Working Together to Advance Energy Research and Development: Best Practices and Lessons-Learned for RD&D Collaboration

Energy and Mines Ministers' Conference
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Executive Summary

Collaboration on research, development and technology demonstrations (RD&D) plays a significant role in advancing innovation in Canada's energy sector. A variety of mechanisms are currently being used to advance the development and deployment of new technologies and innovative solutions to energy system challenges. Collaborative mechanisms will be critical to accelerate the efforts required to advance innovation for a sustainable energy future.

Federal, provincial and territorial (FPT) governments have a shared interest in collaborating on energy technology innovation to encourage the transition to a lower-carbon economy and to enhance the competitiveness of Canada's energy sector. Going forward, enhanced FPT collaboration can play a significant role in meeting shared climate change goals, including Canada's international GHG emissions targets, and in positioning Canada as a world leader in clean technology.

This report profiles a collection of success stories of FPT collaboration across Canada, ranging from shared funding initiatives to lab-to-lab collaboration and joint research studies. The success stories are intended to encourage broader discussions on ways to advance collaboration and suggest a variety of mechanisms that are available to increase partnerships between federal, provincial and territorial governments.

While there are numerous examples of successful FPT energy RD&D collaboration, there are still challenges to collaborative initiatives facing jurisdictions. Funding concerns, including stringent funding requirements and issues surrounding intellectual property rights, may dissuade collaboration. However, these challenges can be overcome with improved program design, as well as with increased information sharing.

Several enabling factors contribute to the success of FPT collaboration. Shared priorities are a key driver, as are information sharing and funding programs that are structured to encourage collaborative initiatives. Governments can build on these elements and other areas of success to enhance FPT collaboration and improve the development and deployment of new and innovative solutions to challenges in Canada's energy sector.

Foreword

Research, development and demonstrations (RD&D) play a critical role in supporting innovation in Canada's energy sector. Innovation through science and technology will help Canada improve the environmental performance and economic competiveness of its energy sector. Government collaboration enhances RD&D investment, leverages resources and capacity and diversifies the risks inherent to energy technology innovation.

The Energy and Mines Ministers' Conference (EMMC) is an annual gathering of federal, provincial and territorial ministers responsible for energy and mining portfolios. At these meetings, ministers discuss shared priorities for collaborative action to advance energy and mining development across the country.

To support this mandate, the EMMC's Energy Technology Working Group (ETWG) has drafted the following report that highlights a collection of best practices of federal, provincial and territorial collaboration on RD&D, covering case studies across a range of different jurisdictions and approaches. The report is intended to inform broader discussions on ways to enhance federal-provincial-territorial collaboration on energy innovation.

Canada's involvement in international energy technology initiatives, such as *Mission Innovation*, also provides a platform for FPT collaboration. Canada, along with a group of 21 international governments, has pledged to double its energy RD&D funding by 2020 and collaborate on clean energy RD&D. This initiative offers opportunities for Canada to improve its access to international knowledge and expertise and to facilitate international market access for Canadian energy and related technologies.

Introduction

At EMMC 2015 in Winnipeg, ministers noted the need for collaboration in order to accelerate energy technology innovation. Building upon previous efforts of the EMMC Energy Technology Working Group to establish shared priorities on specific technology areas, the following report looks at examples of successful RD&D projects that involve participation from a number of sectors, including government, industry and utilities, and draws out a list of enabling factors that contributed to their success.

Building on these enabling factors, the report lays out a number of concluding observations on how Canadian governments can strengthen FPT collaboration on energy RD&D. This feature is particularly timely, given the increased domestic and international recognition of the key role of energy RD&D in enabling a transition to a low-carbon, clean growth economy in the longer term.

