits of innovation programs that emanate from Mission Innovation will be vital to ensure that public investments of money and talent are translated into real progress

in achieving climate goals and transitioning toward a low-carbon economy. Firm-level research on firms whose value proposition is based on innovation would suggest that policy safeguards may be required to assure the take-up of these solutions in fossil fuel and regulated sectors with long-lived capital stocks, where management has a duty to maximize shareholder value from existing assets and technologies.

Through federal-provincial/territorial consultations emanating from Canada's Vancouver Declaration, innovative Canadian firms developing low-carbon solutions (such as MemPore) have stated that the greatest impediments to their growth are access to capital and the ability to intervene with regulators. This finding was confirmed in a survey of 83 innovative energy and clean technology firms, where access to capital and ability to intervene in regulatory reviews were highlighted as the most pressing issues in the short to medium term.⁴ Coupled with these barriers are the skills needed to raise capital and new business development in emerging markets (see Figure 1). Company leaders fear that the hard-earned potential of their innovations will be locked in subscale firms that do not generate a return for shareholders where regulation lags and customers are energy incumbents with deep balance sheets and strong pricing power. Investment in Mission Innovation programs will assist in starting up new firms and financing the demonstration of new innovation, but without careful consideration of the barriers firms are facing when they are ready to scale up, public investments will serve only to grow seedlings that will not mature into firms that can support and, in some cases, take the place of incumbent firms in the transition to the low-carbon economy.

4 A list of participants in the survey appears in the Appendix. Presidents/CEOs of innovative firms were invited to participate in the research. Firms from across Canada and from all stages of development participated in the survey.

Figure 1: Canadian Clean Technology Firms – Barriers (Highest and Most Immediate Priorities)



Source: Author.

At the Crossroad of Climate Change, Innovation and Sustainable Finance

Recent research on the returns of equity funds points to better returns for funds with lower carbon exposure and greater exposure to green firms, that is to say, firms with lower carbon emissions per dollar of sales. The outlier of this research was Canada, where fewer than one percent of firms on public equity market are green, suggesting that structural barriers may be impeding the emergence of green firms (Weber 2016).

Based on firm research in Canada, capital and regulatory barriers for clean technology firms may be impeding the translation of publicly funded innovation into private and public markets. It must be said, though, that markets continue to allocate capital rationally, given legacy market structures and institutional arrangements in Canada. In the words of Adam Smith, the “invisible hand” (the notion that individuals may benefit society better by pursuing their own interests than by pursuing actions intended to benefit society), is still hard at work as low-carbon innovations attempt to emerge.

The question for prudent policy makers participating in or considering participation in initiatives such as Mission Innovation is how to safeguard, for the public good, the large and increasing investments that will be made in low-carbon innovation. As incumbent firms and sectors are bound by fiduciary duty to maximize shareholder value of current assets, existing regulatory pathways and standards may slow the emergence and climate impact of low-carbon innovation to the point where it may not be deployed at scale. This is particularly a risk in the early stages of carbon pricing, where prices are still low.

Policy makers considering how to safeguard the scale-up of low-carbon and environment-related innovation should consider at least three factors underpinning the supply of — and demand for — low-carbon innovation.

First, clean innovation firms operate where prices for the commodities they replace, including energy derived from hydrocarbons, are volatile and where prices for the externalities they reduce (for example, carbon and other pollution) are still very low. Where investments have been made in earlier innovation programs, clean innovation solutions are ready *before* markets for these solutions have formed and while markets for hydrocarbon-based inputs will be subject to downward pressure due to global Paris Agreement commitments.

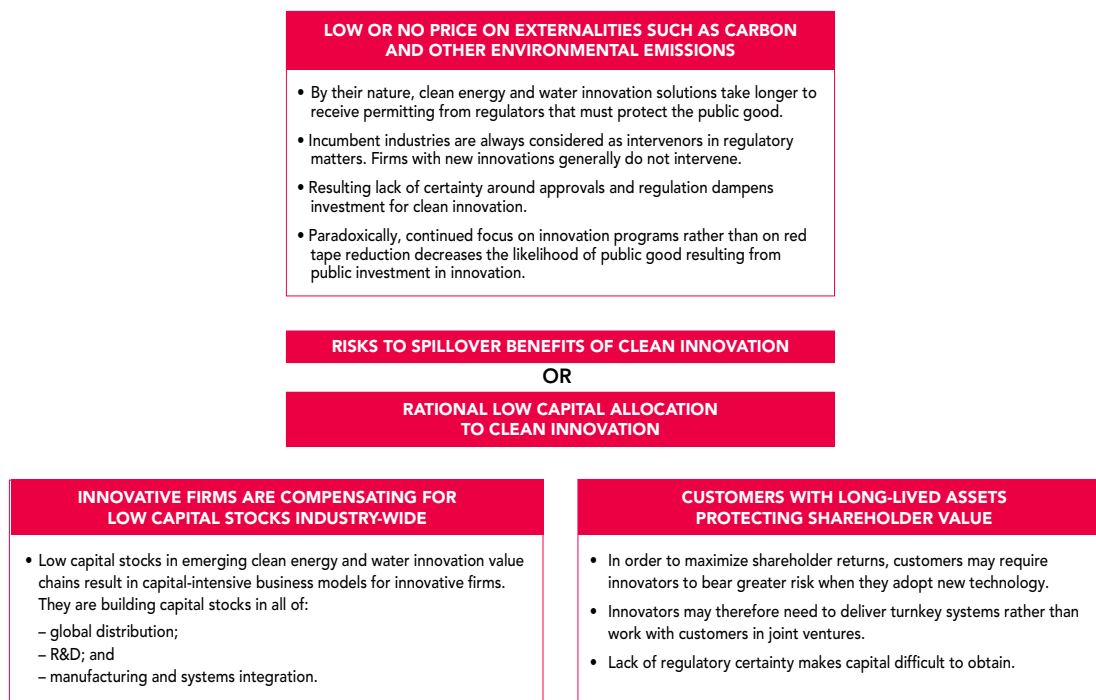
Where permits and approvals are required to implement new technologies, delays are lengthy because authorities grapple with assessing new innovations based on precautionary principles and legacy methods. Where customers are regulated utilities, mandates for innovation have not yet been agreed to and innovators are not generally consulted during regulatory reviews. As a result, shareholders of innovative firms need to “double down” on their investments.

If we were to imagine these energy innovation firms in a sports league, we should picture, on the one hand, the newly established teams playing on fields for which investment is still flowing to provide lighting, build the stadium and set up the transportation system for spectators. Their opposing league, on the other hand, would be playing on a covered and level field well served by public transportation and other infrastructure.

