

CANADA'S NUCLEAR ENERGY SECTOR: WHERE TO FROM HERE?



FINAL REPORT
JANUARY 2014

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The Public Policy Forum is an independent, not-for-profit organization dedicated to improving the quality of government in Canada through enhanced dialogue among the public, private and voluntary sectors. The Forum's members, drawn from business, federal, provincial and territorial governments, the voluntary sector and organized labour, share a belief that an efficient and effective public service is important in ensuring Canada's competitiveness abroad and quality of life at home.

Established in 1987, the Forum has earned a reputation as a trusted, nonpartisan facilitator, capable of bringing together a wide range of stakeholders in productive dialogue. Its research program provides a neutral base to inform collective decision making. By promoting information sharing and greater links between governments and other sectors, the Forum helps ensure public policy in our country is dynamic, coordinated and responsive to future challenges and opportunities.

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ISBN: 978-1-927009-50-5

WITH THANKS TO OUR PROJECT SPONSORS



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ACKNOWLEDGEMENTS

On behalf of the Public Policy Forum and our partners, I wish to thank the individuals and organizations across Canada who participated in the dialogue on the future of Canada's nuclear energy sector. This report synthesizes the results of two workshop discussions (May 14 and 23, 2013) and an executive summit on September 4, 2013, with leaders from the private, public, academic, association, labour and diplomatic communities.

The Forum convened these sessions to strengthen the engagement of Canada's nuclear energy industries as they contemplate their future competitiveness and the role of innovation in improving the sector's performance. Using the comments and observations from these discussions, our goal is to help identify the critical issues that need to be addressed to make the sector more competitive and resilient. These conversations suggest that Canada's rich history in nuclear energy offers a significant advantage that could be effective in repositioning our country as a global leader in this area. This would require public support, along with much more collaboration between governments and the private sector. A more creative, innovative, and focused long-term strategic approach could allow the nuclear sector to move beyond its current position on the world stage.

I would like to acknowledge and thank the generous contributions of our project sponsors who provided us with guidance and the resources to advance this important policy dialogue: the Canadian Nuclear Association, the Canadian Nuclear Safety Commission, Ontario Power Generation, the Power Workers' Union and the Society of Energy Professionals.

Finally, a special thanks to my team at the Public Policy Forum, including Jill Baker, Vice President, for managing this project, James McLean, Project Lead, for writing this report and Dianne Gravel-Normand for her project assistance.



David Mitchell
President & CEO
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EXECUTIVE SUMMARY

The future of global nuclear power is uncertain. On the one hand, the U.S., Japan and Germany are just some of the nations that have recently announced nuclear power plant closures. On the other hand, growing economies such as China, Russia, India and Korea are considering building more plants. China is leading the pack with 30 reactors under construction — more than any other country, accounting for 40% of the world’s new reactor construction.

Strong drivers for nuclear energy include the need for long-term energy supplies and stable electricity prices, and for power sources with lower greenhouse gas (GHG) emissions. However, the barriers to the growth and expansion of nuclear energy are undeniable: significant upfront capital costs of building nuclear power plants and refurbishments, public concerns around safety and security, and competition from lower natural gas prices.

Within this context, the future of Canada’s nuclear energy sector is unclear. Backed by decades of research, experience, and innovation, the sector may be well-positioned to take advantage of opportunities around the world. However, the industry has experienced stagnation over the past decade, due to lagging domestic reactor technology and developments, making it more difficult for Canada to compete globally. With the second-largest uranium deposits in the world, a rich track record of leading-edge

reactor technology, a stable regulatory system, a network of universities and research centres to support research and development (R&D), and a well-educated workforce, Canada has a strong foundation upon which to develop its nuclear energy sector.

However, serious challenges have significantly impaired the industry’s ability to compete in domestic and international markets. Among the greatest is the need to attain and maintain the social licence to build nuclear reactors. Following Japan’s Fukushima Daiichi nuclear disaster in 2011, many industrialized countries have become reluctant to expand or maintain their nuclear energy facilities in the face of perceived public safety concerns. Additionally, high capital costs, an increasingly competitive marketplace, Canada’s historical reliance on CANDU reactors, and a lack of clarity on foreign investment rules, all place significant limitations on our nuclear energy sector.

To help fully understand how these opportunities and challenges could influence the sector’s long-term prospects, Canada’s Public Policy Forum convened experts from across the industry, from uranium mining and fuel production, through to waste management. Through our discussions, we have identified some key challenges and opportunities for the sector.

Challenges	Opportunities
High capital costs	Leverage Canada’s strong reputation to realize new opportunities abroad
Unclear foreign investment rules	Build upon Canada’s mining, production and export expertise
Historical CANDU monopoly situates the sector in a niche market	Enhance R&D capacity
Acquiring and maintaining social license	Strengthen Canada’s high-skilled nuclear and mining labour force
Few political champions	Replace higher carbon-emitting electricity (and support renewables)
	Continue to develop advanced fuels
	Improve engagement with, and education of, the public

For public and private sector leaders interested in realizing a revived position in global markets, it will be useful to review the ‘next steps’ proposed in our report. These suggestions emerged from our policy dialogue and include the following:

Next steps
Generate new sources of financial support for the sector
Pursue the Small Modular Reactor (SMR) opportunity
Work with environmental NGOs and the public through transparent engagement and education
Ensure that foreign buyers meet safety standards
Identify champions for nuclear energy
Strengthen national laboratory capabilities
Enhance engagement and transparency of regulatory regime

Throughout the workshop and summit discussions, experts discussed the need for a long-term sector strategy, which will be necessary for Canada’s nuclear sector to prosper. Developing such a strategy will require leadership from both the private and public sectors, and they will need to collaborate much more closely.

The future of the nuclear energy sector in Canada is dependent upon a number of key factors, including:

- Whether a business case can be made and new technologies can demonstrate long-term competitive economics;
- The continuing success of Canadian nuclear technologies and services in the global market;
- Continued improved safety regulations that foster public confidence;
- Successful implementation of longer-term management plans for radioactive materials; and,
- Future public policies that place a value on carbon, giving priority to lower GHG emitting electricity sources.

It appears that there is a potential strong future for the Canadian nuclear energy sector, and that it has an important role to play both domestically and abroad. However, it will be necessary to address the factors and challenges noted in our report in order for the opportunities to be realized.

INTRODUCTION

CANADIAN NUCLEAR ENERGY AT A CROSSROADS

Canada's nuclear energy sector is facing an uncertain future. For decades, nuclear energy drove innovation, helped us develop and export new products, spurred job growth and established Canada as a leader in advanced science and technology. However, over the past two decades, declining R&D funding, combined with an absence of new domestic nuclear power plant construction, has pushed the sector into a period of stagnation. Political and public support, once a source of strength and pride for the nuclear industry, has waned to such an extent that it is one of the greatest contributors to nuclear energy's decline. Recent decisions by political leaders, including moratoria on uranium mining in Quebec, Nova Scotia and B.C., Ontario's hesitancy to build new reactors, and the federal government's privatization of the reactor business of Atomic Energy Canada Limited (AECL), are seen by many as evidence that governments are now looking to redefine their roles in the sector.

