



Clean Technology in Canada's Natural Resource Sectors:

A Discussion Paper





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1 Introduction and Summary

Canada is a nation rich in natural resources. These natural resources, which include energy, minerals and metals, forests, agriculture, and fisheries, are vital to our economy. Natural resource sectors represent one-fifth of our GDP, and play a foundational role in shaping and anchoring communities across the country. Natural resources are also critical determinants of Canada's environmental performance. Their development and use accounts for the vast majority of our greenhouse gas emissions, and affects air, water and soil quality, public health and safety, and biodiversity and conservation.

As the world moves toward a clean, low-carbon economy, countries that succeed in mobilizing solutions through innovation in clean technologies will have a competitive advantage. Clean technologies are not limited to just devices; rather, they can encompass a range of products, processes and services that, when applied, result in reduced environmental pollution, resource use, and/or waste.

In Canada, innovation and use of clean technology is critical to enhanced productivity and competitiveness and reduced environmental impact in the natural resource sectors. In recognition of this, the federal government has identified support for innovation and the use of clean technologies in the natural resource sectors as a key component of Canada's approach to addressing climate change and generating clean growth, and has pledged to commit \$200 million more each year for clean technology in the natural resource sectors and \$100 million more each year for clean technology producers. Canada has also joined with 21 other partners to launch Mission Innovation, and will seek to double clean energy and clean technology research and development funding to \$775 million by 2020.

This discussion paper outlines how the natural resource sectors stand at the nexus of Canada's economic and environmental agendas. It argues that through innovation and use of clean technology, Canadians can continue to benefit from our rich natural resources, while also accelerating the nation's trajectory towards a clean, low-carbon economy.

The paper sets out a proposed Strategy that would position the natural resource sectors for competitiveness and environmental leadership at the global scale, both by driving cleaner extraction, harvesting and use of the natural resources we know today, and developing the clean energy and natural resource solutions of tomorrow. Discussed are policy and program options that focus on gaps and challenges that clean technology producers and natural resource sectors face in addressing environmental impacts and leveraging innovation to enhance their competitiveness. These options include support to address short-term incremental innovation in the extraction, harvesting and use of natural resources in Canada (to meet Canada's 2030 goals), as well as longer-term technology breakthroughs that would deliver transformative solutions (2050 and beyond).

Your feedback on this proposed Strategy will inform the Government of Canada's choices on how to support clean technology producers and to increase investment in clean technologies in the natural resource sectors.

2 Scope, Definitions and Evidence

This discussion paper is focused on reaching economic and environmental outcomes for the natural resource sectors in Canada through innovation and use of clean technology. These two concepts, natural resource sectors and clean technology, are defined below for the purposes of this paper:

Natural resource sectors: Extractive and harvesting industries, namely energy, forestry, mining, agriculture and agri-food, and fisheries and aquaculture, including both upstream and downstream activities associated with these sectors (e.g., utilities and manufacturers of primary resource-based products).

Clean technology: Clean technology can be considered to belong to two main categories. The first is any product, process or service designed with the primary purpose of contributing to remediating or preventing any type of environmental damage. The second category is related to a product, process or service that is less polluting or more resource-efficient than equivalent normal products that furnish a similar utility. Their primary use, however, is not one of environmental protection.

The **clean technology industry** is an emerging area of economic activity in Canada. **While this paper is focused foremost on the natural resource sectors, the close interplay between natural resource sectors and the clean technology industry in Canada means that both must be actively considered** (see also Box 1).

Definitions of the clean technology industry vary both nationally and internationally. Currently, a common definition of the clean technology industry does not exist; however, Natural Resources Canada, Statistics Canada, and Innovation, Science and Economic Development Canada are working to develop a definition that can be operationalized to collect Canadian statistics (refer to Annex 1). For the purpose of this paper, a broad approach including three elements of clean technology activity is considered. The **core clean technology sector, or “pure play,”** is represented by companies primarily engaged in research and development (R&D) or the manufacture and sale of clean technologies. The clean technology industry also includes **clean technology business lines** in companies whose primary business is not clean technology. This would include, for example, natural resource sector companies that engage in clean technology R&D, manufacturing and sales. Accounting for these business lines is essential to understanding and influencing the magnitude of clean technology activities in Canada. The **adoption of clean technologies**, processes or services in industrial or other economic activities may occur among many companies across the economy, in particular among natural resource companies. Adoption is not considered to be a direct part of the clean technology industry, but is vital to growth in the industry and therefore is an important area of clean technology activity.

In addition to sources cited, **evidence for this discussion paper is being compiled through comprehensive stakeholder engagement on the issues, barriers and opportunities for clean technology in Canada’s natural resource sectors.** Activities to date have engaged 250+ natural resource and clean technology stakeholders through multi-sectoral Ministerial roundtables across the country and meetings of senior government officials with partners and stakeholders. A wide range of federal interdepartmental meetings have also been undertaken to advance a whole-of-government approach to supporting clean technology in the natural resource sectors, including a full-day federal workshop. Collaboration with federal departments representing the natural resource sectors is ongoing through a federal working group charged with elaborating a unified natural resource perspective on options for policy and program instruments for clean technology in the natural resource sectors. The proposed Strategy will be further refined based on feedback from Canadians gathered via an online engagement platform focused

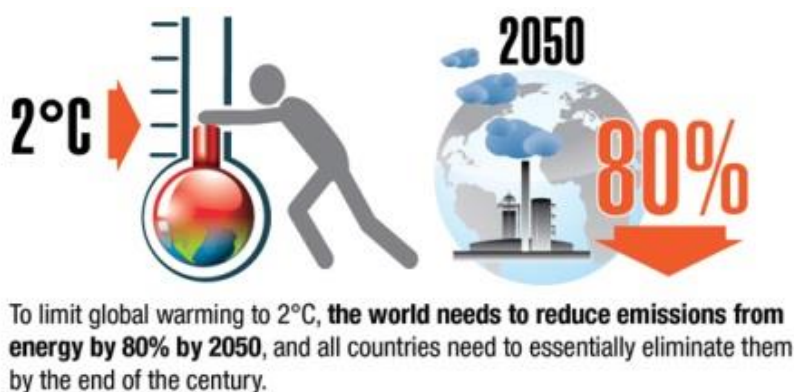
on clean technology in the natural resource sectors and Mission Innovation. The website will collect input through summer 2016.