Second, low-carbon innovation firms operate capital-intensive business models because foundational capital stocks are still being established for the low-carbon economy. As a result, innovative firms balance intense demands for capital as they work to build supply chains and distribution systems for their low-carbon products and services. In other words, the macro-level process of building up supply chains, distribution systems and breakthrough innovations is translated into intense pressure for capital within the firm.

Competing for capital within the firm, the research and development (R&D) team bids for funds to hire scientists and technologists and to buy the equipment needed to deliver globally competitive technology. At the same time, in-house manufacturing and engineering teams need capital for engineers, qualified technicians and equipment to manufacture and integrate first-in-kind solutions. In parallel, sales and marketing teams pitch for dollars to build global

Figure 2: Rational Low Capital Allocation to Clean Growth and Innovation



Source: Author.

distribution partnerships and global customer relationships and markets, again without the benefit of established distribution systems. At the firm level, these competing demands for capital are subject to intense management scrutiny in an effort to allocate scarce dollars wisely. Again, if clean energy innovation firms made up a sports league, we should imagine them observing a rule book requiring specialized, expensive and still bulky equipment. Over time, as specializations emerge and capital stocks deepen, not every clean innovation firm will need to be what it is today: a mini-multinational seeing to the operational and capital needs up and down the value chain.

Third, clean technology firms are often called upon to provide solutions for corporations in industries with long-lived assets and subject to swings in commodity prices. Some of these potential customers may also operate under reduced competitive pressures due to fiscal and public finance subsidies to oil, gas, coal and mining industries. These subsidies contribute to high barriers to entry and, hence, low market pressure to either procure innovation from outside firms or to innovate in-house. These subsidies put

climate-tech firms at a competitive disadvantage and subject them to unfair market conditions.

Moreover, in other sectors, such as financial technology, innovative firms enter into what amount to joint ventures with their customers who license their technology and deploy it within their information technology network. Unlike many financial technology firms, clean technology firms have developed business models to finance and deliver plants that they own and operate, further intensifying their requirements for capital. Again, if we imagine the low-carbon technology industry as a sports league, the cost of a new franchise in the league is much higher than could have been anticipated by investors. An analogy might be to imagine these sports franchise owners having to buy the airplane to transport the team rather than chartering aircraft as needed or booking seats on commercial flights. Financial technology firms, on the other hand, need only deliver software with their customers delivering the capital for the network on which their software resides. As a result, financial technology business models are more aligned to those of venture capital than to those of clean technology firms.

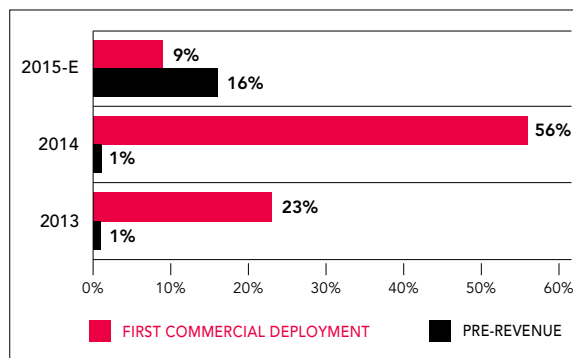
These market conditions, summarized in Figure 2, have led firms to emphasize that their ability to contribute to the low-carbon economy and to growth is compromised because of lack of access to capital.

As a result of these market conditions, investors in clean technology firms have experienced either:

- negative rates of return;
- rates of return below normal market threshold; or
- rates of return above normal market threshold, but below the required premium for the technology, finance and project delivery risk borne by investors.

A more than doubling of venture capital debt, as a share of overall debt secured by Canadian clean technology firms between 2013 and 2014, should raise red flags for policy makers (see Figure 3). Lack of market certainty appears to be slowing deployment of capital to the point where it may put firms at risk of closure. Similarly, interest rates on working capital for Canadian clean technology firms are 31 percent higher than for average Canadian small and medium-sized enterprises (SMEs), and 38 percent higher than Organisation for Economic Co-operation and Development (OECD) counterparts (see Figure 4). As the clean technology industry has been the focus of public investment for many years, firms may be weakened by these

Figure 3: Canadian Clean Technology Firms' Venture Debt as a Percentage of Total Debt



Data source: Bak (2016a).

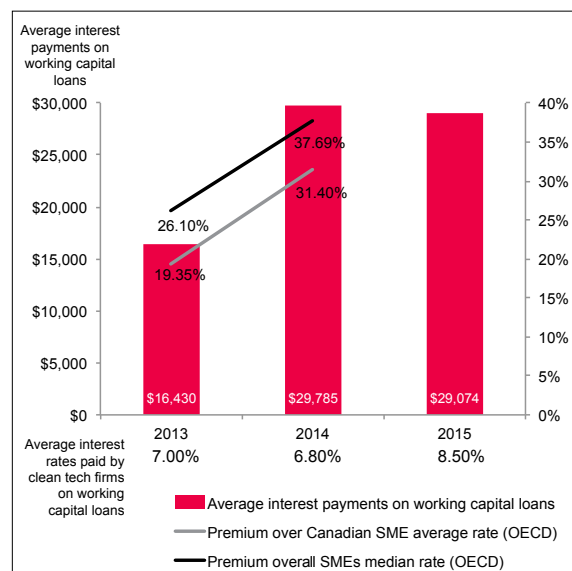
Notes: Firms in “First Commercial Deployment” have begun the commercialization of their innovation. They have sales. Firms in “Pre-Revenue” are focused on commercializing their innovation. They want sales.

systemic costs. The potential for mergers and acquisitions at a discount may limit the spillover benefits to the environment and the economy.

Firm-level Findings: Canada's Clean Technology Firms in Competitive Global Markets

Innovative firms are investing in emerging manufacturing supply chains and distribution systems — capital stocks are still building. As outlined above, there are competing demands for capital within innovative low-carbon and clean technology firms that operate in markets with low regulatory certainty. Research suggests that while there are variations from subsector to subsector, the industry-wide investments in publicly supported R&D remains consistent year over year.

Figure 4: Canadian Clean Technology versus Canadian SME and OECD Firms, Working Capital Interest Rates (2013–2015)



Data sources: Bak (2017); OECD (2016).

For example, investment in R&D by Canadian clean technology firms has hovered at 10 percent of revenue per year for each of the past five years. When compared to other sectors, this is a substantial investment in R&D. The dollar value of annual R&D investments made by this emerging industry is comparable to the Canadian aerospace industry, twice that of the pharmaceutical industry and 10 times that of some resource industries. Global competition in clean energy is intense and, as a result, sustained and substantial R&D investments are table stakes (Bak 2016a).

