Taking Action:

Moving forward together on energy research, technology and innovation

Energy and Mines Ministers' Conference

Halifax, Nova Scotia

July 2015

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Foreword

At the 2014 Energy and Mines Ministers' Conference (EMMC), federal, provincial, and territorial (FPT) ministers emphasized the need to address environmental performance in Canada's natural resource industries through the advancement of research, technology and innovation. In response, the EMMC Energy Technology Working Group (ETWG) has undertaken a multi-jurisdictional and multi-year effort to advance collaboration on innovation through science and technology. The ETWG has representation from all jurisdictions in Canada.

In previous years, the ETWG has produced analytical reports on smart grid technologies (2012), shale resource development (2013) and efforts by Canadian governments to spur energy innovation within their respective jurisdictions (2014). Building upon these efforts to create a common knowledge base, the ETWG is now shifting its focus to look at concrete ways to increase collaboration across federal, provincial, and territorial governments. The ETWG's work for EMMC 2015 focuses on the creation of a new mechanism to enhance FPT collaboration. "**Energy innovation clusters**" were formed to bring together FPT experts to drive collaboration in priority technology areas through the development and implementation of multi-jurisdictional action plans.

The action plans included in this report articulate shared technology priorities, identify current activities, and **propose specific collaborative** actions across jurisdictions. The proposed collaborative actions will be implemented over the coming year with a follow-up report on progress presented to ministers at EMMC 2016. This approach could be replicated in future years to form clusters in other priority technology areas.

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Executive Summary

Canada has been successful in translating an enviable resource endowment into a key pillar of the national economy. The global energy landscape, however, is changing rapidly and dramatically and the ability of nations to innovate will profoundly impact their global energy competitiveness in the decades ahead.

In addition, the Canadian energy innovation system consists of thousands of players, with regional needs and priorities varying widely according to distinct resource endowments and capabilities. Canada's private sector also faces uniquely Canadian challenges that can deter companies from investing in innovation, leading to missed opportunities for the energy sector, and for Canada.

Federal, provincial, and territorial governments use a range of policy instruments to stimulate energy innovation, including direct funding support for public and private RD&D; ensuring access to capital, global markets and skilled labour; providing incentives through instruments such as standards, regulations, and tax incentives; and educating consumers.

Despite Canada's strong enabling conditions, energy innovation remains a complex and challenging enterprise that will require jurisdictions to leverage existing resources through collaboration to provide maximum impact on investments. For these reasons, Canadian stakeholders have consistently called for increased levels of collaboration in order to focus limited capacity, pool existing resources, and share the risks inherent to energy technology innovation.

Building upon previous efforts to gather information on energy technology innovation efforts across Canada, Canadian governments have come together to launch a multi-year effort that includes the creation of new mechanisms to enhance federal, provincial, and territorial (FPT) government collaboration. Through the creation of "**energy innovation clusters,**" FPT experts will drive collaboration in priority technology areas through the development and implementation of multi-jurisdictional action plans.

Based on consultations amongst participating jurisdictions, two energy innovation clusters were formed:

1) **Improving Environmental Performance in Shale Resource Development (Shale Cluster):**
   Participants: Federal government, B.C., Alta., Sask., N.B., N.L., Y.T., N.W.T.

2) **Distributed Power Generation (DPG Cluster):**
   Participants: Federal government, B.C., Man., Ont., Que., N.S., N.B., N.L., P.E.I., N.W.T., Nun.

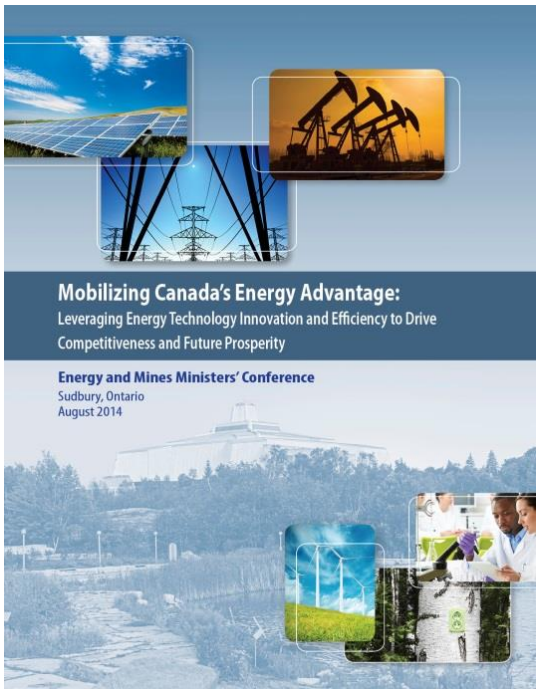
The following report, *Taking Action: Moving Forward Together on Energy Research, Technology, and Innovation*, outlines the case for innovation through collaboration within the energy sector and presents action plans from the two clusters above that both identify shared priorities and **propose specific collaborative actions** that each cluster will undertake in the coming year, to be reported against next year at EMMC 2016. The following table summarizes the shared priority statements and proposed collaborative actions from both clusters.

DPG Cluster – Priorities and Proposed Actions	
Priority 1	Advancing technology-based energy solutions for **northern, remote, or First Nations communities**
Priority 2	Increasing knowledge and understanding to advance the **integration of renewable energy** sources into transmission and distribution systems
Priority 3	Understanding the challenges and opportunities available for the development and adoption of **energy storage** technologies
Priority 4	Enhancing energy management and delivery through the development of **smart grid** technologies
Action 1	Showcasing Canadian technology successes internationally (see page 22) **Participants: Fed / B.C. / Ont. / Que. / N.L. / N.B. / N.S . / P.E.I. / N.W.T. / Nun.**
Action 2	Pan-Canadian database on energy usage in remote communities (see page 23) **Participants: Fed / B.C. / Que. / N.W.T. / Nun.**
Action 3	Quantifying the socio-economic benefits of district energy systems (see page 24) **Participants: Fed / B.C. / N.S. / N.L. / P.E.I. / Nun.**
Action 4	Information sharing session on energy storage technology projects (see page 25) **Participants: Fed / Ont. / Que. / N.S. / N.W.T. / P.E.I**
Action 5	Increasing government engagement in the Renewables in Remote Microgrids Conference (see page 26) **Participants: Fed / B.C. / Que. / N.L. / N.W.T. / Nun.**

Shale Cluster – Priorities and Proposed Actions	
Priority 1	Reducing **emissions** and protecting ambient air quality through research and technology innovation
Priority 2	Improving **water protection and management** through knowledge sharing and technology innovation
Priority 3	Improving the **environmental and economic performance of resource recovery** through research, development, and demonstration
Priority 4	Advancing knowledge of **induced seismicity** from hydraulic fracturing operations through baseline data accumulation and knowledge sharing
Action 1	Technology roadmap on wellbore integrity (see page 38) **Participants: Fed / B.C. / Alta. / Sask. / N.L. / N.W.T.**
Action 2	Identifying geoscience and geo-engineering R&D gaps (see page 39) **Participants: Fed / B.C. / Alta. / Sask. / Man. / Ont. / Que. / N.B. / N.S. / Y.T. / N.W.T.**
Action 3	Environmental baseline data on shale resource development (see page 40) **Participants: Fed / B.C. / Alta. / Sask. / N.L. / Y.T. / N.W.T.**
Action 4	Participation in a flaring and venting regulators forum (see page 41) **Participants: Fed / Y.T.**

1. Energy sector innovation through science and technology

Canada has been successful in translating an enviable resource endowment into a key pillar of the national economy. As the global energy landscape continues to change, the ability of nations to innovate will profoundly impact their global energy competitiveness in the decades ahead.



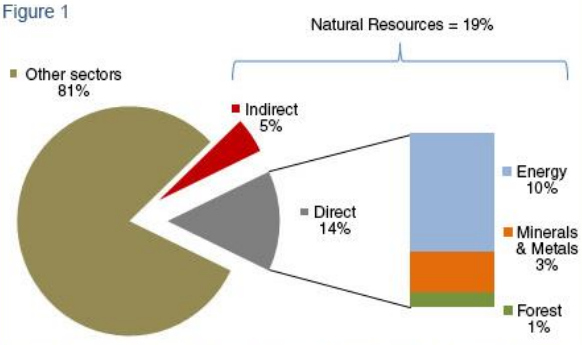
For the 2014 Energy and Mines Ministers' Conference (EMMC), the Energy Technology Working Group (ETWG) tabled a report entitled *Mobilizing Canada's Energy Advantage: Leveraging Energy Technology Innovation and Efficiency to Drive Competitiveness and Future Prosperity*. The report, and its associated *Compendium on Energy Technology Innovation in Canada*, provided an analysis of energy technology innovation performance in Canada, as well as a synopsis of efforts by Canadian governments to spur innovation through research, science, and technology. A key conclusion of the report was that federal, provincial, and territorial (FPT) governments would benefit from greater alignment of priorities and efforts, as well as multi-jurisdictional collaboration.

Building upon these conclusions for EMMC 2015, the ETWG shifted focus from producing an analytical report to actively working towards increasing alignment of energy technology innovation efforts among Canadian governments and proposing specific opportunities for collaborative action, resulting in the action plans contained within this report.

1.1 Canadian and international context

Contribution to Nominal GDP (%), 2013

Figure 1



Source: Natural Resources Canada estimates (August 2013), based on Statistics Canada data

Canada has extensive energy wealth, including oil, gas, uranium, and extensive renewable energy resources, including large hydroelectric, biomass, wind, solar, and marine energy. These resources are spread across a very large landmass, such that the energy options for each region are different based on the particular geography and access to resources. This wealth of resources contributes significantly to economic prosperity in Canada. In 2013, the energy sector directly contributed around 10 percent (or $175 billion) of Canada's gross

domestic product (GDP) and 1.6 percent (or 288,500) of Canada's well-paying direct jobs. When factoring indirect contributions, these statistics rise to 13.4 percent of Canada's GDP (or $237 billion), and 5 percent of employment in Canada (or over 900,000 jobs). Also in 2013, energy accounted for 27 percent of Canada's total public and private capital investment and 29 percent of total domestic merchandise exports.[1]

The global energy landscape is undergoing significant and rapid change. Uncertainty continues to exist around global supply and demand, energy market volatility, economic and/or geopolitical instability, and the pace of technological innovation. The last decade saw extraordinary growth in energy demand, which is forecast to grow by another 37 percent by 2040 as the global economy doubles. More than 60 percent of the projected growth in energy demand will be driven by fast-growing and densely populated economies in the Asia-Pacific region. While demand for all forms of energy will increase, fossil fuels are expected to continue to supply 75 percent of global energy demand in 2040, down from 82 percent in 2012. Renewable energy sources, excluding fuelwood and charcoal, are expected to reach up to 15 percent in 2040 as a share of global primary energy demand, up from 8 percent in 2012, with the renewable share of electricity generation increasing from 21 percent in 2012, to 33 percent in 2040. Global challenges such as energy security, environmental degradation and energy access to alleviate poverty are driving innovation in energy use across all sectors of the economy[2].