3 Rationale

The transition to a clean, low-carbon economy is underway. Agreeing to strengthen the global response of keeping the increase in global average temperature rise to well below 2°C, as well as pursue efforts to limit the increase to 1.5°C, 195 countries including Canada have adopted the Paris Climate Change Agreement. Furthermore, the environmental performance of companies, products and services plays an important role in generating social acceptance in the marketplace. Society increasingly demonstrates that it values a clean environment, and public concern about local air quality, water use and quality, soil quality, public health and safety, and biodiversity and conservation is affecting market opportunities and demand. By supporting improvements in these areas, clean technology plays an important role in building public confidence for natural resource development.

Countries that find solutions for a clean, low-carbon economy through innovation will have a competitive advantage. Extensive research has shown that firms facing constraints (e.g., lower-cost competitors, price volatility) will innovate to gain competitive advantage. The widely studied Porter Hypothesis¹ suggests that environmental policies and regulations² can contribute to innovation by driving firms to improve environmental performance through more efficient use of resources, which leads to greater profitability. This also applies at the level of national economies. The OECD³ has stated that the stringency (level of ambition), predictability (effect on investor uncertainty) and flexibility (allowing innovators space to best meet the objective) of environmental policies each play a significant role in inducing innovation. As the world moves towards implementing measures to achieve climate change and other environmental goals (see Figure 1), countries that create the right conditions for companies to invest in clean innovation will have a competitive advantage in the global market.

Figure 1. Cut in emissions from energy production to limit warming to 2°C



Source: International Energy Agency

¹ Porter, M.E., *The Competitive Advantage of Nations*, Harvard Business Review. 1990.

² For example, the *Reduction of Carbon Dioxide Emissions from Coal-Fired Generation of Electricity Regulations* provided the impetus for the world's first operating carbon capture and storage facility (for power generation) being located in Canada.

³ Johnstone, N., Hascic, I., and M. Kalamova. *Environmental Policy Characteristics and Technological Innovation*. *Economia Politica*. 2010; OECD. *Taxation, Innovation, and the Environment*. 2011.

Global investment and collaboration under Mission Innovation will push breakthrough clean energy innovation like never before. Canada has joined with 21 other partners to double government investment in breakthrough clean energy innovation, encourage private sector investment in early-stage clean energy innovation companies, and increase domestic and international collaboration to advance Mission Innovation goals. As such, the Government of Canada is moving to increase investment in clean energy at all stages of the innovation spectrum, from high-risk, early-stage research that can deliver transformative energy solutions, to later-stage technology demonstrations to help speed the commercialization and adoption of cleaner energy technologies. On June 2, 2016, Canada announced that it will seek to double its 2014–2015 funding of \$387 million for clean energy and clean technology R&D to \$775 million by 2020. By taking early action to implement our Mission Innovation commitments, Canada has an opportunity to be a leader in leveraging clean energy innovation to reduce greenhouse gas emissions, open access to new markets, and create clean jobs.

In Canada, natural resource development and use is central to the development of our clean, low-carbon economy. Natural resource sectors directly comprise about one-fifth of our GDP, and natural resource development and use collectively accounts for 92% of Canada’s greenhouse gas emissions. Natural resource sectors directly contribute about \$312 billion of GDP (18% of total economy)⁴ and 1.6 million jobs in Canada (9% of total economy)⁵, making them an economic anchor and a fundamental source of wealth for many Canadian communities, especially many Indigenous and rural communities. Furthermore, as natural resource sectors undertake significant interventions in the natural landscape and provide the energy and material basis of supply chains, these sectors are critical determinants of Canada’s environmental performance. It is estimated that the natural resource sectors themselves accounted for 58% of Canada’s greenhouse gas emissions (424 megatonnes (Mt) carbon dioxide equivalents [CO₂eq]) in 2014, and that the development and use of natural resource products (including energy) across the economy accounted for 92% of Canada’s greenhouse gas emissions (666 Mt CO₂eq).⁶ Natural resource development is also a major source of environmental challenges outside of climate change, and elicits increasing concern from Canadians about protecting local air quality, water use and quality, soil quality, public health and safety, and biodiversity.

Increasing the development and use of clean technology in the natural resource sectors is key to Canada’s ability to make the clean, low-carbon transition over the near and long term. As recently stated by the Prime Minister⁷, the Minister of Natural Resources⁸ and other experts⁹, the notion of making a choice between an “old” natural resource economy and a “new” clean economy is a false one. Despite recent commodity price weakness, demand for most natural resources is expected to increase due to population growth and rising standards of living in emerging economies. Through clean technology in the natural resource sectors, Canada has the opportunity to leverage this demand to our near-term advantage in global markets, while also developing and delivering clean energy and technology solutions for the low-carbon transition.

⁴ Statistics Canada. Table 379-0029: Gross domestic product (GDP) at basic prices, by North American Industry Classification System (NAICS), annual (dollars), CANSIM (database). (2012 data; accessed: June 2016).

⁵ Statistics Canada. Table 379-0029: Labour statistics consistent with the System of National Accounts (SNA) and North American Industry Classification System (NAICS).

⁶ Environment and Climate Change Canada, National Inventory Report 1990–2014: Greenhouse Gas Sources and Sinks in Canada.

⁷ Trudeau, Justin. Keynote Address. GLOBE Conference. Vancouver. March 2, 2016.

⁸ Address by the Honourable Jim Carr, Minister of Natural Resources on Bill C-15, May 5, 2016.