While R&D is core to all “tech” industries, another difference between clean technology and financial technology firms is that 62 percent of clean technology firms manufacture some or part of their own product. For 2014, Canadian clean technology firms reported 25 and 15 percent of their bill of materials coming from Canada and the United States respectively (ibid., 111). These onshore manufacturing investments stem from the need for physical integration with complex customer systems for both energy and water. As value chains are built over time, the need for in-house and localized manufacturing may decline, freeing up capital for other purposes.

Within the emerging value chains of clean energy innovation, the second leg of the operating model is investment in sales and distribution channels to access global markets. In 2014, the industry overall invested 13 percent of revenues in a range of distribution strategies focused on three main channels: direct sales to end-users, such as corporations and public utilities, via global value chains, which are typically associated with firms that compete, not on the basis of R&D, but rather on lowest-cost manufacturing; sales via agents or distributor, which enable firms to leverage both their own and their agents’ regionally focused presence within priority niche markets; and sales with strategic partners, such as corporations that operate in related fields, which enable firms to leverage their partners’ larger sales force in markets such as China.

In 2014, Canadian clean technology firms assessed the mix of these sales as 49 percent direct to end customers, 17 percent via agents or distributors and 27 percent via strategic partners such as large corporations, with a decreasing emphasis on in-house sales forces (Bak 2016a). This is the normal course of events as product performance becomes more reliable and clearer

paths to customers emerge. It also reflects the deepening of capital stocks in emerging distribution and representation of firms focused on energy and environmental technology.

As an example of the intensity of investment in global distribution strategies, 87 percent of Canadian clean technology firms are engaged in exporting, with 57 percent of industry revenues derived from exports in 2014, up from 48 percent in 2013, and strong non-US market revenues (23 percent of industry revenues in 2014) (ibid.).

Carbon-mitigating innovations are ready before mature carbon markets and other environmental regulation — the bumpy playing field is tilted away for innovators.

In Canada, carbon markets and carbon prices are being established but for the next three years, carbon prices will be too low to stimulate investment in low-carbon innovations such as those of MemPore. Like their renewable energy project development cousins, the second pressure faced by clean technology firms is that, by and large, they are operating before value is placed on reductions in GHGs and other forms of pollution. And even when business cases can be made, regulation and approvals are tilted toward existing solutions. Issues with regulations and permits range from the exclusion of innovations due to specified legacy technology rather than best available solutions, exclusion of innovations due to occupational health and safety standards, and delays of two years or more for permits to implement new solutions once they are contracted. Firms offering green chemical products that are replacements for petroleum-based chemicals face the additional challenge of competing against a commodity whose markets are, and will likely remain, volatile and under downward pressure.

Delays in carbon pricing and complementary regulation have a knock-on effect on public procurement criteria that does not include the full cost of carbon, which is both embedded in infrastructure and resulting from infrastructure operations. The carbon pollution from hydrocarbon inputs needed to operate certain infrastructure, such as back-up power generators, is now being considered in some markets, such as France and the United Kingdom, but these are still exceptions. As a rule, however, public procurement, including infrastructure procurement, does not consider operating costs, replacement costs or a price on carbon inputs and emissions.

International governance mechanisms to accelerate the formation of carbon markets are slowly taking shape around the world. One of the hard-won achievements of the Paris Agreement is Article 6, which provides a mechanism for carbon trading in the form of internationally transferred mitigation outcomes (ITMOs) via carbon markets, which builds on the Kyoto Protocol and markets such as the European Union Emissions Trading Scheme. One way that ITMOs may be operationalized is through carbon credits for projects made possible by clean innovations. If this were to happen, innovators might receive credit for carbon reductions resulting from projects in countries that are eligible for climate finance.

Managers of incumbent industries must maximize shareholder value. They do this by requiring clean energy innovators to build and finance plants rather than entering into joint ventures to license technology. Where clean energy innovation firms cannot attract capital, R&D spillover benefits are lost. Delivering turnkey solutions to customers is a third capital requirement for deployment of clean energy innovation. This reflects the fact that many of these firms' customers are corporations operating long-lived large capital assets in volatile commodity markets, including hydrocarbon markets. To minimize risks and costs, these corporations seek contractual terms where project risk is borne by suppliers such as innovative firms.

Evidence supports a market dynamic whereby raising capital for turnkey systems is the bailiwick of innovators. Canadian clean technology firms reported that sales from turnkey solutions, with

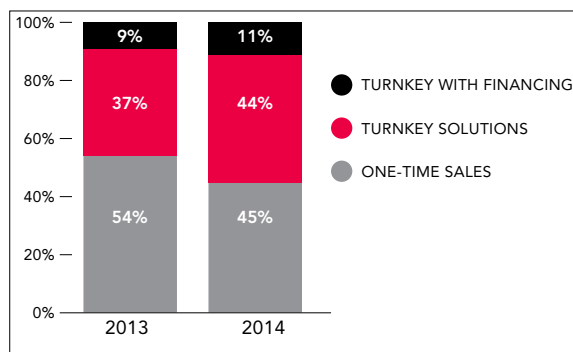
and without financing, as a percentage of total revenues rose from 46 to 55 percent from 2013 to 2014 (see Figure 5). Because many projects involve turnkey solutions in the form of physically integrated plants, management cannot turn to leasing capital markets whose recourse requires mobile assets. Absent regulatory certainty around which capital markets could form, emerging firms will face high hurdles to raise capital for turnkey projects. As a result, publicly funded low-carbon innovations may not be deployed and achievement of climate goals will be put at risk.

As described above, coincident with the rise in the importance of turnkey systems was a steep increase in the percentage of debt that firms sourced from venture debt: from 23 percent of total debt in 2013 to 56 percent of total debt in 2014 (Bak 2016a). Venture debt is costly in terms of high rates of interest that can range from three to four times more than standard corporate debt rates. Venture debt is also structured to make it easy for debt holders to buy out firms when they fail to meet high-interest repayment terms.

Markets for private risk underwriting have not yet formed for clean energy innovation. For corporations implementing capital-intensive plants, including low-carbon investment, project finance has the benefit of being "off balance sheet," meaning that the security for the loan is the project itself rather than the corporate balance sheet. When closing a sale that requires project finance, clean technology firms face additional hurdles. The first barrier is risk underwriting for project delivery and performance to contract (that is, is the solution working according to contracted terms?). Very few lenders today have the risk underwriting experience needed to underwrite innovative low-carbon projects such as combined renewable energy/energy storage projects — this is the inevitability of "first" commercial deployments in emerging sectors. Once its first commercial-scale demonstration project is built, MemPore would benefit from such a risk-underwriting offering.