1. RD&D Collaboration Mechanisms

The following case studies provide insights into the key features of successful collaboration between the federal government and various provincial and territorial governments. The case studies are classified according to the following three types of collaborative mechanisms:

A. **Leveraged Funding Initiatives** — Project funding was provided from a number of sources through independent funding processes

B. **Lab-to-Lab Collaboration** — Projects established between federal and provincial labs in areas of mutual interest

C. **Joint Research Studies** — Studies involving a number of jurisdictions to address energy research gaps

A. Leveraged Funding Initiatives

Initiative: Fundy Ocean Research Centre for Energy

Collaborators: Natural Resources Canada, Province of Nova Scotia

Description

The Fundy Ocean Research Centre for Energy (FORCE) was established as a result of a request for proposals for tidal turbine demonstration projects by Nova Scotia's provincial government in 2007. It serves two main purposes: to enable public and private research in tidal energy and to provide a demonstration facility for tidal turbines.

FORCE receives funding from the federal government, the Province of Nova Scotia and the private sector, including Encana Corporation and various developers. Natural Resources Canada (NRCan) invested $25 million in FORCE, administered through the Clean Energy Fund (CEF). The Nova Scotia government has also reached agreements with FORCE developers to establish a feed-in-tariff of 53¢/kWh for electricity produced by tidal power.

Results

The project is still underway; however, many accomplishments have already been realized. In 2014, four underwater power cables were successfully installed, providing FORCE with the largest transmission capacity for tidal power in the world at 64 MW. The federal funding was used to set up the site's electrical and data monitoring infrastructure, creating an attractive RD&D opportunity for leveraging external investment.

FORCE has the potential to provide significant economic and environmental benefits for Canada. Over 125 companies throughout the tidal energy supply chain have already been involved in the project. Of these 125 companies, 95 percent are Canadian.

Although FORCE was selected independently for funding by both the federal and provincial governments, the project has led to successful collaborative mechanisms, as well as the development of a strong relationship between the two governments — encouraging further collaboration on projects in the future. Among these mechanisms is the development of the Federal/Provincial Joint One Window Committee on In-Stream Tidal Energy to assist in providing a clear path to the development of FORCE. Several federal departments have an active or observing role on the committee, including Natural Resources Canada, and continue to work with the Province of Nova Scotia to ensure the project proceeds.

Initiative: The British Columbia Electric Vehicle Smart Infrastructure Project

Collaborators: Natural Resources Canada, Government of British Columbia, BC Hydro

Description

The British Columbia Electric Vehicle Smart Infrastructure Project is a commercial demonstration initiative funded by Natural Resources Canada (NRCan) and the Province of British Columbia, led by BC Hydro. NRCan's ecoEnergy Innovation Initiative (ecoEII) contributed $4,125,000, just below 50 percent of the total project costs ($8,802,895).

The availability of charging stations has been identified as a major barrier to electric vehicle (EV) adoption due to the limited driving range of EVs. This project supported the installation of over 300 fast-charging electric vehicle stations in British Columbia, 30 of which are along major transportation corridors and concentrated in the Lower Fraser Valley. The project is intended to increase the adoption of electric vehicles in the province by reducing range anxiety for users, ultimately contributing to a more energy-efficient and sustainable transportation sector.

Results

British Columbia's Lower Fraser Valley has been identified as a region with severe ground-level ozone problems, with approximately 84 percent of pollutants resulting from transportation sources. As 93 percent of B.C.'s electricity is produced from clean and renewable sources, the use of EVs directly reduces emissions, many of which contribute to ground-level ozone.

In addition to providing support for this infrastructure initiative, the B.C. government also provides supportive funding through its Innovative Clean Energy (ICE) Fund's Clean Energy Vehicle Program, which offers up to $5,000 for qualifying new battery-electric, fuel-cell electric, and plug-in hybrid electric vehicles, and up to $6,000 for hydrogen fuel cell vehicles for businesses, residents, non-profit organizations and local government organizations.

This project represents a successful collaboration initiative due to the alignment of objectives and shared priorities of the federal and provincial governments to advance British Columbia's clean energy sector and support overall environmental and greenhouse gas reduction priorities across the country. Although the project was funded independently by the federal and provincial governments, it suggests that further collaboration can be beneficial for meeting energy and environmental goals for both governments.