Globally, the situation is very different. Driven by a desire to reduce carbon emissions, improve energy security and stabilize electricity prices, many countries now view nuclear energy as vital for diversifying their energy mix. Despite the 2011 Fukushima Daiichi accident and the natural gas boom, at no other time has there been such high demand for nuclear energy in so many growing markets. The World Nuclear Association reports there are 45 countries with nuclear reactors either planned or proposed. These countries range from sophisticated economies to developing nations.¹ In the foreseeable future, the main growth is expected to come in countries where the technology is already well established, such as China, India, South Korea, Brazil, Turkey, and the United Kingdom.

Canada, an established player in the nuclear energy market for more than 50 years, should be well positioned to provide the technologies, fuel and services that can help meet the world's energy requirements. However, our country also faces many foreign competitors who are innovative, well-organized and often have the full support of their national governments. Many countries are already ahead in sales and construction of new reactors. Competing in a dynamic international marketplace will require Canadian leaders to work together to identify key issues and determine how a more coordinated, multi-sector strategy could help address these challenges.

To help initiate this important policy discussion, Canada's Public Policy Forum launched *The Future of Canada's Nuclear Energy Sector* project to explore the potential opportunities and challenges that sector leaders will face over the next 20 to 25 years. In the spring of 2013, we convened experts from across the nuclear supply chain in workshops in Saskatoon and Toronto, to help identify the potential long-term outlook for the industry. Participants expressed frustration with the sector's inability to come together to move beyond the type of short-term planning that is driven by immediate political and financial considerations. But there was also optimism for Canada's ability to use nuclear energy to meet its own long-term electricity needs and to compete in the global market against other established players.

In September 2013, the Forum convened approximately 60 senior leaders at a summit in Ottawa to build on these findings and explore the strategic options stakeholders might consider to help enhance the sector both domestically and internationally. The summit featured leading experts from Canada, the United Kingdom, and the U.S., who provided broad perspectives on best practices, as well as the key opportunities, challenges and issues facing Canada's domestic nuclear energy sector.

In both the workshop discussions and at the executive summit, participants explored three central questions:

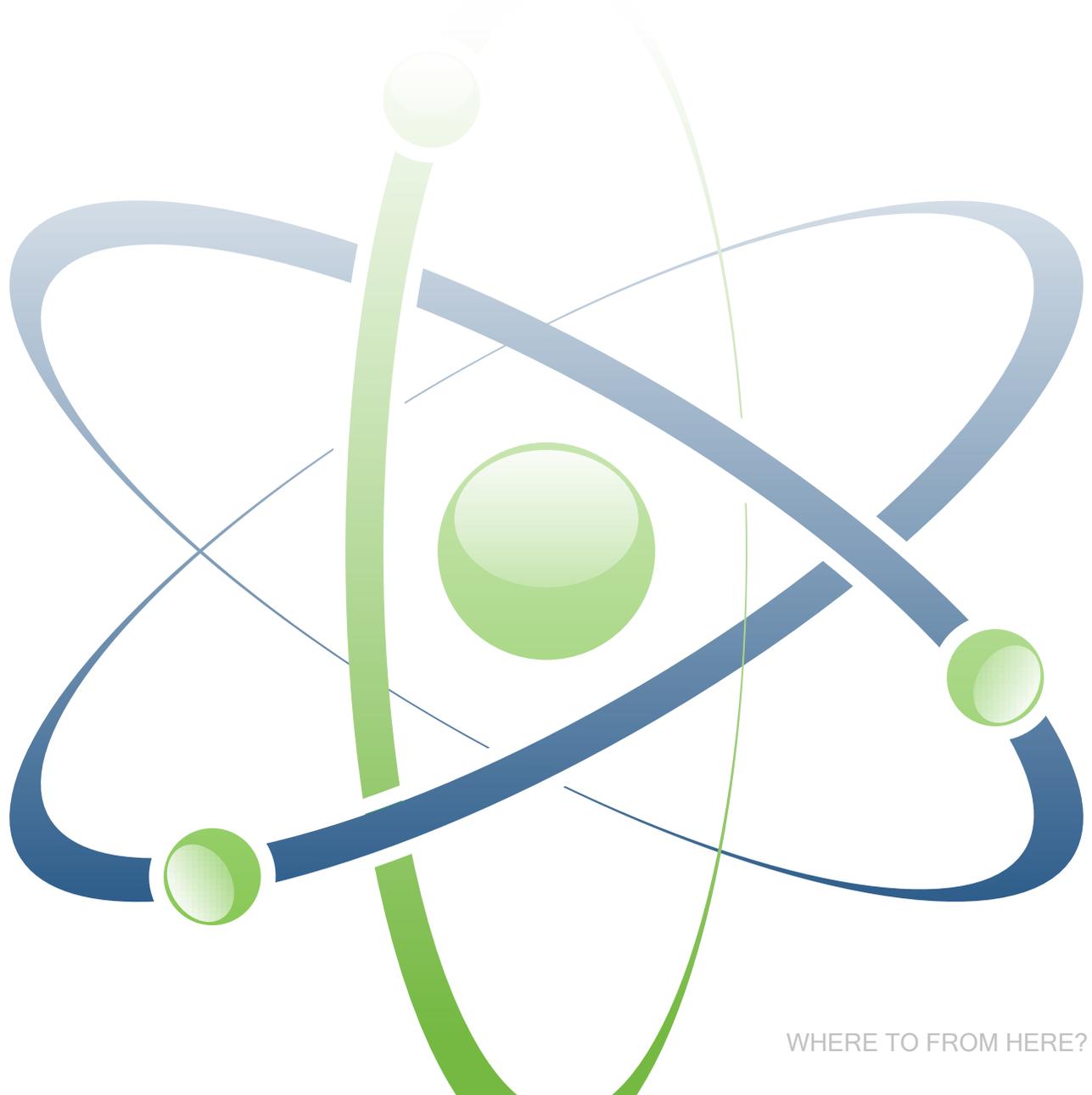
- What are Canada's key strengths and weaknesses as a nuclear energy country?
- Are there lessons that our country can learn, and potentially implement, from other countries involved in the nuclear energy sector?
- What approach, or strategy, might industry leaders take to rejuvenate the Canadian nuclear energy sector at home, and make it more competitive in international markets?

This report explores each of these questions within the current domestic and international context, and offers analysis on the key variables that decision-makers will need to consider if Canada's nuclear energy sector is to move forward.



Based on our discussions, it is clear that no medium or long-term plan or strategy currently exists that can help the sector achieve its potential or, for that matter, avert further decline. If leaders are to help mitigate problems and take advantage of opportunities, a more organized and collaborative approach will be necessary.