For the rare companies that have five or more commercial deployments, a second barrier may appear, even after technical risk is underwritten. Off-balance-sheet project finance lenders typically have a lower bound of US\$250 to US\$500 million, whereas innovative low-carbon projects may require only US\$10 to US\$100 million in debt. What is more, financial facilities to aggregate or warehouse these project loans into green bonds

Figure 5: Canadian Clean Technology Firms – Percentage of Sales from Recurring Revenue



Source: Bak (2016a).

that securitize the loans through secondary markets have yet to form, even within green banks.

To recap: Clean technology firms are under multiple pressures for capital; each of these pressures has its own interdependent policy implications.

First, clean technology firms operate in emerging markets where manufacturing, distribution and R&D value chains are emerging. As a result, they make deep investments in R&D, sales and marketing, as well as in manufacturing and engineering.

Second, the solutions these firms offer are ready now, before carbon and pollution markets pay significant and rising prices for externalities, before regulation and approval processes account for innovation and before demand-side policies that fully account for carbon in procurement and infrastructure projects are in place.

Third, the customers for clean technology are risk-averse and many prefer to source innovation in the form of turnkey systems they can turn on and off at short notice, rather than by licensing technology to implement in joint (risk-sharing) ventures where they finance capital assets and innovators deploy their solution.

Finally, project finance is not available for first commercial plants due to lack of private or public risk-underwriting capacity. When subsequent (less risky) commercial plants are built and proven, transaction sizes are smaller than can be served by existing institutional project finance markets and covered bond markets.

The question for prudent policy makers to consider is: can advanced and emerging economies make the transition to the low-carbon economy — with the attendant expectations for environmental performance, job creation and global exports — without deepening the capital stocks underpinning innovative low-carbon and clean water solutions?

The Need to Safeguard Innovation for the Public Good

Canada's Economy Is in a Low Innovation Equilibrium

In Canada, the challenge of safeguarding the spillover benefits of clean energy innovation must also be considered in light of the economy's overall challenges and priorities, notably that of productivity. For more than 30 years, Canada's economic productivity has trended downward and now stands at three-quarters of that of the United States (Sulzenko 2016, 5). Persistently low and declining levels of business expenditure in research and development (BERD) are often identified as the cause of Canada's declining productivity. Indeed, in 2015, investments by Canadian firms in BERD attained their lowest level since the late 1980s. In aggregate, Canadian corporations have settled into a pattern in which they make low investments in BERD, with declining productivity as one outcome. This declining productivity has a direct bearing on policy responses to climate change because if innovation is not commercialized by firms that scale up, the false dichotomy between the environment and the economy will persist.

At the macroeconomic level, Canada's ability to compete and sustain global market share is borne out, at the sector level, by Canada's performance as the third from the bottom in changes in global market share of exports of manufactured environmental goods over the 2005–2014 period (Bak 2016a, XXXI). Similar results occurred in other trade-exposed industries as disparate as automotive and wood products, where between 2005 and 2013, Canada lost more market share in global exports than any other country in the top 25 global exporters (Bak 2015, 104–9). This should give us pause, especially considering that, unlike emerging low-carbon sectors, industries such as the Canadian automotive industry benefit from established industry associations, strong public policy capacity and strong trade policy expertise. It is clear from these outcomes that market mechanisms have trumped innovation policy, but no economic models would have predicted these unsettling outcomes.

Researchers have posited a number of possible causes for Canada's low-innovation equilibrium. Some suggest that during the high point in the global commodities cycle, the terms of trade ensured commodity profits in some sectors but not others. An alternative theory, based on research on US corporate concentration, points to higher profits accruing to market participants where competitive forces are weak (*The Economist* 2016). Still other economists point to the Porter hypothesis, which posits that low regulatory standards and enforcement weaken investment in innovation and international competitiveness. Under the three theories, corporate investments in new technology demonstration projects may be viewed as mere options for the future insofar as corporations do not find themselves in competitive or regulatory environments that *require* them to vigorously and continuously innovate throughout their operations.

Trends in Canadian corporate profits suggest that capital is increasingly concentrated in Canada. Every year since 1988, corporate profits as a share of GDP have been almost 50 percent higher in Canada (13.9 percent versus 9.4 percent in the United States) (Sulzenko 2016, 18). Even after tax, Canadian corporations' profits as a share of GDP are still higher than those of their US counterparts. Research has not yet been conducted on whether or not emerging innovation firms are playing a role in counterbalancing concentration through accelerated new firm formation.

"Small Catastrophes" and the Political Economy

The question of how to enable the scale-up of productivity driving innovation is complex and has inspired many hypotheses and theories. One proposal for macroeconomic disruption, made in 1972 by the CEO of Northern Electric, was reproduced in a recent report on Canada's low-innovation equilibrium. It states:

It is uncertain whether any incentive plan to stimulate the growth of domestic technology and innovation, or to make corporations expand aggressively into foreign markets, can achieve significant success when it is applied to companies in which the drive to do these things has not already been forced to emerge because of exposure to a real stimulus from the economic environment. What we seem to

need in Canada are "small catastrophes." (Marquez quoted in Sulzenko 2016)

Economists refer to these "small catastrophes" as shocks. Canada recently experienced just such a shock during the global recession, when oil prices fell from \$147 a barrel to briefly below \$40 following a 3.8 percent decline in demand for oil during the 16 months from the first quarter of 2008 to the second quarter of 2009.

It would appear that small catastrophes have not had the expected effect. This volatility in the price of oil has resulted in little policy change. Recommendations to create new markets for low-carbon innovations through public procurement have not borne fruit. For example, to the present, government-sponsored public procurement programs for innovation functioned mostly as information hubs.⁵ Companies such as MemPore have not found any markets via these avenues. Broader anecdotal evidence suggests that companies that participated in public procurement information programs experienced little demand or actual procurement. Still to be determined is whether mission-based programs that include a dimension of public procurement, such as those aimed at "moonshots" challenges, will provide sufficient impetus to drive innovation into public procurement. These programs are generally associated with defence procurement in the United States and have underwritten most of the technologies that make up smartphones and the networks they operate on.⁶

In addition to the thin evidence of the impact of small catastrophes as stimuli for investment in clean energy innovations, there may be an additional paradox in regard to low-carbon innovation in the face of global hydrocarbon markets. The International Energy Agency predicts that in order for CO₂ to remain below 450 parts per million (ppm), global oil demand must drop

5 See the Build in Canada Innovation Program for an example (<https://buyandsell.gc.ca/initiatives-and-programs/build-in-canada-innovation-program-bcip>).

