Canadian National Report for the Convention on Nuclear Safety

Ninth Report
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Canada

Canadian National Report for the Convention on Nuclear Safety – Ninth Report

In conformance with article 5 of the *Convention on Nuclear Safety*

Executive summary

This ninth Canadian report demonstrates how Canada continued to meet its obligations under the terms of the *Convention on Nuclear Safety* (CNS) during the reporting period from April 2019 to March 2022. During this period, Canada effectively maintained and, in many cases, enhanced its measures to meet its obligations under the CNS. Enabled by a comprehensive legislative framework, these measures – which focus on the health and safety of persons and the protection of the environment – are implemented by Canada’s nuclear regulator, licensees of nuclear power plants (NPPs), and other government institutions and industry stakeholders. Canada remains fully committed to the principles and implementation of the CNS by undertaking continuous improvements to maintain the highest level of safety of NPPs in Canada and around the world.

For the purposes of this report, the term “NPP” encompasses the existing operating fleet of CANDU reactors as well as any possible future power- or heat-producing reactor facilities such as small modular reactors (SMRs) or other advanced reactor concepts. Nineteen Canada Deuterium Uranium (CANDU) reactors were operating in Canada during the reporting period and three reactors were in safe storage. Preparations continued for possible new-build projects, including those involving SMRs.

Nuclear-related activities at NPPs in Canada are governed by robust, modern legislation, with appropriate and well-defined powers to ensure the NPPs remain safe. The most important legislation is the *Nuclear Safety and Control Act* (NSCA), which is complemented by regulations and other regulatory instruments. Canada’s nuclear regulator, the Canadian Nuclear Safety Commission (CNSC), is mature and well established. A system of licensing is in place to control activity related to NPPs and to protect the health and safety of persons, the environment, and national security.

The CNSC has a comprehensive program to ensure compliance with the regulatory framework and monitor the safety performance of the NPPs. A comprehensive set of graduated enforcement tools are available to the CNSC to address non-compliances.

The CNSC’s regulatory framework and processes feature a high degree of openness and transparency. The CNSC continued to foster openness and transparency during the reporting period – for example, through its Participant Funding Program, which facilitates the participation of eligible intervenors in the decision-making process and by issuing discussion papers and soliciting early public feedback on potential regulatory changes.

The Canadian regulatory framework, which is largely non-prescriptive, is continuously updated and aligned with international standards. Renewals of operating licences for NPPs are used to introduce new standards and requirements that the licensees actively implement. Periodic safety reviews (PSRs) are also conducted on 10-year intervals to assess and close any gaps with modern standards and requirements. The framework is also being improved to adjust to emerging technologies, including the possible deployment of SMRs.

Canada's nuclear industry has an excellent safety record. During the reporting period, NPP licensees fulfilled the basic responsibilities for safety as required by the NSCA, regulations, and the NPP operating licences. The licensees also addressed any safety issues that arose, in order to keep the risk at reasonable levels – and continued to give safety a high priority at every level of their organizations.

None of the safety-significant events that occurred at Canadian NPPs during the reporting period posed a significant threat to persons or the environment. For example, there were no serious process failures[3] at any NPP during the reporting period. The licensees' efforts to address operational events were effective in correcting any deficiencies and preventing recurrence.

During the reporting period, all Canadian NPPs operated with acceptable safety margins and acceptable levels of defence in depth. The maximum annual worker doses at NPPs were below annual dose limits, and all radiological releases from NPPs were very low – below 1% of derived release limits.

The *Vienna Declaration on Nuclear Safety* (VDNS) was adopted by Contracting Parties to the CNS in 2015. The declaration provides principles for the implementation of the objective of the *Convention on Nuclear Safety* to prevent accidents and mitigate radiological consequences. Canada has demonstrated its fulfillment of the VDNS principles through the activities of the CNSC and its licensees in all aspects of operating NPP facilities. Specifically, the principles of the VDNS have been achieved through the following means:

- The national regulatory framework for siting, design, and construction of NPPs aligns with the International Atomic Energy Agency (IAEA) safety standards, which themselves have been demonstrated to fulfill the principles of the VDNS.
- The designs of Canada's NPPs include features that prevent accidents and mitigate impacts should an accident occur. In addition, actions by the CNSC and licensees have strengthened defence in depth and enhanced emergency response.
- Licensees have implemented updated safety analyses and safety analysis reports that align with the requirements in revised CNSC regulatory documents. Also, licensees are meeting the safety goals associated with probabilistic safety assessments (PSAs).
- PSRs have enhanced the systematic adoption of safety improvements at existing NPPs; the resulting integrated implementation plans have introduced numerous safety upgrades, especially during refurbishment projects at the NPPs.

During the past two reporting periods, Canada addressed two CNS challenges that were identified for Canada at the Sixth Review Meeting:

6RM C-5	Update emergency operational interventional guidelines and protective measures for the public during and following major and radiological events
6RM C-3	Establish guidelines for the return of evacuees post-accident and to confirm public acceptability of it

To address 6RM C-5, Health Canada published *Generic Criteria and Operational Intervention Levels for Nuclear Emergency Planning and Response*, which updated its guidelines for public protective measures (including exposure control, ingestion control, population monitoring and medical management as well as off-site emergency workers).

To address 6RM C-3, Health Canada published *Guidance on Planning for Recovery Following a Nuclear or Radiological Emergency*, which provides direction on establishing public acceptability of any measures taken during the recovery phase of an actual nuclear emergency, including the return of evacuees. The organizations managing the recovery phase will engage the affected communities to develop appropriate strategies that encompass revitalization, support and compensation.

During the past two reporting periods, Canada also addressed the three specific CNS challenges that were identified for Canada at the Seventh Review Meeting:

7RM C-1	Publish the drafted amendments to the *Class I Nuclear Facilities Regulations* and the *Radiation Protection Regulations* that address lessons learned from Fukushima
7RM C-2	Complete the transition to the improved regulatory framework (CNSC regulatory documents)
7RM C-3	Formalize the planned approach to end-of-operation of multi-unit NPPs

To address 7RM C-1, the CNSC amended the *Class I Nuclear Facilities Regulations* and the *Radiation Protection Regulations* in 2017 to address lessons learned from the Fukushima accident.

To address 7RM C-2, the CNSC continued its progress during the reporting period to enhance the regulatory framework by revising and developing various regulatory documents relevant to existing NPPs and new-build projects, including emerging SMR technologies, and aligning them with international standards. The transition to the improved framework is complete, and the CNSC has a robust process to continue reviewing, revising and developing regulatory documents.

To address 7RM C-3, the CNSC has published REGDOC-3.5.1, *Information Dissemination: Licensing Process for Class I Nuclear Facilities and Uranium Mines and Mills.* The CNSC requires the licensee to develop a plan for the facility's end of operation that entails a smooth transition from shutdown to a stable state. The CNSC is applying this approach for Pickering – the only multi-unit NPP in Canada currently approaching the end of commercial operation.

Canada recommends the closure of all the above challenges.

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Acronyms, Abbreviations and Specific Expressions

action level	a specific dose of radiation or other parameter that, if reached, may indicate a loss of control of part of a licensee's radiation protection program and triggers a requirement for specific action to be taken
AECL	Atomic Energy of Canada Limited
ALARA	as low as reasonably achievable
AMP	administrative monetary penalty
BDBA	beyond-design-basis accident
Bq	becquerel
Canadian report	the [nth] Canadian report refers to the [nth] *Canadian National Report for the Convention on Nuclear Safety,* submitted on behalf of Canada for the [nth] Review Meeting of the Convention on Nuclear Safety
CANDU	Canada Deuterium Uranium
CCP	commissioning control point
CMD	Commission member document (prepared for Commission hearings and meetings by CNSC staff, proponents and intervenors)
CNL	Canadian Nuclear Laboratories
CNS	*Convention on Nuclear Safety*
CNSC	Canadian Nuclear Safety Commission
COG	CANDU Owners Group (Inc.)
ConvEx	Convention Exercise (operated under the framework of the IAEA *Convention on Early Notification of a Nuclear Accident*)
Commission	the tribunal component of the Canadian Nuclear Safety Commission
CSA	Canadian Standards Association, refered to organizationally as CSA Group
CSI	CANDU safety issue
DNNP	Darlington new nuclear project
DRL	derived release limit
EFPH	equivalent full-power hours
EME	emergency mitigating equipment
EMEG	emergency mitigating equipment guideline
EPREV	Emergency Preparedness Review
EPRI	Electric Power Research Institute
ERA	environmental risk assessment
FERP	Federal Emergency Response Plan
FNEP	Federal Nuclear Emergency Plan
G7	Group of seven nations (Canada, United States of America, France, United Kingdom, Germany, Italy, Japan and representatives of the European Union)
HFE	human factors engineering
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiological Protection

IEMP	independent environmental monitoring program
INES	International Nuclear Event Scale
INFCIRC	Information Circular (IAEA publication)
INPO	Institute of Nuclear Power Operations
INSAG	International Nuclear Safety Group
IRS	International Reporting System
IRRS	Integrated Regulatory Review Service
ISR	integrated safety review
KI	potassium iodide
LBLOCA	large-break loss-of-coolant accident
LCH	licence conditions handbook
METER	medical emergency treatment for exposure to radiation
mSv	Millisievert
MW	Megawatt
Mwe	megawatt (electrical)
NAYGN	North American Young Generation in Nuclear
NBEMO	New Brunswick Emergency Measures Organization
NEA	Nuclear Energy Agency (OECD)
NEW	nuclear energy worker
NPP	nuclear power plant
NRCan	Natural Resources Canada
NSCA	*Nuclear Safety and Control Act*
NSRB	Nuclear Safety Review Board
OECD	Organization for Economic Co-operation and Development
OP&P	operating policies and principles
OPEX	operating experience
OPG	Ontario Power Generation (Inc.)
PAR	passive autocatalytic hydrogen recombiner
person-Sv	person-sievert
PNERP	Provincial Nuclear Emergency Response Plan
PSA	probabilistic safety assessment (same as probabilistic risk assessment)
PSR	periodic safety review
R&D	research and development
RANET	Response and Assistance Network
REGDOC	regulatory document (CNSC publication)
reporting period	April 2019 to March 2022
RPD	regulatory program division
RPR	*Radiation Protection Regulations*
SAM	severe accident management
SAMG	severe accident management guideline
SCA	safety and control area
SSCs	structures, systems and components
TECDOC	Technical Document (IAEA publication)
UNENE	University Network of Excellence in Nuclear Engineering
USNRC	United States Nuclear Regulatory Commission

VDNS *Vienna Declaration on Nuclear Safety*
WANO World Association of Nuclear Operators
WiN Women in Nuclear

Chapter I – Introduction

A. General

Canada was one of the first signatories of the *Convention on Nuclear Safety* (CNS, also referred to as the Convention), which came into force on October 24, 1996. Canada has endeavoured to fulfill its obligations to the Convention, as demonstrated in the Canadian reports presented at the triennial review meetings of the Convention. Canada remains fully committed to the principles and implementation of the Convention by undertaking continuous improvements to maintain the highest level of safety of nuclear power plants (NPPs) in Canada and around the world.

This ninth Canadian report was produced on behalf of the Government of Canada by a team led by the Canadian Nuclear Safety Commission (CNSC). Contributions to the report were made by representatives from Bruce Power, NB Power, Ontario Power Generation (OPG), SNC-Lavalin Nuclear, the CANDU Owners Group (COG), Natural Resources Canada (NRCan), Health Canada, Global Affairs Canada and Global First Power.

The previous Canadian report (the eighth) was issued in August 2019 in preparation for the Eighth Review Meeting of the CNS. However, the Eighth Review Meeting was postponed due to the global COVID-19 pandemic. A partial peer review (written questions and answers) was conducted prior to the postponement (referred to as the eighth review cycle). The conclusion of that peer review, and the completion of the peer review of this (ninth) Canadian report, is planned for the Joint Eighth and Ninth Review Meeting, scheduled for March 2023.

A.1 Scope

As required by article 5 of the Convention, this ninth Canadian report demonstrates how Canada fulfilled its obligations under articles 6 to 19 of the Convention during the reporting period, which extended from April 2019 through March 2022. The report closely follows the form and structure established by the Contracting Parties to the Convention, pursuant to article 22 and the International Atomic Energy Agency (IAEA) document INFCIRC/572/Rev.5, *Guidelines Regarding National Reports Under the Convention on Nuclear Safety*. This ninth Canadian report describes the basic provisions that Canada has made to fulfill the obligations of the Convention and provides details on the changes that have taken place since the publication of the eighth Canadian report.

In Canada, all reactor facilities are designated as Class IA facilities and regulated under the *Class I Nuclear Facilities Regulations*. The nuclear installations referred to in the articles of the Convention are taken to specifically mean NPPs, which are a subset of Class IA facilities. The term ‘NPP’ is generally understood to mean any power-producing reactor[1] that is not a research reactor. For the purposes of this report, the term “NPP” encompasses the existing operating fleet of CANDU reactors as well as any possible future, power-producing reactor facilities, such as small modular reactors (SMRs) or other advanced reactor concepts. SMR concepts vary significantly in size, design features and cooling types and could be sited in places quite different from past NPP projects in Canada (e.g., in small and isolated communities). Besides potentially serving different electricity markets and enhancing grid stability, they may have uses beyond

[1] Power production is not restricted to electricity generation and could include other commercial uses of process heat

electricity generation, such as hydrogen production, desalinization and industrial or district heating.

In this report, much of the general and specific information pertains to the existing fleet of CANDU reactors. Illustrative examples often reflect the licensees of the operating NPPs, the CANDU design and its design organization. However, details and examples pertinent to SMR projects and vendors are also provided as appropriate.

Information related to the COVID-19 pandemic is found in various parts of this report. Canada's response to the pandemic, in the context of specific CNS obligations, is described in the following parts of the report.

Table 1: COVID-19 sections

Part of report	Topic
Subsection 7.2(iii)	CNSC verification of licensee compliance with regulatory requirements
Article 8	CNSC organizational adjustments
Subsection 9(c)	Licensee collective response and benchmarking
Subsection 11.2(a)	Licensee provisions for staffing, training, qualification and certification

The Canadian report does not cover nuclear research reactors. In addition, this report does not cover nuclear security and safeguards, nor does it cover spent fuel and radioactive waste, except for the discussion in sub-article 19(viii). Spent fuel and radioactive waste are addressed thoroughly in the seventh *Canadian National Report for the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management*, published in October 2020.

A.2 Contents

This report contains three chapters. Chapter I provides important context for the rest of the report. Section A of chapter I provides a general introduction to the report while section B summarizes the outcomes of the Seventh Review Meeting for Canada, including the specific good practices, good performances, suggestion and challenges that were identified for Canada. Section B also describes the challenges from the Sixth Review Meeting that remained open for Canada following the Seventh Review Meeting. Section C describes aspects of nuclear power policy and nuclear-related activity in Canada. Section D provides a high-level description of the nuclear power industry in Canada and recent major developments (life extensions and new-build projects). Although these sections do not directly apply to any particular article of the Convention, they represent the context within which the articles are met. Section E describes the *Vienna Declaration on Nuclear Safety* (VDNS) and the parts of this report that address it.

Chapter II provides an overview of the report's conclusions, including a summary statement of Canada's fulfillment of the articles of the Convention. It also summarizes:

- progress on addressing the challenges and suggestion identified for Canada at the Seventh Review Meeting, and the challenges that remained from the Sixth Review Meeting
- safety improvements and progress on other important issues not covered by the challenges identified for Canada

- measures that addressed the VDNS

Chapter III includes detailed material that demonstrates how Canada implemented its obligations under articles 6 to 19 of the Convention during the reporting period. Chapter III is subdivided into four parts that correspond to the subdivision of the Convention articles:

Part A General provisions (article 6)
Part B Legislation and regulation (articles 7 to 9)
Part C General safety considerations (articles 10 to 16)
Part D Safety of installations (articles 17 to 19)

The sections for each article begin with a grey box that contains the text of the relevant article of the Convention. The term “Contracting Party” in an article refers to each signatory to the Convention. For each article, the description of Canada’s provisions to fulfill the relevant obligations is organized in sub-articles that follow the structure and numbering of the obligations as presented in the article itself. Where a breakdown into finer subsections is used, lowercase letters have been appended to the article or sub-article numbering, for reference purposes (e.g., subsection 8.1(a)).

The challenges and suggestion identified for Canada at the Seventh Review Meeting and those that remain from the Sixth Review Meeting are highlighted in boxes near the beginning of the relevant discussion.

There are two bodies of supplementary information at the end of the report: appendices and annexes. The appendices (identified by letters A through E) provide detailed information that is relevant to more than one article. The annexes, on the other hand, provide supplementary, specific information that is directly relevant to the manner in which Canada fulfills a particular article or sub-article. Each annex’s number corresponds to the number of the article, sub-article, or subsection to which the annex is relevant.

The full text of previous Canadian reports, the Canadian report to the Second Extraordinary Meeting and related documents can be found on the websites of the CNSC and the IAEA. This ninth Canadian report will be available on the IAEA website upon submission in August 2022 and will be posted to the CNSC website in late 2022 or early 2023, in both of Canada’s official languages (English and French). The annual CNSC staff reports on the regulatory oversight of Canadian NPPs and other facilities, as well as the annual reports of the CNSC, can also be found on the CNSC website.

B. Outcome of the Seventh Review Meeting and the Eighth Review Cycle

The following table lists the challenges (C) and suggestion (S) identified for Canada at the Seventh Review Meeting and, as determined at the Seventh Review Meeting, those that remained open from the Sixth Review Meeting. (These were documented in Canada’s Country Review Report for the Seventh Review Meeting, which is available on the CNSC website.) The table also lists the good practice (GP) and good performances (gp) that were identified for Canada at the Seventh Review Meeting. Cross-references to the relevant subsections of this ninth Canadian report are provided. Proposed challenges, good practices and good performances from the eighth review cycle are not included as they are not yet confirmed at a review meeting.

Table 2: Major review results for Canada from the Seventh Review Meeting

Identifier	Text	Subsection
Remaining challenges from Sixth Review Meeting		
6RM C-3	Establish guidelines for the return of evacuees post-accident and to confirm public acceptability of it	16.1(a)
6RM C-5	Update emergency operational interventional guidelines and protective measures for the public during and following major and radiological events	16.1(a)
Challenges from Seventh Review Meeting		
7RM C-1	Publish the drafted amendments to the *Class I Nuclear Facilities Regulations* and the *Radiation Protection Regulations* that address lessons learned from Fukushima	7.2(i)(a)
7RM C-2	Complete the transition to the improved regulatory framework (CNSC regulatory documents)	7.2(i)(b)
7RM C-3	Formalize the planned approach to end-of-operation of multi-unit NPPs	7.2(ii)(e)
Suggestion from Seventh Review Meeting		
7RM S-1	Canada should address any CANDU safety issues that are Category 3 referenced in the 7th national report and provide a report to the 8th RM	14(i)(e)
Good practice from Seventh Review Meeting		
7RM GP-1	CNSC's Participant Funding Program, which fosters openness and transparency and increases safety by providing additional information to the Commission	8.1(f)
Good performances from Seventh Review Meeting		
7RM gp-1	Documenting CNSC requirements and expectations in a single REGDOC	7.2(i)(b)
7RM gp-2	Use of CNSC discussion papers early in regulatory process	7.2(i)(b)
7RM gp-3	CNSC's Inspector Training and Qualification Program	8.1(c)
7RM gp-4	CNSC's vendor design review for new innovative designs (e.g., SMRs)	18
7RM gp-5	CNSC 's Independent Environmental Monitoring Program (IEMP) with on-line results	15(c)
7RM gp-6	NPP licensees' use of simulators, dynamic learning activities and mock-ups for refurb training	11.2(a)
7RM gp-7	NPP licensees' outreach activities	9(c)

Identifier	Text	Subsection
7RM gp-8	International weekly screening committee (COG utility members) to share OPEX	19(vii)

For the planned Eighth Review Meeting, Canada was part of Country Group 4, which also included Japan, Hungary, Armenia, Lithuania, Indonesia, Madagascar, Norway, Saudi Arabia, North Macedonia, Bahrain, Denmark and Benin. During the eighth review cycle, Canada responded to 143 comments and questions from numerous countries. These comments and questions pertained to topics such as safety culture of the licensee and the regulator, design improvements at the NPPs, new build projects (especially SMRs), dose limits and CNSC inspections. A Good practice was also proposed for Canada's use of licence conditions handbooks.

C. National nuclear framework and policy

C.1 General framework

Under Canada's constitution, the development and implementation of nuclear energy policy fall within the federal government's jurisdiction. The Government of Canada's role encompasses research and development (R&D), as well as the regulation of all nuclear materials and activities in Canada. Canada's nuclear policy framework includes the following general elements: a nuclear non-proliferation policy, transparent and independent regulation, a radioactive waste policy framework, a uranium ownership and control policy, support for nuclear science and technology, and cooperation with provincial governments and municipal jurisdictions. The Government of Canada has funded nuclear research and supported the development and use of nuclear energy and related applications for many decades. The first NPP in Canada began operation in 1962. Today, the Government of Canada provides approximately $77 million in yearly government appropriations for nuclear-related R&D activities through the Federal Nuclear Science and Technology (FNST) Work Plan.

In addition to yearly funding, the Government of Canada has also agreed to provide nearly $100 million in direct investment to the nuclear industry since 2020 through the Strategic Innovation Fund and Atlantic Canada Opportunities Agency. The Strategic Innovation Fund is the federal government's main funding mechanism for SMR research, development and demonstration projects, and provides funding (minimum of $10 million in total funding for each project) for large, transformative and collaborative projects that position Canada to prosper in the knowledge-based economy. Additional funding for SMR-related projects has been provided by the Atlantic Canada Opportunities Agency.

See appendix D for a description of nuclear R&D that is funded by these and other sources, including private investment.

In addition, in December 2020, the Government of Canada announced the creation of the Net Zero Accelerator, to provide $3 billion over five years through the Strategic Innovation Fund to rapidly expedite decarbonization projects with large emitters, scale up clean technology and accelerate Canada's industrial transformation across all sectors. The Government of Canada's 2021 budget included an additional $5 billion in funding for the Net Zero Accelerator, for a total program size of $8 billion over seven years. SMR projects are eligible to receive funding through the Net Zero Accelerator.

Although the Government of Canada has important responsibilities related to nuclear energy, the decision to invest in electricity generation rests with each province. It is up to each province, in concert with the relevant provincial energy organizations and power utilities, and regulatory bodies, to determine whether or not NPPs should be built and operated.

Nuclear energy is an emissions-free energy source that is recognized as a reliable and cost-competitive contributor to Canada's 81% decarbonized electricity mix, supporting climate change mitigation. The Canadian nuclear energy sector is a very important component of Canada's economy.

- In 2020, nuclear energy supplied about 15% of Canada's electricity.
- In the province of Ontario, approximately 57% of electricity production comes from NPPs.
- In the province of New Brunswick, the NPP at Point Lepreau is the source of energy for more than one third (39%) of the in-province (non-exported) energy requirements
- Canada Deuterium Uranium (CANDU) reactors have been built and operated in several countries besides Canada, including three in operation in South Korea, two in China, two in Romania and one in Argentina.
- Pressurized heavy-water reactors based on early CANDU technology are also in operation globally, including two in India and one in Pakistan.

Canada is a top producer of uranium, although production was reduced significantly in 2020 as a result of the COVID-19 pandemic. Production for 2020 was 3,878 tonnes of uranium metal (tU), a 45% reduction from the 6,996 tU produced in 2019, and approximately 8% of the total world production in 2020.

Canada is also a major supplier of medical isotopes; developments related to the production of isotopes at NPPs are described in section D.5.

Although the Government of Canada does not have a specific policy for SMRs, it recognizes their potential and is actively engaging stakeholders to help assess priorities and challenges and inform policy regarding the development and deployment of SMRs in Canada. In addition to the funding noted above, NRCan is bringing together essential enabling partners for the possible private sector deployment of SMRs. During the previous reporting period, NRCan began the SMR Roadmap process to better understand stakeholder's views on priorities and challenges related to the possible development and deployment of SMRs in Canada. The report was released in November 2018 with 53 recommendations for all key enablers, including the federal government, provinces and territories, municipalities, Indigenous peoples, power utilities, industry, innovators, laboratories, academia, and civil society. See the eighth Canadian report for additional details.

Following from the SMR Roadmap, Canada's SMR Action Plan was launched on December 18, 2020. Each of the key enablers contributed a chapter to the Action Plan that describes a concrete set of actions they are taking. The Action Plan responds to all 53 SMR Roadmap recommendations and includes voluntary actions that go beyond the recommendations. It complements and highlights ongoing work to develop and deploy SMRs in Canada and internationally by showcasing the over 500 actions being undertaken by a diverse range of stakeholders to seize Canada's SMR opportunity, as well as the alignment between government and partners.

In March 2022, four Canadian provinces (Alberta, Saskatchewan, Ontario, and New Brunswick) released a joint provincial strategic plan aimed at expanding the use of nuclear power using SMRs. It called for continued support to develop three types of SMRs, the regulatory framework, a waste management plan, opportunities for Indigenous participation and public engagement and cooperation with federal authorities.

Details on specific SMR projects are provided section D.4. The CNSC's preparations for the regulation of the potential deployment of SMRs are described in article 8.

Canada's entire nuclear industry, including power generation, contributes approximately $17 billion a year to the gross domestic product, employing approximately 76,000 highly skilled workers.

C.2 Responsibilities for national nuclear policy and regulation

The Government of Canada places high priority on health, safety, national security and the environment in relation to nuclear activities in Canada along with the implementation of Canada's international commitments on the peaceful use of nuclear energy. The Government of Canada has established a comprehensive and robust regulatory regime implemented by Canada's independent nuclear regulator: the CNSC.

Other major federal government departments involved in the Canadian nuclear sector include:

- Natural Resources Canada (NRCan), which:
  - establishes, develops and implements Canadian government policy on nuclear energy, providing advice on energy policy, as well as institutional, legislative and financial frameworks for the nuclear industry in Canada and policy direction for related international activities (e.g., regulatory harmonization)
  - administers the *Nuclear Energy Act*, the *Nuclear Liability and Compensation Act* and the *Nuclear Fuel Waste Act*
  - has overall responsibility for managing historic radioactive wastes for which the Government of Canada has accepted responsibility
  - is responsible for the *Nuclear Safety and Control Act* (NSCA), which establishes and is administered by the CNSC

- Public Safety Canada, which is the lead authority for the all-hazards Federal Emergency Response Plan

- Health Canada, which:
  - establishes radiological protection guidelines, performs research on radiation health effects and undertakes radiological health assessments
  - operates a national environmental radiation monitoring network
  - monitors occupational radiological exposures and operates the National Dose Registry for all occupationally-exposed workers in Canada
  - is responsible for the Federal Nuclear Emergency Plan, an event-specific annex to the Federal Emergency Response Plan, and provides a radiological monitoring and assessment capability for nuclear emergency response

    - serves as competent authority for the *Convention on Early Notification of a Nuclear Accident* and the *Convention on Assistance in Case of a Nuclear Accident or Radiological Emergency*

- Transport Canada, which:
    - develops and administers policies and regulations for the Canadian transportation system, including the transportation of dangerous goods (radioactive materials are included in Class 7 of the *Transportation of Dangerous Goods Regulations*).
    - regulates the international transportation of dangerous goods by the air and marine modes

- Environment and Climate Change Canada (ECCC), which:
    - ensures a clean, safe, and sustainable environment for present and future generations
    - preserves, enhances, and protects the natural environment (water, air, soil, flora, and fauna, species at risk, and migratory birds)
    - reviews nuclear project proposals and technologies as an authority under the *Impact Assessment Act* and its predecessor legislation
    - provides specialist and expert information on environmental matters related to its mandate, including water and air quality, migratory birds, species at risk and ecological assessment

- Global Affairs Canada, which:
    - is responsible for Canada's nuclear non-proliferation policy, including bilateral and multilateral nuclear cooperation
    - has overall responsibility for the negotiation, signing and ratification of international agreements, including those on nuclear safety

- Impact Assessment Agency of Canada, which:
    - is responsible for administering the *Impact Assessment Act* (see subsection 7.1(b))

Various memoranda of understanding exist between the CNSC and other organizations involved in the nuclear industry, such as the organizations in the above list.

The NSCA, the *Nuclear Energy Act*, the *Nuclear Fuel Waste Act* and the *Nuclear Liability and Compensation Act* are the centrepieces of Canada's legislative and regulatory framework for nuclear matters. The NSCA is the key piece of legislation for ensuring the safety of the nuclear industry in Canada. These acts are complemented by other legislation that provides emergency management, environmental protection and worker protection, such as the *Emergency Management Act*, the *Impact Assessment Act*, the *Canadian Environmental Protection Act* and the *Canada Labour Code*.

Atomic Energy of Canada Limited (AECL) is a Crown corporation of the Government of Canada with a mandate to enable nuclear science and technology for the benefit of Canadians and industry, and to fulfill Canada's radioactive waste and decommissioning responsibilities. It utilizes a government-owned, contractor-operated model for its nuclear laboratories. AECL contracts Canadian Nuclear Laboratories (CNL) to provide science and technology to meet core federal needs through the FNST Work Plan (see appendix D.4 for details), and to support the nuclear industry through access to science and technology facilities and expertise on a commercial basis. In addition, AECL retains ownership of the nuclear laboratories' physical and intellectual property assets and liabilities. AECL's infrastructure and the expertise brought by

CNL are strategic elements of Canada’s science and technology capabilities, bringing unique abilities that benefit Canadians and the nuclear sector.

To ensure that CNL has the facilities and infrastructure needed to continue to be a hub for nuclear innovation in Canada, the Government of Canada started investing $1.2 billion for a ten-year period (which began in 2014-15); in the revitalization of Chalk River Laboratories. These investments support the renewal and revitalization of the Chalk River site to serve the needs of the Government of Canada and commercial customers.

Revitalization activities address two main areas:

- New and renewed science infrastructure – These investments are part of a longer-term plan to revitalize the Chalk River site and construct new and renewed science facilities to build a modern, world-class nuclear science and technology campus that serves the needs of government and industry.
- Site support infrastructure – Immediate investments will renew aging infrastructure systems and facilities at the Chalk River site, such as potable water, storm sewer, sewage treatment, electrical systems and other utilities. These investments are necessary to have a site that is responding to the most recent regulatory and health, safety, security, and environmental requirements, as well as to maintain a cost-efficient and reliable site that is viable for the future.

The planning and detailed design activities related to the construction of the Advanced Nuclear Materials Research Centre are currently underway, while the demolition of outdated buildings and construction of new non-nuclear new-build structures are ongoing.

Canada has signed and ratified seven other multilateral, nuclear-related treaties and conventions, including the:

- *Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management*
- *Convention on the Physical Protection of Nuclear Material, and its 2005 Amendment*
- *International Convention for the Suppression of Acts of Nuclear Terrorism*
- *Convention on Early Notification of a Nuclear Accident* (see subsection 16.2(b))
- *Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency* (see subsection 16.2(b))
- *Convention on Supplementary Compensation for Nuclear Damage*
- *Treaty on the Non-Proliferation of Nuclear Weapons*

Canada continues to enhance its international cooperation and assistance to improve nuclear safety worldwide, through cooperation with international partners. Canada is actively involved in the IAEA and fully supports IAEA peer review missions, including those of the International Regulatory Review Service (IRRS) and Emergency Preparedness Review (EPREV) service. To support continuous assessment and improvement, Canada hosted review missions for both the IRRS (in September 2019; see article 8) and EPREV (in June 2019; see section 16.1(g)). Canada has also invited a follow-up EPREV mission (scheduled for June 2023). Canada also contributes to the development of international standards through participation on the IAEA Commission on Safety Standards and its committees.

Canada is actively involved with a number of other international organizations and fora, including the International Nuclear Regulators Association, the IAEA’s CANDU Senior

Regulators Group, the Nuclear Energy Agency (NEA) of the Organization for Economic Co-operation and Development (OECD) and the G7's Nuclear Safety and Security Group. Involvement in these groups allows Canada to influence and enhance nuclear safety from an international perspective and to exchange information and experience with regulatory and other organizations. Details on the CNSC's participation in these groups are provided in subsection 8.1(g). Canada is also a participant in the Generation IV International Forum (see appendix D.6).

During the reporting period, Canada also continued its active engagement in areas related to environmental protection and emergency preparedness and response, through support to the IAEA Technical Cooperation Fund, and by participating in international technical working groups.

D. Nuclear power industry and major activities

D.1 Nuclear power industry in Canada

The locations of NPPs within Canada are shown in the partial map below (only 6 of Canada's 10 provinces are shown). Of the 22 nuclear power reactor units in Canada, 19 are currently producing power. However, at various points during the reporting period, Units 2 and 3 at Darlington, and Unit 6 at Bruce, were shut down for refurbishment activities. More details can be found in section D.2. In addition, two units at Pickering and the one unit at Gentilly-2 are in a safe storage state. The Gentilly-2 unit is moving toward decommissioning (see subsection D.3). The operation and activities of these reactors are governed by five licences issued by the CNSC to four organizations:

- Ontario Power Generation Inc. (OPG), a commercial company wholly owned by the province of Ontario
- Bruce Power Inc. (Bruce Power), a private corporation
- Hydro-Québec, a Crown corporation of the province of Quebec
- NB Power, a Crown corporation of the province of New Brunswick

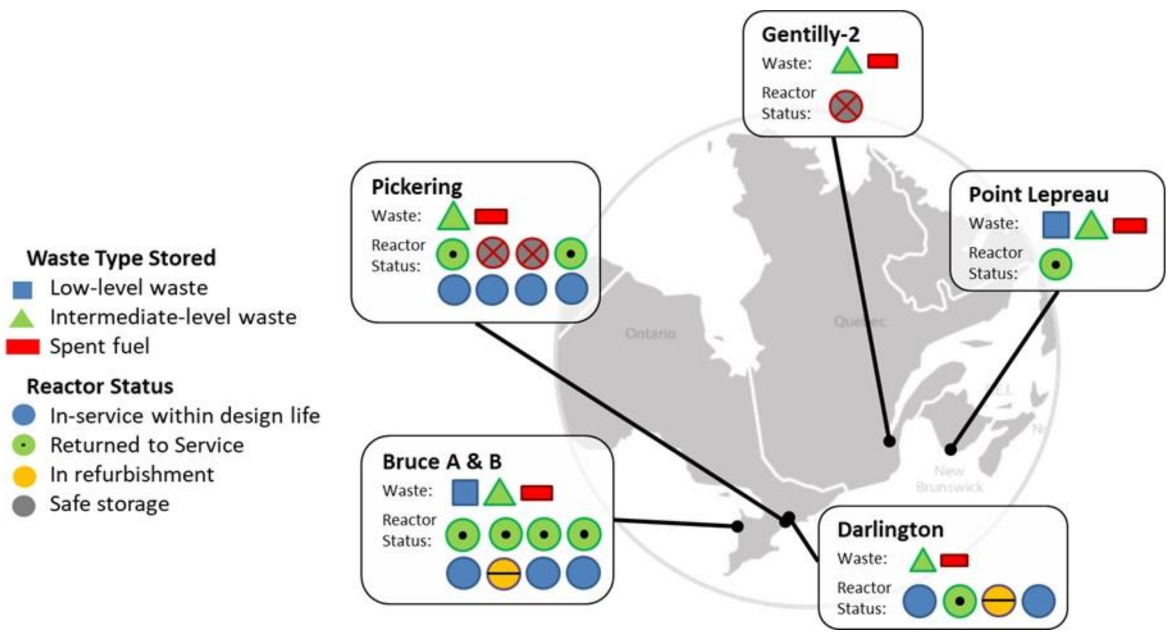


Figure D.1 Partial map of Canada showing the locations of NPPs

Table 3: Number of reactors at each licensed site (and their status during reporting period)

Licensed NPP site	Province	Licensee	Number of reactors	Operating status of reactors
Bruce A and B	Ontario	Bruce Power	8	All operating (1 under refurbishment
Darlington	Ontario	OPG	4	All operating (2 under refurbishment at different times)
Gentilly-2	Quebec	Hydro-Québec	1	Safe storage state
Pickering	Ontario	OPG	8	6 operating, 2 in safe storage state
Point Lepreau	New Brunswick	NB Power	1	Operating

Figure D.2 shows the main historical periods of operation for the NPPs in Canada. From 1998 to 2003 Bruce A was shut down and placed in a layup state to accommodate a very large surplus capacity of electricity in the province of Ontario. Other long periods of non-operation correspond to extended outages, such as for refurbishment.

Figure D.3 shows recent, current, and planned retirements of the operating NPPs.

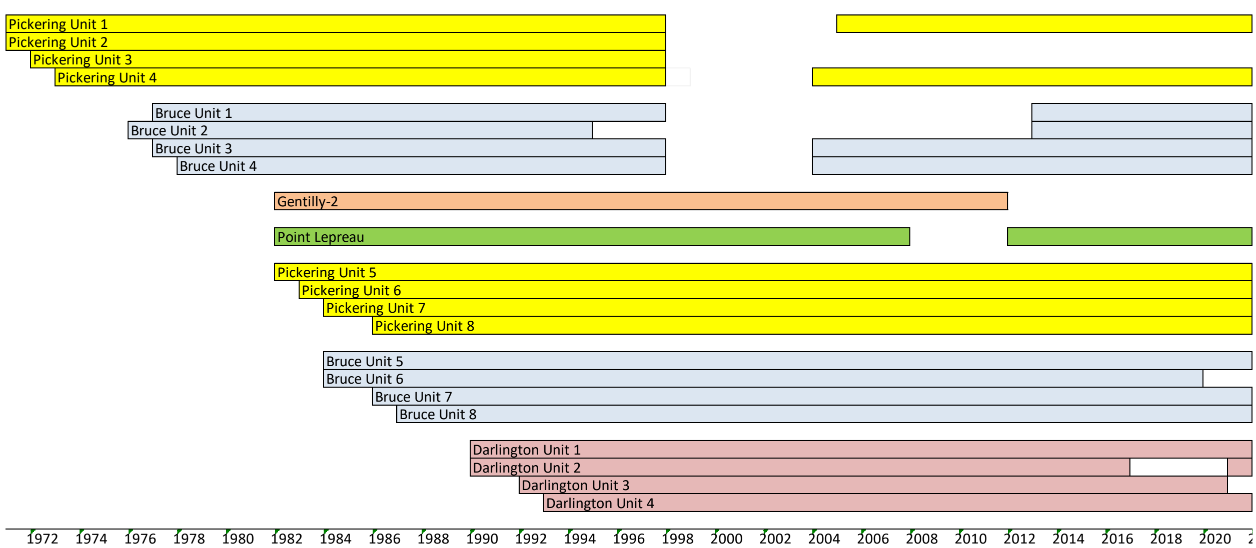


Figure D.2 Timeline of NPPs in Canada

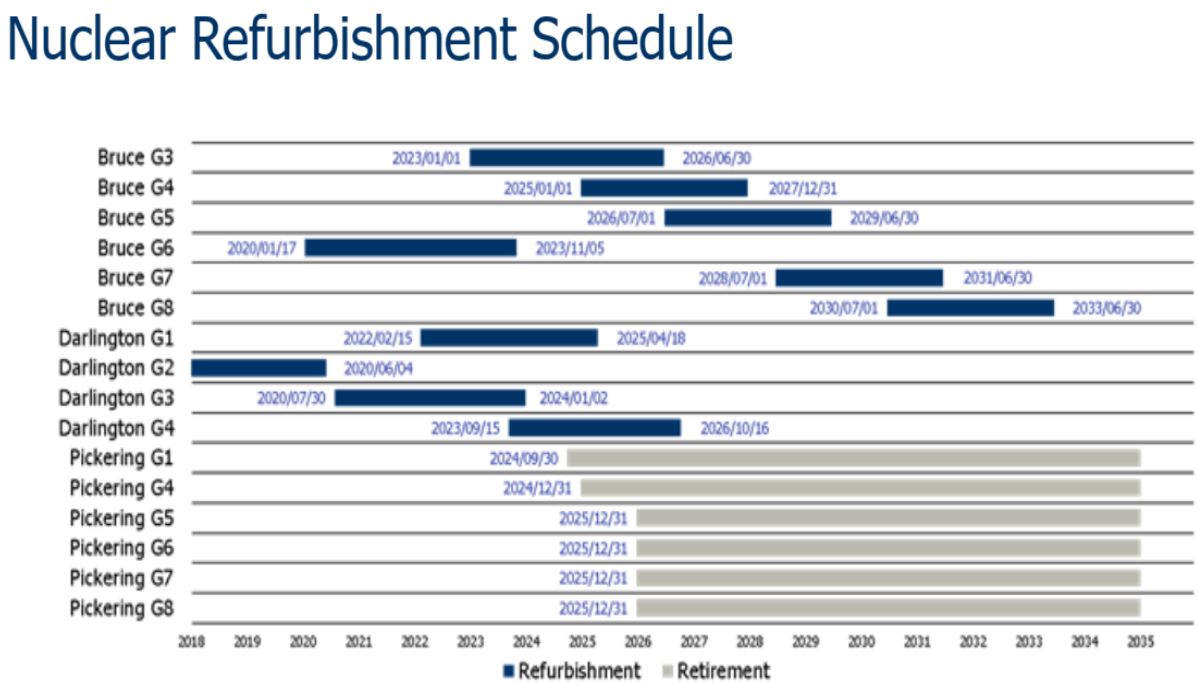


Figure D.3 Nuclear refurbishment schedule

Appendix B provides additional basic information on all NPP units in Canada.

The NPPs in Canada use pressurized heavy-water reactors of the CANDU design (originally developed through a partnership between AECL, Ontario Hydro and GE Canada). Candu Energy now acts as the original designer and vendor of the CANDU technology in Canada. Candu Energy is part of SNC-Lavalin Nuclear, whose activities are described in various parts of this report. Besides Canada, there are 6 other countries with CANDU reactors in operation. Additional information on Candu Energy's CANDU reactor designs is provided in appendix D.3. A full description of CANDU reactors was provided in the first and second Canadian reports.

All CANDU operators in the world (including licensees of operating Canadian NPPs) and CNL are members of the CANDU Owners Group (COG): a not-for-profit organization that provides programs for cooperation, mutual assistance and exchange of information for the successful support, development, safe operation, maintenance and economics of CANDU technology. While membership is restricted to organizations owning or operating a CANDU reactor, suppliers and engineering organizations involved in the design, construction and operation of CANDU reactors are eligible for participation in specific programs. COG also operates a supplier participant program that is open to all suppliers of goods and services to the Canadian nuclear industry. The program has expanded over the past few years to include over 30 supplier participants and has recently welcomed international suppliers as well. COG is described further in sub-article 9(c).

Through COG, the nuclear industry provides approximately $60 million on base R&D programs (described in appendix D.2) and related joint projects that support operating NPPs in Canada. COG has also established the Nuclear Safety Peer Group, which meets regularly to:

- share information on regulatory interactions, strategies and approaches to resolving common issues

- identify, screen and prioritize nuclear safety and licensing issues suitable for industry collaboration
- authorize industry task teams to define unified positions and/or common approaches, and undertake technical reviews, assessments, and safety analyses
- monitor progress on issue resolution and address barriers and constraints
- coordinate industry interaction with the CNSC on industry positions, industry work programs and action item closure criteria, consistent with an agreed protocol

D.2 Life extension of existing NPPs

Several existing CANDU NPPs have undergone major life-extension projects. Currently, life extension is being pursued or considered for many of the reactor units at the Canadian NPPs and abroad. Life extension includes R&D, engineering, analysis and other fitness-for-service activities to support extended operation of structures, systems and components (SSCs) beyond their assumed design life, as well as the refurbishment of components. Life extension activities are identified through a periodic safety review (PSR)[2] and documented in an integrated implementation plan (IIP). CANDU refurbishment typically involves replacement of major reactor components (e.g., fuel channels), along with replacements of or upgrades to other safety-significant systems. Depending on the circumstances, a refurbished reactor with replaced fuel channels could operate for approximately an additional 30 or more years.

Life-extension is being carried out for Bruce A and B, Darlington and Pickering, in coordination with the Independent Electricity System Operator of the Province of Ontario. Each NPP has a condition in its licence to operate that requires the licensee to complete the IIP.

Bruce A and B refurbishment

The Bruce Power Life Extension Program consists of two major parts. The first part is asset management, which involves the maintenance, refurbishment or replacement of equipment during regular maintenance outages to ensure that systems are in good condition until end-of-life. The second part is a set of major component replacement (MCR) outages, during which each reactor is defueled and drained to accommodate the replacement of major components such as fuel channels, feeder tubes and steam generators, along with other equipment that can be replaced only under such conditions. Bruce Power determined the scope of the MCR outages through a PSR conducted for Bruce A and B.

The asset management portion of life extension began on January 1, 2016 and will continue through 2053. The MCR outages began with Unit 6 in January 2020 and will be followed by Unit 3 in early 2023; the activities carried out during these outages will extend the lives of Units 3 to 8 over a period of 13 years. Bruce A Units 1 and 2 were fully refurbished earlier and were returned to service in 2012. Asset management and MCR outages will allow Bruce Power's units to operate safely through to 2064.

Darlington refurbishment

OPG's refurbishment project at Darlington began with Unit 2 in October 2016, and continued through to June 2020. Completion assurance documents were provided to the CNSC to support

[2] In the past, these were also referred to as integrated safety reviews (ISRs), which were one-time applications of PSR for the purposes of life-extension projects.

removal of each of the Unit 2 "regulatory hold points" and demonstrate successful and safe return to service for Unit 2.

In September 2020, OPG started the lead-in refurbishment activities on Unit 3, with the majority of activities centering around preparing the unit for refurbishment, such as defueling and dewatering the reactor. Refurbishment of Unit 3 is estimated to take until the middle of 2023 to complete. OPG also commenced the refurbishment of Unit 1 in February 2022; at the end of the reporting period, two units were in the process of being refurbished. OPG continues to operate the Retube Waste Processing Building, which resumed volume-reduction activities in mid-2021, for wastes generated from refurbishment of its reactors (i.e., fuel channel end fittings, pressure tubes, and calandria tubes).

Pickering extended operation

Pickering Nuclear Generating Station's Units 1 to 4 (formerly known as Pickering A) were refurbished and returned to service in 2005 and 2003, respectively. In 2010, Units 2 and 3 were each placed in a safe storage condition, which involved defueling and dewatering the reactors, isolating these units from the operational part of the station (i.e., containment) and placing the units in a state that prevents start-up. Some Unit 2 and 3 systems remain operational, providing common system support to the operation of Units 1 and 4. Units 2 and 3 will be maintained in safe storage states until the entire NPP is shut down for eventual decommissioning.

OPG decided not to refurbish Pickering Units 5-8 (formerly known as Pickering B), which have fewer years of service than Pickering Units 1 and 4. OPG developed a sustainable operations plan for all operational Pickering Units (1, 4 and 5 to 8) for the approach to the end of commercial operation. During the previous reporting period, as part of the renewal of the licence to operate Pickering, OPG obtained authorization from the Commission to operate up to December 31, 2024 followed by a transition to safe storage by the end of the licence period (2028). OPG is required to inform the CNSC prior to December 31, 2022 of an intent to operate any unit beyond 2024.

See the introduction in the eighth Canadian report for a more detailed history of the planning and developments related to the approach to the end of service life of Pickering.

In August 2019, OPG evaluated its shutdown sequence and identified that extending commercial operation of Pickering Units 5-8 to December 2025 would allow the facility to further optimize the shutdown and safe storage in a safe and effective manner. In support of extending commercial operation for Units 5-8, OPG will reassess the PSR to confirm that the design, condition and operation of Pickering supports an additional year of commercial operation. A formal submission requesting the operational extension will be provided to the CNSC and will require approval from the Commission.

D.3 Transition to decommissioning of Gentilly-2

In December 2014, Hydro-Québec completed work to stabilize operations and activities to transition Gentilly-2 to the safe storage state. During the reporting period, Gentilly-2 was in the dormancy and fuel transfer phase, planned from 2015 to 2020. Activities consisted of completion of the transfer of spent fuel stored in the irradiated fuel bay to the dry storage facility at the NPP's secure site. Two additional storage units were built to store all the spent fuel that was in the bay. In December 2020, Gentilly-2 completed the transfer of all its irradiated fuel into

CANSTOR modules for dry safe storage. Other main activities planned for this phase are the establishment of a program for preventive maintenance; aging management of SSCs; and environmental monitoring. The fuel will remain on the Gentilly-2 site until Hydro-Québec begins transferring it, in 2048, to the site identified by Canada's Nuclear Waste Management Organization. The transfer to this site is planned for completion in 2062. Hydro-Québec foresees that the NPP will be dismantled between 2057 and 2062, and that restoration of the site will be completed by 2064 followed by environmental monitoring between 2064 and 2074.

In light of the progress of this transition, Gentilly-2 is now fully subject to the peer review conducted under the *Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management*. Thus, Gentilly-2 is largely excluded from the peer review associated with the CNS.

D.4 New-build developments

This section briefly describes projects at the planning or development stages, as well as two projects that have reached the licensing stage. The two new-build projects at the licensing stage are the Darlington New Nuclear Project (DNNP) and the SMR project at Chalk River. They are part of the joint provincial strategic plan for SMRs, described above. In addition to the background information that follows for those projects, specific measures taken by the CNSC and licensees/applicants with respect to new-build projects are described in subsection 7.2(i)(c) and sub-article 17(ii).

During the reporting period, development work also progressed on other SMR projects and other aspects of Canada's SMR Action Plan. The Strategic Innovation Fund provided funding to two SMR vendors to progress their designs toward eventual licensing. The Atlantic Canada Opportunities Agency provided funding to another SMR vendor, as well as to NB Power and the University of New Brunswick to enhance SMR readiness. Bruce Power was also involved in feasibility studies for SMRs. See appendix D.3.2 for additional information on those projects.

Darlington New Nuclear Project

In August 2012, the Commission issued OPG a 10-year licence to prepare a site for the DNNP. In subsequent years, OPG pursued several work activities with long-lead-times to fulfill OPG's commitments made during the environmental assessment (term used when the *Canadian Environmental Assessment Act, 2012* was in force) and licensing process. In October 2021, the Commission renewed OPG's licence to prepare site for a 10-year term. In December 2021, OPG announced it would be working with GE Hitachi Nuclear Energy to deploy an SMR at the DNNP site, using the BWRX-300 design. OPG intends to submit an application in 2022 for a licence to construct.

SMR Development at Chalk River

In March 2019, Global First Power submitted an application for a licence to prepare site for an SMR on AECL's property at Chalk River Laboratories. The project involves the deployment of a 15MW(th) high-temperature gas-cooled reactor using the Micro Modular Reactor (MMR ™) technology developed by Ultra Safe Nuclear Corporation. The project is currently undergoing regulatory review and an environmental assessment. The project is expected in commence operation in 2026, following receipt of all required CNSC licences.

D.5 Medical isotope production

The unique design of CANDU reactors allows for the production of medical isotopes, along with electrical energy production. Canada's nuclear technology sector has enabled healthcare providers to improve cancer therapy and diagnostic techniques, as Canada is a major supplier to the world market for medical and industrial isotopes (i.e., cobalt-60 (Co-60) and cesium-137).

Co-60 isotopes are currently being produced at various CANDU units. Sterilization Co-60 is the first and most widely used type of Co-60. It is employed by the healthcare industry to sterilize medical devices such as sutures, gloves and syringes. Bruce Power and OPG have produced sterilization-grade Co-60 at Bruce and Pickering, respectively, for many years.

Medical-grade Co-60 is used worldwide to battle cancer and to treat complex brain conditions by using radiation therapy. Four units at Bruce have been producing medical grade Co-60 since 2018.

To support the long-term production and supply of Co-60 to the medical and other industries, OPG also initiated the Co-60 production modifications project in 2021 with the objective of completing the detailed design of the site modifications, equipment and tooling, procurement and installation to enable Co-60 production at Darlington. The Darlington site modifications will include the replacement of the 16 in-core stainless steel adjuster rods with Co-59 (inactive) adjuster rods to be placed in operation for their activation to Co-60. The Co-60 adjuster rods will then be removed during an appropriate planned outage and transported in a shielded flask and discharged into the wet cask handling bay for storage, processing and shipment off site. This ongoing project involves several companies supporting OPG and Nordion. The design portion is currently targeted for completion in 2022.

In addition, NPP operators in Canada continue to look for innovative means to produce a broad range of isotopes.

In 2018, OPG entered partnership with BWX-Technologies (BWXT) to produce molybdenum-99 (Mo-99) at Darlington for the medical community. Mo-99 decays to technetium-99^{m} (Tc-99^{m}), which is an important medical diagnostic isotope. Approximately 80% of nuclear medicine procedures use Tc-99^{m} for heart, cancer and bone diagnostic scans. Over the years, the traditional Mo-99 supply has encountered numerous challenges with unreliable production. The reliable production of Mo-99 by OPG will assure its long-term supply by using neutron capture of natural molybdenum targets, while reducing concerns related to nuclear proliferation and nuclear waste. OPG is targeting 2023 as its start date to produce Mo-99 at Darlington, which will make it the only supplier of Mo-99 in North America.

Lutetium-177 (Lu-177) is used in targeted radionuclide therapy to treat neuroendocrine tumours and prostate cancer while leaving healthy cells unaffected. In 2019, Bruce Power partnered with Isogen, a joint venture between Framatome and Kinectrics, to undertake a first-of-its-kind solution to enable production of Lu-177 by irradiating the stable isotope, ytterbium-176. This innovative project will utilize a made-in-Ontario isotope production system installed in Bruce Power's reactors through the course of the life extension program currently underway at Bruce. Bruce Power expects to begin supplying the world market with Lu-177 in 2022.

The licensing of new activities to produce medical isotopes at Darlington and Bruce is described in subsection 7.2 (ii) a.

E. *Vienna Declaration on Nuclear Safety*

The *Vienna Declaration on Nuclear Safety* (VDNS) was adopted by Contracting Parties to the CNS at a Diplomatic Conference held in Vienna on February 9, 2015. The declaration provides the following three principles for implementing the objective of the CNS (to prevent accidents and mitigate radiological consequences):

Principle (1) New NPPs are to be designed, sited and constructed, consistent with the objective of preventing accidents in the commissioning and operation and, should an accident occur, mitigating possible releases of radionuclides causing long-term offsite contamination and avoiding early radioactive releases or radioactive releases large enough to require long-term protective measures and actions.

Principle (2) Comprehensive and systematic safety assessments are to be carried out periodically and regularly for existing installations throughout their lifetime in order to identify safety improvements that are oriented to meet the above objective. Reasonably practicable or achievable safety improvements are to be implemented in a timely manner.

Principle (3) National requirements and regulations for addressing this objective throughout the lifetime of NPPs are to take into account the relevant IAEA safety standards and, as appropriate, other good practices as identified *inter alia* in the Review Meetings of the CNS.

Table 4: Details of how Canada fulfilled the VDNS found in the following articles or subsections of this report

Report section	VDNS Principle
Subsection 7.2(i)(c)	Principle (3)
Subsection 14(i)(f)	Principle (2)
Article 17	Principle (1)
Article 18	Principles (1), (2)
Sub-article 19(iv)	Principle (2)

Chapter II – Summary

Statement of compliance with articles of the Convention

Article 5 of the Convention requires each Contracting Party to submit a report on measures it has taken to implement each of the obligations of the Convention. This report demonstrates the measures that Canada has taken to implement its obligations under articles 6 to 19 of the Convention. Obligations under the other articles of the Convention are implemented through administrative activities and participation in relevant fora.

The measures that Canada has taken to meet the obligations of the Convention were effectively maintained and, in many cases, enhanced during the reporting period. These measures are implemented by regulatory and industry stakeholders who focus on nuclear safety, the health and safety of persons, and the protection of the environment.

General conclusions

There are 19 operating nuclear power reactors and three reactors in safe storage state in Canada; all are of the CANDU design and are spread across five sites. There are four sites – Bruce, Darlington, Pickering and Point Lepreau - that have a CNSC licence to operate. During the reporting period Hydro-Québec completed the transition to safe storage of Gentilly-2 and will be proceeding to decommissioning the NPP in accordance with a CNSC licence to decommission.

Canada’s nuclear industry has an excellent safety record spanning several decades at these sites. Nuclear-related activities at NPPs in Canada are governed by robust, modern and, in large part, technology-neutral legislation, with appropriate and well-defined powers to ensure that the NPPs remain safe. The legislation is complemented by regulations and other elements of the regulatory framework that are developed in consultation with stakeholders. Canadian NPP licensees collaborate on various projects to address safety issues and share operating experience, giving safety the highest priority at all levels of their organizations. Both the CNSC and the licensees make a strong commitment to nuclear safety on an ongoing basis and strive for continuous improvement.

Highlights

During the reporting period, all NPP licensees fulfilled their basic responsibilities for safety and their regulatory obligations. At all NPPs, the maximum annual worker doses were well below annual dose limits. In addition, the radiological releases from Canadian NPPs were less than 1 percent of the derived release limits. The licensees’ safety analyses, as described in the safety analysis reports, demonstrated adequate safety margins for all Canadian NPPs. The level of defence in depth also remained adequate during the reporting period for all operating NPPs. The reporting period was one of the safest and most efficient in the history of the Canadian nuclear power program. There were no serious process failures[3] and none of the safety-significant operational events that occurred at Canadian NPPs during the reporting period (see appendix C) posed a significant threat to persons or the environment. The licensees’ efforts to address these operational events were effective in correcting any deficiencies and preventing recurrence.

During the reporting period, the CNSC continued its progress in enhancing the regulatory framework – which included various regulatory documents relevant to existing NPPs and new-build projects, including emerging small modular reactor (SMR) technologies – and aligning the regulatory framework with international standards (as a minimum). Renewals of operating licences for NPPs were used to introduce new standards and requirements, with provisions for implementation of the new requirements over predefined time periods. During the reporting period, the practice of conducting periodic safety reviews (PSRs) on 10-year intervals, as a means of assessing and closing gaps with modern requirements, was also formalized for all operating NPPs. Licence renewal and PSR are described in Article 7.