Overall, ecoEII's EV infrastructure projects, in partnership with provincial and territorial governments and industry, have supported the installation of 1,200 fast-charging stations in Canada, and it is anticipated that this increase will lead to the sale of more than 700 EVs annually. Additionally, over a five-year period, it is estimated that up to 250 jobs will be created with the deployment of 10,000 EVs.

Initiative: **Centre for Arctic Resource Development (CARD)**

Collaborators: Hibernia and Terra Nova Project Owners, Government of Newfoundland and Labrador, C-CORE at Memorial University of Newfoundland (MUN)

Description

CARD, launched in 2011, is a five-year major research initiative intended to help unlock the potential of the Arctic's rich, untapped natural resources. The Centre brings together industry,

academic and technology partners to conduct medium- to long-term R&D focused on improving Canada's capacity and capability to support safe, responsible, cost-effective and sustainable hydrocarbon development in the Arctic and other ice regions.

Operating year-round in the Arctic and offshore Labrador requires the best available information to provide cost-effective solutions related to design, engineering and operations. CARD's research activities intend to look at what makes many Arctic developments cost-prohibitive. CARD serves as a focal point for planning, coordinating and conducting research to fill gaps in the knowledge, technology, methodology and training needed to remove these barriers. The research programs are guided by a five-year R&D plan that has been approved by the Industry Advisory Committee (IAC) to improve exploration and production in harsh, cold environments.

CARD functions as a stand-alone research centre within C-CORE, with C-CORE providing space and business support services. The Centre is supported by the Research & Development Corporation (RDC) of Newfoundland and Labrador and the Hibernia and Terra Nova projects owners.

In 2010–2011, the Hibernia and Terra Nova projects together committed $12.5 million over five years to support CARD. The RDC contributed $4 million under its R&D Platforms initiative to allow C-CORE to expand and enhance its facilities at Memorial to accommodate the new researchers and laboratories. This initial investment has leveraged an additional $7.1 million for expanded Arctic research programs.

Results

In 2011, CARD developed an Arctic Development Roadmap through secondary research and consultation with industry and the broader research community to identify, organize and prioritize key R&D themes. The results were an important input into CARD's five-year research plan and highlighted research priority areas relevant to the broader research community and various sectors of the oil and gas industry.

CARD researchers have published 118 reports and technical papers to date, contributing significantly to the body of knowledge on Arctic engineering issues. CARD researchers have also participated in standards committees, contributing to the advancement of Arctic-related policy and regulation.

Several factors have contributed to the success of the CARD Centre. Funding levels allowed CARD to develop the high-calibre research capacity required and to provide infrastructure enhancements to support its work. Additionally, the IAC provides strong strategic direction and oversight for the Centre, clearly focusing on research goals and priorities.

The Centre's expertise is distributed throughout a network of public and private organizations to contribute to further decision-making in this field, including Atlantic Canada Opportunities Agency's (ACOA) Atlantic Innovation Fund, a Government of Canada initiative that makes strategic investments in R&D in Atlantic Canada, and the National Research Council's Ocean, Coastal and River Engineering facilities in Newfoundland.

CARD has also established strong connections with other research centres, building on the success and insights of other work to further the overall level of knowledge regarding ways to support Arctic resource development. Further, CARD established a Chair in Ice Mechanics at Memorial University, which has strengthened the relationship between CARD and Memorial University, providing access to state-of-the-art research methodologies, as well as to the international community of scholars.

Initiative: **Boundary Dam Integrated Carbon Capture and Storage Project**

Collaborators: Government of Canada, Government of Saskatchewan, SaskPower

Description

Launched in October 2014, the Boundary Dam Integrated Carbon Capture and Storage Project demonstrated a successful retrofit of an aging coal-powered plant to include carbon capture and storage (CCS) technology. SaskPower, a Crown corporation, was the lead on the project, which received support from both the federal and provincial governments.

The Government of Canada committed $240 million in Budget 2008 to SaskPower's Boundary Dam CCS project. The total project costs were roughly $1.4 billion. Saskatchewan's provincial government and SaskPower were responsible for securing the remaining funds.