6 US regulations promulgated under the authority of section 15 of the Small Business Act (1958) authorize agencies to set aside contracts for small businesses generally. With respect to subcontracting requirements, *Public Law 95-507* changed the emphasis from voluntary to mandatory and from "best efforts" to "maximum practicable opportunity" for prime contractors with regard to their subcontracting obligations from SMEs. For reference, please see Federal Acquisition Regulation, subpart 19.7 – The Small Business Subcontracting Program: www.acquisition.gov/far/current/html/Subpart%2019_7.html.

by 15 percent from 97 to 80 million barrels per day (Rubin 2016). A 15 percent drop is nearly four times the drop in demand that occurred during the global recession, causing a 74 percent drop in the price of a barrel of oil. Because of the need to keep CO₂ at less than 450 ppm, downward pressure on the price of oil in the medium term is a scenario being considered by policy makers (Policy Horizons Canada 2016). Innovations that compete with fossil fuels, whose price is volatile, will require safeguards to ensure their deployments and societal benefits from investment in innovation.

National and Global Contexts

In the face of jobless GDP growth, policy foundations for sustainable finance are being considered. At the same time that the world grapples with climate change, it is also struggling with rising joblessness and the consequences and causes of the 2008 global recession. This situation has triggered research on how to broaden and deepen capital markets and on access to finance by SMEs, which are recognized as critical to employment creation and structural renewal. Canadian clean technology firms are a case in point. The industry's 800 relatively young firms employ as many people — including young people — as more established industries such as aerospace manufacturing, non-metallic mineral production, forestry and logging and pharmaceutical manufacturing.

Among OECD countries, bank lending has been assessed as an insufficient source of debt financing for SMEs. As described above, OECD research suggests that markets for SME finance in Canada are less competitive than in other advanced economies. According to reports to the OECD, the risk premium for Canadian SME debt is high. For example, in Canada, the risk premium for all SME lending is four times greater than that in Austria and Belgium (OECD 2016). Green banks in other jurisdictions do not generally target emerging solutions, but a case could be made for greater focus on mechanisms to crowd in finance for emerging firms. Doing so will help

provide investment opportunities as a corollary for divestiture away from carbon-intensive assets.

Within the finance and SME research branches at the OECD, new research is being undertaken to gather evidence and to recommend policies to deepen and broaden debt markets for SMEs. Specifically, structured finance instruments such as covered bonds have been proposed as a mechanism to establish sources of debt that are priced by broader capital markets rather than by banks (Kaousar Nassar and Wehinger 2015). The OECD recently recommended that regulators investigate how they can create the legal frameworks to support the development of covered bond markets as sources of finance for SMEs (Marlatt, Jennings-Mares and Green 2015). These mechanisms could leverage those that led to the creation of existing covered bond markets, now comprised mostly of real estate property mortgages (European Covered Bond Council 2015). It may also be possible that covered bond markets could be established via networks of green investment banks — another area of active research by the OECD — but these policy prescriptions will not be quick to implement. Policies that safeguard investments in innovation may be needed sooner.

New markets for technical risk underwriting. Whereas bonds may be vehicles to broaden and deepen capital markets for project finance, technology risk will remain a barrier to firms seeking project finance for early commercial deployments. Markets are now emerging to underwrite performance warranties for a limited number of clean innovation technologies.

For example, New Energy Risk (a division of the XL Insurance Group)⁷ is exploring underwriting technology performance and availability for projects that offer otherwise bondable conditions via secure feed-stocks, “take or pay” purchasing agreements and first-call debt structures. The warranties underwritten by New Energy Risk might eventually cover dimensions of technology performance such as the conversion efficiency and the availability of energy storage. This insurance would be designed to enable firms to access project finance and to cost less than the risk premium firms would otherwise pay for project finance without the warranty. Further research

⁷ See <http://newenergyrisk.com/>.

will be needed to discern if this market develops in tandem with clean energy innovation.

To recap, the public spillover benefits of investments in clean energy innovations may not be realized because of factors that are specific to the sector and because of other barriers faced by all emerging sectors. Because of the urgency of translating innovation into lower carbon economic activity, recommendations to safeguard public investments in clean energy innovation should be designed in proportion to the risk of the innovations not being taken up in the market. Proportionality can be considered in terms of intervening power with regulators, engagement with standards-setting bodies, proportional market access and proportional access to finance, be it public or private, including preferential fiscal policies for hydrocarbon industries. Recent research on Group of Twenty subsidies to oil, gas and coal production points to \$2.9 billion in fiscal subsidies and equivalent subsidies in public finance via export credit and other subsidies in Canada (Touchette 2015).

The following section includes policy recommendations to safeguard the societal and environmental benefits from innovative firms through payments for GHG reductions, risk underwriting for innovations, global benchmarking of regulations and full life-cycle costing of infrastructure.

Policy Recommendations

In the spring of 2016, the findings and recommendations of primary research into the global and Canadian clean technology industry were presented at the National Press Gallery in Ottawa. This report, the *2016 Canadian Clean Technology Industry Report* (Bak 2016a), was the fifth annual firm-level report on companies that make up the Canadian clean technology industry.

Included in the remarks on the findings and recommendations from the 2016 report was a recommendation to establish both macroeconomic and microeconomic strategies for the low-carbon economy — referred to in the recommendations as “a CMHC [Canada Mortgage and Housing Corporation] for the low carbon economy.”

The CMHC is part of a complex web of institutional and economic policies safeguarding the consumer mortgage sector, enabling citizens to become home owners and enabling the creation of real estate capital stocks, which have become the basis of consumer wealth.⁸

In the case of the low-carbon economy, policies will need to accomplish in less than a decade what took more than five decades for consumer home ownership. That is to say, the interconnected policies and institutions that will lead to the market mechanisms to enable all economic actors to act rationally in the low-carbon economy will need to be built, thoughtfully but quickly.

The question for policy makers to consider is what policies and institutions are needed to make the transition to the low-carbon economy. This is a challenge, given that these policies and institutions must be viewed not only with expectations for climate and environmental stewardship but also for job creation and productivity improvement. There is no doubt that capital stocks need to be deepened to support actors enabling the low-carbon economy. The question is, how?

To foster an interdisciplinary approach, policy proposals in this paper have been formulated based on the policy goals in three different fields of research: innovation, environmental regulation and macroeconomic policy.

The policy goals targeted are the broadening and deepening of:

- capital stocks and risk-bearing capacity in low-carbon and environment markets;
- demand for low-carbon innovation; and
- financial markets to bring down the cost of capital.