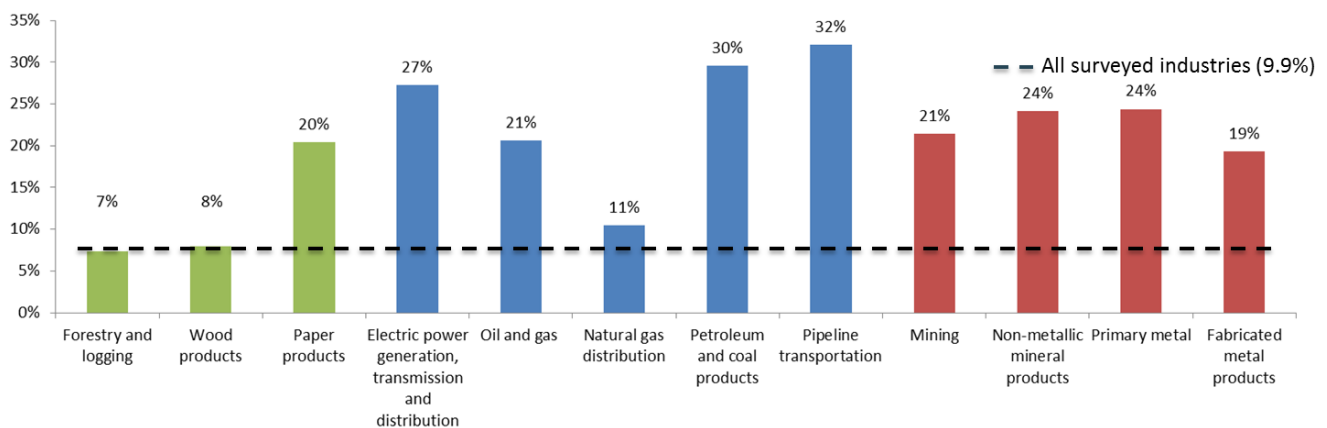
⁹ Transcript from the testimonies of Stewart Elgie, André Plourde, and Michael Moore at the Standing Committee on Natural Resources, May 9, 2016.

This approach aligns with advice provided by Stewart Elgie, Chair of Sustainable Prosperity, to the Standing Committee on Natural Resources. Dr. Elgie states:

Innovation tends to happen around the things you already do in an economy. Innovation is usually not a white bolt of lightning that hits somewhere over there, where nobody's looking. You innovate around the things you're already good at and you already try hard at. All of the expertise we've built up around oil and gas, as well as auto-making and other regional strengths in our economy, will be the places where we'll innovate. Where that innovation will take us is like guessing where the roots of a tree are going to go. We don't know, but the more we drive it, it will create value not just for the oil industry, but for lots of other spinoff industries.¹⁰

Clean technology presents an opportunity to foster growth in both the natural resource sectors and the clean technology industry. In Canada, natural resource companies serve as innovators of clean technologies through their respective business lines, and also as major adopters of clean technologies (compared to other economic sectors in Canada – see Figure 2). However, innovation and adoption rates of clean technology are still low among natural resource sectors and represent an opportunity for improvement. This includes adapting proven technologies from outside natural resource sectors and between natural resource sectors to maximize potential improvements in environmental performance. There are also a growing number of “pure play” clean technology companies (i.e., those primarily engaged in R&D or the manufacture and sale of clean technologies) that are strongly linked to natural resource development and use. Although it is a small segment of the economy, the pure play clean technology sector has been an important area of growth and job creation in Canada over the past several years.¹¹ It is estimated that more than two-thirds of Canadian clean technology companies are focused on addressing challenges related to energy and natural resources.¹² Clean technology development and use in the natural resource sectors allows both resource sectors and the clean technology sector to capitalize on global market opportunities generated by the transition to a clean low-carbon economy.

Figure 2. Adoption rate of advanced “green” technology by natural resource sector (forestry, energy and mining), 2014



Source: Statistics Canada Survey of Advanced Technology

¹⁰ Ibid.

¹¹ Analytica Advisors, *2016 Canadian Clean Technology Industry Report*. Ottawa, ON.

¹² Based on Analytica Advisors, *2015 Canadian Clean Technology Industry Report*. Ottawa, ON.

Box 1. Saltworks Technologies: An example of collaboration between natural resource sectors and clean technology producers

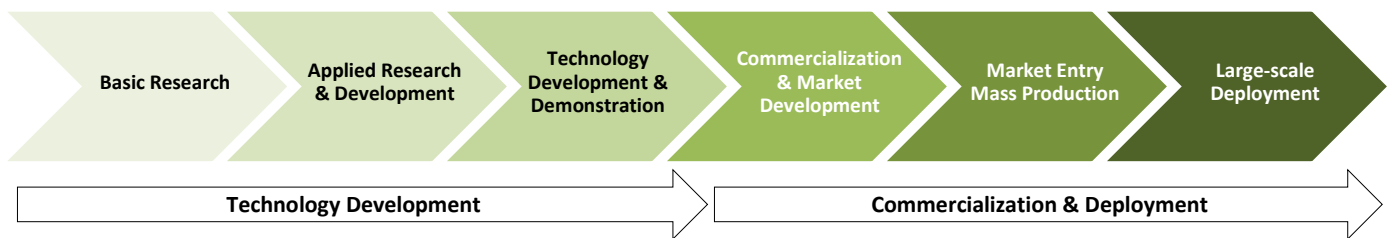
Saltworks Technologies Inc. is a clean technology firm providing advanced water treatment solutions in the Alberta oil sands. Saltworks is using its SaltMaker technology—a low temperature evaporator crystallizer—to produce fresh water from the wastewater of Steam Assisted Gravity Drainage (SAGD) operations. Successful SaltMaker pilots were completed with Suncor Energy and Cenovus Energy, demonstrating true Zero Liquid Discharge of SAGD wastewater.