An important factor in the success of the Boundary Dam CCS project is the 10-year contract between Cenovus Energy and SaskPower for the purchase of captured CO_2 from Boundary Dam to be used in Cenovus' enhanced oil recovery (EOR) project in the Weyburn Field. The remaining CO_2 that is not used for EOR is stored in the Aquistore Project, hosted by SaskPower's Carbon Storage and Research Centre.

Results

Boundary Dam is the world's first commercial-scale coal-fired electricity plant to successfully use CCS technology. The scale of this project has allowed Canada to establish itself as a world leader in CCS. As of October 2015, representatives from over 35 countries have toured the Boundary Dam facilities to gain insight into this technology. The partnership between the Government of Canada, the Government of Saskatchewan, SaskPower and private industry was crucial for achieving the successful demonstration of a clean energy project of this magnitude.

The environmental benefits of the Boundary Dam CCS project are substantial. The technology captures 1.2 $MtCO_2$ per year, significantly reducing emissions from the coal-fired plant and its consequent impact on climate change. An SO_2 absorber and low NO_x burners were also added to the plant, contributing to a further reduction of atmospheric emissions at the facility.

B. Lab-to-Lab Collaboration

Initiative: Alberta–Canada Collaboratory in Cleaner Oil Sands Development

Collaborators: Natural Resources Canada, Government of Alberta

Description

The Alberta–Canada Collaboratory in Cleaner Oil Sands Development was established in 2012 between Natural Resources Canada (NRCan) and the Government of Alberta's Ministry for Economic Development and Trade. The overall purpose of the agreement was to reduce energy use and greenhouse gas emissions in the oil sands industry, specifically through the development of new and improved oil sands technologies. The project has three main objectives: strategic alignment between jurisdictions, strengthening organization relationships and identifying common projects and activities for collaborations.

In March 2016, a letter of understanding (LOU) and associated implementing agreement between Natural Resources Canada's labs (CanmetENERGY Ottawa, Varennes and Devon) and Alberta Innovates – Energy and Environment Solutions was signed to further contribute toward efforts to develop clean technologies for the oil sands.

Results

This successful agreement between federal and provincial labs has achieved cooperation and collaboration on oil sands research, such as the CanmetENERGY Devon and Alberta Innovates Technology Futures' *Strategic Capital Plan* to address safety and program capacity of Devon (federal/provincial) and Millwoods (provincial) research centres.

The impact of the LOU extends beyond the National Oil Sands Programs, confirming the mutual interest of all parties to strengthen transformative clean energy technology research collaborations. Ultimately, the purpose of these agreements is to align Alberta and Canada's innovation energy strategies by developing joint projects and activities.

C. Joint Research Studies

Initiative: Pan-Canadian Wind Integration Study

Collaborators: Natural Resources Canada, Government of British Columbia, Government of Alberta, Government of Saskatchewan, Government of Manitoba, Government of Ontario, Government of Quebec, CanWEA

Description

The Pan-Canadian Wind Integration Study, led by the Canadian Wind Energy Association (CanWEA), is an evaluation of the potential of wind energy to be integrated in provincial electric grids across Canada. The success of the study was reliant on substantial coordination and collaboration between the federal government, provincial and territorial governments, and system operators and public utilities.

The goal of the study was to determine the opportunities and challenges facing high-wind energy penetration in Canada. The results could then be used to determine mitigation measures and operational tools to aid the integration of wind energy in distribution networks.

Natural Resources Canada (NRCan) contributed $1,755,000 of the total project costs ($2,756,963) through its ecoEnergy Innovation Initiative (ecoEII).

Results

The study was the first of its kind to model the entire interconnected North American power system, requiring significant collaboration efforts from participating project partners. The results of the study suggest that a 20 percent integration of wind energy is possible on Canada's

distribution network. This level of wind energy integration would result in GHG emissions reductions of more than 30 $MtCO_2e$ per year.