⁸ This system is now taken for granted, but this was not the case even a relatively short time ago. For example, the author’s grandmother earned a steady salary for decades as a school teacher; however, as a woman widowed in her fifties in 1959, she was financially unable to buy a home and paid rent for all the years she was employed (retiring at 75). The author’s mother, who also was a teacher, used modern credit facilities to buy a modest home for her mother.

Summary of Policy Recommendations

In the section below, four policy recommendations are presented under the following headings:

- Innovative Carbon Emissions Mitigation Fund;
- Sustainable Finance Performance Warranty Program;
- Best Global Regulations for the Low-carbon Economy Program; and
- Sustainable Infrastructure Program.

Each policy proposal is presented in two parts: the problem set, including problems from adjoining policy domains, and the proposed solution.

Problem Sets and Policy Recommendations

Innovative Carbon Emissions Mitigation Fund

Problem Set: Broadening and deepening risk-bearing capacity to support implementation of low-carbon innovation

Low-carbon Economy Challenges:

- Existing capital markets for clean technology projects are thin, making raising project finance slow and costly.
- Thin capital markets are slowing deployment of low-carbon solutions that can contribute to the attainment of Paris Agreement commitments.
- Regulators do not have market signals to provide evidence of the scale and nature of potential clean innovation solutions to address Paris Agreement commitments and other environmental goals.

Solution: Innovative Carbon Emissions Mitigation Fund

In order to prime the pump for deployment of innovations to support the attainment of Paris Agreement goals, financed by the unwinding of fiscal and public finance subsidies to oil, gas and coal, the Innovative Carbon Emissions Mitigation Fund would enable providers of low-carbon solutions whose innovations underpin GHG emissions reductions to monetize pollution credits, thereby increasing their financial resilience. The value of this fund would be proportional to existing fossil fuel subsidies and would be established to operate during the period in advance of substantial prices on carbon and/or significant reductions in emissions permits under cap-and-trade systems.

Firms would apply for accreditation as emissions reduction providers in the funds based on the following three criteria:

- investment in innovation as evidenced by having received a grant for innovation under a federal or provincial program (for example, in Canada, these would include Scientific Research & Experimental Development, the Industrial Research Assistance Program, Sustainable Development Technology Canada and Emissions Reduction Alberta);
- being a grantee in good standing; and
- qualifying as an SME in terms of employees or revenues.

Once accredited under the fund, firms could apply for loans to finance emissions reduction projects delivering GHG reductions from a minimum of 750 tonnes to a maximum of 1,000,000 tonnes. At a carbon price of \$30 per tonne, the Innovative Carbon Emissions Mitigation Fund loans would range between \$22,500 and \$30,000,000.

Emissions reduction providers would be entitled to propose projects outside of Canada under climate finance programs. These projects would be considered for eligibility under bilateral offset trading mechanisms.

The loans would be converted into grants at a pre-established carbon price as and when carbon reductions for projects proposed by emissions reduction providers were realized as planned. Proposed and actual carbon reductions would be certified by arms'-length entities such as environmental non-governmental organizations

that would also apply for accreditation to the fund as emissions reduction certifiers. Firms applying for accreditation as emissions reduction providers would be encouraged to engage early with emissions reduction certifiers and vice versa.

Similar to availability payments made by governments to crowd in private capital into public infrastructure, the loans would be forgivable by the firms at a rate to be determined if planned reductions were not achieved within five years.

Applications to the fund would provide visibility into planned carbon reductions in both public and private sector projects where clean growth and innovation solutions play a part. The horizon for planned carbon reductions would be from 2018 to 2023.

The funds would serve to deepen capital stocks among emissions reduction providers, thereby enabling them to scale up and invest profits to expand deployment of their low-carbon solutions, employ more people and expand global distribution and international trade. They would also serve to build stronger policy ties between officials responsible for innovation programs and those responsible for environmental regulation domains by requiring good standing in innovation program funding as a criterion for accreditation of emissions reduction providers *and* by operating the Innovative Carbon Emissions Mitigation Fund within departments of climate change and the environment. The appropriation for the funds would be assured through the retirement by 2020 of subsidies to the hydrocarbon industry.

In Germany, the national development bank (KfW) operates a climate readiness portal that supports the bankability of potential climate-related projects. The market signals provided via the climate readiness portal have enabled the formation of markets for both project finance and project delivery services for global projects. The same principles are applied to the Innovative Carbon Emissions Mitigation Fund for domestic visibility. In Canada, British Columbia's Low Carbon Fuel Standard provides similar grants for carbon reductions to innovators.

Sustainable Finance Performance Warranty Program

Problem Set: Broadening and deepening financial markets to reduce the cost of financing low-carbon solutions

Low-carbon Economy Challenges:

- Public sector actors seeking to include clean technology in infrastructure or other projects cannot bear the full risk for the technical performance of new low-carbon economy solutions.
- As a result, contractual arrangements between engineering procurement and construction (EPC) and infrastructure project proponents may result in risk downloading to clean technology firms whose balance sheets are still forming, or the exclusion of innovative solutions altogether.
- Financial markets have not received sufficiently concentrated market signals to build or acquire lending and underwriting experience for clean technology innovation project-related risk.
- Performance insurance underwriting capacity exists for risky sectors such as mining, but market signals have not yet triggered a spillover of this capacity to low-carbon innovation performance underwriting.

Solution: Sustainable Finance Performance Warranty Program

The Sustainable Finance Performance Warranty Program would target sellers of clean technology whose customers, such as EPC firms and public procurement actors, require insurance to warranty technology availability and performance.

The program would target the formation of a critical mass of risk-underwriting opportunities to attract private sector underwriters to warranty the performance and availability of innovations being procured by public and private sector buyers. It would be deployed in 2018 to coincide with full life-cycle cost accounting (including carbon costing) for infrastructure procurement.

The program's goal would be to enable the formation of a low-carbon innovation risk underwriting market. The market signals to kick-start the performance warranty

market would come from the accreditation of emissions-reduction providers and applications for emissions-reduction projects under the Innovative Carbon Emissions Mitigation Fund.

The Sustainable Finance Performance Warranty Program would be overseen by an arms' length public agency and operated by a private sector marketplace operator. The market operator would be retained by the administrator under a management contract for four years with the potential for a one-year extension. The management contract, established through a transparent consultation, would combine variable compensation-based on the value of underwritings and the number of underwriting firms participating in the market, with fixed fees for communication and engagement with low-carbon economy project proponents, including municipalities.

The Asian Development Bank established a marketplace for clean technology intellectual property using some of the principles outlined above.