This report offers observations on how stakeholders might begin the process of developing a long-term strategy that sustains the sector and provides economic benefits for Canada. In the current economic environment, policy-makers and government leaders need informed opinions about the competitiveness of different energy options, including full system costs. To that end, this report concludes with observations about broader energy strategies and the potential role of nuclear energy.



CHALLENGES & OPPORTUNITIES

KEY ISSUES FACING CANADA'S NUCLEAR ENERGY SECTOR

Over the past decade, there has been an increased interest in nuclear energy, albeit at a slower pace after the 2011 Japan earthquake and tsunami. Led by an increasing demand for energy among developing economies, as well as by concerns over climate change, gas price fluctuations and the need for greater energy security, countries such as China, India, Russia and the United Kingdom all have plans to expand and upgrade their nuclear energy operations. Reports by the International Energy Agency (IEA)² and the OECD's Nuclear Energy Agency (NEA)³ call for nuclear to be part of the long-term global energy mix. However, these reports also recognize that the extent nuclear energy's future role depends on near-term policy decisions.

Canada's history and expertise in nuclear energy provides a sizeable advantage for benefiting from these opportunities. Our country is already a respected leader in uranium mining, reactor technology, plant manufacturing and operation, R&D, and environmental and safety standards and regulations. These strengths give us an edge to take advantage of opportunities outside our borders.

At the same time, there are significant challenges that, if left unresolved, will inhibit Canada's ability to remain a major player in domestic and international nuclear energy markets. Public concerns and perceptions over the safety of nuclear operations are at the forefront of these issues. The key economic challenge are the high upfront capital costs associated with new construction, especially when relatively cheap natural gas prices make it easier for governments to justify building gas power plants.

On the human capital side, many in the industry expressed concern that the lack of political will to invest in the sector could cause a drain of talented professionals, who are now seeking work in countries with stronger commitments to nuclear energy.

This section explores the interplay between some of the most important economic, environmental and social challenges and opportunities in areas vital to the future of Canada's nuclear energy sector.

Challenges

High capital costs

Of all the challenges facing the nuclear energy sector, without a doubt, the most significant is that associated with the capital costs. The upfront capital costs⁴ required to build new or refurbish existing power plants are enormous. In today's uncertain economic environment, it is difficult to make the political case that public funds should be committed to large, expensive energy projects that may not come online for nearly a decade. Typically, investment costs of nuclear power plants accounts for around 60% of total project lifecycle costs.⁵ Despite the fact that nuclear power provides relatively cheap electricity with low fuel and low operational costs, the upfront investment will continue to play a significant role in decisions to build new plants. According to some workshop participants, government and business leaders may need to explore new investment strategies that spread the financial risk and funding responsibilities among different stakeholders to overcome this obstacle.

Drivers of nuclear energy:

1. Climate change and the need for low-carbon electricity.
2. Increasing demand for electricity, particularly in developing countries.
3. The need for greater energy security.
4. The desire to achieve stability in electricity prices.

Constraints of nuclear energy:

1. High upfront capital costs and long timeframes to build nuclear power plants.
2. Low natural gas prices.
3. Public concern about safety, security and proliferation.

Unclear foreign investment rules

Furthermore, during the executive summit Canada's foreign investment rules were cited as an impediment to the sector's future growth. Organizations that constitute a "strategic asset" to our country may not be available for foreign purchase or takeover. The challenge is that "strategic asset" is not discussed in the *Canada Investment Act*, but its frequent mention by federal and provincial politicians has created confusion in Canada and abroad. As a result, stakeholders suggested that there is uncertainty around whether foreign entities will be able to purchase Canadian nuclear energy companies and assets, or even compete in the Canadian market. In the absence of a transparent investment framework, it is difficult for international organizations to expand or develop operations in our country that could generate greater economic growth.

Historical CANDU monopoly situates the sector in a niche market

The Canada Deuterium Uranium (CANDU) reactor has been the flagship of Canada's nuclear energy sector for almost 50 years. With units operating in Canada, China, India, Pakistan, Argentina, South Korea and Romania, CANDU is best known

for its relative simplicity, safety, and fuel cycle flexibility. Although CANDU allowed Canada to penetrate and expand in the global nuclear energy market, the monopoly it has had in the past, within the domestic market, has created limitations going forward.

The nuclear energy market shifted to light water reactors (LWR) approximately 30 years ago, when France started procuring LWR technology from the U.S. Since then, heavy water reactors (HWRs) have become a minority technology in the global market. Some participants in our workshops expressed concern that the CANDU monopoly, combined with the dominance of LWR technology, has placed our country's reactor production, and potentially the entire value chain, at risk. That said, there is a niche market for new CANDU design reactors, particularly due to their ability to burn LWR spent fuel. For example, Canada could look for opportunities to sell new CANDUs to countries with LWRs, allowing them to use their spent fuel.

Acquiring and maintaining social license

Among the greatest challenges facing stakeholders in the nuclear sector is the lack of social license for new nuclear power plants. This concern does not necessarily exist in



At the Public Policy Forum's nuclear energy summit in Ottawa, September 4, panelists discussed the key issues in the Canadian and international energy markets. L to R: David Mitchell, Tim Stone, Elizabeth Dowdeswell, Trevor Findlay, Richard Myers.



communities near power plants or uranium mines, but it is a broader perspective found within the general population. Concerns around safety, the storage of spent fuel, and high capital costs were noted as factors that have contributed to an absence of public support and political will to support large nuclear construction programs.

A key issue that the sector must address are the environmental concerns that the public has around nuclear waste. Fears that spent fuel could be mismanaged and potentially contaminate the environment are very common, and help contribute to the public's opposition to building new power plants.

Another challenge may be the historical inability to effectively communicate to Canadians about the safety track record and environmental benefits of nuclear energy. For example, nuclear energy emits very limited GHGs over a plant's entire lifecycle (50-70 years), providing countries with an alternative to higher-carbon emitting fuels such as oil, gas and coal. Until very recently, many environmental NGOs have traditionally opposed nuclear energy, raising concerns ranging from effects of power plants on water, to releases of radioactive materials into the environment, to the costs of new power plants. However, the recognition that energy requirements are only going to escalate substantially on a global scale, coupled with the need to provide this energy without increasing GHGs, has led some NGOs to change their position and support nuclear energy.

Fears over nuclear proliferation and plant meltdowns and accidents, like those at Chernobyl, Three Mile Island and Fukushima, are common. In part, this is due to the sector's inability to dispel myths and communicate the overall safety and benefits of nuclear energy to a wide audience. Unlike other nuclear energy producing countries, Canadian provinces do not generally include information about nuclear energy in school curriculums. An absence of information and knowledge can often lead to fear and suspicion.

Few political champions

An important element in any country with a successful nuclear energy program is the presence of leaders who champion the merits of nuclear energy, often at great political risk.