The current pace of clean innovation in Canada is constrained by two key market failures. First, as benefits from investments in innovation often flow beyond the original investor (knowledge spillover), there is an incentive for firms to free-ride on the R&D of others, thus reducing overall investment. Second, in the absence of a market price for pollution, including for greenhouse gas emissions, externalities in the costs of production drive under-investment in abatement efforts, including in clean technologies. Governments have a key role to play in correcting market failures, ensuring that policies and regulations are supportive of innovation and address or avoid innovation barriers, and providing greater predictability for firms, investors and others in regard to the stringency of future government policies. **Given their economic significance and the scale of their environmental challenges, natural resource sectors require targeted government action to help position them as competitive sustainability leaders while also fostering growth in Canada’s clean technology industry.** Targeted government initiatives could address specific opportunities and challenges for clean technology in the resource sectors, and support these sectors’ efforts to transition to the clean, low-carbon economy. This could include driving incremental innovation in these sectors through cleaner natural resource extraction, harvesting and use in order to help meet Canada’s 2030 goals for its environment and economy. It could also include support for longer-term clean energy breakthroughs that will deliver solutions for 2050 and beyond, including in support of Canada’s Mission Innovation objectives. These breakthrough solutions call for higher-risk investment, long-time horizons and a supportive enabling environment for adoption, therefore requiring governments to play a central role in supporting them.

4 Status, Opportunities and Challenges for Clean Technology in the Natural Resource Sectors

The innovation system for clean technology in the natural resource sectors consists of a set of interrelated activities and stages that must align in order to generate results. Figure 3 provides a simplified representation of the innovation system with six main stages. The first three stages focus on **technology development** through research, development and demonstration (RD&D), and serve to “push” technology forward toward the market. The last three stages focus on **commercialization and deployment**, thereby “pulling” technology into the market. Refer to Box 2 for an example of clean technology applied to the natural resource sector which successfully moved through the innovation system.

Figure 3. Stages of the innovation system



Source: Natural Resources Canada Clean Technology Ecosystem Report, 2015

Box 2. Moving through the innovation system: The ECO Chill® example

CIMCO's ECO Chill® system is an engineered solution to lowering energy costs in ice rinks by recycling 100% of the energy used to maintain the ice surface back into building heating systems.

The ECO Chill® system is based on the CoolSolution® approach initially developed by Natural Resources Canada's (NRCan's) CanmetENERGY Research Centre in Varennes, Quebec. Starting in 2000, CanmetENERGY conducted **research** on reducing energy consumption from refrigeration systems. The Centre led the **development** of a CoolSolution® approach that recovers heat from refrigeration systems to heat occupied spaces, optimizes the operation of those refrigeration systems, and uses natural refrigerants that are not harmful to the environment. The Centre acted as a technical advisor and provided support for **demonstration** and **deployment**, allowing CIMCO to install its ECO Chill® system in three ice rinks.

CIMCO estimates that by 2014, these ECO Chill® installations had realized more than 350,000 tonnes of carbon dioxide emission reductions, which is equivalent to removing, for one year, 80,000 cars from the road, each driving 20,000 km in that year. The installations represented a 115% increase in energy efficiency (over conventional approaches) for new buildings and a 40% increase for retrofitted buildings. The ECO Chill® system also reduces the use of harmful chemical refrigerants by replacing them with ammonia.

As of 2014, CIMCO had sold, installed and commissioned 172 ECO Chill® systems with a value of more than \$200 million. CIMCO is the world's leading supplier of refrigeration equipment to ice rinks and ECO Chill® is the de-facto industry standard. CIMCO was the main supplier of refrigeration systems for the 2010 Vancouver Olympic Games and is the official rink supplier for the National Hockey League. CIMCO has also adapted the system for use in large meat-packing plants.

4.1 Status of innovation across the natural resource sectors

Innovation is critical to enhance productivity and competitiveness and reduce environmental impact in the natural resource sectors.

Canada has a number of advantages that support its capacity for innovation in the natural resource sectors. We have abundant natural resource reserves and globally leading expertise in extractive technologies and geological and biological sciences. We have a strong foundational R&D system that provides innovative ideas and knowledge relevant to natural resource sectors, and a skilled workforce. We have an open investment climate and the second lowest marginal tax rate on new business investment in the G7. We also have a strong regulatory framework that supports Canada's global competitiveness by safeguarding food, animals and plants, strengthening environmental management practices, and ensuring sustainable development. A 2012 assessment by the Centre for the Study of Living Standards¹³ concluded that across many indicators such as productivity levels, machinery and equipment, capital intensity, adoption of new technologies, and R&D personnel, the performance of natural resource sectors (energy, mining and forestry) is comparably strong. This conclusion is echoed for the agriculture sector in a 2015 OECD assessment highlighting Canada as a strong contributor to global agriculture innovation with a relatively high R&D intensity compared to other developed countries.¹⁴ Notably, the Science, Technology and Innovation Council (STIC)¹⁵ has recommended that, given their strength and strategic importance, natural resource sectors be a significant area of innovation leadership for Canada.

However, the natural resource sectors have lower rates of R&D investment compared to other sectors. As described above, there are two key market failures that contribute to this underinvestment: knowledge spillover from investments in innovation, which is an incentive for firms to free-ride on the RD&D of others, and the absence of a market price for pollution, which limits investment in abatement efforts, including clean technology.

The natural resource sectors also have some common features that differentiate their innovation processes from other parts of the economy. According to a 2015 report of the Energy and Mines Ministers' Conference¹⁶, these include:

- Commodity production: Many resource-based industries produce products differentiable only on the basis of price, and sold on global markets subject to commodities cycles. Few, if any, of the competitive conditions in these markets are determined in Canada, even when unique endowments are concerned. Commodities are also not valued for their inherent features or characteristics, but rather for the goods and services that they enable.
- Wide range of production environments: Companies are operating in a wide range of production environments, which often precludes the development of "one-size-fits-all" solutions. For example, specific innovations can be required to support the development of different types of resources (e.g., conventional vs. unconventional hydrocarbon reserves) or production in certain regions of the country (e.g., the North).

¹³ Centre for the Study of Living Standards, 2012, *Innovation in Canadian Natural Resource Industries: A Systems-Based Analysis of Performance, Policy and Emerging Challenges*.

