



HOUSE OF COMMONS  
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CANADA

# **THE NUCLEAR SECTOR AT A CROSSROADS: FOSTERING INNOVATION AND ENERGY SECURITY FOR CANADA AND THE WORLD**

## **Report of the Standing Committee on Natural Resources**

**James Maloney  
Chair**

**JUNE 2017**

**42<sup>nd</sup> PARLIAMENT, 1<sup>st</sup> SESSION**

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# **THE STANDING COMMITTEE ON NATURAL RESOURCES**

has the honour to present its

## **FIFTH REPORT**

Pursuant to its mandate under Standing Order 108(2), the Committee has studied The Future of Canada's Oil and Gas, Mining and Nuclear Sectors: Innovation, Sustainable Solutions and Economic Opportunities and has agreed to report the following:





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# THE NUCLEAR SECTOR AT A CROSSROADS: FOSTERING INNOVATION AND ENERGY SECURITY FOR CANADA AND THE WORLD

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## INTRODUCTION

Canadian leadership in the nuclear sector dates back to the Second World War. Canada's Nobel-Prize winning Chalk River laboratories have been at the forefront of nuclear research and development (R&D) and innovation for over 60 years. The first sustained criticality outside of the United States occurred at Chalk River in 1945. Moreover, the laboratories are the birthplace of the world-renowned Candu reactor, and the site of Canada's leading research reactor, the National Research Universal (NRU), which has been used for a wide range of research, medical and industrial applications since 1957. Chalk River also provided the research and facilities for breakthroughs in the application of medical isotopes, including cobalt-60, used for cancer therapy.<sup>1</sup>

Canada's nuclear industry contributes more than \$6 billion every year to the national gross domestic product (GDP), and employs 30,000 Canadians directly and another 30,000 indirectly. It covers the full range of nuclear expertise, from R&D to uranium mining and fuel fabrication, reactor design, plant construction, maintenance, waste management and decommissioning. In addition to the Chalk River laboratories, there are several research reactors and facilities across Canada, contributing to advancements in energy, physics, engineering, medicine, chemistry and biology, among other fields. Canada is also the world's second largest uranium producer, with one of the world's richest uranium ores located in Saskatchewan. Canadian reactors rely exclusively on domestic uranium mined in northern Saskatchewan and processed in Ontario, and 95% of Saskatchewan's uranium is exported to support nuclear power generation in other countries. Finally, Canada's Candu reactor technology and expertise are deployed worldwide, including 19 operating Candu reactors at home (accounting for approximately 16% of the national electricity mix) and 30 operating reactors in other countries.<sup>2</sup>

The Canadian nuclear sector has undergone several major changes over the past few years, namely the restructuring of Atomic Energy of Canada Limited, including the sale of the corporation's Candu division and the creation of the Canadian National Laboratories; the decision to permanently shut down the NRU by 2018; and the initiation of a number of plans and proposals with implications for Canada's economy, energy security, environment, public health, international leadership and exports. In light of these changes – and as part of its broader study entitled *The Future of Canada's Oil and Gas*,

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1 Standing Committee on Natural Resources (RNNR), [Evidence](#), 1<sup>st</sup> Session, 42<sup>nd</sup> Parliament, 17 November 2016 (Richard Sexton, Acting Chief Transition Officer, Atomic Energy of Canada Limited); [Evidence](#), 1<sup>st</sup> Session, 42<sup>nd</sup> Parliament, 22 November 2016 (Jerry Hopwood, President, University Network of Excellence in Nuclear Engineering).

2 RNNR, [Evidence](#), 1<sup>st</sup> Session, 42<sup>nd</sup> Parliament, 15 November 2016 (Niall O'Dea, Director General, Electricity Resources Branch, Energy Sector, Natural Resources Canada); [Evidence](#) (Sexton, AECL).

*Mining and Nuclear Sectors: Innovation, Sustainable Solutions and Economic Opportunities* – the Standing Committee on Natural Resources (“the Committee”) invited a wide range of experts from government, industry and civil society in order to investigate the overall state of the Canadian nuclear industry.

In this report, the Committee’s findings are organized according to four themes: 1) considerations regarding the governance, safety and waste management of nuclear material and/or facilities in Canada; 2) the state of the nuclear energy industry in Canada and abroad; 3) the future of Canadian nuclear R&D; and 4) recommendations to the Government of Canada. The Committee is pleased to present its report, which concludes its study on the nuclear sector.

## **GOVERNANCE, SAFETY AND WASTE MANAGEMENT**

The regulation of nuclear material and activities falls under the jurisdiction of the federal government, while the decision to invest in nuclear power generation is determined by the provinces.<sup>3</sup> The following two organizations report to the Parliament of Canada through the Minister of Natural Resources:

- The Canadian Nuclear Safety Commission (CNSC): Established under the *Nuclear Safety and Control Act*, the CNSC is an independent, quasi-judicial administrative tribunal that regulates all nuclear products and activities in Canada, including uranium mining, fuel fabrication, power generation, the production and use of medical isotopes, site decommissioning and remediation, and nuclear waste management. As an agent of the Crown, the Commission also has a responsibility to meet the duty to consult, and where appropriate, accommodate Indigenous peoples.<sup>4</sup>
- Atomic Energy of Canada Limited (AECL): Established in 1952, AECL is a federal Crown corporation with a twofold mandate: 1) enabling nuclear science and technology to support the federal government and industry; and 2) managing Canada’s radioactive waste and decommissioning liabilities.<sup>5</sup>

The following sections discuss three topics related to governance and safety in Canada’s nuclear sector, based on evidence from the witnesses: 1) the recent restructuring of AECL; 2) the Environment Commissioner’s 2016 audit of the CNSC; and 3) the main plans and proposals addressing nuclear waste management and site decommissioning in Canada.

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3 RNNR, [Evidence](#) (O’Dea, NRCan).

4 RNNR, [Evidence](#), 1<sup>st</sup> Session, 42<sup>nd</sup> Parliament, 17 November 2016 (Michael M. Binder, President and Chief Executive Officer, Canadian Nuclear Safety Commission).

5 RNNR, [Evidence](#) (Sexton, AECL).

## A. The Restructuring of Atomic Energy of Canada Limited

Until 2011, AECL operated through three business divisions: the Candu Reactor Division, the Research and Technology Division, and the Liability Management Unit.<sup>6</sup> In June 2011, following an independent review process of various AECL management and restructuring scenarios, the Government of Canada announced the sale of AECL's commercial division to Candu Energy Inc., a subsidiary of the Montreal-based engineering firm SNC-Lavalin. Furthermore, a new organization known as the Canadian Nuclear Laboratories (CNL) was created to manage AECL's nuclear laboratories under a government-owned, contractor-operated (GoCo) model.<sup>7</sup> Mark Lesinski of the CNL described the laboratories' ownership structure as follows:

AECL retains ownership of the sites, facilities, assets, intellectual property, and decommissioning liabilities and oversees the contract and CNL's performance. Canadian Nuclear Laboratories is owned and operated by the Canadian National Energy Alliance, CNEA, whose shareholders include CH2M, Fluor, Atkins, and SNC-Lavalin Inc., the world's leading engineering and technology companies. Together the members of this consortium provide experience in the areas of site management, operations, decommissioning, and waste management.<sup>8</sup>

Mr. Lesinski added that the consortium is focused on a threefold mission: 1) reducing the legacy liabilities held by AECL; 2) delivering expertise in nuclear science and technology to support federal and commercial missions; and 3) rebuilding CNL's facilities and supporting infrastructure.<sup>9</sup>

As Niall O'Dea of Natural Resources Canada (NRCan) explained, the decision to restructure AECL was taken with the intention of “[allowing] Canada to fully compete in a global nuclear market, and so the [CNL] could benefit from [the] alternative [GoCo] management model,” which had been successfully implemented in other countries. According to Mr. O'Dea, the sale of the Candu business was made “to control costs to government related to the activities of that reactor division – so it allowed the private sector to manage those risks – while also maximizing the return on the government's investments in nuclear energy through the royalty structure that is in place.” With regards to the research division, or the CNL, Mr. O'Dea stated that the GoCo model is intended to “introduce private sector rigour and efficiencies to better position the laboratories to support [Canada's] nuclear industry and to create conditions for the sector to succeed and seize new opportunities in the medium to long term.”<sup>10</sup>

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6 The Candu Reactor Division managed nuclear reactor construction/servicing projects, marketing/business development, and the commercialization of AECL's ACR-1000 (a Generation III+ heavy water nuclear reactor); the Research and Technology Division conducted nuclear and industrial research, produced medical isotopes and managed nuclear waste; and the Liability Management Unit managed waste and decommissioning liabilities on behalf of the Government of Canada.