The ability to overcome the public's concerns has been made much more difficult due to limited political support. Media coverage of the Fukushima disaster generated an almost visceral reaction among the public and elected representatives towards nuclear energy. For example, a former Japanese Prime Minister has come out strongly against nuclear energy, saying "Japan should achieve zero nuclear plants and aim for a more sustainable society."⁶ In Germany and other parts of Europe, leaders have declared their intentions to phase out nuclear energy altogether.

By contrast, political leaders in the United Kingdom have been instrumental in educating the public and driving nuclear energy forward in their countries. In the U.K., the government was able to effectively move the nuclear energy file forward in that country due in part to the fact that both sides of the government were supportive of the proposal to do so. Viewing nuclear energy as an affordable and desirable long-term energy source, the government published a white paper and conducted numerous interviews to help educate the public on the value of nuclear in the country's energy mix. With the help of the government and other private sector champions, the "U.K. government is set to establish itself as the flagship country for a nuclear energy renaissance."⁷

Canada's approach has fallen in between, with political leaders campaigning neither against, nor in favour of, nuclear energy. Instead, government leaders have largely been silent on the future of nuclear energy in our country. This has done little to address public concerns or to clarify Canada's long-term interests in the sector for private sector leaders and investors. Recently, the Ontario government announced its decision to cancel scheduled new nuclear power plants at the Darlington power station, citing an abundance of electricity supply. However, restating their support for refurbishments of two existing power plants that will be necessary to provide a significant portion of the province's long-term baseload requirements.

Opportunities

Leverage Canada's strong reputation to realize new opportunities abroad

Despite its limitations, CANDU has helped sustain our country's nuclear energy sector for six decades, providing upwards of 60,000 direct and indirect job opportunities for engineers, scientists, labourers, miners and others.⁸ Since 1996, Canada has built or maintained 22 CANDU reactors for power generation, plus several research reactors. According to a 2010 report by the Canadian Manufacturers and Exporters (CME),⁹ as many as 10 plants will need to be refurbished over the next decade and could generate significant economic benefits. In a recent CME study, researchers found that building a nuclear power plant, for domestic or international, use could result in direct economic benefits and long-term jobs in the sector.¹⁰

While the majority of countries are adopting light water reactors, some booming economies like India and China continue to use heavy water reactors in general, and CANDU technologies in particular. This provides Canada with a niche market in countries that are seeking to expand their energy capacities. The successful completion of the Qinshan Phase III units in China, which use two CANDU 6 reactors, demonstrated Canada's ability to deliver reactors on time and on budget. This has helped reinforce CANDU's reputation among international customers. Today, with so many new reactors being planned worldwide, Canadian leaders are presented with an opportunity to reinvigorate Canada's domestic supply chain and create jobs and growth, if they are able to sell the new CANDU reactors abroad into expanding, and perhaps new, markets.

Build on Canada's mining, production and export expertise

The prospects for the uranium industry look promising. Over the next decade, the Cigar Lake and Midwest uranium mines in northern Saskatchewan are expected to reach full capacity. Exploration in Saskatchewan, Ontario, Labrador, Nova Scotia and Nunavut shows promise for uncovering new deposits. And Canada is quickly gaining access to emerging economies that have high demand for uranium. Each of these important developments provides opportunities to create and sustain high-skilled jobs, positioning Canada's nuclear industry to be even more innovative and competitive.

The federal and provincial governments' collaborative relationship with the uranium industry is an important advantage. With the completion of the Nuclear Cooperation Agreements and the Government of Saskatchewan's adoption of the Uranium Development Partnership (UDP) in 2009, Canada and Saskatchewan stand ready to expand multi-sector collaboration around mining and associated opportunities across the uranium mining sector.

Enhance R&D capacity

Nuclear experts suggested that the quality of Canada's future R&D capacity and infrastructure will help determine whether our country remains a significant nuclear energy player. Since the 1940s, the National Research Universal (NRU) reactor at Chalk River Laboratories has allowed AECL to conduct innovative research on new fuel sources and applications for CANDU reactors, such as developing recycled and recovered uranium fuel to power China's CANDU reactors. This valuable research facility has allowed scientists to conduct leading-edge research that has pioneered new safety and design models, tested advanced fuels, and developed more efficient nuclear power plants.

The NRU has acted as an important engine of medical discovery, providing benefits well beyond the nuclear energy sector. In the 1950s, Canadian researchers made a significant contribution to medical science when they discovered that the Chalk River reactor could be used to manufacture and export medical isotopes. Today, Canada's NRU provides approximately one-third of the global supply of medical radioisotopes, allowing nearly 27 million people worldwide to receive radiation therapy.¹¹

Chalk River is also home to another driver of scientific innovation, the Canadian Neutron Beam Centre (CNBC). The CNBC provides scientists, engineers and other professionals with a facility to conduct leading research in both physics and manufactured sciences. This centre has contributed to advances in areas as varied as the development of light metals, drug treatments, and room-temperature superconductors. "Improved safety and reliability, reduced costs, or opening of markets are a few of the benefits industrial clients have gained from employing neutron beams as part of their research programs. For example, safety and reliability can be enhanced when engineers know the amount of stress —

e.g., in pipes, or car and airplane parts — that is created by manufacturing processes. Direct stress measurement deep inside metallic industrial components is uniquely suited to neutron beams.”¹²

As a source of nuclear, medical and scientific innovation, Canada’s NRU has contributed significant economic and social benefits to our country. This facility is important not only to the nuclear energy sector, but for many other industries and businesses as well. However, as an aging facility that is in need of either replacement or refurbishment, governments and the private sector need to work together to carefully considering the business case for the reactor’s continued existence. Decision-makers exploring the NRU’s future role in our country should consider its economic and social benefits and whether it might be possible to leverage existing infrastructure to generate additional opportunities. If approached in a strategic way, this historic facility could continue to drive innovative research that produces further economic benefits.

Further, some workshop and summit participants strongly endorsed the idea to expand the capabilities of the labs to develop small modular reactor (SMR) technologies. For decades, SMRs have been highlighted as a potential option for reducing capital costs of new power supplies, and meeting energy demands in small and medium jurisdictions. Interest for these smaller, more portable designs among Canadian energy experts comes from their “greater simplicity of design, economy of mass production, and reduced siting costs.”¹³ These advantages suggest that SMRs may be well-suited for northern and remote communities.

Strengthen Canada’s high-skilled nuclear and mining labour

Nuclear energy is an important part of our national science, technology and innovation system, involving over 30 universities and six major research centres. This offers an opportunity to supply the growing global demand for knowledge, products, and services.

Today, many countries are concerned that they will not have enough skilled experts in the fields of engineering or Nuclear Knowledge Management (NKM), positions vital for ensuring that “design, licensing, procurement, construction, commissioning, operation, maintenance, refurbishment, and decommissioning of nuclear facilities [are] risk-informed and knowledge-driven.”¹⁴ Canada could

meet these needs by providing knowledge-based, technical services to train domestic and international professionals to operate more complex nuclear systems.