North American energy markets are being transformed by the horizontal drilling and hyrdaulic fracturing revolution, which has unlocked vast supplies of shale oil and gas. As a result, the United States (U.S.) is expected to be close to energy self-sufficient within the next decade; by 2020, it will become a net exporter of natural gas and the world's largest oil producer, reversing the steady decline of U.S. oil production that began in the 1980s[3]. Already, shale gas is having a major impact in North America with plans for liquefied natural gas (LNG) terminals changing from import to export facilities, and a significant switch in U.S. electricity generation from traditional coal to cleaner burning natural gas. These changing market dynamics are creating the need for Canada to seek new export markets, with a key opportunity emerging in the energy-hungry Asia-Pacific region.

[1] Natural Resources Canada, *Energy Markets Fact Book*. 2014, pp 3–6. Available online at nrcan.gc.ca/energymarketsfacts.
[2] International Energy Agency, *World Energy Outlook 2014*, pp 53–93.
[3] U.S. Energy Information Administration, *Annual Energy Outlook 2014*. Available online at eia.gov/forecasts/aeo/mt_naturalgas.cfm.

1.2 The role of science and technology

Innovation through science and technology will have a profound impact on the global energy system in the near term. Novel and advanced technologies have already unlocked considerable new oil and gas resources and will be key to advancing renewable energy, energy efficiency and addressing environmental challenges, including greenhouse gas (GHG) reduction. Despite the recent economic downturn and continued fiscal pressures, innovative effort is on the rise globally as a share of economic activity. Public expenditures on energy research, development and demonstration (RD&D) by International Energy Agency (IEA) member countries have increased by 30 percent since the 1990s[4]. For example, government expenditures on energy RD&D in nations such as the United Kingdom and Australia have more than tripled since the early 2000s, while spending in the United States and Germany has more than doubled during this same period of time.[5] Countries are renewing their public RD&D programming and increasing their investments in energy technology RD&D, with an expectation of positive returns on investment. For instance, the European Union estimates an internal rate of return from RD&D investments of 15 percent from 2010–2030.[6] It is worth noting, however, that globally, the energy sector's share of total RD&D spending has been declining over the past 30 years.[7]

Textbox 1: Innovating for a Strong Canadian Energy and Mining Sector

The report *Innovating for a Strong Canadian Energy and Mining Sector,* released at the 2015 Energy and Mines Ministers Conference, emphasizes that continued innovation efforts are needed given the transformative changes that the Canadian energy and mining sector is facing.

The report focuses on the following three main areas and offers key observations for the future:

- Canada's **natural resources advantage**, particularly the elements that have contributed to making Canada a competitive, reliable and responsible supplier of natural resources to North America and the world.
- Canada's **innovation leadership** in the energy and mining sector, including an overview of key innovations that have shaped energy and minerals development over time, as well as a discussion on the role of government, industry and academic stakeholders in supporting innovation.
- The **innovation imperative** as highlighted by the need to improve environmental performance and cost competitiveness in a global economy characterized by lower commodity prices and increased competition.

[4] International Energy Agency, *World Energy Outlook 2014*, p. 69.
[5] International Energy Agency, *Online RD&D Statistics Database*. Available online at wds.iea.org/WDS/Common/Login/login.aspx.
[6] International Energy Agency, *Global Gaps in Clean Energy RD&D: Update and Recommendations for International Collaboration*, 2010, p. 14.
[7] International Energy Agency, *Energy Technology Perspectives 2014*, p. 54.

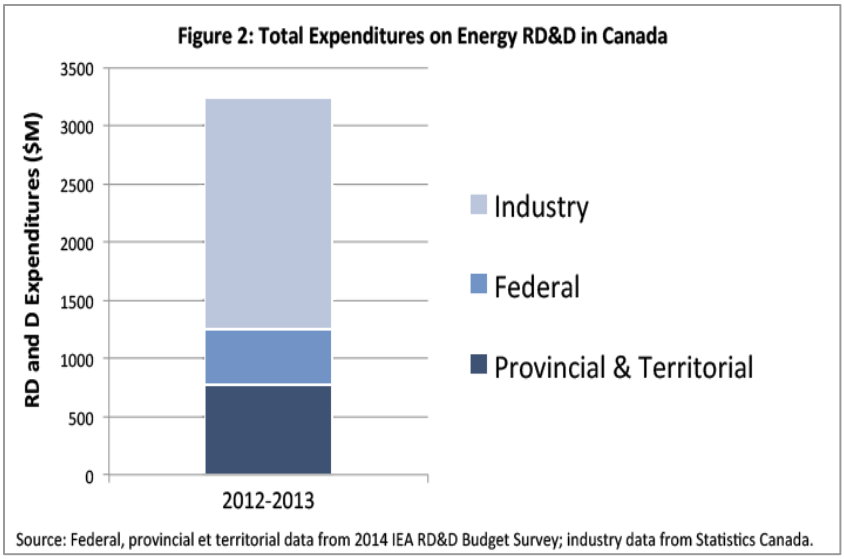
A continued focus on innovation will be critical to maintaining Canada's energy resource advantage and offers the potential for significant economic growth in coming years. Canada's prosperity will increasingly depend on addressing a range of challenges, including the following: accessing new export markets, accessing and developing new resources, maximizing efficient energy use to minimize the economic impacts of volatile energy prices, managing environmental challenges, sustaining and growing a strong and competitive investment environment, and ensuring an adequate supply of skilled labour. Energy technology solutions will play a critical role in addressing these challenges. Based on the experience of other countries (for example Norway in the oil and gas sector), successfully building competitiveness in energy sectors and realizing the full potential of energy technologies can boost annual economic growth throughout the energy chain by up to 2 percentage points[8]. In Canada, this would translate into approximately $74 billion in incremental GDP and 500,000 new jobs by 2020.

2. The need for collaboration

Despite Canada's strong enabling conditions, energy innovation remains a complex and challenging endeavour that will require jurisdictions to leverage their resources through collaboration to maximize the impact of investments.

2.1 Canada's innovation performance

Canada benefits from highly efficient markets, well-functioning and transparent institutions, excellent infrastructure, and is successfully nurturing its human resources compared to other advanced economies. Appropriately, the private sector in Canada leads on investment in energy RD&D (see Figure 2). Governments provide targeted support in order to further incent the private sector to invest more in R&D than they would otherwise do. For example, $1.1 billion in energy innovation funding through Natural Resources Canada since 2006 has leveraged $4.4 billion from over 1,000 partners. Yet despite strong enabling conditions and generous government support, studies have shown that Canada's private sector continues to lag behind other leading nations with respect to levels of investment in R&D. Canadian industry has historically scored low when comparing the ratio of business expenditure on research and development (BERD) to gross domestic product (GDP). In 2010, for example, Canada's score of 0.93 percent ranked well below the Organisation



[8] McKinsey and Co., *Opportunities for Canadian Energy Technologies in Global Markets,* 2012.

for Economic Co-operation and Development (OECD) average of 1.6 percent. Moreover, Canada is one of the only OECD countries to reflect a negative annual BERD growth rate between 2005 and 2010 (-2.8 percent). [9] For comparison purposes, South Korea's average BERD growth rate over this same time period was +9.5 percent, while China's was +19.4 percent.[10]

2.2 A complex innovation system

The Canadian energy innovation system consists of thousands of players. Federal, provincial, and territorial governments in Canada use a range of policy instruments to stimulate energy innovation, including direct funding support for public and private RD&D; ensuring access to capital, global markets and skilled labour; providing incentives through instruments such as standards, regulations, and tax incentives; and educating consumers. Private corporations, industry associations, universities, and non-profit organizations all conduct and commission research and development projects related to energy technology.

Regional resource endowments also lead to distinct priorities and capabilities for energy innovation. Western Canada, offshore Newfoundland and Labrador, and Nova Scotia, for example, are all rich in fossil fuel resources while Canada's North is estimated to hold 40 percent of Canada's future discoveries of light crude oil and natural gas. In contrast, electricity produced in Quebec, Manitoba, British Columbia and Newfoundland and Labrador, representing about one third of electricity generated in Canada, is 96 percent hydro-generated. Similarly, Nova Scotia is home to a growing centre of global expertise and capacity relating to marine energy technologies (see Textbox 2).

Textbox 2: Marine Energy

Marine renewable energy has the potential to provide new energy, as well as economic and environmental benefits to Canada.

One example of Canadian innovation in this area is the Fundy Ocean Research Centre for Energy (FORCE), Canada's leading research centre for in-stream tidal energy, located in Nova Scotia. Thanks in part to $11.2M in funding from the Government of Nova Scotia, along with $25M from the Government of Canada, FORCE acts as a host to technology developers, providing the electrical infrastructure to deliver power to the grid, while also conducting research to better understand the 2,500 megawatt potential of extractable tidal energy resource available in the region.

In 2014, the FORCE project reached a major milestone in laying four cables along the sea floor of the Minas Passage. The cables give FORCE the largest transmission capacity for tidal power in the world with a capacity of 64 megawatts, equivalent to the power needs of 20,000 homes at peak tidal flow.

[9] OECD, Main Science and Technology Indicators: 2012/2, April 2015.
[10] Ibid.

2.3 Challenges to innovation

The private sector in Canada faces several uniquely Canadian challenges that can deter companies from investing in innovation, leading to missed opportunities for the energy sector, and for Canada. Access to private funding and venture capital in Canada, for example, is generally low, and the domestic market for emerging technologies is relatively small and risk averse. As a result, developers must often rely on export markets to be competitive.[11] Canada's geography and geology present further challenges to innovation, as the Canadian private sector cannot necessarily rely upon the international pool of knowledge for technological advancements to Canadian-specific challenges such as technology applications in the far North, or advancements in technologies related to development in the oil sands.

2.4 The benefits of collaboration

For these reasons, Canadian stakeholders have consistently called for increased levels of collaboration in order to focus limited capacity, pool existing resources, and share the risks inherent to energy technology innovation. Strategic alliances and partnerships that work towards common solutions to common challenges, including with non-traditional partners and across different sectors, are vital to the development and deployment of new technologies that will support the productivity and competitiveness of Canadian energy firms. In August 2014, Natural Resources Canada convened a series of energy innovation roundtables across the country to encourage collaboration and solicit perspectives on how Canada can best support energy innovation. The roundtables garnered thoughtful contributions from more than 100 senior executives from industry, academia, utilities, governments, non-governmental organizations and the financial community. Key among the identified themes of discussions was the call for increased collaboration and greater alignment of efforts between industry and federal, provincial and territorial (FPT) governments.

The Canadian energy system already boasts some world-class examples of private-sector collaborative arrangements. The Canadian Oil Sands Innovation Alliance (COSIA), for example, is an alliance of 13 oil sands producers that account for 90 percent of all oil sands production in Canada. COSIA focuses on accelerating the pace of improvement in environmental performance through collaborative action and innovation. Since COSIA's inception in 2012, its member companies have established a legal framework for unprecedented collaboration in a market economy that enables independent-minded, competitive companies to work together in areas of common interest. COSIA has now shared 777 distinct technologies and innovations that have cost more than $950 million to develop.[12] Similarly to industry-led collaborations, FPT governments partner together and with other stakeholders in efforts to ensure the responsible development of Canada's natural resources. The annual Energy and Mines Ministers' Conference (EMMC) provides an annual federal-provincial-territorial forum to enhance collaboration and alignment among jurisdictions on Canada-wide energy and mining issues, including investment, competiveness, environmental protection, and the performance of Canada's regulatory system.