CNSC's compliance activities, and assessments of licensees' safety performance are provided to the Commission and stakeholders annually in the *Regulatory Oversight Report for Canadian Nuclear Power Plants* (see subsection 7.2(iii)(b) for details). The results of the compliance program drive the CNSC's follow-up activities and inform regulatory program planning. During the recent reporting periods, the NPP licensees continued to demonstrate compliance with the vast majority of requirements and acted in an effective and timely manner to address non-compliances (which tended to be minor in nature).

As part of CNSC requirements, full-scale emergency exercises take place every three years to demonstrate the overall preparedness for a highly unlikely nuclear emergency, in addition to drills and exercises that are performed on a regular basis (see Article 16 for details). Canada also demonstrates a commitment to peer review and improvement, including the hosting of international review missions (discussed below) and participation as leaders and reviewers in missions to other countries.

The Commission conducts its regulatory business in public hearings and meetings and, where appropriate, it does so in communities where the regulated activities take place. Indigenous peoples and other members of the public can participate in most public proceedings via written submissions and/or oral presentations. Commission hearings and meetings can also be viewed as live webcasts, and transcripts of public hearings and meetings are also available. Webcasts are archived on the site for at least three months, and the transcripts are available for approximately two years after the session. Access to all Government of Canada Departmental Results Reports, including those of the CNSC, are available through proactive disclosure. In the next reporting period (2022) CNSC staff will be establishing foundations for the future increased availability of compliance and licensing data.

A number of common issues emerged from the CNS Country Group discussions during the 7th Review Meeting. A brief description related to those issues is provided here along with the references to the applicable sections of this report where these items are addressed.

Safety Culture

Canada continues to actively foster a healthy safety culture for individual as well as corporate safety performance. CNSC REGDOC-2.1.2, *Safety Culture*, sets out requirements and guidance for licensees to foster a healthy safety culture and for conducting safety culture assessments based on INPO/WANO 10 Traits of a Healthy Nuclear Safety Culture Framework (see Article 10 and subsection 13(a) for details). The CNSC also fosters regulatory safety culture and has conducted its own self-assessments. Further details are provided in Article 10.

International peer reviews

Canada continues to enhance its international cooperation and assistance to improve nuclear safety worldwide, through cooperation with international partners. Canada is actively involved in the IAEA and fully supports IAEA peer review missions, as well as WANO missions. Details on the hosting of missions to Canada from the IAEA's Integrated Regulatory Review Service (IRRS) and EPREV (Emergency Preparedness Review) service are provided in subsections 8.1(e) and 16.1(g), respectively.

Legal Framework and Independence of Regulatory Body

As noted above and detailed in Article 7, the legal framework for nuclear safety in Canada is comprehensive and robust, as well as responsive to changing needs. The CNSC is mature and well established. Well-developed systems for licensing, verification of compliance and enforcement are in place to control activity related to NPPs and to protect the health and safety of persons, the environment, and national security. The CNSC has *defacto* independence from licensees as well as from the government, but also takes additional steps to ensure it takes independent, well-informed actions and decisions, as described in Article 8.

Financial and human resources

The CNSC is financed by the Government of Canada through Parliamentary and statutory authorities. Included in the statutory appropriation is a revenue-spending authority, which allows the CNSC to spend licence fee revenue. Combined with the statutory ability to retain its own staff, this allows the CNSC to freely hire and train sufficient numbers of employees to carry out the necessary regulatory work. The licensee and other industry and governmental organizations are also well established and funded. These organizations and the CNSC have extensive programs for hiring, retaining, training and managing staff. See Articles 8 and 11 for details.

Knowledge management

Knowledge management and retention continue to be important focus areas for the NPP licensees. Various knowledge management and mitigations plans exist for critical and "at-risk" roles as described in subsection 11.2(b). Subsection 8.1(c) describes knowledge management provisions at the CNSC.

Supply Chain

In Canada, licensees are required to maintain effective supply chain management and procurement quality assurance programs that discover and mitigate the intrusion of counterfeit, fraudulent and suspect items (CFSIs) into their operations. Refer to subsection 13(b) for further details.

Managing the Safety of Aging Nuclear Facilities and Plant Life Extension

Canadian NPPs have well-developed aging management programs for structures, systems and components (SSCs) that are subject to degradation over time. These include inspections and assessments to ensure that all safety-significant SSCs are maintained within the defined safe operating limits. The licensees regularly review and update the programs and CNSC staff review the results of program activities. See subsection 14(ii)(b) for details. Several of the reactors at the NPPs have also undergone major life-extension projects. Life extension activities at an NPP are identified through a periodic safety review (PSR) and documented in an integrated implementation plan (IIP). See subsection D.2 of Chapter I for additional details.

Emergency Preparedness

Canada has a well-developed framework for emergency management with responsibilities that are appropriately shared and fulfilled by licensees, the CNSC, and federal and provincial governmental authorities. Well-developed emergency plans exist at all levels that are integrated and tested through drills and exercises. These activities drive continual improvements, as well as more formal reviews, such as the EPREV mission described above. Details are provided in Article 16. The licensees also maintain programs for accident management and have implemented improvements to address the lessons learned from Fukushima, as described in sub-article 19 (iv) and previous Canadian CNS reports.

Stakeholder Consultation and Communication

The CNSC has well-established and varied mechanisms for consultation with stakeholders, while continually striving to improve them. The CNSC has established the Participant Funding Program (PFP) to enable input and participation from the public and Indigenous nations and communities in Commission proceedings and decisions that otherwise might not be possible. The CNSC and licensees also have active outreach and disclosure activities and communicate with their range of stakeholders, using means tailored to the various audiences. During the reporting period, the CNSC and licensees also made significant progress to make documents and reports readily available online to members of the public. Details are provided in subsection 8.1(f) for the CNSC and subsection 9(c) for the licensees.

Other issues addressed during the reporting period are discussed below in Challenges and Suggestions assigned to Canada from previous review meetings.

Addressing the challenges and suggestion for Canada from previous review meetings

At the Seventh Review Meeting, Country Group 3 concluded that two of the challenges for Canada from the Sixth Review Meeting remained open, as well as identified three new challenges and one suggestion. Due to the COVID-19 pandemic, the Eighth Review Meeting was not conducted as originally scheduled. Therefore, two challenges and a suggestion dating back to the Sixth and Seventh Review Meetings remain open for Canada. The following describes the highlights of activities to address them.

CNS Challenge 6RM C-5: Update emergency operational interventional guidelines and protective measures for the public during and following major and radiological events

During the reporting period, Health Canada published the updated *Generic Criteria and Operational Intervention Levels for Nuclear Emergency Planning and Response*.

The primary purpose of this document was to provide updated guidelines for public protective measures (including exposure control, ingestion control, population monitoring and medical management as well as off-site emergency workers) and align them with the latest recommendations from the IAEA and International Commission on Radiological Protection (ICRP). See subsection 16.1(a) for further details.

The planned activities to address Challenge 6RM C-5 are complete. Canada recommends that this challenge be closed.

CNS Challenge 6RM C-3: Establish guidelines for the return of evacuees post-accident and to confirm public acceptability of it

In December 2020 Health Canada published the *Guidance on Planning for Recovery Following a Nuclear or Radiological Emergency*. It provides direction on establishing public acceptability of any measures taken during the recovery phase of an actual nuclear emergency, including the return of evacuees. The organizations managing the recovery phase will engage the affected communities to develop appropriate strategies that encompass revitalization, support, and compensation. Additional recovery phase measures at the federal level are given in the Federal Nuclear Emergency Plan (FNEP; see annex 16.1(e)).

The planned activities to address Challenge 6RM C-3 are complete. Canada recommends that this challenge be closed.

CNS Challenge 7RM C-1: Publish the drafted amendments to the *Class I Nuclear Facilities Regulations* and the *Radiation Protection Regulations* that address lessons learned from Fukushima

In 2017, the CNSC amended the *Class I Nuclear Facilities Regulations* and the *Radiation Protection Regulations* to address lessons learned from the Fukushima accident. See subsection 7.2 (i)(a) for further details.

The planned activities to address Challenge 7RM C-1 are complete. Canada recommends that this challenge be closed.

CNS Challenge 7RM C-2: Complete the transition to the improved regulatory framework (CNSC regulatory documents)

During the reporting period, the CNSC completed the transition to the improved regulatory framework for ongoing review, revision, and development of regulatory documents for existing NPPs and new-build projects, including SMR technologies. See subsection 7.2(i)(b) for further details.

The planned activities to address Challenge 7RM C-2 are complete. Canada recommends that this challenge be closed.

CNS Challenge 7RM C-3: Formalize the planned approach to end-of-operation of multi-unit NPPs

The regulatory process for end of commercial operation is set out in CNSC REGDOC-3.5.1, *Information Dissemination: Licensing Process for Class I Nuclear Facilities and Uranium Mines and Mills.* The CNSC requires the licensee to develop a plan for the facility’s end of operation that entails a smooth transition from shutdown to a stable state. The CNSC is applying this approach for Pickering – the only multi-unit NPP in Canada currently approaching the end of commercial operation – and documenting it in Pickering’s licence conditions handbook.

CNSC REGDOC-2.11.2, *Decommissioning* contains additional requirements and guidance for the preparation for decommissioning, including the facility’s transition from operation to decommissioning. See subsection 7.2(ii)(e) for further details.

The planned activities to address Challenge 7RM C-3 are complete. Canada recommends that this challenge be closed.

CNS Suggestion 7RM S-1: Canada should address any CANDU safety issues that are Category 3 referenced in the 7th national report and provide a report to the 8th RM

Category 3 CANDU safety issues (CSIs) are those identified as a concern in Canada where measures are in place to maintain safety margins but the adequacy of the measures needs to be confirmed. During the reporting period, no new Category 3 CSIs were opened.

The remaining Category 3 CSIs are separated into two groups. At the end of the reporting period, there were three CSIs remaining at Category 3 that are relevant to large-break loss of coolant accidents (LBLOCAs). CNSC accepted Bruce Power's request to recategorize them; the other licensees are following up accordingly. In addition, the licensees are also developing a composite analytical approach to address the LBLOCA CSIs. The other group of remaining Category 3 CSIs are referred to as non-LBLOCA issues; those two CSIs are related to computer code and model validation and high-energy line breaks. CNSC staff re-categorized the CSI related to code validation to Category 2 in 2020. The CSI related to high-energy line breaks remains at Category-3 only for Pickering Units 1 and 4. CNSC is monitoring results from enhanced inspections at Pickering as part of follow-up to the conditional re-categorization of that CSI.

The planned activities to address Suggestion 7RM S-1 were completed during the reporting period, and the few remaining Category 3 CSIs are nearing recategorization for all NPPs. As Canada always reports on CSI progress in its CNS reports, Canada recommends that this suggestion be closed.

Summary of measures that address the *Vienna Declaration on Nuclear Safety*

The 2015 *Vienna Declaration on Nuclear Safety* (VDNS) was adopted by the Contracting Parties to the CNS. It provides three principles for the implementation of the objective of the CNS to prevent accidents and mitigate radiological consequences.

Canada has demonstrated its fulfillment of the principles of the VDNS through the activities of the CNSC and licensees in all aspects of NPP operation (most details were provided in the seventh Canadian report). Specifically, the principles of the VDNS have been achieved through the following means.

Principles (1) and (3)

- The Canadian regulatory framework has been aligned with the IAEA safety standards, which themselves have been demonstrated to fulfill the principles of the VDNS. Revisions have been made to the Canadian regulations, regulatory documents and standards in response to the lessons learned from Fukushima and other operating experience. See Article 7 for additional details. This fulfills Principle (3) of the VDNS. Processes are in place to apply the regulatory framework for any new NPPs that may be site, built, and operated. This fulfills Principle (1) of the VDNS; details are provided in article 18.

Principle (2)

- The designs of existing Canadian NPPs, which are all CANDU reactors, include features that prevent accidents and mitigate impacts should an accident occur. In addition, actions by the CNSC and licensees have strengthened defence-in-depth and enhanced accident and emergency response (details are provided in article 16 and sub-article 19 (iv)). New reactors would meet the latest requirements for siting, design, and construction. See subsection 18 (i) for additional details.

- Licensees have implemented updated safety analyses and safety analysis reports that align with the requirements in revised CNSC regulatory documents. Also, licensees are meeting the safety goals associated with probabilistic safety assessments (PSAs). Details are provided in subsections 14 (i)(b) and 14(i)(c), respectively. Through verification of analysis, surveillance, testing and inspection, Canadian NPPs have been shown to meet design and safety requirements as well as the operational limits and conditions necessary for meeting the VDNS principles. Finally, considering the aging of Canada's fleet of reactors, NPP licensees have established and implemented rigorous aging programs with the objectives of preventing accidents and should one occur, mitigating possible releases of radionuclides (see subsection 14(ii)(b) for details).
- Integrated safety reviews for the refurbishment of specific NPPs have been completed. The CNSC and licensees have implemented PSRs on 10-year intervals, which will enhance the systematic adoption of safety-related improvements of NPPs as requirements evolve (see article 7 for additional details).

Summary of other safety improvements

In addition to addressing the remaining challenges and suggestion from the previous Review Meetings, numerous other safety improvements were made at the Canadian NPPs during the reporting period, including:

- refurbishment of Darlington Unit 2 and commencement of refurbishment of Unit 3
- replacement of major components (fuel channels, feeder piping and steam generators) in Bruce Unit 6
- installation of a passive containment filtered venting system at Bruce A and Bruce B
- diesel fire pump replacements, as well as installation of a portable heating, ventilation, air conditioning and filtration system for the secondary control area at Point Lepreau
- PSR update for Pickering's extended operation and IIP
- completion of PSR for Bruce A and B and asset management
- ongoing improvements to deterministic safety analysis
- completion of full-scope PSAs at all operating NPPs and methodology development for whole-site PSA

Detailed lists of modifications at Darlington, Pickering, Bruce A and B and Point Lepreau to respond to and mitigate beyond-design-basis accidents and severe accidents are provided in annex 18(i).

The majority of safety improvements planned for the next reporting period are associated with the refurbishment projects noted above, as the work continues on the units mentioned, and work begins on other units.

Chapter III – Compliance with articles of the Convention

Part A
General provisions

Part A of chapter III consists of article 6 – Existing nuclear power plants.

Article 6 – Existing nuclear power plants

> Each Contracting Party shall take the appropriate steps to ensure that the safety of nuclear installations existing at the time the Convention enters into force for that Contracting Party is reviewed as soon as possible. When necessary in the context of this Convention, the Contracting Party shall ensure that all reasonably practicable improvements are made as a matter of urgency to upgrade the safety of the nuclear installation. If such upgrading cannot be achieved, plans should be implemented to shut down the nuclear installation as soon as practically possible. The timing of the shut-down may take into account the whole energy context and possible alternatives as well as the social, environmental and economic impact.

6 (a) List of existing nuclear power plants

There are 19 operating nuclear power reactors in Canada as well as three reactors in a safe storage state; all are of the Canada Deuterium Uranium (CANDU) design and were in operation when the CNS came into force in Canada. They are situated at five sites, each with its own licence issued by the Canadian Nuclear Safety Commission (CNSC). Appendix B provides basic information on all the units at the Canadian nuclear power plants (NPPs).

6 (b) Justification of continued operation of Canadian nuclear power plants

General safety framework and overall description of safety evaluations

Activities related to NPPs in Canada are governed by robust, modern legislation, with appropriate and well-defined powers to ensure the NPPs remain safe. The key legislation is the *Nuclear Safety and Control Act* (NSCA), which is complemented by a system of regulations and other elements of the regulatory framework. The CNSC continues to update its regulatory framework and align it with international standards. The transparency of the regulatory process in Canada (see article 7) helps to keep the focus of regulatory decisions on the health and safety of persons and the protection of the environment. Public participation in the development of the regulatory framework and the licensing process helps to maintain this focus and keep stakeholders informed and engaged. The regulatory compliance program provides comprehensive assessments of the operating NPPs' safety performance against the regulatory framework and helps ensure all reasonable provisions are made to maintain the risk of existing NPPs at a reasonable level.

Canada's nuclear regulator, the CNSC, is mature and well established, as described in article 8. Articles 9 and 10 describe how the NPP licensees fulfill their responsibilities to safety, giving it high priority at all levels of their organizations.

The remaining articles in this report describe the many provisions that contribute to the safe operation of NPPs in Canada. The CNSC, NPP licensees and other industry members make a strong commitment to nuclear safety and strive to continuously improve it. This is evidenced by a willingness to engage in third-party evaluations, such as those done by the Integrated Regulatory Review Service (IRRS) of the International Atomic Energy Agency (IAEA) and the World Association of Nuclear Operators (WANO). The involvement of third-party expertise and participation in international fora and activities, such as the development of IAEA standards, strengthen these provisions.

Safety evaluations and improvements

The safety of all existing NPPs in Canada was fully reviewed during their initial licensing. The licensees’ safety analyses, as described in the safety analysis reports, demonstrate acceptable safety margins for all Canadian NPPs. Both the licensees and the CNSC have continued to conduct broad and updated assessments since then, including updates to the safety analysis reports and probabilistic safety assessments (PSAs). As explained in subsections 14(i)(c) and 14(i)(d), NPP licensees are also updating analyses and implementing new requirements for both deterministic safety analyses and PSAs.

In addition, NPP licensees conduct periodic safety reviews (PSRs) on a 10-year cycle. These exercises include comprehensive and systematic plant condition assessments against modern codes, standards and practices (see subsections 14(i)(b)). Supplemental safety assessments have also been conducted in response to significant events and national and international operating experience. (e.g., related to lessons learned from the Fukushima accident).

The licensees and the CNSC have also conducted many detailed verification activities in support of ongoing operations. The licensees limit the life of critical components (such as CANDU fuel channels) and implement aging management plans to help ensure ongoing safe operation. The licensees also perform thousands of tests of safety and safety-related systems each year to confirm their functionality and availability to meet the safety requirements. (See sub-articles 14(ii) and 19(iii) for more information on programs that verify safety and manage aging mechanisms on a continual basis.)

The CNSC oversees each NPP licensee on a regular basis throughout the lifecycle of a facility and conducts a very detailed assessment in conjunction with the renewal of the licence to operate. During the reporting period, none of the licences for the NPPs were renewed. The CNSC has used operating licence renewals to introduce new requirements for NPPs – for example, the new requirements for deterministic safety analysis and PSA mentioned above. See subsection 14(i)(a) for information on licence renewal assessments and subsection 7.2(ii)(d), under “Licence renewals and updates to the licensing basis” for information on the implementation of new requirements.

Licensees have implemented safety upgrades on a continual basis to maintain safety margins and have incrementally enhanced safety at their sites (see annex 18(i) for examples). Licensees’ PSRs identify safety improvements that are reflected in integrated implementation plans (IIPs). See subsection 14(i)(b) for the results of the licensees’ PSRs.

Canada has committed to fulfilling the 2015 *Vienna Declaration on Nuclear Safety* (VDNS), which provides principles for implementing the Convention’s objective: to prevent accidents and mitigate radiological consequences. Details of the VDNS’s principles are provided in section E of chapter I.

Principle (2) of the VDNS requires comprehensive and systematic safety assessments to be carried out periodically and regularly for existing installations throughout their lifetime in order to identify safety improvements that are oriented to meet the objective of the VDNS. Reasonably practicable or achievable safety improvements are to be implemented in a timely manner.

The measures described above illustrate that comprehensive and systematic assessments of the existing NPPs have been carried out and will continue to be carried out periodically in Canada. These have resulted in numerous safety improvements that helped meet the objective in principle (2) of the VDNS. See subsection 14(i)(g) for further discussion.

Operational safety record

Canada has a mature nuclear industry with an excellent safety record spanning several decades. None of the operational events that occurred at Canadian NPPs during the reporting period posed a significant threat to the health and safety of persons or to the environment. There were no serious process failures[3] at any NPP during the reporting period. Furthermore, the licensees' efforts to address operational events were effective in correcting any deficiencies and preventing their recurrence. The most safety-significant events that occurred during the reporting period and their follow-up are described in appendix C.

During the reporting period, the CNSC did not need to engage in formal enforcement actions (such as the issue of administrative monetary penalties or prosecution) regarding Canadian NPPs. The one exception consisted of orders to Bruce, Darlington and Pickering requiring Commission authorization prior to the restart of non-refurbished units as described in sub-article 7.2(iv).

Conclusion

Based on the many provisions described above and its overall strong safety record, Canada has confidence in the ongoing safety of the NPPs currently licensed to operate across the country.

[3] A serious process failure is defined as a failure that leads to systematic fuel failure or a significant release from an NPP, or could lead to a systematic fuel failure or a significant release in the absence of action by any special safety system.

Chapter III – Compliance with articles of the Convention (continued)

Part B
Legislation and regulation

Part B of chapter III consists of three articles:

- Article 7 – Legislative and regulatory framework
- Article 8 – Regulatory body
- Article 9 – Responsibility of licensees

Article 7 – Legislative and regulatory framework

> 1. Each Contracting Party shall establish and maintain a legislative and regulatory framework to govern the safety of nuclear installations.
> 2. The legislative and regulatory framework shall provide for:
>   (i) the establishment of applicable national safety requirements and regulations;
>   (ii) a system of licensing with regard to nuclear installations and the prohibition of the operation of a nuclear installation without a licence;
>   (iii) a system of regulatory inspection and assessment of nuclear installations to ascertain compliance with applicable regulations and the terms of licences;
>   (iv) the enforcement of applicable regulations and of the terms of licences, including suspension, modification and revocation.

A general description of Canada's nuclear policy is provided in section C of chapter I.

7.1 Establishing and maintaining a legislative and regulatory framework

Canada has a modern and robust legislative and regulatory framework. This framework includes laws (acts) passed by the Parliament of Canada that govern the regulation of Canada's nuclear industry, as well as regulatory instruments such as regulations, Commission licences, orders and documents that the CNSC uses to regulate the industry.

The *Nuclear Safety and Control Act* (NSCA) is the enabling legislation for the regulatory framework. It establishes the powers, duties and responsibilities of the CNSC and authorizes regulations that set out additional requirements and provide guidance on requirements. Requirements are legally binding and mandatory elements that include the regulations made under the NSCA, licences and orders. CNSC regulatory documents, as well as other standards, also become legally binding requirements if they are part of the licensing basis (as defined in subsection 7.2(ii)(a)).

During the reporting period, the CNSC continued to modernize its regulatory framework and library of regulatory documents, taking into consideration opportunities to improve the cataloguing and clarity of the regulatory framework. All activities were carried out with a continued focus on communicating and engaging with stakeholders, and included the use of discussion papers, which play an important role in the selection of regulatory approaches and the development of the regulatory framework.

In keeping with federal policies on public consultation and regulatory fairness, the legislative and regulatory framework for nuclear regulation is open and transparent. The processes in place for the development of regulations and regulatory documents, along with the issuing of licences, provide for the involvement of interested parties and timely communications to stakeholders. (See subsection 8.1(f) for additional information on the CNSC's communications and commitment to openness and transparency.)

Canada continues to review and revise the legislative and regulatory framework to ensure it is both robust and sufficiently flexible to accommodate new technologies (such as SMRs) while ensuring that safety is maintained. This is enabled through, among other things, performance-based requirements, stakeholder engagement, environmental scans, regulatory research, and familiarization of potential licence applicants with elements of the framework, such as the requirements and the licensing process. These provisions are described in more detail in the following subsections and in article 8.

7.1 (a) The *Nuclear Safety and Control Act*

The original legislation in Canada governing nuclear safety was the *Atomic Energy Control Act* of 1946. As regulatory practices evolved to keep pace with the subsequent growth in Canada's nuclear industry and nuclear technology – and to focus more on health, safety, national security, environmental protection and fulfilling Canada's international obligations – updated legislation was required for more explicit and effective nuclear regulation. The NSCA came into force on May 31, 2000. The NSCA established the CNSC, which comprises two components: a tribunal component (hereinafter referred to as the Commission) and a staff organization.

The Commission is an independent[4], quasi-judicial administrative tribunal. It is a court of record with powers to hear witnesses, receive evidence and control its proceedings as long as those proceedings are dealt with as informally and expeditiously as the circumstances and considerations of fairness permit.

The Commission consists of up to seven permanent members appointed by the Governor in Council and hold office during good behaviour for a term of up to five years. One of those permanent members is designated by the Governor in Council to hold office as President. Each member is eligible to be re-appointed. Members generally have a range of experience that can include science, nuclear medicine, engineering, geology and business leadership. They are not necessarily nuclear specialists but bring strong reputations and broad transferrable skills to Commission proceedings.

Section 9 of the NSCA sets out the Commission's objects (or mandate) as follows:

- to regulate the development, production and use of nuclear energy and the production, possession and use of nuclear substances, prescribed equipment and prescribed information in order to:
  - prevent unreasonable risk to the environment and to the health and safety of persons associated with that development, production, possession or use
  - prevent unreasonable risk to national security associated with that development, production, possession or use
  - achieve conformity with measures of control and international obligations to which Canada has agreed
- to disseminate objective, scientific, technical and regulatory information to the public concerning the activities of the Commission and the effects, on the environment and on the health and safety of persons, of the development, production, possession and use of nuclear substances, prescribed equipment and prescribed information

The CNSC regulates all nuclear facilities and nuclear activities in Canada, including:

- the site preparation, design, construction, operation, decommissioning and abandonment of:
  - NPPs

[4] The independence of the Commission is described in subsection 8.2(a)

    - non-power reactors
    - nuclear research and test facilities
    - uranium mines and mills
    - uranium refining and conversion facilities
    - nuclear fuel fabrication facilities
    - waste management facilities
    - high-power particle accelerators
    - heavy-water plants
- the certification and use of prescribed equipment and nuclear substances used in:
    - nuclear medicine (e.g., teletherapy machines and brachytherapy used in cancer treatment and diagnostic medicine)
    - industry (e.g., industrial radiography, oil and gas well logging, density gauges)
    - research
- the certification of persons requiring certain qualifications to carry out duties under the NSCA

The NSCA enables the regulation of facilities (such as NPPs) by establishing a system of licensing and certification and by assigning to the Commission the power to make regulations (with the approval of the Governor in Council) that govern those facilities and to issue, amend, suspend and revoke licences, which set out the specific requirements that control licensed activities.

In addition, the NSCA provides the CNSC with other powers appropriate for a modern regulatory agency, including:

- clearly defined powers for inspectors, with powers in line with legislative practices
- a system of penalties and enforcement options for non-compliance
- clear appeal provisions for orders of inspectors and officers designated by the Commission
- provision for the Commission to redetermine decisions in light of new information
- the authority to order remedial actions in hazardous situations and to require parties to bear the costs of decontamination and other remedial measures
- the authority to include licence conditions (including the power to require financial guarantees for licensed activities, such as operation, decommissioning and waste management)
- recovery of the costs of regulation from entities licensed under the NSCA
- operation of the Participant Funding Program which gives the public, Indigenous Nations and communities and other stakeholders the opportunity to request funding from the CNSC to participate in its regulatory process

The CNSC is also responsible for administering and implementing many of Canada’s international obligations pursuant to existing bilateral and multilateral nuclear cooperation agreements, conventions and undertakings, including nuclear safeguards and the import and export of controlled nuclear equipment, material and information. The CNSC administers and implements the above obligations in collaboration with other government departments, including Global Affairs Canada, which has overall responsibility for international agreements and conventions, as well as Canada’s bilateral and multilateral relationships, and NRCan, which leads on some international files involving policy direction (see section C.2 of the Introduction for details).

7.1 (b) Other legislation

Nuclear regulation is under federal jurisdiction, although certain areas are subject to provincial authority, as described below.

Subsection C.2 of chapter I describes all federal organizations in addition to the CNSC that are involved in regulating or in forming policy that may impact the Canadian nuclear industry.

The following legislation enacted by Parliament also applies to the nuclear industry in Canada:

- *Nuclear Energy Act*
- *Nuclear Liability and Compensation Act*
- *Nuclear Fuel Waste Act*
- *Radiation Emitting Devices Act*
- *Canadian Environmental Assessment Act, 2012*
- *Canadian Environmental Protection Act, 1999*
- *Impact Assessment Act*
- *Canada Labour Code*
- *Fisheries Act*
- *Species at Risk Act*
- *Migratory Bird Convention Act, 1994*
- *Canada Water Act*
- *Navigation Protection Act*
- *Transport of Dangerous Goods Act, 1992*
- *Explosives Act*
- *Emergencies Act*
- *Emergency Management Act*
- *Nuclear Terrorism Act*

The *Impact Assessment Act* (IAA) replaced the *Canadian Environmental Assessment Act, 2012* in August 2019. It focuses on sustainability and considers environmental, health, social and economic effects of projects, both positive and negative.

The *Nuclear Liability and Compensation Act* holds the operator of an NPP responsible to pay up to $1 billion for civil damages resulting from an accident at that NPP. It also provides the Government of Canada the right to establish a tribunal if required in order to accelerate and provide efficient and equitable claim settlements.

Under the Canadian Constitution, provincial laws may also apply to nuclear facilities and activities in areas that do not relate directly to nuclear regulation and that do not conflict with federal law. Where both federal and provincial laws may apply, the CNSC tries to avoid duplicate effort by seeking cooperative arrangements with federal and provincial bodies that have regulatory responsibilities or expertise in these areas. Such arrangements are authorized by the NSCA, in order to avoid regulatory overlap.

For example, conventional health and safety is overseen at the federal and provincial levels of government. In Quebec and New Brunswick, the CNSC shares the regulation of conventional health and safety for NPPs with Employment and Social Development Canada, in accordance with Part II of the *Canada Labour Code*. In Ontario, under an exclusion to the *Canada Labour Code*, provincial legislation is substituted for federal legislation to protect workers at designated nuclear facilities. A memorandum of understanding exists between the CNSC and the Ontario Ministry of Labour to enable cooperation and the exchange of information/data and technical expertise related to the exercise of their respective areas of jurisdiction at designated Ontario NPPs.

As another example, environmental protection for NPPs is regulated through the CNSC, ECCC and provincial level bodies. That is, provincial environmental legislation applies to nuclear facilities and the CNSC also shares the federal regulation of environmental protection with ECCC, in accordance with the *Canadian Environmental Protection Act, 1999*.

7.2 Provisions of the legislative and regulatory framework

In addition to the NSCA and other acts, the Canadian legislative and regulatory framework includes the regulations under the NSCA, CNSC regulatory documents and industry codes and standards, systems of licensing, inspection, and assessment, and powers to enforce compliance with the requirements. These elements are administered in a risk-informed, performance-based regulatory approach that provides the foundation for the safety of NPPs, while remaining flexible to accommodate changing circumstances and innovation. Aspects of the legislative and regulatory framework that relate specifically to new technologies, including SMRs, are discussed in sub-articles 7.2(i) and 7.2(ii).

7.2 (i) National safety requirements and regulations

The NSCA, through licence conditions, allows for a range of requirements, including regulatory documents and standards. Typically, the Canadian approach to setting requirements in regulations and regulatory documents is non-prescriptive; that is, the CNSC sets general, objective, performance-based regulatory requirements and NPP applicants and licensees develop specific provisions to meet the requirements. The CNSC establishes specific requirements where necessary.

During the reporting period, the CNSC reviewed the potential implications of the uses of disruptive, innovative and emerging technologies (DIET) on the regulatory framework. CNSC staff concluded the NSCA, regulations, regulatory documents (REGDOCs) and industry standards were neutral, and hence accommodating, to the potential employment of DIET. The review involved significant engagement of stakeholders. During the reporting period, the CNSC also updated its approach to analyzing regulatory policy and updating REGDOCs to consider DIET. Besides the impact of DIET, the CNSC also initiated research projects on the impact of fusion and artificial intelligence on the regulatory framework.

The CNSC has a long-term regulatory framework plan for designing, implementing and managing the development and use of regulatory instruments. The most recent update to the CNSC’s long-term regulatory framework plan covers the period from 2019 to 2024 and outlines the regulations and regulatory documents that the CNSC will be developing or amending during that time. This plan allows for effective long-term planning of resources and better scheduling of projects within the regulatory framework. The CNSC updates the long-term regulatory framework plan to take into account the CNSC’s priorities, ongoing changes in the nuclear industry or changes in project plans. The updated plan is posted to the CNSC’s external website annually.

7.2 (i) (a) Regulations under the NSCA

Under section 44 of the NSCA, the CNSC has implemented regulations and by-laws with the approval of the Governor in Council. Regulations set general and specific regulatory requirements and information requirements for all types of licence applications and provide certain exemptions from licensing. By-laws are in place to govern the management and conduct of the Commissions affairs.

The following regulations and by-laws are issued under the NSCA:

- *General Nuclear Safety and Control Regulations*
- *Radiation Protection Regulations*
- *Class I Nuclear Facilities Regulations*
- *Class II Nuclear Facilities and Prescribed Equipment Regulations*
- *Nuclear Substances and Radiation Devices Regulations*
- *Packaging and Transport of Nuclear Substances Regulations, 2015*
- *Uranium Mines and Mills Regulations*
- *Nuclear Security Regulations*
- *Nuclear Non-proliferation Import and Export Control Regulations*
- *Canadian Nuclear Safety Commission Cost Recovery Fees Regulations*
- *Administrative Monetary Penalties Regulations (Canadian Nuclear Safety Commission)*
- *Canadian Nuclear Safety Commission Rules of Procedure*
- *Canadian Nuclear Safety Commission By-laws*

Generally, these regulations describe how to comply with legislative requirements in a non-prescriptive manner. With some exceptions – such as the transport packaging and licence exemption criteria for certain devices – the regulations do not specify detailed criteria used in assessing licence applications or judging compliance.

All reactor facilities are defined as Class IA nuclear facilities under the *Class I Nuclear Facilities Regulations*. This includes small modular reactors (SMRs) and research reactors.

The *Canadian Nuclear Safety Commission Rules of Procedure* set out rules of procedure for public hearings held by the Commission and for certain proceedings that have been delegated to officers designated by the Commission.

CNS Challenge 7RM C-1 for Canada from the Seventh Review Meeting
"Publish the drafted amendments to the *Class I Nuclear Facilities Regulations* and the *Radiation Protection Regulations* that address lessons learned from Fukushima"

The above-noted amendments were published and came into force in October 2017. The amendments to the *Class I Nuclear Facilities Regulations* included requirements for NPPs to conduct periodic safety reviews (PSRs; see subsection 7.2(ii)(d)). They also require an applicant for a licence for a Class I facility to describe its proposed human performance program (see subsection 12(a)) and its management system, including measures to promote and support safety culture (see article 10).

The amendments to the *Radiation Protection Regulations* involved an alignment with international guidance on overall preparedness for, and response to, radiological emergencies.

The amendments also established requirements related to radiological hazards for emergency workers. See article 15 for details.

The planned activities to address Challenge 7RM C-1 are complete. Canada recommends this action be closed.

Other changes to the *Radiation Protection Regulations*, unrelated to Fukushima, were made in 2020. See article 15 for details.

The regulations under the NSCA are generally suitable for regulating SMRs, with the exception of the *Nuclear Security Regulations*, which are more prescriptive in nature. The CNSC is in the process of developing more performance-based amendments to the *Nuclear Security Regulations*.

The CNSC's regulation-making process

When making or amending regulations, the CNSC abides by the Government of Canada's *Cabinet Directive on Regulation* (described in annex 7.2(i)(a)) and follows the federal government's regulation process. This ensures that the potential impacts of each regulatory proposal on health, safety, security, the environment, the social and economic well-being of diverse groups of Canadians, obligations under modern treaties and self-government agreements, as well as the costs or savings to government or business and the level of support of the proposed regulations, are systematically considered before they are created.

The CNSC's regulation-making process includes extensive consultation with both internal and external stakeholders. In developing its consultation plan, the CNSC recognizes the multiplicity of stakeholders with different levels of interest, points of view and expectations concerning the nature and content of a proposed regulatory regime. Interested parties are consulted early through discussion papers, workshops or other means to seek feedback before starting to draft the regulation. The Commission's consideration for approval of a new or amended regulation also provides interested parties with another opportunity to comment of the matter before the Commission. The regulation-making process is described in more detail in annex 7.2(i)(a).

7.2 (i) (b) Regulatory framework documents

General description of CNSC regulatory documents

The CNSC uses regulatory documents to support its regulatory framework by expanding on the requirements set out in the NSCA, its regulations and legal instruments such as licences. These documents provide instruction, assistance and information to the licensees.

CNS Challenge 7RM C-2 for Canada from the Seventh Review Meeting
"Complete the transition to the improved regulatory framework (CNSC regulatory documents)"

During the reporting period, the CNSC published a number of regulatory documents that clarify expectations, with many of them related to NPPs. Many of the revisions were to existing regulatory documents:

- REGDOC-1.1.5, *Supplemental Information for Small Modular Reactor Proponents*

- REGDOC-1.2.1, *Guidance on Deep Geological Repository Site Characterization*
- REGDOC-1.4.1, *Licence Application Guide: Class II Nuclear Facilities and Prescribed Equipment*
- REGDOC-1.5.1, *Application Guide: Certification of Radiation Devices or Class II Prescribed Equipment*, version 1.1
- REGDOC-1.6.1, *Licence Application Guide: Nuclear Substances and Radiation Devices*,
- REGDOC-1.6.2, *Radiation Protection Programs for Nuclear Substances and Radiation Devices Licences*, version 2
- REGDOC-2.1.1, *Management System*
- REGDOC-2.2.1, *Human Factors*
- REGDOC-2.2.3, *Personnel Certification, Volume III Certification of Persons Working at Nuclear Power Plants*
- REGDOC-2.2.4, *Fitness for Duty, Volume II: Managing Alcohol and Drug Use*, version 3
- REGDOC-2.2.5, *Minimum Staff Complement*
- REGDOC-2.4.3, *Nuclear Criticality Safety*, version 1.1
- REGDOC-2.5.7, *Design, Testing and Performance of Exposure Devices*, version 1.1
- REGDOC-2.7.1, *Radiation Protection*
- REGDOC-2.7.2, *Dosimetry, Volume I: Ascertaining Occupational Dose*
- *REGDOC 2.7.2, Dosimetry, Volume II: Technical and Management System Requirements for Dosimetry Services*
- REGDOC-2.8.1, *Conventional Health and Safety*
- REGDOC-2.9.1, *Environmental Protection: Environmental Principles, Assessments and Protection Measures*, version 1.2
- REGDOC-2.11, *Framework for Radioactive Waste Management and Decommissioning in Canada*
- REGDOC-2.11.1, *Waste Management, Volume I: Management of Radioactive Waste*
- REGDOC-2.11.1, *Waste Management, Volume III: Safety Case for the Disposal of Radioactive Waste, version 2*
- REGDOC-2.11.2, *Decommissioning*
- REGDOC-2.12.3, *Security of Nuclear Substances: Sealed Sources and Category I, II and III Nuclear Material*, version 2.1
- REGDOC-2.14.1, *Volume I, Information Incorporated by Reference in Canada's Packaging and Transport of Nuclear Substances Regulations, 2015*, version 2
- REGDOC-3.1.3, *Reporting Requirements for Waste Nuclear Substance Licensees, Class II Nuclear Facilities and Users of Prescribed Equipment, Nuclear Substances and Radiation Devices*
- REGDOC-3.2.2, *Indigenous Engagement*, version 1.1
- REGDOC-3.3.1, *Financial Guarantees for Decommissioning of Nuclear Facilities and Termination of Licensed Activities*
- REGDOC-3.5.2, *Compliance and Enforcement, Volume II: Orders under the Nuclear Safety and Control Act*
- REGDOC-3.5.1, *Licensing Process for Class I Nuclear Facilities and Uranium Mines and Mills*, version 2.1
- REGDOC-3.5.3, *Regulatory Fundamentals*, version 2

- REGDOC-3.6, *Glossary of CNSC Terminology*

The CNSC has now established a suite of REGDOCs to effectively cover its safety and control areas (SCAs) for NPPs. The 14 SCAs cover all technical areas of regulatory oversight and are used throughout the CNSC's core processes. The SCA's are grouped into three primary functional areas: management, facility and equipment and core processes. Each SCA addresses an aspect of the overall safety profile of a proposed set of activities, and is then sub-divided into Specific Areas (SpA) that define the key components of each SCA. The SCA framework provides a common set of safety and control terms to ensure consistent reviews, assessments, recommendations and reporting to the Commission. This in turn facilitates better communication among CNSC staff, licensees, the Commission and members of the public.

The transition to the improved regulatory framework, as referenced in Challenge 7RM C-2, is complete. In particular, the publication of the two radiation protection documents (REGDOC-2.7.1 and REGDOC-2.7.2, Volumes I and II), absorbed the majority of the outstanding legacy regulatory documents that had not yet been converted to the new structure. The CNSC's regulatory framework remains subject to continuous review and updates. Canada recommends the closure of Challenge 7RM C-2.

The CNSC's ongoing enhancement and development of regulatory documents is based on a prioritized plan. The CNSC uses five criteria that are based on importance and urgency to schedule and revise its regulatory framework projects (safety issues, stakeholder interest, regulatory clarity, alignment with CNSC priorities and regulatory reform). Also, as noted in sub-article 7.2(i), during the reporting period the CNSC also modified its approach to updating REGDOCs to consider DIET.

The CNSC development process for REGDOCs includes significant consultation with external stakeholders. See annex 7.2(i)(b) for an outline of this process.

The CNSC conducts cyclical reviews of regulatory documents. Documents are reviewed to determine which ones should be withdrawn and archived, retained "as is" for continued use or scheduled for revision. This process ensures that the CNSC's full regulatory framework continues to be current and reflects the latest developments in domestic and international operating experience and guidance.

A table listing the key CNSC regulatory documents that apply to existing NPP licensees and new-build, in the context of the scope of the CNS, is provided in annex 7.2(i)(b).

The CNSC sets requirements and guidance by adopting (or adapting) appropriate industry, national, international or other standards as it deems appropriate.

IAEA standards continue to serve as references and benchmarks for the Canadian approach to nuclear safety, as they have for many years. IAEA standards set out high-level objectives and requirements that can be mapped to the safety and control area framework used by the CNSC to establish regulatory requirements for NPPs. The IAEA standards set out high-level safety goals and requirements that apply to all reactor designs; that is, they are technology-neutral. During the reporting period, the Canadian regulatory framework related to NPPs continued to move toward better alignment with international standards. The Canadian approach recognizes that international standards may only represent minimum requirements, which may need to be augmented to suit the Canadian technology, practices and regulatory approach. Annex 7.2(i)(b) provides numerous examples of where IAEA standards have been referenced in CNSC documents (and CSA Group standards).

The CNSC and Health Canada actively contribute to the development of the IAEA's safety standards, as well as the supporting technical documents that provide more specific technical requirements and best practices for NPP siting, design, construction, operation and decommissioning. CNSC staff participate in the working groups to draft these standards. CNSC representatives also sit on the IAEA Commission on Safety Standards and the five supporting safety standards committees. Health Canada also sits on one of the supporting safety standards committees.

Discussion papers

Discussion papers are used to solicit early public feedback on CNSC proposed policies or approaches, which the CNSC then analyzes and considers so that it can determine the type and nature of requirements and guidance to issue. The use of discussion papers early in the regulatory process underlines the CNSC's commitment to a transparent consultation process, giving stakeholders an early opportunity to present their positions on regulatory initiatives. The four key stages for the development of discussion papers are:

- analyze the issue
- develop the discussion paper
- consult with stakeholders
- decide on a recommended regulatory approach

The following discussion papers were published during the reporting period:

- DIS-21-01, *The Canadian Nuclear Safety Commission: Regulatory Oversight Report Review*
- DIS-21-02, *Proposals to Amend the Nuclear Security Regulations*
- DIS-21-03, *Discussion Paper on Cyber Security and the Protection of Digital Information*

CSA Group standards

The CSA Group (formerly the Canadian Standards Association), Canada's largest, member-based standards development organization, sets voluntary consensus standards developed by national stakeholders and public interests related to NPPs and other nuclear facilities and activities. As many CSA Group standards are related to NPP design and operation, they are referenced in CNSC REGDOCs.

During the reporting period, the nuclear industry, the CNSC and CSA Group continued to collaborate to strengthen Canada's program for nuclear standards. A representative of CNSC senior management is a member of the CSA Nuclear Strategic Steering Committee and its Executive Committee, which are responsible for developing the suite of nuclear standards. Additionally, CNSC managers and technical staff contribute to the technical committees, subcommittees and working groups developing the CSA Group standards.

During the reporting period, the following CSA Group standards that are applicable to NPPs were published. Note that all standards are published in both English and French, however the dates of publication may not match due to translation timelines:

- CSA N290.9:19, *Reliability and maintenance programs for nuclear power plants* (new standard)
- CSA N290.4:19, *Requirements for reactor control systems of nuclear power plants* (new edition)
- CSA N285.4:19, *Periodic inspection of CANDU nuclear power plant components* (new edition)
- CSA N290.15:19, *Requirements for the safe operating envelope of nuclear power plants* (new edition)
- CSA N288.4:19, *Environmental monitoring programs at nuclear facilities and uranium mines and mills* (new edition)
- CSA N287.4:19, *Construction, fabrication, and installation requirements for concrete containment structures for nuclear power plants* (new edition)
- CSA N285.8-15 (R2020), *Technical requirements for in-service evaluation of zirconium alloy pressure tubes in CANDU reactors* (amendment)
- CSA N285.5-18, *Inspection périodique des composants de confinement des centrales nucléaires CANDU* (new edition)
- CSA N294:19, *Decommissioning of facilities containing nuclear substances* (new edition)
- CSA N288.2:19, *Guidelines for calculating the radiological consequences to the public of a release of airborne radioactive material for nuclear reactor accidents* (new edition)
- CSA N290.17-17, *Probabilistic safety assessment for nuclear power plants* (amendment)
- CSA N299.1:19, *Quality assurance program requirements for the supply of items and services for nuclear power plants*, Category 1 (new edition)
- CSA N299.3:19, *Quality assurance program requirements for the supply of items and services for nuclear power plants, Category 3* (new edition)
- CSA N292.1-16 (R2021), *Wet storage of irradiated fuel and other radioactive materials* (amendment)
- CSA N299.2:19, *Quality assurance program requirements for the supply of items and services for nuclear power plants, Category 2* (new edition)
- CSA N299.4:19, *Quality assurance program requirements for the supply of items and services for nuclear power plants, Category 4* (new edition)
- CSA N289.3:20, *Design procedures for seismic qualification of nuclear power plants* (new edition)
- CSA N288.1:20, *Guidelines for modelling radionuclide environmental transport, fate, and exposure associated with the normal operation of nuclear facilitie*s (new edition)
- CSA N287.5:20, *Examination and testing requirements for concrete containment structures for nuclear power plants* (new edition)
- "CSA N289.2:21, *Ground motion determination for seismic qualification of nuclear power plants* (new edition)"
- CSA N1600:21, *General requirements for nuclear emergency management programs* (new edition)
- CSA N285.7:21, *Periodic inspection of CANDU nuclear power plant balance of plant systems and components* (new edition)
- CSA N286.0.1:21, *Commentary on N286-12, Management system requirements for nuclear facilities* (new edition)

- CSA N290.20:21, *Aging management requirements for nuclear power plants* (new standard)
- CSA N289.5-12 (R2017), *Seismic instrumentation requirements for nuclear power plants and nuclear facilities* (amendment)
- CSA N290.11:21, *Requirements for reactor heat removal capability during outage of nuclear power plants* (new edition)
- CSA N292.8:21, *Characterization of radioactive waste and irradiated fuel* (new standard)
- CSA N285.4:19, *Periodic inspection of CANDU nuclear power plant components* (amendment)
- CSA N290.7:21, *Cyber security for nuclear facilities* (new edition)
- CSA N285.8:21, *Technical requirements for in-service evaluation of zirconium alloy pressure tubes in CANDU reactors* (new edition)
- CSA N293S1:21, *Supplement No. 1 to N293-12, Fire protection for nuclear power plants* (application to small modular reactors) (supplement)
- CSA N287.6:22, *Pre-operational proof and leakage rate testing requirements for concrete containment structures for nuclear power plants* (new edition)
- CSA N289.4:22, *Testing procedures for seismic qualification of nuclear power plant structures, systems, and components* (new edition)
- CSA N288.6:22, *Environmental risk assessments at nuclear facilities* (new edition)
- CSA N290.8-15, *Technical specification requirements for nuclear power plant components* (amendment)
- CSA N288.0:22, *Environmental management of nuclear facilities: Common requirements of the CSA N288 series of Standards* (new standard)
- CSA N288.5:22, *Effluent and emission monitoring programs at nuclear facilities* (new edition)
- CSA N292.7:22, *Deep geological disposal of radioactive waste and irradiated fuel* (new standard)
- CSA N285.4:19, *Inspection périodique des composants des centrales nucléaires CANDU* (amendment)

CSA Group standards that are relevant to NPPs, in the context of the scope of the CNS, are shown in the table in annex 7.2(i)(b). The table provides numerous examples of where IAEA standards have been referenced in the CSA Group standards.

Regulatory framework for new NPPs

The CNSC's requirements and guidance for reactor facilities are generally articulated to be technology-neutral and, where possible, to permit the use of the graded approach. The graded approach enables applicants to propose the stringency of design measures, safety analyses and provisions for conduct of their activities commensurate with the level of risk posed by the reactor facility. The factors to be considered in the graded approach are as follows:

- reactor power
- source term
- amount and enrichment of fissile and fissionable material

- spent fuel, high-pressure systems, heating systems and the storage of flammables, all of which may affect the safety of the reactor
- type of fuel elements
- type and the mass of moderator, reflector and coolant
- amount of reactivity that can be introduced (and its rate of introduction), reactivity control, and inherent and additional features
- quality of the confinement structure or other means of confinement
- utilization of the reactor
- siting, which includes proximity to population groups or extent of isolation from emergency responders

Many of the regulatory framework improvements described above took into consideration their applicability for SMRs and advanced technologies. Additional specific information on the new-build regulatory framework and documents under development is provided in article 12 (for human and organizational factors), article 17 (for siting) and article 18 (for design and construction).

7.2 (i) (c) Fulfilling principle (3) of the 2015 *Vienna Declaration on Nuclear Safety*

Principle (3) of the 2015 *Vienna Declaration on Nuclear Safety* (VDNS) states that national requirements and regulations for addressing the objective of preventing accidents and mitigating their radiological consequences throughout the lifetime of the NPP are to take into account the relevant IAEA safety standards and other good practices identified in the review meetings of the CNS. (See section E of chapter I for further details on the VDNS.)

The table in annex 7.2(i)(b) shows how IAEA safety standards continue to serve as guiding principles for the Canadian regulatory framework, which is applicable to both existing NPPs and new-build projects. The suite of CNSC regulatory documents and CSA Group standards incorporate the content of a significant number of IAEA publications as references, and also refer to additional IAEA publications for supporting material.

7.2 (ii) System of licensing

Section 26 of the NSCA prohibits any person from preparing a site for, or constructing, operating, decommissioning or abandoning, a nuclear facility, without a licence granted by the Commission. Subsection 24(4) of the NSCA states the following:

> No licence may be issued, renewed, amended or replaced – and no authorization to transfer one given – unless, in the opinion of the Commission, the applicant or, in the case of an application for an authorization to transfer the licence, the transferee
>
> a) is qualified to carry on the activity that the licence will authorize the licensee to carry on; and
> b) will, in carrying on that activity, make adequate provision for the protection of the environment, the health and safety of persons and the maintenance of national security and measures required to implement international obligations to which Canada has agreed.

Subsection 24(1) of the NSCA gives the Commission the authority to establish classes of licences for regulated activities and set the duration in each licence. Subsection 24(2) gives the Commission the authority to issue, renew, suspend, amend, revoke or replace licences. Subsection 24(5) gives the Commission the authority to include in licences any term or condition that it deems necessary for the purposes of the NSCA, including the requirement for a financial guarantee.

The CNSC's licensing system is administered in cooperation with federal and provincial/territorial government departments and agencies in such areas as health, environment, Indigenous consultation, transportation and labour. Before the Commission issues a licence, the concerns and responsibilities of these departments and agencies are taken into account, to ensure that no conflicts exist with the provisions of the NSCA and its regulations.

The Commission is obligated to comply with any federal legislation and therefore may make its licensing decisions in consultation with any department or agency government bodies at the federal level having independent but related responsibilities with the CNSC.

The *Class I Nuclear Facilities Regulations*, which apply to NPPs, require licences for each of the five types of activities in the lifecycle of a Class IA nuclear facility:

- licence to prepare a site
- licence to construct
- licence to operate
- licence to decommission
- licence to abandon[5]

If the necessary applications are filed with the required information, the Commission may, at its discretion, and in accordance with section 24(4) of the NSCA, issue a licence that includes multiple classes of licences (e.g., a licence to prepare a site and construct, or a licence to construct and operate). A single licence may also be issued for multiple facilities, each at a different stage in their lifecycle.

The *Class I Nuclear Facilities Regulations* and the *Uranium Mines and Mills Regulations* establish a 24-month timeline for projects requiring the CNSC's regulatory review and decision on new applications for a licence to prepare a site for a Class I nuclear facility and a licence to prepare a site and construct a uranium mine and mill. This timeline does not include the time required by proponents to respond to information requests.

These timelines (based on experience from around the world) are affected by:

- completeness of the licence application
- stakeholder support (communities, Indigenous and public consultations, provincial/territorial agencies)
- state of completeness of design
- resolution of outstanding safety issues
- novel features or approaches
- state of completion of supporting R&D
- quality and timeliness of construction and commissioning

The operating reactors covered by this report are spread across five sites, each with a CNSC licence. Bruce, Darlington, and Pickering each have a single facility licence to operate multiple reactors. Point Lepreau has a licence to operate a single reactor. Gentilly-2 (not significantly addressed in this report) has a licence to decommission the power reactor onsite. The Darlington

[5] This is effectively a "release" from licensing.

New Nuclear Project (DNNP) is adjacent to the existing four-unit Darlington site and is licensed under a l*icence to prepare a site*. The proponent for the SMR project at Chalk River has applied for a l*icence to prepare a site*.

7.2 (ii) (a) Licences and licensing process

CNSC REGDOC-3.5.1, *Licensing Process for Class I Nuclear Facilities and Uranium Mines and Mills*, outlines the current licensing process in the context of the NSCA. The CNSC licensing process is one of the core processes in the CNSC management system, which is described in subsection 8.1(d). Figure 7.2 depicts the CNSC licensing process and the key activities to be carried out by the licence applicant, CNSC staff and the Commission.

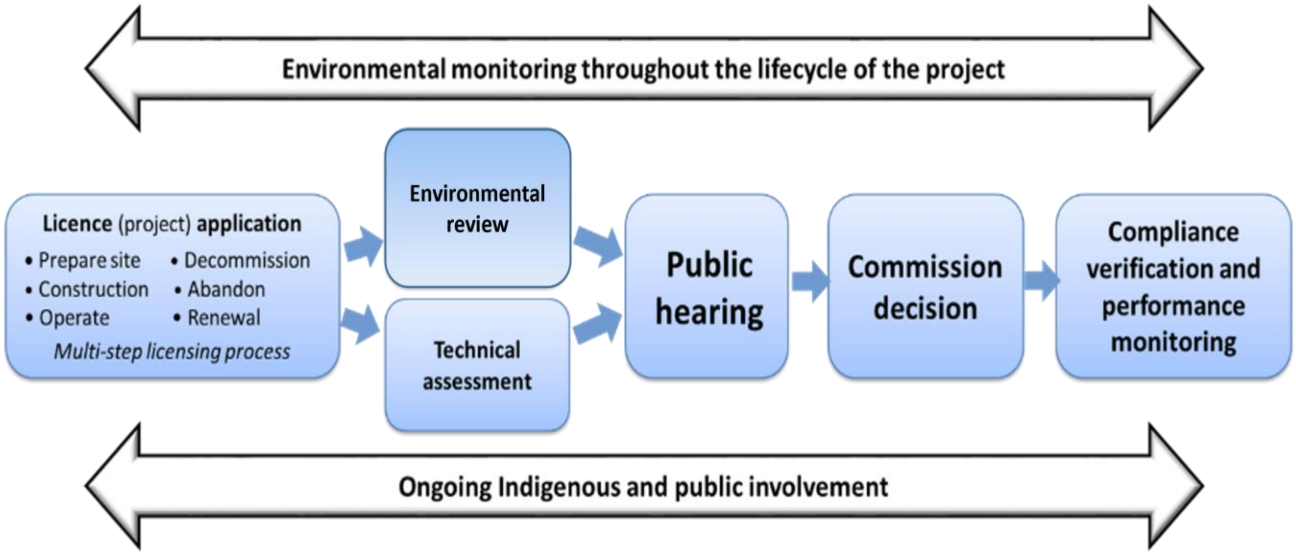


Figure 7.2 Process for obtaining an NPP licence under the NSCA

The licensing process is initiated when the proponent sends an application to the CNSC. A licence application must contain sufficient information to meet regulatory requirements and to demonstrate that the applicant is qualified to conduct the licensed activity.

The regulations under the NSCA provide licence applicants with general performance criteria and details about the information and programs they must prepare and submit to the CNSC as part of the application process. The following table highlights some of the more important information requirements identified in the *General Nuclear Safety and Control Regulations* and the *Class I Nuclear Facilities Regulations*.

Table 5: Licence type in regulations

Licence type	General regulations	Class I regulations
Licence to prepare a site	Section 3	Sections 3 and 4
Licence to construct	Section 3	Sections 3 and 5
Licence to operate	Section 3	Sections 3 and 6

To enhance clarity, the CNSC has published, or plans to publish, supporting regulatory documents for each licence type. These REGDOCs provide additional details and criteria (such as references to other CNSC regulatory documents, national codes and standards, or the IAEA safety standards) so that applicants understand what would likely satisfy the requirements of the applicable regulations under the NSCA.

Table 6: REGDOCs providing guidance on licence applications

Document #	Title	Published
REGDOC-1.1.1	*Site Evaluation and Site Preparation for New Reactor Facilities*, version 1.1	February 2022
REGDOC-1.1.2	*Licence Application Guide: Licence to Construct a Nuclear Power Plant*	August 2019
REGDOC-1.1.3	*Licence Application Guide: Licence to Operate a Nuclear Power Plant*	September 2017
REGDOC-1.1.4	*Licence Application Guide: Licence to Decommission Reactor Facilities*	Not drafted
REGDOC-1.1.5	*Licence Application Guide: Supplemental Information for Small Modular Reactor Proponents*	August 2019

REGDOC-1.1.1 and REGDOC-1.1.3 are described in more detail in subsections 7.2(ii)(b) and 7.2(ii)(d), respectively. CNSC's assessments of licence applications during the reporting period against the guidance in those two documents is described in subsection14(i)(a). REGDOC-1.1.2 is described in subsection 7.2(ii)(c). REGDOC-1.1.5 provides information in addition to REGDOC-1.1.1, REGDOC-1.1.2 and REGDOC-1.1.3; it sets out requirements and guidance for an applicant to consider prior to submitting a licence application to the CNSC for an SMR.