7 RNNR, [Evidence](#) (O'Dea, NRCan).

8 RNNR, [Evidence](#), 1<sup>st</sup> Session, 42<sup>nd</sup> Parliament, 13 December 2016 (Mark Lesinski, President and Chief Executive Officer, Canadian Nuclear Laboratories).

9 RNNR, [Evidence](#) (Lesinski, CNL).

10 RNNR, [Evidence](#) (O'Dea, NRCan).

In their discussion of the sector's new governance structure, some witnesses offered suggestions on how the CNL's new GoCo model can be improved. For example, the Committee heard that the nuclear industry, especially small companies, would benefit from more affordable access to the CNL's equipment and services. According to John Robinson of Tyne Engineering, "CNL now is being forced to lend out its services almost as a private industry." He told the Committee that the organization has equipment and expertise that most small companies could not develop on their own, adding that his company "can't pay CNL prices that are four and five times the prices that [they] use in [their] own offices." Mr. Robinson recommended that the CNL work more collaboratively with small nuclear companies, instead of competing with them.<sup>11</sup>

Moreover, Steven Schumann of the International Union of Operating Engineers criticized the GoCo labour agreement for not allowing employees to continue their participation in the public service pension plan (PSPP). He stated that CNL workers "will no longer be considered government employees, although the facility remains owned by the Government of Canada." Mr. Schumann explained that all employees will be moved to a new pension plan that is currently under negotiation; if an agreement is not made by September 2018, they will have to subscribe to a previously-set "defined contribution pension plan," as opposed to the "defined benefit plan" under the PSPP.<sup>12</sup>

## **B. The Environment Commissioner's 2016 Audit of the Canadian Nuclear Safety Commission**

In 2016, the Commissioner of the Environment and Sustainable Development (CESD) conducted an audit of select CNSC site inspections of nuclear power plants. Environment Commissioner Julie Gelfand summarized the outcome of the audit as follows:

In our audit, we found that the Commission conducted 226 site inspections of nuclear power plants that it had planned over the two-year period that we looked at. [...] We then looked very closely at 42 site inspections and found that the majority of them had non-compliances, so when the inspections were done, non-compliances were found. However, we found that the commission followed up with the licensees, the operators, 100% of the time. Every time there was a non-compliance, the Commission was on it. The commission therefore ensured that all the issues were being addressed, so that was a tick on the good side for the Commission. However, we found that it was unclear whether the Canadian Nuclear Safety Commission was conducting the appropriate number and type of inspections, because its planning process was not very well documented. The Commission could not show that planning was rigorous, systematic, and risk-based to verify that nuclear facilities were complying with all regulations [...]

Overall, our audit concluded that the Commission could not show that it adequately managed its site inspections of nuclear power plants. We did make a number of recommendations to the commission, including to implement a well-documented, systematic, and risk-based planning process, a five-year plan with a minimum number of inspections – not a potential list of inspections – that followed their own procedures,

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11 RNNR, [Evidence](#), 1<sup>st</sup> Session, 42<sup>nd</sup> Parliament, 1 December 2016 (John Robinson, Chief Executive Officer, Tyne Engineering).

12 RNNR, [Evidence](#), 1<sup>st</sup> Session, 42<sup>nd</sup> Parliament, 8 December 2016 (Steven Schumann, Canadian Government Affairs Director, International Union of Operating Engineers).

meaning with approved inspection guides for every inspection. The Commission agreed with our recommendations, and its responses are published in our audit report. I also understand and have seen that the Commission has posted an action plan on its website, indicating that it has already started to address our recommendations.<sup>13</sup>

Michael Binder of the CNSC confirmed that the Commission “accepted the findings of the audit and took immediate corrective action.”<sup>14</sup> Furthermore, Mr. O’Dea told the Committee that three of the five concerns that the CESD raised have already been addressed.<sup>15</sup>

### **C. Waste Management and Decommissioning**

Canada is signatory to the *Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management*, which stipulates that radioactive waste should be recognized as the “ultimate responsibility of the state” and should be disposed of in the state in which it was generated.<sup>16</sup> In 2002, the Nuclear Waste Management Organization (NWMO) was established as a requirement of the federal *Nuclear Fuel Waste Act* with a mandate to design and implement a long-term management plan for used nuclear fuel in Canada. In 2005, the NWMO proposed the “adaptive phased management” (APM) approach, which includes the development of a deep geological repository (DGR) for the long-term isolation of Canada’s used fuel in “an informed and willing host community.” Optimized for used Candu fuel, the DGR can be manufactured domestically and can be used by companies seeking to export Canadian expertise and materials to manage Candu fuel waste in other countries. The APM was formally selected by the Government of Canada in June 2007.<sup>17</sup>

In May 2010, the NWMO initiated the site selection process for the proposed DGR. By the end of 2016, nine Ontario communities were being considered as potential hosts for the project.<sup>18</sup> According to a NWMO document submitted to the Committee on 30 November 2016:

The NWMO has a multi-year, multi-phased assessment process that is aimed at selecting a single site that will meet or exceed regulatory requirements for safety. There must also be a compelling demonstration that the community is informed and willing to host the project. The NWMO has committed that the project will only proceed with the involvement of the interested community, First Nation and Métis communities in the area, and surrounding communities, working in partnership to implement it.<sup>19</sup>

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13 RNNR, [Evidence](#), 1<sup>st</sup> Session, 42<sup>nd</sup> Parliament, 24 November 2016 (Julie Gelfand, Commissioner of the Environment and Sustainable Development, Office of the Auditor General of Canada).

14 RNNR, [Evidence](#) (Binder, CNSC).

15 RNNR, [Evidence](#) (O’Dea, NRCan).

16 RNNR, [Evidence](#), 1<sup>st</sup> Session, 42<sup>nd</sup> Parliament, 1 December 2016 (Richard Wiens, Director, Strategic Supply, Gamma Technologies, Nordion).

17 RNNR, [Evidence](#), 1<sup>st</sup> Session, 42<sup>nd</sup> Parliament, 24 November 2016 (Laurie Swami, President and Chief Executive Officer, Nuclear Waste Management Organization).

18 RNNR, [Evidence](#) (Swami, NWMO); [Evidence](#) (O’Dea, NRCan).

19 NWMO, Submission (30 November 2016).



From 2002 to 2015, the NWMO spent \$329,576,062 on advancing Canada's long-term nuclear used fuel management plan.<sup>20</sup> The \$22-billion DGR project is expected to be in service between 2040 and 2045.<sup>21</sup>

The Committee heard that there is international consensus that DGRs are the best and safest mechanism for the long-term management of spent nuclear fuel.<sup>22</sup> Richard Wiens of Nordion urged the government to consider including other types of waste in the APM plan, namely the spent sources of cobalt-60 used in Nordion's facility (a total volume of approximately 15 cubic metres). The NWMO's current mandate restricts the plan to spent fuel only.<sup>23</sup>

Ontario Power Generation (OPG) is also proposing the construction of a DGR at Bruce County, for the storage of low- and intermediate-level nuclear waste from their province. According to Glen Jager of OPG, the project and site have been subjected to "a rigorous environmental and approvals process for nearly 16 years, [...and] nearly a decade of scrutiny, public hearings, and input from local residents." He told the Committee that various independent assessments concluded that the proposed facility and management plan would be safe, adding that "every study or review has concluded that DGR would not cause any adverse effects to the environment or Lake Huron." Furthermore, Mr. Jager stated that over 70% of residents in the communities that were considered for the project were in favour of OPG's waste plan, "specifically the DGR."<sup>24</sup> A joint review panel, established in 2012 by the Ontario Minister of the Environment and the president of the CNSC to study the proposal, recommended that the project proceed.<sup>25</sup>

OPG's proposed DGR site is part of the traditional territory of the Saugeen Ojibway Nation (SON). Mr. Jager told the Committee that the ongoing discussions with the SON have been progressing well, and that OPG has committed that the project would not proceed without the First Nation's concurrence: "Notwithstanding that, they absolutely have a veto."<sup>26</sup> Meanwhile, OPG continues to seek environmental assessment (EA) approval for the project.<sup>27</sup>

The witnesses discussed other waste management and decommissioning plans in the sector, including the CNL's plans to decommission over 120 structures at Chalk River in order to make way for new capital projects needed to revitalize the laboratories,<sup>28</sup> CNL's proposal to construct a near surface disposal facility at Chalk River for operation

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20 *Ibid.*

21 RNNR, [Evidence](#) (Swami, NWMO); [Evidence](#) (O'Dea, NRCan).

22 RNNR, [Evidence](#) (Binder, CNSC); [Evidence](#) (Swami, NWMO); [Evidence](#), 1<sup>st</sup> Session, 42<sup>nd</sup> Parliament, 24 November 2016 (Glenn Jager, President and Chief Nuclear Officer, Ontario Power Generation Inc.).