[11] McKinsey and Co., *Opportunities for Canadian Energy Technologies in Global Markets,* 2012.
[12] About COSIA. Aavailable online at cosia.ca/about-cosia.

2.5 Taking action

Within this context, the Energy Technology Working Group has initiated a new, multi-year mechanism to enhance FPT collaboration on priority technology areas. Inspired by the growing international trend of establishing clusters, or geographically centered concentrations of companies and research institutions that leverage the expertise and assets of a particular region through collaboration, the Energy Technology Working Group has launched several "energy innovation clusters" of policy and program experts from Canadian governments to work together towards common objectives in energy research, technology and innovation. Using principles similar to geographically centered clusters, where proximity, coupled with relationship, creates the conditions necessary to spur innovation through the sharing of expertise, ideas, and capabilities, these newly created clusters will drive FPT collaboration through the development of multi-jurisdictional action plans.

As the primary deliverable of these clusters, the action plans will focus on articulating shared priorities, sharing information on planned activities, and proposing collaborative actions to advance mutual priorities. The proposed collaborative actions will be implemented over the coming year with a report on results being developed for ministers at the subsequent 2016 EMMC. This approach could be replicated in future years to form clusters in other priority technology areas.

Amongst jurisdictions, a number of technology areas were reviewed as potential areas of focus for a cluster. Notable examples included marine energy, energy efficiency, carbon capture and storage, bioenergy, offshore oil and gas, and transportation. While all of these technology areas would benefit from greater FPT alignment and collaboration, two areas stood out as topics of particular interest across jurisdictions. As a result, the ETWG launched the following two clusters:

1. **Cluster on Improving Environmental Performance in Shale Resource Development**
   Participants: Federal government, B.C., Alta., Sask., N.B., N.L., Y.T., N.W.T.

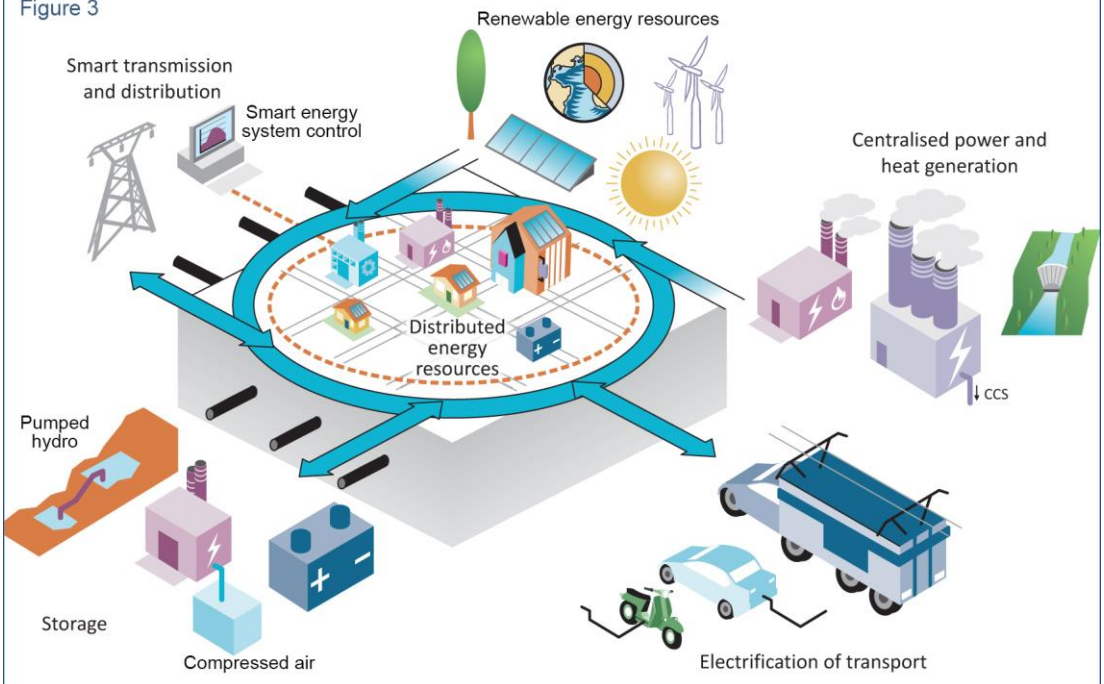
2. **Cluster on Distributed Power Generation**
   Participants: Federal government, B.C., Man., Ont., Que., N.S., N.B., N.L., P.E.I., N.W.T., Nun.

3. Distributed Power Generation Action Plan

The continued advancement of science, technology and innovation in energy management systems, energy storage technologies, and the integration of renewable energy sources into transmission and distribution systems will improve energy security, reliability, and environmental performance, particularly in remote, northern, and Aboriginal communities.

Distributed energy resources

Figure 3



3.1 Policy context

Distributed power generation (DPG) refers to an approach that uses small-scale technologies, often renewables, to produce electricity close to the energy consumer. In some cases, distributed generation can create lower-cost electricity and greater reliability and security than traditional centralized power generators, with improved environmental performance.[13]

The role of distributed power is significant within the Canadian context, particularly as it relates to remote, northern, and aboriginal communities. Continued science, technology and innovation will be necessary as the interaction between power producers and consumers continues to evolve. Renewable,

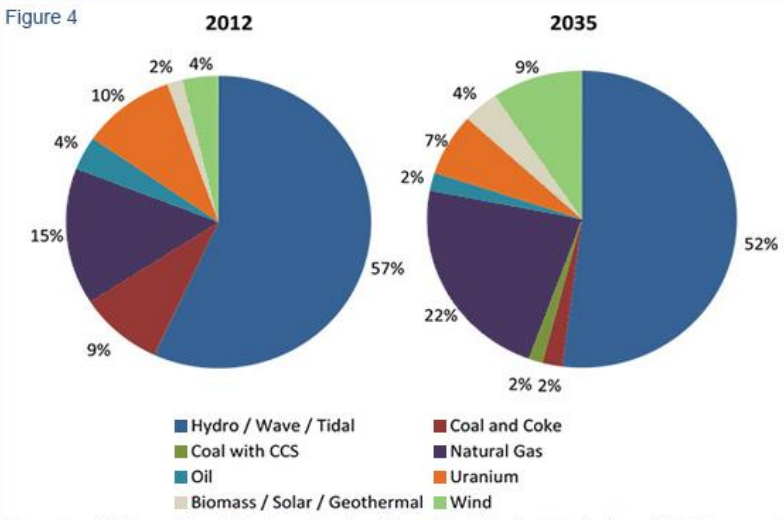
[13] Virginia Polytechnic Institute and State University, Education Modules: Distributed Generation, *Introduction to Distributed Generation*. Available online at www.dg.history.vt.edu/ch1/introduction.html.

distributed power generation, coupled with smart energy management and delivery technologies, will be required to meet the changing needs of Canada's electricity system.

The role of renewables as a source of distributed power within Canada continues to expand. Figure 4 shows the capacity mix by primary fuel for electricity generation in 2012 and expected in 2035. In 2012, the major contributors to the electricity generation mix by capacity were hydro (57 percent), natural gas (15 percent), uranium (10 percent) and coal (9 percent). Non-hydro renewables altogether accounted for 6 percent of capacity.[14] By 2035, it is expected that wind energy alone will account for 9 percent of Canada's total electricity supply, with solar, biomass, and geothermal accounting for an additional 4 percent.

Capacity Mix by Primary Fuel, 2012 and 2013, Reference Case

Figure 4



Source: Canada's Energy Future 2013 – Energy Supply and Demand Projections to 2035 – An Energy Market Assessment. Original available on the National Energy Board's (NEB) website at https://www.neb-one.gc.ca/nrg/ntgrtd/ftr/2013/index-eng.html#fg8_2. This copy not reproduced in affiliation with, or with the endorsement of, the NEB.

However, while significant growth in generation capacity is expected, a number of constraints still limit the growth of renewables within the Canadian electricity distribution system, commonly referred to as "the grid". Concerns about managing variable generation have led utilities and system operators, in some cases, to set penetration limits for intermittent renewables. In other cases, conditions and requirements have been imposed through codes as governments work to increase their capacity to integrate renewable energies into distribution systems. Wind energy has also faced public acceptance challenges that slow or limit growth, with concerns regarding health impacts, visual impacts, and environmental impacts being raised in the public sphere. In addition, the harsh Canadian climate (extreme cold, higher capacity factors) is impacting performance and operating costs to an extent that is not always anticipated by owners/operators relying on experience in other parts of the world.

Further, Canada's electricity grid infrastructure, the network underpinning todays centralized power systems, is aging. Considerable investments are required to renew aging components in a cost-efficient fashion while simultaneously allowing for new technologies such as distributed power generation, storage, electric vehicles and demand-side management. The level of investments required is significant,

[14] National Energy Board, *Canada's Energy Future 2013*, www.neb-one.gc.ca/nrg/ntgrtd/ftr/2013/2013nrgftr-eng.pdf

estimated at $350 billion over the next 20 years according to the Canadian Electricity Association[15]. Continued innovation will be instrumental to minimize the impact this will have on electricity rates.

Federal, provincial, and territorial governments all have a role to play in innovation as investors in, and performers of, energy technology RD&D and will continue to facilitate commercial deployment by developing regulatory and market solutions that allow new technologies and actors to enter the marketplace. This will require regulatory approaches that support both conventional and new technologies and that share costs, benefits, and associated risks.

Textbox 3: National Policy Symposium on Energy Management and Delivery

Across Canada, there are important innovations happening in the energy delivery and management sector (electricity, natural gas, thermal and storage). The Symposium gave participants the opportunity to share insights, solutions, and best practices and to identify opportunities and challenges, which helps accelerate innovation in this sector and enables it to become more innovative, competitive, and efficient.

The National Policy Symposium on Energy Management and Delivery took place on April 15, 2015 and was delivered by QUEST – Quality Urban Energy Systems of Tomorrow, in partnership with this year's Energy and Mines Ministers' Conference hosts, the Nova Scotia Department of Energy and Natural Resources Canada. Sponsorship was in part provided by the Canadian Gas Association and Canadian Electricity Association. The Symposium drew over 80 senior industry executives from government, industry, utilities, regulators, and other organizations from across Canada.

Key insights from the Symposium:

- Efficient collaboration is critical, and intergovernmental working groups and agencies can advance the energy innovation agenda;
- Identify regional priorities within a national framework to accelerate innovation and enable Canadian leadership in global supply chains;
- Co-ordinate/streamline federal, provincial and innovation funding processes;
- Support community level innovation and community energy planning;
- Technology, policy and regulation drive each other;
- Many innovations happen at the local level and result in lower energy costs, enhanced reliability, better environmental performance and local economic benefits;
- How we deliver and manage energy is becoming as important as how we produce it; and
- Canada can be a global leader for energy delivery and management solutions by harnessing local solution experience as an export market opportunity.

[15] Canadian Electricity Association, *Electric Utility Innovation Toward Vision 2050*, p 3. Available online at electricity.ca/media/ElectricUtilityInnovation/ElectricUtilityInnovation.pdf.