Best Global Regulations for the Low-Carbon Economy Program

Problem Set: Broadening and deepening demand for low-carbon solutions to gain the climate and economic productivity benefits

Low-carbon Economy Challenges:

- Civil society, including academia and environmental not-for-profits, does not currently have the opportunity to become aware of how innovations are being deployed globally to achieve climate and environmental goals.
- Provisions in article 6 of the Paris Agreement will lead to increasing international cooperation and a greater need for bilateral regulatory harmonization as well as multilateral engagement.
- Many national and sub-sovereign carbon-related and environmental regulators and approval authorities are not now structured to accommodate innovative solutions.
- Innovative firms have low regulatory engagement and yet are successfully deploying their solutions in global markets.

They are knowledgeable of regulations and policies that enable the deployment of their solutions in these international markets.

Solution: Best Global Regulations Program

The Best Global Regulations Program would enable firms to request third-party assessment of the potential within their country of international policies and regulations that have enabled commercial deployment of their products and services. The intent of the Best Global Regulations Program would be to recruit global civil society including environmental non-governmental organizations and academia to assess the effectiveness of low-carbon economy policies and regulation internationally and their potential to spur take-up of innovation domestically. These reports would be made public and would serve as evidence to determine and prioritize environmental regulation modernization.

The Best Global Regulations Program would be established for a period of five years.

Following the second year of operation, a report on sub-sovereign jurisdiction considerations for Best Global Regulations would be submitted to a joint commission of federal and provincial commissioners for the environment.

In parallel, an operational review of permit approval and regulatory processes would be undertaken to assess the impact of these processes on the take-up of innovation. The review would consider structural impediments such as costs, delays and current intervener status.

Sustainable Infrastructure Program

Problem Set: Broadening and deepening demand for low-carbon solutions to gain climate and economic productivity benefits

Low-carbon Economy Challenges:

- Infrastructure procurement criteria generally assess one-time capital expenditures only, with no requirement to consider the cost of future carbon emissions and other operating costs or cost-effective alternatives, even though the World Trade Organization's Government Procurement Agreement program allows for such criteria (Bak 2016b).

- With very few exceptions, clean technology firms have been unsuccessful in integrating their innovations into public infrastructure projects.
- As an example of demand-side stimulus, the Government of Canada plans to invest \$120 billion in infrastructure over the next 10 years. Take-up of innovative solutions within infrastructure would be a vehicle to ensure that spillover benefits are realized from investments in innovation.

Solution: Sustainable Infrastructure Program

Under sustainable infrastructure procurement, an approach with three stages would be taken to evaluate new infrastructure proposals:

1. Full economic life-cycle cost assessment, including taking into account operating costs, societal benefits, and the impacts of climate change and more extreme weather.
 - Many requests for proposals under infrastructure procurement agreements only take into account upfront costs. Benefits of options with lower carbon footprints are not properly accounted for.
2. Full carbon cost assessment, accounting for embodied, operational, end-of-life and sequestered carbon.
 - The impact of this approach would be more cost-effective infrastructure decisions, a lower carbon footprint, increased productivity and innovation spillover benefits. Carbon content would be evaluated in at least four forms:
 - embodied — from material production, construction processes and waste;
 - operational — from functional use of a project over its useful life;
 - end of life — from decommissioning, reuse, recycling and/or disposal; and
 - sequestered — for example, through restoration and enhancement of natural features (such as wetlands, sloughs, swales, buffers) for water quality and flood/storm water mitigation.

3. “Best available solutions” assessment that requires project proponents to undertake an analysis of whether the need associated with the infrastructure project can be met through innovative or natural means.

For example, using different farming practices (costing less than \$1,000) or wetlands to protect drinking water sources from excessive nitrate, may be more cost-effective than hard infrastructure in the form of a new centralized water treatment facility (costing more than \$250,000). At the same time, new innovations may radically reduce the cost of water treatment through decentralized water treatment approaches.

Safeguarding the environmental and societal benefits of innovation is one way for advanced and emerging economies to ensure growth in the transition to the low-carbon economy with attendant benefits to climate, job growth and productivity.

Appendix

Barriers Survey Participants and Interviewees

Company	Name	Title
Agrisoma Biosciences Inc.	Steven Fabijanski @	CEO
Airborne International Holdings	Murray Mortson *	Chairman
Airex Energy	Sylvain Bertrand *	CEO
Aspin Kemp & Associates	Jason Aspin *	CEO
ATD Waste Systems Inc.	J. Victor Van Slyke *	President
ATI Airtest Technologies Inc.	George Graham *	President
AUG Signals Ltd	Cindy Dongxin Hu *	Senior Project Manager
BI Pure Water Inc.	Scott Foster @	President
BioAmber	Anne Waddell *#	Vice President, Government Affairs
Biosecur Lab. Inc.	Yves Methot @	President
Biothermica	Guy Drouin @#	President and CEO
Blue-Zone Technologies Ltd.	Dusanka Filipovic *	President and Vice-Chair
BuiltSpace Technologies Corp.	Rick Rolston *	CEO
Canadian Solar Solutions Inc.	Ryan Tourigny *	Director Business Development, Western Canada, Energy Group
CarbonCure	Robert Niven *#	President & CEO
Carbon Engineering	Geoffrey Holmes *#	Director of Business Development
Catalyst Agri-Innovations Society	Christopher Bush *	CEO
CHAR Technologies Ltd.	Andrew White *	CEO
Cielo Waste Solutions Corp.	Don Allan *	President
CircuitMeter	Paul Mertes *@	CEO
Clean Energy Canada	Sarah Petreva #@	Senior Policy Advisor
CleanTech Capital	James Sbrolla *	President
Clevest Solutions Inc.	Thomas Ligocki @	CEO
CO2 Solutions	Evan Price * #	President and CEO
Coastal Hydropower Corporation	Neil Anderson *	President
Cormark Securities Inc.	Stefan Coolican *#	Director, Investment Banking
Cowater	Rod Lever *#@	Vice President
Daymak	Aldo Baiocchi *	President
DeMarco Allen LLP	Lisa DeMarco #@	Senior Partner
Diacarbon Energy Inc	Jerry Ericsson *	CEO
dPoint	James Dean *	CEO
dTechs	Roger Morrison @	CEO
Eco-Tec Inc.	Phillip Simmons @#	CEO
Enerkem	Marie-Hélène Labrie *#@	Senior Vice President, Government Affairs and Communications
EnerMotion Inc.	Jack MacDonnell *@	Founder, CEO and President
Ensyn Technologies Inc.	Ian Barnett @	Vice President of Sales and Business Development
Etalim Inc.	Ron Klopfer *@	CEO
eTime Energy	Peter Tung @	CEO
Fênix Energy	Ed Smith @	Managing Director
Fielding Environmental	Ellen McGregor *#@	President and CEO
General Fusion	Nathan Gilliland *@#	CEO
Greenlight Innovation	Ross Bailey *	CEO
GreenMantra Technologies	Kousay Said *	President and CEO
GreenNH3	Roger Gordon *	Manager
GreenScience Technologies	John Ashbee @	CEO
Hifi Engineering Inc.	Steven Koles @	President and CEO