23 RNNR, [Evidence](#) (Wiens, Nordion).

24 RNNR, [Evidence](#) (Jager, OPG).

25 RNNR, [Evidence](#) (O'Dea, NRCan).

26 RNNR, [Evidence](#) (Jager, OPG).

27 RNNR, [Evidence](#) (O'Dea, NRCan).

28 RNNR, [Evidence](#) (Lesinski, CNL).



by 2020;<sup>29</sup> AECL’s estimated \$8 billion in federal liability for the Chalk River and Whiteshell sites, which contain some buildings that were internally contaminated over the course of 60 years of research;<sup>30</sup> as well as plans to decommission retired reactors, including the Douglas Point reactor in Ontario and the Gentilly-1 reactor in Quebec.<sup>31</sup> The Committee heard that Canada has an opportunity to develop decommissioning expertise and technologies for future domestic and international applications, by using some of its retired reactors as “test beds” to gain experience in the field.<sup>32</sup> Mr. Robinson pointed out that Canada is currently decommissioning some of the oldest reactors in the world, a situation that will eventually appear in other countries. He stated that “[developing] decommissioning technologies now [will] reap economic benefits in the future.”<sup>33</sup>

## AN ENERGY INDUSTRY FOR CANADA AND THE WORLD

The following sections discuss three aspects of Canada’s nuclear energy sector, based on evidence from the witnesses: 1) nuclear power generation and reactor refurbishment plans in Canada, 2) the state of the Candu industry, and 3) Canada’s potential role in developing next-generation nuclear technologies, namely advanced reactors (ARs).

### A. Nuclear Power Generation in Canada

Nuclear energy constitutes approximately 16% of Canada’s electricity mix, including over 50% and about 30% of the electricity supply in Ontario and New Brunswick respectively.<sup>34</sup> As a non-emitting source of steady, baseload power, it has been recognized by G7 leaders as a key contributor to greenhouse gas (GHG) emission reduction and climate change mitigation.<sup>35</sup> In Ontario, the fleet of six nuclear reactors has enabled the province to phase out coal power, nearly eliminating GHG emission from its electricity sector.<sup>36</sup> Several witnesses highlighted the role of nuclear energy in helping Canada meet its climate change commitments and baseload demand for electricity.<sup>37</sup>

There are currently 19 operating nuclear reactors in 4 power facilities in Canada: Bruce Power (8 units), Pickering (6 units) and Darlington (4 units) in Ontario, and the Point

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29 RNNR, [Evidence](#) (O’Dea, NRCAN).

30 RNNR, [Evidence](#) (Sexton, AECL).

31 RNNR, [Evidence](#), 1<sup>st</sup> Session, 42<sup>nd</sup> Parliament, 8 December 2016 (Gordon Edwards, President, Canadian Coalition for Nuclear Responsibility).

32 RNNR, [Evidence](#) (Edwards, CCNR).

33 RNNR, [Evidence](#), 1<sup>st</sup> Session, 42<sup>nd</sup> Parliament, 1 December 2016 (Vince Robinson, Tyne Engineering).

34 RNNR, [Evidence](#) (O’Dea, NRCAN).

35 *Ibid.*

36 RNNR, [Evidence](#) (Jager, OPG); [Evidence](#), 1<sup>st</sup> Session, 42<sup>nd</sup> Parliament, 15 November 2016 (Colin Hunt, Secretary, Canadian Nuclear Society).

37 RNNR, [Evidence](#), 1<sup>st</sup> Session, 42<sup>nd</sup> Parliament, 13 December 2016 (Brett Plummer, Chief Nuclear Officer and Vice-President Nuclear, New Brunswick Power Corporation); [Evidence](#), 1<sup>st</sup> Session, 42<sup>nd</sup> Parliament, 1 December 2016 (Justin Hannah, Director, Marketing, Strategy and External Relations, SNC-Lavalin International); [Evidence](#) (Jager, OPG); [Evidence](#) (Hopwood, UNENE).

Lepreau facility (1 unit) in New Brunswick. In 2008, New Brunswick's 600-megawatt Candu 6 reactor underwent refurbishment to extend its operating life for an additional 25 to 30 years.<sup>38</sup> Despite cost overruns, Brett Plummer of the New Brunswick Power Corporation told the Committee that the station's refurbishment will have long-term benefits for the province:

In terms of the refurbishment cost, the overruns were \$1.4 billion. The energy replacement cost was \$1 billion. Those costs are incorporated into the price of Point Lepreau over the life of the plant. The cost of the life of the plant is still 8.3¢ per kilowatt, which is extremely competitive [...] Point Lepreau is set up to run for another 35 to 40-plus years of non-emitting electricity for the province of New Brunswick. It's a huge baseload for New Brunswickers.<sup>39</sup>

The nuclear energy industry is currently focused on extending the lifespan of 10 power generating reactors at Ontario's Bruce Power and Darlington sites by up to 30 years. According to NRCAN, the \$25-billion investment "could create 14,000 jobs over the next 10-year refurbishment period."<sup>40</sup> Furthermore, the Committee heard the following with regards to each site:

- At the Bruce Power site, refurbishments over the next 20 years are expected to provide 5,000 direct and indirect jobs annually, representing \$980 million to \$1.2 billion in labour income into the Ontario economy, in addition to \$751 million to \$1.07 billion in annual economic benefit through equipment, supplies and materials both directly and indirectly. Furthermore, the site is expected to create and sustain 22,000 direct and indirect jobs annually through 2064, "while creating \$4 billion in annual Ontario economic benefit through the direct and indirect spending on operational equipment, supplies, materials and labour income."<sup>41</sup>
- At the Darlington site, the mid-life refurbishment of four nuclear reactors, which account for 20% of Ontario's power supply, is expected to cost \$12.8 billion over a 10-year period. By extending the station's operational life to 2055, the project is "the equivalent of removing two million cars from Ontario's roads per year," and will contribute an estimated \$89.9 billion to the provincial GDP (based on estimates from the Conference Board of Canada).<sup>42</sup> Moreover, it will create jobs for "thousands of skilled trades workers [...] and provide an opportunity for apprentices to gain valuable work experience."<sup>43</sup>

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38 RNNR, [Evidence](#) (Plummer, NB Power).

39 *Ibid.*

40 RNNR, [Evidence](#) (O'Dea, NRCAN).

41 Bruce Power, *The Role of Nuclear: Present and Future* (17 November 2016).

42 RNNR, [Evidence](#) (Jager, OPG).

43 RNNR, [Evidence](#) (Schumann, IUOE).

Ontario's Pickering reactors are expected to cease commercial operation in 2024, with no replacement plan in sight. According to Mr. Jager, the decision to refurbish the Darlington and Bruce Power units, but not the Pickering units, has been a matter of economics: the former are large reactors with a large return on investment, while Pickering's are smaller units that would be more economical to replace with new facilities. Mr. Jager told the Committee that OPG has a licence to construct new nuclear reactors adjacent to the Darlington facility, pending decisions on technology and vendor. He explained that such decisions would have to be part of the province's long-term energy plan, adding that the replacement power for Pickering "would be largely obtained from existing capacity or gas power installations, or renewable energy in the short term."<sup>44</sup>

The Committee heard that nuclear projects face challenges of public confidence, especially due to economic considerations (e.g., high capital costs or cost overruns in some cases), and safety concerns regarding the security of nuclear facilities and the long-term management of radioactive waste.<sup>45</sup> The Committee also heard that the general lack of understanding of nuclear technologies among Canadians contributes to low public confidence in nuclear technologies.<sup>46</sup> According to Dale Austin of Cameco, unlike for other forms of electricity generation, "polling typically shows that support for the nuclear industry is often strongest where nuclear operations exist; and that the more individuals know and understand about the nuclear sector, the more supportive they tend to be."<sup>47</sup> Studies conducted by the OPG found that support for nuclear power in Ontario, where the nuclear industry is most prominent, is "among the highest in the world,"<sup>48</sup> while surveys in New Brunswick indicate that the "overwhelming majority [of New Brunswickers] approve of Point Lepreau and nuclear power."<sup>49</sup>

In reference to public opinion in Ontario, Colin Hunt of the Canadian Nuclear Society identified three major groups: 1) a small but vocal group that opposes nuclear power; 2) a slightly larger group that strongly supports nuclear power; and 3) "the vast majority of citizens in the middle who are mildly supportive, who don't know much about it, and who aren't much interested unless something hits the headlines and causes a big sensation."<sup>50</sup> He added that public opposition to nuclear energy tends to rise when new reactors are being proposed, mostly because of concerns over cost rather than fear of nuclear power and its consequences. Conversely, he told the Committee that public

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44 RNNR, [Evidence](#) (Jager, OPG).