For new NPPs, information on decommissioning plans and financial guarantees is required early in the licensing process. The *Class I Nuclear Facilities Regulations* require an applicant to provide information on its proposed plan for decommissioning a nuclear facility or site, while the *General Nuclear Safety and Control Regulations* require information on financial guarantees to accompany a licence application. Financial guarantees can be used to ensure sufficient funds are available so that the facility does not pose any unnecessary risk in the event that the licensee can no longer operate the facility. To date, these have mostly been used for decommissioning an NPP at the end of its operating life and for the long-term management of spent nuclear fuel. Information on proposed financial guarantees should include any obligations for funding the decommissioning and long-term management of nuclear fuel waste, pursuant to the *Nuclear Fuel Waste Act*. Financial guarantees for decommissioning are discussed in subsection 11.1(b).

The environmental review of new reactor projects would be conducted under the *Impact Assessment Act* (IAA). When a proposed NPP meets the thresholds in the IAA's *Physical Activities Regulation*s, known as the "project list", an integrated impact assessment (IA) is conducted by an independent review panel (which includes Commission members) who considers the requirements of both the IAA and the NSCA in a public hearing. Their recommendation goes to the Governor in Council, who determines whether the project is in the public interest. If it is, the integrated review panel – acting as the Commission – makes the licensing decision. An IA addresses all the phases of the project lifecycle, from site preparation through to abandonment, while the applicant determines which licence(s) for which they are applying. IAs are described in more detail in subsection 17(ii)(a).

New NPP designs, such as SMRs, may employ a number of novel approaches. The Canadian regulatory approach to licensing novel designs is built on the foundation of risk-informed regulation that has been applied to traditional reactor facilities. Regulatory tools and decision-making processes are structured to enable a licence applicant for a reactor facility to propose alternative or novel ways to meet regulatory objectives. Where standards either do not apply or do not exist, the CNSC will consider information that is relevant to the specific application and demonstrates that the proposed safety and control measures will meet or exceed CNSC requirements. This is in line with the Government of Canada's *Cabinet Directive on Regulation* and is consistent with the CNSC's vision of regulatory excellence. The CNSC approach to licensing novel technologies also relies on early and frequent engagement of stakeholders and on transparency in decision making.

The CNSC has established processes for the licensing of SMR projects that utilize a graded approach. During the reporting period, CNSC published REGDOC-1.1.5 and revised REGDOC-3.5.3, *Regulatory Fundamentals*, both of which expand upon graded approach principles as they would be applied to all CNSC SCAs. The CNSC also drafted a revised version of REGDOC 1.1.2, *Licence Application Guide: Licence to Construct a Reactor Facility*, to ensure it is fit for purpose for SMRs, and incorporates graded approach principles. The CNSC also conducted (or is in the process of conducting) pre-licensing vendor design reviews (VDRs) on several different reactor designs. One of the goals of a VDR is to provide early identification and resolution of potential regulatory or technical issues in the design process. The VDR process has helped demonstrate that the Canadian regulatory framework is largely fit for purpose when applied in a graded manner to novel and diverse reactor designs. These initiatives, in turn, have enhanced CNSC staff's readiness to review applications involving novel nuclear technologies. During the next reporting period, the CNSC plans to continue measures to ensure effective and efficient licensing activities for SMR projects that are brought to the Commission for decision.

Canada has also promoted the goal of international harmonization with respect to licensing SMRs. CNSC has established numerous memoranda of understanding with other nuclear regulatory bodies. During the reporting period, CNSC entered into new memoranda of cooperation with the United States Nuclear Regulatory Commission (U.S. NRC) and the United Kingdom's Office for Nuclear Regulation that focus on advanced reactor SMR technologies. During the reporting period the CNSC and U.S. NRC published three joint review reports on SMRs. See subsection 8.1 (g) for additional discussion of CNSC's participation in international efforts to harmonize the regulation of SMRs. In another development, COG collaborated with the World Nuclear Association's (WNA's) Cooperation in Reactor Design Evaluation and Licensing (CORDEL) working group in 2021 to produce a paper titled *Harmonization of Reactor Design Evaluation and Licensing: Lessons Learned from Transport*. The paper recommended that an international framework be established for the harmonization of reactor design evaluation and licensing.

Licensing recommendations, decisions and related approvals

The CNSC staff assessment of an applicant's information is augmented by input from federal and provincial government departments and agencies responsible for regulating health and safety, environmental protection, emergency preparedness and the transportation of dangerous goods in relation to nuclear-related projects. The CNSC maintains memoranda of understanding with these departments and agencies. The NSCA also requires that members of the public be invited to participate in licensing hearings of Class I facilities (NPPs, conversion facilities, research reactors) and uranium mines and mills.

When an NPP is not subject to an IA involving an integrated review panel, CNSC staff document the conclusions and recommendations from their reviews in Commission member documents (CMDs), submitting them to the Commission for a public hearing. The Commission may choose to hold a public hearing in one or two parts. The *Canadian Nuclear Safety Commission Rules of Procedure* set out the requirements for one-part and two-part public hearings. For the more conventional two-part hearing the Commission considers the documentary information, written submissions and presentations of CNSC staff and the applicant/licensee during Part 1. For Part 2 of the public hearing, the Commission focuses on the presentations and submissions of intervenors (e.g., members of the public, non-government organizations, Indigenous Nations and communities, labour unions, municipalities, other government departments, industry) as well as all information submitted by the parties who participated in Part 1 of the hearing.

For the licensing of NPPs, intervenors are typically allotted significant periods of time at the Part 2 hearing to present their information and engage the Commission. (This usually involves a 10-minute oral presentation to summarize the key points of their written submission, followed by questions from the Commission members for which no time limit is ascribed.) CNSC staff and applicants may also present supplementary or revised information at the Part 2 hearing as follow-up to discussion at Part 1. The hearings are webcast live and the video is available online for a minimum of three months following the hearing. In addition, a verbatim transcript is prepared for these proceedings and available to the public within one week of the day of the proceedings.

During and after public hearings, the Commission deliberates upon the information provided and makes the final decision on the granting of the licence. The CNSC issues news releases to inform the public of the decisions made. The records of proceedings from the hearings, along with the reasons for the Commission's decisions, are available in both of Canada's official languages, posted on the CNSC website and sent to all participants.

Subsection 37(1) of the NSCA authorizes the Commission to designate any person whom the Commission considers qualified to be a designated officer. The Commission may then authorize a designated officer to carry out any of the activities enumerated in subsection 37(2) of the NSCA, including licensing actions for certain classes of licence identified by the Commission. However, this designation by the Commission does not extend to NPP licences.

Content of licences - general

CNSC licences for NPPs contain a general requirement to conduct the licensed activities in accordance with the licensing basis. The licensing basis is defined as:

(i) the regulatory requirements set out in the applicable laws and regulations
(ii) the conditions and safety and control measures described in the facility's or activity's licence and the documents directly referenced in that licence
(iii) the safety and control measures described in the licence application and the documents needed to support that licence application

Thus, the information and commitments submitted with a licence application become a legal requirement for the licensee (specifically, part (iii) of the licensing basis). The documents needed to support the licence application are detailed documents supporting the design, safety analyses and aspects of operation to which the licensee refers, such as those related to conduct of operations and conduct of maintenance.

The CNSC's compliance program (see sub-article 7.2(iii)) is designed to ensure licensees continue to meet requirements and conduct the licensed activity within the licensing basis during the licence period. The licensee can improve its provisions, operations or facility design during the licence period as long as the improvements are within the licensing basis and executed according to the licensee's management system. To make a change to the licensing basis, the licensee must obtain the written approval of the Commission.

CNSC facility licences also contain a general condition requiring the licensee to notify the CNSC in writing when it changes its safety and control measures. This allows CNSC staff to confirm that operations remain in accordance with the licensing basis. Licences may also contain other terms and conditions. Subsection 24(5) of the NSCA authorizes the Commission to include any licence term or condition that the Commission considers necessary for the purposes of the NSCA.

NPP licences contain relatively general requirements that are common to all NPPs in Canada; they are organized per the CNSC SCAs. NPP licences may also include specific control provisions that require approval or consent to proceed for situations or changes where the licensee could be:

- non-compliant with regulatory requirements set out in applicable laws or licence conditions
- outside the licensing basis

Also, a common type of approval included in an NPP licensee is a "hold point" – a specific milestone that is established in a licence to separate critical phases of a work plan and allows for regulatory review before the licensee is authorized to proceed. The licensee seeks approval of the Commission or consent of a person authorized by the Commission prior to the removal of a hold point. See subsection 7(ii)(d) for examples of regulatory hold points.

Licence amendments

As noted, the NSCA gives the Commission the authority to amend licences (e.g., to modify existing licence conditions or to add new licensing requirements). The general nature of NPP licences greatly reduces the need for the Commission to amend the licence during the licence period. Nevertheless, licence amendments can be initiated by the Commission or through an application by the licensee, and can be executed relatively quickly if necessary. This ability enables the CNSC to effectively address safety-related and other issues at the licensing level. During the reporting period, the Commission amended the following licences:

- Bruce and Lepreau operating licences amended in March 2020 to add REGDOC-2.2.3, *Personnel Certification, Volume III: Certification of Persons Working at Nuclear Power Plants* as a requirement[6]
- Darlington and Pickering operating licences amended in April 2020 to add REGDOC-2.2.3 as a requirement

[6] Although CNSC licences for Class I facilities include few references to REGDOCs, the licences to operate do refer to REGDOC-2.2.3 because clause 9(1)(a) of the *Class I Nuclear Facilities Regulations* requires an application for personnel certification to indicate how the certification candidate meets the requirements referred to in the licence.

- Bruce operating licence amended in September 2021 to allow the production of lutetium-177
- Darlington operating licence amended in October 2021to allow the production of molybdenum-99

Licence conditions handbooks

Each NPP site with a licence has an associated licence conditions handbook (LCH), the contents of which are under the responsibility of CNSC staff. A licensing hearing before the Commission always includes a proposed LCH for the Commission to review. LCHs are organized by the licence conditions and hence by the CNSC SCAs.

Intended to inform both the licensee and CNSC staff, the LCH gathers in a single document all the regulatory details, explanations, expectations and associated processes for definitions, interpretations and administrative control of the licence conditions. The LCH is read in conjunction with the licence. The LCH associates each licence condition with compliance verification criteria (CVC) that are used by CNSC staff to confirm the licensee's compliance with the licence condition. The CVC are aligned with the licensing basis and document the implementation plans, action items and transition dates required to meet specific licence conditions. They provide the latest revisions and effective dates of the CNSC regulatory documents and industry standards that form part of the licensing basis. They also detail the process by which the licensee notifies the CNSC of changes to its documentation that comprises part (iii) of the licensing basis. Finally, the CVC provide information on obtaining Commission approval or CNSC staff consent of specified changes (e.g., hold points), as discussed above.

In addition, the LCH provides guidance for each licence condition, which include non-mandatory suggestions or advice on how the licensee can comply with the licence condition.

7.2 (ii) (b) Licence to prepare a site

The selection of a site for the long-term development of a new NPP is not, in itself, a regulated activity in Canada (although the activities of site characterization and evaluation, which support site selection, are regulated). The choice of site is largely a matter between the project proponent and the municipalities and provinces/territories involved. The only exception to this practice is when the Government of Canada, through NRCan, assumes the role of proponent if it directly sponsors a federal NPP project (i.e., an NPP project run by the federal government). In either event, the CNSC is not involved in the site-selection process.

When applying for a licence to prepare a site, it is the applicant's responsibility to demonstrate to the CNSC that the proposed site is suitable for future development and that the activities encompassed by the licence will not pose unreasonable risks to health, safety, security and the environment for the site and its surrounding region. In addition to addressing the activities pertaining to site evaluation and site preparation, submissions for selected topics for the licence to prepare a site are expected to consider the entire lifecycle of the proposed facility. The applicant must also demonstrate that the proposed licensed activity meets all applicable regulatory requirements.

The CNSC regulatory document REGDOC-1.1.1, *Site Evaluation and Site Preparation for New Reactor Facilities*, describes the general process for evaluating an NPP site in Canada. It supplements the related application requirements contained in the regulations and codifies experience from recent assessments for potential new NPPs and addresses lessons learned. Specifically, it:

- provides site evaluation criteria (e.g., to address the impact of the site on the environment, emergency planning and natural and human-induced external hazards)
- sets expectations for collecting site-related data
- sets expectations for quality assurance as well as public and Indigenous consultation

Additional information on the site evaluation criteria in REGDOC-1.1.1 is provided in article 17.

Regulatory efficiencies can be maximized if the applicant thoroughly evaluates the proposed site for the project and fully documents the site selection case before initiating the licensing (and where applicable IA) processes. REGDOC-1.1.1 includes criteria for the level of facility design information needed to support the site selection case.

As part of the site evaluation process, the CNSC expects the applicant to publicly announce its intention to construct the facility and initiate a robust public communication program that will continue for the life of the project. This includes public meetings, held by the applicant, where members of the public can express their views and question the applicant.

During the reporting period, OPG applied for a renewal of its licence to prepare site for the DNNP. CNSC staff assessed OPG's application against the requirements and guidance in REGDOC-1.1.1; see subsection 14(i)(a) for details on the assessment of the licence application. The Commission renewed the licence in October 2021 for a period of 10 years. Also during the reporting period, Global First Power submitted an application for a licence to prepare site for an SMR on AECL's property at Chalk River Laboratories.

7.2 (ii) (c) Licence to construct

When applying for a licence to construct a new NPP, it is the applicant's responsibility to demonstrate to the CNSC that the proposed NPP design conforms to regulatory requirements and will provide for safe operation on the designated site over the proposed plant life. The information required in support of the application to construct an NPP is referred to as the "safety case" and includes, for example, the following:

- a description of the proposed design for the new NPP, taking into consideration physical and environmental characteristics of the site
- environmental baseline data on the site and surrounding area
- a preliminary safety analysis report demonstrating the adequacy of the design
- measures to mitigate the effects on the environment and health and safety of persons that may arise from the construction, operation or decommissioning of the facility
- information on the potential releases of nuclear substances and hazardous materials and proposed measures to control them
- programs and schedules for recruiting and training staff for the construction, commissioning, and operation phases of the project
- programs and activities that will be undertaken by the applicant to perform the oversight of design, procurement, construction, commissioning and operation activities, in order to provide assurance that the plant will conform to regulatory requirements and the design and safety analysis, as presented in the application

During the reporting period, CNSC published regulatory document REGDOC-1.1.2, *Licence Application Guide: Licence to Construct a Nuclear Power Plant*. Based on a previously-published regulatory document, it provides guidance to applicants on the information to submit in an application for a licence to construct an NPP. During the reporting period, the CNSC also commenced a revision of REGDOC-1.1.2 to provide guidance on applying for a licence to construct, and to ensure its applicability for SMR licence applications and the use of a graded approach.

CNSC staff use REGDOC-2.3.1, *Conduct of Licensed Activities: Construction and Commissioning Programs* to assess new applications for licences to construct reactor facilities. REGDOC-2.3.1 provides assurance to the applicant and the CNSC that reactor facilities will be constructed per design, meet their safety requirements and operate safely. In order for the applicant to demonstrate that the reactor facility can operate safely in the modes for which it has been designed, it is necessary for the design of the facility and the safety analysis to be well advanced and supported by appropriate and adequate research, including experimental tests and analysis.

The CNSC's review of an application for a licence to construct is designed to obtain reasonable assurance that the facility design meets all regulatory requirements and can be constructed, commissioned and operated safely as designed and that no new safety issues will be identified prior to reactor operation. Upon receipt of the application, the CNSC performs a comprehensive assessment of the design documentation, preliminary safety analysis report, construction program and all other information required by the regulations. The evaluation involves rigorous engineering and scientific analysis, as well as engineering judgment, taking into consideration the CNSC's experience and knowledge of best practices in NPP design and operation gained from existing NPPs in Canada and around the world.

During the construction stage, the CNSC carries out compliance activities to verify the licensee's compliance with the NSCA, associated regulations and the licence. Compliance activities focus on confirming that the NPP construction is consistent with the design and that the licensee is demonstrating adequate project oversight and meeting quality assurance requirements.

The scope of a licence to construct covers all facility construction and Phase A commissioning as described in REGDOC-1.1.2 and in REGDOC-2.3.1 (i.e., the commissioning of all structures, systems and components (SSCs) done without fuel loaded). The purpose of Phase A commissioning is to verify, to the extent practicable (without fuel loaded), that all SSCs have been installed correctly and are performing according to the design intent (which includes their response to abnormal conditions, as credited in the safety analysis). Details on commissioning activities are provided in sub-article 19(i).

The licensee must also build a significant portion of the operating organization such that facility operations, processes and procedures will be in place in anticipation of the licence to operate. This approach is part of an overall philosophy to facilitate the transition from construction to commissioning to commercial operation. In addition, the approach may increase regulatory certainty for an operating licence if the licensee demonstrates good regulatory performance regarding facility construction.

Regulatory oversight activities include, but are not limited to:

- inspections, surveillance, reviews, witnessing of commissioning tests and evaluations of commissioning test results

- inspections at manufacturing facilities
- assessment of the effectiveness of the applicant's oversight of construction and commissioning activities
- granting of Commission approval or CNSC staff consent pertaining to commissioning hold points
- oversight of the licensee's progress on its organizational development in preparation for the anticipated application for a licence to operate

During the reporting period, OPG announced its intent to submit, in late 2022, an application for a licence to construct at the DNNP site.

7.2 (ii) (d) Licence to operate

Initial licence to operate and licence renewal - General

For a licence to operate a new NPP, the application must demonstrate that all Phase A commissioning has been successfully completed and all the systems important to safety are ready for the reactor core to accept first fuel. In addition to assessing the information included in the initial application, the CNSC verifies that any outstanding issues from the construction licensing stage have been resolved.

The initial operating licence will enable the operator to load nuclear fuel and begin fuel-in commissioning:

- Phase B starts before the end of the reactor guaranteed shutdown state
- Phase C involves the approach to critical and low-power tests
- Phase D involves high-power tests

These activities complete the overall commissioning program of all SSCs to confirm that:

- the key operational safety characteristics match those used in the safety analyses
- the NPP has been constructed in accordance with the design
- the SSCs important to safety are functioning reliably

Commissioning is discussed in more detail in sub-article 19(i).

When applying for a licence to operate (new or renewal), it is the applicant's responsibility to demonstrate to the CNSC that it has established appropriate safety management systems, plans and programs for safe and secure operation. The information required in a successful application for a licence to operate an NPP, in order to satisfy the regulations and CNSC regulatory documents, is specified in REGDOC-1.1.3, *Licence Application Guide: Licence to Operate a Nuclear Power Plant*. It includes:

- a description of the SSCs, including their design and operating conditions
- the final safety analysis report
- proposed measures, programs, policies, methods and procedures for:
  - conducting Phase B, C and D commissioning
  - operating and maintaining the NPP
  - handling nuclear substances and hazardous materials
  - controlling releases of nuclear substances and hazardous materials into the environment

  - preventing and mitigating the effects on the environment and health and safety of persons resulting from plant operation and decommissioning
  - assisting offsite authorities in emergency preparedness activities, including procedures to deal with an accidental, offsite release
  - developing and maintaining nuclear security
- the public information and disclosure program to keep the public and target audiences informed of the anticipated effects of the NPP's operation on their health and safety and on the environment
- the updated preliminary decommissioning plan
- the proposed financial guarantee for the activities to be licensed

CNSC staff conduct a balanced assessment of the proposed programs and activities against the requirements and guidance in REGDOC-1.1.3. This type of information may become part of the licensing basis of the NPP should a licence to operate be granted, as described in subsection 7.2(ii)(a). CNSC staff's assessment guides the regulatory activities that are planned in the anticipated licence period. See subsection 14(i)(a) for the results of CNSC staff's assessment during the reporting period of NB Power's application to renew its licence to operate Point Lepreau. The pending renewal of the Point Lepreau licence is discussed further at the end of subsection 7.2(ii)(d).

Regulatory hold points

The Commission may add conditions to any licence that require the licensee to obtain specific permission to proceed to a specific step or phase in the licensed activity; these are called regulatory hold points and are relatively common in licences to operate NPPs. Regulatory hold points provide a measure of additional regulatory control that is commensurate with the novelty or uncertainty associated with some aspect of licensed operation. Regulatory hold points may be established for new-build projects as well as for existing NPPs.

For example, the licence to operate Bruce A and B includes a condition requiring Bruce Power to obtain the approval of the Commission, or the consent of a person authorized by the Commission, before proceeding with specific phases of the major component replacement project. The four applicable hold points, which are identified in the LCH, are:

Phase A	Prior to fuel load
Phase B	Prior to removal of guaranteed shutdown state
Phase C	Prior to exceeding 1% full power
Phase D	Prior to exceeding 35% full power

For each phase, the Commission delegated the authority for the removal of regulatory hold points for the return to service to the Chief Regulatory Operations Officer of the CNSC.

The licence to operate the Darlington NPP and the associated LCH have similar provisions for the facility's regulatory hold points related to refurbishment.

Licence renewal and updates to the licensing basis

For the renewal of a licence to operate, the licensee must indicate any changes in information that was submitted in the previous application. (See appendix C of the seventh Canadian report for a summary of information typically submitted with an application to renew an NPP operating licence.) CNSC staff conduct a comprehensive review of the facility and of the licensee's past activities and performance and future plans.

Licence renewal is a mechanism for implementing new requirements from recently published CNSC REGDOCs or standards, thus contributing to the continuous safety improvement of NPPs. Before implementation, the CNSC consults with licensees on the need for a transition period or implementation plan. The implementation of CNSC REGDOCs or standards frequently involves a series of consultations, such as CNSC–industry workshops and CNSC staff visits to NPPs. The Commission may provide direction on the planned implementation of new REGDOCs and standards during the licence renewal process. Following the licence renewal, the implementation details of these REGDOCs and standards are recorded in the LCH. For example, the LCH may contain an anticipated implementation date of the new REGDOC or standard, that is projected to occur after the start of the licence period.

As part of continuous improvement during their licence periods, NPP licensees also implement new regulatory documents and standards (and new versions thereof) that were not considered at the time of the renewal of their licences to operate. This is done on a risk-informed basis, which considers the most effective and efficient time to adjust programs to meet evolving expectations. The LCH is used to document, on an ongoing basis, the implementation status of new regulatory documents and standards. CNSC staff informs the Commission on an annual basis of major changes to the LCH, including information on progress in implementing new regulatory documents and standards. This annual reporting is described in appendix E.

The licensees of operating NPPs also conduct periodic safety reviews (PSRs) in support of ongoing operation, which also account for the possible implementation of new requirements associated with modern codes, standards and practices.

Evolution of licensing periods and periodic safety review within the licensing framework

The CNSC uses flexible licence periods that enable it to regulate NPPs in a more risk-informed manner (particularly through adjusting the licence period according to the licensee's previous performance and the findings resulting from CNSC compliance verification activities). The licensee may also request a specific licence period to match its planned activities or anticipated change in status (such as the beginning or end of refurbishment).

CNSC Commission member document CMD 02-M12, *New Staff Approach to Recommending Licence Periods*, compiles the factors CNSC staff need to consider when making recommendations to the Commission on licence periods. These factors include:

- facility-related hazards
- implementation of the licensee's quality management programs
- implementation of a compliance program by both the licensee and the CNSC
- licensee experience
- CNSC ratings of licensee performance under the CNSC SCAs
- the requirements of the *Canadian Nuclear Safety Commission Cost Recovery Fees Regulations*
- the facility's planning cycle

There is no explicit limit on licence periods in Canada. The imposition of a relatively short licence period by the Commission is an option when overall licensee performance, or one of the other factors listed above, is unsatisfactory.

During the reporting period, the practice of PSR in the context of the licensing framework continued to evolve. As described in previous Canadian reports, the practice was initially known as integrated safety review, or ISR, and was conducted in the context of NPP refurbishment. In the previous reporting period, CNSC staff began recommending 10-year operating licences for NPPs, with a PSR performed every 10 years to synchronize with licence renewal. In 2017, the CNSC amended the *Class I Nuclear Facilities Regulations* to require all NPPs to conduct a PSR at an interval specified in the licence. The requirements for PSR are found in CNSC REGDOC-2.3.3, *Periodic Safety Reviews*, which is consistent with the IAEA's Specific Safety Guide No. SSG-25, *Periodic Safety Review for Nuclear Power Plants*. The NPP licensees began implementing REGDOC-2.3.3 during the previous reporting period. The CNSC SCAs that provide the framework for the licence renewal safety assessment (and PSR) cover the IAEA PSR safety factors. The PSR results in an integrated implementation plan (IIP), which is submitted to CNSC staff for acceptance per REGDOC-2.3.3. REGDOC-2.3.3 establishes 10 years as the appropriate interval, but allows shorter intervals, or slightly longer than 10 years, to accommodate operational plans. PSRs support the application to renew the licence to operate for the subsequent licence period.

Refer to subsection 14(i)(b) for the results of the most recent PSRs for operating NPPs in Canada.

The licences to operate Bruce, Darlington and Pickering each have a period of 10 years[7]. The Commission considered the results of the PSRs and the proposed IIPs when granting those licences.

In 2018, at the time of the licence renewal for Pickering, OPG planned to operate the NPP until 2024 (before the end of the 10-year licence period). The licence to operate does not require OPG to conduct a PSR in support of the next licence period, but it does require OPG to implement the IIP from the 2018 PSR. In the context of the 10-year licence, the portion of the licence period from 2024 to 2028 would involve the transition to safe storage. During the reporting period, OPG determined that extension of the commercial operation of Pickering Units 5-8 to December 2025 could accommodate the optimization of the shutdown and safe storage of Pickering in a safe and effective manner. As stipulated in the LCH, OPG is updating the 2018 PSR to support this extension in accordance with REGDOC-2.3.3 and plans to obtain approval from the Commission in the next reporting period.

During the reporting period, NB Power applied for a renewal of its licence to operate Point Lepreau for a period of 25 years (significantly longer than recent NPP licence renewals). At the end of the reporting period, CNSC staff recommended to the Commission that the licence period be for 20 years, noting that a 25-year licence would extend past the current prediction for the end of safe operating life (2042). CNSC staff expressed a high level of confidence in the industry's readiness for longer-term licences. Licence renewal applications are no longer needed as a mechanism to drive the resolution of safety issues. Also, multiple avenues are available, besides licensing hearings, for engaging stakeholders in issues that interest them. These include regulatory oversight reports and environmental protection review reports (discussed in subsections 7.2(iii)(b) and 15(b), respectively). The maturation of the regulatory framework, including the implementation of PSR and CNSC's compliance program, also support the

[7] The period for the Darlington licence is actually slightly less than 10 years.

implementation of longer licences. The Commission will render a decision in the next reporting period.

7.2 (ii) (e) Licence to decommission

Specific requirements for an application for a licence to decommission a Class I nuclear facility are listed in section 7 of the *Class I Nuclear Facilities Regulations*. Information listed in section 3 of the *General Nuclear Safety and Control Regulations* and the general requirements section of the *Class I Nuclear Facilities Regulations* is also required. Examples of the information required in an application for a licence to decommission a Class I nuclear facility include:

- effects on the environment and the health and safety of persons that may result from the decommissioning, and the measures that will be taken to prevent or mitigate those effects
- proposed measures to control releases of nuclear substances and hazardous substances into the environment
- proposed measures to prevent or mitigate the effects of accidental releases of nuclear substances and hazardous substances on the environment, the health and safety of persons; and to maintain national security, including an emergency response plan

The *Class I Nuclear Facilities Regulations* require an applicant for a licence to prepare site, licence to construct, or licence to operate a Class I facility to provide information on the proposed plan for decommissioning. The CNSC requires that planning for decommissioning take place throughout a licensed activity's life-cycle, and that both a preliminary decommissioning plan and a detailed decommissioning plan be prepared for approval by the CNSC. REGDOC-2.11.2, *Decommissioning* , which was published in January 2021, stipulates regulatory expectations to licensees regarding the preparation and content of preliminary and detailed decommissioning plans for activities licensed by the CNSC.

Furthermore, CSA Group standard N294, *Decommissioning of facilities containing nuclear substances* sets out additional requirements and guidance on decommissioning of nuclear facilities and other locations where nuclear substances are managed, possessed, or stored.

As a condition of their licences, the Commission routinely requires licensees to maintain a decommissioning plan and a financial guarantee for decommissioning.

CNS Challenge 7RM C-3 for Canada from the Seventh Review Meeting
"Formalize the planned approach to end-of-operation of multi-unit NPPs"

The expected regulatory process for end of commercial operation is set out in CNSC regulatory document REGDOC-3.5.1, *Information Dissemination: Licensing Process for Class I Nuclear Facilities and Uranium Mines and Mills*. During operation, a licensee will identify a target date for end of commercial operation of the facility. Normally, this occurs several years in advance, which allows appropriate plans to be developed.

Per REGDOC-3.5.1, the CNSC requests the licensee to develop a plan for the facility's end of commercial operation. This is a broad plan that comprises steps for approaching permanent shutdown and the facility's smooth transition from shutdown to a stable state (i.e., stabilization activities). REGDOC-3.5.1 provides for two basic approaches – "immediate" decommissioning following the end of commercial operation and deferred decommissioning, which would include an extended period of storage with surveillance prior to commencing dismantlement and site restoration.

The CNSC is applying this approach for Pickering – the only multi-unit NPP in Canada currently approaching the end of commercial operation. Units 2 and 3 are in safe storage while units 1, 4, and 5 to 8 are continuing in commercial operation[8]. The operating licence for Pickering includes a licence condition requiring OPG to implement and maintain plans for the end of commercial operation for all units. OPG has established a strategy for the end of commercial operation, which includes a sustainable operations plan for the approach to shutdown of the remaining operating units, a stabilization activity plan for transitioning to a stable state, a decommissioning plan, and the associated financial guarantee under its operating licence. When shutdown approaches, OPG will update its decommissioning plan. The details of OPG's approach and CNSC's requirements for the transition are captured in the LCH for Pickering. OPG is required to provide annual updates to the CNSC on its sustainable operations plan and stabilization activity plan, including a report on the progress and effectiveness of measures in those plans.

REGDOC-2.11.2 contains additional requirements and guidance for the preparation for decommissioning, including the transition to the end of commercial operation and decommissioning strategy. All NPP licensees can pursue a phased implementation of REGDOC-2.11.2, for example, when updating their preliminary decommissioning plans.

Canada recommends this challenge be closed.

7.2 (iii) System of regulatory inspection and assessment

Section 30 of the NSCA authorizes CNSC inspectors to carry out inspections to verify licensee compliance with regulatory requirements, including any licence conditions. Per paragraph 24(4)(b) of the NSCA, these inspections are intended to confirm that the licensee has sufficient provisions to adequately protect the environment and the health and safety of persons, maintain national security and implement Canada's international obligations.

The CNSC designs and executes a compliance verification program that:

- is informed by risk (to health, safety, the environment and national security)
- considers the effective implementation of international agreements to which Canada has agreed
- accounts for the compliance record of the regulated person or organization

The CNSC implements a corporate-wide compliance verification process (one of the core processes in the CNSC management system; see subsection 8.1(d)) that integrates the following elements:

- promotion to encourage compliance (subsection 7.2(iii)(a))
- verification activities to confirm licensees are complying with requirements and expectations (subsection 7.2(iii)(b))
- reactive control measures to enforce compliance (sub-article 7.2(iv))
- consistency in the method and conduct of compliance activities

[8] As noted in subsection D.2 of chapter I, Pickering is approved for commercial operation until December 2024, but is planning to seek regulatory approval for an extension of that period for units 5 to 8 to December 2025.

The compliance verification process provides input to the initial issuance of licences and the operating licence renewal process described in sub-article 7.2(ii).

7.2 (iii) (a) Promotion of compliance

Promotion of compliance refers to all activities related to fostering conformity with requirements. The goal is to maximize compliance, by strengthening those factors that encourage it and mitigating those that hinder it. Compliance promotion can take the form of consultation, acknowledgement of good performance, collaboration with other regulatory bodies, and dissemination of information to the regulated community about regulatory requirements/standards and the rationale behind them. Specific compliance promotion activities include, but may not be limited to, training, seminars, workshops and conferences.

7.2 (iii) (b) Verification of compliance

General

Compliance verification includes all the activities related to determining and documenting whether a licensee’s programs and performance comply with requirements and conform to acceptance criteria. Verification activities include:

- Type I inspections, which consist of audits of licensee programs or processes and their implementation
- Type II inspections, which focus on the performance or output of the programs or processes, as well as walkdowns (or rounds) and routine system inspections
- field inspections, which focus primarily on observations made within the nuclear power plant and can be completed within a short time frame
- desktop inspections, which focus on the performance or output of the programs or processes through document review
- compliance technical assessments, which involve reviews of documentation submitted to the CNSC by licensees (or applicants)
- surveillance and monitoring, which includes the review of NPP records and attendance at meetings related to production, return to service and outage planning
- independent environmental monitoring program, which complements and informs the CNSC compliance program by verifying environmental monitoring results submitted by the licensees (thus confirming details needed to demonstrate compliance)

In general, acceptance criteria that can be used to assess compliance during these activities may be derived from compliance verification criteria in the LCH, licensees’ documents, CNSC regulatory documents and standards, and criteria that are not in the LCH such as the following:

- CNSC documents not listed in the LCH that clarify how the Commission intends to apply the legal requirements
- additional information supplied by licensees defining how they intend to meet legal requirements in performing the licensed activity
- CNSC staff’s expert judgment, including knowledge of industry best practices

Inspections

Inspections typically include interviews with responsible licensee staff; reviews of documentation, data, logs and event reports; observation, and field component line-up checks. Some inspections monitor licensee activities as they unfold (e.g., exercises, outages).

See annex 7.2(iii)(b) for a listing of systems and areas of verification activities through inspections at NPPs.

The CNSC has in place a comprehensive process for conducting inspections for all regulated activities concerning NPPs. This process has been responsible for the development of procedures, templates and guides used by CNSC staff to improve the consistency and efficiency of inspections for all regulated facilities and activities. A feedback mechanism is also in place for CNSC staff to recommend revisions to inspection documents.

CNSC staff members who conduct the inspection are chosen based on the area being assessed and typically include specialists from the head office and inspectors from the site office. The site office inspectors are designated per section 29 of the NSCA and have various powers and limitations described in sections 30 to 35 of the NSCA. A site office inspector generally leads the inspection team, with support from the technical specialist staff. The licensee is notified in advance of the inspection and its subject area. Entrance meetings, daily briefings of results and exit meetings are included in the inspection plans for Type I and Type II inspections. The results are recorded in a CNSC report to the licensee and follow-up actions are documented and assigned target completion dates.

Type I inspections are used to evaluate licensee programs, and may be conducted after programmatic changes. As the licensees of the operating NPPs are well-established, Type I inspections are rarely conducted. Type I inspections are planned with a high degree of detail, with acceptance criteria spelled out in advance. The results from Type I inspections are transmitted by letter to licensees. These inspections involve both an onsite and remote desktop-based component.

Type II inspections are used to evaluate the output of licensee programs and are conducted at a regular frequency. The results of Type II inspections are transmitted by letter to licensees. These inspections involve both an onsite and remote desktop-based component.

Desktop inspections are used to evaluate the output of licensee programs and are conducted at a regular frequency. The results of desktop inspections are transmitted by letter to licensees. These inspections involve only a remote, desktop-based component.

Field inspections are limited scope, onsite inspections used to determine the current status of the NPP, and its personnel and management system. CNSC site staff at NPPs conduct field inspections at a regular frequency and communicate their preliminary observations to the licensees through a field inspection record. CNSC staff also submit a quarterly summary of the findings from field inspections by letter to the licensees.

Type II and field inspections are executed using inspection guides. The suite of inspection guides was updated during the reporting period and additional guides were developed. The guides are continuously improved to reflect the current state of the CNSC compliance program and changes to the licensing basis. A suite of CNSC desktop inspection guides was updated during the reporting period and additional guides were developed.

Compliance verification baseline and additional activities

To help achieve regulatory effectiveness, efficiency, consistency and clarity, the CNSC compliance program uses a planned set of baseline compliance verification activities, which include inspections and compliance technical assessments suited for typical NPP operation. The baseline program represents the minimum set of activities required to verify licensee compliance with regulatory requirements. The baseline activities represent a reasonable set of inspections for a licensee with satisfactory safety performance and are balanced to reflect the relative risk significance of each of the SCAs. Within each SCA, a risk-informed approach is used to identify an effective and efficient set of compliance verification activities, which can be tailored to individual licensees and circumstances.

The baseline regulatory activities take place over a schedule of five years. For SCAs where the CNSC rating of licensee performance is below expectations, risk management principles are used to identify focused activities that CNSC staff will undertake in the next period to supplement the baseline inspections. Monitoring includes the quarterly review of results of all verification activities.

While most inspections are planned and scheduled with licensees, inspectors have and do use the power to conduct reactive inspections, in reaction to events or other findings (for example, inspections related to the failure of a pump motor for the primary heat transport system at Point Lepreau, as described in appendix C).

In addition to inspections, the baseline includes compliance technical assessments and surveillance and monitoring. Compliance technical assessments include reviewing licensee documents, such as the safety analysis reports, quarterly reports and event reports. Some specific forms of technical assessment are supported by CNSC staff work instructions to ensure consistency of approach and to optimize regulatory effectiveness and efficiency. Compliance technical assessments are also conducted when licensees propose certain changes to their operations, documentation, etc. As indicated in subsection 7.2(ii)(a), licences require the licensees to notify the CNSC of such changes. CNSC staff members perform these compliance technical assessments to confirm that the change, if it were to proceed, would remain in accordance with the licensing basis for the facility.

Surveillance and monitoring activities collect real-time information about licensee performance and possible emerging issues.

Results of the CNSC's compliance activities, and assessments of licensees' safety performance are provided to the Commission and stakeholders annually in the *Regulatory Oversight Report for Canadian Nuclear Power Generating Sites* (see appendix E for details).

During the reporting period, CNSC conducted a project known as the Forge that focused on the implementation of regulatory innovations in inspections and the potential applications of artificial intelligence. The project team gathered suggestions for improvement and innovation internally from staff and met with nuclear industry representatives and regulatory counterparts to identify innovations being implemented that could be applied by the regulator. The project team developed recommendations of innovations that could be implemented for CNSC senior management consideration, such as leveraging virtual/augmented reality technologies to enhance inspector training and adding cross-functional training to broaden inspector capabilities. These recommendations have been incorporated into other existing CNSC improvement initiatives for more efficient and strategic implementation.

Besides the CNSC, other organizations play a role in verifying the compliance of NPP licensees with the various requirements. For example, Health Canada operates the National Dose Registry (NDR), which contains the dose records of all individuals in Canada who are monitored for occupational exposures to ionizing radiation. The NDR assists in regulatory control by notifying regulatory authorities of overexposures within their jurisdiction. See subsection 15(a) for details.

Licensee reporting, follow-up, recording and tracking

CNSC REGDOC-3.1.1, *Reporting Requirements for Nuclear Power Plants*, consolidates and expands upon almost all legislated reporting requirements contained in the NSCA and its associated regulations that apply to NPPs. REGDOC-3.1.1 sets out the timing for information that NPP licensees are required to report to the CNSC. It includes requirements for scheduled (periodic) and unscheduled (e.g., event) reports and has been incorporated in the licences of all NPPs.

REGDOC-3.1.1 provides detailed examples and guidance on the types of situations and events that must be reported. The list is comprehensive and includes many events that would not meet the threshold for international reporting (such as for the Incident Reporting System or the International Nuclear Event Scale (INES)). Preliminary reports for the most safety-significant situations or events (as defined in the regulatory document) must be provided to the CNSC immediately. Other preliminary reports must be provided on or before the first business day after the day that the licensee determines that the situation or event is reportable. The least significant reportable events are required to be reported quarterly or annually, primarily for trending and analysis of long-term safety and regulatory issues.

CNSC staff assess the significance of the reported events and situations. Significance is determined using operational procedures or expert judgment. The urgency with which follow-up to the event should be conducted is also evaluated. The CNSC reviews do not aim to duplicate the assessments already performed by licensees; their purpose is to ensure licensees have adequate processes in place to take necessary corrective actions and incorporate the lessons learned from past events into their day-to-day operations. CNSC staff will only carry out detailed reviews of those events considered particularly significant to safety. CNSC staff may also investigate events of higher safety significance to independently confirm the event causes and required corrective actions.

CNSC staff use the Central Event Reporting and Tracking System database to record the details of reported events; to code, trend and sort events using various criteria; and to track licensee and CNSC follow-up.

Situations deemed to be of noteworthy significance with respect to the protection of health, safety and the environment, the maintenance of national security, and compliance with international obligations are reported to the Commission in an event initial report, thus making the information available to all stakeholders.

REGDOC-3.1.1 requires the NPP licensees to report data for a set of 25 safety performance indicators on a quarterly basis. CNSC staff use these safety performance indicators to:

- benchmark acceptable levels of operational safety

- track operational trends important to safety and, in some cases, performance comparisons across NPPs

The safety performance indicators are divided among seven categories:

- radiation and contamination
- environment, waste, and health and safety
- international benchmarking
- maintenance
- emergency response
- operations
- chemistry

CNSC staff's assessment of safety performance indicator data is presented in the *Regulatory Oversight Report for Canadian Nuclear Power Generating Sites*.

REGDOC-3.1.1 also provides the CNSC's requirements for self-reporting of compliance monitoring for operating NPPs. The scheduled compliance reports are based on the 14 CNSC SCAs. These reports include information about the least significant reportable events discussed above that the CNSC uses for trending and analysis. The quarterly compliance reports are designed to highlight areas of potential non-compliance with regulations and licence conditions. Annual reports provide information on program status and performance.

Adjustment of compliance verification program due to the COVID-19 pandemic

In March 2020, CNSC suspended all regular NPP compliance verification activities and identified activities that were considered critical in order to support continued safe operation and regulatory decision making.

In April 2020, a new procedure to plan and conduct compliance verification activities at NPPs during the COVID-19 pandemic was approved to ensure continued regulatory oversight. This procedure was utilized during the calendar year 2020 and will be used until normal compliance processes resume. It provides direction for the conduct of oversight activities both remotely and onsite, as well as direction on revising the annual compliance plan. The procedure provides a framework for conducting remote oversight activities and enhancing the capabilities of site inspectors to work remotely.

In addition to this new procedure, a pandemic-related pre-job brief was developed as additional instruction to be delivered by the site office supervisors to site inspectors prior to performing on-site oversight activities. Provision of personal protective equipment to site inspectors prior to any onsite activities forms part of this pre-job brief.

CNSC staff worked with licensees to provide comprehensive and remote access to site information systems, actual plant data and participation in all key plant management meetings.

Also, in April 2020, CNSC staff launched a benchmarking exercise with 19 countries about their inspection practices during the pandemic. The CNSC received responses from 16 countries, including France, the USA and the United Kingdom. CNSC considered this information during the development of its own procedure on planning and conducting inspections during the pandemic and during the revision of its inspection pre-job briefing.

In May 2020, onsite oversight activities resumed at NPPs in a modified capacity. These activities focused on general health and safety issues (e.g., control of combustible material, housekeeping, contamination posting), as well as licensees adherence to their pandemic response plans and COVID-19 health protocols. The CNSC has made adjustments to the way oversight is conducted. For example, CNSC staff have utilized remote video-conferences to make sure that the presence of specialists during inspections can continue and to conduct the documentation portion of an inspection via desktop inspection. All licensee safety and health procedures are being followed by CNSC site inspectors. CNSC staff continue to conduct oversight activities during the pandemic to ensure the protection of the environment, and the health and safety of people.

Regulatory oversight report

CNSC staff produce the *Regulatory Oversight Report for Canadian Nuclear Power Generating Sites*, which is presented to the Commission and later published. In addition to the operating NPPs, recent reports have covered Gentiilly-2 and the waste management facilities at the same sites as the NPPs. The regulatory oversight report summarizes the safety performance at each NPP for all the CNSC SCAs, using the rating system described in appendix E. It provides the Commission, the public, stakeholders, and licensees with information and feedback on performance and other topics of interest during the licence period. In addition, the regulatory oversight report describes progress on issues that had been identified in the previous report. The Commission follows up with questions to CNSC staff and licensees at a Commission meeting and also invites submissions from intervenors. The CNSC provides funding for interventions to eligible applicants through its Participant Funding Program.

During the reporting period, the CNSC commenced comprehensive review of the RORs and the ROR process. The objectives of the review were to:

- consider the frequency at which RORs should be presented to the Commission
- define and better understand the needs of the ROR’s target audience(s)
- seek input from licensees, stakeholder, and Indigenous groups and communities to help the CNSC refine the content and delivery of the RORs to the Commission

In support of the third objective, the CNSC published discussion paper DIS-21-01, *The Canadian Nuclear Safety Commission: Regulatory Oversight Report Review* to seek feedback on the RORs and the ROR process from licensees, stakeholder, and Indigenous groups and communities. CNSC staff presented the preliminary results of the review to the Commission in January 2022; potential changes to the *Regulatory Oversight Report for Canadian Nuclear Power Generating Sites* (and other CNSC regulatory oversight reports) may be rolled out during the next reporting period.

7.2 (iv) Enforcement

Enforcement includes all activities to compel a licensee into compliance and to deter non-compliance with requirements. The choice of enforcement tool is governed by the CNSC graduated enforcement strategy handbook. It provides details on the effective application of the enforcement tools described below and outlines the responsibilities of CNSC staff and the Commission in their execution of these tools. If the initial enforcement action does not result in timely compliance, increasingly severe enforcement actions may need to be used. In the graduated approach, the severity of the enforcement measure depends on the safety significance of the non-compliance and other related factors, such as:

- the risk significance of the non-compliance with respect to health, safety, national security, the environment and Canada’s international obligations
- the circumstances that have led to the non-compliance (including acts of willfulness)
- the licensee’s previous compliance record
- operational and legal constraints
- industry-specific strategies, efforts and ability to return to compliance and/or rectify the situation

Graduated enforcement tools available to the CNSC include:

- written notices
- increased regulatory scrutiny
- request from the Commission for information
- administrative monetary penalties
- orders
- licensing actions
- prosecution

Written notices, increased regulatory scrutiny and prosecution do not require the involvement of the Commission (as they are typically handled by CNSC staff).

Written notices are the most common enforcement tools used for NPPs. There are two types of written notices: recommendations and notices of non-compliance.

A recommendation is a written suggestion to effect an improvement based on good industry practice. It is, technically speaking, not an enforcement tool in that it is used when the licensee is still in compliance with regulatory requirements.

A notice of non-compliance is a written notice from the CNSC requesting that the licensee take the necessary action(s) to correct a non-compliance. The notice of non-compliance indicates that a non-compliance has been confirmed and requests that the licensee respond with one of the following:

- confirmation that compliance has been restored
- a timeframe for restoring compliance
- a timeframe within which a corrective action plan will be submitted

If compliance is restored within an acceptable time frame and to the satisfaction of the CNSC, no further regulatory action is necessary.

Increased regulatory scrutiny includes the focused verification activities referred to in subsection 7.2(iii)(b).

The Commission (or an authorized person) can make a formal request for more information, as stipulated in subsection 12(2) of the *General Nuclear Safety and Control Regulations*. These types of formal requests are infrequent. The licensee can be asked to explain how it plans to address a concern raised by the Commission or the authorized person.

An administrative monetary penalty (AMP) is a financial penalty imposed by the CNSC, without court involvement, in response to a violation of a regulatory requirement. It can be applied to any person, which includes corporations, subject to the NSCA. AMPs serve as a credible deterrent, thereby achieving higher levels of compliance.

The NSCA sets the maximum AMPs for individuals and persons other than an individual (i.e., a corporation or other institution) at $25,000 and $100,000, respectively and addresses the rules surrounding violations and designates who can issue AMPs and review them. The review framework is based on the current CNSC appeal process; reviews are conducted by the Commission, during which time payment is pending. The *Administrative Monetary Penalties Regulations (Canadian Nuclear Safety Commission)* set out the schedule of violations that are subject to AMPs under the NSCA, as well as the method by which the penalty amounts are determined, and the way notices of violation are served.

CNSC regulatory document REGDOC-3.5.2, *Administrative Monetary Penalties*, *Version 2*, provides information about the AMP program. It describes how and where AMPs fit into the CNSC's approach to compliance, and provides an overview of how they are administered.

The CNSC issued a total of 3 AMPs during the reporting period. None of these AMPs were issued to an NPP.

The NSCA gives the Commission, inspectors and designated officers of the Commission the authority to issue an order without prior notice, where necessary to do so in the interests of health, safety, the environment, national security or Canada's international obligations. The NSCA includes provisions for the review of orders by the Commission, which includes an opportunity for the affected licensee to be heard. Orders to NPP licensees are rare, but CNSC issued orders to two licensees of operating NPPs during the reporting period. Following the discovery of elevated measurements of equivalent hydrogen in pressure tube scrape samples at Bruce Units 3 and 6, CNSC issued an order to Bruce Power to obtain authorization from the Commission prior to the restart of any of Units 3, 4, 5, 7 or 8 following any outage that results in a cooldown of the heat transport system. See appendix C for details. A similar order was sent to Darlington for Units 1 and 4 and Pickering for Units 1,4,5,6,7 and 8. An order was not issued to NB Power because Point Lepreau is not in extended operation – operation at a hydrogen level exceeding safe limits is improbable.

Licensing action can be taken in the context of a licensing matter initiated by the licensee/applicant. The Commission could grant a licence for a shorter term – for example, so that it can reconsider a specific compliance issue in the relatively near future. Alternatively, the Commission could also grant a licence renewal for a shorter licence term to allow the licensee sufficient time to make certain improvements or provide clarifications before the licence is considered for the next renewal.

Examples of other licensing actions that can be initiated by the CNSC include:

- licence amendment: CNSC staff may recommend that the Commission amend a licence. Licence amendments cover a wide range of possibilities and are decided case-by-case; an enforcement example might be the imposition in the licence of a limit to on-power operation.
- decertification of persons
- refusal to certify or renew certification
- licence suspension or revocation: CNSC staff may recommend that the Commission suspend or revoke a licence; this course of action can be taken in any of the following circumstances:

- the licensee is in serious non-compliance
- the licensee has been successfully prosecuted
- the licensee has a history of non-compliance
- the CNSC has lost confidence in the licensee's ability to comply with the regulatory requirements

Notwithstanding the above, the NSCA gives the Commission the authority, on its own motion, to renew, suspend in whole or in part, amend, revoke or replace a licence under prescribed conditions.

A licensee that is subject to enforcement action which involves an order or amendment, suspension or revocation of the licence, is entitled to appeal to the Commission to contest the action. For a licence amendment, suspension, or revocation, the licensee would normally receive advance notice and have an opportunity to be heard by the Commission.

Where warranted, prosecution is also an enforcement option available to the CNSC. Specific instances of non-compliance that might lead to prosecution include:

- exposures to the public or workers in excess of the dose or exposure limits
- failure to take all reasonable measures to comply with an inspector's order

Significant enforcement actions against NPP licensees are summarized for the Commission and stakeholders in the annual regulatory oversight report (see subsection 7.2(iii)(b)).

Article 8 – Regulatory body

1. Each Contracting Party shall establish or designate a regulatory body entrusted with the implementation of the legislative and regulatory framework referred to in Article 7, and provided with adequate authority, competence and financial and human resources to fulfill its assigned responsibilities.
2. Each Contracting Party shall take the appropriate steps to ensure an effective separation between the functions of the regulatory body and those of any other body or organization concerned with the promotion or utilization of nuclear energy.

Adaptation of the regulatory body to change

During the reporting period, the CNSC made various preparations to adapt to emerging technologies (notably SMRs) and changing circumstances, many of which are discussed in this article. CNSC's strategy for ensuring regulatory readiness for SMRs is built upon three basic pillars, shown in the figure below:

1. a robust but flexible regulatory framework that provides a sound legal basis upon which regulatory decisions can be made and enforced
2. risk-informed processes by which the regulatory framework is applied
3. a capable workforce with sufficient capacity and technical expertise, operating within an agile organization

Figure 8.1(a) Regulatory readiness for SMRs

The CNSC has established an SMR Steering Committee to provide senior management governance, ensure the pillars are appropriately balanced, and prioritize the activities that support the strategy, including those associated with the review and licensing of SMR technologies. The CNSC is also looking beyond the nuclear sector for models or examples of international harmonization with respect to technological advances and their regulation (e.g., in the aviation, medical, or transport sectors). The readiness of the CNSC's organization and workforce to address SMR regulation is described in subsections 8.1(b) and 8.1(c), respectively. Specific international activities related to readiness for SMRs are described in subsection 8.1(g).

During the reporting period, the CNSC also adapted to the COVID-19 pandemic. On March 15, 2020, the CNSC activated its business continuity plan in response to the pandemic. Effective March 16, 2020, all CNSC staff in Ottawa and at regional and site offices were directed to work from home. The CNSC made significant efforts to enable its workforce to work remotely. This included the procurement of tablets, the expansion of remote server capacity, and the leveraging of video conference software. All CNSC employees were asked to avoid non-essential travel outside of Canada. Those returning from outside of Canada were directed to self-isolate for 14 days. The CNSC recommended the adoption of a variety of self-care practices to its employees in order to promote mental wellness. Employees were also required to disclose to the CNSC, per Part II of the *Canada Labour Code*, if they had tested positive for COVID-19.

The CNSC developed a plan for the return to the workplace using the guidance from the public health authorities, based on a phased approach while taking into consideration future developments. A series of protocols were and are being developed for the workforce and workplace, in preparation for a smooth return to work. At the end of the reporting period, CNSC staff continued to work from home as a rule. Entry to CNSC buildings required prior approval from CNSC management and business travel has resumed, although with additional scrutiny/restriction.

CNSC outreach activities, discussed in subsection 8.1(f), were also adjusted to facilitate effective sharing of information and engagement in spite of the limitations placed on in-person meetings.

The CNSC's adaptation of NPP compliance verification activities during the pandemic is described in subsection 7.2(iii)(b).

8.1 Establishment of the regulatory body

The NSCA establishes the CNSC as the nuclear regulatory body in Canada. The CNSC strives for regulatory excellence; its vision, as stated in its *Management System Manual* (see subsection 8.1(d)), is "to be the best nuclear regulator in the world". This vision is supported by a commitment to self-assessment, peer review and continual improvement.

The CNSC fulfills its mandate (see subsection 7.1(a)) through the work of the Commission, a quasi-judicial administrative tribunal comprising a maximum of seven members. Commission members are chosen on the basis of their credentials and are independent of all political, governmental, special interest group or industry influences. Members are appointed by the Governor in Council for terms not exceeding five years and may be reappointed. One member of the Commission is designated as both the President and Chief Executive Officer of the CNSC as an organization.

Subsection 16(1) of the NSCA stipulates that the Commission can employ staff (see subsection 8.1(b)) to meet the purposes of the NSCA.

The Commission conducts its business in an open and transparent manner. The public hearings and meetings of the Commission represent the public's primary opportunity to participate in the regulatory process. For more information on openness and transparency, as well as the CNSC's efforts to engage stakeholders, see subsection 8.1(f).

The Commission holds hearings for the purpose of considering applications, CNSC staff recommendations, interventions and related information pertinent to licensing decisions (section 7.2(ii)(a)). The Commission also holds meetings to discuss other issues and conduct other business within its mandate (e.g., to approve draft CNSC REGDOCs for publication or consider NPP status, licensees' performance and the results of CNSC compliance verification activities.

CNSC staff regularly attend public hearings and meetings to advise, report and make recommendations to the Commission.

Subsection 17(1) of the NSCA stipulates that the Commission can also retain the services of external persons having technical or specialized expertise to advise it, independently of CNSC staff. This provision is used as needed and would be the foundation for establishing *ad hoc* or permanent committees to support the Commission. An example is the External Advisory Committee on Pressure Tubes, established in July 2021, whose goal is to provide Commission members with objective and impartial expert advice in technical matters related to pressure tubes - notably on exceedance of limits for equivalent hydrogen content and related modelling.

The CNSC research program provides access to independent advice, expertise, experience, information and other resources via contracts and contributions placed in the private sector and with academic institutions and other agencies/organizations across Canada and around the world. The research program helps the CNSC meet its regulatory mission and is independent of the extensive R&D program conducted by the industry. Appendix D describes the research objectives of the CNSC (and the Canadian nuclear industry) during the reporting period.

For some technical issues, the CNSC has also jointly sponsored, with the nuclear industry, independent technical panels to review certain aspects of a particular issue (such as the analysis of effects associated with the issue or the proposed methodology to address it). For an example of one of these reviews see the seventh Canadian report. More recently, industry participated with CNSC staff in a CNSC-sponsored research project to review the extreme-value statistics methodology used to calculate neutronic trip set-points for CANDU NPPs.

The general characteristics of the CNSC described above and in the following subsections enable it to readily fulfill its mandate while also allowing flexibility to adapt to changing circumstances.

8.1 (a) Position and funding of the CNSC within the government structure

Position of the CNSC in the government structure

The CNSC is independent of government and reports to the Parliament of Canada through a Minister, designated by the Governor in Council. Currently, this designate is the Minister of Natural Resources.

The Commission requires the involvement and support of the Minister of Natural Resources to make or amend regulations and to address matters of administration. Ministerial approval is required for regulation proposals submitted to the Governor in Council for approval. In addition, the Commission requires the involvement and support of the Minister for requests for funding of activities not funded under the *Canadian Nuclear Safety Commission Cost Recovery Fees Regulations*, as described in the next subsection.