Replace higher carbon-emitting electricity (and supporting renewables)

As discussed, the emergence of relatively low natural gas prices has made gas plants an attractive short-term energy option for Canadian provinces seeking to expand or replace their existing electricity supplies. However, building new nuclear power plants, including SMRs, and refurbishing existing facilities, may also present governments with many long-term benefits: diversifying Canada’s energy mix, reducing carbon emissions, and providing long-term energy with relatively low operational costs and fuel prices. As governments develop lower-carbon energy strategies, predominantly through the construction of wind turbines and a shift away from coal-fired plants, many experts in the energy/electricity and environmental fields agree that nuclear energy’s long-term affordability and lower carbon footprint could make it a natural fit with this low-carbon energy strategy.

Developing Canada’s nuclear energy industry could allow certain regions to develop and use more renewable energy sources in other sectors. For example, electrification of the transportation sector will create a greater demand for electricity. Nuclear power plants could be a viable option that can respond to such growing needs, providing greater baseload to the distribution systems, which in turn would reduce use of higher carbon fuels such as gasoline. In the short-term, this appears to be an alternative available to only those provinces with existing nuclear power. However, with SMRs, this may become a viable longer-term option.

Continue to develop advanced fuels

One advantage that Canada’s HWRs have over many other designs is their ability to use different fuel sources, including spent fuel from LWRs. In 2010, China was able to extract uranium from spent fuel recovered from their light water reactors, and use it to power its HWR Qinshan Phase III CANDU reactor. This successful experiment demonstrated CANDU’s adaptability, providing countries with a cost-effective and environmentally-friendly energy option to “get more energy from imported uranium and reduce stocks of highly-radioactive used nuclear fuel at the same time.”¹⁵ As participants noted in the Toronto workshop, CANDU’s

ability to leverage existing uranium supplies provides fast-growing countries, such as China and India, with economic and environmental incentives to procure Canadian reactors and technologies. AECL's laboratories are another example of Canadian ingenuity working to develop advanced fuels.

Improve open and transparent public engagement

Improved engagement with Canadians about the long-term economic and environmental benefits of nuclear energy would make it much easier to foster the political will to build and refurbish power plants. Many Canadians continue to hold misconceptions about nuclear energy. The sector and governments have a responsibility to better communicate fact-based information regarding the safety, security and environmental considerations of nuclear energy.

It was suggested that an important aspect of informing the public will be for political leaders to act as “nuclear champions” and speak on behalf of the sector. However, stakeholders should not necessarily wait for governments to take the lead. Instead, sector representatives may want to consider how they can better use their resources and expertise to connect with Canadians and dispel the myths that may be limiting governments' ability to incorporate nuclear energy into their long-term green energy plans. A key component of this approach will be to engage younger Canadians, who often develop inaccurate perceptions of nuclear energy at a young age. This could be accomplished through roundtables and changes to school curriculums.

Finally, the Nuclear Waste Management Organization (NWMO) has recently established a long-term plan for the safe storage of spent fuel. The NWMO will work with communities and through its public engagement approach. Its focus on safety and environmental protection presents the sector with an opportunity to educate the public on the precautions leaders are taking to ensure the long-term storage of nuclear fuel is secure.



NEXT STEPS

RECOMMENDATIONS FROM THE EXPERTS

Throughout the course of our workshops and executive summit, experts provided many ideas to address challenges and allow the sector to act upon the opportunities. A summary of these suggestions is provided here.

Generate new sources of financial support for the sector

Countries seeking to expand their nuclear energy programs should consider public-private partnerships (P3s) that can help drive accelerated innovation agendas. By partnering on risk-sharing and funding, public and private sector leaders could better develop new technologies, products and services. There are a number of options, such as power purchase agreements (PPAs), loan guarantees and risk-sharing arrangements. These have seen greater success outside Canada, providing case studies that Canadian stakeholders may wish to explore. For example, the U.K.'s electricity market reform may provide some insights into how to secure the necessary investment for a low-carbon energy mix that includes nuclear.

Governments and others working in the nuclear energy sector should also consider opportunities to acquire funding from foreign lenders and investors. Pursuing this will require two things from Canadian leaders:

- **Build a strong business case for investment**

Industry and governments need to work together to build a strong business case for the entire sector, one that demonstrates value for investors. A key aspect of such a business case is the ability to look beyond the short-term and encourage investors to think through the long-term implications. All energy sectors are in tight competition for limited resources, both at the private and public levels. Investors need to consider both the short-term and long-term gains of investing in energy. Nuclear energy must make a strong argument, over the long-term, if it is to demonstrate its financial viability. This must include showing not just the direct, but also the indirect costs and benefits associated with the sector.

- **Clarify foreign investment rules**

The federal government may need to clarify foreign investment rules. According to participants at our Executive Summit, there is great interest among

foreign banks and mining firms to invest in Canada's uranium industry. Clarity around foreign investment could provide new opportunities for foreign capital to help create jobs in Saskatchewan, Nunavut and other mining jurisdictions. As discussed previously, clearer rules could also allow sector leaders to pursue foreign funding in other parts of the nuclear value chain.

Pursue the Small Modular Reactor (SMR) opportunity

While Canada has built its reputation in the nuclear sector on the CANDU technologies, workshop and summit participants heralded the future opportunities associated with SMRs. Given government interest and support for the nuclear energy sector in Ontario, Saskatchewan and a few other provinces, Canadian governments could explore the long-term potential of SMRs to provide a sustainable source of baseload electricity and jobs to rural and northern populations. A recent industry report by Strategic Insights identified the advantages that SMRs have over larger reactors in the Canadian context, including:

- Smaller size for greater portability;
- Effective energy output for smaller communities;
- Shorter construction schedule;
- Greater cost and schedule certainty; and,
- Increased security and efficiency.

Bringing SMRs to Canada will require stakeholders to take steps to open the Canadian market. For example, business leaders may need to take some risk by investing time and resources into developing a practical SMR design for northern communities. Governments would also need to work closely with private sector leaders and regulators to ensure safe transport of SMR fuel and spent fuel across Canada. All stakeholders would need to explain to Canadians the potential benefits, costs and risks associated with SMRs, in comparison with other alternatives and the status quo.

Work with environmental NGOs and the public through transparent engagement and education

One approach to address the concerns of the anti-nuclear movement is to engage and work with environmental NGO leaders, to foster trust and a less-polarized dialogue. Such dialogues will be difficult and will take time. According to workshop participants, this approach was successful in the forestry sector; however, it required much time and effort

over two decades. It was noted that in order for nuclear to gain social licence and broader acceptance, groups outside of the sector will need to initiate such discussions. The start of this dialogue can be seen in the U.S., with recent efforts by some prominent environmental NGO leaders, who had once been opposed to nuclear. However, with a new understanding of how the technology and science has evolved, in concert with the need to increase low-carbon electricity around the world, these experts are now embracing nuclear energy, and promoting as an important component of any energy strategy.