¹⁴ OECD. (2015), *Innovation, Agricultural Productivity and Sustainability in Canada*, OECD Publishing, Paris.

DOI: <http://dx.doi.org/10.1787/9789264238541-en>

¹⁵ Ibid.

¹⁶ Energy and Mines Ministers' Conference, *Innovating for a Strong Canadian Energy and Mining Sector*, 2015.

- Capital intensity and long payback horizons: Resource operations, particularly in the extractive industries (mining, oil and gas), entail very large capital investments with projected payoff periods that are measured in decades. Initial investments in technology and structure often result in capital that remains in service for several years, and may be difficult to change once put in place. This feature can slow the development and adoption of new technologies.
- Complexity and uncertainty: The production processes of natural resource products are multidimensional and involve numerous activities such as exploration, resource management, extraction and/or harvesting, manufacturing, and the prevention and mitigation of environmental impacts. Investments also occur in an environment that can include significant price volatility, shifts in global supply and demand, weather and climate uncertainties, and a certain level of uncertainty related to policy directions and regulations.

There is a growing acceptance within Canada’s natural resource sectors of the necessity to further innovate to improve environmental performance, build public confidence, and enhance global competitiveness (known as the “triple bottom line”—economic profitability, environmental sustainability, and social equity).¹⁷ This is driven by growing demand from consumers and value chain partners to improve environmental and social outcomes, and institutional investors putting greater emphasis on opportunities that not only have potential financial gains, but environmental and social benefits as well.

4.2 Sector perspectives on clean technology in the natural resource sectors

The development and use of clean technology is at different stages across each of the five natural resource sectors. Table 1 presents a summary of perspectives on clean technology across the energy, mining, forestry, agriculture and agri-food, and fisheries and aquaculture sectors, as well as the perspective of the clean technology sector. Refer to Annexes 2 to 7 for in-depth sector perspectives.

Table 1. Summary of sector perspectives on clean technology

Energy Sector	<ul style="list-style-type: none"> • This diverse sector includes producers (e.g., oil and gas, electricity) and adopters/users (e.g., transportation, industry, buildings) of clean technology, and is a major driver of Canada’s clean technology industry. • Innovation and industry collaboration (e.g., Canada’s Oil Sands Innovation Alliance) are helping to improve performance, with major opportunities for transformation in a low-carbon economy. • Barriers to innovation include the absence of clear market signals, the capital and time-intensive nature of developing new technology, and the risk and impact of knowledge spillover. • Enhanced coordination of federal levers (regulatory, programs, and research expertise and facilities) and enhancing public-private collaboration would help to address barriers.
Mining Sector	<ul style="list-style-type: none"> • Although direct investment in R&D by mining firms has been scaled back over the past 10-15 years, recent collaborative efforts (e.g., Canada Mining Innovation Council, Green Mining Initiative) are seeking to reinvigorate the mining innovation system through new R&D and the expansion of clean technology demonstration, verification and adoption programs.

¹⁷ Elkington, J. (1994), “Towards the sustainable corporation: Win-win-win business strategies for sustainable development” and OECD (2012), “Defining and measuring green investments.”

	<ul style="list-style-type: none"> • Challenging business environments, capital intensity, diverse operating conditions, a lack of coordination among innovators and adopters, and risk aversion to the high costs of developing and implementing unproven technologies are barriers to the widespread integration of clean technology across the sector. • Greater coordination, including the revitalization of the sector’s approach to innovation (by leveraging industry, academic, and government funding/expertise), and the integration of proven technologies and processes from outside the sector, could accelerate clean technology uptake throughout the sector.
Forestry Sector	<ul style="list-style-type: none"> • This sector is both a producer and adopter of clean technology, with an advanced innovation system and an abundance of sustainable forests and forest biomass to support the bioproducts¹⁸ industry. The sector is also emerging as a provider of “green” input material for other manufacturing sectors (e.g., bioplastics, biochemicals, advanced biomaterials, etc.). • Bioproducts producers in the forestry sector face challenges that are commonly encountered by small and medium-sized enterprises: lack of funds for the RD&D of their products as well as regulatory shortcomings that impede technology-to-market efforts. • A national strategy with long-term policy and financial commitments for clean technology is seen as a solution to mitigate these innovation barriers, while adoption of clean technology could be further accelerated with stronger regulations and access to financing.
Agriculture and Agri-Food Sector	<ul style="list-style-type: none"> • Similar to forestry, this sector is both a producer and adopter of clean technology, with an emerging level of clean technology collaboration and a large agricultural land base that enables a growing bioproducts sector and offers opportunities to innovate in sustainable farming technologies and practices. • Clean technology development and use in this sector could be strengthened through stronger market demand signals; adoption has been primarily focused on technologies demonstrating agronomic benefits and economic returns to the farmer, rather than environmental benefits. • A focus on encouraging adoption of clean technologies is important in the agriculture sector—with 83% of farm operators waiting until innovations have been tested by at least a few others before they are willing to try something new.¹⁹
Fisheries and Aquaculture Sector	<ul style="list-style-type: none"> • Innovation and adoption of clean technology is at an immature stage in the wild capture fisheries sector. • The Aquaculture sector, in contrast, is an active innovator—developing and adopting clean technologies to mitigate environmental impacts (often in response to regulations) and address economic pressures. • In both areas, opportunities exist for reduced environmental impacts of operations and increased sustainable production, processing and harvesting practices. • Renewed R&D, incentives to encourage adoption and enhanced coordination are key to seize opportunities.
Clean Technology Sector	<ul style="list-style-type: none"> • Currently available data suggests that the majority of clean technology firms are small and medium-sized enterprises and many are early-stage and internationally focused. • Venture capital (VC) is an important source of private equity financing to support growth. Generally, VC tends to focus on investments that are easily scaleable and have

¹⁸ Bioproducts refers to renewable products other than food and feed that are derived from biological sources (e.g. agricultural, aquatic or forestry resources, or municipal wastes).