The Commission submits to Parliament its annual report as well as its *Departmental Plan*. The President of the CNSC, as the head of the Commission, appears before parliamentary committees to elaborate on matters related to the administration of the regulatory regime. Regulatory decisions by the Commission can be reviewed, but only by the Federal Court. As a federal agency, the CNSC is subject to various laws (e.g., the *Canadian Charter of Rights and Freedoms*, the *Official Languages Act*, the *Privacy Act*, the *Access to Information Act* and the *Financial Administration Act*).

Although the CNSC is the clear regulatory authority with respect to nuclear safety in Canada, various other federal organizations play important, complementary roles. Legislation is established to set the relevant requirements for other areas of jurisdiction that are also applicable to nuclear-related activities. Memoranda of understanding and working relationships are established between these organizations and the CNSC to ensure nuclear regulation is effective and consistent, safety is not compromised, all responsibilities are borne by the appropriate body and no ambiguity or overlap exists. Examples of such areas of jurisdiction are emergency preparedness, the transportation of dangerous goods, environmental protection, and conventional health and safety.

CNSC staff communicate with management and staff of Natural Resources Canada (NRCan) in areas of mutual interest. NRCan formulates the Government of Canada’s policy regarding uranium, nuclear energy and radioactive waste management. Another close partner is Global Affairs Canada, with which the CNSC frequently works to ensure the fulfillment of Canada’s international commitments pursuant to bilateral and multilateral treaties, conventions and understandings.

Under the *Impact Assessment Act* (IAA) the CNSC provides technical expertise to the Impact Assessment Agency of Canada, with Commission members participating as integrated review panel members. See subsection 7.2(ii)(a) for details.

In addition to federal government entities, the CNSC works with several provincial and municipal organizations, as appropriate, in fulfilling its mandate (see subsection 7.1(b)).

The CNSC issues licences for the nuclear operations of provincially-owned electrical utilities OPG, Hydro-Québec and NB Power (as well as for Bruce Power, which is a private-sector organization). The following publicly-owned institutions or agents of the federal and provincial governments also hold other types of CNSC licences:

- NRCan
- Canadian universities
- hospitals and research institutions
- federal and provincial government departments

Funding

The CNSC is a departmental corporation, listed in schedules II and V of the *Financial Administration Act.*

The CNSC has statutory authority – pursuant to subsection 21(3) of the NSCA – to spend during a fiscal year any revenues that it receives in the current or previous fiscal year through the conduct of its operations. The revenues received from regulatory fees for licences and applications are charged in accordance with the *Canadian Nuclear Safety Commission Cost Recovery Fees Regulations*. This authority to spend revenues provides a sustainable and timely funding regime to address the rapid changes in the regulatory oversight workload associated with the Canadian nuclear industry.

Revenue recovered from fee-paying applicants and licensees accounts for almost 70 percent of the CNSC's funding. While the CNSC always seeks to increase the efficiency of its operations, it can address workload pressures associated with fee-paying licensees through an increase of its regulatory fees.

CNSC activities that are not recovered through cost recovery fees are funded through annual appropriations from Parliament, which require the involvement and support of the Minister of Natural Resources. These appropriations account for the remaining 30 percent of the CNSC's funding. Certain organizations are exempt from cost recovery and are not charged licence fees. These include not-for-profit institutions such as schools, medical facilities and emergency services, as well as government departments or agencies that hold a licence for an abandoned, contaminated site (assuming the licensee did not create the contamination). In addition to the exempt organizations, the types of activities funded through the annual appropriations are activities that the CNSC is obliged to conduct and that have no direct benefit for individual licensees (e.g., activities related to non-proliferation, emergency preparedness, public information programs and the maintenance of the NSCA and its associated regulations). For fluctuations associated with these licensees or activities, the CNSC can also request incremental funding through the Government of Canada's annual budget process.

8.1 (b) Organization of CNSC staff

The CNSC consists of a President, the federally-appointed members of the Commission and over 900 staff members, as of the end of the reporting period. Subsection 12(1) of the NSCA states that the President *"has supervision over and direction of the work of the members and officers and employees of the Commission"* including professional, scientific, technical and other officers employed for the purpose of carrying on the work of the Commission. The CNSC's current organizational structure is described in figure 8.1 (b):

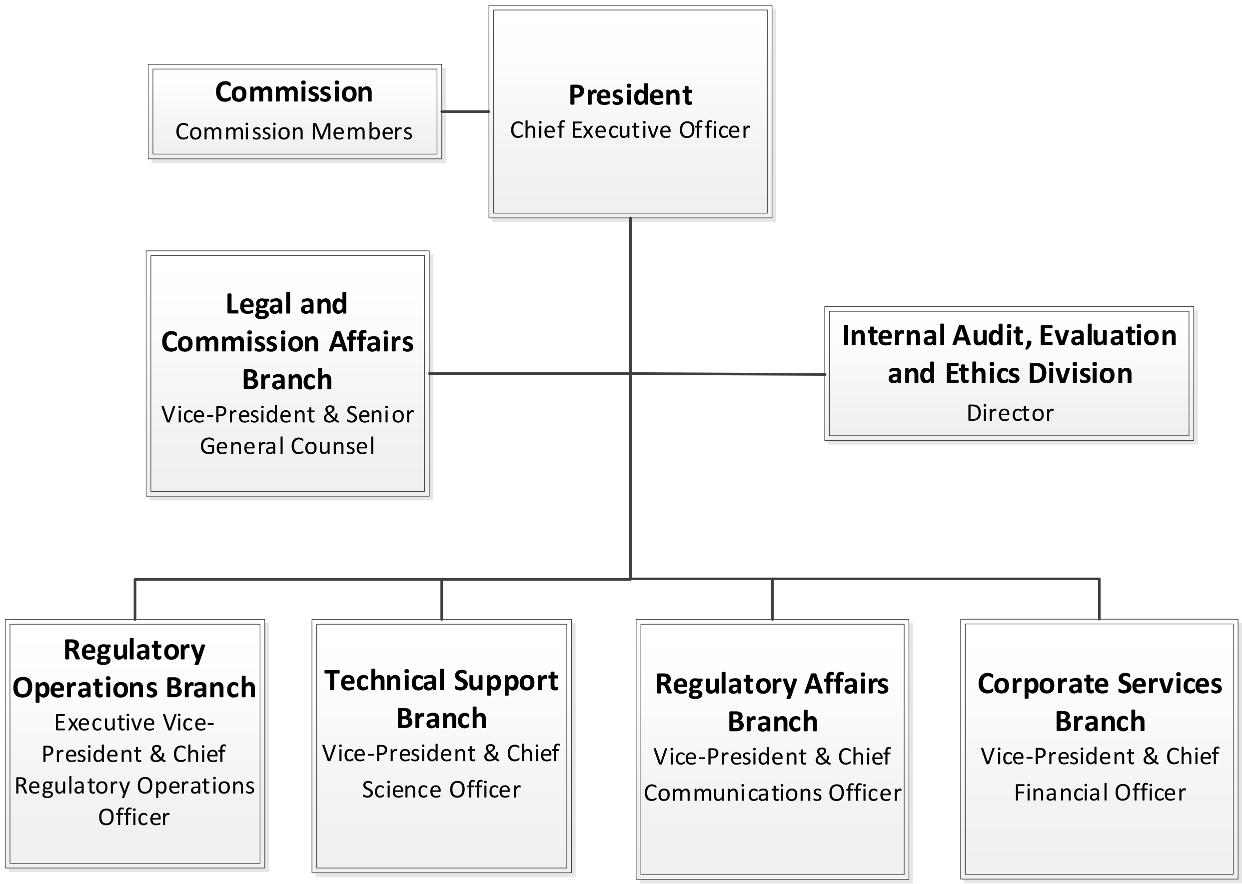


Figure 8.1 (b) Organization of the CNSC

Internal Audit, Evaluation and Ethics Division (IAEED)

The Internal Audit, Evaluation and Ethics Division (IAEED) provides a suite of independent, objective and neutral internal audit, evaluation and values and ethics services designed to support the achievement of the CNSC's strategic goals and improve the operations and staff experience at the CNSC. The division includes the Office of Values and Ethics, which provides services related to conflict of interest, external complaints, informal conflict management, investigation, and other areas. (See annex 8.1 (b) for additional details about provisions related to values and ethics at the CNSC). IAEED reports directly to the CNSC President but also reports to the Performance Measurement and Evaluation Committee (PMEC) and the Departmental Audit Committee (DAC). The DAC is an independent, objective advisory committee to the President and Chief Executive Officer and provides assurance, advice and recommendations that inform decision-making at the CNSC. The DAC consists of five members composed of three external members, the CNSC President and the Commission Registrar (described in next subsection). The DAC reviews all core areas of CNSC management control and accountability, risk management, values and ethics practices, and the internal audit function.

The CNSC includes five branches that are led by five Vice-Presidents: Legal and Commission Affairs, Regulatory Operations, Technical Support, Regulatory Affairs and Corporate Services. The first two branches are described here, while the Technical Support, Regulatory Affairs and Corporate Services Branches are described in annex 8.1(b).

Legal and Commission Affairs Branch

The Legal and Commission Affairs Branch was formed during the reporting period, combining under one branch and Vice-President the two formerly separate functions of Legal Services and the Commission Registry (formerly known as the Commission Secretariat). Legal Services acts as counsel to the Commission in its statutory roles and provides legal representation in litigation and prosecution cases. It also provides advice and legal opinions to CNSC staff. The Commission Registry consists of the Commission Registrar and supporting staff. It plans the Commission's hearings and meetings; provides technical and administrative support to the President and other members of the Commission; communicates with stakeholders including government departments, intervenors, licensees, media and the public; acts as the official registrar for Commission documentation; and provides guidance about values and ethics.

Regulatory Operations Branch

The Regulatory Operations Branch is responsible for managing regulatory activities, including those related to licensing, compliance verification and enforcement. Relevant regulatory decisions may be made by designated officers within the branch, if and when the Commission formally assigns specific authorities to those officers in accordance with the provisions set out in the NSCA and its regulations. It is headed by the CNSC Executive Vice-President and Chief Regulatory Operations Officer and comprises the following directorates:

- Directorate of Power Reactor Regulation
- Directorate of Nuclear Cycle and Facilities Regulation
- Directorate of Nuclear Substance Regulation
- Directorate of Advanced Reactor Technologies

The Directorate of Power Reactor Regulation regulates the development and operation of NPPs in Canada, in accordance with the requirements of the NSCA and its associated regulations. The directorate consists of the following five divisions:

- four regulatory program divisions (RPDs)
  - Pickering
  - Darlington
  - Gentilly-2/Point Lepreau
  - Bruce
- Power Reactor Licensing and Compliance Integration Division

The four RPDs are accountable for the planning, management and implementation of the power reactor regulatory program at their respective sites. Each RPD also acts as a single point of contact for internal stakeholders and licensees for most issues associated with the site. A correspondence protocol is in place to govern both official communications (usually at the level of RPD director) and unofficial communications between CNSC staff and the licensees.

There are CNSC staff from each RPD who work full time onsite at each operating NPP to lead and assist in the conduct of the CNSC compliance program activities (described in subsection 7.2(iii)(b)). Led by a site supervisor, these site inspectors inspect the premises, monitor activities and ensure compliance with the licensing basis. The inspectors are designated as such per section 29 of the NSCA.

In addition to the site inspectors at the NPP, regulatory program officers and additional support staff at the CNSC’s head office are also assigned to each RPD. The RPDs are also supported by staff from the Technical Support Branch.

The Power Reactor Licensing and Compliance Integration Division is accountable for discharging the CNSC’s international obligations with respect to the NEA/IAEA Incident Reporting System (see sub-article 19(vi)) and the International Nuclear Event Scale (INES). It also ensures consistency in licensing and compliance activities across NPP sites, assists in the development of LCHs and preparations for the renewal of NPP operating licences, identifies trends in compliance information, manages safety performance indicator data and conducts event investigations as needed. During the reporting period, the Power Reactor Licensing and Compliance Integration Division continued to lead the development of inspection guides and developed various reports related to NPPs, including the *Regulatory Oversight Report for Canadian Nuclear Power Generating Sites*.

The consistency of the implementation of the regulatory programs across the NPPs is fostered by a common approach to training (see subsection 8.1(c)). Meetings are also held regularly to foster common understanding and consistent approaches among directorate staff. This includes weekly teleconferences, divisional meetings, bi-monthly site supervisor meetings, quarterly review meetings and semi-annual staff meetings.

The Directorate of Nuclear Cycle and Facilities Regulation and the Directorate of Nuclear Substance Regulation contribute to the regulatory program for NPPs. The Directorate of Nuclear Cycle and Facilities Regulation is responsible for, among other things, the various facilities associated with NPPs, such as uranium mines and refineries, conversion and fuel-fabrication facilities, and facilities for spent fuel storage and management of low- and intermediate-level radioactive waste. The Directorate of Nuclear Substance Regulation is responsible for some licences related to NPPs that fall outside the scope of the operating licence (e.g., licences for nuclear substances and radiation devices, as well as packaging and transport).

The Directorate of Advanced Reactor Technologies was formed during the reporting period to provide a dedicated directorate focused on innovative technologies (such as SMRs). At the end of the reporting period, this directorate consisted of four divisions:

- Advanced Reactor Licensing Division
- Advanced Reactor Assessment Division
- Internal Quality Management Division
- Regulatory Operations Coordination Division

The Advanced Reactor Licensing Division is mandated to provide regulatory oversight through licensing, compliance, and other activities for potential new SMRs to be built in Canada; this division ensures a state of readiness for licensing any emerging technologies.

The Advanced Reactor Assessment Division manages the CNSC’s pre-licensing vendor design reviews, which provide vendors with regulatory guidance on their reactor designs.

The Directorate of Advanced Reactor Technologies participates in international activities that have a bearing on new-build projects, including those of the Small Modular Reactor Forum; it also participated in the Multinational Design Evaluation Programme (MDEP). See the preamble to article 18 for more details on pre-licensing vendor design reviews and MDEP.

The Internal Quality Management Division is responsible for, among other functions strengthening the CNSC's management system, promoting a healthy safety culture, conducting and coordinating improvement initiatives, and implementing self-assessments of key regulatory processes. The responsibilities of the Regulatory Operations Coordination Division include the coordination of annual operations planning, the monitoring and reporting process, as well as the maintenance and central coordination of support activities and programs across regulatory programs. During the next reporting period, a further re-organization of the CNSC may be undertaken to re-align and strengthen these important functions – moving them out of the Directorate of Advanced Reactor Technologies, while also continuing to maintain and build the capacity of the two remaining divisions within that directorate.

8.1 (c) Maintaining competent staff

Workforce management

Maintaining a competent, agile and engaged workforce is critical to the CNSC's success and its goal of being "an employer of choice." Because of the limited availability of experienced technical staff within the nuclear industry and the anticipated attrition of CNSC staff, workforce planning is now integrated into the organizational planning cycle. Management teams meet quarterly to review short and long-term workforce plans (e.g., update critical roles, identify successors and develop learning plans). Capacity-building at the staff level to enhance readiness for SMR developments emerged as a key priority during the reporting period.

A renewal initiative at the CNSC has brought in 215 employees since 2014, resulting in the permanent integration of 118 employees into the organization. To enable the professional development of these new employees within the first two years, and to help them progress within the organization, these employees are expected to gain diversified work experience. This diversified experience can take many forms, with the most common being an assignment in a different part of the organization.

Professional development

The CNSC values and is committed to the ongoing development of a professional, competent, versatile and motivated workforce. To ensure that the CNSC meets its evolving priorities and objectives, each CNSC staff member has an individual learning plan to identify both immediate and future development needs. The CNSC offers a variety of technical and non-technical training to its staff directly in support of those needs. During the reporting period, increasing emphasis was placed on training, workshops, and other learning opportunities associated with emerging technologies and new reactor designs.

The CNSC supports the building of leadership capability at all levels. During the reporting period, the following learning activities were offered: emotional intelligence, influence and persuasion (without authority), building high performance teams, building resilience and critical thinking, understanding and overcoming unconscious bias in the workplace, confronting and resolving issues, and communicating risk to the public.

To enhance the CNSC's leadership capacity, senior managers collectively assess leadership candidates against key leadership competencies and provide one-on-one individualized feedback to support the development of future leaders.

The CNSC's inspector training and qualification program (ITQP) combines core training, service-line specific training and on-the-job training to establish a consistent approach to train, assess and qualify inspectors across all service lines.

As part of the ITQP, the Directorate of Power Reactor Regulation uses a systematic approach for NPP-related knowledge and on-the-job-training for NPP site inspectors. This program includes a training plan that identifies the core, specific and on-the-job training required for NPP site inspectors. A training qualification record is used to document the inspector's progress and leave an auditable trail. Each inspector is required to take courses related to the regulatory process, CANDU design, non-technical topics (such as technical writing and effective interviewing), radiation protection and occupational health and safety. An inspector certificate is issued only when the CNSC's site supervisor at the NPP determines that the inspector-in-training has achieved all the training requirements. It takes an inspector approximately 18 months to obtain an inspector's certificate.

To support senior inspectors who are coaching inspectors-in-training, the CNSC offers a course in transferring knowledge effectively.

The CNSC has a well-established 15-month co-op student program that comprises three rotations of five months each. To date the CNSC has welcomed students from the Royal Military College, Ecole Polytechnique, Ontario Tech University (formerly called the University of Ontario Institute of Technology), McMaster University, the University of Saskatchewan, the University of British Columbia, and the University of Calgary.

8.1 (d) Management system and planning process for regulatory activities

The CNSC management system (also known as the Navigator) links the people, processes and resources within the overarching regulatory framework. It reflects an integrated, fit-for-purpose approach to managing the performance of mandated functions, allowing for differences in implementation across CNSC programs and sub-programs. The CNSC management system is based on principles and requirements found within international quality standards and internationally recognized frameworks for organizational excellence. It also aligns with the IAEA safety standard *GSR Part 2 – Leadership and Management for Safety*, and other related safety standards. Additional CNSC-specific elements, such as its regulatory philosophy, internal safety culture and strategic priorities, as well as its vision to remain a world class regulator, are all incorporated into the management system to ensure it meets the needs of the CNSC.

The CNSC *Navigator Manual* is the top-level document in the management system's document hierarchy. It applies to all CNSC staff and covers both regulatory activity areas and internal service activity areas.

The *Navigator Manual* explains how the organizational components of the CNSC fit together and describes at a high level the essential elements and interactions in CNSC's work. The manual identifies the high-level policies, principles and processes and mechanisms by which the CNSC achieves its goals and objectives. The manual is supported by policies, process documentation, detailed work instructions and other tools, developed as needed, that guide staff and collectively provide direction on how work is to be conducted at the CNSC.

The CNSC documents its operations planning process within the management system. The overall plan for the CNSC is summarized in its annual *Departmental Plan*, which is presented to Parliament.

At the working level, integral with its annual planning exercise, the CNSC organizes its inspections, assessments and other regulatory activities for NPPs by creating, implementing, monitoring and adjusting regulatory workplans for each NPP. Workplans are reviewed to ensure they cover specific goals, are risk-informed, and are consistent among NPPs. Activities in each NPP workplan are also consolidated into a summary – the regulatory activity plan – which is costed to establish an estimate of the annual licence fee for each NPP (see subsection 8.1(a)). The regulatory activity plan, along with a notification containing the licence fee estimate, is sent to each licensee at the beginning of each fiscal year.

8.1 (e) Assessment and improvement mechanisms

Office of the Auditor General

The Canadian government's Office of the Auditor General regularly conducts audits of various CNSC programs. The eighth Canadian report described the results and follow-up for the most recent audit that involved NPPs. At the end of the reporting period, the Office of the Auditor General was completing an audit of programs related to nuclear waste; if there are any findings relevant to operating NPPs, or reactors under construction, the results will be discussed in the tenth Canadian report.

EPREV mission to Canada

In June 2019, the Emergency Preparedness Review (EPREV) mission to Canada took place. The CNSC, along with other federal, provincial and municipal emergency preparedness and response stakeholders, as well as the licensees of operating NPPs, participated in the mission. See subsection 16.1(g) for more details on the results.

Integrated Regulatory Review Service (IRRS) mission to Canada

The CNSC previously hosted an IRRS mission in 2009. The IRRS review team determined that Canada had a mature and well-established nuclear regulatory framework. A follow-up mission took place in 2011 to assess the CNSC's progress against the initial peer review findings and assess the CNSC's response to the Fukushima Daiichi accident. The follow-up mission review team noted that the CNSC's response to the events at Fukushima was prompt, robust and comprehensive. Both missions produced an IAEA report and a CNSC management response. The results, findings and follow-up of the 2009 mission and the 2011 follow-up mission were described in the fifth and sixth Canadian reports, respectively. All actions from the 2009 IRRS mission and the 2011 follow-up mission have been closed.

As part of its commitment to regulatory excellence, the CNSC hosted its second IRRS mission in September 2019 to review elements of its framework for safety and its core regulatory processes. At the conclusion of the 2019 IRRS mission to Canada, a report outlining the mission's findings was prepared and made available to the public. The report provided valuable insights to the CNSC and other Canadian federal departments and resulted in Canada being presented with 6 good practices, 16 suggestions and 4 recommendations. Several of the suggestions were not directly relevant to NPPs, and several others were not accepted by Canada and will not be discussed in this report. Two of the four recommendations are also outside the scope of the CNS, but are mentioned here for completeness.

The first recommendation was regarding the Canadian radioactive waste management policy framework, which is discussed further in the seventh *Canadian National Report for the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management*. The second recommendation was related to establishing dose constraints for all Class I facilities, which is being addressed during the development of REGDOC-2.9.2, *Controlling Releases to the Environment*. The third recommendation was related to consistency of radiation protection requirements, which has been addressed by the recent revision to the *Radiation Protection Regulations* (see article 15). The final recommendation was related to the revision of guidance for package design certification applications. This will be addressed through a revision to CNSC regulatory document RD-364, *Joint Canada-United States Guide for Approval of Type B(U) and Fissile Material Transportation Packages*, which is expected to be published in 2023.

As mentioned, several of the suggestions were not directly related to NPPs. However, those that were relevant covered topics such as:

- ensuring qualified and competent staff to regulate existing facilities as well as emerging technologies
- consolidation of safety policies into a single document
- the formalization of inspector exchanges between sites
- ensuring the objectivity and independence of on-site inspectors.

The CNSC will be addressing these suggestions through various initiatives and the formalization of existing practices.

The IRRS mission also acknowledged several good practices of the CNSC that pertain to NPPs, such as:

- having a comprehensive system for collecting, analyzing and sharing regulatory experience feedback
- commitment to ensuring a high level of transparency and openness with the public, stakeholders and interested parties about its regulatory activities and decisions
- proactively developing extensive guidance and processes to assist potential applicants determine the content of SMR licence applications

Canada's full response to the 2019 IRRS mission can be found at: Canada's response to the 2019 IRRS Report - Canadian Nuclear Safety Commission.

Other CNSC improvement initiatives

Continuous improvement at the CNSC is driven by an organizational commitment to excellence and facilitated by specific initiatives. A number of improvements (e.g., to the regulatory framework) are described elsewhere in this report, but a few initiatives internal to the CNSC are briefly described here.

In 2019 the CNSC launched a strategic review, called Project Athena, to prepare for anticipated changes to the nuclear industry over the next 5 to 10 years. The industry and the CNSC's operating environment are experiencing rapid change, with many challenges emerging simultaneously. Project Athena's goal is to generate high-quality, evidence-based information on CNSC activities, and to develop credible options for change to ensure that the CNSC is ready to adapt to the new environment and remain an effective, modern and agile regulator. The project gathered evidence from multiple lines of evidence such as self-evaluations, benchmarking and engagement with stakeholders. In addition, as a result of extensive internal engagement, the project generated nearly 700 staff suggestions to improve or enhance the CNSC's work. In 2021-22, the project reached a critical milestone, beginning to make evidence-based decisions about actions that will help position the CNSC for the future.

Certain adaptive improvement projects were also initiated during the reporting period. As noted in article 7.2 (i), the DIET project reviewed the suitability of the regulatory framework in light of developments involving disruptive, innovative and emerging technologies that were being implemented or considered by licensees. As noted in subsection 7.2(iii)(b), the Forge project also reviewed the application of new technologies, but in terms of how they could be leveraged to improve the effectiveness or efficiency of CNSC regulatory oversight.

During the reporting period, the CNSC also undertook various initiatives to understand issues and foster a healthier environment with respect to equity, diversity and inclusion. A number of networks were established or continued and grew (Women in STEM Network, Black Employee Network, Indigenous Network, Accessibility Network, Pride Network and Diverse Employee Network). These networks foster dialogue and raise issues that, in addition to benefitting individuals, make the overall regulatory workforce more receptive, insightful and adaptive. Finally, the CNSC also established a formal process (piloted by DPRR) to initiate ideas and address opportunities for improvement.

CNSC internal oversight

CNSC management controls include self-assessments, internal audits and evaluations. These services follow internal CNSC guidance, as well as established Government of Canada policies and procedures.

The Internal Quality Management Division is responsible for the self-assessments, whereas IAEED conducts the internal audits and evaluations per an integrated, multiyear, risk-based audit and evaluation plan that is approved by senior management, the Departmental Audit Committee (DAC) and the PMEC. Internal audits assess the management system and its processes, etc, whereas evaluations assess programmatic results. Internal audit and evaluation reports are shared with the Canadian government's Treasury Board Secretariat and on the CNSC external website.

During the reporting period, the CNSC conducted 15 internal audit and evaluation engagements, including the following that were relevant to NPPs:

- Status Report - Directorate of Power Reactor Regulation - Type II Inspections
- Review of the Directorate of Environmental and Radiation Protection and Assessment Inspection Processes
- Review of the Directorate of Security and Safeguards Inspection Processes
- Evaluation of the Role of the Radiation Safety Officer

The various assessments result in action plans that are approved and then monitored by senior management, as well as by IAEED, DAC and PMEC.

In addition, the CNSC participated in horizontal audits, with other federal departments led by the Office of the Comptroller General. The latest of these audits was published in 2020 and can be found at the following link: OCG Final Report for the Horizontal Internal Audit of Physical Security in Large and Small Departments

Other

CNSC staff also actively participate in international conferences, workshops and peer reviews to gain useful insights and lessons learned that can be leveraged to strengthen the CNSC management system. CNSC attendees/participants are required to complete trip reports that are shared within the organization and, where relevant, are asked to participate in CNSC improvement activities related to their insights. Interactions with IAEA Member States and other Government of Canada agencies regularly take place on many technical and non-technical topics.

8.1 (f) Openness and transparency, engagement and consultation

Dissemination of information – general

Dissemination of objective scientific, technical and regulatory information is a part of the CNSC's mandate (see subsection 7.1(a)). The CNSC takes advantage of various means of communication to maximize the dissemination of information and engagement with stakeholders, which benefits both stakeholders and the CNSC.

Beginning in 2018, documents submitted for Commission proceedings became downloadable from the CNSC website. In 2022, the CNSC will further increase the release of information that supports regulatory activities and decisions, and will make scientific reports, documents and data more accessible and easier to use through facility registries on the CNSC website, as well as on Government of Canada open science platforms.

The CNSC has many outreach and engagement activities focusing on youth, Indigenous Nations and communities, municipal governments in the areas where major facilities are located, medical communities, professional associations and non-governmental organizations. To reach target audiences, the CNSC uses many tools such as its website, Facebook, Twitter, LinkedIn, YouTube, webinars, interactive online modules, email updates to subscribers and attendance at third-party events and conferences. CNSC staff also host information sessions to explain to stakeholders how the nuclear industry is regulated and how stakeholders can participate in the regulatory process.

During the reporting period, the CNSC held a number of meetings with Indigenous groups, and hosted webinars regarding new-build projects. These concerned the status of the DNNP project, emphasizing the scope, approach and licensing process for the renewal of the site preparation licence. They also focused on the environmental assessment and licensing processes for Global First Power's proposed project at Chalk River Laboratories.

The CNSC is equally committed to helping licensees and the nuclear industry to understand and comply with the CNSC's regulatory framework. The CNSC has undertaken a variety of engagement activities, including the following:

- offering information sessions on draft regulatory documents
- participating in the Certification and Training Advisory group (co-chaired by the CNSC and the industry), involving policy-level discussions about the training and certification of NPP personnel
- participating in COG Nuclear Safety Peer Group meetings, as well as meetings of the Chief Nuclear Officer/CNSC Executive Forum (discussed at the end of this subsection) to promote common understanding of generic safety and licensing issues

Open and transparent processes

In keeping with federal policies on public consultation and regulatory fairness, the legislative and regulatory framework for nuclear regulation is open and transparent. The CNSC is fully committed to maximizing the openness and transparency of its affairs and the undertakings of the Commission.

The CNSC takes all stakeholder feedback into account when finalizing its regulatory approach. In cases where diverse viewpoints are presented to the CNSC, additional consultations or meetings may be used to explore the issue. However, in all cases, the CNSC sets requirements in accordance with the best available science and other information, to deliver on its mandate.

Before the Commission makes decisions about whether to license nuclear-related activities, it considers applicants' proposals, recommendations from CNSC staff and stakeholder views. Each decision to grant a license is based on information demonstrating that the activity or the operation of a given facility can be carried out safely and that the environment will be protected. To promote openness and transparency, the Commission conducts its business where possible in public hearings and meetings and, where appropriate, in the communities where activities take place. Members of the public can participate in hearings via written submissions and oral presentations. Commission hearings and meetings can also be viewed online as webcasts on the CNSC website, and transcripts of public hearings and meetings are also made available.

During the reporting period, Part 1 of a hearing associated with the licence renewal of the Point Lepreau NPP was held virtually. Part 2 will be held in the host community in May 2022. Public participation for the upcoming hearing was promoted through advertising in local community newspapers, by notices sent to CNSC email subscribers and through the CNSC's Facebook, Twitter, LinkedIn and YouTube channels. CNSC information sessions were also held in the communities, in person and virtually, well in advance of the hearing. The Commission will consider more than 240 public submissions, both written and oral during these hearings.

The CNSC also has significant opportunities for public involvement in its regulation making process (subsection 7.2(i)(a)) and its writing process for regulatory documents (subsection 7.2(i)(b)). The use of CNSC discussion papers and the analysis and publication of the feedback they generate have also enhanced the degree and interactive nature of engagement.

The CNSC takes every opportunity to encourage other national nuclear regulators and international organizations involved in nuclear safety to share information with the public.

Facilitating public participation in regulatory decisions

To assist in its decision-making process, the CNSC has a Participant Funding Program (PFP), which offers funding to Indigenous Nations and communities, members of the public, and stakeholders to support their participation in the CNSC's regulatory processes. Funding is offered to support participation in the CNSC's public Commission proceedings for major projects, licence renewals, and other topics of regulatory interest. Recipients can use the funding to hire a consultant, review documentation, host meetings, submit a written intervention, and travel to the Commission proceeding to present before the Commission (where applicable). This allows Indigenous Nations and communities and the public to participate in aspects of licensing actions for nuclear facilities as well as provide comments on RORs that can be considered before they are published. In addition, funding is offered through the PFP to Indigenous Nations and communities to host meetings with CNSC staff on CNSC-regulated facilities and activities of interest. Starting in 2017, funding has also been offered to Indigenous Nations and communities to conduct Indigenous knowledge studies near CNSC-licensed facilities, and to enable Indigenous participation in the CNSC's independent environmental monitoring program. An independent funding review committee, composed of external experts, reviews all funding applications and makes recommendations to the CNSC on potential funding recipients, individual amounts, and deliverables. The CNSC approves the total amount of funding awarded.

CNS Good Practice 7RM GP-1 for Canada from the Seventh Review Meeting
"CNSC's Participant Funding Program, which fosters openness and transparency and increases safety by providing additional information to the Commission"

During the reporting period, the CNSC awarded $3,494,324.09 through the PFP in relation to CNSC regulatory activities and processes including environmental assessments, licence renewals/amendments, Indigenous knowledge studies, collaborative monitoring activities, and consultation and engagement activities with Indigenous Nations and communities.

Indigenous consultation and engagement

The CNSC's commitment to effective and meaningful Indigenous consultation and engagement processes is guided by Canada's *Aboriginal Consultation and Accommodation – Updated Guidelines for Federal Officials to Fulfill the Duty to Consult – March 2011*. The CNSC's policy statement, *CNSC's Commitment to Indigenous Consultation and Engagement*, outlines the organization's approach to building relationships and fulfilling its legal obligations, as an agent of the Crown and as Canada's nuclear regulator, for Indigenous consultation and engagement on CNSC-regulated projects.

CNSC REGDOC-3.2.2, *Indigenous Engagement* sets out requirements and guidance for licensees whose proposed projects may raise the Government of Canada's duty to consult with Indigenous Nations and communities. This ensures that potential or established Indigenous and/or treaty rights and related interests are considered. While the CNSC cannot delegate its obligation, it can delegate procedural aspects of the consultation process to licensees, where appropriate. The information collected and measures proposed by licensees to avoid, mitigate, or offset adverse impacts may be used by CNSC staff in helping to meet the CNSC's consultation obligations. The implementation of REGDOC 3.2.2 has led to more meaningful Indigenous engagement, consistency between the CNSC and the licensee's approach to consultation and engagement and strengthened relationships with Indigenous Nations and communities.

In 2021, the CNSC published and implemented an Indigenous knowledge policy framework which provides an overview of the CNSC's approach to working with Indigenous knowledge (IK). The CNSC acknowledges the importance of considering Indigenous knowledge to follow best practices, comply with legislative requirements (e.g., *Impact Assessment Act*), build relationships and trust with Indigenous Nations and communities, and fulfill duty-to-consult obligations. Overall, Indigenous knowledge can help enhance the CNSC's understanding of the potential impacts of nuclear projects and strengthen the rigour of project reviews and regulatory oversight.

The CNSC has worked in collaboration with Indigenous Nations and communities to formalize relationships through terms of reference for long-term engagement. CNSC staff are committed to continuing engagement activities outside of the CNSC's regulatory processes for specific nuclear projects with Indigenous Nations and communities regardless of whether terms of reference have been signed. The CNSC's approach to engagement is expected to help build long-term, meaningful relationships and trust with Indigenous Nations and communities that will increase their participation in the CNSC's ongoing activities and lead to more effective consultation and engagement on future projects. The CNSC's approach to consultation, engagement and collaboration with Indigenous peoples is consistent with the principles of the United Nations Declaration on the Rights of Indigenous Peoples, as well as with the Government of Canada's goal to advance meaningful reconciliation with Indigenous peoples in Canada.

Collaborative approach to the resolution of safety issues

The Chief Nuclear Officers/CNSC Executive Forum provides an effective channel of high-level communication between the executives of NPP licensees responsible for safe nuclear operations and the CNSC. The participants discuss strategic issues that involve both the licensees and the CNSC, thereby promoting a mutual understanding of and helping to focus action on various safety issues related to NPPs. It is used to identify strategic challenges and opportunities that may influence the Canadian nuclear power industry and the CNSC. The forum helped focus efforts to address various safety issues during the reporting period. Although the forum is not a mechanism for decision making, it has facilitated dialogue on the following:

- existing and emerging issues pertaining to the CNSC's mandate for health, safety, security and the environment
- new industry developments, major projects and planned emergency exercises
- respective focus areas and strategic plans and priorities where practical and appropriate
- IAEA missions and other third-party audits planned at Canadian NPPs, such as those conducted by the International Physical Protection Advisory Service, Operational Safety Review Team, and EPREV, and their outcomes
- discussion of new regulatory requirements through regulations and REGDOCs to understand the impacts of implementation at the NPPs

The CNSC also participates, with industry members, in the standard-setting work of the CSA Group, as described in subsection 7.2(i)(b).

8.1 (g) International activities and harmonization

The CNSC participates in various international activities and contributes to international harmonization with respect to nuclear regulation. The CNSC chairs the CANDU Senior Regulators' Meeting, which is organized through the IAEA, to facilitate the sharing of regulatory information that is specifically relevant to CANDU NPPs. The CNSC also actively participates in the G7's Nuclear Safety and Security Group.

The CNSC has signed numerous memoranda of understanding with the nuclear regulators of other countries. During the reporting period, CNSC entered into new memoranda of cooperation with the United States Nuclear Regulatory Commission and the United Kingdom's Office for Nuclear Regulation; the memoranda that focus on advanced reactor SMR technologies, as noted in subsection 7.2(ii)(a).

The CNSC is also an active participant in the IAEA's SMR Forum. Previous discussions and reports focused on the licensing process. Past work of the forum included reports on first of a kind vs nth of a kind designs, as well as the licensing of projects with multiple modules. Current topics under discussion at the SMR Forum include collaboration, joint assessments, mutual regulatory recognition/acceptance and harmonization.

CNSC collaborated with the Nuclear Energy Agency (NEA) in December 2020 on a virtual workshop to discuss best regulatory practices when licensing new and innovative technologies. The workshop provided a forum for regulators and stakeholders from different sectors, including nuclear, to exchange experiences of standardization, design review, licensing and reporting systems, and international co-operation. Themes that were explored included the need to balance harmonization with the sovereignty/responsibility of each national regulator and the importance of ensuring public trust in related developments and the resultant decisions.

Canada is a strong supporter of the IAEA's Nuclear Harmonization and Standardization Initiative; plans are to commence it in the next reporting period.

CNSC also continued its work in MDEP, although its participation wound down during the reporting period; see article 18 for details.

8.2 Status of the regulatory body

8.2 (a) Separation of the CNSC and organizations that promote and utilize nuclear energy

The NSCA separates the functions of the regulatory body from organizations that promote or use nuclear energy. The mandate of the CNSC (see subsection 7.1(a)) focuses clearly on the health, safety and security of persons, the preservation of national security and the protection of the environment, and the implementation of Canada's international obligations. The mandate does not extend to economic matters (such as the promotion of nuclear power).

The NSCA defines the Commission (described in subsection 7.1(a)) as a court of record, which allows it to conduct its matters in an independent manner. Commission members are subject to guidelines on conflict of interest and ethics that assure separation between them and the various stakeholders. Commission members hold office "during good behaviour" rather than being appointed "at pleasure". This means they can only be removed for cause (such as fraud). No member of the Commission has ever been removed for cause.

The Commission's decisions are not subject to review by any minister or other parts of the government executive. The NSCA provides that only the Governor in Council may issue directives to the Commission and these must be broad and not directed at any particular licensee. In addition, such an order would be published in the *Canada Gazette* and laid before each House of Parliament. To safeguard the integrity of the Commission's role as an independent decision maker, contact between the Commission and CNSC staff occurs through the Commission Registry (formerly called the Secretariat). With the exception of the Commission Registry and the President, CNSC staff have limited interaction with the Commission.

The CNSC, as an organization, is also independent of other organizations in the government, as described in subsection 8.1(a). As stated there, the CNSC does not report to a minister, but rather to Parliament through the Minister of Natural Resources.

8.2 (b) Other mechanisms that facilitate regulatory independence

The CNSC fosters open interaction and communication with its stakeholders, thereby continuously gathering input from all parties with an interest in Canada's nuclear industry. Transparent regulatory processes make the consideration of that input more systematic and fairer (see subsection 8.1(f) for more information). These provisions help prevent undue influence from any one party or concern. Other mechanisms that help maintain the independence of the CNSC include a risk-informed framework for decision-making as well as a strong framework for ethical and responsible action. Details of the CNSC's framework for ethical and responsible action are provided in annex 8.1 (b).

Article 9 – Responsibility of the licence holder

> Each Contracting Party shall ensure that prime responsibility for the safety of a nuclear installation rests with the holder of the relevant licence and shall take the appropriate steps to ensure that each such licence holder meets its responsibility.

9 (a) Legislation assigning responsibility to the licence holder

Paragraph 26(e) of the NSCA prohibits any person from preparing a site for, or constructing, operating, modifying, decommissioning or abandoning a nuclear facility without a licence granted by the Commission. As stated in sub-article 7.2(ii), the Commission can issue licences only to applicants who are qualified to operate the NPP and who will adequately provide for the health and safety of persons and the protection of the environment.

Subsection 12(1) of the *General Nuclear Safety and Control Regulations* assigns various responsibilities to the licensees regarding nuclear safety. Paragraph 12(1)(c) requires the licensee to take all reasonable precautions to protect the environment and the health and safety of persons and to maintain the security of nuclear facilities and nuclear substances. Other paragraphs assign responsibility to the licensee to:

- provide and adequately train a sufficient number of qualified workers
- provide and maintain the required devices
- require that all people onsite properly use equipment, devices, clothing and procedures
- take all reasonable precautions to control the release of nuclear or hazardous substances to the environment
- take measures to instruct its staff on security provisions and to alert itself in the event of illegal activities or sabotage

9 (b) Means by which licence holders discharge safety responsibility

For the most part, Canada has a relatively non-prescriptive nuclear regulatory regime for NPPs that sets general requirements and performance standards, thereby allowing the licensees some flexibility to meet them in a manner that best meets their needs. The licensees are responsible for addressing the requirements in their systems, programs, processes and designs. Descriptions of these provisions are submitted to the CNSC at the time of licence application. Once accepted by the CNSC, these provisions become part of the licensing basis for the NPP (defined in subsection 7.2(ii)(a)) and dictate future regulatory activities.

Licensees must demonstrate that NPP operations satisfy performance standards and that the NPP continues to meet applicable criteria throughout its licence period and the designated operating life.

As explained in subsection 13(a), all licensees implement and maintain a management system, which applies to the licensee organizations as well as organizations contracted by the licensees. An NPP management system is expected to establish safety as the paramount objective, foster the safe operation of the NPP during all phases of its life-cycle, and implement practices that contribute to excellence in worker performance. Licensee management systems have various provisions that help ensure safe operation, such as ensuring worker competence, sharing and using operating experience, verifying the correctness of work, identifying and resolving problems and controlling changes. The licensees' processes also require independent assessments to confirm the effectiveness of the management systems in achieving the expected results. These measures help ensure that the licensees' responsibility to safety is fulfilled.

Each licensee structures its organization so that the safety of the nuclear facilities under its responsibility is optimized. Each licensee has appointed a key management leader who is responsible for the operation and safety of the NPP. These nuclear executives or nuclear officers participate in the Chief Nuclear Officers Forum (see subsection 9(c)).

During operation, licensees fulfill their responsibilities through the following specific activities that are described elsewhere in this report:

- complying with the regulatory requirements set out in applicable laws and regulations
- operating in accordance with the licensing basis (article 19)
- defining and following safe operating limits and working within them (sub-article 19(ii))
- developing safety policies and an organizational culture committed to ensuring safe NPP operation (Article 10)
- monitoring employee performance, facility performance and operating experience (OPEX) to ensure expectations are met (subsection 12(a), subsection 14(ii)(a) and sub-article 19(vii))
- ensuring adequate financial resources are available to support the safety of each NPP throughout its life (sub-article 11.1)
- ensuring adequate qualified resources are always available to conduct planned activities and establish contingencies, as well as to manage unplanned situations, including emergencies (subsection 11.2(a))
- maintaining the necessary human resources in the long term (see subsection 11.2(b))

9 (c) Other mechanisms that facilitate the licence holder's execution of responsibility

Peer and other reviews

The licensees host independent reviews that help confirm that their responsibilities for safety are being met. For example, the NPP licensees are members of the World Association of Nuclear Operators (WANO) and host WANO reviews on a regular basis (see subsection 14(i)(e)). As another example, Bruce Power, OPG and NB Power initiate regular, independent, external nuclear safety assessments through a Nuclear Safety Review Board (NSRB) to provide assurance that the requirements of their respective nuclear safety policies and nuclear management systems are being fulfilled. The NSRB is a team of external industry experts that performs assessments (typically three to five days in duration) of NPP activities that might affect nuclear safety and performance. The NSRB reports directly to the Chief Nuclear Officer at OPG and NB Power, while at Bruce Power it reports to the Board of Directors.

Collective measures

Although the regulatory framework and licensee governance are in place to ensure each individual licensee fulfills its responsibility to safety, the licensees in Canada also act collectively to help fulfill that responsibility. The purpose of this collective effort is to pool understanding and expertise (when appropriate), coordinate and prioritize the resolution of issues and improvement initiatives and enhance overall adherence to regulatory requirements.

In addition to membership in WANO and the CSA Group, all NPP licensees in Canada and Canadian Nuclear Laboratories (CNL) are members of the CANDU Owners Group (COG, described in sub-section D.1 of chapter I). COG has provided the mechanism for many projects to improve the safety of CANDU reactors, several of which are described in this report. In addition to its R&D program (described in appendix D.2), COG facilitates the execution of licensee responsibility by:

- sharing OPEX and providing support to resolve technical and operating problems for all COG members
- initiating and managing jointly-funded projects and services
- adopting common strategies and plans for the resolution of regulatory issues related to nuclear safety
- sharing best practices, delivering jointly-developed training programs and developing knowledge-retention tools such as the CANDU textbook

COG has initiated two vehicles for industry members to develop common technical positions to support SMR deployment among vendors and partners. One is the SMR technology forum, which allows industry members to collaborate in common areas of interest; the other is the SMR vendor participants program, which allows vendors to share perspectives and lessons learned.

In addition to ongoing COG programs, the members form peer groups to address specific issues that arise.

The Chief Nuclear Officers Forum, which includes senior representatives from all NPP licensees and CNL, facilitates a coordinated approach to resolving significant technical and regulatory issues. It provides high-level direction to, and oversight of, the work done by peer groups to better understand and resolve safety issues. The benefits include consistency of licensing positions, alignment of strategic directions and pooling of resources. COG facilitates the meetings of the Chief Nuclear Officers Forum, which helps ensure the alignment of the high-level direction with ongoing COG programs and projects.

A COG Pandemic Forum was established in March 2020 at the request of the Chief Nuclear Officers. Members of the COG Pandemic Forum include representatives from OPG, Bruce Power, NB Power, CNL, Societatea Nationala Nuclearelectrica (Cernavoda, Romania) and Nucleoelectrica Argentina SA (Embalse, Argentina). The forum was also represented on the pandemic teams of the Institute of Nuclear Power Operations (INPO) and the Nuclear Energy Institute (NEI), and the IAEA. Regular virtual meetings allowed members to develop and implement best practices on critical staff isolation plans, graded response to event escalation, shift crew schedules, vaccination and testing policies, mask usage, commodity stock piling, guidance for supervisors and recovery protocols. Operators also benchmarked with INPO and WANO, especially with respect to the execution of outages.

Members of the Chief Nuclear Officers Forum also engage in high-level communications with CNSC executives (see subsection 8.1(f)).

Proactive disclosure and public communications

CNSC REGDOC-3.2.1, *Public Information and Disclosure*, requires all major licensees, including NPPs, to maintain active public information and disclosure programs. Programs must be supported by robust disclosure protocols regarding events and developments involving their facilities or activities. Program requirements are derived from the objectives of the Commission in the NSCA and paragraph 3(j) of the *Class I Nuclear Facilities Regulations*, which requires licence applicants to describe "the proposed program to inform persons living in the vicinity of the site of the general nature and characteristics of the anticipated effects on the environment and the health and safety of persons that may result from the activity to be licensed."

The public disclosure protocols must describe the type of information or reports to be made public, the criteria for determining when such information and reports are to be published and the medium of disclosure. To define what information and reports are of interest to the different audiences, the licensees and applicants must consult with stakeholders and interest groups. The protocols must be posted on the internet and any revisions sent to the CNSC.

The elements of the licensees' public information and disclosure program, along with specific examples of the outreach activities conducted by NPP licensees and licence applicants during the reporting period are, provided in annex 9(c).

9 (d) CNSC verification and oversight of licensees' responsibilities

To ensure that the licensees comply with the various regulatory requirements, the CNSC:

- sets and documents clear requirements using a process that includes consultation
- cooperates with other organizations and jurisdictions to foster the development of consistent regulatory requirements
- indicates acceptable ways to meet regulatory requirements, but allows licensees to propose alternative methods that take into account risk and cost-benefit
- promotes compliance with regulatory expectations
- verifies that processes and programs satisfy regulatory requirements
- enforces requirements using an escalating, consistent regulatory approach based on the level of risk
- uses appropriate industry, national, international or other standards

These regulatory activities are described in more detail in sub-article 7.2 and cover all operational states, including accidents.

The licensing basis for each NPP is established through the process of issuing each licence, reaffirming the responsibility of the licensees. Licensees implement new regulatory documents and standards, on a regular basis, both at licence renewal and during the licence period.

The licensing basis dictates CNSC regulatory activities during the licence period, such as inspections. Between licence renewals, the CNSC compliance program ensures that licensees meet their defined responsibilities. The CNSC maintains trained, experienced inspectors at all NPP sites with operating reactors on a permanent basis. They provide a high degree of day-to-day interaction with the licensees and scrutiny of their activities (see subsection 8.1(b) for more details).

Reporting requirements are an important aspect of the CNSC's assurance that licensees continue to meet their responsibilities. Operating licences refer to CNSC REGDOC-3.1.1, *Reporting Requirements for Nuclear Power Plants*, which establishes reporting requirements for safety-significant developments and for non-compliances with legal requirements (see subsection 7.2(iii)(b)).

The transparency of the Canadian nuclear regulatory framework and the licensing process also helps ensure that the licensees' execution of their responsibility to safety is apparent to all stakeholders.

9 (e) Summary of fulfillment of safety responsibilities during the reporting period

During the reporting period, NPP licensees fulfilled the fundamental responsibilities for safety as required by the NSCA and its regulations. The licensees' fulfillment of this responsibility was manifested by the strong safety record of the Canadian NPPs during the reporting period, as described throughout this report. The use of regulatory enforcement action such as licensing actions or prosecution (as described in sub-article 7.2(iv)) by the CNSC was not required for resolving safety-related issues at Canadian NPPs. The CNSC's regulatory activities involving promotion and verification of compliance were sufficient to address and resolve safety-related issues and the regulatory tools were adequate to maximize conformance with regulatory requirements by all NPP licensees.

The licensees further fulfilled their responsibility to safety during the reporting period by implementing numerous improvements to safety. Since NPPs were originally constructed, the NPP licensees in Canada have made many safety improvements based on CNSC requirements, industry research, national and international OPEX and heightened public expectations. These improvements continued throughout the COVID-19 pandemic, although there may have been some delays early in the pandemic while the licensees developed COVID safety protocols to ensure the safety of workers performing the work.

Chapter III – Compliance with articles of the Convention (continued)

Part C
General safety considerations

Part C of chapter III consists of seven articles:

- Article 10 – Priority to safety
- Article 11 – Financial and human resources
- Article 12 – Human factors
- Article 13 – Quality assurance
- Article 14 – Assessment and verification of safety
- Article 15 – Radiation protection
- Article 16 – Emergency preparedness

Article 10 – Priority to safety

> Each Contracting Party shall take the appropriate steps to ensure that all organizations engaged in activities directly related to nuclear installations shall establish policies that give due priority to nuclear safety.

Introduction and general requirements

The collective priority given to safety of organizations engaged in activities related to nuclear facilities is, in part, demonstrated by their commitment to peer review and continuous improvement. For example, the Canadian NPP licensees regularly participate in World Association of Nuclear Operators (WANO) assessments (see subsection 14(i)(e)). The Canadian government also demonstrates a commitment to peer review and improvement, including the hosting of missions from the IAEA's Integrated Regulatory Review Service (IRRS) and EPREV (Emergency Preparedness Review) service (see subsection 8.1(e)). Further, the licensees and CNSC demonstrate an ongoing commitment to safety through their sponsorship of, and involvement in, safety-related R&D activities (see appendix D for details).

The *Class I Nuclear Facilities Regulations* require licence applicants for Class I facilities to describe their proposed measures to promote and support safety culture.

The NPP licensees have implemented CNSC REGDOC-2.1.2, *Safety Culture*. REGDOC-2.1.2:

- formalizes the CNSC's commitment to promoting a healthy safety culture in the nuclear industry by providing a clear definition and describing the characteristics of a healthy safety culture, ensuring a shared understanding of these concepts between the CNSC and its stakeholders
- formalizes requirements and expectations for licensees regarding safety culture at NPPs
- clarifies and implements the CNSC's oversight role and strategy to verify that NPP licensees are conducting and implementing appropriate safety culture self-assessments and that corrective actions arising from these assessments are effectively implemented

REGDOC-2.1.2 applies to both safety culture and security culture as they coexist and mutually reinforce one another. The term safety culture is understood to include security culture.

10 (a) Establishment of licensee policies and supporting processes for NPPs that give due priority to safety

To make safety an overriding priority, the executive and management of an organization must state and demonstrate safety as a core value. Its management system must consistently uphold and restate this priority at all levels of the management structure. The management system (see article 13) provides assurance that policies, principles and high-level safety requirements are adequately carried through to licensee activities.

All NPP licensees have established policies that give due priority to nuclear safety. All licensees have also embedded in their management systems the principle that safety is the paramount consideration that guides decisions and actions. The implementation of the principles found in these policies differs by licensee, as described in annex 10(a).

NPP licensees’ management system processes ensure that conditions adverse to safety are systematically evaluated and resolved. Corrective action programs are formalized to ensure issues affecting safety are addressed properly and promptly. These processes continue to mature each time they are used and the lessons learned are shared with the other licensees.

Operability evaluations are completed when the ability of systems and components to carry out their safety-related function is uncertain. Decision-making processes are used to resolve significant problems that require a prompt, coordinated response to indeterminate or known degraded conditions that affect safety. Other practices, such as management presence in the field and oversight committees, also help keep the priority on safety.

NPP licensee management systems are based on CSA Group standard N286-12, *Management system requirements for nuclear facilities*, which builds upon the principal that safety is the paramount consideration guiding decisions and actions by including a requirement on safety culture that states:

> Management shall use the management system to understand and promote a safety culture by:
> (a) issuing a statement committing workers to adhere to the management system;
> (b) defining and implementing practices that contribute to excellence in worker performance;
> (c) providing the means by which the business supports workers in carrying out their tasks safely and successfully, by taking into account the interactions between individuals, technology, and the organization; and
> (d) monitoring to understand and improve the culture.

Many other organizations, besides the licensees, conduct activities that are directly related to the safety of NPPs. However, per article 9, it is the licensee that is directly responsible for safety. The NPP licensees’ management systems have provisions to verify the policies of other organizations that the licensees engage for contracted work. See subsection 13(a) for details.

10 (b) Safety culture at operating NPPs

General approach

The safety culture at Canadian NPPs is based on a collective belief among all employees and management that safety is the first priority when decisions are being made and work performed. Employees and management accomplish this priority by considering risks and maintaining adequate safety margins, maintaining respect and a sense of responsibility for the reactor core and reactor safety and confirming that a task can be performed safely before executing it. The foundation of safety culture is further established by constantly examining nuclear safety, cultivating a “what if?” approach to safety planning and preparation, embracing organizational learning, and promoting a “just culture” that aims to learn as much as possible from events or near misses without removing the possibility of holding persons responsible for their actions.

Clear lines of authority and communication are established, so that individuals throughout the organization are aware of their responsibilities toward nuclear safety. Senior management is ultimately responsible for the safety of the NPP and is, therefore, expected to develop processes to encourage and track the effectiveness of safety programs and to demonstrate through action that safety is the overriding concern. Supervisors’ behaviour must also show that they expect their workers to follow safety processes while, at the same time, encouraging a questioning attitude. At the individual level, the emphasis is on nuclear professionalism and accountability for each individual engaged in an activity that affects the safety of the NPP. All employees are expected to be aware of and adhere to all procedures. This approach ensures that rules, policies and regulations related to reactor safety, radiation safety, environmental protection, industrial safety, security, fire protection and other relevant areas addressed in the procedures are followed. These expectations are promoted through training and leading by example; monitored through field observations, oversight committees and self-assessments; and strengthened by means of coaching and mechanisms to encourage problem identification and effective corrective action.

Safety culture self-assessments

NPP licensees conduct safety culture self-assessments, conduct follow-ups to assess safety culture issues, develop appropriate corrective actions and complete post-assessments.

The benefits of a safety culture assessment are the learning and improvement opportunities created. However, in a safety culture self-assessment there is the potential for licensees to overlook key topics or circumstances due to complacency and over-familiarity with internal ways of conducting business. For this reason, the industry has taken several approaches to try to overcome the potential for “organizational blindness,” including:

- the development of common safety culture assessment guidance and information exchange among Canadian NPP licensees through the COG Safety Culture and Human and Organizational Factors Peer Group; the licensees use guidance from WANO, the Institute of Nuclear Power Operations (INPO) and the Nuclear Energy Institute (NEI) as their primary source of self-assessment requirements
- the inclusion of safety culture as part of regular, third-party assessments by other industry organizations
- the implementation of safety culture monitoring processes between safety culture assessments to identify possible, subtle changes in safety culture

The NPP licensees have adopted the nuclear safety culture monitoring panel process, which monitors process inputs that are indicative of the health of the organization’s nuclear safety culture (internal events, trends, and organizational changes), and identifies areas of strengths and potential concern that merit additional attention by the organization. They also monitor the actions from safety culture assessments on a periodic basis. Executive management considers the insights produced by this process.

The results of safety culture self-assessments and other safety culture activities during the reporting period are summarized here for the licensees of operating NPPs.

<u>Ontario Power Generation</u>

All Canadian NPPs have implemented REGDOC-2.1.2 Safety Culture, and as such, conduct comprehensive nuclear safety and security culture self-assessment at least every five years. The established assessment methodology has two phases: a detailed safety and security culture survey that is sent to all employees and resident contractors, and an onsite assessment by an assessment team involving interviews, focus groups, document review and observations. The assessment focuses on perceptions, attitudes and behaviours of the organization.

The assessment methodology continues to be refined based on the lessons learned from each preceding assessment and industry best practices. For example, the CANDU Owners Group

(COG) recently developed a tool that will allow survey output and onsite assessment findings to be captured in the same database, enhancing efficiently.

During this reporting period, OPG completed one nuclear safety and security culture assessment in 2021 at Darlington that involved both internal and external team members from various organizations. Overall, the assessment determined that Darlington has a healthy nuclear safety culture, a strong respect for nuclear safety, and that nuclear safety is not compromised by production priorities. OPG also concluded that Darlington's strong respect for nuclear safety is driven by its staff's questioning attitude and the recognition that nuclear is special and unique. Darlington has a strong sense of teamwork and collaboration. The Darlington team demonstrates a collective willingness to support each other when help is needed, and understands safety is something to talk about often and openly.