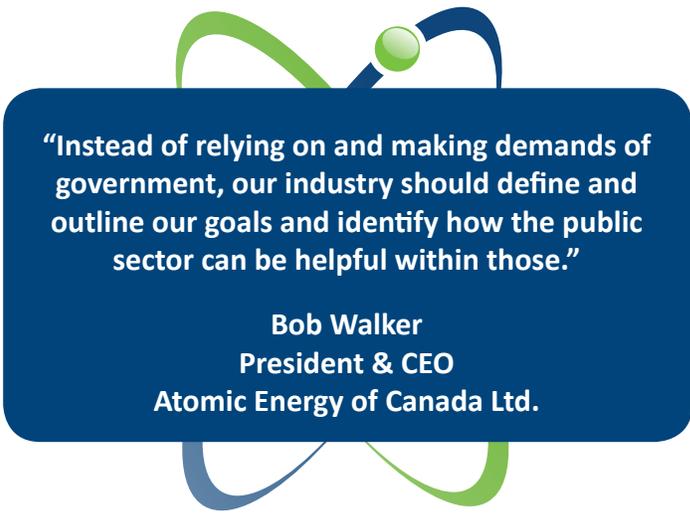
Governments and industry leaders may wish to provide more opportunities for the public to learn about the potential role of nuclear energy in reducing GHGs. Open and transparent dialogue regarding the full costs and benefits of nuclear energy, including the externalities such as carbon emissions, could be helpful in a better understanding of the sector.

The often passionate public reaction against nuclear power is a significant challenge. With extensive media coverage of the Fukushima Daiichi disaster in Japan, bad memories of Chernobyl and Three Mile Island, and common misunderstandings around radiation, the public is often reluctant to embrace plant construction or to view nuclear as a viable energy source. A key to success in both the U.K. and France is the inclusion of information about nuclear energy in school curriculums. By educating students about nuclear energy, both countries have been successful in helping to dispel myths around safety and security that persist in many other countries. For governments seeking to engage their citizens in a more enlightened discussion on nuclear energy, these countries have shown that school education could be a useful first step. Given the diverse energy sources in Canada, school boards would be wise to develop science programs that explore all types of energy; and allow for students to be exposed to and learn about the positive and negative aspects of all energy types.

Ensure that foreign buyers meet safety and security standards

During the Executive Summit, participants noted that governments that purchase French nuclear goods or services are obliged by France to follow a high standard of nuclear safety and operation capabilities, especially on environmental issues. The French government, in

collaboration with private sector leaders, works with client countries to identify areas that need to be improved before any deal is approved. Participants suggested that Canada and the global nuclear community could build upon this approach and develop a set of 'best practices' which could be adopted by all countries with nuclear power plants and capabilities



“Instead of relying on and making demands of government, our industry should define and outline our goals and identify how the public sector can be helpful within those.”

**Bob Walker
President & CEO
Atomic Energy of Canada Ltd.**

Identify champions for nuclear energy

In 2012, Canada signed nuclear co-operation agreements with both India and China, providing miners and exporters in Saskatchewan and, potentially, Quebec and Nunavut, with greater access to the world's two fastest-growing markets. Part of the success of these agreements stems from the political support they enjoyed at the highest political office. On an official visit to China in February 2012, Prime Minister Stephen Harper and Chinese Premier Wen Jiabao agreed in principle to enhance bilateral nuclear trade, setting up a year of negotiations that eventually led to the Canada-China Nuclear Co-operation Agreement.¹⁶ On a similar trade mission to India in fall 2012, Prime Ministers Harper and Manmohan Singh agreed to open the Indian nuclear market to more Canadian uranium exports through the Canada-India Nuclear Cooperation Agreement. These agreements demonstrate clearly how crucial the presence of senior political can be for creating and realizing new opportunities. Industry leaders should consider whether and how they can build on these successes to encourage other agreements with emerging nuclear energy markets.

Strengthen national laboratory capabilities

The NRU's role in facilitating nuclear energy research, development and innovation should be enhanced. For nearly seven decades, the NRU has been a wellspring of discovery and knowledge, allowing Canadian researchers to develop new nuclear energy products, fuels, services and regulations. This R&D capability has yielded economic benefits as well as improved plant efficiency and safety standards. As one workshop participant commented, without a strong R&D capacity, led by the NRU, it will be very difficult to maintain a strong nuclear energy sector.^{17 c}

Elected officials, industry leaders and researchers should weigh the benefits that a national nuclear research laboratory provides for our economy and competitiveness, with the financial implications of maintaining its operation. Consideration should be given to whether costs can be managed and how the R&D potential can be further leveraged to provide enhanced benefits for the nuclear energy sector and other industries.

Enhance engagement and transparency of regulatory regime

In both the workshop and executive level discussions, participants from all sectors lauded Canada's regulatory agency for working with private and academic leaders to make regulation more transparent and understandable. A key success is the dialogue among industry leaders, governments and regulators that ensures a solid understanding of each other's challenges. Recent changes to the federal environmental assessment and regulatory process for new nuclear projects, provides a good example of private and public sectors working together to successfully bring about change. Public confidence depends on a strong, credible regulator, and it is incumbent on both the industry and regulators that safety is observed at the highest levels.



At the Executive Summit in Ottawa, September 4, Michael Binder, President and CEO of the Canadian Nuclear Safety Commission (second from left) explained how his organization works closely with industry leaders to ensure that Canada's regulatory framework is able to accommodate evolving technologies and demands.

PLANNING FOR THE FUTURE

A LONG-TERM SECTOR STRATEGY

As stakeholders consider whether and how to implement the potential next steps outlined in the previous section, it will be useful to identify some of the main goals the sector is trying to achieve. Each of the next steps could be implemented in a piecemeal fashion. However, a coherent strategy would help organize the sector so it can achieve its goals. Such an approach would also provide a longer-term “road map” to guide leaders as they make decisions that will affect the sector and the Canadian economy well into the future.

A good strategy should achieve a number of high-level goals:

- Uniting organizations and leaders across the value chain in a common purpose;
- Giving the sector “one voice” and therefore more influence in dealing with governments and foreign customers;
- Helping industries and organizations throughout the sector work together and, potentially, gain access to new markets; and,
- Demonstrating to foreign creditors and investors that Canada has a serious, long-term business plan for the sector.

To provide a starting point for development of a sector strategy, workshop participants provided ideas that have resulted in the proposed sector vision on the following page. The intent of putting forward this vision is to prompt further discussion amongst the sector experts and leaders themselves.

Lessons for Canada from the U.K. for developing a long-term nuclear energy strategy:

1. Improve and always maintain public acceptability
2. Generate and maintain cross-party political support (which may only occur during an energy crisis)
3. The sector needs to find a better way to communicate to government and the public, principally through clear, easily understandable facts.
4. Determine a desired outcome, and build a strategy to reach it.