In order to enhance collaboration in this area, the ETWG has initiated a multi-jurisdictional energy innovation cluster on distributed power generation (DPG). Representatives of Natural Resources Canada (NRCan) and the Governments of British Columbia, Manitoba, Ontario, Quebec, Nova Scotia, New Brunswick, Newfoundland and Labrador, Northwest Territories, and Nunavut met several times over the last year in order to share information on current and planned activities, to establish shared priorities and to enhance collaboration in order to improve Canadian performance in these technology areas. The following pages present the DPG Cluster's shared priority statements, along with a number of proposed collaborative actions that cluster members plan to pursue over the coming year.

3.2 Shared priorities and current activities

DPG Priority 1: Advancing technology-based energy solutions for northern, remote, or First Nations communities

The North represents the majority of Canada's land mass. With world-class mineral, oil and gas deposits, the North is a place of incredible economic opportunity. For remote and northern communities and local businesses to thrive, a number of factors need to be present, including access to reliable and affordable energy. In many communities, this is a particular challenge due to reliance on costly and inefficient diesel as the main energy source for both power and heat generation. In addition to non-technological challenges, such as high installation costs, being faced to deploy currently available technologies, the requisite expertise to manage and operate projects, and the necessary alignment of community, utility, and government priorities, innovative energy technologies have a key role to play to both decrease energy demand through increased energy efficiency and improve energy supply with respect to quality, availability, affordability and reliability[16].

What Canadian jurisdictions are doing, in collaboration with other stakeholders, to address this priority:

- **Natural Resources Canada** is engaged in a variety of policy initiatives and funding projects to advance energy solutions in remote, northern or Aboriginal communities. Examples of specific initiatives include the Canada Remote Microgrid Network, Canada's Remote Communities Energy Use Database, the Remote Microgrid Sector Profile Report, and funding programs like the Clean Energy Fund and the ecoENERGY Innovation Initiative.

- **British Columbia** is engaged in projects to address energy needs in three remote communities where it has been deemed uneconomical to be connected to the grid: Hartley Bay, Da'naxda'xw, and Lasqueti Island.

- **Manitoba** is evaluating increasing the proportion of renewable-based electricity to reduce dependence on diesel in remote, northern and Aboriginal communities.

[16] Mariano Arriaga, Claudio Canizares and Mehrdad Kazerani, "Renewable Energy Alternatives for Remote Communities in Northern Ontario," *IEEE Transaction on Sustainable Energy* (Nov. 2012).

- **Ontario** is looking to develop on-site generation options in four communities where connection to the electricity grid is economically unfeasible.

- **Quebec** is engaged in a review of its energy policy as well as in funding a variety of projects to reduce greenhouse gas emissions by replacing diesel with renewable energies in remote communities. Projects include a wind energy and storage project at a remote mining location; a feasibility study on a wind power and biomass plant; and a 7.5-MW hydroelectric project near Inukjuak to replace diesel use.

- **Newfoundland and Labrador** is looking at integrating wind and small hydro generation in several communities currently reliant on diesel. Newfoundland and Labrador is also progressing to Phase 2 of the Ramea Wind-Hydrogen project.

- **Northwest Territories** is conducting a feasibility study on installing an Organic Rankine Cycle generator in a thermal community in order to use residual heat from a power plant to save electricity.

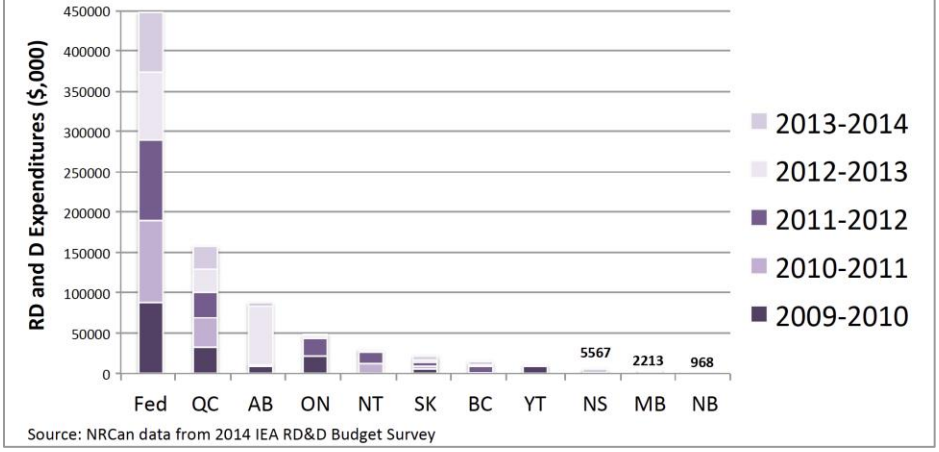
- **Yukon**'s Micro-Generation program has 11 grid-connected installations in its first year (9 residential; 2 commercial).

- **Nunavut** is exploring ways to integrate renewable energy systems into their community electricity grids. In support of this goal, a small solar PV demonstration system is being installed on the Iqaluit power plant.

DPG Priority 2: Increasing knowledge and understanding to advance the integration of renewable energy sources into transmission and distribution systems

Renewable energy capacity in Canada is growing at a rapid rate. The Canadian wind industry is expected to have the largest three-year growth in its history, adding 5.1 GW of new wind capacity by the end of 2016. More than 70 percent of this growth will occur in Ontario and Quebec. Canada's total installed photovoltaic (i.e., solar) capacity increased from 33 MW in 2008 to 1,211 MW in 2013, representing an annual growth rate of 206 percent. Other renewable sources also continue to increase in Canada. In the year 2000, for example, there were only five biomass projects for commercial and institutional buildings and district heating in Canada. By 2014, that number had grown

Figure 5: Federal, Provincial and Territorial RD&D Expenditures on Renewable Energies



Source: NRCan data from 2014 IEA RD&D Budget Survey

to 200. Progress has also been made in incorporating marine energy into the Canadian electricity mix with the Bay of Fundy, the largest tidal resource in the world, close to a major power grid and in the process of being developed. Figure 5 depicts RD&D expenditure on renewable energy sources by federal and provincial governments since 2009.

The principle challenge facing the growth of renewable energy capacity is intermittency, where power output may fluctuate from moment to moment. In addition, many renewable sources of energy are best utilized in specific locations (e.g., solar panels in areas that experience significant levels of sunshine) and unlike traditional, stationary sources, which have the option to transport fuel (e.g., coal) to a designated generation location, renewables often require the energy resource and generation machinery to be co-located, potentially leading to an increase in transmission costs.[17] Significant steps will need to be taken in the next 15–20 years to modernize the electricity distribution system in Canada so that it can handle these challenges.

What Canadian jurisdictions are doing, in collaboration with other stakeholders, to address this priority:

- **Natural Resources Canada** has allocated funding over the next four years for R&D by federal energy laboratories in the areas of bioenergy, northern and remote energy systems, and grid integration of renewables. NRCan also conducts joint work in this area with the United States through the Clean Energy Dialogue.

- **British Columbia** is conducting a study to illuminate how further grid integration of renewables will influence costs, system structure, reliability, and emissions intensity.

- **Quebec** is engaged in research on integrating wind power into the transmission system. Quebec is also exploring the integration of emerging renewable energy sources such as hydrokinetic and geothermal systems.

- **New Brunswick** is working through the electric utility, NB Power and other Atlantic Canadian partners participating in Powershift Atlantic to find more cost-effective ways to integrate renewable energy into the electric system.

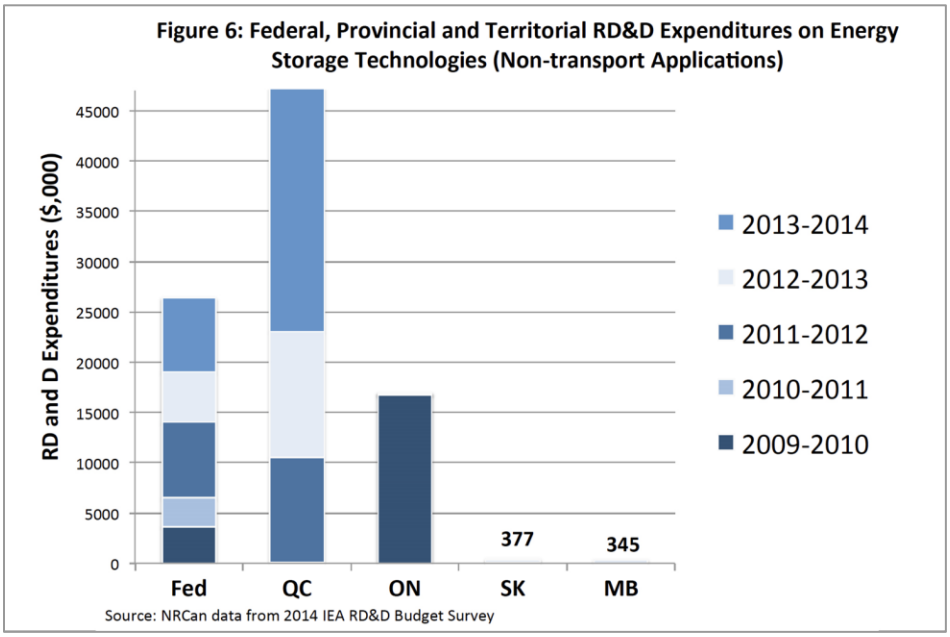
- **Yukon** has conducted public and stakeholder consultations on its new Independent Power Production policy to complement its Micro-Generation policy. Larger power purchase agreements will require the approval of the Yukon Utilities Board.

- **Northwest Territories** has completed a project in Colville Lake in which 54 kW of solar photovoltaic panels and 200 kWh of battery storage have been integrated alongside 350 kW of diesel generator set capacity to provide electricity for the community. A second phase is currently being planned that will include an additional 84 kW of solar photovoltaic generation.

[17] International Electrotechnical Commission, *Grid Integration of Large-Capacity Renewable Energy Sources and Use of Large-Capacity Electrical Energy Storage*, Geneva Switzerland, 2012, pp 23–24.

DPG Priority 3: Understanding the challenges and opportunities available for the development and adoption of energy storage technologies

Energy storage can help optimize energy generation and transmission assets and operations. The concept involves storing electricity that cannot be feasibly dispatched into the grid by converting electrical energy into another form. A number of technologies exist that can enable this conversion and storage of electrical energy, including pumped hydro storage, compressed air energy storage, battery storage, flywheels, superconducting magnetic energy storage (SMES), and electric double-layer capacitors (EDLCs). However, innovation is still required to develop storage technology at a sufficient cost and scale to accommodate new opportunities and challenges associated with growth in renewables as well as new demands such as electric vehicle charging.



Energy storage could allow for greater integration of variable sources of power such as wind and solar, which would reduce the carbon intensity of Canada's electricity supply. This can improve the dispatchability of the power source, allowing for greater overall integration of variable renewable power into Canada's generation portfolio and electricity markets. Another benefit of energy storage is the possibility to use it as a "back-up" capacity in cases of service disruption or major power outages.

Evolving battery technologies and increasing electricity prices are converging with the potential to drive commercial deployment of energy storage systems. Battery technologies are rapidly evolving and reducing in cost, and government funded demonstration projects may reveal important information about commercial feasibility as this technology evolves.