The assessment noted a few areas where additional focus was required, specifically in expanding the qualifications of the work force, developing the proficiency of new staff, improving the efficiency of the work management process, and sharing information effectively through increased field time for leaders.

This was the first time OPG assessed its nuclear security trait "Vigilance". While staff knew to notify their supervisor or security if a situation arose, an opportunity was identified to increase the awareness and understanding of potential risks and threats associated with nuclear security, including cyber security.

Actions to address these findings are being tracked by the Darlington nuclear safety and security culture monitoring panel, which meets three times a year.

Bruce Power

The most recent nuclear safety and security culture assessment was a comprehensive, site-wide self-assessment completed in 2016. The assessment used the INPO/WANO framework for 10 traits of a healthy nuclear safety culture and drew upon draft IAEA guidance for conducting assessments of culture for security. This was the first assessment of safety culture, conducted at a Canadian NPP, that also integrated an assessment of security culture.

The 2016 assessment included a survey, interviews, and focus groups. In addition, the 2016 assessment included contract workers for the first time. The results showed improvements in all areas of the assessment repeated from the previous assessment in 2013. The overall results from the assessment were considered and the corrective action program was used to address findings.

Bruce Power plans to conduct another safety culture assessment in 2022, in accordance with CNSC REGDOC-2.1.2, *Safety Culture*. This assessment, originally scheduled for 2020, has been delayed due to the impacts of the COVID-19 pandemic on the ability to conduct group interviews for the assessment, which Bruce Power considers to be integral to the assessment.

NB Power

NB Power also utilizes the INPO/WANO framework for 10 traits of a healthy nuclear safety culture. Action statements in the framework provide information on what the traits should mean to all employees at NB Power.

NB Power conducted a comprehensive nuclear safety and security culture assessment in the fall of 2021 in accordance with REGDOC 2.1.2; which, for the first time, incorporated security culture into the assessment.

The assessment compared the results against the previous (2016) assessment. The assessment team concluded that Point Lepreau has a healthy nuclear safety and security culture and a strong respect for nuclear safety and that security, and that nuclear safety and security are not compromised by production pressure.

10 (c) Safety culture in other nuclear industry organizations

In addition to the licensees of operating NPPs, other organizations that make significant contributions to nuclear safety also conduct safety culture self-assessments, e.g., the CNSC, as described in sub-section 10(d), and organizations that are contracted by the licensees to carry-out safety-critical work. As an illustrative example, the following describes self-assessments carried out by SNC-Lavalin Nuclear, which offers a variety of services to NPP licensees.
SNC-Lavalin Nuclear has made safety both in the workplace and within technical activities a key commitment at all levels of the organization. In 2015, the two organizations comprising SNC-Lavalin Nuclear joined INPO as supplier members. SNC has developed and implemented a comprehensive “Building a Culture of Excellence” program that incorporates many of the elements of the INPO framework, including the 10 traits of a healthy nuclear safety culture). SNC-Lavalin Nuclear commences every meeting with a health and safety message, which includes messages associated with attributes provided in its “Building a Culture of Excellence Handbook”.

SNC-Lavalin Nuclear has provided significant support to foster similar improvements across the Canadian nuclear industry and supplier community, in order to promote a healthy nuclear safety culture. As part of the healthy dialogue between licensees and the CNSC on human performance, SNC-Lavalin Nuclear engagement has included assisting industry to broaden the INPO human performance principles with definitions of the fundamentals to provide defence in depth as an organizational strategy within the management systems through:

- learning from successes as well as failures
- recognition of the worth and influence of informal as well as formal leadership on culture
- moving individual accountability from a compliance mindset to a personal commitment to use error-reduction techniques

On the whole, Canadian NPPs and SNC-Lavalin Nuclear actively promote with other licensees and the supply chain the need to embrace a managed defences approach to support human performance excellence and safety culture.

In the next reporting period, increased attention will be paid to organizations associated with licensees and applicants for licences involving SMRs.

10 (d) CNSC framework for assessing safety culture

REGDOC 2.1.2 defines safety culture as:

> the characteristics of the work environment, such as the values, rules and common understandings that influence workers’ perceptions and attitudes about the importance that the organization places on safety.

REGDOC-2.1.2 is based upon the following safety culture framework from the IAEA:

- Safety is a clearly recognized value.
- Accountability for safety is clear.
- A learning organization is built around safety
- Safety is integrated into all activities in the organization.
- A safety leadership process exists in the organization.

Safety performance can be influenced by the ways in which responsibilities are assigned within the organization, from the senior management team to the personnel in the field where operational activities are carried out. It can also be influenced by the ways in which organizational changes are made and communicated to staff, and by the effectiveness of its training programs.

When reviewing NPP management systems, the CNSC pays particular attention to the way that nuclear, radiological and conventional safety, environmental protection and the security of the facility are all managed and integrated within the general management system. Canadian management system requirements introduce the promotion of safety culture (as discussed in subsection 10(a)) and include several measures related to organizational changes.

CNSC staff also check for other indicators of a healthy safety culture at NPPs, such as whether:

- documentation exists that describes the importance and role of safety in the operation of organization, such as a safety management program
- the use of continuous self-assessment is evident

CNSC staff examine the self-assessment approach for safety culture proposed by each licensee and review licensees' plans to conduct specific assessments. They also provide licensees with feedback on their self-assessments and examine how licensees evaluate security culture in the context of safety culture. During the next reporting period, CNSC will confirm that NPP licensees have engaged in activities to foster a healthy safety culture and are monitoring safety culture by conducting comprehensive, systematic and rigorous assessments.

10 (e) Priority to safety at the CNSC

The CNSC prioritizes safety in all its activities. The CNSC *Management System Manual* has clear statements on the consideration of safety in every decision made. The CNSC's management system and *Management System Manual* also reflects the CNSC's commitment to and understanding of the key aspects of a healthy regulatory safety culture. In support of this, all regulatory processes within the CNSC management system are developed respecting the CNSC's focus on protecting the health and safety of the people and the environment and fulfilling Canada's international obligations.

The regulatory independence of the CNSC allows CNSC staff to maintain their focus on nuclear safety while addressing all organizational priorities.

In the previous reporting period, CNSC staff completed a regulatory safety culture self-assessment using principles from the Nuclear Energy Agency's (NEA's) *The Safety Culture of an Effective Nuclear Regulatory Body* and presented the findings, recommendations, and management action plan to the Commission. A management action plan outlining continuous improvement and innovation, collaboration, openness and transparency was implemented to strengthen the safety oversight culture as well as key behavioural and leadership competencies.

Other actions included conducting periodic safety culture town hall meetings led by the Executive Vice President and Chief Regulatory Operations Officer. Additionally, the CNSC implemented several policies, such as the Policy on Science in a Regulatory Environment as well as the Open-Door Policy. The specific additional initiatives are ongoing and the CNSC staff is planning a follow-up assessment during the next reporting period.

Article 11 – Financial and human resources

1. Each Contracting Party shall take the appropriate steps to ensure that adequate financial resources are available to support the safety of each nuclear installation throughout its life.
2. Each Contracting Party shall take the appropriate steps to ensure that sufficient numbers of qualified staff with appropriate education, training and retraining are available for all safety-related activities in or for each nuclear installation, throughout its life.

11.1 Adequacy of financial resources

The NPP licensees' primary responsibility for safety (article 9) dictates the provision of adequate financial resources to support the safety of each NPP throughout its life. Paragraph 3(1)(l) of the *General Nuclear Safety and Control Regulations* requires all licence applicants to provide a description of any proposed financial guarantee relating to the activity to be licensed. In addition, NPP licensees in Canada are required by licence conditions, imposed pursuant to a specific reference in subsection 24(5) of the NSCA, to provide financial guarantees acceptable to the CNSC for the costs of decommissioning NPPs.

11.1 (a) Financing of operations and safety improvements made to nuclear power plants during their operating life

Canadian NPP licensees maintain budgets for operation, maintenance and capital improvements. For large-scale improvements, an item is costed for financing over the estimated remaining effective lifetime of the NPP. Expenditures are dictated by the licensee's financial position, current and planned performance, service obligations (electrical load forecast) and financial and business strategies. These inputs are used to develop the envelopes for ongoing operating expenditures and capital investments.

Canadian NPP licensees place a high priority on safety-related programs and projects. This ensures adequate financial resources are applied to safety improvement programs and projects throughout the life of each NPP.

11.1 (b) Financial resources for decommissioning

Licensees of nuclear facilities, including spent fuel and radioactive waste management facilities, must provide guarantees that ensure adequate financial resources are available for the decommissioning of these facilities and management of the resulting radioactive wastes. Canada's four NPP licensees have opted for different methods of supplying decommissioning financial guarantees, as detailed by CNSC regulatory document REGDOC-3.3.1, *Financial Guarantees for Decommissioning of Nuclear Facilities and Termination of Licensed Activities*, which was published in January, 2021. In each case, the financial guarantee arrangements include legal agreements that grant the CNSC access to the guaranteed funds in the event of default by the licensee. The licensees maintain preliminary decommissioning plans, cost estimates and financial guarantees and report periodically to the CNSC that these remain valid, in effect and sufficient to meet the decommissioning needs. The preliminary decommissioning plans and financial guarantees are kept up to date in response to events such as changes to NPP operating plans, changes in financial conditions and the development of plans for the long-term management of spent fuel under the *Nuclear Fuel Waste Act*. The financial guarantees encompass not only the decommissioning of the NPP but also the safe storage of nuclear waste and spent fuel produced by the NPP. NPP licensees submit to the Commission annual reports on the status of their financial guarantees

Acceptable financial guarantees include cash, letters of credit, surety bonds, insurance and legally binding commitments from a government (either federal or provincial). The acceptability of the guarantees is assessed by the CNSC according to the following general criteria:

- Liquidity: The proposed funding measures should be such that the financial vehicle can be drawn upon only with the approval of the CNSC and that payout for decommissioning purposes is not prevented, unduly delayed or compromised for any reason.
- Certainty of value: Licensees should select funding, security instruments and arrangements that provide full assurance of their value.
- Adequacy of value: Funding measures should be sufficient, at all or predetermined points in time, to fund the decommissioning plans for which they are intended.
- Continuity: The required funding measures for decommissioning should be maintained on a continuing basis. This may require periodic renewals, revisions and replacements of securities provided or issued for fixed terms. For example, during a licence renewal the preliminary decommissioning plan may be revised, and the financial guarantee updated accordingly. Where necessary and in order to ensure that there is continuity of coverage, funding measures should include provisions for advance notice of termination or intent not to renew.

The decommissioning financial guarantees required from Hydro-Québec, NB Power and OPG cover the full breadth of decommissioning, including the initial steps to place the facilities in a safe storage state. Under the lease conditions of the Bruce site to Bruce Power, the owner (OPG) maintains the decommissioning financial guarantees for the Bruce reactors.

The financial guarantee and the associated preliminary decommissioning plans are required to be revised by NPP licensees every five years or when requested by the Commission. The preliminary decommissioning plan provides the long-term vision for the storage and surveillance period (approximately 30 years) prior to demolition and site restoration. In the preliminary decommissioning plan, the estimated costs associated with decommissioning and form the basis for the decommissioning financial guarantees.

Further details on financial guarantees and decommissioning can be found in the *Canadian National Report for the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management*.

Financing of the Pickering safe storage project

The financing of the placement of Pickering Units 2 and 3 into safe storage and the isolation of interfaces to the operating NPP was provided primarily from OPG’s nuclear decommissioning fund.

The project scope and cost estimate for the placement of Pickering Units 1, 4, 5, 6, 7 and 8 into safe storage at the end of their operating lives are in development. As of the end of the reporting period, OPG was working on plans to transition the NPP into safe storage beginning in 2024 with completion by approximately mid-2028. Under these plans, two units will be shut down at the end of 2024; at the end of the reporting period, OPG was proposing to shut down the remaining four units at the end of 2025. In December 2021, OPG submitted to CNSC its stabilization activity plan, which describes the transition of Pickering into safe storage.

11.1 (c) Requirements under the Nuclear Liability and Compensation Act

The civil liability regime provided by the *Nuclear Liability and Compensation Act* establishes the absolute, exclusive and limited liability of the operator for civil damages. It is designed to provide certainty on the treatment of legal liability for nuclear damage resulting from a nuclear incident (including losses resulting from a preventive measure) and to provide prompt compensation with minimal litigation. Highlights of the legislation include the following:

- The absolute liability limit of an NPP operator is $1 billion
- Compensable damage includes, in addition to bodily injury and property damage under the current legislation, some forms of psychological trauma, economic loss, losses resulting from preventive measures and environmental damage.
- The limitation period is 30 years for submitting compensation claims for bodily injury and loss of life.
- Operators are required to maintain financial security to cover their full liability limit.
- A quasi-judicial claims tribunal replaces the courts, if necessary, to accelerate claim payments and provide an efficient and equitable forum.

In 2021, Natural Resources Canada undertook the first five-year review of the $1 billion liability limit under the *Nuclear Liability and Compensation Act.* Subject to the legislative requirements, the review considered the consumer price index, international nuclear liability standards, and other considerations.

11.2 Adequacy of human resources

Paragraph 12(1)(a) of the *General Nuclear Safety and Control Regulations* requires licensees to “ensure the presence of a sufficient number of qualified workers to carry on the licensed activity safely and in accordance with the Act, the regulations made under the Act and the licence.” The expression “Adequate human resources” means the employment of enough qualified staff to carry out all normal activities and to respond to the most resource-intensive conditions under all operating states, including normal operations, anticipated operational occurrences, design-basis accidents, and emergencies.

As described in the following subsections, the licensees have extensive programs for training, staffing, examination, workforce capacity evaluation, hiring, knowledge retention and R&D that contributed to the effective management of human resources.

11.2 (a) Requirements and measures related to staffing levels, qualifications, training and certification of workers

Licensees are responsible for the safe operation of their respective NPPs. As such, they are responsible for both training and testing their workers to ensure they are fully qualified to perform the duties of their positions.

Licensee training programs

CNSC REGDOC-2.2.2, *Personnel Training*, sets out the requirements and guidance for the analysis, design, development, implementation, evaluation, documentation and management of existing and new training at nuclear facilities, including the principles and elements essential to an effective training system. Licensees must ensure that the workers who carry on licensed activities are trained and qualified to do the work assigned to them through the use of a training system that is systematically developed and performance-oriented. Licensees must also use this training system whether the training is defined, designed, developed, implemented, evaluated, recorded and managed internally by the licensee or externally though vendors or contractors.

The CNSC regularly performs compliance verification activities to evaluate licensees' training programs and to verify that all workers, including certified staff, temporary workers and contractors, are qualified and competent to perform the work assigned to them. Regulatory activities include the assessment of training processes and procedures, review and evaluation of licensee training programs and onsite evaluation and inspections of training program outputs.

Licensee training programs are established in accordance with the principles of the systematic approach to training, which ensures that licensee staff receive training pertinent to their positions. Departmental programs are routinely reviewed, and training needs analytically identified to allow training courses to be revised or developed as necessary to guarantee that the training replicates the procedures and equipment used in the NPPs. Furthermore, training program evaluation processes and procedures are regularly applied to assess the effectiveness of the training programs. Licensees use performance and accreditation objectives and criteria for training programs, such as those developed by the Institute of Nuclear Power Operations (INPO). All key training performance areas are evaluated and assessed against these objectives quarterly. OPG, for example, uses them as the basis for a number of training performance indicators.

All NPP licensees have internal training programs that focus on training in CANDU technology and on the development of soft skills (such as behavioural competencies). Operations and maintenance training is provided to create and maintain job performance capability. This training normally includes classroom instruction, workshops, full-scope simulator exercises, on-the-job instruction, supervisory coaching and informal briefings. Most staff are also trained to a radiation protection level that qualifies them to be responsible for their own protection, sponsor supplemental staff and provide radiation protection oversight.

A number of enhancements have been made to the training programs at Canadian NPPs during the reporting period. Annex 11.2(a) provides examples from Bruce Power, OPG and NB Power.

The number of staff working in the regulatory field is too small for a single Canadian NPP licensee to maintain and deliver an in-house training program on regulatory affairs. Therefore, an industry working group coordinates a joint regulatory affairs training program. It includes courses on the following topics, developed by individual licensees, the CNSC and Canadian Nuclear Laboratories (CNL) and coordinated by COG:

- NPP operating licences
- REGDOC-3.1.1, *Reporting Requirements for Nuclear Power Plants*
- the NSCA and its regulations
- regulatory issues management

Licensee training programs consider the requirements for supplemental personnel, who are important to licensees' performance of critical work on safety systems and safety-related systems during maintenance outages (e.g., electrical, hoisting and rigging, pressure boundary) as well as personnel performing a contract management role. While supplemental workers are typically recruited to augment outages, they can also be involved in engineering or design work. The training programs consider previous training and experience through the use of standard task evaluations based on the Electric Power Research Institute (EPRI) methodology or apprentice-related certificates of qualification. The training and qualification of supplemental workers ensures familiarity with nuclear-related practices such as human performance tools and corrective action programs. Specialized training is provided in areas such as environmental qualification, foreign material exclusion, respiratory protection, human performance and radiation protection, all of which include industry-related operating experience. The programs to assess the competencies of the supplemental staff include the evaluation of the knowledge and skills necessary to conduct specific work at the NPPs.

Other industry members also maintain training programs related to nuclear safety. For example, SNC-Lavalin Nuclear provides internal and external training in CANDU technology as well as training in other nuclear technologies that support its products and services for NPPs. For example, during the reactor components design of the retube projects, SNC-Lavalin Nuclear utilizes three-dimensional smart-plant software for the layout of the feeders. Integration of this software with laser scans of the reactor building structures produces real-space holographic simulations of the feeder and the surrounding structures that can be used to train the feeder installers to carry the feeder to the final installation location (i.e., wearing a holographic headset) prior to completing the actual field execution work. In addition, the innovation was utilized to identify in advance any potential interferences with surrounding structure within the building that may occur during the transfer the feeders into the reactor building for installation.

The training activities include the design engineering process, CANDU design technology, pressure boundaries, Canadian nuclear standards, human performance, and management leadership, including participation in INPO training. Recent training, such as on seismic probabilistic safety assessment and various CANDU industry standard toolset computer codes has been offered both in Canada and in other CANDU countries. The training program is integrated with the development programs as part of the performance reviews. SNC-Lavalin Nuclear has implemented annual planning of training and a software system to facilitate employee-initiated training followed by the respective approvals to assist with defining the training plan for the upcoming year(s).

Qualification and numbers of workers

The CNSC defines and establishes regulatory requirements and criteria for the qualification, examination, certification and numbers of licensee personnel, including certified staff at NPPs.

Annex 11.2(a) provides specific details on the hierarchy of these requirements and guidance. Some of the more pertinent documents are discussed in detail in the following.

CNSC REGDOC-2.2.3, Personnel Certification, Volume III *Certification of Persons Working at Nuclear Power Plants,* sets the certification requirements for persons in certified positions at NPPs (the actual positions are described in annex 11.2 (a)). It also sets requirements for processes by which the licensees train and examine their candidates for certified positions. The

CNSC administers examinations for some certified positions (senior health physicists) while the NPP licensees are responsible for independently administering examinations for all other certified positions. The CNSC provides oversight of the training and examination programs and acts as the certifying body, verifying that persons in certified positions at NPPs meet CNSC requirements. One aspect of ensuring the presence of a sufficient number of qualified workers is defining the minimum number of workers with specific qualifications who will be available to the nuclear facility at all times. This sufficient number is known as the minimum staff complement (MSC). CNSC REGDOC-2.2.5, *Minimum Staff Complement* provides guidance to assist Class I nuclear facility licensees and applicants to demonstrate to the CNSC how they ensure the presence of a sufficient number of qualified workers. The number and qualifications of workers should be adequate to successfully respond to all credible events, including the most resource-intensive conditions for any facility state. The MSC is specific to each facility and is influenced by the design of the facility, operating and emergency procedures and organizational functions.

NPP licensees conduct a systematic analysis to determine the specific numbers and qualifications of staff required in the MSC. This analysis considers all work groups essential to ensuring the safe operation of the NPP and adequate emergency response capability, such as certified and non-certified staff, maintenance, emergency response and fuel handling. It also considers the response necessary to mitigate the consequence of all design-basis events including common-mode events and multi-unit facilities. For NPPs, CNSC staff reviews the licensee’s systematic analysis that is used to determine the MSC and observe the integrated validation exercises used to demonstrate the adequacy of the MSC. The analyses and validation reports are part of the licensing basis for each NPP.

At Pickering, significant staff reductions are anticipated to be required as a result of the end of commercial operations at the NPP. OPG has established and is implementing an integrated plan to ensure there is an engaged and skilled workforce that enables continued operational excellence through to the end of commercial operations, including defueling and dewatering. This integrated plan includes the plans for resourcing as well as plans for the physical plant, such as the safe storage project and decommissioning plans. Resourcing plans are in place to ensure that an adequate number of qualified employees are available to continue safe operations through to the end of commercial operations and that internal redeployments into other areas such as decommissioning are optimized.

Small Modular Reactors (SMRs)

Efforts are underway by current and future licensees to define the training, qualification, and certification requirements for SMRs through the Certification and Training Advisory Group and licensee specific meetings with the CNSC. The focus is establishing programs and processes appropriate for newer, simpler reactor technologies with additional inherent safety features.

Licensee COVID-19 pandemic response

The NPP LCHs include a requirement for licensees to maintain a business continuity plan. Such plans to provide for essential services through a sustained period with significant employee absenteeism. In response to the COVID-19 pandemic, all NPP licensees implemented their business continuity plans.

All NPP licensees took measures to ensure that the minimum staff complement was not compromised by the COVID-19 pandemic, such as:

- having all non-essential personnel work from home
- restricting access to the NPP, especially the main control room
- closing several buildings onsite to allow for cleaning crews to focus on more critical infrastructure
- staggering shift changes to minimize the number of staff in the same area
- switching rooms for shift turn-over meetings to allow for greater social-distancing and using thermal-imaging cameras to support active screening of staff on-site

All NPP licensees initially delayed major activities in order to minimize the number of personnel/contractors onsite. Outages continued to be planned for critical periodic inspections. A major consideration was to ensure the completion of inspections and collection of data to demonstrate to the CNSC the continued fitness for service of critical systems. All rescheduled activities maintained adequate safety margins and were able to demonstrate the acceptable level of fitness for service.

Overall, licensees are adequately prepared with their plans for events involving labour and pandemic actions.

Other industry members also pivoted during the COVID-19 pandemic. For example, SNC-Lavalin Nuclear implemented various measures to maintain support for CANDU operations, which included:

- an onsite rapid testing program for employees working from or visiting the offices
- a self-health screening program prior to visits to the offices
- the requirement to maintain social-distancing, and to wear face masks in the offices
- limitations on the maximum capacity within locations such as conference rooms
- working remotely

11.2 (b) Capability maintenance at NPP sites

Core programs

The nuclear industry in Canada has robust workforce-development and worker-replacement programs in place to meet future needs, as well as leadership development programs. Changes in workforce demographics and anticipation of increasing industry human resources requirements (e.g., due to refurbishments and possible new construction that may compete for resources with other large energy-related projects) have led to initiatives in four related areas:

- workforce capability analyses
- hiring programs
- external training programs
- knowledge-retention programs

Industry-wide effort is also aimed at maintaining R&D capacity.

Most of the examples and details in the following are for NPP licensees. However, other supporting organizations with safety-related activities also strive to maintain safety-related capability – a few illustrative examples are also provided for SNC-Lavalin Nuclear.

Workforce capability analyses

NPP licensees regularly conduct detailed workforce capability analyses to predict gaps between forecast supply and planned resource levels in the operator, maintenance and engineering job-families. These analyses focus on assessing critical gaps in skills that need to be retained, replaced and resourced. Training requirements are also identified. Annex 11.2(b) provides, as an example, a detailed description of the workforce planning process used by Bruce Power.

OPG and Bruce Power continue to collaborate to ensure that industry vendor capability exists to perform complex work at both utilities. For workforce capability, this joint initiative ensures sufficient capacity to perform the volume of work and feasibly mitigate schedule overlaps between OPG and Bruce Power. The workforce focus is in three streams.

<u>Improve supply and demand data</u>

- OPG, Bruce Power, the Electrical Power Systems Construction Association, vendors and unions share skilled trades information and development of forecasts (total nuclear long-term demand for all nuclear-related skilled trades) and partnership strategies. Currently, trade supply for boilermakers is critical to meeting forecast demand
- Trade demand forecasts are updated quarterly
- Trade demand forecasts are being actively updated to include trades related to SafeStor, SMRs and Renewable Generation
- Other specialized trade forecasts have been developed working with labour-market consultants

<u>Build new source of trades</u>

- Tri-partite agreement between Durham College, the Boilermakers' Union and OPG fast-tracked 100 new pre-apprentices into the Boilermakers' Union for 2019
- A new boilermaker "helper" classification was created to help address supply challenges.
- OPG and Bruce Power collaborated with the United Association of Plumbers and Pipefitters and the Canadian Welding Bureau Foundation to build 21 new welding booths in 4 Durham Region high schools and engage youth in hands-on training at union training halls
- A new Introduction to Millwright program recruited eight new indigenous candidates to receive training to become millwright apprentices (all are working at OPG on refurbishment)
- A pilot collaboration with millwrights and Durham College hired four women from Durham College as millwright apprentices

<u>Optimize the current supply of trades</u>

- OPG and Bruce Power streamlined practices for security clearance.
- The Job Ready Dispatch program was created to eliminate the need for duplicate trades training
- OPG and Bruce Power maximized the use of travel cards and permit trades
- OPG and Bruce Power created the Temporary Foreign Worker program with the Government of Canada to promote the recruitment of skilled trade persons from outside Canada

- Darlington's Indigenous Opportunities in Nuclear program was established to improve the recruitment and retention of Indigenous peoples working on the refurbishment project, as well as across OPG's nuclear fleet
- Indigenous Opportunities in Nuclear partnered with a local Indigenous employment centre
- The Government of Canada helped establish Indigenous partnerships aimed at raising awareness of opportunities

Succession-planning processes are also in place at the NPPs to predict, plan and prepare for the replacement of senior-level personnel. Leadership positions down to the level of department manager are identified and assessments of employee readiness to assume a position (from "ready now" to "ready in one to two years" to "ready in three to five years") are being conducted. Development plans prepare potential candidates to assume critical positions as employees retire. To address anticipated readiness gaps at senior levels, OPG uses focused development and targeted learning events.

SNC-Lavalin Nuclear addresses workforce capability through a comprehensive resource-management system that focuses on the delivery of engineering products and services to nuclear facilities around the world, the refurbishment of existing reactors and the construction of new reactors. This functionally-managed system covers various groups in SNC-Lavalin Nuclear and takes an optimal approach to dealing with changes in the business, balancing customer needs and ensuring a consistent approach. System elements are grouped on the basis of supply, demand, resource planning, resource development and performance management. Skills of individual technical staff are identified and maintained with succession plans established to meet commercial demands. The attrition risks of these employees are actively managed by a dedicated functional resource management team that continually assesses worker skills, knowledge and qualification to identify gaps and utilize a combination of targeted and on-the-job commercial training opportunities to close the gaps.

SNC-Lavalin Nuclear's employee qualification program maintains the qualification status and training of employees in a database that acts as a qualification, skill, and certification validation repository to support requirements and processes. The database maintains qualification information such as the engineering personnel qualification record, which is a document outlining the required qualifications for an engineering role/position and the evidence to support that an individual has obtained the required qualifications and experience to perform work within that role.

Hiring programs

NPP licensees continued to replenish their workforces through hiring programs to recruit workers into the operator, maintenance and engineering job-families. Recruitment of mechanical and control maintenance workers and operators is largely conducted through community colleges; the NPP licensees have established partnerships with colleges in their regions, often advising on curriculum and career opportunities (see previous subsection). Recruitment of engineers includes both experienced workers and new graduates from Canadian universities, some of which offer nuclear engineering programs.

To further promote the industry and increase the pool of potential applicants, the NPP licensees are active in programs such as campus outreach and robotics competitions, as well as in organizations such as Women in Nuclear (WiN) and North American Young Generation in Nuclear (NAYGN).

WiN-Canada emphasizes and supports the role of women in addressing the general public's concerns about nuclear energy and the application of radiation and nuclear technology. WiN-Canada also works to provide an opportunity for women to succeed in the industry through initiatives such as mentoring, networking and personal development opportunities. The industry has collaborated on a number of joint initiatives in partnership with WiN, including the production of a video to encourage young women in high school to pursue a career in the nuclear industry and an initiative to provide the human resources community with recommendations for developing more robust strategies to have women pursue trades careers in the electricity sector.

A number of young professionals in the licensee organizations and SNC-Lavalin Nuclear are part of the NAYGN. This organization provides opportunities for a young generation of nuclear enthusiasts to develop leadership and professional skills, create life-long connections and engage and inform the public.

The NPP licensees have programs aimed at hiring members of Indigenous Nations and communities. For example, Bruce Power has committed to hiring a minimum of 50 Indigenous people each year either directly or through vendors (in addition to training, as discussed above, Bruce Power is funding scholarships and internships for Indigenous people. Both NB Power and OPG have similar programs in place.

At SNC-Lavalin Nuclear, the supply of personnel in the needed skills is maintained by internal postings and external hiring, including that of experienced personnel on contract (such as retirees, including those from licensee organizations). Furthermore, recruitment by SNC-Lavalin Nuclear utilizes innovative partnerships with Canadian universities.

External training programs

For a detailed description of specific training programs within Canada to develop new workers for the nuclear industry, see the eighth Canadian National Report.

Knowledge-retention programs

Knowledge management and retention continue to be important focus areas for the NPP licensees. Various knowledge management and mitigations plans exist for critical and "at-risk" roles due to the departure of a significant portion of the nuclear industry's knowledge workers.

Some of the initiatives implemented by NPP licensees in Canada to mitigate knowledge retention risks include:

- knowledge repositories that use common documentation
- a high-potential development program for emerging leaders and middle managers that accelerates the development of high-potential employees for future leadership roles
- a recruitment and resourcing strategy to achieve a mix of new graduates, experienced hires, on-the-job developmental opportunities and rotations, and contract staff
- partnerships with selected external service providers to provide a new means of implementing projects
- ongoing mentoring and coaching of employees

- on-the-job and classroom-based training communities for sharing best practices and discussing solutions to common issues and challenges
- centres of excellences, which establish a critical mass of expertise and a consistent enterprise-wide approach in key areas important to the business

For example, OPG uses both internal and external approaches to knowledge management. The internal approach uses internal tools and resources to assess the risk of knowledge loss by determining a total attrition factor that includes a rating based on the estimated time until retirement (or departure) and the position criticality. This information is then utilized in developing an approach to manage the key issues. The external approach involves engaging a vendor to capture knowledge through specialized knowledge mapping software. Both approaches are integrated into OPG's succession-planning cycle when critical and "at-risk" roles are reviewed and identified, with specific focus placed on critical positions where knowledge loss is the greatest threat.

OPG managers periodically review knowledge-retention plans to assess the overall criticality of the roles and the availability of knowledge to the organization.

As another example, NB Power continues to implement a knowledge management initiative. Critical skills have been identified using a document and metric that includes a position risk factor and retirement departure factor broken into positions that require several years of experience to develop the necessary knowledge, specialists with unique or crucial technical expertise and/or a licence-mandated leadership role. For those positions deemed critical, knowledge transfer tool kits were circulated to directors and managers for completion by those in critical roles supported by their leadership. The tool kits identify and capture knowledge in the areas of process/technical knowledge as well as informal working knowledge.

To support the knowledge management and retention initiatives of CANDU NPPs, SNC-Lavalin Nuclear provides the following engineering support services:

- attachment of experienced SNC-Lavalin Nuclear staff to CANDU NPPs
- provision of training programs (see subsection 11.2(a))

SNC-Lavalin Nuclear has developed a knowledge management database, which provides the quarterly status of the knowledge maintained in the various engineering skills using various metrics/criteria. In addition, knowledge management is supported by succession planning, including individual development plans, and by the training program.

Maintaining R&D capability

There has been some concern that available funds for nuclear power R&D may be insufficient to sustain the core R&D elements of people and facilities. Canada recognizes that it is important to retain adequate core R&D capability, preserve expert knowledge and train future experts.

On a semi-regular basis, COG produces a report on the R&D capability of the Canadian nuclear industry. This report examines and documents Canadian R&D capability in order to ensure adequate financial resources for R&D, with the view of supporting continued safe and reliable operation of NPPs. The last assessment in 2017 of the different R&D programs provided evidence that the current plans and funding for the regular COG R&D program and the new Strategic R&D program, supplemented by joint projects for high-priority issues, were adequate to maintain the R&D capabilities in the CANDU industry. While the older experimental facilities at Canadian Nuclear Laboratories are facing the possibility of decommissioning due to underutilization, the Chalk River site is being rejuvenated and continues to meet the foreseeable R&D requirements of the CANDU community.

The CNSC monitors both the capability of the Canadian nuclear industry to sustain R&D and the results of the R&D programs themselves.

Appendix D describes the R&D programs for Canadian NPPs during the reporting period.

Article 12 – Human factors

> Each Contracting Party shall take the appropriate steps to ensure that the capabilities and limitations of human performance are taken into account throughout the life of a nuclear installation.

Introduction and applicable requirements

"Human factors" are the factors that influence human performance as it relates to the safety of a nuclear facility or activities over all phases, including design, construction, commissioning, operation, maintenance and decommissioning. These factors may include the characteristics of the person, the task, the equipment or tools used, the organizations to which the person belongs, the work environment and the training received. The application of human-factors knowledge and methodologies across the systems (i.e., human, technology and organization) can help prevent errors from propagating into problems at all levels of the business.

The CNSC considers human factors during its licensing, compliance and standards-development activities. During licensing, the CNSC evaluates the extent to which the applicant has considered human factors and applied that knowledge in its proposed programs. The CNSC published regulatory document REGDOC-2.2.1, *Human Factors* in 2019 to describe how the CNSC will take human factors into account during its licensing, compliance and standards-development activities. The CNSC has issued several other regulatory documents and guides to assist licensees and licence applicants in the planning and implementation of human factors activities. Human factors is a cross-cutting domain, so considerations of human factors are also included in many additional regulatory documents relevant to other SCAs and systems. In addition, a number of CNSC regulatory documents include specific requirements for the consideration of human factors during new-build and life-extension projects. Human factors are also considered in a number of CSA Group nuclear standards.

In the next reporting period, CNSC staff will continue to develop and improve the regulatory framework in support of human factors. Such work will include initiatives to further define expectations surrounding human performance, minimum staff complement and general design consideration for human factors

The CNSC subdivides its assessment of human factors into technical review areas. The sub-article/subsection number in the table indicates where the factor is described in this report.

Table 7: Location of technical review area topics

Technical review area	Sub-article/subsection
Reporting and trending	7.2(iii)(b), 19(vii)
Safety culture	10(b)
Minimum staff complement	11.2(a)
Human performance program	12(a)
Fitness for duty	12(b)
Procedures	12(c)
Human actions in safety analysis	12(d)

Human factors engineering	12(e)
Organizational performance	12(f)
Work organization and job design	12(g)
Accident management and recovery	19(iv)

12 (a) Human performance programs

Human performance relates to the work activities carried out by people and teams, as well as their results. It is the outcome of human behaviours, functions and actions in a specified environment, reflecting the ability of workers and management to meet the system's desired standard of performance under the conditions in which the system is employed. The human performance program provides a human-centric view of the work activities within the business to understand the work and its context to be able to learn and continually improve. An effective human performance program integrates the full range of human factors considerations – not just the people but also the tools, equipment, tasks and environments in which they work – to ensure people are fully supported to strengthen the ways that desired outcomes can be achieved and sustained. The desired human performance is supported by hardware and software design that considers the users, high-quality procedures, good procedural adherence, effective work organization and careful job design. It is also necessary to ensure workers are fit for duty and are supported by appropriate organizational mechanisms, continuous monitoring and an organizational commitment to improvement. (These review areas are discussed in subsequent subsections.)

The requirement for a licensee to have a human performance program is a licence condition in NPP operating licences. An NPP licensee's human performance program should be developed, reviewed for effectiveness and updated continually (or at frequent intervals) and at all phases of the NPP lifecycle, from design through to decommissioning.

In 2016, CNSC published discussion paper DIS-16-05, *Human Performance*, which considered the approach to human performance at an organizational level and discussed the development of stronger links between the human performance program and the range of human factors topics, which would lead to a strong, integrated consideration of human performance (i.e., adopting a systemic approach to establish and make explicit the relationships between the humans, technology and organization in the business). CNSC incorporated feedback from the discussion paper into the new version of REGDOC-2.2.1, now titled *Human Performance* which is scheduled for public consultation in 2022.

All Canadian NPPs have implemented human performance programs that emphasize detection and correction of human error with a focus on monitoring individuals' behaviours. Licensees' human performance improvement programs encourage assessment of internal and external events and operating experience as opportunities to address problems before errors occur. All licensees conduct detailed reviews of operational conditions, activities, incidents and events (e.g., review of station condition records), as well as apparent-cause evaluation or root-cause analyses to facilitate the detection and correction of human performance and other issues related to human factors. Licensees have developed coding schemes to effectively identify and track the causes of adverse conditions (see sub-article 19(vii)).

In this learning environment, licensees strive to operate in a blame-free environment, this approach increases the willingness of staff to identify errors in their work.

The mechanisms by which NPP licensees assign responsibilities and accountabilities for human performance are described in annex 12(a).

More recently, some licensees have broadened the focus of their human performance programs to consider managing defences against human error and supporting workers to achieve the desired safety performance. Defence methods, which are identified through risk assessment, include elimination, engineering controls, administrative controls and personal protective equipment. The CNSC recognizes the benefits when licensees encourage employees to get more involved in devising methods to improve the quality, reliability and safety of their work, as well as when they more fully appreciate their employees' roles in nuclear safety.

CNSC staff's review of human performance programs assesses the licensee's ability to create, integrate and implement defences that prevent or mitigate the consequences of human error in work activities, and learn from successful daily work activities to support its workers to achieve the desired human performance. This includes a review of programs for performance monitoring that detect latent organizational conditions and weaknesses, the consideration of human and organizational factors in organizational processes, strategies for improvement and the licensee's overall commitment to fostering a healthy safety culture.

The CNSC review of performance monitoring and improvement focuses on ensuring that there is a systematic, objective and comprehensive process for monitoring and improving safety. The CNSC reviews of NPP events ensure that corrective action plans are systematically developed, comprehensive and effective for addressing the causes of an event.

12 (b) Fitness for duty

Fitness for duty is a broad topic that touches on occupational medicine, physical and psychological fitness, and the management of fatigue and alcohol and drug use. Fitness for duty is defined as a condition in which workers are physically, physiologically and psychologically capable of competently and safely performing their tasks.

The CNSC has several regulatory documents that address various aspects of fitness for duty. CNSC REGDOC-2.2.3, *Personnel Certification, Volume III, Certification of Persons Working at Nuclear Power Plants*, requires licensees to have a documented fitness-for-duty program for certified workers. More detailed requirements are contained in the following three related regulatory documents.

CNSC REGDOC-2.2.4, *Fitness for Duty: Managing Worker Fatigue* was published in 2017 following extensive research, benchmarking and public consultation. It includes a comprehensive suite of requirements and guidance for managing worker fatigue at high-security sites, including NPPs. These measures are intended to reduce high levels of fatigue and fatigue-related errors. Fatigue management provisions apply to all workers who could pose a risk to nuclear safety or security. Prescriptive limits on hours of work apply to a smaller subset of workers in safety-sensitive positions. The prescriptive limits focus on the highest risk aspects of shiftwork – extended shifts and night work.

CNSC REGDOC-2.2.4, *Fitness for Duty, Volume II: Managing Alcohol and Drug Use, version 2* was also published in 2017. This document is applicable to all workers holding safety-critical or safety-sensitive positions at high-security sites and includes the full breadth of requirements, including drug and alcohol testing, to provide reasonable assurance that these workers are free from the influence of alcohol and drugs while at work. As part of the process to ensure workers possess the capacity to perform their jobs safely and competently, licensees are required to implement alcohol and drug testing across a broad range of testing circumstances including random testing. Random and pre-placement testing is limited to workers in safety-critical positions such as control room operators. In January 2021, the CNSC published version 3 of Volume II of REGDOC-2.2.4, which expanded the approved drug testing methods, and their associated cut-offs, to include oral fluid testing and point-of-collection testing. Other changes in response to the legalization of recreational use of cannabis in Canada were also included.

Canadian NPPs started to implement REGDOC-2.2.4, *Fitness for Duty, Volume II* Version 3.0 in a phased approach. For example, Bruce Power planned to subject safety-sensitive and safety-critical positions to mandatory drug and alcohol testing, commencing in July 2021. Mandatory random drug and alcohol testing requirements for nuclear workers were to come into effect in January 2022.

Prior to the implementation of requirements for random drug and alcohol testing, the unions that represent the affected workers submitted a joint petition to the Federal Court of Canada to suspend certain requirements. On January 21, 2022, the Federal Court of Canada granted an injunction allowing the labour unions' application to put on hold the implementation of pre-placement (that is, testing a worker before hiring them and/or upon transferring them to a safety-critical position) and random alcohol and drug testing of workers in safety-critical positions at high-security nuclear facilities.

While the Federal Court of Canada considers the merits of the legal challenge to the fairness and constitutionality of the requirements, the licensees suspended the implementation of the random and pre-placement testing requirements at the operating NPPs. However, existing programs to assure fitness for duty for certified staff and nuclear security officers remain effective. All other requirements in REGDOC 2.2.4 Volume II have been implemented including drug and alcohol testing for-cause under reasonable grounds, as well as for post-incident situations and as part of return-to-duty or follow-up testing.

In addition, supervisors are trained to monitor workers as they arrive on the job for signs of impairment as well as physical or emotional fatigue. Licensees' regular health screening programs include the opportunity for assessment from a mental health perspective if and as required. Additionally, there are support programs for employees who voluntarily disclose drug or alcohol issue

In addition to the requirements for fitness for duty noted above, CNSC REGDOC-2.2.4, *Fitness for Duty, Volume III: Nuclear Security Officer Medical, Physical and Psychological Fitness* sets out the fitness-for-duty requirements specific to nuclear security officers including the requirement to obtain medical, physical and psychological certificates. The physical fitness test that officers are required to undertake is also included.

12 (c) Procedures

NPP licensees have processes for developing, validating, maintaining and modifying technical procedures used for testing, maintenance and operations (both normal and abnormal). In addition, most licensees have a writers' guide that addresses relevant human factors considerations for written procedures.

CNSC staff's review of procedures focuses on ensuring there is an adequate process for the development, validation, implementation, modification and use of procedures that account for human performance. CNSC staff members also focus on ensuring that the process is implemented effectively and that there are demonstrated mechanisms for managing procedural adherence.

12 (d) Human actions in safety analysis

Human actions are considered in probabilistic and deterministic safety analyses to examine the possible contribution of human error and human reliability to hazards and risks.

Human reliability analysis is an integral component of probabilistic safety assessment (PSA) in situations where humans are involved in system performance. (More information on PSA is provided in subsection 14(i)(d).) It is a method for estimating the probability that a system-required human action, task or job that is necessary for safety will not be completed successfully within the required time period. It can also consider the probability that extraneous tasks or actions detrimental to system reliability or availability will be performed. Other safety analyses that consider human actions include hazard and operability studies, failure modes, effects analyses, and hazard analyses.

Licensees use industry-accepted human reliability assessment methods within their PSAs to incorporate the probability of human errors in risk-important sequences. While the CNSC does not require its licensees to use any particular method for human reliability analysis, it verifies that the method chosen meets industry good practices and is carried out in a systematic way. One commonly used method is the technique for human error rate prediction.

The CNSC is conducting research into the standardized plant analysis risk – human reliability analysis method with regard to adapting the factors that shape human performance. This could eventually assist licensees with developing their Level 2 PSAs[9], to include consideration of the use of emergency mitigating equipment and severe accident management guides.

CNSC staff's review of human actions focuses on the execution of components of emergency operating procedures in the control room and field.

12 (e) Human factors engineering

The consideration of human factors engineering (HFE, but also referred to as human factors in design) applies to the entire system design of new facilities and to the modification and decommissioning of existing facilities and extends beyond nuclear systems of NPPs (e.g., balance of plant, fuel handling, engineered tooling, waste management systems, offsite emergency centre and emergency equipment). HFE is concerned with ensuring that the design modification or decommissioning of facilities, systems and equipment integrates information about human characteristics, performance and limitations so as to ensure safe and reliable task and system performance and to minimize the potential for human error. The concept considers the cognitive, physical and sensory characteristics of people who operate, maintain or support the system, ensuring that the system and equipment are designed to support human performance.

HFE effort increases with higher levels of interface complexity or criticality; greater HFE effort is typically required for reactor operator tasks.

[9] Level 2 PSA analyses containment behaviour for events that may lead to the loss of core structural integrity and massive fuel failures, evaluates the radionuclides released from the failed fuel and quantifies the releases to the environment.

The NPP licensees have implemented several documents with HFE requirements. CNSC REGDOC-2.5.2, *Physical Design – Design of Reactor Facilities: Nuclear Power Plants*, includes requirements for addressing human factors in the design of new NPPs (see sub-article 18 (iii) for details). In addition, CNSC REGDOC-2.6.2, *Maintenance Programs for Nuclear Power Plants* and CSA Group standard N290.12-14, *Human factors in design for nuclear power plants* include requirements for addressing human factors in maintenance and design, respectively.

A description of how the Canadian nuclear industry considers human factors through its application of HFE is provided in annex 12(e).

As part of a PSR, licensees must determine the extent to which the current NPP and its performance conform to modern standards and practices and identify any gaps between those standards and actual performance (see subsection 14(i)(b) for details). The CNSC expects that modern HFE principles and standards as well as other best practices will be consulted when considering NPP modifications. CNSC staff continue to work with licensees conducting PSRs to ensure the reviews against modern standards address expectations related to human factors that could limit safe long-term operation. In addition, modifications in response to the Fukushima accident have included HFE considerations.

CNSC staff's review of HFE ensures that there is a systematic process for effectively incorporating human factors considerations into system requirements, definition, analysis, design, verification and validation activities, as well as monitoring engineering design changes following implementation. CNSC staff also focus on ensuring that the process of incorporating HFE is implemented effectively by suitably trained, qualified and competent human-factors specialists.

12 (f) Organizational performance

CNSC staff review the licensees' management processes related to organizational performance (e.g., business planning, the establishment of the organization, change management of roles and responsibilities, communications, and resourcing) and consider the influence of such processes on safety performance at Canadian nuclear facilities. For example, safety performance at NPPs can be influenced by the ways in which organizational changes are made and communicated, how contractors are managed, how the organization conveys its vision and mission, and how responsibilities are assigned within the organization ─ from the senior management team to the field where the work is carried out.

The CNSC's review of licensees' organizational processes and performance is described further in subsection 10(d).

12 (g) Work organization and job design

Work organization and job design relate to the organization and provision of a sufficient number of qualified staff and the organization and allocation of work assigned to staff to ensure that work-related goals are achieved in a safe manner. They include, but may not be limited to, staffing levels and minimum staff complement, which are discussed in more detail in subsection 11.2(a).

Article 13 – Quality assurance

> Each Contracting Party shall take the appropriate steps to ensure that quality assurance programs are established and implemented with a view to providing confidence that specified requirements for all activities important to nuclear safety are satisfied throughout the life of a nuclear installation.

13 (a) General management system requirements

Safe and reliable operation requires a commitment and adherence to a set of management system principles and, consistent with those principles, the establishment and implementation of a planned and systematic pattern of actions that achieve the expected results.

The *Class I Nuclear Facilities Regulations* require each licence applicant to propose its management system for the following licensed activities:

- site preparation
- construction
- operation
- decommissioning

The CSA Group standard, N286-12, *Management system requirements for nuclear facilities*, is the management system requirement for all new licence applications and licence renewals for NPPs. N286-12 promotes the integration of management systems and requires that safety be the paramount consideration guiding decisions and actions. It follows and builds on the model provided in the IAEA general safety requirements document GSR Part 2, *Leadership and Management for Safety*. N286-12 applies to the top management with overall accountability for the facility, throughout its lifecycle including design, supply chain, construction, commissioning, operation and decommissioning and integrates the management system requirements for health, safety, environment, security, economics and quality. Management systems based on N286-12 include processes to define, plan and control the licensed activities by identifying relevant requirements to be met; establishing objectives that achieve the requirements; identifying and controlling risks; establishing plans, measures and targets; monitoring that results are achieved; and taking appropriate corrective measures if they are not. As part of the management system, these processes are subject to regular monitoring and reporting to assess effectiveness and identify opportunities for improvement.

N286-12 includes the following generic requirements for management systems:

- The management system is used to develop understanding and promote a safety culture.
- Requirements are identified, risks to objectives are identified and controlled, and results are monitored to ensure planned results are achieved.
- The organizational structure, authorities, accountabilities, responsibilities, and decision-making process are defined.
- Resources required to carry out the business plan with a focus on competent human resources, and the means to achieve this requirement, are identified.
- Processes exist to ensure effective communications and to make workers aware of the relevance and significance of their work.

- The management system is documented, information is provided to those who need it in a timely manner, and document control and records are managed.
- Work is planned, controlled and independently verified, including when conducted by third parties (i.e., contractors).
- Problems are identified, evaluated, documented, and resolved, and the effectiveness of the resolution confirmed.
- Required changes are identified, justified, reviewed, approved, implemented and assessed.
- Self-assessments and independent assessments are conducted.
- Experience gained within the industry and from other industries is reviewed for relevance and used to initiate improvement.
- Management continually improves the management system and periodically assesses its effectiveness to achieve planned results.

The CNSC expects licensees' management systems and performance to demonstrate adherence to these principles through the implementation of processes aligned with the generic requirements that apply to all their licensed activities.

During the reporting period the CSA Group published CSA N286.0.1:21, *Commentary on N286-12, Management system requirements for nuclear facilities*. It aids users that have a management system aligned with N286-12 or plan to implement a management system per the requirements of N286-12. It provides background information on certain clauses and requirements, based on experience collected since the standard was published.

In addition, CNSC REGDOC-2.1.1, *Management System* provides licensees and applicants with information on the CNSC SCA Management system, along with supplemental information on various current issues related to management systems. This includes information related to N286-12, and supporting information on:

- management systems that are applicable to different types of CNSC licensees
- specific topics that have been the subject of recent developments in management system standards, as well as those of recent regulatory interest with respect to management systems:
    - leadership, safety culture, supply chain (including counterfeit, fraudulent and suspect items (CFSIs) and contractor management), configuration management and software quality assurance
- radiation safety oversight related to nuclear substances, radiation devices and Class II nuclear facilities

13 (b) Requirements for contractors and suppliers

The management system requirements in N286-12 also applies to supplier(s) contracted by NPP licensees to perform the life-cycle activities of design, supply chain, construction, commissioning, operation, and decommissioning of the nuclear facility. Notably, it applies equally to engineering procurement and construction providers for refurbishment and new build projects and to other providers for routine operations at existing NPPs. However, the top management of the licensee of the nuclear facility remains accountable to ensure the requirements of the standard are met.

Sub-article 19(v) includes additional information on the necessary capabilities of licensee's technical staff in the context of supply chain management.

NPP licensees maintain effective supply chain management and procurement quality assurance programs that discover and mitigate the intrusion of CFSIs into their operations. To further improve the effectiveness of their programs, the licensees implemented a variety of enhancements to increase surveillance of suppliers and sub-suppliers quality programs and to enhance awareness and training of supply chain staff with respect to CFSIs. Requiring suppliers to follow the CSA Group standard N299, *Quality assurance program requirements for the supply of items and services for nuclear power plants* strengthens the licensee programs in this area. N299 is an update to the former Z299 series of standards into which requirements for measures to address CFSIs have been introduced. As an example, SNC-Lavalin Nuclear has implemented N299 as part of its overall corporate quality assurance program.

In 2019, OPG was notified by one of its vendors that a supplier of ingots, since 1995, had been falsifying chemical analysis results obtained from the top and bottom of the ingots when they did not meet customer specifications. A supplier performed material chemical analysis of the tubes extruded from those ingots and found them to meet the necessary specifications. These tubes were used in Pickering bleed condenser tubes and Darlington shutdown cooling heat exchangers. Since the material met code requirements, OPG did not need to formally approve the non-conformance reports nor obtain approval of the pressure boundary authority. OPG assessed the extent of condition and found 14 history dockets, since 1995, containing material that was produced and tested by the supplier. OPEX notifications were sent to COG and WANO.

Article 14 – Assessment and verification of safety

> Each Contracting Party shall take the appropriate steps to ensure that:
> (i) comprehensive and systematic safety assessments are carried out before the construction and commissioning of a nuclear installation and throughout its life. Such assessments shall be well documented, subsequently updated in the light of operating experience and significant new safety information, and reviewed under the authority of the regulatory body;
> (ii) verification by analysis, surveillance, testing and inspection is carried out to ensure that the physical state and the operation of a nuclear installation continue to be in accordance with its design, applicable national safety requirements, and operational limits and conditions.

14 (i) Assessment of safety

The CNSC and NPP licensees conduct or arrange various comprehensive safety assessments, including assessment of licence applications, periodic safety review (PSR), deterministic safety analysis, probabilistic safety assessment (PSA), third party assessments, and assessments of CANDU safety issues.

14 (i) (a) Assessment of licence applications

CNSC staff perform detailed assessments of safety in relation to NPP licence applications. Sub-article 7.2(ii) describes the general CNSC licensing process for both new-build projects and currently operating NPPs and provides specific information related to CNSC licences to prepare the site for, construct and operate an NPP. The CNSC's assessment of safety for a licence application is conducted against the application requirements set out in the *General Nuclear Safety and Control Regulations*, the *Class I Nuclear Facilities Regulations*, and other relevant regulations. The CNSC has also published licence application guides for NPPs to supplement the regulations. They are written in the context of the 14 CNSC SCAs as well as the other matters of regulatory interest described in appendix E.

For an application to renew a licence, CNSC staff rate the applicant's performance under each of the SCAs.[10] CNSC staff also review the applicant's operational plans and proposals for work to maintain and improve safety during the next licence period. For operating NPPs, this includes reviews of the PSR and integrated implementation plan (IIP) of improvements that the applicant has undertaken in support of the renewal application process.

CNSC staff use assessment plans, along with staff work instructions and comprehensive sets of technical assessment criteria to aid their assessments. The results of the assessment are presented to the Commission in support of CNSC staff's licensing recommendations during licensing hearings for NPPs. The results impact the content of the draft licence and LCH that CNSC staff present to the Commission for its consideration. See sub-article 7.2(ii) for more information on

[10] These ratings are, in fact, produced for all licensees and all SCAs on an annual basis, as described in appendix E.

the overall approach to licensing and details for licensing during the lifecycle phases of NPPs, which apply to both new-build projects and existing NPPs.

Global First Power submitted an application in 2019 for a licence to prepare a site for an SMR on AECL's property at Chalk River Laboratories. The CNSC's assessment of the application (and the required environmental assessment, as described in subsection 17(ii)(a)) is ongoing.

During the reporting period, OPG applied for a renewal of its licence to prepare a site for the DNNP. Although CNSC staff did not use CNSC regulatory document REGDOC-1.1.1, *Site Evaluation and Site Preparation for New Reactor Facilities*, when they reviewed the initial application, they did assess OPG's more recent application to renew the licence against the requirements and guidance in REGDOC-1.1.1. CNSC staff assessed as satisfactory the SCAs that were relevant to a licence to prepare a site for an NPP, as well as other matters of regulatory interest (e.g., Indigenous consultation, financial guarantees, and others). CNSC staff concluded that the site remained suitable for the proposed activity and that OPG remained qualified to carry on the activity (site preparation) and would make adequate provision for the protection of the environment, the health and safety of persons and the maintenance of national security and measures required to implement international obligations to which Canada has agreed. After reviewing the application and CNSC staff's recommendation, the Commission renewed the licence to prepare a site for 10 years.

During the reporting period, NB Power applied for a renewal of its licence to operate Point Lepreau, for a period of 25 years. CNSC staff's assessment of NB Power's renewal application confirmed that it met the requirements of CNSC regulatory document REGDOC-1.1.3, *Licence Application Guide: Licence to Operate a Nuclear Power Plant*.

As this was the first application for this length of licencing period, CNSC staff benchmarked with international regulators that regularly licence for long-term operations. CNSC staff also engaged in substantial Indigenous and public outreach prior to the licence renewal hearing, attending NB Power's Community Liaison Committee meeting, discussing the renewal application at regularly-held Indigenous engagement meetings, hosting two webinars and attending NB Power open houses where they presented information on the application.

CNSC staff assessed as satisfactory all the SCAs, as well as other matters of regulatory interest (e.g., Indigenous consultation, financial guarantees). They concluded that NB Power maintained adequate provisions to protect the public and workers throughout the current licensing period. CNSC staff noted that NB Power's PSR did not identify any major gaps between the current state of the NPP and modern requirements and confirmed that its IIP identified corrective actions and completion dates for closing the identified gaps, noting that the committed safety improvements would maintain Point Lepreau in a state comparable to that of a new NPP. CNSC staff also confirmed that NB Power's preliminary decommissioning plan met the regulatory requirements and that the associated financial guarantee made adequate funds available to cover the decommissioning costs outlined in the plan.

CNSC staff concluded that NB Power remained qualified to carry on the activity (NPP operation) and would make adequate provision for the protection of the environment, the health and safety of persons and the maintenance of national security and measures required to implement international obligations to which Canada has agreed. The results of the assessment were presented to the Commission during Part 1 of the licensing hearing for the renewal (January 26, 2021); Part 2 of the hearing will take place in the next reporting period (May 2022).

14 (i) (b) Periodic safety review

Per CNSC regulatory document REGDOC-2.3.3, *Periodic Safety Reviews*, the documentation to be submitted to the CNSC for a PSR includes:

- PSR basis document
- reports on the review of each safety factor (safety factor reports)
- global assessment report
- IIP

The IIP identifies corrective actions and safety improvements that address all gaps found in the PSR. REGDOC-2.3.3 requires the licensee to obtain CNSC staff acceptance for both the PSR basis document and the IIP. Additional direction on PSR is provided in CSA Group standard N290.18-17, *Periodic safety review for nuclear power plants*; it is cited as a guidance document in the LCHs of operating NPPs.