45 RNNR, [Evidence](#) (O'Dea, NRCan).

46 RNNR, [Evidence](#), 1<sup>st</sup> Session, 42<sup>nd</sup> Parliament, 22 November 2016 (Glenn Harvel, Associate Dean, Faculty of Energy Systems and Nuclear Science, University of Ontario Institute of Technology); [Evidence](#), 1<sup>st</sup> Session, 42<sup>nd</sup> Parliament 17, November 2016 (Ron Oberth, President and Chief Executive Officer, Organization of Canadian Nuclear Industries).

47 RNNR, [Evidence](#), 1<sup>st</sup> Session, 42<sup>nd</sup> Parliament, 29 November 2016 (Dale Austin, Manager, Government Relations, Cameco Corporation).

48 RNNR, [Evidence](#) (Jager, OPG).

49 RNNR, [Evidence](#) (Plummer, NB Power).

50 RNNR, [Evidence](#) (Hunt, Canadian Nuclear Society).

support for the refurbishment of existing nuclear power plants in Ontario has been consistent, “[running] well above 80%.”<sup>51</sup>

Despite being cost-competitive in the long-term, the high up-front capital cost of nuclear projects was identified as a major barrier to the development of new nuclear generating capacity in Canada.<sup>52</sup> According to Mr. O’Dea, the competitiveness of nuclear energy requires “a long-term vision and specific energy strategies, since we need to make profitable the significant initial investment required for nuclear energy.” He explained that such investment becomes competitive over time, because most nuclear facilities can last for 60 years or longer.<sup>53</sup> On the other hand, Shawn-Patrick Stensil of Greenpeace told the Committee that the costs of nuclear energy “have only ever risen, [while] renewable costs are declining rapidly.” He advised government to consider more opportunities in the renewable energy sector.<sup>54</sup>

## **B. The State of the Candu Industry**

The Canadian Deuterium Uranium (Candu) Reactor is a world-renowned Canadian invention that was developed in the 1950s by AECL, in cooperation with industry, and remains one of the single largest R&D investments ever made by the Canadian government.<sup>55</sup> The Committee heard that the state of Candu technology remains strong both in Canada and internationally,<sup>56</sup> and that new international Candu sales could have significant economic benefits for Canada. Justin Hannah of SNC-Lavalin told the Committee that his company recently commissioned the Conference Board of Canada to conduct a study on the potential economic impact of exporting two new Candu reactors; the Board estimated the impact to be “up to 37,000 person-years of employment, with a net GDP increase of approximately \$3.8 billion.”<sup>57</sup>

Candu technology has already been exported to China, India, Pakistan, South Korea, Romania, and Argentina. Furthermore, SNC-Lavalin is pursuing potential new-build opportunities in Argentina (1 unit), Romania (2 units), the United Kingdom (4 units) and China (2 units).<sup>58</sup> According to Mr. Hannah, the joint Canadian-Chinese development project of Advanced Fuel Candu Reactors (AFCRs) is of special interest:

The project is aimed at adapting the unique design of the Candu reactor to utilize recycled uranium fuel, and in the longer term, thorium. This significant innovation positions the AFCR as a more sustainable nuclear solution through its ability to consume spent nuclear fuel and to reduce overall waste volume by 30% to 40%. It will also allow

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51 *Ibid.*

52 RNNR, [Evidence](#) (O’Dea, NRCan).

53 *Ibid.*

54 RNNR, [Evidence](#), 1<sup>st</sup> Session, 42<sup>nd</sup> Parliament 8 December 2016 (Shawn-Patrick Stensil, Nuclear Analyst, Greenpeace Canada).

55 RNNR, [Evidence](#) (Hannah, SNC-Lavalin).

56 RNNR, [Evidence](#) (Hunt, Canadian Nuclear Society).

57 RNNR, [Evidence](#) (Hannah, SNC-Lavalin).

58 *Ibid.*

China to expand its nuclear fleet while reducing dependence on imported uranium and coal-fired electricity, all while meeting the highest safety standards and environmental protections. [In September 2016], SNC-Lavalin and [the China National Nuclear Corporation] signed a joint venture agreement in Ottawa, in the presence of the Prime Minister and Chinese Premier Li, to signify the bilateral commitment [...] to further progress this innovative technology.<sup>59</sup>

Mr. Hannah added that SNC-Lavalin is positioning the AFCR as a synergistic technology with China's existing light-water reactor fleet. He explained that China is expected to build about 150 reactors over the next 20 years, and that SNC-Lavalin has shown that the optimal deployment ratio for AFCRs consuming recycled uranium is 4:1 (i.e., 20 AFCR units for each 100 reactors).<sup>60</sup>

According to Mr. O'Dea, the biggest opportunities for the Canadian industry are overseas, especially in growing economies like India's and China's where wide systems of nuclear power plants are on the horizon. He added that other countries, such as Romania and Poland, are aiming to increase their energy independence, and have already expressed interest in importing Canadian nuclear technologies.<sup>61</sup> Canada has signed international nuclear co-operation agreements and MOUs with several countries, including China, India, the United States, and the United Kingdom.<sup>62</sup>

To maximize on the industry's international economic opportunities, Mr. Hannah recommended that the government extend the export credits that have historically supported Candu exports to include the full supply chain of Canadian nuclear exports and international operations.<sup>63</sup> He stated that the availability of export credit will have "a direct correlation to [the industry's] economic impact, because it allows offshore clients to [...] procure or purchase Canadian goods and services from Canada, to the benefit of Canadian exporters."<sup>64</sup>

The Committee also heard of Candu spinoff technologies and industries with R&D potential. Examples include nascent reactor designs with the ability to recycle spent Candu fuel, and spinoff industries that use helium-3, a by-product of the decay of tritium, to create sensitive neutron detectors.<sup>65</sup> According to Mr. Jager, nascent reactors that can run on spent Candu fuel are still in an early development stage; they require fuel reprocessing capabilities, which are currently not available in Canada.<sup>66</sup> Rick Holt of Queen's University

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59 *Ibid.*

60 *Ibid.*

61 RNNR, [Evidence](#) (O'Dea, NRCan).

62 *Ibid.*

63 RNNR, [Evidence](#) (Hannah, SNC-Lavalin); RNNR, [Evidence](#) (Oberth, OCI).

64 RNNR, [Evidence](#) (Hannah, SNC-Lavalin).

65 RNNR, [Evidence](#), 1<sup>st</sup> Session, 42<sup>nd</sup> Parliament, 1 December 2016 (Mark Daymond, Professor, Mechanical and Materials Engineering, Queen's University); [Evidence](#) (Robinson, Tyne Engineering); [Evidence](#) (Plummer, NB Power); [Evidence](#) (Austin, Cameco).

66 RNNR, [Evidence](#) (Jager, OPG).

told the Committee that advancing Candu technologies beyond the current systems requires long-term investments from government.<sup>67</sup>

### C. Advanced Reactor Technologies

The Committee heard that nuclear technologies are still in their early stage of development. According to Jerry Hopwood of the University Network of Excellence in Nuclear Engineering (UNENE), even though Canada has been developing nuclear energy since the 1940s, there is much prospect to refine current technologies and make them more beneficial and widely applicable.<sup>68</sup> Furthermore, Simon Irish of Terrestrial Energy highlighted the potential of industry-led advanced reactor (ARs) design, explaining that ARs are smaller, less expensive and simpler to build compared to current commercial reactors, and have the potential to reduce civilian nuclear energy waste by more than 95%.<sup>69</sup> He argued that ARs represent an opportunity for Canada to increase industrial competitiveness and support economic growth, while helping meet its climate goals and maintain its international leadership role in the production and export of nuclear technology.<sup>70</sup> Professor Glen Harvel of the University of Ontario Institute of Technology told the Committee that the success of advanced nuclear reactors will ultimately depend on the capital and operational cost of each reactor unit.<sup>71</sup>

The following sections discuss three types of advanced reactors that were brought to the Committee's attention: small modular reactors (SMRs), fusion nuclear reactors, and the integral molten salt reactor (IMSR).