It is anticipated that this study will support additional research across jurisdictions, as well as collaboration opportunities between the federal government, provinces/territories, and utilities.

Initiative: Research on Diluted Bitumen Spills Compared with Conventional Crudes

Collaborators: Natural Resources Canada, Government of Alberta

Description

To better understand the properties and behaviour of Alberta's oil products, Alberta Innovates – Energy and Environment Solutions (AI-EES), Alberta Energy, Alberta Environment and Parks (AEP), Alberta Innovates Technology Futures (AITF), Natural Resources Canada, Petroleum Technology Alliance Canada (PTAC), Canadian Energy Pipeline Association (CEPA), the University of Alberta, the University of Calgary and the University of Lethbridge collaborated to conduct research on diluted bitumen spills.

Understanding the behaviour of energy products in various environments helps to address public confidence concerns and to support the development of evidence-based policy and decision-making related to planning, emergency response and risk mitigation for safe and secure energy transportation.

Funding sources and support for the project were provided between AI-EES' partnerships with the Government of Alberta, Government of Canada, industry associations and post-secondary institutions.

Results

The opportunity for collaboration arose from an interest in exploring potential knowledge gaps related to the impact and behaviour of different crude oil compositions in marine and fresh water spill response.

Expert research to better understand how different crude oils behave in marine environments is important in the continued development of a world-class prevention, preparedness and response regime. Through compositional laboratory tests and spill tank experiments that simulate aquatic environments, this study demonstrated that diluted bitumen products are similar to other conventional heavy crudes.

The results strongly supported and correlated with prior research suggesting that risks associated with diluted bitumen are reduced and/or similar to those of conventional crudes. In providing guidance to regulators and policy makers, these test results point to a critical time frame for maximum efficiency in oil spill response and remediation.

The success of the project resulted from the early establishment of research partnerships with policy and regulatory bodies to ensure the alignment of research to address critical issues concerning uncertainty and risk to public confidence. Furthermore, the development of a long-term research plan to address additional knowledge gaps and develop new projects ensures a commitment to the initiative from all project partners.

Initiative: The Mississippian–Devonian Shales Unconventional Gas Resources Assessment

Collaborators: National Energy Board, Government of British Columbia, Yukon Geological Survey, Northwest Territories Geological Survey

Description

The National Energy Board, Northwest Territories Geological Survey, Yukon Geological Survey, British Columbia Oil and Gas Commission and British Columbia Ministry of Natural Gas

Development conducted a joint assessment to evaluate the potential of marketable, unconventional gas in shale reservoirs of the Liard Basin.

The Liard Basin, located in the far northwest region of the Western Canada Sedimentary Basin (WCSB), has been a source of conventional natural gas since the 1960s. As a result, gas pipelines are already in place in British Columbia and both territories. Existing technologies for horizontal drilling and multi-stage hydraulic fracturing have allowed for the recovery of unconventional natural gas in recent years, significantly increasing the potential for marketable natural gas across all three jurisdictions.

Results

The collaborating agencies released the report "T*he Unconventional Gas Resources of Mississippian–Devonian Shales in the Liard Basin of British Columbia, the Northwest Territories, and Yukon*" in early 2016, describing the observations and results of the assessment, including an estimate of the total ultimate natural gas potential of the WCSB. The study benefited from the collaboration of federal and provincial government agencies, which shared expertise and resources, that contributed to its successful completion.

The study, the first of its kind to assess the unconventional potential of the basin in detail, determined that the thick and geographically extensive Exshaw and Patry shales in the Liard Basin's Besa River Formation are expected to contain 6.20 trillion m^3 of marketable natural gas. Although the study suggests significant potentials in the Northwest Territories and Yukon, the majority of the marketable gas is located in British Columbia. In combination with prior studies and assessments of conventional natural gas potential, it is estimated that the WCSB has a marketable natural gas potential of more than 29 trillion m^3.