¹⁹ Statistics Canada (2013) Farm Financial Survey

- shorter time horizons.
- Global investment trends in clean energy, water and wastewater, and desalination, among others, present significant opportunities to capture a greater share of the global market.

4.3 Cross-sectoral gaps and challenges for clean technology in the natural resource sectors

There are a set of common, cross-cutting gaps and challenges for government action on clean technology that have been identified based on recent stakeholder engagement conducted by Natural Resources Canada. These gaps and challenges, presented in Table 2, occur across the innovation system, affecting both technology development (RD&D) and commercialization and deployment, and are relevant for players across the economy (including in the natural resource sectors).

Table 2. Cross-cutting gaps and challenges for clean technology in the natural resource sectors

Innovation Stage	Gap or Challenge
System-Wide	<p>Vision and alignment: Need for whole-of-government coordination, improved information and greater partnerships among natural resource and clean technology firms, governments and other stakeholders to better link technology development and deployment.</p> <p>Competitive advantage: Government support for innovation should be directed towards areas of Canadian competitive advantage.</p> <p>Market signals: A price on carbon incentivizes the adoption of market-ready clean technologies and the creation of new, breakthrough solutions.</p>
Technology Development (RD&D)	<p>Transformational R&D: Support for higher-risk, longer-term investment is needed to accelerate the development of breakthrough clean technologies that have potential to disrupt markets and achieve climate change and environmental goals.</p> <p>Predictable and sustained R&D funding: Long-term funding to allow firms to better plan their R&D programs and to attract required private capital.</p> <p>Support for RD&D collaboration: Lack of mentorship for early-stage entrepreneurs and support for domestic & international collaborations.</p> <p>Risk capital for clean technology development and scale-up (including early adoption) in the natural resource sectors: Financing gap exists between early R&D and full commercialization (“valley of death”).</p>
Commercialization and Deployment	<p>Framework conditions for clean technology adoption: Governments are not fully leveraging the tools at their disposal to incent clean technology adoption (e.g., procurement, regulations, codes/standards, and greening government operations).</p> <p>Capital for commercial deployment: Insufficient financing to deploy technologies and scale for growth after successful demonstration.</p> <p>Support for market expansion: Lack of accessible analysis and advice for clean technology firms looking to expand into international markets.</p> <p>Loss of global clean technology market share, low investment attraction: Limited efforts to attract global investment, build Canada’s market share abroad and equip Canadian exporters with leading-edge investment information is causing Canada to</p>

lose ground.

Discussion Question 1: What do you think of the gaps and challenges for clean technology in the natural resource sectors? Are there considerations that have been overlooked or overstated?

5 A Strategy for Advancing Clean Technology in the Natural Resource Sectors

The proposed federal Strategy provides a platform from which to advance whole-of-government coordination and deliver targeted policies and programs that meaningfully increase the development and use of clean technologies in the natural resource sectors in line with Canada’s environmental and economic goals. Such action would address short-term incremental improvements in the extraction, harvesting and use of natural resources in Canada (to meet Canada’s 2030 goals), as well as longer-term technology breakthroughs that would deliver transformative solutions (2050 and beyond). Elements of the Strategy will contribute to the pan-Canadian Framework for Clean Growth and Climate Change, as well as to supporting the Innovation Agenda, the Trade and Export Strategy, the Canadian Energy Strategy, and the North American Climate, Clean Energy, and Environment Partnership Action Plan. **The proposed Strategy is presented in Table 3.**

Proposed elements are grouped around two main streams in the innovation system: **technology development** and **commercialization and deployment**. Technology development options seek to address gaps and challenges faced by technology producers for bringing concepts effectively to market (including early adoption of unproven technologies). Such activities could include supporting longer-term breakthrough clean energy technologies, enhancing incremental clean technology innovation, and advancing domestic and international RD&D collaboration. Commercialization and deployment options seek to leverage federal actions to support clean technologies in the marketplace, including through actions that enhance conditions for clean technology adoption, increase access to capital, and increase access to global markets. The elements proposed span the mandates of multiple federal departments.

Table 3. Proposed Strategy for advancing clean technology in Canada’s natural resource sectors

<p>Vision: The development and use of clean technology in the natural resource sectors asserts Canada’s competitiveness and environmental leadership at the global scale</p>			
<p>Principles</p>			
<p>Balanced: Support for clean technology development across the innovation spectrum: recognizing that an exclusive focus on technology push or market pull limits results.</p>	<p>Focused on results: Clean technology innovation is primarily undertaken to achieve near and long-term environmental results (e.g., reduce GHGs, improve environmental performance).</p>	<p>Growth-driven: Support clean technologies that improve the competitiveness of natural resource sectors and/or grow the clean technology industry.</p>	<p>Cross-sectoral: Support open, merit-based processes across all sectors, and encourage cross-sectoral knowledge sharing, collaboration, and application (engage outside of government).</p>
<p>Possible Elements</p>			
<p>System-Wide</p>	<p>Establish vision and improve coordination: Implement a whole-of-government approach, including better data and a single point-of-contact for stakeholders, to address barriers to advancing clean technology in the natural resource sectors and help to bridge technology development and commercialization activities.</p> <p>Establish market signals: incentivize the adoption of market-ready clean technologies and the creation of new, breakthrough solutions through a price on carbon.</p>		
<p>Technology Development</p>	<p>Support clean technologies that address critical environmental “missions” in natural resource sectors: Longer-term, cross-sectoral support and associated tech-to-market coaching for applied research through to early adoption projects focused on advancing clean technologies that address key environmental challenges/opportunities in the natural resource sectors.</p> <p>Support breakthrough technology development: Support high-risk/reward breakthrough clean technologies that can transform the economy beyond 2030 (could be modelled after the U.S. “Advanced Research Projects Agency-Energy”).</p> <p>Increase capacity for international clean technology partnerships: Support R&D partnerships with Mission Innovation countries and others to increase Canada’s access to international consortia/resources and promote early market share.</p>		
<p>Commercialization and Deployment</p>	<p>Enhance domestic markets with framework conditions: Align market signals and tax measures to drive clean technology development and use; Harness greening government operations/procurement to increase market pull; Ensure regulations, codes and standards promote rather than impede technology innovation; and, Green infrastructure.</p> <p>Increase firms’ access to capital: Increase capital for commercial deployment and replication; Enhance existing measures (e.g., BDC, EDC, SDTC) to improve fit with clean technology sector; Attract foreign investment.</p> <p>Increase access to global markets: Demonstrate emerging clean technologies in international markets; Enhance investment climate; Equip Canadian clean technology producers/users with market and export intelligence.</p>		
<p>Intermediate (3-year) Outcomes</p>			
<p>Accelerated clean technology RD&D for sustainable natural resource development and use, including for breakthrough clean energy technologies.</p>	<p>Growth in private investment in clean technology RD&D in the natural resource sectors.</p>	<p>Increased collaboration between clean technology producers and natural resource sectors.</p>	
<p>Long-Term (10-year) Outcomes</p>			