Tim Stone CBE, former Chair, Office for Nuclear Development, & former Senior Advisor to Secretary of State, Dept. of Energy & Climate Change, UK

A sector vision

Workshop participants were asked to conceptualize a vision for Canada’s nuclear energy sector. The purpose was to identify the characteristics of a future scenario to encourage leaders to think about how the sector could change over the next 20 years, and the steps they can take to help bring this evolution about. The ideas from the workshops led to two vision statements, one domestic, and the other global:

Nuclear energy plays an essential role in meeting domestic energy needs, helping to drive economic growth, job creation and innovation

For Canada’s nuclear energy sector to be thriving two decades from now, participants suggested that a greater use of nuclear power facilities, products and services will be required to meet domestic energy needs. More specifically, more nuclear power plants will need to be in operation in large markets, such as Ontario and Quebec, and SMRs and very small modular reactors (vSMRs) will need to have been adopted to provide energy to remote communities in northern Saskatchewan and, potentially, to help power Alberta’s oil sands.

Canada’s nuclear energy sector is a strong international competitor, producing innovative technologies, fuels and services to both emerging and existing markets

With a stronger domestic presence, participants suggested that Canada’s nuclear energy sector could be more competitive internationally. For example, Canada could be exporting more CANDU mixed oxide fuel (MOX) reactors to the U.K.; establishing a presence within the U.S. market; dramatically increasing the reactors, fuel and services sold to China and other emerging economies; and continuing to promote CANDU.

Key roles and responsibilities

Workshop and executive summit participants agreed that a key component of any potential long-term strategy will be to clearly identify the role that each stakeholder should play in moving the sector forward. Collaboration among all stakeholders will be essential. But it will also be important to recognize that business, government, labour and academic leaders all possess unique strengths, including expertise, resources and influence, which could be better employed for the betterment of the entire sector. Workshop and executive summit participants offered the following observations on the roles for each stakeholder group.

“We need to educate and motivate political leaders, but also the business community. The private sector is well engaged on the international front but less on issues within Canada, and Ontario specifically. Engaging the private sector and attracting investment is where the UK has been effective, and is an excellent case study for our country.”

Tom Mitchell
President & CEO
Ontario Power Generation

Private Sector

According to workshop participants, the private sector could play a leadership role in driving renewal and forward momentum in Canada’s nuclear energy sector. More specifically, business leaders could help governments, financial institutions and the public understand the sector’s potential by building a solid business case for continued growth and expansion. They may also assist government by identifying the necessary conditions that will help stimulate innovation, mobilize investment, enhance market access, and further develop a talented, skilled work force.

The private sector cannot wait for government to act first. Instead, participants noted that business leaders should provide the business cases that will convince governments to approve new plant construction, adjust regulatory

policies, and commit more resources. In the absence of this type of sector initiative, participants suggested that it is unlikely that governments and others will be able to fully appreciate the potential economic benefits that Canadian industry leaders could bring to the sector.

“We have to make sure that we are flexible, and can understand and anticipate new technologies and approaches. We have to be able to maintain our staff and competencies internally. We have to engage with international agencies and events to better understand our own sector. Doing all of these things will help ensure that we are not a barrier to innovation.”

Michael Binder
President & CEO
Canadian Nuclear Safety Commission

Governments

Within the energy sector, there is a common perception that expanding exports will depend on whether Canada is able to demonstrate to the world that it champions its own technology and services at home. Canada’s main international competitors – France, Russia, South Korea and the United States – all procure their domestic products and services. According to some workshop participants, a country’s willingness to purchase from its own industries demonstrates confidence and is often a prerequisite for other nations looking to make purchases.

Over the next decade, there are a number of opportunities where Canada could bolster its industries by making greater investments in nuclear energy. Recent refurbishments at the Darlington and Bruce power plants have both been successful and relatively cost-effective, helping to show that our country’s nuclear energy sector can manage complex projects. According to some participants, demonstrating confidence in our domestic nuclear industry may require the construction of large and small nuclear power plants. Recent announcements by the Ontario Government to move ahead with the refurbishments of existing nuclear power plants in the province demonstrate this support. Furthermore, looking to the long term, participants

suggested that, as a consumer of nuclear reactors and fuel, governments need to work closely with industry leaders to make clear their intentions for meeting electricity demands, beyond the short term.

Of course, a key function for government will be to create regulation that ensures that nuclear energy remains a safe and effective energy option. As technologies and needs change, participants suggested that government regulators will need to continue working with business leaders to eliminate duplication and other unnecessary regulation. The goal, according to some participants, should be to create a regulatory framework that guarantees safety, transparency, and energy efficiency, without limiting innovation or expansion opportunities.

“We need to realize that this is a global project. It requires a long-term view and we don’t do that well in government or industry. It’s a process about having independent facts, trust and public engagement. The issues are not so much about technical change as they are about understanding public attitudes and behaviours.”

Elizabeth Dowdeswell
Founding President & CEO
Nuclear Waste Management Organization

In creating new regulations, governments may also need to be flexible and responsive to evolving expectations. For example, there is a need for greater alignment around liability. The federal government is currently updating the *Nuclear Liability and Compensation Act*. The proposed legislation will increase the amount of compensation available to address civil nuclear damage from \$75 million to \$1 billion; broaden the number of categories for which compensation may be sought; and improve the procedures for delivering compensation.¹⁸

Further, government’s role in helping to open new markets for the sector is invaluable. As was demonstrated by the federal government in the 2012 Nuclear Co-operation Agreements, when political and public sector leaders take an active approach in campaigning on behalf of the sector, new opportunities emerge. In the years ahead, governments could seek to identify how they can build off

of these successes by using their international influence to create new economic opportunities for the sector.

As discussed, governments will also be essential for ensuring investment in the domestic market, by ensuring that investment rules are clear and fair, and provide foreign organizations with incentives to invest in Canada.

The public sector will also play an instrumental role in encouraging and funding innovation. As part of a long-term strategy, government leaders may need to work closely with industry leaders to determine where public funds and resources can make the greatest impact.

Additionally, given government’s neutral role, the public service may be ideally suited to help educate the public on the merits and safety of nuclear energy. Through the media and, perhaps, the classroom, government could help dispel some of the myths believed by many Canadians that have helped to limit the nuclear energy sector in our country.

Post-secondary institutions

Greater engagement is required from all levels of the education system, from teaching children about nuclear energy, to producing nuclear scientists and engineers through university and technical education programs, to supporting research institutions that develop innovations that can make Canada internationally competitive. Universities, colleges and trade schools will be essential in developing the skills and knowledge required to drive Canada’s nuclear energy sector forward. In the future, post-secondary institutions may need to work more closely with private and public leaders to determine the types of courses and training required, to ensure graduates have the skills and expertise that can keep Canada’s nuclear energy sector innovative and competitive.

Global governance

During the Executive Summit, participants suggested that Canadian stakeholders from all sectors will need work with their foreign counterparts to strengthen the international institutions and regimes governing nuclear energy. For example, one participant noted that leaders need to harmonize different safety and security standards in order to ensure that everyone is playing by the same rules. This could potentially be achieved through a United Nations Convention on Nuclear Safety.