The following subsections describe the developments during the reporting period for PSRs applicable to each of the operating NPPs.

Bruce

Bruce Power conducted a PSR in support of the 2017 application for renewal of the licence to operate Bruce A and B for a period of 10 years. This period includes the major component replacement outages.

Bruce Power submitted the combined IIP for Bruce A and B (the designs are similar and they share common programs) in 2016. The IIP was approved through the licence renewal process in 2018. The operating licence includes a condition that requires Bruce Power to implement the IIP. The CNSC reviews Bruce Powers IIP reports annually and confirm that Bruce Power is making progress on all IIP items. As of December 2021, Bruce Power had completed 53 of 191 IIP items. At the end of the reporting period, CNSC staff were reviewing the 2021 IIP annual report.

Pickering

The most recent PSR for Pickering was an update on the review basis of the earlier OPG PSR work. Specifically, it consisted of:

- the Pickering B integrated safety review[11] (ISR), performed in support of potential refurbishment and continued operation (for another 30 years) of Pickering Units 5-8
- the ISR for Pickering units 1 and 4 performed prior to the Pickering A return to service, in support of approval to restart units 1 and 4
- The Darlington ISR, performed in support of refurbishment and continued operation (the programmatic parts were applicable to Pickering).

The Pickering IIP was approved through the licence renewal process in 2018. The review considered a ten-year licensing period. The operating licence includes a condition that requires OPG to implement the IIP. The PSR concluded that OPG had effective programs and processes for continued safe operation through 2024 (projected end of commercial operations). As part of the associated IIP, OPG committed to completing enhancements, which were subsequently

[11] Integrated safety review was the term used for the one-time application of PSR prior to major refurbishment work.

accepted by the CNSC. By June 2021, OPG had completed all the IIP actions to which it had committed as part of licence renewal; and CNSC staff had accepted them as closed.

In August 2019, Pickering evaluated its shutdown sequence and identified that extending commercial operation of Pickering Units 5-8 to December 2025 would allow Pickering to further optimize the shutdown and safe storage in a safe and effective manner. In support of extending commercial operation for Units 5-8, OPG will reassess the PSR to confirm that the design, condition and operation of Pickering supports an additional year of commercial operation.

Darlington

During the previous reporting period, OPG conducted an ISR in support of its application for renewal of the licence to operate Darlington. The IIP was approved through the licence renewal process in 2015. The operating licence includes a condition that requires OPG to implement the IIP. The refurbishment work began in October 2016 and will continue into the next reporting period. The current IIP consists of 625 items and as of December 2021, OPG had completed 431 IIP items and were progressing according to the schedule for each IIP item.

The licence to operate Darlington contains a separate condition requiring OPG to conduct its first PSR in support of its next licence renewal. Currently, the PSR project for Darlington licence renewal covering 2025 to 2035, is in progress, with the first two phases already complete: the CNSC has accepted OPG's PSR technical basis document and received the 15 safety factor reports. The third phase (global assessment report) is in progress and OPG plans to submit it to the CNSC before the end of 2022. The fourth phase is the development of the IIP based on the proposed enhancements resulting from the global assessment report. The IIP will provide the proposed timeline for the implementation of the safety enhancements. OPG plans to submit the IIP to the CNSC in September 2023.

Point Lepreau

During the reporting period, NB Power conducted an ISR in support of its refurbishment that concluded with Point Lepreau's return to operation in 2012. The current licence to operate Point Lepreau expires in 2022. NB Power completed and submitted a PSR, global assessment report and IIP in June of 2021 in support of the 2022 license renewal process.

14 (i) (c) Deterministic safety analysis

General requirements and approach

Deterministic safety analysis is a rigorous method to demonstrate that safety objectives for postulated accidents at NPPs are met. The set of requirements and siting criteria used to assess the acceptability of currently operating NPPs can be found in subsection 14(i)(c) of the seventh Canadian report. For new-build, CNSC REGDOC-2.5.2, *Design of Reactor Facilities: Nuclear Power Plants* stipulates the design requirements, including those typically demonstrated by deterministic safety analysis.

Requirements for the submission of deterministic safety analyses are found in the *Class I Nuclear Facilities Regulations*. Paragraph 5(f) requires an applicant for a construction licence to submit a preliminary safety analysis report. The regulations also specify supporting design information that must be submitted in an application for a licence to construct a Class I nuclear facility. This includes:

- a description of the proposed design of the nuclear facility, including the manner in which the physical and environmental characteristics of the site are taken into account in the design (paragraph 5(a))
- a description of the environmental baseline characteristics of the site and the surrounding area (paragraph 5(b))
- a description of the structures proposed to be built as part of the nuclear facility, including their design and their design characteristics (paragraph 5(d))
- a description of the systems and equipment proposed to be installed at the nuclear facility, including their design and their design operating conditions (paragraph 5(e))
- the proposed quality assurance program for the design of the nuclear facility (paragraph 5(g))

For new-build projects, REGDOC-2.5.2 stipulates that the preliminary safety analysis report shall assist in the establishment of the design-basis requirements for items important to safety and demonstrate whether the NPP design meets applicable requirements.

The *Class I Nuclear Facilities Regulations* also stipulate requirements for an application to operate a Class I nuclear facility. Per paragraphs 6(a) and 6(b), an application for a licence to operate shall contain descriptions of the systems, structures and equipment of the facility, including their design and design operating conditions. Paragraph 6(c) further requires the application to contain a final safety analysis report demonstrating the adequacy of the design of the facility. Details on the content of a typical safety analysis report for a currently operating NPP are provided in annex 14(i)(c).

REDGDOC-2.5.2 further states that the final safety analysis report shall:

- reflect the as-built NPP
- account for postulated aging effects on structures, systems and components (SSCs) important to safety
- demonstrate that the design can withstand and effectively respond to identified postulated initiating events
- demonstrate the effectiveness of the safety systems and safety support systems
- derive the operational limits and conditions for the plant, including:
    - operational limits and set points important to safety
    - allowable operating configurations, as well as constraints for operational procedures
- establish requirements for emergency response and accident management
- determine post-accident environmental conditions, including radiation fields and worker doses, to confirm that operators are able to carry out the actions credited in the analysis
- demonstrate that the design incorporates sufficient safety margins
- confirm that the dose limits and derived acceptance criteria are met for all anticipated operational occurrences and design-basis accidents
- demonstrate that all safety goals have been met

The licensees use integral mechanistic models in sophisticated computer codes to simulate accident progression and consequences. The tools and methodologies used in licensees’ safety analysis reports are supported by national and international experience and are validated against relevant test data and benchmark solutions. In addition to the quality assurance requirements specified in paragraph 5(g) of the *Class I Nuclear Facilities Regulations* noted above, the licensees follow CSA Group standard N286.7, *Quality assurance of analytical, scientific and design computer programs for nuclear power plants*, which is part of the licensing basis for all operating NPPs. The NPP licensees have established specific validation programs in accordance with N286.7 for industry standard tool (safety analysis) codes to provide the necessary confidence in the analytical results. During the reporting period, the industry extended the validation of these codes to align with expanded applications.

In accordance with CNSC REGDOC-3.1.1, *Reporting Requirements for Nuclear Power Plants*, the NPP licensees, within five years of the date of the last submission of their NPP description and final safety analysis report (or when requested by the CNSC), must submit an updated NPP description and an updated final safety analysis providing:

- a description of the changes made to the site and the NPP's SSCs, including any changes to the design and design operating conditions of the SSCs
- safety analyses that have been appropriately reviewed and revised and that take into account the most up-to-date and relevant information and methods, including the experience gained and lessons learned from the situations, events, problems or other information reported pursuant to REGDOC-3.1.1

Updates to safety analysis reports for existing NPPs are continuous – e.g., to include the effects of aging of the primary heat transport system (discussed below).

During the reporting period, CNSC staff reviews of the safety analysis reports confirmed that the safety margins for all operating NPPs remained acceptable.

In addition to the analysis of design-basis accidents, licensees perform analyses of design extension conditions accidents (a subset of beyond-design-basis accidents (BDBAs)), including severe accidents. In this context, a design extension conditions accident is a BDBA that is not included in the NPP design basis but for completeness is analyzed using best-estimate methods.

An example of a design extension conditions accident resulting in fuel damage but maintaining intact core geometry is a large-break loss of coolant accident (LBLOCA) coincident with a loss of emergency core cooling where the moderator serves as an ultimate heat sink. This event was formerly considered as a design-basis accident and its analysis continues to (typically) be included as part of safety reports. Other BDBAs, such as a prolonged station blackout, are analyzed using PSA, which is discussed in subsection 14(i)(d).

If the safety consequences of an event are significant (e.g., severe core and fuel damage and the potential to exceed the regulatory dose limits), it is referred to as a severe accident. NPP licensees are continuing to perform further deterministic analyses for representative severe core damage accidents. Such safety analysis has already been conducted to help decide on the scope of refurbishment activity for NPPs undergoing life extension. The licensees are also evaluating the existing models for BDBA analyses to specifically address multi-unit events.

Furthermore, NPP licensees use deterministic severe accident analyses to:

- develop computational aids, guidelines and procedures
- identify potential strategies for mitigating severe accident consequences
- assess instrumentation and equipment survivability and the habitability of facilities in severe accidents

- train staff and conduct validation exercises

Updating safety analysis requirements and methods

The key document related to safety analysis is CNSC REGDOC-2.4.1, *Deterministic Safety Analysis*. Aligned with the IAEA standards on safety analysis, it has modernized and improved operation of Canadian NPPs. REGDOC-2.4.1 identifies high-level regulatory requirements for an NPP licence applicant's preparation and presentation of deterministic safety analysis in the evaluation of event consequences. REGDOC-2.4.1 prescribes a systematic process for event identification and classification of the events into categories based on event frequency. It requires BDBAs to be addressed.

All future new-build projects will be expected to fully comply with REGDOC-2.4.1. Although it is recognized that the existing safety cases are not in question, Canadian NPP licensees are updating certain analyses through the implementation of REGDOC-2.4.1 – examples for each NPP licensee are provided in annex 14(i)(c). PSRs are used to assess the gaps between the requirements of REGDOC-2.4.1 and the existing safety reports and prioritize the safety report updates. The safety margins and degree of conservatism in the analyses will continue to be re-assessed in light of OPEX and new knowledge, for example in the area of aging management. To facilitate this work, a task team involving the CNSC and industry met during the reporting period to discuss challenges regarding the implementation of REGDOC-2.4.1.

To better coordinate safety report updates across the industry, the NPP licensees have established a safety analysis improvement program through COG; one of its purposes is to facilitate the implementation of REGDOC-2.4.1. Specific areas of focus for the program include assessing the impact of aging on the heat transport system and evaluating the conservatism of, and correcting inconsistencies in, the safety analyses. The activities undertaken as part of the safety analysis improvement program were chosen, in part, to address the CANDU safety issues described in subsection 14(i)(f). The program is being led by Bruce Power.

Fire safety assessment

Each NPP has a fire protection assessment (which involves a fire hazard assessment and fire safe shutdown analysis) that is issued and submitted to the CNSC in accordance with CSA Group standard N293-12, *Fire protection for nuclear power plants*, which is part of the licensing basis for all NPPs. Per their commitment to the CNSC, the licensees resolve any recommendations to enhance fire protection or corrective actions, following revisions of the fire protection assessments.

14 (i) (d) Probabilistic safety assessments

A PSA is a comprehensive and integrated assessment of the safety of an NPP that considers the probability, progression and consequences of equipment failures or transient conditions to derive numerical estimates that provide a consistent measure of safety. There are three levels of PSAs:

Level 1 identifies and quantifies the sequences of events that may lead to the loss of core structural integrity and massive fuel failures

Level 2 starts from the Level 1 results and analyzes the containment behaviour, evaluates the radionuclides released from the failed fuel and quantifies the releases to the environment

Level 3 starts from the Level 2 results and analyzes the distribution of radionuclides in the environment, evaluating the resulting effect on public health

The main objectives of the PSA are to:

- provide a systematic analysis that gives confidence that the design will comply with the fundamental safety objectives
- demonstrate that a balanced design has been achieved
- provide confidence that small changes of conditions that may lead to a catastrophic increase in the severity of consequences (i.e., cliff-edge effects) will be prevented
- assess the probabilities of occurrence for severe core damage states and the risks of major radioactive releases to the environment
- assess the probabilities of occurrence and the consequences of site-specific external hazards
- identify NPP vulnerabilities and systems for which design improvements or modifications to operational procedures could reduce the probabilities of severe accidents or mitigate their consequences
- assess the adequacy of emergency procedures
- provide insights into the severe accident management (SAM) program
- provide the basis for comparison of the severe core damage and large-release frequencies against the safety goals

Requirements for probabilistic safety assessment

CNSC REGDOC-2.4.2, *Probabilistic Safety Assessment (PSA) for Nuclear Power Plants*, sets out the requirements for the PSA s of operating NPPs. REGDOC-2.4.2 is also applied to the construction phase for new-build projects. REGDOC-2.4.2 refers to the IAEA safety series (SSG-3 and SSG-4) to provide general guidance on PSA methodology. One of the key requirements is CNSC acceptance of the methodology and the computer codes used for the PSA. In general, the methodologies developed by the licensees are based on the guidance available in documents issued by internationally recognized organizations such as the IAEA and the United States Nuclear Regulatory Commission, as well as good practices.

The PSA update interval in REGDOC-2.4.2 is five years – or sooner if major changes occur in the facility. The updates are subject to regulatory review. During this 5-year period, updates are also made to the external hazard analysis which takes into account effects of climate change.

The assessments of the probabilities of occurrences for severe core damage states, along with the assessments of the risks of major radioactive releases into the environment, are compared with safety goals. Quantitative safety goals for new NPPs are established in two CNSC regulatory documents:

- REGDOC-2.5.2, *Design of Reactor Facilities: Nuclear Power Plants*, which was written for water-cooled reactors
- RD-367, *Design of Small Reactor Facilities*, which is technology-neutral and written for research, isotope production, steam generation, electricity production or for other facilities containing a reactor with a power level less than approximately 200 megawatts thermal

The quantitative safety goals, which are consistent with those in International Nuclear Safety Group document INSAG-12, *Basic Safety Principles for Nuclear Power Plants*, are summarized in the table below

CNSC safety goals

Table 8: Quantitative safety goals

Safety goal	Rationale	Numerical objectives	
		REGDOC-2.5.2	RD-367
Core damage frequency	Related to accident prevention	The sum of frequencies of all event sequences that can lead to significant core degradation shall be less than 10^{-5} per reactor-year.	The sum of frequencies of all event sequences that can lead to significant core degradation shall be less than 10^{-5} per reactor year.
Small-release frequency	Release that would trigger evacuation	The sum of frequencies of all event sequences that can lead to a release to the environment of more than 10^{15} Bq of I-131 shall be less than 10^{-5} per reactor-year. A greater release may require temporary evacuation of the local population.	The sum of frequencies of all event sequences, whose release to the environment requires temporary evacuation of the local population, shall be less than 10^{-5} per reactor year.
Large-release frequency	Release that would trigger long-term relocation	The sum of frequencies of all event sequences that can lead to a release to the environment of more than 10^{14} Bq of Cesium-137 shall be less than 10^{-6} per reactor-year. A greater release may require long-term relocation of the local population.	The sum of frequencies of all event sequences, whose release to the environment requires long-term relocation of the local population, shall be less than 10^{-6} per reactor year.

The CNSC is revising REGDOC-2.5.2, with plans to combine content from both the existing version of REGDOC-2.5.2 and RD-367; the new version may include a revision of the quantitative safety goals for small-release frequency and large-release frequency, formulated to be generally applicable to a wider range of possible reactor technologies.

Although there are no explicit requirements for safety goals at the existing NPPs, the CNSC does expect the licensees of operating NPPs to establish safety goals that are aligned with international practices. Consistent with INSAG-12 and/or IAEA specific Safety Guide SSG-3, *Development and Application of Level 1 Probabilistic Safety Assessment for Nuclear Power Plants*, the NPP licensees have established and meet, the following safety goals for the existing NPPs:

- severe core damage frequency of less than 10^{-4} per reactor-year
- large-release frequency of less than 10^{-5} per reactor-year

Consistent with international practice, small-release frequency is not included in the safety goals of existing Canadian NPPs.

Development of probabilistic safety assessment and implementation of REGDOC-2.4.2

REGDOC-2.4.2 requires Level 1 and Level 2 PSAs to be conducted for facilities that include all potential, site-specific initiating events and potential hazards; that is:

- internal initiating events and internal hazards
- external hazards, both natural and human-induced, but non-malevolent

Consideration of potential combinations of hazards is also required, and the screening criteria of hazards shall be acceptable to the CNSC. These requirements include consideration of all sources of radioactivity (other than the reactor core such as the spent fuel pool (also called irradiated fuel bay). REGDOC-2.4.2 requires the inclusion of multi-units if applicable. A PSA is required for both the full-power and shutdown states of the NPP, as well as any state where the reactor is expected to operate for extended periods of time.

REGDOC-2.4.2 endorses a graded approach towards risk assessment of NPPs, where the level of analysis, the depth of documentation and the scope of actions necessary to comply with PSA requirements are commensurate with the relative risk and the characteristics of a facility or activity.

NPP licensees have completed Level l and Level 2 PSAs that address, among other things, re-evaluation of site-specific external initiating events. These include:

- Level 1 and 2 at-power internal events
- Level 1 outage internal events
- Level 1 and 2 internal flood events
- Level 1 and 2 fire events
- Level 1 and 2 seismic
- Level 1 and 2 high wind events

All licensees have completed full-scope PSAs by 2020 that are in full compliance with REGDOC-2.4.2 requirements. All licensees update their PSAs every five years or sooner if the facility undergoing major changes.

To address requirements for the irradiated fuel bay PSA, which may be dealt with through alternative methods to PSA (as allowed by REGDOC-2.4.2), guidance has been developed by industry.

Industry collaborated through COG in the development of a concept-level, whole-site PSA methodology, and the results of a pilot application for multi-unit PSA to Pickering were presented to the Commission during hearings in 2017 for the renewal of the licence to operate Pickering. The preliminary results illustrated the site level risk in terms of core damage frequency and large-release frequency and demonstrated that the Pickering site met the CNSC's requirements to prevent unreasonable risk to the environment and to the health and safety of persons. In addition, Bruce Power and OPG (Darlington) submitted aggregate risk values, which demonstrated that safety goals for SCDF and LRF were maintained. They also demonstrated adherence to the IAEA fundamental safety principle: Protect people and the environment from harmful effects of radiation. There have been no updates of the Pickering whole-site PSA during the current reporting period, as part of OPG's more recent PSA updates because the aggregated LRF submitted to the CNSC as part of the 2017 Pickering whole-site PSA remains valid and bounding.

Use of probabilistic safety assessment

Licensees are at various stages of utilizing the results from their PSAs. Typical applications, in addition to those listed in the bulleted list of main objectives at the start of section 14(i)(d), include the use of PSA results in conjunction with deterministic analytical results to refine programs for reliability and maintenance. For example, PSA results are used to support the identification of the systems important to safety for the reliability program (see section 19(iii)). Recent developments at NPPs indicate a growing use of PSAs for risk monitoring. All licensees have used the most recent revisions of the PSAs to develop computerized tools (e.g., for equipment out of service) for routine risk-monitoring for both outages and full-power operation. The licensees will continue to use the PSAs to enhance operational risk monitoring programs, optimize testing and maintenance programs and provide input to NPP design change and to decisions on refurbishment and safety improvement. For example, OPG investigated and implemented cost-effective measures to reduce the core damage frequency for existing NPPs as part of the overall operational plan until the end of life for Pickering.

The CNSC utilizes the results of PSAs to evaluate licensee performance, identify safety improvement opportunities, evaluate proposed plant changes or licensing basis changes, and inform licensees' compliance verification programs. To that end, CNSC staff initiated a risk handbook project to provide introductory PSA training for CNSC regulatory program officers and site inspectors and to summarize each operating NPP licensee's PSA results and important risk insights in a user-friendly, web-based application. The handbooks have interactive dashboards and tables, including search, sorting and filter capabilities. They also enable trending of systems and components important to safety using information from the licensees' annual risk and reliability reports. The handbook assists with CNSC inspection planning by helping inspectors to focus on multi-unit initiating events and/or accident precursors as well as using PSA importance measures to help with identifying systems and components with the highest unavailability significance.

Status of PSAs at each NPP

<u>Bruce A and Bruce B</u>

In 2019, Bruce Power completed the update of the PSAs for Bruce A and Bruce B to comply with REGDOC-2.4.2, addressing new regulatory requirements (such as multi-unit impact, other radioactive sources such as spent fuel pool, possible combination of external hazards, and other operational states) as part of the lessons learned from the Fukushima accident.

In addition, Bruce Power has developed a whole-site PSA methodology that is aligned with industry guidance and practice.

Bruce A and Bruce B PSA results and insights have been used for licensing renewal support, identification of systems important to safety for reliability program, risk configuration management (equipment out of service) for power operation and outage schedule planning, operational events ranking, and other activities.

Point Lepreau

NB Power had developed a full scope set of PSAs (including Level 1 and Level 2, for internal and external events, and for both full-power operation and shutdown states). The PSAs have been in compliance with REGDOC-2.4.2 since 2016 and include consideration of spent fuel pools and the potential combination of external hazards. The PSA results confirm that Point Lepreau met the safety goals for existing plants.

The updated PSA for Point Lepreau, along with updated PSA methodologies, was completed in the fall of 2021.

NB Power has used PSA results and insights to support licence renewal, identify systems important to safety for its reliability program, and support risk configuration management for at-power operation and outage schedule planning, and other activities.

Darlington

During the previous reporting period, OPG developed or updated a full scope set of PSAs (including Level 1 and Level 2, for internal and external events, and for both full-power and shutdown states) for Darlington to meet the requirements in CNSC regulatory standard S-294, *Probabilistic Safety Assessment (PSA) for Nuclear Power Plants*[12]. The PSA results showed that Darlington met the safety goals for existing plants.

In 2018, OPG revised the PSA methodologies for Darlington to comply with REGDOC-2.4.2. The Darlington PSA, which demonstrated compliance with REGDOC-2.4.2, was completed in 2020.

Darlington PSA results and insights have been used in licensing renewal support, identification of systems important to safety for reliability program, risk configuration management (EOOS) for power operation and outage schedule planning, refurbishment support, and other activities.

Pickering A (units 1 and 4) and Pickering B (units 5-8)

OPG developed/updated a full scope set of PSAs (including Level 1 and Level 2, for internal and external events, and for both full power and shutdown states) for both Pickering B (2017) and Pickering A (2018) to meet S-294. The PSA results showed that both Pickering B and Pickering A met the safety goals for existing plants.

In 2018, OPG revised the PSA methodologies for Pickering A and Pickering B to comply with REGDOC-2.4.2. The Pickering PSA, which demonstrated compliance with REGDOC-2.4.2, was completed in 2020.

Pickering PSA results and insights have been used in licensing renewal support, identification of systems important to safety for reliability program, risk configuration management (equipment out of service) for at-power operation and outage schedule planning, identification of safety improvement items for continuation of operation of Pickering NGS, among other activities.

[12] S-294 was superseded by REGDOC-2.4.2.

14 (i) (e) Reviews by the World Association of Nuclear Operators (WANO) and IAEA

The NPP licensees are members of WANO, which aims to help its members achieve the highest levels of operational safety and performance. WANO conducts periodic evaluations to promote excellence in the operation, maintenance and support of operating NPPs, with a focus on safety and reliability. These evaluations are not required by law or regulation but are requested on a voluntary basis by WANO members. Details of the WANO peer-review process are provided in the sixth Canadian report.

The following WANO peer reviews were conducted in Canada during the reporting period.

Bruce A and B (corporate)	October 2019
Bruce A	October to November 2021
Bruce B	June 2019
Darlington	October 2020
Pickering	October 2021
Point Lepreau	November 2019

The feedback, insights and learning from the WANO peer-review process are highly valuable. The process drives major improvements and helps to continually raise the standard of performance and practice across the industry. In support of general improvement, WANO shares good practices identified during reviews with all members.

The following WANO peer reviews are planned in Canada during the next reporting period:

Bruce A and B (corporate)	July 2022
Bruce A	October 2023
Bruce B	June 2022
Darlington	October 2022
Pickering	October 2023
Point Lepreau	October 2022

14 (i) (f) Assessment and resolution of CANDU safety issues

Comprehensive provisions for the assessment and verification of safety for Canadian NPPs have confirmed the ongoing safety of operating NPPs in Canada. These provisions have led to the identification and resolution of safety issues, some of which have been described in previous Canadian reports. Canada has a systematic approach to identify, prioritize and resolve safety issues to optimize the efforts for improving safety.

In 2009, the CNSC and the Canadian industry collaborated on a project to survey and rank generic safety issues related to CANDU NPPs and evaluate strategies for addressing them in a risk-informed manner. The CANDU safety issues (CSIs) were distributed into three broad categories according to the adequacy and effectiveness of the control measures implemented by the licensees to maintain safety margins.

- Category 1 represents issues that have been satisfactorily addressed in Canada.
- Category 2 represents issues that are a concern in Canada, but appropriate measures are in place to maintain safety margins.
- Category 3 issues are a concern in Canada and measures are in place to maintain safety margins, but the adequacy of these measures needs to be confirmed.

The continued operation of an NPP in the presence of these issues is judged to be permissible – none of the Category 3 issues involves a level of incremental risk that requires immediate corrective action. Issues with confirmed and immediate safety significance are addressed by other means on a priority basis, e.g., through enforcement.

A risk-informed decision-making process (as described in the sixth Canadian report) was applied to the Category 3 CSIs to identify, estimate and evaluate the risks associated with each issue and to recommend risk control measures. In accordance with defence-in-depth principles, the risk assessment covered all possible combinations of events that could potentially lead to fuel damage, adverse effects to people or the environment, or any combination thereof.

The CNSC maintains regulatory control of the resolution of the CSIs by monitoring the path forward, established through a mutual agreement with the NPP licensees. Many of the previously designated Category 3 CSIs had been re-categorized for some or all NPPs in previous reporting periods. During the reporting period, no new Category 3 CSIs were opened. Some of the other issues were downgraded from Category 3 to Category 2 for some (but not all) of the NPPs.

Category 3 CSIs have been logically separated into two groups – those relevant to LBLOCAs and those that are not (referred to as non-LBLOCA issues) – so that they may be effectively addressed.

For the non-LBLOCA issues, work during the reporting period focused on two CSIs (CSI numbers in parentheses):

- computer code and model validation (AA3)
- high-energy line breaks (IH6)

CNSC staff assessed the AA3 status update on the computer code and plant model validation program for all licensees and determined that the CNSC comments on the code validation and accuracy estimation guidelines were addressed and implemented in the revised versions of both guidelines. CNSC staff re-categorized CSI AA3 to Category 2 in 2020. CNSC staff noted that some progress on the code applicability assessment was made; however, more validation work is needed to continue to evaluate the effect of modeling uncertainties and code accuracies on the analysis of postulated accident scenarios.

The CSI related to high-energy line breaks (IH6) remains at Category-3 only for Pickering. During the reporting period, CNSC staff completed the review of OPG's submission of piping inspection results for Pickering. Based on OPG's follow-up clarifications to CNSC staff questions, CNSC staff were satisfied with OPG′s inspection results obtained from additional inspection points in the 3 non-nuclear high-energy lines inside the reactor building. CNSC staff will monitor OPG's implementation of these new inspection points, through compliance verification activities for OPG's periodic inspection program. Furthermore, CNSC staff continued to use its oversight of Pickering's integrated implementation plan to track OPG's completion of the conditions associated with the conditional re-categorization of this CSI from Category 3 to Category 2 for PNGS units 1 and 4. For Pickering units 5 to 8, the CSI had been re-categorized from Category 3 to Category 2 in 2018.

In terms of issues related to LBLOCA, work during the reporting period focused on three CSIs that remained at category 3:

- analysis for void reactivity coefficient (AA9)
- fuel behaviour in high-temperature transients (PF9)
- fuel behaviour in fuel pulse transients (PF10)

In 2019, CNSC staff accepted Bruce Power's analysis methodology and results demonstrating that the frequency of pipe breaks larger than the threshold break size (TBS) for Bruce reactors is in the frequency band associated with BDBAs. CNSC accepted Bruce Power's request for the re-categorization of the three LBLOCA CSIs (AA9, PF9 and PF10) from Category 3 to Category 2, given the demonstrated low likelihood of the large breaks. Subsequently, in January 2020, Bruce Power submitted a revised LBLOCA safety analysis using realistic conditions for breaks above the TBS and requested that CNSC staff reclassify breaks above the TBS as BDBA events. CNSC staff have determined that Bruce Power's submission established a generally acceptable approach for safety analysis of LBLOCA events above the TBS. In August 2020, CNSC staff accepted Bruce Power's request to reclassify breaks above the TBS from DBA to BDBA, given the demonstrated low likelihood of breaks above the TBS and the corresponding low risk. CNSC staff's review of Bruce Power's LBLOCA safety analysis is ongoing.

OPG has informed CNSC staff that it intends to use the same methods developed by Bruce Power in its next LBLOCA safety analysis submissions for their NPPs.

In addition to the above, the industry continues to develop the composite analytical approach (CAA) to address the LBLOCA CSI's. Through an industry-wide agreement, Bruce Power is taking the lead in the development and implementation of probabilistic analysis techniques for break frequency of large diameter heat transport piping. It continued to discuss the development and implementation of the methodology during the reporting period with CNSC staff.

More detailed descriptions of the remaining Category 3 issues and the required risk control measures are provided in recent publications of the CNSC annual *Regulatory Oversight Report for Nuclear Power Generating Sites*.

CNS Suggestion 7RM S-1 for Canada from the Seventh Review Meeting

Canada should address any CANDU safety issues that are Category 3 referenced in the 7th national report and provide a report to the 8th RM

By submitting this report, the planned activities for addressing suggestion 7RM S-1 are complete, although work will continue in the next reporting period toward re-categorization of the remaining Category 3 CSIs. Canada recommends this suggestion be closed, noting that Canada continually monitors known and emerging safety issues.

14 (i) (g) Fulfilling principle (2) of the VDNS

Principle (2) of the VDNS requires comprehensive and systematic safety assessments to be carried out periodically and regularly for existing installations throughout their lifetime to identify safety improvements that are oriented to meet the objective of principle (1) of the VDNS. As described in section E of chapter I, the objective in principle (1) is that new NPPs are designed, sited and constructed, consistent with the objective of preventing accidents in the commissioning and operation and, should an accident occur, mitigating possible releases of radionuclides causing long-term offsite contamination and avoiding early radioactive releases or radioactive releases large enough to require long-term protective measures and actions. Principle (2) of the VDNS also requires reasonably practicable or achievable safety improvements, in support of that objective, to be implemented in a timely manner.

Canada fulfills principle (2) through both global and specific assessments that are described in detail in this article. NPP licensees have completed PSRs that are based on regulatory documents. The PSR process includes IIPs to systematically execute safety improvements that address gaps found during the PSR. See subsection 14(i)(b) for a description of the most recent PSRs completed by each of the licensees. The IIPs have included significant safety upgrades when practicable – these have been completed during refurbishments, maintenance outages and other activities.

Other assessments and verifications (which are also conducted using updated regulatory documents and standards) include:

- updated safety analyses and safety analysis reports
- PSAs (and ongoing work to enhance them)
- surveillance, testing and inspection activities that confirm the NPPs meet the appropriate detailed design and safety requirements as well as operational limits and conditions
- rigorous aging management programs

These assessments and verifications, also described in this article, have led to safety improvements aligned with updated regulatory documents and standards.

14 (ii) Verification of safety

This subsection describes the activities to verify – by analysis, surveillance, testing or inspection – that an NPP meets the appropriate design and safety requirements as well as its operational limits and conditions. While these activities are carried out primarily by the licensee, the CNSC also conducts various verifications of safety (as described in other articles of this report). For example, the CNSC maintains permanent staff members at each NPP (see subsection 8.1(b)) who monitor operations, verify safety in certain circumstances and conduct a wide range of inspections with the assistance of specialists from CNSC headquarters in Ottawa.

CNSC staff members also review details in reports submitted by NPP licensees per CNSC REGDOC-3.1.1. These include event reports and quarterly/annual reports on matters such as safety performance indicators, fuel monitoring and inspection, pressure boundaries, radiation protection, environmental protection, and risk and reliability. The most safety-significant situations are pursued by reviews or focused inspections, which are often followed up through specific action items at individual NPPs. CNSC staff members also review the safety analysis reports and safety system reliability studies that are submitted per REGDOC-3.1.1.

Furthermore, CNSC staff verify that proposed operational changes will be within the licensing basis (e.g., by confirming that they would not significantly erode the margin of safety for the NPP that was agreed upon at the time of licensing).

CNSC licences to operate the existing NPPs contain conditions governing the licensee’s verification of safety through various fitness-for-service programs. The licensees’ programs include testing (subsection 14(ii)(a)) and various aging management programs to address specific critical systems and aging mechanisms (subsection 14(ii)(b)).

14 (ii) (a) Testing - General

CNSC REGDOC-2.6.1, *Reliability Programs for Nuclear Power Plants* includes general requirements for the reliability program for systems important to safety. REGDOC-2.6.1

addresses the roles of inspection, testing, modelling and monitoring in the identification of systems important to safety, their failure modes and their appropriate reliability targets, as well as confirmation that the targets are met (see sub-article 19(iii) for more information).

The NPP licensees execute periodic inspection programs for critical SSCs. The licensing bases for operating NPPs include standards with extensive requirements for testing and acceptance criteria, such as the following CSA Group standards:

- N285.4, *Periodic inspection of CANDU nuclear power plant components*
- N285.5, *Periodic inspection of CANDU nuclear power plant containment components*
- N285.7, *Periodic inspection of CANDU nuclear power plant balance of plant systems and components*
- N287.7, *In-service examination and testing requirements for concrete containment structures for CANDU nuclear power plants*

Portions of N285.7 were developed using the methodologies and definitions for risk-informed, in-service inspection from publications of the Electric Power Research Institute (EPRI) and the American Society of Mechanical Engineers (ASME).

Thousands of safety-related tests are conducted annually at each NPP. These tests typically have a pass rate on the order of 99.9%.

14 (ii) (b) Aging management

All NPPs experience material degradation. Their SSCs are subjected to a variety of chemical, mechanical and physical influences during operation. In time, stressors such as corrosion, load variations, flow conditions, temperature and neutron irradiation cause degradation of materials and equipment. This time-dependent degradation is referred to as aging. Aging management is the set of engineering, operational, inspection and maintenance actions that control, within acceptable limits, the effects of physical aging and obsolescence on the SSCs.

Experience with several significant material degradation mechanisms during the life of currently operating NPPs in Canada has led to the development, formalization and documentation of a number of aging management programs. These programs provide for materials and component inspection and assessment techniques and intervals to ensure that all safety-significant SSCs are maintained within the safe operating limits allowed by the applicable codes and standards. Aging management programs are based on comprehensive methodologies involving surveillance, the production and monitoring of system health reports, inspections by qualified inspection personnel and preventive maintenance. They are regularly reviewed and updated, as required, to incorporate and allow for new information and findings. CNSC staff members regularly review the results of activities covered by the aging management programs.

The requirements and guidance in CNSC REGDOC-2.6.3, *Aging Management* emphasize the need for early and proactive consideration of aging management for all stages of an NPP's lifecycle: design, fabrication, construction, commissioning, operation, life extension, and decommissioning. It also provides requirements for the establishment, implementation and improvement of integrated aging management programs, through the application of a systematic and integrated approach. The approach includes organizational arrangements, data management, SSC selection, aging evaluation and condition-assessment processes, documentation and interfaces with other supporting program areas (such as the review and improvement of the program).

The main areas of focus under aging management include feeder pipes, fuel channels, flow-accelerated corrosion, steam generators, containment and general component replacement. The basic aging management programs for these areas are described in annex 14(ii)(b). The fuel channel lifecycle management project is particularly important in that its results help confirm the safety of ongoing operation of the existing NPPs as they approach their anticipated end of life, since the pressure tubes in the fuel channels are typically the major life-limiting component in the CANDU design. To support long-term operation, the CNSC has used licence renewal to update requirements related to monitoring, inspection and reporting related to the fitness for service of pressure tubes.

The original assumed pressure tube design life was based on 30 years of operation at 80% capacity factor (which corresponds to 210,000 equivalent full power hours (EFPH) per reactor from the date of first criticality). As the reactors began approaching their operational target, licensees were able to demonstrate that the pressure tubes were not approaching the dimensional or material property design limits. This was the basis for extending the operating lives of the reactors beyond 210,000 EFPH. It was determined that pressure tube design life depends more on factors such as fracture toughness than on EFPH. Extending the operation of pressure tubes does not compromise safety as long as the limits of the material properties are not exceeded.

Through a joint fuel channel lifecycle management program that entails R&D activities in several key areas of fuel channel material degradation, industry developed refined engineering methodologies and models for predicting material properties over the full operational life of the fuel channel components (specifically, pressure tubes and annulus spacers that are made of Inconel X-750). NPP licensees routinely apply these methodologies and models to demonstrate the continued fitness for service of components operated beyond 210,000 EFPH and some have already been incorporated into CSA Group standard N285.8, *Technical requirements for in-service evaluation of zirconium alloy pressure tubes in CANDU reactors.* Additionally, utilities updated their fuel channel life cycle management programs (which include routine inspection and maintenance activities as well as examinations and destructive tests on components that have been removed from the reactor) to ensure continued validation of the engineering assessments that are routinely performed to assess fitness for service. This work has supported the demonstration of safe operation of fuel channels beyond the assumed design life of 210,000 EFPH.

The CNSC exercises regulatory control of the operation of reactors with older pressures tubes by identifying specific limits on operation. The limits are unique to each facility and depend, in part, on the information available at the time of licence renewal. The NPPs are currently authorised to operate up to the following pressure tube service limits.

Table 9: Effective full-power hour limits for pressure tunes at Canadian NPPs

NPP	EFPH limit
Bruce A and B	300,000
Darlington	235,000
Pickering Units 1, 4	247,000
Pickering Units 5-8	295,000
Point Lepreau	210,000 *

* Point Lepreau is not predicted to exceed the assumed design life of the pressure tubes during its current licence period.

The lifecycle management process (planning and completing inspection activities, confirming results are consistent with predictive models, and adjusting the monitoring and updating models, where required) was applied in addressing the recent industry measurements of elevated hydrogen equivalent concentrations in the outlet pressure tube region (as described in appendix C). These findings resulted in adjustments to sampling programs of equivalent hydrogen for in-service and removed tubes, as well as additional inspections in the region to demonstrate continued fitness for service. Industry work is in progress to reflect the measurements in the respective predictive models.

Article 15 – Radiation protection

Each Contracting Party shall take the appropriate steps to ensure that in all operational states the radiation exposure to the workers and the public caused by a nuclear installation shall be kept as low as reasonably achievable and that no individual shall be exposed to radiation doses which exceed prescribed national dose limits.

Introduction and changes to requirements

A significant portion of Canada's R&D in the field of nuclear safety (see appendix D) addresses the areas of radiation protection, radiation monitoring, environmental protection, environmental management and other related topics.

In Canada, high-level requirements related to controlling radiation exposure of nuclear energy workers[13] (NEWs) and members of the public are found in the *General Nuclear Safety and Control Regulations*. In particular, paragraph 12(1)(c) of the *General Nuclear Safety and Control Regulations* requires every licensee to take all reasonable precautions to protect the environment, and the health and safety of persons, and to maintain the security of nuclear facilities and of nuclear substances. Key requirements are also found in the *Radiation Protection Regulations* (RPR). The current RPR are informed by the International Commission on Radiological Protection (ICRP) Publication 103 (2007) and the IAEA's GSR Part 3, *Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards* (2014).

IRRS Recommendation R3

"CNSC should ensure that the radiation protection requirements are consistent with the requirements of General Safety Requirements (GSR) Part 3"

As identified in the seventh and eighth Canadian reports, the project to modernize the RPR was initiated in 2013 through the publication of a discussion paper seeking stakeholder feedback. The proposals to amend the RPR took into consideration the updates to international recommendations, as well as areas of improvement identified through operational issues and lessons learned from implementing the RPR. The CNSC solicited feedback from stakeholders and members of the public on the amendment proposals. As a result of the discussion paper review, as well as focused consultation with interested parties, the RPR were initially amended in 2017, as described in the eighth Canadian report. During the current reporting period, further amendments to the RPR were published in November 2020 with additional transitional provisions coming into force in January 2021. Some of the key amendments to the RPR made during the reporting period include:

- enhancements of the requirements for licensees to provide information to a NEW regarding:

[13] A NEW is a person who is required, in the course of the person's business or occupation in connection with a nuclear substance or nuclear facility, to perform duties in such circumstances that there is a reasonable probability that the person may receive a dose of radiation that is greater than the prescribed limit for the general public.

    - the worker’s responsibilities and associated risks during the control of an emergency
    - the risks to breastfed infants from intakes of nuclear substances
    - the importance of a pregnant NEW informing the licensee when they are pregnant or breastfeeding
- removal of the requirement for a NEW to disclose her pregnancy to the licensee
- a new requirement for a licensee to use a licensed dosimetry service to ascertain equivalent dose to the skin or to the hands and feet for a NEW who may receive > 50 mSv in a one-year dosimetry period
- a revision to the equivalent dose limit for the lens of an eye for a NEW from 150 mSv to 50 mSv in a one-year dosimetry period
- the addition of a specific record retention period for dose records
- a new requirement for licensees to ensure that radiation detection and measurement instrumentation is selected, tested, and calibrated for its intended use

To support licensees in the implementation of the amended RPR, during the reporting period the CNSC published three new regulatory documents:

- REGDOC-2.7.1, *Radiation Protection*
- REGDOC-2.7.2, *Dosimetry, Volume I: Ascertaining Occupational Dose*
- REGDOC-2.7.2, *Dosimetry, Volume II: Technical and Management System Requirements for Dosimetry Services*

These new regulatory documents supersede existing regulatory guides and standards, providing new and updated guidance for radiation protection and dosimetry that is aligned with the revised RPR.

To verify compliance with licence conditions and regulations, CNSC staff review documentation and operational reports submitted by applicants and licensees and, through technical assessments and compliance activities, evaluate the implementation of licensees’ radiation protection and environmental protection programs. CNSC staff also monitor and evaluate the radiological and environmental impacts of licensed activities, verify compliance of licensed dosimetry services and review information on occupational exposures from the National Dose Registry (NDR).

Events related to potential and actual exposure to radiation or hazardous substances and releases to the environment of nuclear and hazardous substances (e.g., reaching an action level for radiation protection or environmental protection, see below) are reported to the CNSC in accordance with CNSC REGDOC-3.1.1, *Reporting Requirements for Nuclear Power Plants*. CNSC staff members review the event reports and the reporting, analysis, and corrective processes of licensees, to verify their compliance with regulatory requirements and their effectiveness in correcting weaknesses. CNSC staff members also investigate significant events related to radiation protection, if needed.

Paragraph 3(1)(f) of the *General Nuclear Safety and Control Regulations* requires that an application for a CNSC licence contain any proposed action levels. An action level is defined in subsection 6(1) of the RPR as a specific dose of radiation or other parameter that, if reached, may indicate a loss of control of part of a licensee’s radiation protection program and triggers a requirement for specific action to be taken. When an action level, whether for radiation protection or environmental protection, is reached, the licensee must notify the CNSC, conduct an investigation to establish the cause for reaching the action level and take action if needed to restore the effectiveness of the radiation or environmental protection program.

15 (a) Radiation protection for workers and application of the ALARA principle

General requirements and activities for radiation protection of workers

In addition to the requirements in the *General Nuclear Safety and Control Regulations* mentioned above, paragraph 12(1)(e) requires all persons at the site of a licensed activity to use equipment, devices, clothing and procedures in accordance with the NSCA, the regulations and the licence.

Paragraph 4(a) of the RPR requires that every licensee implement a radiation protection program and, as part of that program, keep the amount of exposure to radon progeny and the effective dose and equivalent dose received by and committed to persons as low as is reasonably achievable (ALARA), social and economic factors being taken into account, and below CNSC regulatory dose limits.

Section 13 of the RPR requires that every licensee ensure the following effective dose limits are not exceeded:

- 50 mSv in a one-year dosimetry period and 100 mSv over a five-year dosimetry period for a NEW
- 4 mSv for the balance of the pregnancy for a pregnant NEW
- 1 mSv per calendar year for a person who is not a NEW

Section 14 of the RPR prescribes the following equivalent dose limits:

- 50 mSv to the lens of an eye in a one-year dosimetry period for a NEW
- 15 mSv to the lens of an eye in a one calendar year period for any other person
- 500 mSv to the skin in a one-year dosimetry period for a NEW
- 50 mSv to the skin in a one calendar year period for any other person
- 500 mSv to the hands and feet in a one-year dosimetry period for a NEW
- 50 mSv to the hands and feet in a one calendar year period for any other person

Annex 15(a) provides additional information on the RPR, dosimetry requirements, and guidance related to the ALARA principle and the setting of radiation protection action levels.

To fulfill the related regulatory requirements, NPP licensees establish, maintain and document radiation protection programs to effectively manage and control radiological risk to workers, as well as the public. An objective of these programs is to ensure that licensees implement processes to ensure workers’ radiological exposures are kept ALARA, through:

- management control over work practices
- personnel qualification and training
- control of occupational and public exposure to radiation
- planning for unusual situations

Examples of three specific licensee strategies to minimize the dose to workers are described below.

Increased use of technology

The effective use of technology is a key component of the ALARA program. Some licensees have installed remote monitoring equipment to improve radioactive work planning and reduce doses to workers. Remote monitoring and the use of robotics for radiological hazards have reduced doses by not requiring staff to enter certain areas to perform routine radiation surveys and have enabled workers to select protective equipment appropriate to the current and anticipated hazard conditions, as well as respond to changing conditions. Some licensees have used robotics to inspect and remove hot spots of elevated contamination, thereby minimizing doses to workers. In the future, there will be more focus on the use of robotics for inspections and maintenance in high radiation dose fields. Remotely-operated cameras have been used to perform visual inspections and monitoring of inaccessible areas. Radiography services at NPPs are implementing pulsed x-ray technology instead of gamma sources to reduce the dose that workers would normally receive from handling the sources. One licensee has designed and implemented a new reactor inspection/maintenance tool to reduce worker time in high dose rate areas.

Source term control measures

Measures are in place to reduce doses to workers from exposure to various hazards. The measures include more frequent replacement of desiccant in dryer units and improvement of the material condition of dryer systems; some licensees also de-tritiate their heavy-water inventory. Several licensees have implemented shielding canopies and reactor-face shielding tiles to reduce gamma dose to workers. Licensees are also working to reduce the recurrence of hot spots through initiatives involving either reduction of the filter pore size or an increase in the flow rate of the heat transport purification system. Filter pore size reduction is being addressed through new technology such as new-generation nano-fibre media and cobalt-60 scavenging resins to improve efficiency at removing colloidal matter from the primary heat transport system. Finally, by applying OPEX, all licensees have enhanced their contamination control programs to better manage and control risks from alpha hazards. Bruce Power is planning chemical decontamination of reactor systems to reduce source terms for upcoming major component replacement outages.

Training

Training is essential to keeping doses ALARA. Some licensees provide mock-up training for jobs with elevated radiological risk. In preparation for refurbishment, full-scale mock-ups for tool testing and worker familiarization have been or are in the process of being built. The use of mock-ups enables optimization of procedures that reduce time spent in the radiation field. One licensee has actively pursued the use of dynamic learning activities, wherein an activity or task being taught includes, as much as possible, the actual conditions encountered and tools required; real-world situations are simulated and the activity is enhanced with role playing by other participants. To further limit tritium exposure, some licensees reinforce the need to plug in plastic suits at every opportunity to refill them with fresh air (thereby limiting unplugged periods to less than 60 seconds). Furthermore, mock-ups have also been used to give NEWs experience with a number of different respiratory protective equipment configurations, such as air-supplied plastic suits or negative pressure particulate respirators to acclimatize workers prior to performing the task in a radiation field.

Each year, licensees establish challenging radiation dose performance targets based upon the planned activities and outages for the year. They are analogous to the constraints recommended in the IAEA Safety Guide GSG-7, *Occupational Radiation Protection*. CNSC staff members verify that the NPP licensees monitor their performance against internal radiation dose performance targets and that this information is used to improve radiation protection performance.

IRRS Recommendation R2
"The CNSC should establish or approve dose constraints for all Class I type facilities"

This finding was identified by the CNSC through its self-assessment carried out prior to the peer review mission. The CNSC imposes dose limits for public exposure for all facility types and requires the application of BATEA (best available technologies economically achievable) to be demonstrated as part of a licence application. The CNSC has previously identified inconsistent application of dose constraints for derived release limits for Class I facilities. This is being addressed in draft REGDOC-2.9.2, *Controlling Releases to the Environment*, which will address the role of dose constraints in optimization and in support of the process for authorization of discharges. The public consultation of REGDOC-2.9.2 will take place in 2020 with the Commission approval being contemplated for 2021

Doses to workers

Health Canada maintains the NDR, which is Canada's national repository for dose records of workers who are monitored for occupational exposure to ionizing radiation. The NDR supports Health Canada and Canadian regulatory authorities in their mandates to protect the health and safety of Canadians exposed to ionizing radiation in the workplace. The NDR provides dose histories to individual workers and organizations for work planning and for compensation and litigation cases, and assists in regulatory control by notifying regulatory authorities of overexposures within their jurisdiction. The NDR has records for over half a million workers, including well over 100,000 workers who are currently monitored; it contains monitoring records back to the 1940's.

Doses to workers were below regulatory limits during the reporting period (see annex 15(a)). During the reporting period, the total collective dose at Canadian NPPs varied due to factors such as:

- the dose rates associated with the type of work being performed
- the number of outages each year
- the scope and duration of outage work
- the number of people involved in outage work

15 (b) Environmental protection

Requirements for protection of the environment

In Canada, the NSCA and its regulations include environmental protection provisions. For example, the purpose of the NSCA (paragraph 3), is to provide for the limitation, to a reasonable level of the risks to safety of persons and the environment that are associated with the development, production and use of nuclear energy. The *General Nuclear Safety and Control Regulations* provide additional details on requirements for environmental protection. Paragraph 12(1)(c) of the *General Nuclear Safety and Control Regulations* includes a requirement for every licensee to take all reasonable precautions to protect, among others, the health and safety of persons and the environment. Paragraph 12(1)(f) requires every licensee to take all reasonable precautions to control the release of radioactive nuclear substances or hazardous substances within the site of the licensed activity and into the environment as a result of the licensed activity.

The general and specific requirements during operations of NPPs related to protecting people and the environment are found in the *Class I Nuclear Facilities Regulations*. These regulations provide general requirements, as well as requirements for each stage of the lifecycle of an NPP (site preparation, construction, operation and decommissioning). The general environmental protection requirements for NPPs in the *Class I Nuclear Facilities Regulations* are as follows:

- Paragraphs 3 (g), (h), and (k) require licence applicants to submit their proposed environmental protection policies and procedures, effluent and environmental monitoring programs, as well as the proposed plan for the decommissioning of the NPP.
- Paragraph 3 (j) requires licence applicants to submit their program to inform persons living in the vicinity of the site of the general nature and characteristics of the anticipated effects on the environment, and the health and safety of persons that may result from the activity to be licensed at all stages of its life cycle.

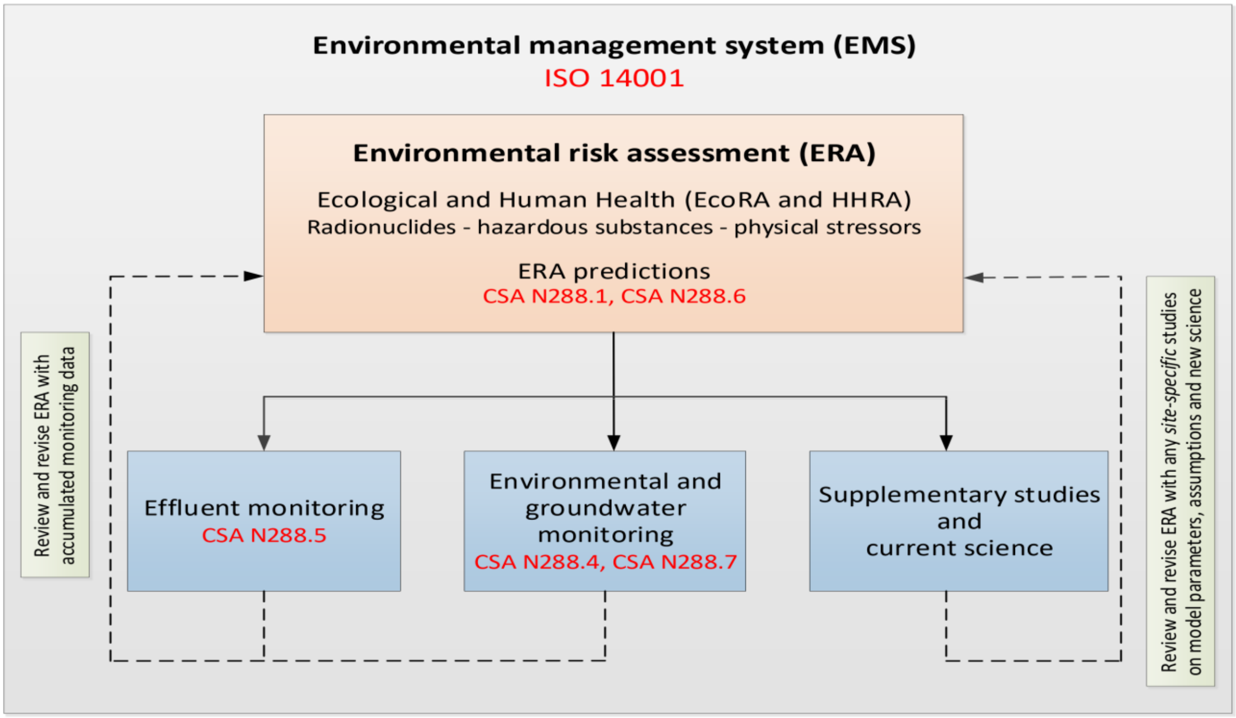
Using operations as an example of a lifecycle stage, the specific requirements of the *Class I Nuclear Facilities Regulations* for NPP licensees are that an application to operate a Class I nuclear facility shall describe:

- Paragraph 6 (h): the effects on the environment and the health and safety of persons that may result from the operation and decommissioning of the nuclear facility, and the measures that will be taken to prevent or mitigate those effect
- Paragraph 6 (i): the proposed location of points of release, the proposed maximum quantities and concentrations, and the anticipated volume and flow rate of releases of nuclear substances and hazardous substances into the environment, including their physical, chemical and radiological characteristics
- Paragraph 6 (j): the proposed measures to control releases of nuclear substances and hazardous substances into the environment
- Paragraph 6 (k): the proposed measures to prevent or mitigate the effects of accidental releases of nuclear substances and hazardous substances on the environment, the health and safety of persons and the maintenance of national security

The licensees of operating NPPs have implemented CNSC REGDOC-2.9.1, *Environmental Protection: Environmental Principles, Assessments and Protection Measures*, version 1.1. The requirements and guidance in this document are consistent with modern national and international practices; address issues and elements that control and enhance nuclear safety; and establish a modern, risk-informed approach to environmental protection.

The general regulatory framework for environmental protection, as described in REGDOC-2.9.1, is reproduced in figure 15(b). Note that environmental assessment (EA), as identified in the figure, corresponds to the more recently established practice of impact assessment (IA), which is described in subsection 17(ii)(a).

Figure 15(b) Ensuring adequate provision for the protection of the environment



REGDOC-2.9.1 requires NPP licensees to establish an environmental management system that includes environmental risk assessments (ERAs) as well as the monitoring programs (e.g., effluent, emissions, environmental and groundwater) used to verify the ERA predictions. Supplementary studies may also be required to assess, for example, the impacts of thermal effluent on sensitive fish species. The environmental management systems have programs to control and monitor the effect of operations on people and the environment. These programs include an objective to maintain a low level of public risk to human health and the environment (both nuclear and hazardous) compared to other normal public risks that arise from industrial activity. In addition to ERA and monitoring, typical elements include management of releases and waste, worker training and informing the public.

The sections below discuss in more details the ERA and the effluent, emission and environmental monitoring programs.

CNSC staff review the information collected by the monitoring programs on an annual basis to verify that ERA predictions have been met.

The CNSC also conducts environmental protection reviews (EPRs) for all nuclear facilities with potential project-environmental interactions, in accordance with its mandate under the NSCA to prevent unreasonable risk to the environment and the health of persons. EPRs are science-based environmental technical assessments that are conducted by CNSC staff and documented in stand-alone EPR reports, or reported directly in Commission Member Documents (CMDs). EPR reports focus on items that are of Indigenous, public and regulatory interest, such as potential environmental releases from normal operations, as well as risk of radiological and hazardous substances to the receiving environment, valued components and species at risk. The information provided in the EPR reports summarizes CNSC staff’s findings that may inform and support staff recommendations for the future licensing and regulatory decisions, as well as inform the public.

For each NPP, the CNSC confirms that NPP operators have made adequate provision for the protection of the environment by keeping releases of radiological substances to the environment ALARA, social and economic factors being taken into account and by applying the best available technology and techniques economically achievable (BATEA) for hazardous substances where appropriate.

Although the authorization to operate an NPP is based on these ERA predictions, in 2021, CNSC staff started a new approach to publishing EPR reports on a regular cycle, linked with the licensee's 5-year ERA cycle, and separate from a specific licensing decision. EPR reports are published on the CNSC's website and on Canada's "Open Government" platform.

Environmental risk assessment

NPP licensees use ERAs to predict radiological and hazardous risks to the environment as well as physical stressor effects (e.g., impingement and entrainment of fish) after ALARA and BATEA mitigation measures, as appropriate, are implemented to prevent or reduce environmental effects.