Improved competitiveness and environmental performance across the natural resource sectors.	Increased development of clean technologies by Canadian firms, including breakthrough clean energy technologies.	Enhanced market opportunities for Canadian clean technology and natural resource producers.
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Discussion Question 2: What are your thoughts on the Strategy? Should other elements be considered?

6 Considerations

6.1 Linkages with federal priorities

The proposed Strategy would contribute to the pan-Canadian Framework for Clean Growth and Climate Change. The federal government’s collaboration with provincial and territorial governments to establish the pan-Canadian Framework will help to set the economy-wide conditions for clean innovation and technology, most notably through the establishment of carbon pricing. The Strategy and related investments in early 2017-18 would demonstrate federal action in an area of critical importance for provinces and territories.

Strategy elements would also play a central role in delivering Canada’s Mission Innovation commitments. The government’s June 2 announcement that Canada will seek to double its 2014-15 funding of \$387 million for clean energy and clean technology innovation to \$775 million by 2020 underscored the role that clean technology will play in reducing greenhouse gas emissions, diversifying the Canadian economy, opening access to new markets, and creating good, well-paying jobs for Canadians. The government has also committed to working to encourage greater private-sector investment and increase domestic and international collaboration to advance Mission Innovation goals.

Internationally, the government is actively seeking opportunities with international partners to expand its collaboration on clean technology innovation in line with Mission Innovation. For example, Prime Minister Trudeau met in March 2016 with American President Barack Obama in Washington D.C., during which the two leaders issued a *Joint Statement on Climate, Energy and Arctic Leadership* that included a pledge to leverage participation in Mission Innovation and strengthen collaboration on clean energy research and development for: reducing methane emissions; improving electrical grids; accelerating electric vehicle development and integration; unconventional oil and gas; carbon capture, use and storage; and, new cutting-edge technologies. Canada is also working trilaterally with its North American partners, the United States and Mexico, through the *North American Climate, Clean Energy, and Environmental Partnership Action Plan* (June 2016). Other key Mission Innovation country partners with whom Canada is pursuing collaboration include China and South Korea. A *Joint Declaration on Canada-China Clean Technology Cooperation* was signed in Ottawa on February 25, 2016. In addition, a *Memorandum of Understanding on Cooperation in Innovation and Energy Technologies* with the Korean Ministry of Trade, Industry and Energy was signed on March 3, 2016 at the GLOBE Summit in Vancouver.

The proposed Strategy is presented in the context of the government’s election commitment to invest \$200 million more each year to support innovation and the use of clean technology in the natural resource sectors and \$100 million more each year for clean technology producers.²⁰ Budget 2016 affirmed this commitment by providing over \$1 billion over four years, starting in 2017-18, to support

²⁰ Also announced in conjunction with Canada’s endorsement of Mission Innovation.

clean technology, including in the natural resource sectors.²¹ This investment is complemented by a set of early strategic funding actions announced in Budget 2016 which signal the government's intent and build momentum toward its clean technology and natural resource sector objectives. These actions, led or co-led by Natural Resources Canada, include the implementation of \$62.5 million for electrical vehicles and alternative transportation fuels infrastructure, \$50 million to develop cleaner oil and gas technologies, and \$2.1 million to work with Statistics Canada to improve data on the clean technology sector.

Strategy elements could be designed to link to (or encompass) a range of government commitments that will set conditions for clean growth and clean technology deployment across the economy. These include additional new investments such as the \$2 billion Low Carbon Economy Trust to work with provinces and territories to fund projects that reduce carbon emissions, and significant new spending on green infrastructure. They also include a range of policy actions to encourage clean technology development and adoption and enhance conditions for clean technology investment, such as national leadership on carbon pricing, phasing out fossil fuel subsidies, policies for greening government operations and early government adoption of clean technologies, , improving energy efficiency standards, and working with provinces and territories to develop the Canadian Energy Strategy.

The Strategy will support the government's Innovation Agenda which, as outlined in Budget 2016, will redesign and redefine how the government supports innovation and growth in partnership with the private sector, provinces, territories and municipalities, universities and colleges, and the not-for-profit sector. The Innovation Agenda has an economy-wide focus and is expected to address ongoing and systemic challenges in Canada's innovation system, including low productivity, low business investment in R&D, and poor access to risk capital. The Strategy would provide a distinct, but parallel, contribution to the Innovation Agenda focused on federal support for clean technology in the natural resource sectors.