#### 1. Small Modular Reactors

The term "small modular reactor" refers to a size of reactor, typically less than 300 megawatt electric,<sup>72</sup> rather than a type of technology. The Committee heard that SMRs could be used to generate non-emitting power in off-grid communities and sites,<sup>73</sup> or to supply urban households with stable, low-emission energy in lieu of larger, more capital-intensive nuclear plants.<sup>74</sup> The anticipated socioeconomic benefits of SMRs include: 1) providing a cost-effective, low-emission baseload energy source for northern/remote communities and resource development sites across Canada; 2) reducing the country's overall reliance on fossil fuels, and thus greenhouse gas emissions;

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67 RNNR, [Evidence](#), 1<sup>st</sup> Session, 42<sup>nd</sup> Parliament, 1 December 2016 (Rick Holt, Professor Emeritus, Mechanical and Materials Engineering, Queen's University).

68 RNNR, [Evidence](#) (Hopwood, UNENE).

69 RNNR, [Evidence](#), 1<sup>st</sup> Session, 42<sup>nd</sup> Parliament, 29 November 2016 (Simon Irish, Chief Executive, Director, Terrestrial Energy Inc.).

70 RNNR, [Evidence](#) (Irish, Terrestrial Energy).

71 RNNR, [Evidence](#) (Harvel, UOIT).

72 Terrestrial Energy, *The Nuclear Choices Facing Canadians* (9 December 2016).

73 RNNR, [Evidence](#) (Hunt, Canadian Nuclear Society); [Evidence](#), 1<sup>st</sup> Session, 42<sup>nd</sup> Parliament, 17 November 2016 (John Barrett, President and Chief Executive Officer, Canadian Nuclear Association).

74 RNNR, [Evidence](#) (Jager, OPG).



3) maintaining Canada's international leadership position in nuclear energy and security; and 4) helping meet Canada's climate goals and commitments to mission innovation in COP 21.<sup>75</sup>

The Committee heard that Canada is uniquely positioned to benefit from developing SMRs for two main reasons: 1) existing expertise in nuclear technology development, including “a performance-based regulator able to incorporate different types of technologies in its reviews;” and 2) an existing market for SMRs, including remote communities and natural resource development operations that would benefit from alternatives to fossil fuels such as diesel.<sup>76</sup> Furthermore, Mr. Lesinski of the CNL told the Committee that SMRs, and vSMRs (i.e., very small modular reactors of 1-50 megawatt electric), are gaining appeal in leading nuclear nations, and thus represent an opportunity for Canada “to take a leadership role in the development of this versatile technology.”<sup>77</sup> He added that seizing these opportunities would require the government to establish a goal of having a demonstration SMR or vSMR in Canada within the next 10 years.<sup>78</sup> Mr. Stensil was more sceptical of the potential of SMRs. In reference to remote communities in Canada, he advised governments to consider other alternatives to diesel, namely renewable micro-grids, stating that “to get to a good decision, we need to have both options on the table, and right now [...] the only options we have are SMRs against diesel.”<sup>79</sup>

While some SMRs have already been built,<sup>80</sup> the technology is still short of wide-scale commercialization.<sup>81</sup> The CNL is proposing a 10-year plan that would see the commissioning of a demonstration SMR or vSMR by year nine for an estimated total cost of \$600 million. As Mr. Lesinski explained:

The notional funding profile, which would be further refined if there were interest in pursuing this proposal, calls for modest investment of approximately \$15 million in the first two years to conduct a request for expressions of interest, or RFEOI, that would serve to gather concrete information on the following: the level of interest in the private sector; the technologies available, together with their merits and risks; the potential for risk sharing with investors and technology vendors; opportunities for cost sharing and alternative financing arrangements; stakeholder and first nations interest; and potential host communities, among others. This initiative could be managed and overseen by AECL, with CNL as a service provider, so that AECL, as the government's adviser on nuclear technology could properly assess overall value to Canada.<sup>82</sup>

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75 RNNR, [Evidence](#) (Lesinski, CNL); [Evidence](#) (Hunt, Canadian Nuclear Society).

76 RNNR, [Evidence](#) (O'Dea, NRCAN).

77 RNNR, [Evidence](#) (Lesinski, CNL).

78 *Ibid.*

79 RNNR, [Evidence](#) (Stensil, Greenpeace).

80 RNNR, [Evidence](#) (Hopwood, UNENE).

81 RNNR, [Evidence](#) (Jager, OPG).

82 RNNR, [Evidence](#) (Lesinski, CNL).

Richard Sexton of AECL told the Committee that one of the main challenges facing SMRs is that there are currently over 100 different designs with potential for commercialization. He added that the Chalk River Laboratories could help both government and commercial companies identify the most appropriate technologies to pursue.<sup>83</sup> According to Mr. Binder, by the end of 2016, “five SMR vendors have engaged the CNSC in vendor design reviews to verify, at a high level, if the design meets regulatory requirements and to identify any fundamental barriers.”<sup>84</sup>

In 2016, Sustainable Development Technology Canada (SDTC) provided \$5.7 million for the development of Terrestrial Energy’s SMR-related project. Furthermore, NRCan has partnered with the Government of Ontario to study the feasibility of different small modular reactor (SMR) technologies, and has funded a study by the Fedoruk Centre on Aboriginal attitudes toward nuclear energy to better understand the potential application of SMRs in remote communities.<sup>85</sup>

## 2. Fusion Nuclear Reactors

Nuclear fusion is a process whereby hydrogen atoms are fused together at high temperatures and pressures to create energy. According to Michael Delage of General Fusion, it is a non-emitting process that relies on an abundant fuel source (i.e., hydrogen) and produces large amounts of energy: “one kilogram of fusion fuel produces the same amount of energy as roughly 10,000 tonnes of coal.”<sup>86</sup>

In a supporting document submitted to the Committee on 16 January 2017, General Fusion outlines Canada’s long history of R&D in fusion energy:

In the 1960’s, recognition of the potential of fusion energy led to the establishment of a number of groups studying plasma physics and fusion energy, particularly at the Universities of British Columbia, Alberta, Saskatchewan, Toronto and Institut National de la Recherche Scientifique (INRS) in Montreal. All of these were major players in the field in the 1970’s and 1980’s. In addition, the Laser-Plasma group at the National Research Council (NRC) became a significant player in laser fusion related studies during this period. These activities eventually led to the establishment of a Canadian fusion energy program in the 1980’s with the construction and operation of the Tokamak de Varennes (TdeV) in Quebec and the Canadian Fusion Fuels Technology Project (CFFTP) in Ontario, led by Ontario Hydro (the provincial electric power utility) and Atomic Energy of Canada Limited (AECL). Canada was also an initial member of the development group for ITER.<sup>87</sup>

The document adds that, even though the federal government cancelled the national fusion energy program in the mid-1990s, “there is still significant core expertise

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83 RNNR, [Evidence](#) (Sexton, AECL).

84 RNNR, [Evidence](#) (Binder, CNSC).

85 RNNR, [Evidence](#) (O’Dea, NRCan).

86 RNNR, [Evidence](#), 1<sup>st</sup> Session, 42<sup>nd</sup> Parliament, 29 November 2016 (Michael Delage, Vice-President of Technology and Corporate Strategy, General Fusion).

87 Fusion Energy, *Fusion 2030: Roadmap for Canada* (16 January 2017).



remaining in a few of the groups which now can be used to start a new effort to finally achieve fusion energy [in Canada].” Canadian innovative capacity is evidenced by existing expertise in magnetic and laser fusion energy technologies in Saskatchewan and Alberta; world leading expertise in tritium technology, fusion fuels, and neutron-material interactions at the CNL and various universities in Ontario; as well as expertise in supporting areas, such as materials and nano-materials development, in several universities in Quebec and Ontario.<sup>88</sup>

According to General Fusion, a new Canadian National Fusion Program would require “an initial investment of approximately \$25M per year over the first five years from the federal government, matched by additional provincial contributions.” Subsequently, such efforts would lead to “an initial assessment review in 2020 to determine the path forward to an engineering “demo” fusion system, to be operational by 2030.”<sup>89</sup> SDTC has recently provided General Fusion’s reactor project with two rounds of funding: \$13.9 million in 2009 and \$12.7 million in 2016.<sup>90</sup>