An ERA is a systematic process that identifies, quantifies and characterizes the risk posed by contaminants (nuclear or hazardous substances) and physical stressors in the environment. It provides science-based information to support decision-making and to prioritize the implementation of mitigation measures. Canadian NPP licensees are required to follow CSA Group standard N288.6-12, *Environmental risk assessment at Class I nuclear facilities and uranium mines and mills*. The ERA identifies specific characteristics and site-specific environmental characteristics, identifies interactions between those characteristics and assesses the risk to the environment and the public. In particular, the ERA uses the NPP-specific estimates of physical stressors (e.g. impingement and entrainment of fish and shellfish) and releases (radiological and hazardous substances or thermal releases) to predict the:

- source terms of releases
- transport of radiological and hazardous substances through environmental pathways (e.g. atmosphere, surface water)
- subsequent public exposure and dose, exposure and effects on representative biota, and changes in habitat and effects on species that rely on that habitat.

The ERA is updated on a five-year basis, or sooner should there be major facility changes, with the data collected from the effluent and environmental monitoring programs, special studies, and new science. In the event that ERA predictions are not met, adaptive management measures (e.g., mitigation or off-setting) can be implemented, if necessary.

Effluent and emission monitoring

Important measures in the environmental management system that support the monitoring programs include the establishment of environmental release limits and action levels. Although radioactive material released into the environment through gaseous emissions and liquid effluents from NPPs can result in radiation doses to members of the public through environmental exposure pathways, the doses received by the public from routine releases from NPPs are too low to measure directly. Therefore, to ensure that the public dose limit is not exceeded, the CNSC restricts the amount of radioactive material that licensees may release. These gaseous and effluent limits are derived from the public annual dose limit of 1 mSv, and are called derived release limits (DRLs). A DRL for a given radionuclide/radionuclide group is a specific release limit for a route of release (exposure pathway) from an NPP. If the total of the measured releases for each gaseous emission or waterborne effluent, expressed as percentages of their respective DRLs, exceeds 100%, members of the public with the greatest exposure may exceed the public dose limit over the calendar year. The phrase "members of the public with the greatest exposure" refers to individuals who receive the highest doses from a particular source due to factors such as proximity to the release, dietary and behavioural habits, age and metabolism, and variations in the environment.

The calculation of DRLs is based on methodology in the CSA Group standard N288.1, *Guidelines for modelling radionuclide environmental transport, fate, and exposure associated with the normal operation of nuclear facilities*. DRLs are also based on other developments in radiation protection (e.g., ICRP dose conversion factors). DRLs are unique to each facility and depend on several factors (for example, assumptions, representative person characteristics, site-specific data). The calculation of DRLs can vary from simple to exceedingly complex. As a result, DRLs are reviewed and, if necessary, updated approximately every five years. Note that the assessment of health risk to members of the public in ERAs utilizes the same methodology as the DRL calculations, except that public dose is estimated from measured effluent and emission monitoring data for specific routes of release.

For environmental protection, licensees set environmental action levels well below the DRLs. When exceeded, these action levels provide a warning, of a possible loss of control in the emissions management systems and allow for prompt corrective action. This enables licensees to keep liquid effluent and gaseous emission releases well below their respective DRLs.

All NPPs release small quantities of radioactive materials, in a controlled manner, into both the atmosphere (as gaseous emissions) and adjoining water bodies (as liquid effluents). NPP licensees monitor airborne emissions for tritium, iodine, noble gases, carbon-14 and particulates, as well as waterborne tritium, carbon-14 and gross beta-gamma radioactivity. The CNSC publishes data on these releases, along with the corresponding DRLs on the Open Government Portal. During the reporting period, releases from Canadian NPPs were less than 1% of the DRLs. From 2016 to 2018, there was only one reported case of an environmental action level being exceeded.[14]

The licensees' effluent monitoring programs are based onis based on requirements are based on the licence, that requires compliance with the CSA group standards N288.5, *Effluent monitoring programs at Class I nuclear facilities and uranium mines and mills,* N288.1, *Guidelines for modelling radionuclide environmental transport, fate, and exposure associated with the normal operation of nuclear facilities* and REGDOC-2.9.1, *Environmental Principles, Assessments and Protection Measures, Version 1.2.*

Environmental Monitoring

In addition to tracking radiological emissions and effluents from the NPP, licensees have radiological environmental monitoring programs to monitor radioactivity and other interactions with the environment around the facilities. These programs specifically monitor the air, water and food chain products. The environmental monitoring programs aim to:

[14] In early 2022, Bruce Power reported an exceedance of an environmental action level for iodine 131 (which had recently been significantly lowered) due to a failed fuel discharge from unit 1.

- assess the level of risk on human health and safety, and the potential biological effects in the environment of the contaminants and physical stressors of concern arising from the facility
- demonstrate compliance with the predictions made by the ERA on the concentration and/or intensity of contaminants and physical stressors in the environment or their effect on the environment
- check(independently of effluent monitoring), and provide public assurance of, the effectiveness of containment and effluent control
- refine models used in the ERA, or reduce the uncertainty in the predictions made by the ERA

The licensee environmental monitoring programs are based on the requirements of CSA Group standards N288.4-10 *Environmental monitoring programs at Class I nuclear facilities and uranium mines and mills*, and may also be informed by N288.7, *Groundwater protection at Class I nuclear facilities and uranium mines and mills* and N288.9-18, *Guideline for design of fish impingement and entrainment programs at nuclear facilities*. The results from these monitoring programs are used to confirm that the public legal limit in Canada for effective dose from the operation of NPPs is not exceeded and that the environment is protected based on the ERA predictions used to authorize the activity.

CNSC independent environmental monitoring program

The CNSC's independent environmental monitoring program (IEMP) complements CNSC staff reviews of elements of licensees' environmental management systems and confirms that licensees are adhering to the regulatory requirements, licence conditions and approved programs throughout the operation of nuclear facilities. The IEMP is performed by CNSC staff in public areas and consists of sampling environmental media and analyzing radiological and non-radiological substances released from facilities in all areas of the nuclear fuel cycle: uranium mines and mills, processing facilities, NPPs, research reactors and waste management facilities.

Samples are analyzed at the CNSC's state-of-the art laboratory using industry best practices. Samples are analyzed for radiological and non-radiological contaminants related to the activities of the nuclear facility. Samples may be taken for air, water, soil, sediment, vegetation (e.g., grass) and foodstuffs (e.g., meat, fish, milk and produce). The results are compared to appropriate federal and/or provincial guidelines to support the determination that the public and the environment in the vicinity of the facility are safe and that there are no expected health impacts as a result of facility operations. Conclusions and data are then posted on a user-friendly map on the CNSC website. A full technical report is also available upon request.

IEMP results for operating Canadian NPPs are available on the CNSC website for the following years:

- Bruce A and B 2013, 2015, 2016, 2019
- Darlington 2014, 2015, 2017, 2021
- Pickering 2014, 2015, 2017, 2021
- Point Lepreau 2014, 2015, 2016, 2017, 2021

Health Canada Canadian Radiological Monitoring Network and Fixed Point Surveillance Network

Health Canada undertakes environmental surveillance and monitoring activities through its Canadian Radiological Monitoring Network (CRMN) and Fixed Point Surveillance (FPS) network. Initiated in 1959 to monitor environmental releases of radioactivity from atmospheric nuclear weapons testing and accidents at nuclear facilities, the current surveillance activities of the CRMN and FPS serve to establish background radiation levels across Canada, as well as obtain information on levels of radioactivity near NPPs from routine operations, or from radioactivity that may result from a nuclear accident. This in turn provides a basis for accurate health assessments.

The CRMN is a national network comprising 26 sites that routinely collects air particulate, precipitation, external gamma dose, drinking water, atmospheric water vapour, and milk samples for radioactivity analysis at Health Canada's state-of-the-art laboratories. Additional sites in the vicinity of nuclear reactors collect atmospheric water vapour and external gamma dose. The FPS network integrates 80 radiation detectors across Canada to monitor radiation dose to the public in real-time from radioactive materials in the terrestrial environment, whether they are airborne or on the ground. The FPS detectors are located in every province and territory of Canada with larger numbers near major Canadian nuclear facilities and ports where nuclear-powered vessels sometimes harbour.

Data from the CRMN is made available to the public semi-annually via the Open Government Portal. Data from the FPS network is made available in real-time to authorities through the IAEA's International Radiation Monitoring Information System, to the public through the European Radiological Data Exchange Platform, and as quarterly summaries on the Government of Canada website.

The objective of the Ontario Ministry of Labour's Ontario Reactor Surveillance Program (ORSP) is to establish, operate and maintain a radiological surveillance network to assess radiological concentrations around designated major nuclear facilities in the province. The purpose of the ORSP is to assure the public living and working in the vicinity of nuclear facilities that their health, safety, welfare and property is not affected by emissions from those facilities. The ORSP monitors the air, water and food around NPPs in Ontario for radioactivity; the most recent ORSP report was in 2014.

Article 16 – Emergency preparedness

1. Each Contracting Party shall take the appropriate steps to ensure that there are on-site and off-site emergency plans that are routinely tested for nuclear installations and cover the activities to be carried out in the event of an emergency. For any new nuclear installation, such plans shall be prepared and tested before it commences operation above a low power level agreed by the regulatory body.
2. Each Contracting Party shall take the appropriate steps to ensure that, insofar as they are likely to be affected by a radiological emergency, its own population and the competent authorities of the States in the vicinity of the nuclear installation are provided with appropriate information for emergency planning and response.
3. Contracting Parties which do not have a nuclear installation on their territory, insofar as they are likely to be affected in the event of a radiological emergency at a nuclear installation in the vicinity, shall take the appropriate steps for the preparation and testing of emergency plans for their territory that cover the activities to be carried out in the event of such an emergency.

16.1 Emergency plans and programs

16.1 (a) Highlights of general responsibilities and guidance for stakeholders

General responsibilities of the licensees and government authorities

Within Canada’s constitutional framework, emergency management is a shared responsibility between the federal and provincial governments. On an operational level, federal, provincial and municipal governments take responsibility. Most emergencies are local in nature, and are managed at the community or provincial/territorial level. The Government of Canada can become involved where it has primary jurisdiction or when its assistance has been requested due to the scope of the emergency. Canada has robust arrangements in place for the coordination of emergency preparedness and response between the operating organization and local, regional, provincial and national authorities, as well as at the international level.

In Canada, licensees of nuclear facilities are responsible for onsite emergency planning, preparedness and response. Onsite nuclear emergencies are those that occur within the physical boundaries of the facility.

Offsite nuclear emergencies are those that have an effect outside the boundaries of the facility. In the event of an accident at an NPP with potential offsite consequences, the offsite response would follow a process involving the following parties:

- the licensee
- municipal government
- provincial/territorial governments
- federal government

The provincial governments are the primary off-site authority having jurisdiction for the response and are responsible for:

- overseeing public health and safety and protection of property and the environment
- enacting legislation to fulfill the province's lead responsibility for public safety
- preparing emergency plans and procedures and providing direction to municipalities that they designate to do the same
- managing the offsite response and coordinating the efforts of organizations with responsibility in a nuclear emergency
- coordinating support from the NPP licensee and the Government of Canada during preparedness activities and response to a nuclear emergency

At the federal level, the *Emergency Management Act* (EMA) sets out ministerial responsibilities for the prevention and mitigation of, preparedness for, response to and recovery from emergencies.

Federal government support and response for potential offsite impacts are required for addressing areas of federal responsibility, including an incident's effects that extend beyond provincial or national borders. Federal responsibility also encompasses a wide range of contingency and response measures to prevent, correct or eliminate accidents, spills, abnormal situations and emergencies, and to support provinces and territories in their responses to a nuclear emergency. The Government of Canada is also responsible for:

- liaison with the international community
- liaison with diplomatic missions in Canada
- the assistance of Canadians abroad
- coordination of the national response to a nuclear emergency occurring in a foreign country

Coordinated federal assistance may also be required when requested by an affected province or territory. Some provinces have agreements with the Government of Canada for the provision of specific types of technical support to manage the offsite radiological consequences of an emergency.

Under the *Emergency Management Act*, Public Safety Canada ensures coordination across all federal departments and agencies responsible for national security and the safety of Canadians, including during nuclear emergencies. It is the lead authority for the *Federal Emergency Response Plan* (FERP), which is Canada's all-hazards plan. The FERP outlines the processes and mechanisms to facilitate an integrated Government of Canada response to an emergency in support of the provinces and territories.

Health Canada has the responsibility for coordinating federal nuclear emergency preparedness and response. Health Canada is the lead authority for the *Federal Nuclear Emergency Plan* (FNEP), an event-specific annex to the FERP. The FNEP itself has provincial annexes to establish the link between federal and provincial nuclear emergency response plans. The FERP, FNEP and FNEP provincial annexes are aligned to prevent conflict in roles and responsibilities.

The FNEP is supported by two standing nuclear emergency preparedness advisory committees and the technical assessment group (see subsection 16.1(e) for details)

In addition to managing and being the lead authority of the FNEP, Health Canada has responsibilities related to radiation protection, including cross-Canada monitoring networks: the Fixed Point Surveillance Network, the Canadian Radiological Monitoring Network (see subsection 15(b)) and the radiation monitoring stations within the Canadian portion of the

Comprehensive Nuclear Test-Ban Treaty International Monitoring System. See appendix C in Canada's report to the Second Extraordinary Meeting of the CNS for details. Health Canada also operates radiological sample analysis laboratories (including fixed and mobile facilities), decision support systems, mapping and information-management platforms, contamination-monitoring capabilities (including portal monitors), and internal and external dosimetry programs for exposed individuals (including emergency workers). Health Canada provides radiation protection guidance and expertise, maintains a nuclear exercise calendar and organizes emergency exercises.

Internationally, Health Canada and the CNSC serve as national competent authorities to the IAEA and represent Canada on the IAEA's Emergency Preparedness and Response Standards Committee.

In addition to Public Safety Canada, Health Canada and the CNSC, other federal organizations with responsibilities in nuclear emergency preparedness and response, as described in the FNEP, include:

- the Department of National Defence/Canadian Armed Forces, which are responsible for dealing with emergencies involving foreign nuclear-powered vessels entering Canadian waterways
- Transport Canada, which is responsible for the Canadian Transport Emergency Centre
- Environment and Climate Change Canada, which is responsible for providing atmospheric modelling services to the FNEP Technical Assessment Group, provincial science groups and the IAEA as part of its emergency response functions ranging from local to global atmospheric dispersion modelling capabilities, including dispersion and trajectory modelling, and forward/backward modelling, as a Regional Specialized Meteorological Centre under the World Meteorological Organization
- Natural Resources Canada, which is responsible for providing aerial and ground radiation surveying and mapping, providing policy advice and coordinating federal actions in relation to nuclear liability
- the Public Health Agency of Canada, which is responsible for public health issues and is the national authority for reporting to the World Health Organization under the *International Health Regulations* (IHR) (2005). As a signatory to the IHR, Canada is committed to help strengthen global health security by building capacities to detect, assess, report, and respond to public health events both domestically and internationally.

Guidance to support emergency preparedness and response

In addition to governing legislation, the various stakeholders for nuclear emergency preparedness and response are supported by regulations, regulatory documents and standards and other guidance that are used to develop their various emergency plans and measures. The following paragraphs describe some of the developments during the reporting period in these areas.

The CNSC amended the *Radiation Protection Regulations* in 2020 to address radiation protection for emergency workers (see subsection 15(a) for details).

CNS Challenge 6RM C-5 for Canada from the Sixth Review Meeting

"Update emergency operational intervention guidelines and protective measures for the public during and following major and radiological events”

As described in the eighth Canadian report, in June 2018, following extensive public consultation and incorporation of lessons learned from emergency exercises, Health Canada published *Generic Criteria and Operational Intervention Levels for Nuclear Emergency Planning and Response,* which contained updated guidelines for public protective measures. The guidelines aligned with the latest recommendations from the IAEA and ICRP and addressed protective measures for the public (including exposure control, ingestion control, population monitoring and medical management) and off-site emergency workers. As mentioned above, the provinces are the authority having jurisdiction for the offsite response to a nuclear emergency, so the revised guidelines were incorporated into the nuclear emergency plans of the provinces of Ontario and New Brunswick, ensuring a consistent approach to protective measures in the various Canadian jurisdictions.

The planned activities to address Challenge 6RM C-5 are complete. Canada recommends this challenge be closed.

In January 2020, provincial stakeholders in Ontario published an Environmental Radiation and Assurance Monitoring Group Plan and associated procedures, which supports the PNERP. Supported by training, these would be implemented in an emergency to inform decision-making regarding ingestion control and recovery planning.

The CNSC was involved in a number of recovery preparedness initiatives, including participation in the IAEA’s Modelling and Data for Radiological Impact Assessments Programme. Working groups within this initiative studied a variety of topics, including model testing and comparison for accidental tritium releases and the use of decision making tools in the post-release response phase supporting the transition to the recovery phase.

CNS Challenge 6RM C-3 for Canada from the Sixth Review Meeting
“Establish guidelines for the return of evacuees post-accident and to confirm public acceptability of it”

The FNEP includes measures to manage the recovery phase as needed at the federal level - see annex 16.1(e).

During the previous reporting period, the CNSC conducted a public review of draft REGDOC-2.10.1, *Emergency Management and Fire Protection, Volume II: Framework for Recovery After a Nuclear Emergency* (produced in collaboration with Health Canada and Natural Resources Canada). This regulatory document discussed and provided examples of best practices for preparedness for post-accident recovery. The opportunity to comment engaged various stakeholders, including federal and provincial governments.

Ownership of the draft regulatory document was transferred to Health Canada in November 2019. Health Canada established a working group with the CNSC, Natural Resources Canada, the Department of National Defence/Canadian Armed Forces and Public Safety Canada to finalize the document for publication. The working group addressed the stakeholder comments, updated the document in a guidance format, and organized another review by each organization.

The working group updated the document to address the 116 additional comments received, although none significantly changed the content of the original draft (e.g., removal of the assignment of roles and responsibilities to specific organizations during the recovery phase so that the guidance is more general and non-prescriptive.

The document aligns with the most recent guidance from the IAEA on the termination of a nuclear emergency and addresses recommendations that were identified by the EPREV mission to Canada in 2019 (see subsection 16.1(g)). This document incorporates lessons learned from past nuclear disasters to provide guidance to decision makers for planning offsite recovery activities, including individual monitoring, environmental monitoring, food chain monitoring, remediation and waste management. Key themes include exposure situations, reference levels, psychosocial considerations, establishment of a recovery management organization and community engagement throughout the preparedness, response and recovery phases. The role of the recovery management organization is highlighted so that long-term objectives can be achieved to allow relief of emergency management organizations to be ready to respond to the next emergency and to ensure that the roles and responsibilities for recovery are managed from the transition to the end point. The document also focusses on the non-radiological impacts of nuclear emergencies to the public - namely, psychosocial impacts - and provides best practices for minimizing the psychosocial impacts that are applicable to most emergency recovery scenarios. The inclusion of psychosocial consequences is new to the field of emergency management in general, and to nuclear emergency management in particular. This guidance provides federal, provincial and municipal emergency management organizations with a starting point for developing detailed recovery plans and arrangements. The guidance extends to the “new normal”, which involves the consideration of factors that would influence decisions about return of evacuees and resettlement. Health Canada published the *Guidance on Planning for Recovery Following a Nuclear or Radiological Emergency* in December 2020.

To establish the public acceptability of any measures taken during the recovery phase of an actual nuclear emergency, including the return of evacuees, the organizations managing the recovery phase would engage the affected communities to develop appropriate strategies that encompass revitalization, support and compensation.

The planned activities for addressing Challenge 6RM C-3 are complete. Canada recommends this challenge be closed.

16.1 (b) Onsite emergency plans

While the CNSC would continue to have regulatory oversight of the NPP licensees in the event of a nuclear emergency, the licensees are responsible for onsite emergency preparedness and response. Paragraph 6(k) of the *Class I Nuclear Facilities Regulations* specifies an application for a licence to operate a Class I nuclear facility must describe the proposed measures to prevent and mitigate the effects of accidental releases of nuclear substances and hazardous substances on the environment, the health and safety of persons, and the maintenance of national security, including measures to:

- assist offsite authorities in planning and preparing to limit the effects of an accidental release
- notify offsite authorities of an accidental release or the imminence of an accidental release
- report information to offsite authorities during and after an accidental release

- assist offsite authorities in dealing with the effects of an accidental release
- test the implementation of the measures to prevent or mitigate the effects of an accidental release

The application should describe the proposed facility, activities, substances and circumstances to which its emergency plans apply. The emergency plans should also be commensurate with the complexity of the associated undertakings, along with the probability and potential severity of the emergency scenarios associated with the operation of the facility.

A condition in each licence to operate an NPP requires the licensee to implement an emergency preparedness program to ensure it is capable of executing its onsite emergency plan. Emergency preparedness plans and programs are updated and fine-tuned over the life of the NPP as new requirements are identified or to address changing conditions, OPEX and identified deficiencies. The CNSC assesses licensees' emergency preparedness programs and inspects their emergency drills and exercises. Although the programs have matured and are well maintained, CNSC staff members have observed that NPP licensees in Canada proactively seek ways to continuously improve their emergency preparedness programs.

The licensees continued to implement CNSC REGDOC-2.10.1, *Nuclear Emergency Preparedness and Response*, version 2 during the reporting period. It sets requirements for the establishment of the planning basis for emergencies, emergency response plans and procedures and the maintenance of preparedness (e.g., training, testing, etc). Additionally, CSA Group standard N1600, *General requirements for emergency management for nuclear facilities* contains guidance regarding offsite provisions and specifically addresses lessons learned from the Fukushima accident.

Each licensee's emergency plan is specific to its particular site and organization; however, all emergency plans typically cover:

- documentation of the emergency plan
- basis for emergency planning
- personnel selection and qualification
- emergency preparedness and response organizations
- staffing levels
- emergency training, drills and exercises
- emergency facilities and equipment
- emergency procedures
- assessment of emergency response capability
- assessment of accidents
- activation and termination of emergency responses
- protection of facility personnel and equipment
- interface arrangements with offsite organizations
- arrangements with other agencies or parties for assistance
- recovery program
- public information program
- public education program

Descriptions of the onsite emergency plans for each NPP are provided in annex 16.1(b).

16.1 (c) Emergency preparedness expectations for new-build projects

The CNSC is establishing requirements and expectations for emergency preparedness for new-build projects. The CNSC REGDOC-1.1.1, *Site Evaluation and Site Preparation for New Reactor Facilities* specifies that the following factors related to population and emergency planning must be considered when a proposed site is being evaluated against safety goals:

- the planning basis as described in CNSC regulatory document REGDOC-2.10.1, *Nuclear Emergency Preparedness and Response*, Version 2
- population density, characterization and distribution within the emergency planning zone with particular focus on existing and projected population densities and distributions in the region including resident populations and transient populations (note: this data is to be updated over the lifecycle of the reactor facility)
- present and future use of land and resources
- physical site characteristics that could impede the development and implementation of emergency plans (for example, the ability to deliver fuel in a timely manner to backup generators)
- populations, including vulnerable populations, in the vicinity of the reactor facility that are, or may become, difficult to evacuate or shelter (e.g., schools, prisons, or hospitals)
- the ability to maintain population and land-use activities in the emergency planning zone at levels not impeding implementation of the emergency plans

Emergency planning zones are areas beyond the exclusion zone that should be considered with respect to implementing emergency measures. These zones are established by the province or territory and are under control of the region or municipality.

Before submitting the application for a licence to prepare a site, the applicant must confirm with the surrounding municipalities and the affected provinces, territories, foreign states and neighbouring countries that the implementation of their respective emergency plans and related protective actions will accommodate the lifecycle of the proposed project. Discussions around early plans shall include plans and consideration of the following:

- onsite response, including the capacity to bring offsite equipment onsite
- ability of offsite licensee staff to communicate with and access the site during a catastrophic event
- offsite response, and how it is coordinated between the licensee and the relevant federal, provincial and municipal government agencies
- how the licensee will coordinate with regulatory bodies
- how the licensee will respond and coordinate with emergency service providers (fire department, ambulance, hospital, fuel, food, etc)

The applicant shall document the strategy and process for effective, two-way, ongoing consultation with emergency management agencies affected by site operations throughout the project's lifecycle. Emergency management agencies include security agencies involved in the assessment of threats/risks for site-selection report

The CNSC extends these considerations of emergency preparedness into the requirements for the licence to construct and the licence to operate power reactors, for which the following regulatory documents also apply:

- REGDOC-2.3.2, *Accident Management*, version 2

- REGDOC-2.4.1, *Deterministic Safety Analysis*
- REGDOC-2.4.2, *Probabilistic Safety Assessment (PSA) for Nuclear Power Plants*
- REGDOC-2.5.2, *Design of Reactor Facilities: Nuclear Power Plants*
- REGDOC-2.10.1, *Nuclear Emergency Preparedness and Response*, version 2

The additional criteria in these regulatory documents that need to be considered at the design and construction phase include the following:

- The containment allows sufficient time for the implementation of offsite emergency procedures.
- The main control room, secondary control room and emergency response facilities reliably facilitate all operations and support required for onsite and offsite emergency measures.
- The design features and equipment to support post-accident environmental monitoring are robust and reliable.
- The hazard analysis defines the emergency planning and coordination requirements for effective mitigation of the hazards.
- The probabilistic safety assessment (PSA) is used to assess the adequacy of accident management and emergency procedures.

16.1 (d) Provincial and territorial offsite emergency plans

The provincial/territorial governments are responsible for overseeing public health and safety and the protection of property and the environment within their jurisdictions. Accordingly, they assume lead responsibility for the arrangements necessary to respond to the offsite effects of a nuclear emergency by enacting legislation and providing direction to the municipalities where the NPPs are located. Typically, their administrative structures include an emergency measures organization (or the equivalent) to cope, in accordance with defined plans and procedures, with a wide range of potential or actual emergencies. The provinces maintain emergency operations centres to coordinate protective actions for the public and to provide the media with information. In addition, the provincial governments coordinate support from the licensees, the Government of Canada, and departments and agencies of all levels of government during their preparedness and response activities.

Every province/territory has its own unique emergency management structure and provincial nuclear emergency plans, which contain more information on specific areas under provincial responsibility and which detail components required to respond to a variety of radiological events. For Ontario, this is outlined in the *Provincial Nuclear Emergency Response Plan* and for New Brunswick in the *Point Lepreau Nuclear Off-Site Emergency Plan.* Both plans were updated during the reporting period. Changes addressed during these revisions included arrangements for post-accident recovery and updates to the planning zones in Ontario based on a review of the planning basis.

The provinces determine the needs for, and direct the implementation of, protective actions, which include, among other areas:

- sheltering
- evacuation
- ingestion of potassium iodide (KI) pills
- ingestion control measures

Furthermore, the provinces also ensure arrangements are in place for:

- facilitating the availability of KI pills
- establishing reception and evacuation centres to accommodate evacuees (typically maintained at the municipal level)
- establishing centres to ensure radiation protection for emergency workers (typically managed at the municipal level)

The plans also identify responsibilities and broad measures to manage the recovery phase following an accident.

To facilitate timely federal support to the provinces, provincial annexes to the FNEP have been developed by Health Canada and the relevant provincial authorities. These annexes describe the specific arrangements between the FNEP and provincial nuclear plans, including linkages between the federal and provincial/territorial emergency structures. Annexes are provided for those provinces that have operating NPPs or ports hosting foreign nuclear-powered vessels.

Highlights of the offsite nuclear emergency plans of the provinces that host NPPs are provided in annex 16.1(d). Additional details for each provincial plan, including a description of planning zones, event assessment, public alerting and protective measures, are provided in appendix B of Canada’s report to the Second Extraordinary Meeting of the CNS.

Distribution of iodine thyroid-blocking agents

CNSC regulatory document REGDOC-2.10.1, *Nuclear Emergency Preparedness and Response* includes requirements for licensees to provide the necessary resources and support to provincial and regional authorities to ensure that a sufficient quantity of iodine thyroid-blocking agents (such as KI pills) are pre-distributed and/or stockpiled centrally as required. This involves both pre-distributing KI pills to all residences, businesses and institutions within the designated plume exposure planning zone (typically 8 to 16 km from the NPP) and pre-stockpiling KI pills within the designated ingestion control zone (typically 50 to 80 km from the NPP). In New Brunswick, KI is pre-distributed out to 20 km, and stockpiled in several locations within 50 km of Point Lepreau. In Ontario, KI is pre-distributed in the detailed planning zone (nominally 10 km from the NPP) and stockpiled within the ingestion planning zone (typically 50 km from the NPP). During 2019, the CNSC established a KI Pill Working Group and Advisory Committee to provide clarity on the existing plans and associated responsible authorities to distribute KI pill in the ingestion planning zone, in the event of an emergency at Pickering.

During the reporting period, all licensees of operating NPP s worked closely with their respective regional government officials in the distribution of KI pills. The procurement and pre-distribution of KI pills for the areas surrounding the OPG NPPs and Bruce A and B was completed by the end of 2015. KI pills distributed in the areas surrounding OPG NPPs will not expire until 2027. Pre-distribution of KI pills to residents within the specified area for Point Lepreau has been in place since 1982, with new KI pills being redistributed during the fall of 2021. Bruce Power plans to redistribute KI pills in 2025.

To date, Canadian NPP licensees have been responsible for the pre-distribution and stock piling of nearly 8.8 million KI pills in areas surrounding their facilities. Along with the pre-distribution, the NPP licensees launched a public education campaign with information for the public on the availability and use of KI pills through a combination of websites, pamphlets and various presentations to the public.

16.1 (e) Federal emergency plans

The Government of Canada’s emergency planning, preparedness and response are based on an “all-hazards” approach. The *Emergency Management Act* sets out broad policy direction and general responsibilities for Public Safety Canada and all other federal ministers and their respective departments/agencies. It stipulates the scope of emergency preparedness at the federal level to include the four pillars of emergency management: mitigation, preparedness, response and recovery. The Minister of Public Safety has numerous responsibilities pertaining to the preparation, maintenance, testing and implementation of emergency plans. Among other things, these include:

- establishing policies
- providing advice to government institutions
- analyzing and evaluating emergency management plans prepared by government institutions
- monitoring potential, imminent and actual emergencies
- coordinating the Government of Canada’s response
- coordinating federal and provincial responses; establishing arrangements with each province
- promoting public awareness of matters relating to emergency management
- conducting research related to emergency management

In support of this role, Public Safety Canada has prepared the all-hazards FERP to address governance and coordination issues for federal entities and to support the provinces and territories. The FERP is designed to harmonize federal emergency response efforts with those of the provinces and territorial governments, non-government organizations and the private sector, through processes and mechanisms that facilitate an integrated response. The FERP outlines the processes and mechanisms to facilitate an integrated Government of Canada response to an emergency and to eliminate the need for federal government institutions to coordinate a wider Government of Canada response. It has both national and regional-level components that provide a framework for effective integration of effort both horizontally and vertically throughout the federal government. The FERP identifies key emergency support functions, which are the functions most frequently used in providing federal support to provinces/territories or assistance from one federal government institution to another during an emergency. Governance for the FERP is provided by the Assistant Deputy Ministers Emergency Management Committee structure, which is led by Public Safety Canada. The FERP, last updated in 2011, is currently undergoing review for a new update.

While leadership for emergency management falls to the Federal Minister of Public Safety, the *Emergency Management Act* sets out responsibilities of other federal ministers. Coordination of federal nuclear emergency planning and response is specifically delegated to the Minister of Health. Because of the inherent technical nature and complexity of a nuclear emergency, hazard-specific planning, preparedness and response arrangements that supplement all-hazards arrangements are required. The Radiation Protection Bureau of Health Canada administers the comprehensive FNEP, which is integrated with and forms an annex to the FERP to coordinate the Government of Canada’s technical response and support to the provinces/territories for managing the radiological consequences of any domestic, transboundary or international nuclear emergency. The FNEP complements the relevant nuclear emergency plans of other jurisdictions inside and outside Canada.

The FNEP undergoes periodic review to determine if updates are required. The last major update of the FNEP was published in 2014 and incorporated lessons learned from the Fukushima accident. The last minor update on the roles and responsibilities of participating organizations was in June 2019. The FNEP is currently being reviewed with the intention of incorporating lessons learned from the Government of Canada's response to COVID-19 that are applicable to nuclear emergency preparedness and response.

The FNEP describes the roles and responsibilities of federal departments and agencies. It also describes measures they should follow to manage and coordinate the federal response to a nuclear emergency based on the scenarios identified in the plan, focusing on the provision of coordinated scientific support to manage radiological consequences. There are 18 federal departments and agencies involved in the FNEP, including Health Canada, Public Safety Canada, the CNSC, Environment and Climate Change Canada, the Public Health Agency of Canada, Global Affairs Canada, Natural Resources Canada (NRCan) and Transport Canada. Atomic Energy of Canada Limited (AECL) and Canadian Nuclear Laboratories (CNL) provide technical support to the FNEP. All departments and agencies are responsible for developing, maintaining and implementing their own organization-specific emergency response plans that align with and support the objectives of the FERP and FNEP. Some of these organization-specific plans are described below.

Health Canada supports the FNEP through the Federal Nuclear Emergency Management Committee (FNEMC) and the Federal/Provincial-Territorial -Nuclear Emergency Management Committee (FPTNEMC). Both committees provide a forum for information exchange and the development of plans and joint projects to improve nuclear emergency management (e.g., updates to standard operating procedures and technical assessment products) at the federal level and within federal-provincial jurisdictions. They also provide advice and assistance to authorities responsible for nuclear emergency management. During the reporting period, committee topics included the FNEP exercise and training program, the development of a nuclear exercise strategy, and work on Canada's action plan in response to the June 2019 EPREV mission.

In terms of the provincial annexes to the FNEP during the reporting period, the British Columbia FNEP Annex was published and approved in February 2021. The Ontario Annex was tested through an exercise at Bruce Power and two exercises at Darlington. The New Brunswick Annex was tested through an exercise at Point Lepreau. See subsection 16.1(f) for details about exercises at operating NPPs. In all cases, lessons learned were addressed in follow-up actions focused on the development of more detailed operating procedures and arrangements.

Annex 16.1(e) describes the provisions of the FNEP in more detail.

In addition to managing the FNEP, Health Canada's Radiation Protection Bureau maintains a 24/7 duty officer service that receives notifications of any nuclear emergency, activates arrangements under the FNEP, and chairs the FNEP Technical Assessment Group.

Health Canada has a memorandum of understanding with Environment and Climate Change Canada – Canadian Centre for Meteorological and Environmental Prediction to provide a suite of atmospheric dispersion modelling capabilities for nuclear emergency management. For nuclear emergencies having transborder impact, arrangements have been developed with the United States. These bilateral agreements are established at the regional and national level. For instance, Health Canada has developed a statement of intent with the United States Department of Energy regarding nuclear and radiological emergency management and incident response capabilities.

This bilateral arrangement promotes mutual assistance and collaboration between the two countries. See subsection 16.2(b) for details.

Emergency plans of federal departments and agencies

Per the *Emergency Management Act*, individual federal organizations, maintain their own all-hazards and event-specific plans that integrate with the FERP and FNEP, and support their mandates, roles and responsibilities in a nuclear emergency response .

Other federal organizations have specific primary functions for nuclear emergency preparedness and response under the FNEP: the Public Health Agency of Canada, the CNSC, Transport Canada, Environment and Climate Change Canada, NRCan, the Department of National Defence and Canadian Armed Forces, and the Canadian Food Inspection Agency. Several other federal organizations provide a supporting role. All organizations involved in the FNEP are expected to develop, maintain or update plans, procedures and capabilities consistent with their responsibilities detailed in the FNEP.

The CNSC has its own nuclear emergency response plan that clearly defines and enables its roles within the context of the FNEP. The CNSC participates directly in emergency planning activities with other FNEP core agencies. The CNSC also participates in some exercises to practice discharging its own emergency-related responsibilities. During an emergency, the CNSC continues its regulatory oversight of the affected licensee(s). The CNSC also provides expertise in an advisory capacity for the management of the emergency response. The CNSC has a well-developed and mature nuclear emergency management program that is based on its emergency response plan.

During the reporting period, the NPP licensees established links with the CNSC's Emergency Operations Centre to enable online, automated transfer of plant data during an emergency; these measures have enhanced the CNSC's ability to execute its oversight and advisory responsibilities during a nuclear emergency. See annex 16.1(e) for more details on the CNSC's role in emergency preparedness.

Health Canada and the Public Health Agency of Canada maintain an all-hazards plan, the *Health Portfolio Emergency Response Plan*, which describes its response framework to a range of emergencies that could impact public health. It includes a specific nuclear emergency annex to support the FNEP.

Other federal departments and agencies also develop their own nuclear emergency response plans. For example, Transport Canada administers the *Transportation of Dangerous Goods Act, 1992* and the *Transportation of Dangerous Goods Regulations* and operates the Canadian Transport Emergency Centre to ensure hazardous substances are transported safely and to help emergency response personnel handle related emergencies, including those involving nuclear substances. Transport Canada cooperates with the CNSC in emergencies and incidents involving nuclear substances, in accordance with the FNEP, relevant federal legislation and formal administrative arrangements.

16.1 (f) Emergency training, exercises and drills

All levels of government in Canada participate in nuclear emergency exercise programs with recurring cycles. These exercise programs incorporate a continuous improvement process, whereby response organizations at the federal, provincial and local level produce reports following each exercise and develop management action plans to incorporate lessons learned into future exercises and planning updates.

Emergency exercises confirm adequate implementation of onsite and offsite provisions in nuclear emergency response plans. Emergency drills are designed to provide training opportunities for enhancing the abilities of involved parties to respond to emergency situations and to protect public health and safety during an event at a nuclear facility. Emergency exercises serve to test the sharing of information and to ensure all response efforts are coordinated and communicated effectively.

The frequency of emergency exercises at NPPs is defined in CNSC REGDOC-2.10.1, *Nuclear Emergency Preparedness and Response, version 1*. REGDOC-2.10.1 states that licensees are directly responsible for training their personnel and involving them in emergency exercises and for appointing qualified personnel to their emergency teams. A schedule for both emergency drills and emergency exercises is established every year to ensure all responders, including alternates, have the opportunity to practice the required skills on a regular basis. All emergency exercise objectives are addressed over a seven-year period, with a full-scale emergency exercise conducted every three years. Full-scale emergency exercises involve, at minimum, several onsite and provincial and regional offsite stakeholders.

CNSC staff evaluate the full-scale emergency exercises at the NPPs to ensure licensees are effectively managing and implementing their emergency responses (specifically, the onsite provisions). During the reporting period, two such exercises were evaluated; the CNSC's conclusions are briefly summarized as follows:

- Bruce hosted a provincial exercise, Huron Resilience, over a two-day period in October 2019. This event challenged Bruce Power's response to a large-scale seismic event in addition to a variety of other related and unrelated incidents.
- NB Power and the offsite agencies successfully conducted Synergy Challenge 2021 which demonstrated collective emergency preparedness, interoperability and response to a simulated radiological event that was initiated by a cyber security event affecting Point Lepreau. The inclusion of the cyber security event in the scenario was based on a recommendation from the 2019 IAEA EPREV review (see next subsection) to include security events in a radiological response.
- In February 2022, OPG, conducted a three-day, full-scale integrated inter-operability exercise called Exercise Unified Command (ExUComm) with participation from the Province of Ontario, neighbouring municipalities and federal and international agencies. This exercise simulated a beyond-design-basis accident (BDBA) at Darlington that resulted in an uncontrolled offsite release as well as security-related and contaminated casualty response scenarios.

Details of these exercises are provided in annex 16.1(f).

The municipalities, the provinces, the CNSC and other federal organizations may also participate in the exercises with NPP licensees (to a certain degree), depending on scope and objectives. The CNSC participates in some emergency exercises to practice discharging its own emergency-related responsibilities and to ensure communication lines are in place and in a state of readiness. Health Canada frequently participates in exercises with offsite components to provide support to the province in accordance with the FNEP provincial annexes. Other federal departments may also participate.

The FNEP committees developed a seven-year exercise strategy to include different types of radiological/nuclear exercises. The strategy is integrated with Public Safety Canada's national exercise program as well as with provincial exercise programs. One major principle of the strategy is to hold a national priority exercise once every seven years involving multiple organizations from all jurisdictions and the participation of senior management in order to exercise decision-making at all levels. Smaller-scale exercises occur routinely between the national-priority exercises. The first priority exercise within this strategy was Synergy Challenge 2021 at Point Lepreau.

16.1 (g) EPREV

During the previous reporting period, Health Canada had invited the IAEA to undertake an Emergency Preparedness Review (EPREV) for Class I facilities (NPPs) in Canada. Per the EPREV guidelines, Canada undertook a self-assessment of its emergency preparedness arrangements against IAEA Safety Standard Preparedness and Response for a Nuclear or Radiological Emergency (GSR Part 7) and submitted it to the IAEA in January 2018, with an update submitted in January 2019. The mission took place in June 2019 and involved a range of federal, provincial and municipal emergency preparedness and response stakeholders, as well as the NPP licensees. It focused on arrangements for emergencies at Class I nuclear facilities, including the NPPs in the provinces of Ontario and New Brunswick.

The mission presented Canada with 6 suggestions, 6 recommendations and 5 good practices, which are detailed below:

Recommendations	
1	The government should ensure that the results of the nuclear security threat assessment are incorporated in a hazard assessment.
2	The government should ensure that the protection strategy includes provisions for justification and optimization of the individual protective actions and the overall strategy. Once completed, the existing set of generic criteria should be expanded to cover the full set of protective actions (including the early response phase and transition phase as defined in the IAEA safety standards), and operating organizations should review the existing EALs to ensure consistency.
3	The government should revise and further develop its arrangements for the protection of emergency workers and helpers and clarify how helpers in an emergency would be utilized.
4	The government should ensure that there is a detailed monitoring strategy or strategies in place for emergency response and that sufficient resources are available in a suitable time to implement the strategy throughout the emergency response.
5	The government should document and fully develop roles and responsibilities and arrangements for the safe management of off-site radioactive waste arising from an emergency.
6	The government should develop detailed arrangements to terminate a nuclear or radiological emergency, including criteria and procedures for making a formal decision.
Good practices	
1	The government and Nuclear Insurance Association of Canada (NIAC) have implemented a streamlined process for timely submission and processing of claims

	after a nuclear or radiological emergency, including a fully accessible web platform.
2	The implementation of the arrangements for pre-distribution of KI pills maximizes the public awareness and the effectiveness of the protective action.
3	The Warden Service in New Brunswick is an innovative approach to help ensure that relevant information is provided to the public during the preparedness stage.
4	The use of social media simulators in exercises has enhanced the ability of response organizations in Canada to effectively respond to misinformation on social media.
5	Canada completed a detailed self-assessment prior to the EPREV mission and published its national self-assessment for all users of the Emergency Preparedness and Response Information Management System (EPRIMS). This allows other States to benefit from the experience of Canada in preparing for and hosting an international peer review.
Suggestions	
1	New Brunswick should consider conducting a comprehensive hazard assessment to ensure that emergency arrangements are fully in line with the hazards identified and potential consequences, including other facilities and activities concurrently with Point Lepreau Nuclear Generating Station.
2	The government should consider revising arrangements for nuclear or radiological emergencies initiated by nuclear security events, including conducting exercises to test the arrangements.
3	Ontario should consider designating medical personnel trained in the clinical management of radiation injuries.
4	The government should consider continuing the current initiative to review the federal governance system for emergency preparedness and response and should consider any implications for national (federal-provincial-territorial) governance.
5	The government should consider conducting an analysis of minimum resource requirements and training qualification for response organizations at all levels.
6	The government should consider continuing the implementation of the strategy to ensure regular participation of senior officials with strategic decision-making authority in drills and exercises.

Canada accepted all the findings from the EPREV mission and developed an action plan to address the recommendations and suggestions. The EPREV report and Canada's response is available on the Government of Canada's website. Work on the action plan is ongoing and a return EPREV mission has been confirmed for 2023.

16.2 Information to the public and neighbouring states

16.2 (a) Measures for informing the public during a national nuclear emergency

As described in subsection 9(c), the NPP licensees have implemented public disclosure programs that meet the requirements of CNSC REGDOC-3.2.1, *Public Information and Disclosure*. The information to be disclosed would include the impact of natural events (such as earthquakes), routine and non-routine releases of radiological and hazardous materials to the environment and unplanned events, including those exceeding regulatory limits. These requirements therefore cover severe accidents. For emergencies occurring at licensed nuclear facilities, the licensee operator and the CNSC provide information about onsite conditions.

For domestic nuclear emergencies, each level of government and the nuclear facility are responsible for providing emergency public information to the media on their own jurisdiction's aspect of the emergency response. The provinces, however, are responsible for providing detailed protective action messages to affected parties. The provinces inform all relevant stakeholders prior to issuing the emergency bulletins to the public, which is done via broadcast and social media.

The FERP contains an emergency support function for communications at the federal level. The Federal Public Communications Coordination Group, led by Public Safety Canada and in collaboration with the provinces/territories, coordinates the federal government's communications response to the public, media and affected stakeholders (including private sector stakeholders). Federal government institutions contribute information to this group according to their mandates. The Government of Canada also provides communications in areas of federal jurisdiction (e.g., information to federal workers in affected areas). The Chief Public Health Officer of the Public Health Agency of Canada is the lead spokesperson for federal communications concerning offsite public health consequences.

To support the activities of the federal communications group, the FNEP has a support group to develop and/or provide technical input into communications products during a nuclear emergency. These products address topics such as technical information on the emergency, monitoring results and assessment of impacts. FNEP federal spokespersons also present the federal position on the nuclear emergency according to the specific issues and in coordination with the provincial information centres.

In addition to the federal spokesperson, other federal public affairs staff may be dispatched to the provincial/territorial information centres, when the latter are established, to help coordinate information to the media and the public. For international communications, Global Affairs Canada (GAC) will provide advice and input into whole-of-government messaging regarding any international dimensions of a crisis as per GAC's emergency response function under the FERP. GAC will also act as the central channel for official communications with foreign states and international organizations resident in Canada, including with foreign diplomatic missions.

16.2 (b) International arrangements, including those with neighbouring countries

Canada participates in the IAEA International Nuclear Event Scale (INES) reporting system. Canada has excellent working relationships with the United States for the exchange of emergency preparedness expertise. In addition, Canada has signed the following international emergency response agreement and ratified the two conventions noted.

Statement of Intent between Health Canada and United States Department of Energy

Health Canada and the National Nuclear Security Administration of the United States Department of Energy developed a statement of intent supporting joint Canada–U.S. nuclear emergency preparedness and response capabilities. It is supported through annual coordination meetings between Health Canada and the U.S. Department of Energy, to identify areas where coordination and cooperation, including information sharing and mutual assistance, would be beneficial to nuclear emergency management programs and capabilities and to elaborate strategies for moving forward with these.

Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency

Canada is a signatory of the IAEA's *Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency* (1986), which sets out an international framework for cooperation among countries and with the IAEA to facilitate prompt assistance and support in the event of nuclear accidents or radiological emergencies. It requires countries to notify the IAEA of the available experts, equipment or other materials they could offer in assistance. In case of a request for assistance from an affected country, each country decides whether it can offer the requested assistance. The IAEA serves as the focal point for such cooperation by channeling information, supporting efforts and providing its available services. The agreement sets out how assistance is requested, provided, directed, controlled and terminated. Since 2012, Health Canada and AECL have registered their radiological biodosimetry capabilities with the IAEA's Response and Assistance Network (RANET) in support of this convention. The CNSC and NRCan have also registered their NPP accident-analysis capability under RANET in 2016 and 2021 respectively. Health Canada participates in RANET technical meetings to review and update the RANET guidelines as necessary and to exchange experience on the practical arrangements for activating/deploying national assistance capabilities, such as radiological monitoring in response to nuclear or radiological incidents and emergencies.

Convention on Early Notification of a Nuclear Accident

Canada is a signatory to the IAEA's *Convention on Early Notification of a Nuclear Accident* (1986), which establishes a notification system for nuclear accidents having the potential for international transboundary release that could be of radiological safety significance for another country. The accident's time, location, radiation releases and other data essential for assessing the situation must be reported, both directly to the IAEA and to other countries (either directly or through the IAEA). In support of this convention, Health Canada provides real-time data from its Fixed Point Surveillance (FPS) radiation monitoring network to the IAEA's International Radiation Monitoring Information System (IRMIS). During the reporting period, Canada participated in various IAEA organized Convention Exercises (ConvEx) organized in support of this convention as detailed in annex 16.1(f), as well as in development and implementation activities related to the IRMIS platform.

16.3 Emergency preparedness for Contracting Parties without nuclear installations

This part of Article 16 does not apply to Canada.

Chapter III – Compliance with articles of the Convention (continued)

Part D
Safety of installations

Part D of chapter III consists of three articles:

Article 17 – Siting
Article 18 – Design and construction
Article 19 – Operation

Article 17 – Siting

> Each Contracting Party shall take the appropriate steps to ensure that appropriate procedures are established and implemented:
>
> (i) for evaluating all relevant site-related factors likely to affect the safety of a nuclear installation for its projected lifetime;
>
> (ii) for evaluating the likely safety impact of a proposed nuclear installation on individuals, society and the environment;
>
> (iii) for re-evaluating as necessary all relevant factors referred to in sub-paragraphs (i) and (ii) so as to ensure the continued safety acceptability of the nuclear installation;
>
> (iv) for consulting Contracting Parties in the vicinity of a proposed nuclear installation, insofar as they are likely to be affected by that installation and, upon request providing the necessary information to such Contracting Parties, in order to enable them to evaluate and make their own assessment of the likely safety impact on their own territory of the nuclear installation.

Introduction

In Canada, the term "siting" comprises site evaluation and site selection. The applicant's selection of a site is not a regulated activity. However, the resultant site selection case is assessed as part of the application for a licence to prepare a site. The framework and process for issuing a licence to prepare a site for an NPP are described in sub-article 7.2(ii), with further details in subsection 7.2(ii)(b).

The proposed location of a NPP and its thermal output will influence the type of environmental review(s) conducted to inform a licensing decision. For example, requirements for an integrated impact assessment (IA) from the *Impact Assessment Act* (IAA) are imposed if the proposed NPP meets the IAA project list threshold[15]. Alternatively, the proposed NPP may require an environmental assessment within another jurisdiction (e.g., province/territory/area with a land claim agreement). The various environmental review types are described in more detail in subsection 17(ii)(a).

CNSC REGDOC-2.9.1, *Environmental Protection: Environmental Principles, Assessments and Protection Measures*, outlines the CNSC's environmental protection principles and describes the different types of environmental reviews and environmental protection measures.

Fulfilling principle (1) of the VDNS as it relates to siting

Principle (1) of the VDNS states that new NPPs are to be designed, sited and constructed, consistent with the objective of preventing accidents in the commissioning and operation and, should an accident occur, mitigating possible releases of radionuclides causing long-term offsite contamination and avoiding early radioactive releases or radioactive releases large enough to require long-term protective measures and actions.

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[15] The IAA replaced the older *Canadian Environmental Assessment Act*, 2012 during the reporting period, as noted in subsection 7.1(b). Any environmental assessments that commenced while the previous legislation was still in force continued under that legislation.

Following the Fukushima accident in 2011, the IAEA revised five safety requirements. Subsequently, the Chair of the Commission on Safety Standards determined that there was no need for further revisions because the technical objectives of the VDNS were already well reflected in the IAEA safety requirements.

As explained in subsection 7.2(i)(b), CNSC regulations and regulatory documents align with the IAEA safety standards, including those used for siting NPPs. This article provides further examples of how the regulatory framework for siting addresses IAEA safety standards. Therefore, the CNSC framework and processes used in the regulation of activities related to site preparation ensure that the siting of new NPPs in Canada will meet principle (1) of the VDNS.

See article 18 for a similar statement on the activities of design and construction.

Level of NPP design information expected to demonstrate site suitability

Under the NSCA, the decisions made by the Commission on an application for a licence to prepare a site for a new NPP may be made with high-level facility design information from a range of reactor designs that might be deployed later at the site.

In order to obtain a licence to construct, sufficient information must be provided to describe the NPP-site interface and take into consideration the characteristics of the proposed site. The underpinning of the bounding approach is that the environmental effects of the reactor design eventually selected for construction must fit within the bounding envelope established in the environmental review and licensing process. Although the CNSC accepts high-level information in support of the site evaluation case, there is an increased level of regulatory scrutiny during the construction and operation licensing processes to validate the claims made. If the level of information provided at the outset is limited, with no plan to provide additional information throughout the licensing process, there is a greater likelihood that fundamental barriers to licensing may appear during the review process for a licence to construct.

The required level of design information for a site evaluation includes:

- a technical outline of the facility layout (preliminary or schematic in nature)
- qualitative descriptions (or technical outline) of all major structures, systems and components (SSCs) that could significantly influence the course or consequences of principal types of accidents and malfunctions
- qualitative descriptions (or technical outline) of the functionality of the SSCs important to safety
- qualitative descriptions of principal types of accidents and malfunctions to identify limiting credible sequences that include external hazards (both natural- and human-induced), design-basis accidents and beyond-design-basis accidents (BDBAs, which include severe accidents)

Information on severe accidents must be sufficiently detailed to assess whether proposed measures for emergency preparedness will be adequate at the site evaluation stage and at subsequent licensing stages. The severe accident sequences include, where applicable, multi-unit events, simultaneous with loss of the electrical grid/station blackout events, and events with a simultaneous loss of offsite power and loss of heat sink for an extended period of time.

A description of specific (out-of-reactor) criticality events must be provided, showing that these events do not violate criteria established by international standards and national guidance as triggers for public evacuation.

An applicant may choose to pursue a licence to prepare a site without choosing a final NPP technology. In such a case, the activities permitted under the issued licence to prepare the site would be limited to site preparation activities that are independent of any specific reactor technology. Such activities include clearing and grading the site or building support infrastructure such as roads, power, water and sewer services, but do not include excavation for the purposes of establishing the facility footprint.

Regardless of the approach used by an applicant to apply facility design information to its site selection case, a fundamental expectation of the CNSC is that the applicant will demonstrate the capability of an “intelligent customer”. This means that the applicant will be expected to demonstrate a clear understanding of the technologies it is proposing to use and the basis on which the site selection case is developed. See article 13 for additional information.

Site evaluation criteria – general

The information provided in an application for a licence to prepare a site is assessed against the criteria described in CNSC REGDOC-1.1.1, *Site Evaluation and Site Preparation for Nuclear Reactor Facilities*. REGDOC-1.1.1 guides the applicant to use a robust process to characterize proposed sites over the full lifecycle of the facility and then develop a fully-documented defence of the site selection. It adapts the tenets set forth by the IAEA safety requirements document NS-R-3, *Site Evaluation for Nuclear Installations* and its associated guides. REGDOC-1.1.1 addresses some Canadian expectations that are not addressed in NS-R-3, such as protection of the environment, security of the site, and protection of prescribed information and equipment.

REGDOC-1.1.1 elaborates upon the criteria for evaluating the effect of the site on the safety of the NPP (see subsection 17(i)) and the impact of the NPP on the surrounding population and the environment (see subsection 17(ii)(b)). Specifically, REGDOC-1.1.1 articulates the CNSC’s expectations with respect to the evaluation of site suitability over the life of a proposed NPP, and includes:

- the potential effects of external events (such as earthquakes, tornadoes and floods) and human activity on the site
- the characteristics of the site and its environment that could influence the transfer to persons and the environment of radioactive and hazardous material that may be released
- the population density, population distribution and other characteristics of the region, insofar as they may affect the implementation of emergency measures and evaluation of risks to individuals, the surrounding population and the environment

REGDOC-1.1.1 also requires the consideration of certain aspects, such as security and decommissioning requirements, projected population growth in the vicinity of the site, and possible future life extension activities, when evaluating the site.

If the site evaluation indicates safety concerns that design features, site protection measures, or administrative procedures cannot remedy, the site would almost certainly be deemed unacceptable by the Commission at a hearing and a licence would not be issued. Additional details related to site evaluation criteria are provided under sub-articles 17(i) and 17(ii).

17 (i) Evaluation of site-related factors

The safety case for the licence to prepare a site includes an assessment of hazards or bounding analysis and should address the impact of site-specific factors on the safety of the NPP. Such factors include the site's susceptibility to flooding (e.g., storm surge, dam burst), hurricanes, tornadoes, ice storms or other severe weather, and earthquakes. The return periods for severe weather, flood or wind are not prescribed. However, the applicant is expected to propose adequate periods based on criteria identified in the IAEA documents that are referenced in REGDOC-1.1.1.[16]

The applicant or licensee also has to perform a site-specific external hazards screening to identify other hazards. Furthermore, the applicant or licensee must consider combinations of events, including consequential and correlated events. Examples of consequential events include external events (such as a cooling water intake blockage caused by severe weather, a tsunami caused by an earthquake or a mud slide caused by heavy rain) and internal events (such as a fire caused by an earthquake). Examples of correlated events include heavy rainfall concurrent with a storm surge or high winds caused by a hurricane.

REGDOC-1.1.1 requires the applicant to consider climate change when evaluating the potential impact of these phenomena.

Site-related factors also include the proximity of the site to one or more of the following:

- railroad tracks (possibility of derailments and the release of hazardous material)
- flight paths for major airports (possibility of airplane crashes)
- toxic chemical plants (possibility of toxic releases)
- propane storage facilities or refineries (possibility of industrial accidents)
- military test ranges (possibility of stray missiles)

The above concerns are further affected by projected land use near the site, present and predicted population growth in the vicinity of the site, access to the site, emergency preparedness and security.

Additional factors that may be important to the safety of the proposed NPP include principal water sources, movement of water and water usage.

The applicant addresses these criteria during the application process for a licence to prepare site under the NSCA (and in the IA process, described in the next sub-article), the results of which are integrated into the safety case.

The review of OPG's application to renew its licence to prepare site for the DNNP, against the criteria in REGDOC-1.1.1, is described in subsection 14(i)(a).

17 (ii) Impact of the installation on individuals, society and the environment

17 (ii) (a) Environmental reviews

As noted at the beginning of this article, the type of environmental review that is conducted on a new reactor proposal depends on the proposed location of the reactor and its energy output, among other considerations.