Company	Name	Title
Hydrogen In Motion Inc.	Grace Quan *	CEO
Hydrogenics	Daryl Wilson *#@	President and CEO
Hyteon Inc	Jean-Guy Chouinard *	Executive Vice President
Idénergie Inc.	Claire Ho *	Environmental Economist
Imtex Membranes Corp.	Glenn Towe *	President and CEO
inMotive	Paul Bottero @	CEO
Inventys Inc.	Alison Cartier *@#	Manager, Marketing and Communications
Island Water Technologies	Patrick Kiely *@	CEO, Co-founder
Ivey International Inc.	George (Bud) Ivey *@	President and Senior Remediation Specialist
Lockhart Industries	Doug Lockhart *	CEO
Marnoch Thermal Power Inc.	Ian Marnoch @	President
MaRS Advanced Energy Centre	Ron Dizy *#	Managing Director
MaRS Discovery District	Jonathan Dogterom *#	Managing Director, and Physical Science Venture Services
MemPore Environmental Technologies	Alastair Samson *@	President and CEO
MetaFLO	Andrew McNabb @	President and CEO
MineSense	Jeff More *	CEO
Nelson Environmental Remediation	Darryl Nelson @	President and CEO
New Energy Corporation Inc.	Clayton Bear *	President and CEO
Nexterra Systems Corp	Darcy Quinn @	Director, Business Development
NRStor	Annette Verschuren #@	Chair and CEO
NRStor	Jason Rioux *#	VP
PBES	Grant Brown *	Vice President Marketing
Permolex Ltd.	Bridgette Duniece *	VP Operations and External Affairs
PIPS	Anatoly Arov *	Inventor
Pivot Strategic Consulting	Aaron Freeman @	Principal
Power Systems Technology	Laurie Ferris *	President
QSBR INNOVATIONS	Robert Stinson *	Senior Managing Partner
Quadra Solar Corp.	Ra'ed Arab @	Founder, CEO
Quadrogen Power Systems	Nelson Chan @	Director of Business Development
Quantiam Technologies Inc.	Dr. Steve Petrone *@	CEO and CTO
Questor Technology Inc.	Audrey Mascarenhas *#@	President and CEO
RenewABILITY Energy Inc.	Hannah Toman *	Office Administrator
Responsible Energy Inc.	Gordon Fraser *@	President and CEO
Round River Technologies Ltd.	Michael J Walker *	Owner
SiREM Lab	Phil Dennis @	Senior Manager
Sofame Technologies Inc.	John Gocek *	President
SunPump Solar Inc	Bruce Gray *	Chief Technical Officer
Sysgaz Inc.	Charles Tremblay *	President
Tandem Investment Capital	David Bookbinder *#@	Managing Partner
Temporal Power	Eric Murray *#@	President & CEO
Terragon Environmental Technologies	Ron Denom @ #	Director
Titan Clean Energy — Carbon Smart Technologies	Jamie Bakos *	President and CEO
Titanium Corporation	Scott Nelson *#	President and CEO
Titanium Corporation	Jennifer Kaufeld *#	Vice President, Finance and CFO
Torrefusion Technologies Inc.	Paul Adams *	Director
Tri-Y Enterprises Ltd.	Joe R Zhao *	R&D Manager
Tugliq	Pierre Rivard *#	President and CEO
Tyromer Inc.	Sam Visaisouk *	CEO

Company	Name	Title
Ubiquity Solar Inc.	Cathy MacLellan @	Vice President, HR and Outreach
Ubiquity Solar Inc.	Ian MacLellan * @	President and CEO
Vancouver Economic Development	Brian Buggy * #	Director, Strategic Initiatives and Sector Development
Vive Crop Protection	Keith Thomas *	CEO
WCI Environmental Solutions Inc.	David Martin *	Managing Director
Westport Innovations	Karen Hamberg * # @	Vice President, Industry and Government Relations
Will Solutions Inc.	Martin Clermont @	CEO
Zero Waste Energy Systems	Bruce Coxhead *	President

Canadian Clean Technology Innovation Partnership Attendees

Company	Name	Title
ALUS	Lara Ellis #	Director, Ecosystem Markets Development
ArcTern Ventures	Tom Rand #	Managing Partner
Ballard Power Systems	Karim Kassam #	Vice President, Business and Corporate Development
Canadian Solar	Ken Rowbotham #	General Manager, Energy Group
Canadian Solar	Shawn Qu #	Chairman, President and CEO
Carbon Engineering	Adrian Corless #	President and CEO
Carmanah	John Simmons #	President and CEO
Cormark Securities Inc.	Jim Kofman #	Vice Chairman
Council of Canadian Innovators	Ben Bergen #	Executive Director
Cowater	David Baron #	President
Delta Management	Gavin Pitchford #	Chief Talent Officer
Eco-Tec Inc.	Mike Dejak #	Senior Vice President
Ecotech Québec	Denis Leclerc #	President
Enerkem	Lisa Hanke #	Director, Government Affairs
Enerkem	Vincent Chornet #	President and CEO
Environmental Defence	Tim Gray #	Executive Director
General Fusion	Jean-François Beland #	Vice President, Government Relations and Corporate Affairs
General Fusion	Michael Delage #	Vice President, Strategy and Corporate Development
Inventys	Daryl Wolanski #	Vice President, Business Development
Inventys	Denis Connor #	Board Member, Director (Inventys)
Ivey Foundation	Andrea Moffat #	Vice President
Ivey Foundation	Bruce Lourie #	President
Nsolv	Alexander Stickler #	Vice President, Business Operations
S2G Biochem	Mark Kirby #	President and CEO
Saltworks	Ben Sparrow #	President and CEO
Tandem Investment Capital	Marc Weiner #	Principal
Terragon Environmental Technologies Inc.	Peter Tsantrizos #	President and CEO
Vancouver Economic Commission	James Raymond #	Manager, Research and Analysis

Legend: * Barriers survey participant

@ Interviewees

Canadian Clean Technology Innovation Partnership (CCTIP) attendee

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