### 3. The Integral Molten Salt Reactor

Another advanced reactor design that was presented to the Committee is the integral molten salt reactor (IMSR) – a 400 megawatt thermal, non-emitting, molten fluoride salt reactor system, fuelled by low enriched uranium. According to a brief provided by Terrestrial Energy to the Committee on 9 December 2016, the IMSR’s key innovation is “the integration of the primary components of the reactor core into a sealed and replaceable vessel that has an operating life of seven years.” Such design choice avoids the challenges related to material lifetime that often impede early deployment. Furthermore, the IMSR is the only commercial scale reactor to operate on a liquid fuelled system (i.e., using molten salt, as opposed to conventional solid fuels), a feature that enhances the reactor’s safety profile by allowing heat from the fission process to dissipate through convection in the salt mixture, thereby eliminating the need for the pressurized water coolants used in solid-fuelled systems. Terrestrial Energy describes the IMSR to be a “walk-away safe” reactor: “even if all power to the system failed and no human were present at the plant, the reaction would shut down and the reactor would cool quietly on its own.”<sup>91</sup>

In the words of Mr. Irish, “the IMSR promises to give industry a better product, industrial heat that is not tethered to grid or pipeline.” It can be used for various applications in markets around the world – for example, to fuel natural resource extraction, petrochemical production and desalination activities, or to back up wind and solar power in lieu of natural gas. According to Mr. Irish, Terrestrial Energy is on track with its plans to

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88 *Ibid.*

89 *Ibid.*

90 RNNR, [Evidence](#) (O’Dea, NRCan).

91 Terrestrial Energy, *The Nuclear Choices Facing Canadians* (9 December 2016).

license, construct, and commission the \$2-billion IMSR project, which could become “the first commercial advanced nuclear power plant in the world.”<sup>92</sup>

## CANADIAN RESEARCH BEYOND THE NATIONAL RESEARCH UNIVERSAL

The Committee heard that the impending closure of the nearly 60-year-old NRU in 2018 is one of the main challenges facing the Canadian nuclear R&D sector.<sup>93</sup> As a large research reactor, the NRU has been a reliable source of high-flux neutrons used in a wide range of medical and industrial sectors, including the production of medical isotopes for diagnosis and treatment of various cancers and cardiovascular diseases (among others),<sup>94</sup> and to conduct research with applications in the environment, agriculture and natural resource sectors.<sup>95</sup> According to Christopher Heysel of McMaster University, neutrons are “especially important for research into materials sciences because they penetrate deep into materials and provide information about interior structures of matter at the atomic level.” This function is important for developing advanced materials for diverse products, including clean energy technologies, high-efficiency engines, and information technology hardware.<sup>96</sup> Furthermore, Dr. Jean Koclas of the École Polytechnique de Montréal explained that access to a reliable neutron source is essential for the future of the Candu industry. He stated the following:

The only place in Canada where advanced materials for the future of the Candu reactor can be studied with confidence is when we have a high neutron flux in a high volume, not in a very small location but in a very large core area where conditions resemble what we have in nuclear power plants. You need this type of facility to conduct such research. You also need a larger research reactor to accommodate actual fuel from Candu reactors. In the absence of a large research reactor in our country, we will have to send fuel designs outside of the country. It should be clear to anyone that the facilities outside this country do not provide what is required to restore fuel in the complete fuel bundle of a Candu reactor; they can only provide small parts. It means that in the medium to long term, the Canadian way of dealing with nuclear power plants will simply get off the grid in global terms. We will not be able to go from generation II reactors, which we have now, to generation III, and even less so, for generation IV.<sup>97</sup>

Mr. Hunt told the Committee that “unless the supply of high-flux neutrons is addressed by the Government of Canada, over the long term there is a risk that nuclear expertise in Canada must diminish.”<sup>98</sup> The NRU shutdown is expected to displace approximately 250 Canadian neutron beam researchers that may have to change their

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92 RNNR, [Evidence](#) (Irish, Terrestrial Energy).

93 RNNR, [Evidence](#), 1<sup>st</sup> Session, 42<sup>nd</sup> Parliament, 22 November 2016 (Christopher Heysel, Director, Nuclear Operations and Facilities, McMaster Nuclear Reactor, McMaster University).

94 RNNR, [Evidence](#) (Barrett, Canadian Nuclear Association).

95 RNNR, [Evidence](#) (Heysel, McMaster University).

96 *Ibid.*

97 RNNR, [Evidence](#), 1<sup>st</sup> Session, 42<sup>nd</sup> Parliament, 22 November 2016 (Jean Koclas, Professor, Nuclear Engineering Institute, Engineering Physics Department, École Polytechnique de Montréal).

98 RNNR, [Evidence](#) (Hunt, Canadian Nuclear Society).

research area, or relocate to other countries to access neutron sources.<sup>99</sup> According to Ron Oberth of the Organization of Canadian Nuclear Industries (OCNI), OCNI members are already looking to collaborate with international facilities “that can do some of the things NRU does to ensure that [they] continue to support [the nuclear] industry with constructive and valuable R&D.”<sup>100</sup>

The Committee heard of several plans and proposals to supplant the NRU functions in the short-, medium- or long-term. Examples include:

- **The revitalization of the Chalk River laboratories:** In 2015, the federal government committed \$800 million over five years to revitalize the Chalk River Labs.<sup>101</sup> Furthermore, CNL’s Vision 2026 is expected to transform the Chalk River Campus into “a world-class, right-sized and sustainable nuclear laboratory delivering science and technology, structured to meet current and adapt to changing Canadian federal, commercial, and public priorities.”<sup>102</sup> A major new facility for testing a variety of materials and processes, the Harriet Brooks Building, named for Canada’s first female nuclear physicist, was recently inaugurated at the labs.<sup>103</sup> Other facilities are being planned.<sup>104</sup>
- **Increasing the power and operating time of other reactors:** The McMaster University reactor is planning to increase its power and operating time to address the gap in nuclear research and medical isotope production. In addition to housing Canada’s second most powerful research reactor after the NRU, the McMaster facility is complemented by a new cyclotron facility that produces fluorine-18 (a medical isotope used for cancer diagnosis), and a new, industrial-size, post-irradiation examination hot cell facility where researchers can test highly radioactive materials, such as components from Canada’s nuclear power plants. The Committee heard that the McMaster option is a “viable, medium-term solution” to keep Canada through a neutron gap until another large neutron source is developed.<sup>105</sup>
- **Alternative technologies to produce medical isotopes:** The federal government has invested in the development of alternative technologies to produce medical isotopes, including cyclotrons and linear accelerators. The Sherbrooke centre in Quebec, which has been one of the recipients of such funding, is expected to move into the commercial stage by the spring or

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99 RNNR, [Evidence](#) (Heysel, McMaster University).

100 RNNR, [Evidence](#) (Oberth, OCNI).

101 RNNR, [Evidence](#) (O’Dea, NRCan).

102 RNNR, [Evidence](#) (Lesinski, CNL).

103 RNNR, [Evidence](#) (O’Dea, NRCan).

104 RNNR, [Evidence](#) (Sexton, AECL).

105 RNNR, [Evidence](#) (Heysel, McMaster University).

summer of 2018.<sup>106</sup> Furthermore, Nordion and Bruce Power are working to develop alternative ways to produce the kind of high specific activity cobalt previously produced at the NRU.<sup>107</sup> Their plan is to replace “a good portion” of the isotope, currently produced at Chalk River, by the first quarter of 2019. Accelerator-based isotopes can supply only local markets due to their short half-life.<sup>108</sup>

- **TRIUMF’s proposed Institute for Advanced Medical Isotopes (IAMI):** TRIUMF, a leading developer of accelerator technology in Canada, is proposing the creation of a new institute that would produce next-generation isotopes for treating cancer and other diseases.<sup>109</sup> According to TRIUMF, IAMI will provide the infrastructure necessary to keep the organization’s laboratory, and by extension Canada, at the cutting edge of innovation in nuclear medicine. TRIUMF and its regional research partners (i.e., the University of British Columbia, the BC Cancer Agency, and Simon Fraser University) are requesting \$12.25M each from the federal and provincial governments for the capital construction of the facility.<sup>110</sup>
- **Requests for a new source of high-flux neutrons:** Some witnesses recommended that the government find a long-term source of high-flux neutrons for research purposes, namely by building a new reactor or upgrading an existing reactor to replace the NRU’s functions.<sup>111</sup> According to Mr. Heysel, the McMaster facility could be refurbished to be a large neutron source to support Canadian research. However, its application for funding through the Canada Foundation for Innovation’s major science initiatives program was not considered “on the grounds that neutron-based research activities remain a responsibility of the federal government through NRCan.”<sup>112</sup> One of the main recommendations of the 2009 report of the Expert Review Panel on Medical Isotope Production is to build a new nuclear reactor to replace the NRU.<sup>113</sup>

The Committee heard that the future of Canadian nuclear R&D requires long-term investment in the sector. Aside from university-based research, Mark Daymond of Queen’s University told the Committee that industry-sponsored R&D takes place in few

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106 RNNR, [Evidence](#), 1<sup>st</sup> Session, 42<sup>nd</sup> Parliament, 22 November 2016 (Éric Turcotte, Associate Professor, Department of Nuclear Medicine and Radiation Biology, Université de Sherbrooke).