There is also a need to develop a globally-acceptable “code of conduct” for the sale and installation of nuclear reactors. As discussed previously, the government of France works with its industry to ensure that customer nations have the necessary training, safeguards and regulatory standards that will ensure the safe, effective functioning of French reactors. This type of government-industry partnership should be encouraged and adopted by other jurisdictions, potentially through international directives.

Many participants agreed that the International Atomic Energy Agency (IAEA) could play a greater role in regulatory enforcement and education and awareness. As a credible, trusted organization, the IAEA could be instrumental in

“We need to have confidence in the nuclear enterprise; it’s in every country’s interest to improve their own system, as well as the international regime that governs global nuclear energy.”

Trevor Findlay, Professor,
Carleton University and Harvard University

providing people around the world with the data and information they need to make informed decisions.



Cassie Doyle, Consul General of Canada (Northern California), at nuclear summit September 4, explains why nuclear energy could continue to remain an important part of Canada’s nuclear energy mix.

CONCLUSION

Canada's Public Policy Forum has been engaging experts and stakeholders across the nuclear energy value chain to better understand the importance of this sector. Through two workshop discussions, in Saskatoon and Toronto, and an executive-level meeting in Ottawa, we discovered that this sector plays a key role in driving innovation, generating jobs, and providing many Canadians with relatively low electricity rates. It also became clear that, while Canada has developed a first class reputation and nuclear infrastructure over the past seven decades, waning government support, and the lack of a coherent strategy to unite the sector, has meant that Canadian firms do not enjoy the same advantages in international markets as they once did.

What international lessons could help inform a Canadian energy strategy?

- The changing use of electricity in society, such as the development and usage of electrical vehicles.
- The need to develop alliances across industries, sectors and fields. Alliances could help build trust and independent validation around nuclear energy, two things that will be crucial for the sector's long-term sustainability.

Cassie Doyle, Consul General of Canada in the United States of America (Northern California, Nevada, Hawaii)

In order to spur a broader discussion on the role of nuclear energy in Canada's economy and energy mix, we sought to explore how this sector might evolve over the next two decades. This report identifies many of the key economic, environmental and social challenges that currently face the Canadian nuclear sector. These issues are complex and have contributed to the slow decline of the sector. There was widespread agreement in our Saskatoon, Toronto and Ottawa discussions that overcoming these challenges will require strong leadership from all stakeholders as well as multi-sector collaboration.

In our discussions, we also identified a number of opportunities that Canadian leaders can consider and act upon. This report explores each opportunity in detail and proposes a series of potential next steps that could help guide decision-makers.

Finally, many workshop participants made it clear that the sector could benefit from a more collaborative approach, working together to develop a long-term sectoral strategy. This report identifies a potential vision, contextual considerations and roles that could be considered in the development of this prospective strategy.

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Saskatoon Workshop

May 14th, 2013

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Jean LeClair
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Toronto Workshop

May 23th, 2013

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Strategic Insights

APPENDIX A PARTICIPANT LISTS

Ottawa Executive Summit

September 4, 2013

Moderated by:

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APPENDIX B EXPERT OBSERVATIONS FROM THE U.S.

David Hill, Ph.D. Deputy Director Emeritus, Idaho National Laboratory

Any country that has developed or implemented a nuclear energy program must have a federal nuclear research laboratory.

The reasoning behind this assertion is multifold. First of all, the dual-use nature of nuclear material and the hazards of nuclear energy-related activities mean that there is an inherent national interest in having a trained cadre of experts that can advise government, providing the technical basis to nuclear energy and safety and security policies. Secondly, a nuclear country must have the means to regulate nuclear activities and provide for the safety and security of its citizens. Thirdly, like all technologies, nuclear technologies do not stand still; for a country not to seek to continue to develop nuclear technology is tantamount to ceding control to those foreign interests who are continuing to invest. Fourthly, for countries whose energy portfolio contains nuclear energy, the ultimate economic viability is called into question without active research around issues such as aging of components. In sum, once a country adopts nuclear technology, it will need to nurture the critical capabilities indefinitely.

The United Kingdom serves as a case in point regarding the requirement for a national nuclear lab. In the 1980s, arguing that nuclear energy was an industrial concern, the U.K. government dismantled its research complex, commercialized the S&T elements and stopped funding nuclear energy research. The response was the closing of academic departments and, correspondingly, the supply of nuclear-trained professionals and trades vanished. By the 2000s, the U.K. government realized that it did not have the means to support operating reactors, support the construction and operation of new reactors, or execute programs that address nuclear liabilities. Therefore, they set out to recreate a nuclear ecosystem with an innovation agenda that contained support for academic programs and the creation of a National Nuclear Laboratory at Sellafield. A very similar story could be told of the U.S. and its Idaho National Laboratory (INL). Neither the U.K. nor the U.S. is a perfect analogue to Canada, but the lessons are clear.

Consideration of the inherent national interests described above leads to the realization that such a capability must be under federal control. That is not say that it should not do work for industrial customers on a commercial basis. In fact, the opposite is true. The investment in nuclear research capability (research reactors, hot cells etc.) easily reaches billions of dollars, and cannot be replicated at multiple locations in any country (or even a region). The capabilities

must be leveraged by making them available under the right financial model for both industrially funded and academic nuclear research and development.

The U.S. has implemented a user facility model for executing nuclear research. Idaho National Laboratory is designated as the U.S.'s National Nuclear Laboratory primarily because of a large, irreplaceable, infrastructure which includes the Advanced Test Reactor, Materials and Fuels Complex, and other facilities. The user facility program enables access to these facilities for the best ideas through federal funding in a peer-reviewed, competitive, proposal approach. Many nuclear facilities around the U.S., at labs, universities and in industry, have volunteered for inclusion in this approach. Even non-U.S. participants have joined the scheme.

The benefits of a nuclear research laboratory can be seen in other applied research areas, especially those with an inherent government role. For example, INL conducts research into wireless communication, the electrical grid, and cyber security as it applies to large infrastructure, batteries, biomass, energy systems, critical materials and many other domains. All of these programs rely on the unique attributes of INL, and take advantage of technologies developed for nuclear application (fuel cycle chemistry), capabilities developed during nuclear-related experimentation (diagnostics and instrumentation) or unique infrastructure (a legacy isolatable electrical grid which can be used for experimentation without risking public power supplies). It is particularly in the area of applying an institution's expertise to non-traditional problems that the U.S. Government Owned Contractor Operated (GOCO) model is effective. The contractor is incentivized to find other sources of funding than the sponsoring agency and uses entrepreneurial talents to find other problem sets where institutional capabilities can be applied.

Underpinning all of these arguments is probably the strongest one of all: human capital. A national research enterprise that develops the human capital a country needs to maintain its nuclear identity, solve problems, create new products, and provide an exciting and demanding outlet for the innovative capabilities of researchers, young and old, is essential to the health and sustainability of the nuclear enterprise.

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CANADA'S NUCLEAR ENERGY SECTOR: WHERE TO FROM HERE?



CANADA'S
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