There are several challenges to the wide-scale adoption of grid-scale energy storage technologies, which are common to many cutting-edge technologies. These challenges include cost competitiveness, unavailable processes for both evaluating and reporting on performance, and a lack of available codes, standards and regulatory frameworks, which may be hindering their acceptance and commercial adoption.[18]

[18] U.S. Department of Energy, *Grid Energy Storage*, December 2013, pp 30–31.

In order to address these challenges, governments and industry are investing in RD&D to develop novel technologies and to decrease the costs associated with existing technologies (see Figure 6).

What Canadian jurisdictions are doing, in collaboration with other stakeholders, to address this priority:

- **Natural Resources Canada** is currently working to develop smart technology to optimize control methodologies surrounding the use of energy storage across the energy system while upgrading techno-economic modelling analytics to assess the viability of hydrogen storage in different contexts. NRCan is also working with Industry Canada and the U.S. Department of Energy on advancing hydrogen storage technologies.

- **Manitoba** is pursuing an evaluation of battery repurposing opportunities.

- **Ontario** has committed to a procurement process that includes 50 MW of energy storage capability, including the use of solid-state and flow batteries, and flywheel, thermal, and hydrogen storage technology options.

- **Quebec** has funded demonstration projects of thermal energy storage and hydrogen storage. Researchers from L'institut de recherche d'Hydro Québec (IREQ) are conducting extensive work on developing advanced materials for lithium-ion batteries designed for energy storage. To date, Hydro-Québec holds 15 licences and 100 patents that have resulted from IREQ's work on battery materials.

- **Yukon** is examining electric thermal storage as a means of utilizing surplus renewable energy.

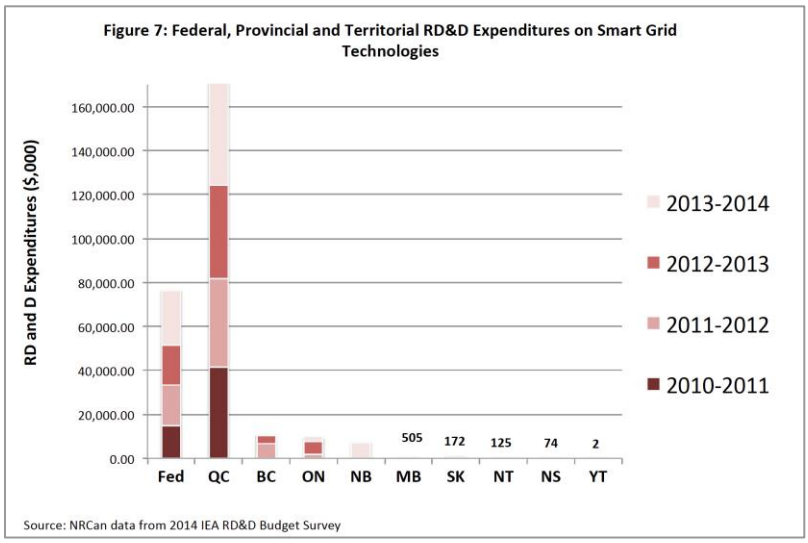
- **Nova Scotia** is funding an R&D project with LightSail Energy on grid-scale energy storage technology.

DPG Priority 4: Enhancing energy management and delivery through the development of smart grid technologies

Smart grid is a broad concept that describes the integration of modern technologies and communications networks into an electricity grid. It allows for the two-way flow of energy and information and can offer significant environmental, economic, and social benefits. Smart grid technologies can enable Canada's transition to a lower carbon emission economy by optimizing the capacity of existing assets, enabling greater energy conservation, and incorporating large amounts of variable renewable generation.

The conventional electricity grid is evolving to meet the needs of a modern society. Modern societies do not simply demand electricity; they demand reliable, secure, clean, and economic electricity with choice and control over how they consume it or supply it to the grid. Integrating advanced digital, communication, and control technologies can help satisfy these demands, so conventional electricity grids around the world are evolving towards a smarter grid.

Research, development and demonstrations of technologies and systems that lead to innovation in electricity supply and demand solutions are an important component of the efficiency of electrical systems, reducing greenhouse gas emissions and responsibly managing resources. Integrating more variable generation from renewable sources, such as wind, and integrating more variable loads, such as electric vehicles, pose significant challenges to managing Canada's electricity systems.



What Canadian jurisdictions are doing, in collaboration with other stakeholders, to address this priority:

- **Natural Resources Canada** is currently funding nine RD&D projects focused on smart grid technologies through the ecoENERGY Innovation Initiative. This builds on a previous $100 million provided through the Clean Energy Fund to advance smart grid, energy storage, wind energy, biomass, geothermal, and marine/hydro technologies. NRCan is also working to improve the reliability and resiliency of electricity systems through renewable energy microgrids and innovation in microgrid design, microgrid controls, and robust component technologies and systems. NRCan also manages the Canada Smart Grid Action Network that publishes the annual Smart Grid in Canada report in order to facilitate greater collaboration and learning amongst governments, industry and academia.

- **Ontario** is currently engaged in Round 2 of applications for its $50-million Smart Grid Fund. The Fund is intended to help companies demonstrate and commercialize next-generation smart grid solutions. Ontario is also conducting focused stakeholder engagement on proposed enhancements to the Feed-in Tariff (FIT) and microFIT programs.

- **Quebec**, via Hydro-Québec, is partnering with industry, universities and other organizations to progressively transform the existing power system into an increasingly smart grid. For example, Hydro-Québec is conducting an interactive smart grid project to improve the distribution grid's energy efficiency and performance. The testing area is powered by the Pierre-Boucher substation, which mainly covers the city of Boucherville.

- **Nova Scotia** hosted a National Energy Management and Delivery Policy Symposium in April 2015, to bring together innovators and key market players to create opportunities and to identify pathways to innovation in the field of energy delivery and management. Nova Scotia is also working on a new market structure that would enable customers to buy low-impact renewable energy directly from suppliers.

- **New Brunswick**, through NB Power and their partner, Siemens Canada, is working to build a fully integrated "energy internet" enabling all-way communications between customers, homes, power plants, and distribution systems.

- **Northwest Territories** has launched a project to install smart meters within the territory to gather data and create baseline information on the potential impact of photovoltaic systems in the North.

- **Nunavut** has launched a project to install smart meters throughout the city of Iqaluit.

3.3 Proposed collaborative actions

Action 1: Showcasing Canadian technology successes internationally

Priorities addressed: Remote-northern / Grid integration / Energy storage / Smart grid

Project co-leads: NRCan / Ontario

Participants: British Columbia / Quebec / Newfoundland and Labrador / New Brunswick / Nova Scotia / Northwest Territories / Nunavut

Project description:

Natural Resources Canada (NRCan) and the Ontario Ministry of Energy (Ontario Energy) are partnering to co-host the biannual International Conference on Integration of Renewable and Distributed Energy Resources (IRED) in October 2016 in Niagara, Ontario. As part of the planning for this event, Ontario Energy and NRCan have discussed the creation of a conference-endorsed side event to showcase success stories of relevant research, development, and demonstration funding programs. As a result of cluster discussions, it was proposed that an opportunity existed to broaden participation of this side event to include other jurisdictions in order to provide a more comprehensive look at Canadian energy technology innovation in the area of distributed power generation. To this end, Newfoundland and Labrador, Quebec, Nova Scotia and Northwest Territories have agreed to join with Ontario and NRCan to work towards the development of this side event, including discussion on how Canadian industry could potentially be engaged and involved.

Anticipated results:

The creation of a federal, provincial and territorial collaborative event that will showcase made-in-Canada solutions to energy-related challenges to a prestigious international audience, with a focus on smart grid and energy storage technologies and the integration of renewable energies into transmission and distribution systems.

Timeframe:

October 2016

Action 2: Pan-Canadian database on energy usage in remote communities

Priorities addressed: Remote-northern

Project co-leads: NRCan / Quebec

Participants: British Columbia / Nunavut / Northwest Territories

Project description:

The cluster is working to facilitate an update to Natural Resources Canada's national database on energy production and usage in remote communities. This centralized, public repository of data provides valuable energy production and use information on all of Canada's 294 remote, "off-grid" communities.

The database provides a range of benefits to governments, utilities, academia, industry, communities, and the general public, including the following:

- Knowledge of how energy is produced and used in remote communities;
- Information on the cost of electricity on a site-by-site basis;
- Common format, accessible to all, and all in one location; and
- Quality controlled source of data for use in project planning.

The database has been created with the ability to designate "users" who are able to enter information within the database. Users may also have access to certain information that has been kept from the public sphere, such as privately negotiated energy prices for certain communities. This project proposes to convene a group of jurisdiction representatives that will assist NRCan in the collection, entry and validation of energy data from remote communities within their respective jurisdictions.

Anticipated results:

A more fully developed, searchable, and centrally located database of energy production and use information for all of Canada's 294 remote communities.

Timeframe:

Summer 2015 to spring 2016

Action 3: Quantifying the socio-economic benefits of district energy systems

Priorities addressed: Remote-northern / Grid integration / Smart grid

Project lead: NRCan

Participants: British Columbia / Nova Scotia / Newfoundland and Labrador / Nunavut

Project description:

Developers of District Energy and other community-scale energy delivery systems across Canada often promote the socio-economic advantages along with their obvious efficiency and environmental benefits. Quantification of those benefits however, has to date been difficult to achieve due to the lack of either measured data or an acceptable process for their calculation.

To address these issues, Natural Resources Canada has developed the District Energy Economic Model (DEEM). Using life financial investment information, the model determines a project's value based on the social, economic and environmental benefits generated. These benefits are calculated for both the immediate community and the surrounding province.

The political geography of Canada has created uneven industrial composition and population densities within each province. To fully understand the socio-economic impact of district energy or other community scale, distributed energy systems within a single province or region, the variation in industrial base, and hence economic multipliers, need to be addressed within the model.

DEEM currently utilises the economic multipliers developed by Statistics Canada for industrial sectors. Created for each province, they estimate the direct and indirect impacts of sector investment in terms of job creation, GDP and taxation revenue. However, design assumptions limit their accuracy when applied at an intra-provincial or regional level, the area in which DEEM appears most effective.

In response, the cluster is pursuing an opportunity to enhance the utility and rigour of the model by providing Natural Resources Canada with regional-level data.

Anticipated results:

A more useful and rigorous economic model that enables government bodies, project proponents and communities to quantify the socio-economic benefits of district energy projects within their jurisdiction.

Timeframe:

Summer 2015 to spring 2016

Action 4: Information sharing session on energy storage technologies

Priorities addressed: Storage

Project lead: NRCan

Participants: Northwest Territories / Ontario / Quebec / Nova Scotia

Project description:

Several jurisdictions are engaged in research, development and demonstration activities related to energy storage technology. Activities range from demonstration projects on new technologies (e.g., flywheel, hydrogen etc.) to explorations of recycling opportunities (e.g., repurposing batteries for use in transportation), to procurement programs. While cluster members agree that energy storage is an area of priority in Canada, the variety of the activities makes specific collaboration on research and development difficult. The cluster agreed that a session to share information on current and planned activities and to discuss challenges facing the deployment of energy storage technologies in Canada would be valuable.