107 RNNR, [Evidence](#), 1<sup>st</sup> Session, 42<sup>nd</sup> Parliament, 24 November 2016 (James Scongack, Vice-President, Corporate Affairs, Bruce Power); RNNR, [Evidence](#) (Oberth, OCI).

108 RNNR, [Evidence](#) (Scongack, Bruce Power).

109 RNNR, [Evidence](#), 1<sup>st</sup> Session, 42<sup>nd</sup> Parliament, 1 December 2016 (Jonathan Bagger, Director, TRIUMF).

110 TRIUMF, *Protecting Canada’s Global Leadership in Nuclear Innovation and Technology* (1 December 2016)

111 RNNR, [Evidence](#) (Koclas, École Polytechnique de Montréal); [Evidence](#) (Turcotte, Université de Sherbrooke); [Evidence](#) (Heysel, McMaster University).

112 RNNR, [Evidence](#) (Heysel, McMaster University).

113 RNNR, [Evidence](#) (Turcotte, Université de Sherbrooke).

organizations, drawing on a “somewhat diminishing pool of funds.” Dr. Daymond urged the federal and provincial (Ontario) governments to signal a long-term intent to pursue nuclear technology in order to sustain the future development of the sector in Canada.<sup>114</sup> Similarly, Mr. Austin stated that “it’s apparent that if there isn’t further investment in nuclear innovation, R&D, and technology development, the competitive advantage that Canada currently has all across the nuclear value chain is not going to be there in the years to come.”<sup>115</sup>

The Committee also heard that the nuclear industry would benefit from more focused funding. For example, according to Professor Harvel, current R&D funding, which covers Canada’s full nuclear industry spectrum, ends up being too spread out, leading to “marginal improvements in each area, as opposed to significant advancements in maybe some key focus areas.” He expressed the need for more focus, particularly in cases of competing technologies that require large capital investment to be developed.<sup>116</sup> Furthermore, Mr. Robinson stated that “the strength in the Canadian nuclear industry over the years was primarily due to some focal points in R&D, such as the NRU reactor and the fusion industry.” Mr. Robinson suggested that the government focus its investment on small and medium industries that can create commercially viable products.<sup>117</sup>

Other witnesses advised governments against focusing their funding on specific programs or technologies, calling for policies that support nuclear R&D, while allowing industry experts to decide where to invest most strategically.<sup>118</sup> While agreeing that current R&D funding is somewhat diluted and that nuclear research tends to be rather scattered, Dr. Éric Turcotte of the Université de Sherbrooke argued that funding various research groups helps maintain leadership in a competitive R&D environment. He stated that “if a decision was made in the nuclear sector to concentrate everything within a single centre, all the other centres would close within one or two years, and that would be catastrophic.”<sup>119</sup> Mr. Delage expressed a similar view with regards to investment in different advanced reactor technologies; he favoured a strategy of “watering many flowers,” adding that the need for larger investments in specific technologies is still a few years ahead of the current state of R&D.<sup>120</sup> Lianne Ing of Bubble Technology Industries was also supportive of policies – namely, the federal Scientific Research and Experimental Development (SRED) Tax Incentive Program – that allow companies to decide on what technologies are best suited for their business markets. She stated the following:

It is very difficult to predict what is going to be the next disruptive technology. It is disruptive because people aren’t expecting it to happen. When government tries to pick

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114 RNNR, [Evidence](#) (Daymond, Queen's University).

115 RNNR, [Evidence](#) (Austin, Cameco).

116 RNNR, [Evidence](#) (Harvel, UOIT).

117 RNNR, [Evidence](#) (Robinson, V., Tyne Engineering).

118 RNNR, [Evidence](#) (Irish, Terrestrial Energy); [Evidence](#), 1<sup>st</sup> Session, 42<sup>nd</sup> Parliament, 29 November 2016 (Lianne Ing, Vice-President, Bubble Technology Industries Inc.); [Evidence](#) (Delage, General Fusion).

119 RNNR, [Evidence](#) (Turcotte, Université de Sherbrooke).

120 RNNR, [Evidence](#) (Delage, General Fusion).

winners by focusing funding into very specific technology selections, there's a possibility that you end up undermining a small company that might be on the verge of some remarkable breakthrough. We think the SRED tax incentive program is very good in that it allows us to decide what sort of research we think our company should pursue.<sup>121</sup>

Ms. Ing's only criticism of the SRED program was that it no longer covers capital expenditure. She stated that many research projects are capital-equipment-intensive and require significant investment by businesses; "having no support for capital expenditures [makes] it difficult for companies to compete in the high-tech sector."<sup>122</sup>

## RECOMMENDATIONS

Based on the evidence presented in the previous sections, the Committee recommends the following:

- 1) The Committee recommends that the Government of Canada work with industry, Indigenous governments and communities, provincial/territorial governments, and international partners to ensure that Canada's nuclear sector continues to advance its rigorous regulatory and safety practices by:**
  - a) continuing to invest in research and development (R&D) and innovations to advance the sector's safety profile, including its operations and waste management practices in Canada and abroad;**
  - b) ensuring that enough financial securities are available to address the impacts of any unexpected nuclear incident or accident on public safety, health and/or the environment; and**
  - c) staying abreast of international developments in the fields of nuclear safety and waste management.**
- 2) The Committee recommends that the Government of Canada continue its support for Canadian nuclear R&D and innovation in the short, medium and long term, by:**
  - a) considering long-term options to provide a reliable, high-flux neutron source for Canadian researchers;**
  - b) working in collaboration with industry, especially small companies, to ensure that researchers and experts have access to the services and infrastructure they need to excel in their innovation and R&D pursuits; and**

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121 RNNR, [Evidence](#) (Ing, Bubble Technology).

122 *Ibid.*





- c) supporting programs that can train the high-skilled professionals needed to develop future nuclear technologies and industries, namely spin-off Candu technologies and advanced nuclear reactors.**
- 6) The Committee recommends that the Government of Canada continue to support the development of small modular reactors (SMRs), recognizing the potential for SMRs to provide clean and reliable power to remote and northern communities and open new areas to economically valuable resource development.**
- 7) The Committee recommends that industry, along with academia and innovators, establish a nuclear innovation council with representatives from the federal and provincial governments to leverage non-power applications (e.g., for health care, agriculture, manufacturing, etc.) of the nuclear sector for national benefit.**



# APPENDIX A LIST OF WITNESSES

Organizations and Individuals	Date	Meeting
<p><b>Canadian Nuclear Society</b> Peter Easton, Director of Communications Colin Hunt, Secretary</p>	2016/11/15	32
<p><b>Department of Natural Resources</b> Sharonne Katz, Acting Director Nuclear Energy Division, Electricity Resources Branch, Energy Sector Dave McCauley, Director Uranium and Radioactive Waste Division, Electricity Resources Branch, Energy Sector Niall O'Dea, Director General Electricity Resources Branch, Energy Sector</p>	2016/11/15	32
<p><b>Atomic Energy of Canada Limited</b> Shannon Quinn, Vice-President Science, Technology and Commercial Oversight Richard Sexton, Acting Chief Transition Officer</p>	2016/11/17	33
<p><b>Canadian Nuclear Association</b> John Barrett, President and Chief Executive Officer</p>		
<p><b>Canadian Nuclear Safety Commission</b> Michael M. Binder, President and Chief Executive Officer Ramzi Jammal, Executive Vice-President and Chief Regulatory Operations Officer</p>		
<p><b>Organization of Canadian Nuclear Industries</b> Ron Oberth, President and Chief Executive Officer</p>		
<p><b>École Polytechnique de Montréal</b> Jean Koclas, Professor Nuclear Engineering Institute, Engineering Physics Department</p>	2016/11/22	34
<p><b>McMaster University</b> Andrea Armstrong, Research Associate McMaster Nuclear Reactor Christopher Heysel, Director Nuclear Operations and Facilities, McMaster Nuclear Reactor Karin Stephenson, Manager, Commercial Operations McMaster Nuclear Reactor</p>		
<p><b>Université de Sherbrooke</b> Eric Turcotte, Associate Professor Department of Nuclear Medicine and Radiation Biology</p>		