2. Enabling Factors

Several common elements exist across the various successful mechanisms of collaboration for RD&D initiatives between federal, provincial and territorial governments. These enabling conditions, or elements of success, can be capitalized upon to facilitate collaboration and accelerate the deployment of sustainable energy solutions. The following list outlines enabling factors that have contributed to the success of the case studies analyzed in this report and is in line with the international literature on collaborative energy RD&D mechanisms.[1]

- Partnerships based on shared priorities and vision: Improving the environmental performance of Canada's energy production and use is a common priority for both the federal government and provincial/territorial governments. Commitments such as reducing GHG emissions and reaching renewable electricity production targets motivate collaboration.

- Long-term financial commitments: Consistency of funding and/or revenue sources diminishes the risks associated with RD&D initiatives. For governments, the availability of long-term, stable program funding for FPT collaboration on RD&D projects is critical to seizing opportunities to accelerate technology innovation as they arise. For industry, longer-term sources of revenue and the resulting stability it provides (e.g., SaskPower's CES project), can be a determining factor when technology project developers are making their investment decisions.

- Flexible Funding: Funding programs that are structured in a flexible way that allows for the leveraging of funding from other programs is beneficial to inter-jurisdictional collaboration. This does not impede the ability of individual jurisdictions to ensure that their program objectives are met.

- Information Sharing: Although many jurisdictions are engaged in energy RD&D activities, collaboration opportunities may be limited due to a lack of knowledge on the capabilities and technology interests of potential partners. Open information sharing facilitates better outcomes and reduces unnecessary duplication of effort or resources. The benefits of information sharing were acknowledged at the 2015 Energy and Mines

[1] carbontrust.com/resources/reports/technology/united-innovations-cost-competitive-clean-energy/
cleanenergyministerial.org/Portals/2/pdfs/CEM6-Roundtables-Summary_Report.pdf.
IEA, "Energy Technology Perspectives 2015"

Ministers' Conference (EMMC 2015). Through the Distributed Power Generation and Shale Resource Development innovation clusters that were announced at EMMC 2015, information sharing sessions were held on technical areas of mutual interest (see separate status report on the cluster action plans for more details).

- Intellectual property: The ability to address intellectual property rights concerns in a way that suits the needs of partners is an important enabler of collaboration. Intellectual property rights need to be clearly assigned in the collaboration agreements (e.g., MOU, letter of understanding) as collaborative energy RD&D projects are being designed.

3. Conclusion

Canadian governments are well positioned to participate in collaborative energy RD&D initiatives, and these initiatives can have a significant impact on accelerating efforts toward finding technology solutions. The following key factors have either facilitated collaboration among the provinces, territories and federal government or have the potential to do so going forward.

- Shared priorities remain a key driver for FPT collaborative initiatives. Information sharing in areas of mutual interest and relative capability is critical to identifying these priorities.

- Successful RD&D collaboration generally occurs when a project proponent has been able to secure funding from multiple partners, often including varying levels of government, public utilities, Crown corporations and the private sector.

- There is an opportunity to expand FPT collaboration efforts. In some cases, this collaboration can take the form of leveraging energy RD&D funding programs (e.g., collaboration on program design and/or joint funding calls) or joint research among energy RD&D organizations (e.g., joint research by federal and provincial research laboratories, the sharing of facilities and/or experts).
- Given the critical role that energy technology innovation plays in achieving economic and environmental goals, there is an opportunity for enhanced FPT collaboration on energy RD&D to contribute to several intergovernmental initiatives (e.g., the Council of the Federation's *Clean Energy Strategy* and the P*an-Canadian Framework on Clean Growth and Climate Change*) to initiate greater levels of collaboration.

- The federal government's participation in international clean energy initiatives (e.g., Mission Innovation and the Clean Energy Ministerial) presents further opportunities to establish international partnerships and capitalize on emerging global opportunities for Canadian clean energy technology companies and research organizations.

- Existing mechanisms, such as the EMMC's Energy Technology Working Group, will continue to be a critical forum for the sharing of information and to better target and coordinate energy technology projects to deliver on our shared energy technology goals and priorities going forward.