More specifically, the cluster agreed to identify specific policy and technical experts within their jurisdictions, potentially to include industrial representatives, and to convene a teleconference meeting at which information would be shared and specific challenges facing the deployment of energy storage technologies in Canada would be discussed.

Anticipated results:

Broader understanding on the range of current activities across Canada relating to energy storage technologies, as well as a shared list of common challenges experienced in increasing the deployment of these technologies.

Timeframe:

Fall 2015

Action 5: Increasing government engagement in the Renewables in Remote Microgrids Conference (Yellowknife, Northwest Territories, in September 2015)

Priorities addressed: Remote-northern / Smart grid

Project lead: NRCan

Participants: British Columbia / Quebec / Northwest Territories / Nunavut / Newfoundland and Labrador

Project description:

This biannual conference to promote renewable energies (primarily wind and solar), coupled with smart grid technologies in remote and/or northern communities is set to take place in Yellowknife N.W.T., in September 2015. The event will bring together community members, manufacturers, researchers and government workers from across North America to facilitate a discussion of lessons-learned and innovative policy solutions to remote energy challenges that offer important opportunities for remote communities to stabilize long-term costs, reduce pollution, and improve local energy security.

With NRCan participating on the organizing committee, several jurisdictions have agreed to meet to help provide direction on the event's agenda and to enhance the robustness of the conference by broadening provincial/territorial participation. In addition, the planning committee is considering a workshop to be held in conjunction with the event where participants would have an opportunity to become involved through a more in-depth discussion of case studies and practical training modules.

Anticipated results:

A conference agenda that more fully reflects the priorities and needs of jurisdictions across Canada, as well as a more full and comprehensive dialogue as a result of broader participation from provinces and territories.

Timeframe:

September 2015

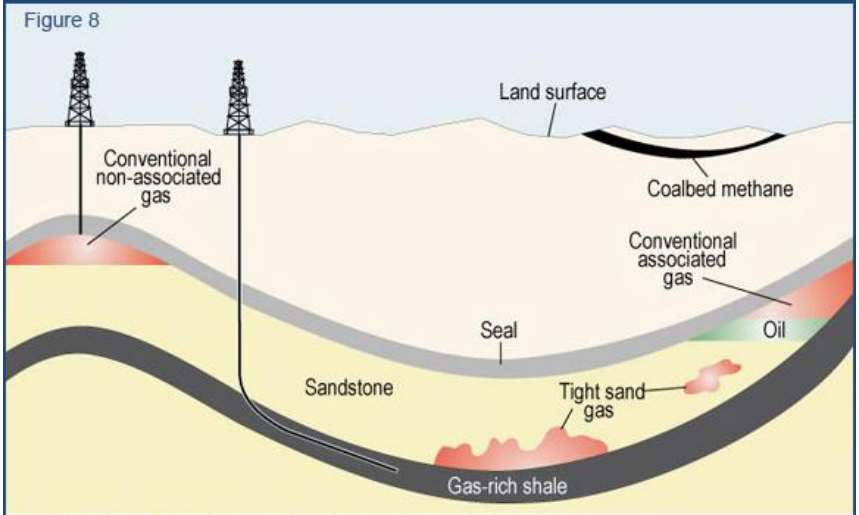
4. Shale Cluster Action Plan

Technological innovations such as horizontal drilling and multi-stage hydraulic fracturing have unlocked vast shale oil and gas resources in Canada. Governments have a role to play in supporting further science, technology and innovation to ensure that these resources are developed responsibly and efficiently.

Shale and tight resources are hydrocarbons (crude oil, natural gas and natural gas liquids) that are trapped in geological formations characterized by very low permeability. Like conventional hydrocarbons, they formed when organic material (plants and animals) was buried and subjected to intense heat and pressure. Some of this organic material escaped into adjacent rock layers to form conventional hydrocarbons that are relatively easy to extract. However, the majority of it remained locked in the tight, low-permeability layers.

Schematic geology of natural gas resources

Figure 8



Source: U.S. Energy Information Administration (April 2015).
Available online at www.eia.gov/energyexplained/index.cfm?page=natural_gas_where

Low permeability refers to rocks with pores so small or poorly connected that oil and gas cannot flow through them easily (tight reservoirs). Hydrocarbons found in these types of reservoirs are referred to as "tight gas" or "tight oil". Shale is a common type of tight reservoir that is composed of extremely fine-grained, sedimentary rock, and may contain natural gas – referred to as "shale gas". Throughout this report, the term "shale resources" will generally be used to encompass all forms of "tight" oil and gas resources unless specifically noted otherwise.

4.1 Policy context

The development of shale and tight resources has the potential to make significant contributions to the Canadian economy. Benefits include jobs for Canadians, lease and royalty payments to the provincial governments that own the resources, and tax payments to municipal, provincial, and federal governments. Macroeconomic benefits also include increased investment, a stronger trade balance, and reduced dependence on imported energy. The contribution of the shale industry to the economy is significant and will become more so as conventional resources continue to decline. As of 2013, the oil and gas industry comprises about 20 percent of the Toronto Stock Exchange[19]. Government revenue associated with oil and gas production is used for meeting government priorities, such as reducing taxes, reducing the deficit, supporting infrastructure projects and delivering a variety of programs and services to the public. Shale gas development remains a strategic resource that can be used to replace diminishing conventional natural gas supplies. The lower emissions intensity of natural gas compared to other fossil fuels, along with its reliability and low cost, make it favourable for continued domestic use in both transportation and power generation.

Textbox 4: New Web Portal to Disseminate Federal, Provincial and Territorial Research on Canada's Shale Resources

Working in partnership with the provinces and territories through the EMMC Markets and Trade Working Group, Natural Resources Canada has launched a new web portal to disseminate federal, provincial and territorial research on shale and tight resources.

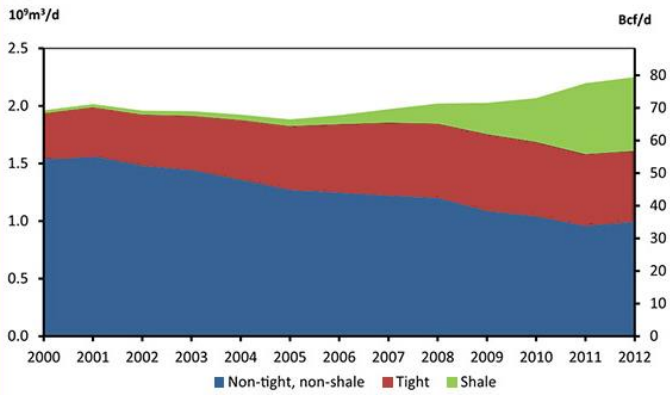
The Shale and Tight Resources web portal is a collaborative product prepared by federal, provincial and territorial governments to enhance fact-based public understanding and dialogue concerning shale/tight oil and gas development in Canada. Users have the option to "drill down", by selecting a topic for more detailed information, or "drill laterally", by selecting a province or territory, to learn more about shale and tight resource development in a particular jurisdiction.

New technologies have unlocked vast amounts of previously uneconomic shale resources, which are increasingly dominating Canada's energy sector. Since the 1950s, hydraulic fracturing has been used to stimulate over 175,000 wells in Western Canada.[20] In addition, over 75 percent of wells drilled in North America today are horizontal. In British Columbia, 90 percent of new gas wells are targeting shale gas.[21]

[19] Canadian Association of Petroleum Producers, Basic Statistics. Available online at capp.ca/library/statistics/basic/Pages/default.aspx.
[20] Canadian Association of Petroleum Producers, *Governments Regulate Shale Gas, Industry Promotes Operating Practices*, June 11, 2012. Available online at capp.ca/aboutUs/mediaCentre/NewsReleases/Pages/governments-regulate-shale-gas.aspx.
[21] Canadian Society of Unconventional Resources, *Unconventional Natural Gas Development: A Look at Emerging Issues*, 2014. Presented at CERI Natural Gas Conference 2014.

Canada and U.S. Combined Marketable Natural Gas Production

Figure 9



Source: Canada's Energy Future 2013 – Energy Supply and Demand Projections to 2035 – An Energy Market Assessment. Original available on the National Energy Board's (NEB) website at https://www.neb-one.gc.ca/nrg/ntgrtd/ftr/2013/index-eng.html. This copy not reproduced in affiliation with, or with the endorsement of, the NEB.

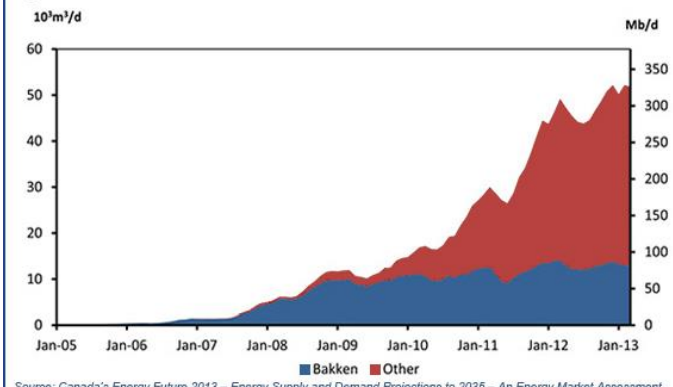
The recent abundance of Canadian shale natural gas resources has also created a unique opportunity for diversifying markets for Canadian producers through liquefied natural gas (LNG) exports. Around 18 projects are currently being proposed on the west coast that would export Canadian LNG to Asia.

The rise in shale gas production in North America has resulted in a dramatic shift in available supply and contributed to the decline of prices by nearly 75 percent from July 2008 to January 2013. Prices in North America are projected to remain in the $4–$5/MMBtu range, whereas, in contrast, the average price of natural gas in Europe and Asia remains at around $10/MMBtu.[22]

Shale oil production has also increased sharply in North America in recent years making North America the fastest growing oil-producing region in the world outside of the Organization of Petroleum Exporting Countries (OPEC)[23]. In Canada, the increase in shale oil production has reversed the recent decline in conventional crude oil production and built upon existing production in the Bakken Formation, with conservative estimates of proven and probable shale oil reserves reaching around 500 million barrels[24].

Canadian Tight Oil Production

Figure 10



Source: Canada's Energy Future 2013 – Energy Supply and Demand Projections to 2035 – An Energy Market Assessment. Original available on the National Energy Board's (NEB) website at https://www.neb-one.gc.ca/nrg/ntgrtd/ftr/2013/index-eng.html. This copy not reproduced in affiliation with, or with the endorsement of, the NEB.