Organizations and Individuals	Date	Meeting
<p><b>University Network of Excellence in Nuclear Engineering</b> Jerry Hopwood, President</p>	2016/11/22	34
<p><b>University of Ontario Institute of Technology</b> Glenn Harvel, Associate Dean Faculty of Energy Systems and Nuclear Science</p>		
<p><b>Bruce Power</b> James Scongack, Vice-President Corporate Affairs</p>	2016/11/24	35
<p><b>Nuclear Waste Management Organization</b> Elena Mantagaris, Director, Government and External Relations Laurie Swami, President and Chief Executive Officer Derek Wilson, Vice-President</p>		
<p><b>Office of the Auditor General</b> John Affleck, Principal Julie Gelfand, Commissioner of the Environment and Sustainable Development</p>		
<p><b>Ontario Power Generation Inc.</b> Glenn Jager, President and Chief Nuclear Officer</p>		
<p><b>Bubble Technology Industries Inc.</b> Lianne Ing, Vice-President</p>	2016/11/29	36
<p><b>Cameco Corporation</b> Dale Austin, Manager Government Relations</p>		
<p><b>CANDU Owners Group Inc.</b> Fred Dermakar, President and Chief Executive Officer</p>		
<p><b>General Fusion</b> Michael Delage, Vice-President of Technology and Corporate Strategy</p>		
<p><b>Terrestrial Energy Inc.</b> Simon Irish, Chief Executive</p>		
<p><b>Nordion</b> Emily Craven, Marketing Manager Richard Wiens, Director, Strategic Supply Gamma Technologies</p>	2016/12/01	37
<p><b>Queen's University</b> Mark Daymond, Professor Mechanical and Materials Engineering Rick Holt, Professor Emeritus</p>		

<b>Organizations and Individuals</b>	<b>Date</b>	<b>Meeting</b>
Mechanical and Materials Engineering <b>SNC-Lavalin International</b> Justin Hannah, Director Marketing, Strategy and External Relations <b>TRIUMF</b> Jonathan Bagger, Director <b>Tyne Engineering</b> Vince Robinson, President John Robinson, Chief Executive Officer	2016/12/01	37
<b>Canadian Coalition for Nuclear Responsibility</b> Gordon Edwards, President <b>Greenpeace Canada</b> Shawn-Patrick Stensil, Nuclear Analyst <b>International Union of Operating Engineers</b> Steven Schumann, Canadian Government Affairs Director	2016/12/08	39
<b>Aecon Construction Group Inc.</b> James Gandhi, Director, Business Development <b>Canadian Nuclear Laboratories</b> Mark Lesinski, President and Chief Executive Officer Lou Riccoboni, Vice President Corporate Affairs <b>New Brunswick Power Corporation</b> Kathleen Duguay, Manager Community Affairs and Nuclear Regulatory Protocol Brett Plummer, Chief Nuclear Officer and Vice-President Nuclear	2016/12/13	40



# APPENDIX B LIST OF BRIEFS

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## Organizations and Individuals

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**Bruce Power**

**General Fusion**

**Greenpeace Canada**

**Terrestrial Energy Inc.**

**TRIUMF**



# REQUEST FOR GOVERNMENT RESPONSE

Pursuant to Standing Order 109, the Committee requests that the government table a comprehensive response to this Report.

A copy of the relevant *Minutes of Proceedings* ([Meetings Nos. 32, 33, 34, 35, 36, 37, 39, 40](#)) is tabled.

Respectfully submitted,

James Maloney  
Chair





## Supplementary Opinion of the New Democratic Party

The nuclear energy and research sector is a large sector that many hard-working Canadians depend on for employment, energy and medical needs. We would like to thank our colleagues on the Natural Resources committee from the Liberal and Conservative parties for working together on this study in a constructive and collegial manner. As a result of that work, we believe this report is a strong reflection of our many shared concerns for this sector.

We do, however, have some areas of concern that require a stronger response or more attention. We have approached this study with some guiding principles that we believe are important to be reflected in this report. One of those principles is ensuring that government agencies and watchdogs are properly fulfilling their mandates, completely and with full transparency. When a government oversight body is not reaching that level of expectation, Canadians start to lose faith in that body's effectiveness, independence and ability to protect the Canadian public. We have seen how these kinds of issues have effected the National Energy Board over time, and it would behoove other government agencies to try to avoid those same pitfalls.

The Canadian Nuclear Safety Commission (CNSC) has a very serious and important role to fulfill in the oversight of Canada's nuclear sector and to ensure that Canadians are protected through proper regulation of said sector. Unfortunately, the effectiveness of the CNSC was brought into serious doubt in the Fall 2016 report of the Environment Commissioner, who audited the work of the CNSC. As the Commissioner noted in her testimony, "it was unclear whether the CNSC was conducting the appropriate number and type of inspections, because its planning process was not very well documented." She also noted that the CNSC "could not show that planning was rigorous, systematic, and risk-based to verify that nuclear facilities were complying with all regulations."

The concerns raised by the Environment Commissioner echo concerns raised by CNSC whistleblowers in a July 2016 letter. Unfortunately, when this letter was made public, the

head of the CNSC, Dr. Michael Binder, dismissed its significance. As various media reports stated, at a CNSC public meeting on Wednesday August 17th, 2016, Dr. Binder openly questioned if the whistleblower letter was in fact genuine and from CNSC staff. He further went on to joke that this may be part of a conspiracy theory. Further to this, the CNSC indicated that a written submission from Greenpeace, which included Access to Information documents lending support to some of the whistleblower allegations, would not be accepted or be considered. This is despite the fact that the CNSC has put their unsolicited submissions on the record at past meetings. These actions do not help the CNSC nor do they build public confidence in the institution.

When Dr. Binder testified before the committee, Mr. Cannings specifically asked if “CNSC ever publicly released an assessment of the off-site consequences of a Fukushima-scale radioactive release at a Canadian nuclear plant, yes or no?” Dr. Binder answered in the affirmative and then tabled a document with the committee which was purported to be what Mr. Cannings had requested. But the committee later received correspondence from Dr. Sunil Nijhawan which refuted Dr. Binder’s testimony and the document Dr. Binder tabled with the committee. His letter stated that the report that Dr. Binder tabled “did not in fact consider the offsite effects of a “Fukushima-scale radioactive release” requested by Mr. Cannings.”

During testimony before the committee, Shawn-Patrick Stensil of Greenpeace testified to the importance of this information. He stated the following:

“...because for emergency planning purposes we should be ready for worst-case scenarios. That's what other countries such as Germany and Belgium have done since Fukushima. They've actually modelled these types of accidents and asked what they need to be ready for off-site, so that they can protect the public.

The CNSC, at hearings in 2012 and 2013, heard from hundreds of Ontarians that we need to look at these types of studies, whatever you think about the nuclear industry, to better our emergency plans. They've consistently dodged modelling a

Fukushima-scale accident and done a lot of—I don't know—bafflegab to avoid actually addressing the question.

This goes back to your original question about the CNSC. It really worries me that they haven't been direct with the public about that.”

Finally, during her testimony before the committee, the Environment Commissioner indicated that CNSC “was quite difficult to work with” and stated that CSNC “was aggressive” with auditors from the CNSC. She went on to say that “If you look at the Canadian Nuclear Safety Commission's response, you will see there is a kind of code. It says it agrees with our findings, but that it will continue on as before and that it is doing everything correctly.”

This sort of approach from CNSC is, in our opinion, inappropriate from a national regulator. It is inappropriate for a national regulator to thumb its nose at officers of Parliament or at elected Members of Parliament, all who serve the people. This approach risks further eroding public confidence in the Canadian nuclear industry, at no fault of the industry itself.

Upon their election, the current government promised to clean up government, make it more transparent and open, and to bring “sunny ways” to our country. Unfortunately, recent controversy with the leadership of the CNSC is casting a cloud that is contrary to the government’s commitments. The Minister must stop avoiding his responsibilities and address the issues affecting public trust in Canada’s nuclear regulator.

We also would like to note that the committee heard testimony that was not included in the majority report about the balance between investment in new nuclear technologies and clean, renewable technologies such as solar. Mr. Stensil testified before the committee that “the challenge facing the nuclear industry involves not only the costs of disposing of waste and the risk of accidents, but also the competition. Technologies are improving very quickly.” He went on to state that “in the last RFP the Ontario

government put out, they got wind power in at 6.5¢ for the first time. That's lower than nuclear generation, and it's lower than wind was five years ago at 13¢.”

While decisions on construction of energy generation infrastructure fall to other levels of government, we believe that the testimony on the rising competitiveness of alternate forms of renewable energy technology merit consideration in the allocation of federal funding for research and development.

We believe that if the Government of Canada enacts the recommendations above, we will be able to better ensure the viability and safety of the nuclear sector to the benefit of all Canadians.