6.2 Role of partners

Innovation and clean technology in the natural resource sectors takes place within a wider innovation system comprised of a number of players. **Aligning the federal actions proposed under this Strategy with those of other players is important to effect the greatest possible change for clean technology in the natural resource sectors.**

Through the engagement activities described in Section 2, a clear understanding of stakeholder perspectives on the opportunities and challenges for clean technology in the natural resource sectors has been gained. Moving forward, connections between partners, particularly across sectors (e.g., between natural resource sectors and with clean technology firms), will be important to drive demand and accelerate environmental wins. Other federal priorities, such as the pan-Canadian Framework for Clean Growth and Climate Change and the Innovation Agenda, are playing a central role in making connections across partners to enable the economy-wide conditions for innovation throughout all sectors. The Federal-Provincial-Territorial Working Group on Clean Technology, Innovation and Jobs, established as part of the process to develop the pan-Canadian Framework, has created an inventory of examples of key regulations and programs supporting clean technology across Canada.²² The Working Group will issue a final report in September 2016 on stimulating economy-wide growth and innovation across all sectors in support of transitioning to a low-carbon economy. Initiatives grounded in the

²¹ The Budget further identified that future details about the allocation of this funding will be provided as part of the implementation of the Government's Innovation Agenda.

²² Interim report of the Working Group on Clean Technology, Innovation and Jobs, Final Draft, June 2016.

proposed Strategy could be an important federal contribution towards meeting the desired outcomes identified by the Working Group.

As the primary owners of many of this country's natural resources, **provinces and territories** (PTs) play a critical role in this sector, defining regulatory frameworks, setting strategic direction around innovation and clean growth (including related programs and policies), and undertaking region-specific market development/investment attraction activities. Many jurisdictions have set ambitious green growth targets (e.g., eliminating coal-fired electricity generation) and are supporting these targets with a range of program/policy interventions (e.g., Alberta's Climate Change and Emissions Management Corporation, British Columbia's carbon tax). Further, a number of PTs are advancing clean technology RD&D via the creation of dedicated agencies (e.g., Alberta Innovates), targeted project financing (Investissement Québec) and support to regional clusters rooted in jurisdictional competitive advantages (e.g., green chemistry in Sarnia, Ontario). The federal government has an opportunity to build on cross-jurisdictional collaboration with PTs, which occurs via a range of sector-specific councils (e.g., Energy and Mines Ministers' Conference, Canadian Council of Forest Ministers, Canadian Council of Ministers of the Environment, Canadian Council of Fisheries and Aquaculture Ministers, Federal, Provincial and Territorial Ministers of Agriculture). PTs, via the Council of the Federation, are also laying the groundwork for a Canadian Energy Strategy. **Municipalities**, through their role as clean technology developers and end-users, and the hosts of innovation hubs, are also key players in this sector. They are positioned to contribute expertise, R&D facilities, and potentially resources, toward joint clean technology projects relevant for both natural resource sector firms and municipal systems (e.g., water treatment advances can support industrial facilities and municipalities).

Industry players are at the heart of clean technology in Canada, acting as developers, adopters and producers of clean products, processes and services. Without the industrial implementation of clean technologies, the associated environmental and economic benefits, as well as broader green transformation, would not be possible. Both clean technology firms and natural resource firms seeking to adopt clean technologies or implement "clean" business lines will therefore be critical partners in advancing priorities in this sector.

Academia has long been recognized as a key source of clean innovation and early-stage research. With world-class infrastructure (e.g., labs and research sites) across the country, ties to international research, and networks/partnerships with industry, academia is a key performer of clean technology R&D and a producer of highly qualified personnel. Academia (including via participation in think-tanks and non-governmental organizations) is also providing a critical function in terms of defining key clean technology challenges and the impetus for economic transformation, while offering valuable evidence/analysis and proposing diverse visions for the future (e.g., Sustainable Prosperity). Through a number of established programs (granting councils, Canadian Foundation for Innovation, Mitacs, etc.), the federal government is closely linked to academia and positioned to leverage the capacity therein toward advancing clean innovation and technology in the natural resource sectors.

Investors, incubators and accelerators also play key roles in driving and supporting clean technology innovation. Canada's venture capital (VC) community is an important source of private equity financing to support innovation and scale-up in Canada, making 33 deals in 2014 worth \$134 million.²³ VCs are closely linked to incubators and accelerators, such as MaRS Discovery District, to provide a suite of services to companies. Traditionally, Canadian VC has been focused on investments that are easily scaleable and have shorter time horizons, since capital-intensive, transformative clean technology projects are viewed as too risky with unacceptable payback periods.

²³ Canadian Venture Capital & Private Equity Association.

7 Conclusion

Innovation and clean technology in the natural resource sectors has public good value due to its potential to address national and global challenges such as climate change. This is why the federal government has a role in providing support for innovation and clean technology in these sectors, and in taking action to address the issues that act as barriers to innovation and investment.

The federal government **coordinates and convenes** players across the country, and represents the interests of the many **resource-dependent Indigenous communities** across Canada.

Furthermore, **national laboratories play key roles in performing early-stage R&D to create and incubate new technology ideas, and in engaging industry to develop and test technologies.** For example, Natural Resources Canada's CanmetENERGY laboratories have played a role in almost every significant energy technology innovation in Canada since their creation in the 1970s.

Canada's commitment to clean energy innovation under Mission Innovation, and the unique needs of breakthrough technology innovation, provide further imperative for federal action. The challenges of climate change and clean energy are global in scope, and require Canada to be connected with international partners in finding solutions. At the international level, the federal government has a role in facilitating clean energy R&D collaboration with partners under Mission Innovation. The federal government will also convene partners, particularly the private sector, to encourage greater investment and partnerships in breakthrough clean energy technology development in Canada. The Mission Innovation focus on breakthrough clean energy technologies requires participating governments to particularly play a role in supporting higher-risk and longer-term investment areas that are not sufficiently supported by other parts of the innovation system.

Canada's natural resource sectors stand at the nexus of this country's environmental and economic futures. It is through these sectors' transition to "green," low-carbon production systems, and the development of energy and environmental breakthroughs, that Canada will be positioned as a global clean growth leader, drawing continued prosperity from sustainable and competitive natural resource industries. This paper contextualized the need for this transformation and proposed a Strategy whereby the federal government could advance clean technology in the natural resource sectors. In conjunction with wider online discussions, it is intended to provide a starting point to engage stakeholders on the key elements of this Strategy, with a view to informing the development of program and policy options.

Discussion Question 3: What roles do you see for the federal government and other partners in advancing clean technology in the natural resource sectors?