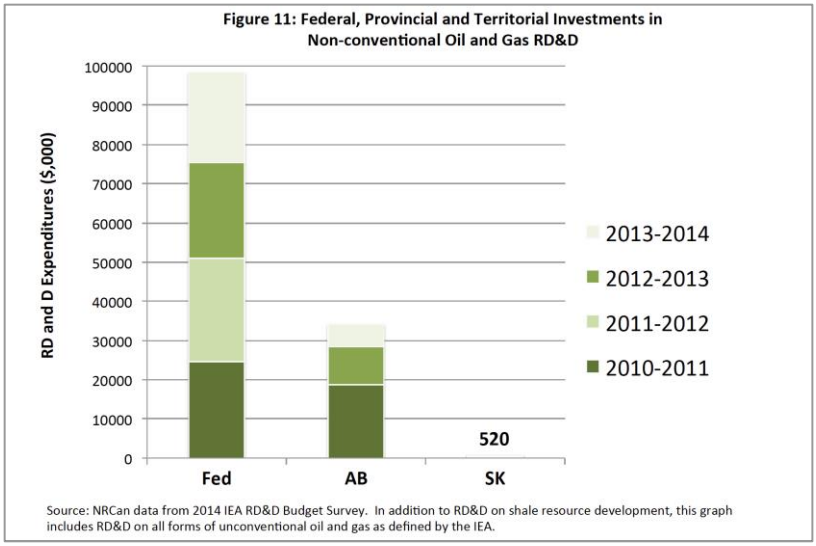
With the increase in shale oil and gas production, Canadians have raised concerns related to the environmental impact of the development of these resources. Environmental protection and public awareness, engagement and disclosure are important considerations for policy makers, regulators and operators as they consider shale resource development in Canada.

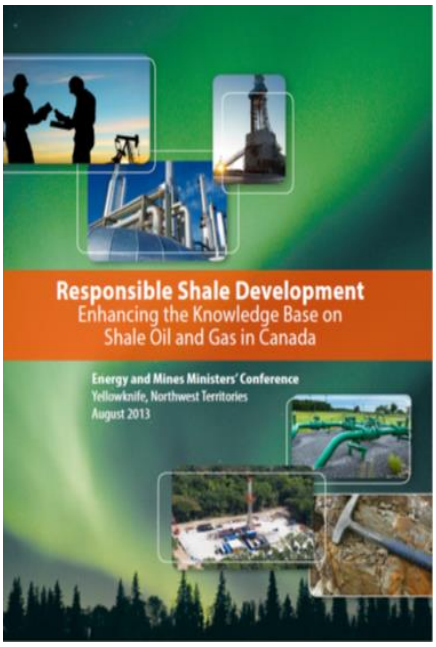
[22] Jed Chong and Milena Simikian, *Shale Gas in Canada: Resource Potential, Current Production and Economic Implications*, Library of Parliament Research Publications, 2014. Available online at parl.gc.ca/Content/LOP/ResearchPublications/2014-08-e.htm#ftn52.

[23] Natural Resources Canada, North American Tight Light Oil. Available online at nrcan.gc.ca/energy/crude-petroleum/4559#fn8.

[24] National Energy Board, Energy Briefing Note, *Tight Oil Developments in the Western Canada Sedimentary Basin*, December 2011.

The Canadian Council of Academies was asked to report on the environmental impacts of shale gas extraction in Canada and mitigation options. Its report, published in May 2014, identified that potential impacts may differ by region, due to different environments, ecosystems, geographies, and geologies. Two issues noted of particular concern were water resources and fugitive greenhouse gas emissions, both related to well integrity and management at the surface. It identified a need for improved technologies and monitoring for well integrity. Other impacts considered were land, health and social impacts, air contaminants and seismic events. The report concludes that "well-targeted science is required to ensure a better understanding of the environmental impacts of shale gas development. Currently, data about environmental impacts are neither sufficient nor conclusive." Ultimately, such science is required to improve knowledge, mitigation and to inform the public.





Governments have a key role to play in supporting science, technology, and innovation and the responsible development of shale resources in Canada. This includes ongoing efforts to modernize policy and regulatory frameworks, supporting scientific research to better understand the resource potential and the implications of its development for the environment and human health, and engaging in meaningful communication and consultation with the public**.**

To this end, and building upon the report on Responsible Shale Development completed for EMMC 2013, Natural Resources Canada and the Governments of British Columbia, Alberta, Saskatchewan, Newfoundland and Labrador, Yukon, and Northwest Territories have come together to pursue opportunities to work together to advance Canada's ability to develop shale resources in an environmentally responsible manner.

Textbox 5: Energy Geoscience and Geo-Engineering – Collaborative Open Innovation Network (EG-COIN)

Shale oil and gas represent a very large and mostly untapped resource for Canada. As conventional oil and gas reserves decline, Canada's ability to develop this next generation of energy resources in an environmentally responsible manner will be key to maintaining its strong competitive position in the global energy market.

To this end, Natural Resources Canada led a series of workshops in Halifax, Québec City, Ottawa, Winnipeg, Calgary and Vancouver, in February and March 2015, with close to 200 federal, provincial and territorial government, industry and academia representatives on hand to discuss knowledge gaps and barriers to innovation in the understanding and mitigation of the risks associated with this development. The workshops addressed three themes: 1) how to better assess resources and characterize reservoirs; 2) development of engineering technologies and best practices; and 3) how to increase understanding, tools and methods to address environmental challenges.

During the workshops, it was acknowledged that Canadians have concerns related to potential impacts on water, soil and air (including fluid migration pathways influenced by hydraulic fracturing, seismic events, long-term well integrity). As such, environmental baseline data and methodologies are needed for monitoring and understanding potential changes to aquifers or associated lands.

Also, from a national perspective, a better understanding of our resources (where, what kind, and how much) will enable governments to make sound decisions (e.g., related to infrastructure development).

The main R&D themes discussed at the workshops were as follows:

- Common barriers to innovation (lack of co-ordination and access to industry/government data, insufficient, unstable and highly competitive research funding, and shrinking and aging research communities – difficulties attracting the next generation);
- Geological and aquifer mapping to support water resources protection;
- Fugitive GHG emissions, wellbore leakage and induced seismicity;
- Enhanced oil recovery; improved secondary/tertiary recovery techniques; and
- Rock formation characterisation to better assess location and quantity of oil and gas.

EG-COIN is proposing to leverage industry, government and academia's expertise, funding and facilities to address shared research priorities, to reduce the risks inherent to the development and adoption of new technologies and practices for shale oil and gas extraction. EG-COIN also plans to take into account related communities' concerns on the impacts of development and to facilitate the adoption of socially innovative approaches to expand the reach of scientific innovation.

4.2 Shared priorities and current actions

Shale Priority 1: Reducing emissions and protecting ambient air quality through research and technology innovation

Multi-stage hydraulic fracturing is still relatively early in its maturation, and more can be known about its effects on air quality and emissions. Shale resources in Canada range widely in terms of their geology, hydrology, land uses, and population density. Innovation can help minimize flaring or economically capture gas that can be delivered to market. There is also an opportunity to better monitor and bolster the effectiveness of cement casings surrounding drilled wells (i.e., wellbore integrity), which is the linchpin in preventing fugitive emissions and fracturing fluid leakage. Likewise, some fields may produce shale gas with a higher carbon dioxide content than others. Innovation can help overcome this challenge by capturing the carbon dioxide for use in enhanced oil recovery or by sequestering it in saline aquifers.

The oil and gas sector is under intense scrutiny for its contributions to climate change. Given the early state of the industry and diversity of formations, jurisdictions have an opportunity to encourage, produce, and share scientific research and innovation to support responsible development across the industry.

Examples of what Canadian jurisdictions are doing, in collaboration with other stakeholders, to address this priority:

- **Natural Resources Canada** is conducting research and development on novel tracer technologies for early, reliable, and cost effective detection of leaks from hydraulically fractured shale gas fields and wellbores.

- **British Columbia** has begun Phase 2 of a multi-year Northeast Air Monitoring Project to enhance monitoring and data collection in order to provide long term air quality information to the public and decision makers. British Columbia is completing the final phase of the Northeast BC Oil and Gas Human Health Risk Assessment that evaluates human health concerns related to oil and gas resource development activities. British Columbia is also providing funding to academic partners to evaluate gas migration and cementing fluid mechanics to advance research on wellbore integrity.

- **Alberta** is exploring the technical and economic impacts of using a natural gas gathering system to minimize venting and flaring from fractured wells. Alberta's Climate Change and Emissions Management Corporation is funding Seal Well Inc. in its efforts to commercialize proprietary plugs and procedures that are more effective, reliable, and less expensive than cement in sealing abandoned oil and gas wells. Alberta is also developing a technology roadmap for tight oil and gas that will identify opportunities for improving environmental performance.

- **Saskatchewan** is implementing the Saskatchewan Energy and Resources Directive S-10 (Upstream Petroleum Industry Associated Gas Conservation Directive), which requires the collection of associated gas that meets or exceeds an economic threshold.

- **New Brunswick** has conducted a comprehensive assessment of air quality near shale gas development activities as part of an ambient air quality impacts study.

- **Yukon Territory** is currently developing regulatory directions on flaring, venting and fugitive emissions, and is supporting research on advancing geochemical tracer and monitoring techniques.

Shale Priority 2: Improving water protection and management through knowledge sharing and technology innovation

Water management is also important in responsible development and is a focus for the Shale Cluster. Opportunities exist to develop technologies that improve water recycling and reuse, better characterize deep aquifers for water supply and disposal, manage cumulative regional water usage, replace water with other fluids in applicable formations, lower the costs of alternative fluids, and develop monitoring systems that can distinguish anthropogenic from naturally occurring substances in groundwater.

Textbox 6: FracFocus Chemical Disclosure Registry

FracFocus is a collaborative initiative between provinces, territories, regulators and industry to provide Canadians with the following: objective information on hydraulic fracturing; information on existing legislation and regulations to protect the environment, including groundwater; and transparency on the ingredients that make up hydraulic fracturing fluid.

The website was built by the BC Oil and Gas Commission and is designed so that all provinces and territories can participate with public access to data regarding the location of oil and gas activity by enabling jurisdictions to upload data regarding hydraulic fracturing fluids provided to them by industry.

The website can be found at www.fracfocus.ca

As is the case with Priority 1, wellbore integrity is of paramount importance in ensuring that shale resource development does not impair the quality of water resources, including potable groundwater aquifers. Areas of focus include best practices for well construction, installation, operation, abandonment, testing, and repair; better understanding of cement deterioration; and gathering baseline data.

What Canadian jurisdictions are doing, in collaboration with other stakeholders, to address this priority:

- **Natural Resources Canada** is conducting research and development into enhancing sub-surface monitoring and leakage detection techniques, such as noble gas and isotope tracers, and is developing a federal R&D roadmap on improving wellbore integrity.

- **British Columbia** is conducting a variety of water resource mapping activities, including GIS-based hydrology decision-support tools for water use approvals, as well as baseline environmental data collection on water quality and quantity, environmental impact studies on water resources, and research and development on water recycling, treatment, storage, transportation and disposal. British Columbia is using forums such as the Western Regulators Forum and the Canadian Standards Association to improve knowledge and standards regarding wellbore integrity. British Columbia has also created the FracFocus Chemical Disclosure Registry and Information Site. This website is intended to provide objective information on hydraulic fracturing, fracturing fluids, groundwater and surface water protection and related oil and gas activities in Canada.

- **Alberta** is working on treatment options for used and produced water from hydraulic fracturing operations and is exploring shale development water recycling for reuse in mining and in-situ thermal recovery operations. Alberta is also looking at ways to minimize/reduce the use of potable water, in addition to classification, storage, transportation, disposal and reuse of sludge and flowback waste.

- **New Brunswick** is addressing this issue through a groundwater baseline monitoring study and through the mapping of groundwater inflows and the characterization of baseline water quality and aquatic species to determine environmental impact.

- **Yukon Territory** is working on the development of a new Water Strategy that includes a focus on baseline data collection.

Textbox 7: CanmetENERGY Workshops on Shale Oil and Gas Development

Building upon the gaps identified within the EG-COIN workshops (see Textbox 5), Natural Resources Canada's CanmetENERGY, in partnership with industry, academia and government, organized three workshops to discuss potential technology-based solutions to address environmental challenges and improve the efficiency of extraction.

On March 12, 2015, CanmetENERGY and Alberta Innovates Technology Futures held a workshop in Calgary to discuss wellbore integrity, which was identified in a recent report by the Canadian Council of Academies as an area of primary concern. This workshop was the first step in completing a Technology Roadmap that will, with the input of industry, academia, and government participants, identify and guide the development of R&D required to detect and reduce wellbore leakage.

A related workshop was held with leading scientists in Ottawa on March 19, 2015 to discuss methods, such as geochemical tracers, of detecting well leakage in shallow potable aquifers. Of particular interest are methods to distinguish between gas contamination from natural pathways and potential contamination from well leakage. The workshop confirmed the robustness of geochemical detection and fingerprinting tools and will serve to inform projects that will i) evaluate the magnitude of wellbore leakage of methane into shallow aquifers in oil and gas producing regions; ii) detect wellbore leakage; and, iii) conduct baseline environmental characterization studies of yet-to-be developed regions.

Lastly, CanmetENERGY, in collaboration with the Petroleum Technology Research Centre, organized a workshop in Calgary on March 12, 2015, to discuss research and development (R&D) to optimize oil production from tight reservoirs, including methods with improved environmental performance. The workshop concluded that a much improved understanding of tight oil reservoirs is required in order to optimize production. CanmetENERGY is in discussion with other R&D agencies to pursue collaborative projects, including the use of CO_2 as a fracturing fluid that has the potential to improve environmental performance by reducing both water usage and greenhouse gas emissions.

These types of workshops are essential to ensure that often complex and costly R&D is pursued in a collaborative manner that leverages expertise and funding to address identified priority issues.

Shale Priority 3: Improving the environmental and economic performance of resource recovery through research, development and demonstration

Technology innovation is what initially made horizontal drilling and multi-stage hydraulic fracturing economically viable. At a fundamental level, technology and innovation can produce complimentary economic and environmental outcomes by improving extraction economics while simultaneously reducing environmental impacts. For example, decreased water use in the extraction process typically means a smaller footprint in local basins and results in reduced costs to pump and dispose of water. Jurisdictions are working in concert to address this opportunity to support economically and environmentally sustainable resource development.

What Canadian jurisdictions are doing, in collaboration with other stakeholders, to address this priority:

- **Natural Resources Canada** is conducting research and development on several resource recovery methods that have environmental and economic co-benefits such as impulse fracturing and the use of CO_2 in fracturing operations. NRCan is also exploring approaches to better characterize and assess existing resources, resulting in more targeted development that is both more efficient and has less environmental impact.

- **British Columbia** is funding Phase 2 of an assessment of green additives and chemical compounds to improve the environmental performance of hydraulic fracturing and is modeling hydraulic fracture propagation and shale–proppant interactions during post-fracturing fluid flowback and fracture closure. British Columbia and its industry partners have developed innovative water source systems that utilize deep saline or recycled waste water.

- **Alberta** is conducting research into the viability of using CO_2 to enhance resource recovery and to measure the performance of ultra-lightweight proppant technologies to evaluate and provide a better understanding of environmental and production benefits.

- **Saskatchewan** is investigating the potential for CO_2 to be used in enhanced tight oil recovery and is also participating in an international research consortium to investigate enhanced oil recovery processes for tight oil.

Shale Priority 4: Advancing knowledge of induced seismicity from hydraulic fracturing operations through baseline data accumulation and knowledge sharing

Induced seismicity refers to seismic events caused by human activities. Work is ongoing to determine whether linkages exist between hydraulic fracturing operations and micro-seismic events, specifically investigating linkages between seismicity and wastewater reinjection. Requirements in B.C. and Fox Creek, Alberta, to monitor and report on seismic activity show that more research is needed in this area to understand the connections, causes, and implications for induced seismic activity in resource development locations. The Shale Cluster is supporting work to understand the observed links between shale activity and induced seismicity. This work can help determine natural seismicity patterns and recognize unusual patterns from anthropogenic activities.

What Canadian jurisdictions are doing, in collaboration with other stakeholders, to address this priority:

- **Natural Resources Canada** is currently examining linkages between hydraulic fracturing and/or flowback reinjection and seismicity and is gathering baseline data in both emerging and frontier plays.

- **British Columbia** has produced two key reports on Induced Seismicity (one for Horn River, and a more recent report for the Montney formation). The province is engaged in a project to install a seismic array network in the northeast to collect baseline seismicity information. British Columbia is also funding an investigation of hydrofracture and stress field interactions on critically stressed faults and induced seismicity and has developed comprehensive approval conditions for operating, monitoring, measurement and reporting by industry on disposal wells.

- **Alberta** is funding a project to develop a Slimline Borehole Seismic System for geophysical imaging and monitoring of induced seismicity.

- **New Brunswick** is in the process of upgrading five temporary seismic monitoring stations to permanent stations. The monitoring stations are strategically located to establish baseline data for seismic activity.

- **Yukon Territory** has partnered with Natural Resources Canada to install a seismic monitoring station in a remote area of northern Yukon where seismic data is limited. In addition, Yukon is participating in a joint project with Alaska that involves a moveable seismic monitoring grid, and which includes 58 sites in western Yukon.

4.3 Proposed collaborative actions

Action 1: Technology roadmap on wellbore integrity

Priorities addressed: Air / Water

Project lead: NRCan

Other participants: British Columbia / Alberta / Saskatchewan / Newfoundland and Labrador / Northwest Territories

Project description:

In March 2015, Natural Resources Canada and Alberta Innovates co-hosted a workshop to identify technology gaps related to wellbore integrity, a primary cause of environmental underperformance in shale and other related oil and gas operations. Several provinces were represented at the March workshops (see Textbox 7 on page 33).

The results of this workshop will be used to inform the development of a multi-jurisdictional technology roadmap to address gaps in this area and to contribute to improving the environmental performance of shale resource development. Several topics were raised for discussion at the workshop, including the following:

- The magnitude and frequency of gas leakage into the shallow subsurface (i.e., gas that leaks along a well, but does not escape to the atmosphere);
- Methods to improve the initial completion (i.e., cementing) of wells to avoid and reduce wellbore leakage; and
- Maximizing the success of wellbore remediations and reducing cost.

Anticipated results:

Multi-jurisdictional technology roadmap to both identify and provide a plan for addressing research- and technology-based gaps related to wellbore integrity.

Timeframe:

Spring/Summer 2016

Action 2: Identifying geoscience and geo-engineering R&D gaps

Priorities addressed: Air / Water / Recovery methods / Seismicity

Project co-leads: NRCan and British Columbia

Other participants: Alberta / Saskatchewan / Manitoba / Ontario / Quebec / New Brunswick / Nova Scotia / Yukon Territory / Northwest Territories

Project description: NRCan has convened a series of regional workshops across the country comprised of personnel from Canadian governments, industry, and academia on topics related to the geoscience and geo-engineering aspects of shale resource development. Workshops were held in Halifax, Quebec, Winnipeg, Calgary and Vancouver.

The initiative focused primarily on identifying and addressing knowledge gaps related to the extraction of shale resources and culminated in a national roundtable. A final report tabling the results of the regional and national workshops is currently being produced to inform policy makers and industry as to the future development of shale resources (see Textbox 5 on page 29).

Anticipated results:

The summary report is to include the outcomes of the discussions at the regional and national workshops, including the identification of specific knowledge and technology gaps relating to shale resource development. Shale Cluster members will be able to leverage the summary report to help identify and/or close gaps within their own jurisdictions.

Timeframe:

Natural Resources Canada, through the Geological Survey of Canada, held a series of regional workshops in 2015, including in Halifax (Feb. 23); Quebec (Feb. 26); Calgary (March 3); Vancouver (March 4); and Winnipeg (March 5).

Action 3: Environmental baseline data on shale resource development

Priorities addressed: Air / Water

Project leads: NRCan

Other participants: British Columbia / Alberta / Saskatchewan / Newfoundland and Labrador / Yukon Territory / Northwest Territories

Project description: With many jurisdictions collecting baseline environmental data on a variety of environmental areas related to shale resource project sites (i.e., air emissions, water quality, water availability, seismicity), the cluster determined that there would be value in comparing and contrasting methodologies of data collection.

Cluster members agreed to convene a teleconference meeting at which information would be shared on each jurisdiction's methodologies for collecting and analyzing their environmental baseline data.

Anticipated results:

Broader understanding on the range of methodologies for collecting and analyzing environmental baseline data related to shale resource development across Canada.

Timeframe:

Fall 2015

Action 4: Participation in a flaring and venting regulators forum

Priorities addressed: Air

Project leads: NRCan

Other participants: Yukon Territory

Project description: Discussions are ongoing regarding enhancing participation in the Canadian Flaring and Venting Regulators Forum.

The venting and flaring of gases associated with tight oil and gas operations has been a topic of interest within the Shale Cluster. The advancement of technologies to reduce these greenhouse gas and other CAC emissions has the potential to positively impact the environmental performance of tight oil and gas operations.

The Shale Cluster has an opportunity to leverage the work of the Canadian Flaring and Venting Regulators Forum by promoting this organization to the collection of FPT subject matter experts involved with the Shale Cluster. Already, the Yukon Department of Energy, Mines and Resources, which has not previously participated, has expressed interest in joining the Forum. Other jurisdictions will be invited to participate through the Energy Technology Working Group.

Anticipated results: (TBD)

Broader Canadian participation in the Canadian Flaring and Venting Regulators Forum.

Timeframe:

2015–16

5. Conclusion

Continuing innovation through science and technology can have a profound impact on the global energy system. The development of novel and advanced technologies will be key to advancing Canada's economic competitiveness and achieving environmental performance objectives. A continued focus on innovation will be critical to maintaining Canada's energy resource advantage and offers the potential for significant economic growth in the coming years.

Governments have a clear role to play within the energy innovation system. Increasingly in the future, strategic alliances and partnerships that work towards common solutions to common challenges will be vital to the development and deployment of new technologies that will both support the productivity and competitiveness of Canadian energy firms and help reduce their environmental footprint.

In response, the Energy Technology Working Group (ETWG) has undertaken a multi-jurisdictional and multi-year effort to advance federal, provincial and territorial (FPT) collaboration on energy science, technology and innovation. Building upon previous efforts, the ETWG has created a new approach, "energy innovation clusters", which bring together FPT experts to drive collaboration in priority technology areas through the development and implementation of multi-jurisdictional action plans. The action plans included in this report have articulated shared technology innovation priorities, identified existing activities, and **proposed specific collaborative** actions across jurisdictions for the coming year, with a follow-up report on progress planned for ministers at EMMC 2016.

The need for innovation through energy research and technology development is clear, and the necessity of enhancing collaboration between Canadian jurisdictions apparent. Building upon the proposed collaborative actions contained within this report, Canadian governments will be well situated to take action and move forward together on energy research, technology and innovation.