[16] specifically, IAEA safety guides NS-G-1.5, NS-G-3.2, NS-G-3.4 and NS-G-3.5

When a proposal is listed in the IAA's *Physical Activities Regulations*, an integrated IA is required. This process considers the requirements of both the *Impact Assessment Act* (IAA) and the NSCA in a single review.

If the proposal is below the IAA regulatory thresholds, an environmental protection review under the NSCA would be conducted and CNSC staff would present their findings to the Commission to inform its licensing decision.

The outcome of two other environmental review processes help inform the Commission's licensing decision, if applicable: a federal lands review to meet IAA requirements if an NPP is proposed on federal Crown lands, or an environmental assessment if required by a province or area subject to a land claim agreement (such as the territories and parts of Quebec and Newfoundland and Labrador).

The Commission uses the information gathered in the IA process in its licensing decision under the NSCA.

REGDOC-1.1.1 and REGDOC-2.9.1 highlight the applicant's environmental risk assessment (ERA; see subsection 15(b)) as a key input to environmental reviews.

As mentioned in subsection D.4 of the Introduction, Global First Power submitted an application in 2019 for a licence to prepare site for an SMR on AECL's property at Chalk River Laboratories. At that time, the *Canadian Environmental Assessment Act*, 2012 was still in effect. Global First Power's site preparation licence is currently undergoing regulatory review and the project is completing an environmental assessment.

17 (ii) (b) Criteria for evaluating the safety impact of the NPP on the surrounding environment and population

As stated above, REGDOC-1.1.1 stipulates that the evaluation of site suitability includes consideration of specific factors relevant to the impact of the proposed NPP on the environment and population:

- site characteristics that could have an impact on the public or on the environment
- population density, distribution and other characteristics of the emergency planning zone that may have an impact on the implementation of emergency measures

The safety impact on the population examines the population dose from postulated events. Given that the NPP will perform as designed under accident conditions, it is important to consider population-related factors to meet radiation dose limits set by regulations. Such factors include the size, nature (e.g., subdivision, rural, industrial, school or hospital), distribution and demographics of population around the facility. Other factors include: local weather, seismicity, neighbouring facilities, and air and rail transport corridor activity. The applicant addresses these criteria in the safety case, which calculates the population doses and verifies that the NPP design meets its safety targets.

Before submitting an application for a licence to prepare site, the applicant should confirm with the surrounding municipalities and the affected provinces, territories, foreign states and neighbouring countries that the implementation of their respective emergency plans and related protective actions will accommodate the lifecycle of the proposed project.

Outreach to stakeholders and the local populace of the potential site – in particular, explaining the safety impact and how it is evaluated – is an important activity related to understanding the impact of a proposed NPP on the population and the environment.

More information on public information and disclosure and outreach activities related to new-build projects that was conducted by the CNSC and the applicants/licensees during the reporting period is provided in subsection 8.1(f) and annex 9(c), respectively.

17 (iii) Re-evaluation of site-related factors

17 (iii) (a) Licensee activities to maintain the safety acceptability of the NPP, taking into account site-related factors

The continued acceptability of the NPP against the criteria mentioned in sub-articles 17(i) and 17(ii) is periodically verified against appropriate standards and practices. Possible changes to the site's demographics or significant changes to the understanding of the local environment must be examined through activities that include regular reviews of the licensee's emergency response measures, security measures and safety analysis report. Such changes include:

- new insights from updated hazard studies that take environmental changes, including climate change (e.g. flood risk), into consideration
- changes to neighbouring man-made facilities (such as a newly constructed oil refinery, rail corridor, airport flight path or chemical plant)

Historical data assessment (for the past century) and future climate change prediction (for the next century) were performed in support of the original DNNP site preparation licence application. OPG considered key climatic parameters such as temperature, precipitation and wind speed. The impact on the extreme conditions due to climate change was addressed in the evaluation of meteorological events. Overall, the changes in extreme conditions did not go beyond the review level conditions for the assessment; the ones that posed any hazard will be mitigated through designed barriers. Detailed hazard analysis and safety assessment with respect to climate change will be performed under OPG commitments as a part of its application for a licence to construct an NPP.

CNSC REGDOC-3.1.1, *Reporting Requirements for Nuclear Power Plants*, requires licensees to regularly submit to the CNSC certain reports describing the effects of the NPP on the environment:

- updates to facility descriptions and final safety analysis report
- probabilistic safety assessment (PSA)
- environmental risk assessment (ERA)

These reports are to be submitted within five years of a previous submission or when requested by the CNSC. They include consideration of any relevant new techniques or information, which could include new data or insights related to external events.

Deterministic safety analysis and PSAs are described in subsections 14(i)(b) and 14(i)(c), respectively. ERAs are described in subsection 15(b).

REGDOC-3.1.1 also requires an annual report detailing the results of environmental monitoring programs, together with an interpretation of the results and estimates of radiation doses to the public resulting from NPP operations. See subsection 15(b) for details.

17 (iv) Consultation with other Contracting Parties likely to be affected by the installation

The Espoo Convention, an international environmental convention developed under the auspices of the United Nations Economic Commission for Europe, requires the parties to the convention to assess the environmental impacts of certain activities at an early stage of planning; provide to the government and public of an affected country an opportunity to participate in the assessment; and ensure that the results of the assessment are taken into account in the final decision about the project.

Canada shares borders with the United States, Denmark (Greenland), and France (Saint Pierre and Miquelon). All four countries are signatories of the Espoo Convention. However, the USA is the only country that has not ratified the Convention and is, therefore, not bound by its terms. Consequently, the Espoo Convention does not apply to projects that could have potential transboundary effects between Canada and the United States.

Although there are no transboundary notification requirements, the CNSC can use existing communication mechanisms through formal arrangements to notify and keep interested parties outside of Canada informed. Canada and the United States have a longstanding practice of cooperation with respect to transboundary impacts through such treaties as the *Boundary Waters Treaty* of 1909, the *Great Lakes Water Quality Agreement* of 1978 and the *Canada-United States Air Quality Agreement* of 1991. In addition, the CNSC and the United States Nuclear Regulatory Commission have an administrative arrangement for the exchange of technical information and cooperation in nuclear safety matters, including the siting of any designated nuclear facility in either country.

Canada would use the IAA processes to implement the requirements of the Espoo Convention if an NPP proposal had the potential for transboundary impacts for other parties to the convention. The IAA requires that effects to the environment that may occur outside of Canada (transboundary effects) be included in the environmental review for proposals requiring an impact assessment or a federal lands review, including proposed NPPs.

Furthermore, public participation opportunities (such as public hearings) are an important component of the CNSC’s licensing process. The CNSC emphasizes public engagement and participation; members of the public, including people from outside Canada, are provided the opportunity to review licensing documentation and participate as intervenors in public hearings.

Article 18 – Design and construction

> Each Contracting Party shall take the appropriate steps to ensure that:
> (i) the design and construction of a nuclear installation provides for several reliable levels and methods of protection (defense in depth) against the release of radioactive materials, with a view to preventing the occurrence of accidents and to mitigating their radiological consequences should they occur;
> (ii) the technologies incorporated in the design and construction of a nuclear installation are proven by experience or qualified by testing or analysis;
> (iii) the design of a nuclear installation allows for reliable, stable and easily manageable operation, with specific consideration of human factors and the man-machine interface.

Introduction and developments related to new-build

All operating NPPs in Canada are CANDU designs. CANDU reactors feature heavy-water coolant and moderator and natural uranium fuel, as well as fuel channel and fuel bundle designs that enable online fueling. The pressure tube is the central component of the fuel channel that supports the fuel and acts as a pressure boundary for the coolant. Some specific CANDU design features related to assessing and improving defence in depth are described in annex 18(i). The first and second Canadian reports contain extensive information on the evolution of the design and construction of CANDU-type NPPs.

At the end of the reporting period, there were two new-build projects in Canada that were at the licensing stage: OPG had renewed its licence to prepare a site for the DNNP and Global First Power had submitted an application for a licence to prepare a site at Chalk River Laboratories.

For the DNNP, OPG is working with GE Hitachi Nuclear Energy on a boiling water SMR based on the BWRX-300 design. The design of the 300 MWe, water-cooled BWRX-300 is based on GE Hitachi's 1,520 MWe Economic Simplified BWR[17]. As a "smart reactor," the BWRX-300 uses natural circulation and passive cooling isolation condenser systems to promote simple and safe operating rhythms.

For the project at Chalk River Laboratories, Global First Power is working with Ultra Safe Nuclear Corporation to develop an SMR based on the Micro Modular Reactor (MMR TM) design. The MMR-5 being proposed is a 5 MW(e), or 15 MW(th), high-temperature, helium-cooled reactor that delivers heat through a molten salt intermediate thermal storage system configured to customer energy requirements. The core uses fully ceramic microencapsulated fuel pellets in a graphite block configuration. The fuel is high-assay, low-enriched uranium (maximum 19.75% enrichment) and the planned service life of the fuel cartridge is 20 years at full power. The MMR is designed to cool passively in all scenarios without the need for external power or water supply.

Although the DNNP renewed its licence to prepare a site during the reporting period, and Global First Power applied for a licence to prepare a site for its planned SMR at Chalk River Laboratories, neither project has reached the stage of requiring a licence to construct. However,

[17] Certified by the United States Nuclear Regulatory Commission

OPG intends to apply for such a licence in the next reporting period. When applying for a licence to construct, the applicant will be expected to submit design information to verify that the evaluations presented previously for the licence to prepare site remain valid, while expanding upon the information required to support the licence to construct.

The general CNSC framework and process for issuing a licence to construct a Class IA nuclear facility (of which an NPP is an example) are described in sub-article 7.2(ii). In response to existing, and in preparation for potential, additional new-build licence applications, the CNSC continues to update its design requirements for NPPs, participate in relevant international efforts and conduct pre-licensing vendor design reviews. The CNSC has also participated in the Multinational Design Evaluation Programme (MDEP). These activities are described in the following subsections.

Canada sponsors significant R&D that addresses the area of design and construction (see appendix D for details).

Specific design requirements and licensee provisions related to defence in depth, proven technologies, and reliable and manageable operation are described in sub-articles 18(i), 18(ii) and 18(iii), respectively, for the currently operating NPPs and potential new-build projects.

Updating design requirements for new-build projects

CNSC criteria for evaluating designs of new NPPs continued to be updated to be technology-neutral and to allow for the licensing of a wide range of reactor technologies, sizes and uses, including non-water-cooled technologies.

CNSC REGDOC-2.5.2, *Design of Reactor Facilities: Nuclear Power Plants*, sets out requirements and guidance for the design of new, water-cooled NPPs. To a large degree, REGDOC-2.5.2 represents the CNSC's adoption of the tenets set forth in the IAEA safety standards SSR-2/1, *Safety of Nuclear Power Plants: Design*, and the adaptation of those tenets to align with Canadian practices. Annex 7.2(i)(b) describes in greater detail how REGDOC-2.5.2 reflects various IAEA safety standards. To the extent practicable, REGDOC-2.5.2 sets technology-neutral requirements related to defence in depth, the use of proven technology and easily manageable operation of NPPs (e.g., reliability, human factors). Similar to SSR-2/1, REGDOC-2.5.2 requires the concept of defence in depth to be applied to all organizational, behavioural and design-related safety and security activities to ensure they are subject to overlapping provisions. Defence in depth is to be applied throughout the design process and operation of an NPP. The scope of REGDOC-2.5.2 addresses the interfaces between NPP design and other topics, such as environmental protection, safeguards, and accident and emergency response planning. Additional details on REGDOC-2.5.2 are provided in annex 18.

The CNSC is revising REGDOC-2.5.2. Version 2 is intended to combine the existing version with the content of CNSC regulatory document RD-367, *Design of Small Reactor Facilities*. As with the existing version, the new version is intended to be technology-neutral to the extent practicable with respect to water-cooled reactors.

Upgrading designs of existing NPPs

For existing NPPs, the licensees have continuously made design improvements even though many of the updated design requirements were established after the NPPs were built. For example, design changes have been made to address new standards, on an ongoing basis, when the licences are renewed or amended (as described in subsection 7.2(ii)(d)). Furthermore, life-extension projects have provided an opportunity to upgrade the existing CANDU NPPs to align with REGDOC-2.5.2 and other new standards. In addition, PSRs have been implemented, which require the licensee to determine reasonable and practical modifications to enhance the safety of the facility to a level approaching that described in modern standards. Integrated implementation plans identify strengths and shortcomings for each of the safety factors identified in the PSR, rank the shortcomings in terms of safety significance, and prioritize corrective measures, including design and other safety improvements.

The design improvements that have been effected in Canada as part of life extension have addressed the various factors discussed in sub-articles 18(i), (ii) and (iii). The general regulatory approach to life extension and the use of PSR are described in subsection 7.2(ii)(d). Some examples of design changes to existing NPPs are given in annex 18(i) in the context of improvements to defence in depth.

Fulfilling principle (1) of the 2015 Vienna Declaration on Nuclear Safety as it relates to design and construction

Principle (1) of the VDNS states that new NPPs are to be designed, sited and constructed, consistent with the objective of preventing accidents in the commissioning and operation and, should an accident occur, mitigating possible releases of radionuclides causing long-term offsite contamination and avoiding early radioactive releases or radioactive releases large enough to require long-term protective measures and actions.

As explained in article 17, the technical objectives of the VDNS were already well reflected in previous updates of the IAEA safety requirements. Furthermore, as explained above in subsection 7.2(i)(b), CNSC regulations and regulatory documents align with the IAEA safety standards, including those used for design and construction of NPPs (e.g., REGDOC-2.5.2, as discussed above). Therefore, the CNSC framework and processes used in the regulation of activities related to design and construction ensure that new NPPs constructed in Canada will meet principle (1) of the VDNS.

Fulfilling principle (2) of the 2015 Vienna Declaration on Nuclear Safety as it relates to design and construction

Principle (2) of the VDNS requires comprehensive and systematic safety assessments to be carried out periodically and regularly for existing installations throughout their lifetime to identify safety improvements that are oriented to meet the objective of principle (1) of the VDNS. As described in section E of chapter I, principle (1) requires new NPPs to be designed, sited and constructed, consistent with the objective of preventing accidents in the commissioning and operation and, should an accident occur, mitigating possible releases of radionuclides causing long-term offsite contamination and avoiding early radioactive releases or radioactive releases large enough to require long-term protective measures and actions. Principle (2) also requires that reasonably practicable or achievable safety improvements be implemented in a timely manner.

As noted in previous Canadian reports, the designs of existing Canadian NPPs, which are all CANDU reactors, include features that prevent accidents and mitigate impacts should an accident occur. As noted above, actions by the CNSC and licensees during the reporting period further strengthened defence in depth of the existing NPPs.

Multinational Design Evaluation Programme

In the past, CNSC played an active role in MDEP, which has representatives from 14 countries, with the OECD's Nuclear Energy Agency (NEA) providing a technical secretariat function. Aiming to harmonize regulatory requirements and regulatory practices, MDEP seeks to:

- enhance multilateral cooperation within existing regulatory frameworks
- promote multinational convergence of codes, standards and safety goals
- implement MDEP products to facilitate licensing of new reactors

During the reporting period, the CNSC's participation in MDEP was gradually phased out. Areas of CNSC involvement in MDEP, and any related transitional activities, included the following.

- design-specific safety issues and activities surrounding the Westinghouse AP1000 design:
    - CNSC used MDEP information during its vendor design review (process described below) of the AP1000 design.
- methods for multinational vendor inspections:
    - In May 2019, CNSC staff participated as an observer in a US NRC inspection by the United States Nuclear Regulatory Commission of a supplier based in the United States. The inspection focused on the fabrication, testing, and commercial grade dedication of electrical equipment. Work on this issue was transitioned to a working group in the NEA's Committee on Nuclear Regulatory Activities (CNRA).
- convergence of pressure boundary component codes and standards:
    - Work on this issue was transitioned to a working group under the CNRA.
- resolution of regulatory issues around digital instrumentation and control standards

Pre-licensing vendor design reviews

The CNSC has established a pre-project, vendor-optional process to assess reactor facility designs based on a vendor's reactor technology. The term "pre-project" signifies that a design review is undertaken prior to the submission of a licence application to the CNSC. This service does not certify a reactor design or involve the issuance of a licence under the NSCA and it is not required as part of the licensing process for a new NPP. The conclusions of any pre-licensing vendor design review do not bind or otherwise influence decisions made by the Commission.

A pre-licensing vendor design review is an assessment completed by CNSC staff at the request of the vendor. The objective is to verify, at a high level, the acceptability of a reactor design with respect to Canadian regulatory requirements and expectations. This includes identification of fundamental barriers to licensing a new design in Canada. The process also assesses whether the vendor is developing the expected detailed evidence to support the adequacy of the proposed design.

CNSC REGDOC-3.5.4, *Pre-licensing Review of a Vendor's Reactor Design,* describes the process to interested parties and stakeholders. The CNSC assessment process is divided into three distinct phases. Typically, the CNSC provides a confidential report to the vendor at the end of each phase and an executive summary is posted on the CNSC website. The phases of vendor pre-project design reviews are described in annex 18, which also describes the status of the many pre-licensing vendor design reviews for SMRs conducted during the reporting period.

The CNSC has found the vendor design reviews to be extremely valuable – not only as part of preparing for future licence submissions but also in investigating new design issues and their potential impacts on the regulatory framework. This process has contributed significantly to the CNSC's readiness for future licensing activities. Potential applicants may find that the vendor pre-project design reviews are helpful for informing applications for a licence to prepare the site or construct an NPP.

18 (i) Implementation of defence in depth in design and construction

REGDOC-2.5.2 describes five levels of defence in depth, which would ensure a low probability of failures or combinations of failures that would result in significant radiological consequences:

- preventing deviation from normal operation as well as failures of SSCs
- detecting and intercepting deviations from normal operation to prevent anticipated operational occurrences from escalating to accident conditions and to return the NPP to a state of normal operation
- minimizing accident consequences by providing inherent safety features, fail-safe design, additional equipment, and mitigating procedures
- ensuring radioactive releases from severe accidents are kept as low as practicable
- mitigating the radiological consequences of potential releases of radioactive materials during accident conditions

Design for the defence-in-depth approach considers the following:

- conservative design and high quality of construction to minimize abnormal operation or failures
- provision of multiple physical barriers (e.g., the fuel, pressure boundary and containment) that prevent the release of radioactive materials to the environment
- provision of multiple means for each of the basic safety functions (e.g., reactivity control, heat removal, confinement of radioactivity)
- use of reliable, engineered protective devices in addition to the inherent safety features
- supplementation of the normal control of the NPP by automatic activation of safety systems or by operator actions
- provision of equipment and procedures to detect failures, along with backup accident prevention measures to control the course and limit the consequences of accidents

The Canadian approach to NPP safety evolved from the recognition that even well-designed and well-built systems may fail. However, when the defence-in-depth strategy is properly applied, no single human error or mechanical failure has the potential to compromise the health and safety of persons or the environment. Emphasis has been placed on designs that incorporate "fail-safe" modes of operation that can be used should a component or a system failure occur. The approach also recognizes the need for separate, independent safety systems that can be tested periodically to demonstrate their availability to perform their intended functions.

The CANDU design and defence-in-depth strategy allows the currently operating Canadian NPPs to safely operate and, when necessary, safely shutdown their reactors, even for low-probability or rare internal and external events. As noted briefly above, the two new-build projects at the licensing stage in Canada involve SMRs. The designs being proposed for the DNNP and Chalk River are similarly intended to provide for safe shutdown and passive cooling in all scenarios for extended periods without the need for external power or water supply.

Some of the criteria that have guided the design of the currently operating NPPs in Canada and contributed to defence in depth are described in conjunction with the safety analysis criteria (described in subsection 14(i)(c)). Specific design criteria and requirements are found in some of the CSA Group standards included in the licensing basis for existing NPPs, such as:

- N285.0, *General requirements for pressure retaining systems and components in CANDU nuclear power plants*
- N293, *Fire protection for CANDU nuclear power plants*

As well, REGDOC-2.5.2 contains updated requirements related to defence in depth (see annex 18) that will be applied to new-build projects and considered as part of PSRs for existing NPPs.

During the reporting period, CNSC staff deemed the level of defence in depth at all operating Canadian NPPs to be acceptable. It was also concluded that the risk to the Canadian public from beyond-design-basis accidents (BDBAs) at the existing NPPs was very low. Given the design features and defence in depth for Canadian NPPs, adequate time would be available for long-term mitigation of a BDBA. Although the risk of an accident is very low, NPP operators implemented several modifications to improve defence-in-depth and enhance their ability to withstand prolonged losses of power and other challenges, such as the loss of all heat sinks. See annex 18(i) for details.

The defence-in-depth of SMR designs proposed for the DNNP and Chalk River (and other possible SMR projects) will be assessed as the projects move forward. For example, CNSC staff will assess the defence-in-depth of the BWRX-300 design if OPG submits, as anticipated, an application for a licence to construct in the next reporting period. One of the design goals of the BWRX-300 is to be capable of being licensed internationally.

The BWRX-300 design has been developed with a strict adherence to a philosophy that follows the IAEA defence-in-depth guidelines. The BWRX-300 defence-in-depth concept uses four fundamental safety functions (control of reactivity, fuel cooling, long-term heat removal and containment of radioactive materials) to define the interface between the defence lines and the physical barriers. In a given plant scenario, if the functions are performed successfully, then the corresponding physical barriers will remain effective.

18 (ii) Incorporation of proven technologies

Provisions in the regulatory framework ensure the application of proven technologies. In addition, novel and innovative approaches can also be implemented, provided that sufficient evidence exists, along with adequate provisions, to show that they can be implemented safely. In each phase of licensing, documents have to be submitted that describe, verify and validate the technology employed. These include the design and safety analysis information contained in the safety analysis report and the quality assurance program(s) for design and safety analysis.

REGDOC-2.5.2 includes requirements and guidance related to proving engineering practices and qualifying designs (see annex 18). These would apply to new-build projects and to the existing reactors through the application of PSR – specifically, for any design enhancements or safety analyses identified in the integrated implementation plan. At the end of the reporting period, the CNSC was revising REGDOC-2.5.2.

CNSC REGDOC-2.4.1, *Deterministic Safety Analysis* also includes requirements and guidance related to the use of methods and inputs that have been proven by validation. Specifically, it requires applicants and licensees to demonstrate how safety analysis computer codes meet the requirements of CSA Group standard N286.7, *Quality assurance of analytical, scientific and design computer programs for nuclear power plants*. REGDOC-2.4.1 is applicable to new-build projects, and the licensees of existing NPPs are applying it for new and revised safety analyses.

Most SMR concepts, although based on technological work and OPEX from older NPPs, employ a number of novel approaches. As noted above, CNSC licensing reviews will assess the potential effect of novel approaches, or proven approaches used in different ways, by applying the safety objectives, high-level safety concepts and safety management requirements outlined in REGDOC-2.5.2. Specifically, CNSC staff will assess the impact of alternate approaches on the certainty of plant performance under both normal operation and accident conditions. The application of requirements and guidance in documents such as REGDOC-2.5.2 and REGDOC-2.4.1, which are technology-neutral and non-prescriptive, in a risk-informed and graded manner, is intended to ensure that the technologies associated with SMRs will be sufficiently proven without unnecessarily impeding innovation.

For the existing operating reactors, the CANDU design criteria and requirements specify that the design and construction of all SSCs to follow the best applicable code, standard or practice and be confirmed by a system of independent audit.

In particular, for pressure boundaries, the CNSC reviews the design against the requirements of the NSCA and the associated regulations and approves the classification using the requirements in CSA Group standard N285.0, *General requirement for pressure-retaining systems and components in CANDU nuclear power plants*. The licensee then registers the design with an authorized inspection agency, which audits the fabrication of the design, inspects the construction, installation and tests, and countersigns the pressure test results.

Licensees use safety analysis computer codes that have been validated in accordance with the requirements of N286.7. The tools and methodologies used in the safety analysis report are proven according to national and international experience and reflect the modern state of the knowledge.

The licensees of operating NPPs update their safety analysis reports at least once every five years or when requested to do so by the CNSC. REGDOC-2.4.1 sets the expectation for updates of the safety analysis report to incorporate new information, address new issues that have been identified, use current tools and methods, and address the impact of modifications to the design and operating procedures. Revisions to the safety analysis report incorporate experimental data and R&D findings. As a result, some of the events in the safety analysis report are re-analyzed when necessitated by advances in science and technology.

Furthermore, CNSC REGDOC-2.4.1, *Deterministic Safety Analysis* stipulates the selection of computational methods or computer codes, models and correlations that have been validated for the intended applications. The requirements in REGDOC-2.4.1 will be gradually addressed for existing NPPs, as explained in subsection 14(i)(b).

SNC-Lavalin Nuclear continues to pursue advancements in technologies through various initiatives such as its product development program. Under this program, advancements in the toolset for the removal and installation of reactor components for the CANDU refurbishment (retube) projects were successfully completed and implemented. As part of fuel channel removal in the retube project, the fuel channel and fuel channel components are removed followed by the removal of the calandria tubes. SNC-Lavalin Nuclear developed an innovative approach to simultaneously remove the pressure tube and calandria tube, which resulted in a reduction in worker dose while achieving a significant reduction in critical path time on the retube project. The prototype tool was designed, developed, tested, and qualified in the large-scale laboratory at SNC-Lavalin Nuclear.

Environmental qualification programs at operating Canadian NPPs also help to prove that safety systems and safety-related systems will operate as intended, insofar as they are relied upon to help prevent, manage and mitigate accidents. The NPP licensees have ongoing programs to systematically sustain (and, if necessary, update) the environmental qualification of safety and safety-related systems in accordance with CSA Group standard N290.13, *Environmental qualification of equipment for CANDU nuclear power plants*. To ensure environmental qualification technical issues are managed in a timely way, these programs typically involve a governance mechanism, a list of equipment to be maintained in the environmental qualification state, staff training, technical basis documents, and processes for dealing with emerging issues. The CNSC monitors the progress of these programs, in addition to conducting ongoing inspections of the systems.

18 (iii) Design for reliable, stable and manageable operation

Consideration is given to human factors and human–machine interfaces throughout the entire life of an NPP to make sure the NPP is tolerant of human errors.

The consideration of human factors in design and the application of human factors in engineering are described in subsection 12(e). Detailed design requirements in REGDOC-2.5.2 that are related to reliability, operability, human factors and the human–machine interface are provided in annex 18.

Additionally, CNSC REGDOC-2.3.2, *Accident Management*, Version 2 takes into account personnel needs, including aspects such as information, procedures, training and habitability of facilities required to manage accidents.

The requirements for safety parameter display illustrate how human factors and human–machine interface are considered in the design of Canadian NPPs. REGDOC-2.5.2 specifies a safety parameter display system that presents sufficient information on safety-critical parameters for the diagnosis and mitigation of design-basis accidents and design extension conditions. The safety parameter display system must be integrated and harmonized with the overall control room human–system interface design. The panel displays for existing CANDU NPPs can all show post-accident monitoring parameters (parameters that monitor when process or safety limits are being approached and the status of safety systems). SNC-Lavalin Nuclear has designed a dedicated safety parameter display system to provide a concise display of critical safety parameters and safety system status to aid the operations and emergency response staff in rapidly and reliably determining the safety state of the NPP.

Article 19 – Operation

Each Contracting Party shall take the appropriate steps to ensure that:

(i) the initial authorization to operate a nuclear installation is based upon an appropriate safety analysis and a commissioning programme demonstrating that the installation, as constructed, is consistent with design and safety requirements;

(ii) operational limits and conditions derived from the safety analysis, tests and operational experience are defined and revised as necessary for identifying safe boundaries for operation;

(iii) operation, maintenance, inspection and testing of a nuclear installation are conducted in accordance with approved procedures;

(iv) procedures are established for responding to anticipated operational occurrences and to accidents;

(v) necessary engineering and technical support in all safety-related fields is available throughout the lifetime of a nuclear installation;

(vi) incidents significant to safety are reported in a timely manner by the holder of the relevant licence to the regulatory body;

(vii) programmes to collect and analyze operating experience are established, the results obtained and the conclusions drawn are acted upon and that existing mechanisms are used to share important experience with international bodies and with other operating organizations and regulatory bodies.

(viii) The generation of radioactive waste resulting from the operation of a nuclear installation is kept to the minimum practicable for the process concerned, both in activity and in volume, and any necessary treatment and storage of spent fuel and waste directly related to the operation and on the same site as that of the nuclear installation take into consideration conditioning and disposal.

Introduction

Although sub-article 19(i) covers initial authorization to operate an NPP, the Canadian regulatory regime also entails set durations for licences to operate, as described in subsection 7(ii)(d), leading to renewals of the licences to operate the NPPs. During the reporting period, NB Power applied to renew its licence to operate Point Lepeau; the CNSC’s review of the application is described in subsection 14(i)(a).

This reporting period was one of the most efficient and safest in the history of the Canadian nuclear power program. There were very few events of any significance, which can be attributed to the operators focus on equipment reliability. For example, at Bruce Power there was a specific focus on reducing maintenance backlogs, eliminating operator challenges and work arounds, human performance training, eliminating single point vulnerabilities and reducing the number of deferrals of preventative maintenance. All of the operators have taken similar initiatives and as a result there has been fewer events and forced outages. This has also helped operators achieve long event free production runs. For example, at Bruce Power, it is now normal to have production runs of 500 or 600 plus days and for OPG, Darlington Unit 1 set the world record production run for a nuclear power reactor at 1105 days.

19(i) Initial authorization

There were no initial licensing activities related to operating a new NPP during the reporting period.

The CNSC's consideration of an application for an initial licence to operate an NPP is predicated on the applicant having already demonstrated conformance with the requirements for siting, design and construction (as outlined in subsections 7.2(ii)(b) and 7.2(ii)(c) and in articles 17 and 18). The information that an applicant is expected to submit with an application for a licence to operate is outlined in CNSC regulatory document REGDOC-1.1.3, *Licence Application Guide: Licence to Operate a Nuclear Power Plant* (see subsection 7.2(ii)(d) for additional details). The granting of an initial licence to operate is based upon an appropriate safety analysis and a commissioning program demonstrating that the NPP, as constructed and commissioned, meets design and safety requirements.

General requirements related to deterministic safety analysis and probabilistic safety assessment (PSA) are described in subsections 14(i)(c) and 14(i)(d), respectively. The final safety analysis report submitted with an application for a licence to operate a new NPP will be assessed against CNSC regulatory documents REGDOC-2.4.1, *Deterministic Safety Analysis*, REGDOC-2.4.2, *Probabilistic Safety Assessment (PSA) for Nuclear Power Plants*, and REGDOC-2.5.2, *Design of Reactor Facilities: Nuclear Power Plants*.

The objectives of regulatory oversight of the NPP commissioning program are to determine that:

- the commissioning program is comprehensively defined and implemented to confirm that the structures, systems and components (SSCs) important to safety and the integrated plant will perform in accordance with the design intent, safety analysis and applicable licensing requirements
- the operating procedures covering all operating and abnormal states have been validated to the maximum extent practicable
- the commissioning and operating staff have been trained and qualified to commission the NPP and operate it safely in accordance with the approved procedures
- the management system has been adequately defined, implemented and assessed to provide a safe, effective and high-quality working environment to perform and support the conduct of the commissioning program

Commissioning tests are to be performed in phases and in a logical progressive sequence as detailed in CNSC regulatory document REGDOC-2.3.1, *Conduct of Licensed Activities: Construction and Commissioning Programs*. There are at least four phases:

Phase A	prior to fuel load
Phase B	prior to leaving reactor guaranteed shutdown state
Phase C	approach to critical and low-power tests
Phase D	high-power tests

It should be noted that licensees may incorporate additional phases in a project; and that SMRs could have entirely different phases. There is a regulatory hold point at the end of each phase and, depending on the situation, the CNSC may request additional regulatory hold points. The selection of regulatory hold points will generally be agreed by the licensee and the CNSC and incorporated into the licence to operate the NPP.

Before proceeding to the next commissioning phase, the licensee demonstrates to the CNSC that all prerequisites established between the licensee and the CNSC necessary for proceeding beyond the current phase are met. In addition, before transitioning to the subsequent phase, the licensee ensures that SSCs credited in the safety case for that phase have been installed and confirmed to the extent practicable to meet their designed safety function.

The following steps should be undertaken at the end of each commissioning phase:

- Documents to certify the performance of tests and provide phase clearances for the continuation of the commissioning program should be prepared and issued.
- Test certificates should be issued by the commissioning organization to certify that the tests have been completed in accordance with authorized procedures, stating any reservations about departures from or limitations of the procedures.
- Phase completion certificates should be issued by the commissioning organization to certify that all the tests in the respective commissioning phase have been satisfactorily completed (listing all deficiencies and non-conformances, if any). Phase completion certificates should also list associated test certificates.
- It should be ensured that succeeding phases can be conducted safely and that the safety of the reactor facility is never dependent on the performance of untested SSCs.

As there is a regulatory hold point in place at the end of each phase, the written request to the CNSC for approval to proceed beyond a commissioning phase should confirm that:

- all related project commitments tied to the phase have been completed
- all systems required for safe operation beyond the phase are available
- all specified operating procedures have been formally verified and validated
- specified training has been completed and staff are qualified
- all non-conformances and unexpected results identified leading up to the next phase have been addressed

For each phase of commissioning, the licensee is expected to establish a set of commissioning control points (CCPs) to achieve a transparent, accountable and effective process for ensuring that the prerequisites for the release of each CCP have been formally demonstrated.

Some CCPs will also be regulatory hold points, requiring prior authorization by the Commission or a person authorized by the Commission to proceed further in the commissioning program. “Non-licensing” CCPs are usually treated as witness points that are observed by CNSC staff. Licensees are expected to exercise appropriate control of all CCPs. All applicable non-licensing CCPs must be satisfactorily completed to obtain the release from the regulatory hold points.

Details on the conduct of NPP commissioning programs, reactor designer input and the regulatory oversight of commissioning are provided in annex 19(i).

19 (ii) Operational limits and conditions

19 (ii) (a) Identification of safe operating limits

Paragraph 6(b) of the *Class I Nuclear Facilities Regulations* states the requirement to describe, in an application for a licence to operate, the facility's systems and equipment, including their design and operating conditions.

The safe operating limits satisfy regulatory requirements, standards and guidelines related to NPP design and operation, including defence-in-depth principles. Historically, these are implemented in operating manuals and impairment manuals (see sub-article 19(iv)).

The full set of requirements for safe operation of a CANDU NPP includes:

- requirements on special safety systems and safety-related standby equipment or functions (e.g., set points and other limiting parameters, and availability requirements)
- requirements on process systems (e.g., limiting parameters, testing and surveillance principles and specifications, and performance requirements under abnormal conditions)
- prerequisites for removing special safety systems and other safety-related or process standby equipment from service

These requirements are derived from design-basis safety analyses that are described in the safety analysis report. The safety analysis examines the NPP's responses to disturbances in process functions, system failures, component failures and human errors. Other requirements (e.g., those identified through design support analysis or PSA) could include limitations related to equipment and materials, operational requirements, equipment aging, instrumentation and analysis uncertainties, and more. Assessments of failure modes and effects analysis can also identify requirements that form part of the safe operating envelope (SOE). In principle, the analysis considers all allowable power levels; however, it is not feasible to analyze in advance every potential state that could occur throughout the life of an NPP. Therefore, the analysis attempts to consider sufficient situations to define operating limits that encompass the expected variations in conditions at a reasonable level of system/equipment performance detail. Operating limits for Canadian NPPs are identified in the SOE documentation. Changes to these limits that may negatively affect safety require appropriate justification by operations support staff and are reviewed by the CNSC.

19 (ii) (b) Safe operating envelope

The purpose of the SOE program is to clearly define the safe operating limits for NPPs so that they can be readily monitored by or on behalf of the operations staff. In the past, the licensees primarily used the operating policies and principles (OP&Ps) to define relevant operational limits. However, because the OP&Ps represented only a subset of the relevant limits, during previous reporting periods the licensees established a comprehensive set of limits, which are documented in operational safety requirements. The limits were based on deterministic safety analysis in accordance with CSA Group standard N290.15-10, *Requirements for the safe operating envelope of nuclear power plants*.

With SOEs now implemented, all licensees of operating NPPs commenced the maintenance phase and periodically review document changes resulting from revisions to design, operation, safety analysis or licence requirements against the SOE documents.

19 (iii) Procedures for operation, maintenance, inspection and testing

Operation, maintenance, inspection and testing of SSCs at the NPPs are conducted in accordance with approved governance and procedures that are incorporated in the NPP's management system (see subsection 13(a)). The governance defines the organizational and administrative requirements for the establishment and implementation of preventive, corrective and predictive maintenance; periodic inspections; tests; repairs and replacements; training of personnel; procurement of spare parts; provision of related facilities and services; and generation, collection and retention of operating and maintenance records.

CNSC REGDOC-2.6.2, *Maintenance Programs for Nuclear Power Plants* sets the requirements for policies, processes and procedures for maintaining the SSCs of each NPP. The range of maintenance activities specified includes monitoring, inspecting, testing, assessing, calibrating, servicing, overhauling, repairing and replacing parts – all intended to ensure that the reliability and effectiveness of all equipment and systems continue to meet the relevant requirements.

CNSC REGDOC-2.6.1, *Reliability Programs for Nuclear Power Plants* specifies that a reliability program for an NPP shall:

- identify all systems important to safety
- specify reliability targets for those systems
- describe the potential failure modes of those systems
- specify the minimum capabilities and performance levels of those systems needed to satisfy regulatory requirements and the safety targets of the NPP
- provide input for the maintenance program to maintain the effectiveness of those systems
- provide for inspections, tests, modelling, monitoring and other measures to assess the reliability of those systems
- include provisions to assure, verify and demonstrate that the program is implemented effectively
- document the elements of the program
- report the results of the program

The identification of systems important to safety is done using input from PSAs, deterministic analyses and expert panels.

NPP's have requirements for the maintenance and testing procedures for special safety systems to ensure that no safety function is ever compromised by maintenance activities. Safety system testing is required at a frequency that demonstrates each safety function is operating correctly and meets availability limits (typically, greater than 99.9% in the currently operating NPPs). Each component of a special safety system is subject to regular testing. Specific requirements for testing to confirm the availability/functionality of safety and safety-related systems are described in subsection 14(ii)(a).

Procedures used by NPP staff during routine operation of the NPP and its auxiliary systems are located in the operating manuals. The operating manuals contain:

- system-based procedures that assist the operators during normal operations, such as system start-up and shutdown and minor malfunctions limited to individual systems
- overall unit-control procedures that coordinate major evolutions such as unit start-up and shutdown and major plant transients

- alarm response manual procedures that provide the operations staff with information regarding alarm functions; typical information provided includes set points, probable causes of alarms, pertinent information, references and operator responses

To aid the safe and consistent operation of the NPPs, the licensees write detailed station condition records or event reports. These documents provide information on undesirable events considered significant in the operation of NPPs. They are reviewed to confirm safe operation and help identify necessary corrective actions or opportunities for improvement (see sub-article 19(vii) for more details). Less significant issues are also reported for trending purposes.

The NPP licensees implemented several improvements during the reporting period that will positively affect various aspects of operation, maintenance, inspection, testing and reliability. Improvements to surveillance hardware and software were also implemented to improve component and system surveillance and trending capabilities. For example, Bruce Power created efficiencies in its processes through the use of data analytics and artificial intelligence tools to reduce duplication and automate processes. This helped Bruce Power to reduce its priority maintenance backlogs by over 80% in 2021.

At Darlington, the shutdown system (SDS) monitoring computers for each unit were replaced in 2015 with a modern platform and software to address hardware obsolescence and implement operator interface improvements, as well as to sustain shutdown system reliability and plant safety for extended Darlington operations. Similarly, OPG is replacing the trip and display/test computers for both computerized safety shutdown systems during its scheduled refurbishment windows. The shutdown system computer replacement is complete on two units and the remaining replacements are planned between 2022 and 2026. Although all OPG NPPs have always had digital control and monitoring for reactor control and fuel handling, OPG is transitioning other control room instrumentation from analog to digital continued at all its NPPs to improve monitoring and control capabilities.

OPG has also implemented artificial intelligence tools to enhance efficiencies in the areas of engineering, maintenance and operations.

19 (iv) Procedures for responding to operational occurrences and accidents

The *Class I Nuclear Facilities Regulations* require each NPP licensee to have measures to prevent or mitigate the effects of accidental releases of nuclear substances and hazardous substances, as well as measures to assist offsite authorities in emergency preparedness activities. CNSC REGDOC-2.10.1, *Nuclear Emergency Preparedness and Response*, Version 2 provides the detailed requirements for onsite emergency plans and response capability. Emergency plans and programs, including accident management provisions, are submitted to the CNSC as part of the licence application (see subsection 16.1(b) for details). The CNSC also observes emergency training, exercises, drills and on-site severe accident management to confirm adequate implementation of the licensees' onsite provisions in their emergency response plans.

The consequences of reactor accidents can be minimized by sound onsite and offsite accident management. This is achieved by developing operating procedures in advance to assist and guide operators in responding to accidents. Each NPP licensee maintains a minimum staff complement to make sure there are always sufficient numbers of appropriately qualified staff available to respond to emergencies (for details, see annex 11.2(a)). All Canadian NPPs have a comprehensive, hierarchical set of manuals and procedures – covering normal plant operation, anticipated operational occurrences and accident conditions – that are routinely tested in onsite drills. Although procedures vary among NPPs, the system generally contains:

- an abnormal incident manual
- a special safety system impairments manual (which may be a subset of the abnormal incident manual)
- a radiation protection manual (or radiation protection directives)

The suite of abnormal incident manual procedures directs the operations staff following safety system impairment, process system failure or a common-mode event (anticipated operational occurrences). These are typically event-based procedures and have as their end points the safe shutdown of the unit. Critical safety parameter procedures provide support for all procedures but are especially useful during transients. They provide structure for the augmented monitoring of critical NPP operating parameters during specific accident conditions and in cases when the specific event cannot be determined. They also provide symptom-based frameworks for controlling the reactor, cooling the fuel and containing radioactivity.

Radiation protection manual procedures are provided to protect the safety of the operators and the general public under normal conditions and in the event of a significant radiation incident. These procedures:

- direct event classification and categorization
- provide for offsite notification
- direct protective actions and monitoring during accident conditions

Significant events are followed up by formal determination of root causes and with corrective actions that are commensurate with the situation.

Examples of safety-significant operational events occurring at Canadian NPPs during the reporting period are listed in appendix C. They illustrate how the licensees responded to the events and how the CNSC conducted regulatory follow-up. The licensees' efforts to address these operational events were effective in correcting deficiencies and preventing recurrence. None of the events posed a significant threat to persons or the environment. For example, there were no serious process failures[3] at any NPP during the reporting period. As noted above, the reporting period was one of the safest and most efficient in the history of the Canadian nuclear power program.

Severe accident management

Severe accident management (SAM) focuses on preventing the progression of an accident into a severe accident or mitigating a severe accident when the preventive means have failed. It relies on the design, guidance and procedural provisions used by NPP staff as well as appropriate training activities. Response to severe accidents can be enhanced by external resources that supplement or replace the onsite resources, including fuel, water, electric power or equipment such as pumps or generators. The CNSC's requirements and guidance are found in CNSC REGDOC-2.3.2, *Accident Management*, version 1 but are also addressed in CNSC REGDOC-2.3.2, *Accident Management*, version 2.

SAM provisions may differ among NPPs, depending on the location and nature of the NPP (single-unit facilities in relatively remote rural locations versus are multi-unit facilities close to major urban centres).

Severe accident management guidelines

The development and implementation of plant-specific SAM guidelines (SAMGs) require considerations of plant-specific designs, operation, equipment, instrumentation and organizational structure. This has included the development of instructions for roles and responsibilities of the personnel involved in SAM and emergency response, guidelines for control room and technical support group operations, specific staff training requirements and appropriate drills and exercises as part of SAMG validation.

The post-Fukushima review of procedural guidance and design capabilities of operating NPPs to cope with accidents, including those involving significant core damage, confirmed that SAMGs are adequate. The implementation of the post-Fukushima updates in SAMGs and the demonstration of SAMG effectiveness through exercises and plant drills are ongoing.

Emergency mitigating equipment (EME) guidelines (EMEGs) have been developed and implemented to guide the deployment of EME as an additional onsite capability to provide water and electricity to cope with accidents. Integration of plant procedures (e.g., abnormal incident manuals and emergency operating procedures) with SAMGs and EMEGs is complete. NPP licensees have deployed SAMG kits at strategic locations to allow for rapid implementation of SAMG measures. The kits include the tools, materials and equipment needed to carry out SAMG actions in a timely fashion.

Verification of the SAMG/EMEG documentation and training, along with the validation of the SAM program is being done mainly through table-top exercises, plant drills or large-scale emergency exercises that simulate severe accident scenarios.

CNSC staff oversight of SAM programs and SAMGs

During the reporting period, CNSC staff undertook a number of activities to review the licensees' SAM programs and SAMGs. These activities included:

- compliance review of the technical basis and documentation for NPP-specific SAMGs
- reviews of the EMEGs and their integration with SAMGs and other plant procedures and manuals
- evaluations of plant drills simulating severe accidents where SAMGs and EMEGs were exercised
- analytical simulations of severe accident progression with and without the SAMG-specified actions
- integral assessment while taking into account all the above

Fulfilling principle (2) of the VDNS

Principle (2) of the VDNS requires comprehensive and systematic safety assessments to be carried out periodically and regularly for existing installations throughout their lifetime to identify safety improvements that are oriented to meet the objective of principle (1) of the VDNS (chapter I). As described in section E of chapter I, the objective in principle (1) is that new NPPs are designed, sited and constructed, consistent with the objective of preventing accidents in the commissioning and operation and, should an accident occur, mitigating possible releases of radionuclides causing long-term offsite contamination and avoiding early radioactive releases or radioactive releases large enough to require long-term protective measures and actions. Principle (2) of the VDNS also requires reasonably practicable or achievable safety improvements, in support of that objective, to be implemented in a timely manner. The NPP licensees have procedures and guidelines to respond to operational occurrences and accidents that prevent escalation to more severe conditions and mitigate the consequences that could occur. The licensees have continued to improve those procedures for their existing facilities in a timely manner.

19 (v) Engineering and technical support

Necessary engineering and technical support in all safety-related fields must be available throughout the lifetime of an NPP, including during accident conditions or in the decommissioning phase.

Article 11 addresses licensee financial and human resources, which are planned throughout the NPP's life, including decommissioning. Budgets are also available to hire external service providers and establish contracts for support in areas outside the technical or engineering expertise of full-time staff. All NPP licensees have service contracts with other Canadian companies that include research, engineering, analysis, assessment, maintenance, inspections and design support. The CANDU R&D program, which supports the operating NPPs, is described in appendix D.

Canadian NPP licensees have supply chain processes to ensure that the services rendered to them serve the purpose and meet the relevant requirements. For example, OPG's supply chain process identifies a number of key attributes to enable recognition of the quality of outputs provided by outside organizations that might affect safety:

- sufficient staff to maintain specialized expertise in the required discipline (e.g., thermal hydraulics)
- in-depth knowledge of past and present regulatory issues
- rapport with regulatory staff specialists
- in-depth knowledge of NPP design and operation
- ability to provide leadership on technical issues within the Canadian nuclear industry

General information on the licensees' provisions for supply chain management is provided in article 13.

The NPP licensees utilize a design authority function to ensure that the integrity of approved designs and the design process is maintained. The design authority is executed by the Chief Engineer, which encompasses overall responsibility for the design process, approval of design changes, and assurance that the requisite knowledge of the reference design is maintained as defined and implemented in the management system. The scope of accountability ensures that:

- a knowledge base of relevant aspects of the facility and products is established and kept up to date, while experience and research findings are taken into account
- all design information required for a safe facility is available
- the requisite security measures are in place
- design configuration is maintained for approved designs
- appropriate design verification is applied
- all necessary interfaces are in place
- all engineering and scientific skills are maintained
- appropriate design rules and procedures, including codes and standards, are used

- engineering work is executed by qualified staff using appropriate methods in compliance with procedures

All Canadian licensees of operating NPPs have generally the same reactor design. Therefore, licensees work closely with their partners (e.g., through COG). Additionally, licensees can easily share technical and engineering resources. The licensees presently share the same contractors, including specialists, in such areas as:

- emergency response organizations
- technical support groups that include contractors to provide support during accident response for SAMG

Further, there are mutual assistance agreements within industry. Membership in organizations such as WANO and COG also provides access to assistance between member organizations.

19 (vi) Reporting incidents significant to safety

Licensees use station condition records or event reports to provide information on undesirable events that are considered significant in the operation of NPPs. The licensees determine the significance of these events using specific operational procedures. During the reporting period, the licensees reported safety-significant events to the CNSC in a timely manner and in accordance with the requirements of CNSC REGDOC-3.1.1, *Reporting Requirements for Nuclear Power Plants*. Additional information on the requirements and the work of CNSC staff to track and follow-up on safety-significant events at NPPs is provided in subsection 7.2(iii)(b).

The CNSC submits the descriptions of events that meet International Nuclear Event Scale (INES) thresholds to the IAEA Nuclear Event Web-based System.

Canada is also committed to reporting significant events occurring at Canadian NPPs to the International Reporting System (IRS) - a database of international events that is operated by both the IAEA and the NEA. Canada appoints a member of CNSC staff as a national coordinator to collect, analyze and submit information on events occurring in Canada. Actions taken in Canada to address events reported internationally are presented annually by Canada through its delegates to the appropriate fora, such as the IRS Technical Committee and/or the NEA Expert Group on Operating Experience.

Issues arising from OPEX (other than events) are reported in different fora. At the CNSC, such issues are disseminated at management meetings and via inspection reports. The screening of those issues that are to be shared with the public and international fora is performed as part of the preparation of event initial reports, which are submitted to the Commission.

At all NPPs, the significance of discoveries other than incidents (e.g., unexpected degradation of equipment, management issues raised through various means including WANO peer reviews, design weaknesses) is rated using criteria in the corrective action program.

19 (vii) OPEX

The NPP licensees conduct analysis and trending of events with relatively small safety significance to help prevent the occurrence of events with more significant consequences. The licensees have active OPEX programs facilitated by COG, WANO and the Electric Power Research Institute (EPRI).

Existing mechanisms are used to share important OPEX throughout the CANDU industry and with international bodies and other operating organizations and regulatory bodies.

The process of collecting, analyzing and disseminating lessons learned from information arising from OPEX is normally part of the licensees' quality assurance programs. CSA Group standard N286, *Management system requirements for nuclear facilities* requires measures to ensure OPEX is documented, assessed and incorporated into the operation of the NPP and its quality assurance programs, as appropriate. It also calls for sharing this information with personnel in the other phases of the NPP's lifecycle.

The primary sources of OPEX are station condition records and event reports. Other licensee reports include the licensees' quarterly and annual reports, in-service reports and internal audit reports.

The licensees integrate OPEX into all aspects of NPP operation and management. For example, Bruce Power, OPG and NB Power have developed a problem identification and corrective action system, while OPG has an OPEX intranet site that provides convenient access to the WANO, COG and Institute of Nuclear Power Operations (INPO) websites, as well as other OPEX resources.

COG provides an information exchange program and chairs a weekly OPEX screening meeting teleconference that serves as a CANDU screening committee of industry OPEX representatives to review event reports from CANDU NPPs and nuclear industry sources.

Additionally, the CNSC has established the OPEX Clearinghouse program to systematically review domestic and international events and to leverage the integrated expertise of CNSC staff to ensure that relevant events are followed up in a timely manner. The OPEX Clearinghouse draws information from several sources including the:

- Central Event Reporting and Tracking System, a database used to collect and categorize reported events at Canadian NPPs and track follow-up
- IRS
- NEA Expert Group on Operating Experience

Problems or issues that arise from event reviews and that may be applicable to other NPPs are identified and brought to the attention of CNSC site inspectors and different CNSC specialist groups.

CNSC staff incorporate the results of root-cause analyses in their reviews and assessments of a licensee's corrective actions in response to a certain event. Further actions are requested if the corrective actions undertaken by the licensee are considered inadequate. In addition, the CNSC site inspectors review the status of corrective actions to make sure they have been completed expeditiously.

CNSC inspection teams consult the OPEX in the Central Event Reporting and Tracking System when planning strategies for their inspections and in identifying problem areas in operation or maintenance (such as procedural non-compliance, procedural deficiencies and the use of non-standard components). Similarly, CNSC assessments often utilize the OPEX recorded in this database. As part of the inspection baseline, CNSC inspectors check the licensee's station condition records or event reports, along with system health reports, to ensure OPEX and the extent of condition review findings have been applied to the systems by the licensees.

19 (viii) Management of spent fuel and radioactive waste onsite

Responsibility and regulatory framework

The Government of Canada has established a comprehensive radioactive waste policy framework that consists of a set of principles governing the institutional and financial arrangements for disposal of radioactive waste by waste producers and owners. The Government of Canada will ensure that radioactive waste disposal is carried out in a safe, environmentally sound, comprehensive, cost-effective and integrated manner. The federal government has the responsibility to develop policy, to regulate and to oversee producers and owners to ensure that they comply with legal requirements and meet their funding and operational responsibilities in accordance with approved waste disposal plans. The waste producers and owners are responsible, in accordance with the principle of "polluter pays", for the funding, organization, management and operation of disposal and other facilities required for their wastes.

CNSC REGDOC-2.11, *Framework for Radioactive Waste Management and Decommissioning in Canada* describes the overall framework.

Under the CNSC's performance-based approach to regulation, the licence applicant proposes a waste management approach supported by scientifically defensible benchmarks. The CNSC then assesses the proposal against existing regulatory requirements to ensure the health, safety, and security of the public and the protection of the environment.

Paragraph 3(1)(j) of the *General Nuclear Safety and Control Regulations* requires all licence applicants who perform waste management activities to provide the name, quantity, form, origin and volume of any radioactive waste or hazardous waste that may result from the activities to be licensed. This information includes waste that may be stored, managed, processed or disposed of at the site of the activities to be licensed, and the proposed method for managing and disposing of that waste.

The *Class I Nuclear Facilities Regulations* specify that an application for a licence to operate any Class I nuclear facility, including a predisposal waste management facility, must contain the proposed measures, policies, methods and procedures for operating and maintaining the nuclear facility as well as the proposed procedures for handling, storing, loading and transporting nuclear substances and hazardous substances.

CNSC regulatory documents with requirements and guidance relevant to waste management include:

- REGDOC-2.11.1, *Waste Management, Volume I: Management of Radioactive Waste*
- REGDOC-2.11.1, *Waste Management, Volume III: Safety Case for the Disposal of Radioactive Waste*, Version 2

Additionally, the CSA Group has published the following standards relevant to waste management activities:

- CSA N292.0-19, *General principles for the management of radioactive waste and irradiated fuel*
- CSA N292.8-21, *Characterization of radioactive waste and irradiated fuel*
- CSA N294-19, *Decommissioning of facilities containing nuclear substances*

Oversight of radioactive waste management

The CNSC is responsible for licensing the management of radioactive waste, including, as applicable, its transport, storage and disposal. Since all nuclear substances associated with licensed activities will eventually become radioactive waste, the safe long-term management of all radioactive waste is considered during the licensing review process for any CNSC-licensed facility or activity.

When making regulatory decisions about the management of radioactive waste, the CNSC considers the extent to which the owners of the waste have addressed the following six principles, stipulated in REGDOC-2.11:

- the generation of radioactive waste is minimized to the extent practicable by the implementation of design measures, operating procedures and decommissioning practices
- the management of radioactive waste is commensurate with the waste's radiological, chemical and biological hazard to the health and safety of persons, to the environment and to national security
- the assessment of future impacts of radioactive waste on the health and safety of persons and the environment encompasses the period of time during which the maximum impact is predicted to occur
- the predicted impacts on the health and safety of persons and the environment from the management of radioactive waste are no greater than the impacts that are permissible in Canada at the time of the regulatory decision
- the measures needed to prevent unreasonable risk to present and future generations from the hazards of radioactive waste are developed, funded and implemented as soon as reasonably practicable
- the trans-border effects on the health and safety of persons and the environment that could result from the management of radioactive waste in Canada are not greater than the effects experienced in Canada

Waste minimization is also a key principle of CSA N292.0. For example, CSA N292.0 includes a requirement that the generation of radioactive waste shall be considered at all stages of a facility`s lifecycle, including design, construction and installation, commissioning, operation and decommissioning.

The CNSC requires licensees to implement and maintain a waste management program. Licensee waste management programs, must consider the waste hierarchy (i.e., reduce, reuse and recycle) and include strategies to minimize the production of waste and to reduce the overall volume of waste requiring long-term management, while taking into consideration the health and safety of workers and the environment in accordance with CSA N292.0.

Canada is a signatory to the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management (Joint Convention), an international agreement governing all aspects of the management of spent fuel and radioactive waste. The Joint Convention is a legally binding treaty that aims to ensure worldwide safe management of radioactive waste. It represents the participating countries' commitment to achieving and maintaining a consistent high level of safety in the management of spent fuel and radioactive waste as part of the global safety regime for ensuring the protection of people and the environment. The Joint Convention allows for the international peer review of a country's radioactive waste management programs. Prior to the peer review, Canada submits a national report demonstrating the measures taken to implement the agreement's obligations. Canada's national reports to the Joint Convention are published every three years and are available on the CNSC and IAEA websites.

Radioactive waste management

Canadian NPP licensees manage radioactive waste using methods similar to those practiced in other countries. The steps involved in the management of radioactive waste include: generation and control, handling (collecting, sorting, segregating, packaging, loading, transferring), processing (pre-treatment, treatment and conditioning), storage, transport, and disposal.

As final disposal options for radioactive waste disposal facilities are not yet available, primary emphasis is placed on: managing waste management; finding safe, practicable and environmentally acceptable solutions for the long-term management of radioactive waste to avoid imposing an undue burden on future generations; and controlling and minimizing the generation of radioactive waste.

NPP licensees minimize radioactive waste through:

- preventing the generation of radioactive waste, for example, through:
  - material control procedures to ensure materials do not unnecessarily enter radioactive areas
  - enhanced waste monitoring capabilities to reduce the inclusion of non-radioactive wastes with radioactive wastes
  - launderable personal protective equipment instead of single-use items
  - employee training and awareness
- reducing the volume (compaction, incineration, shredding, etc.) and radioactivity content of radioactive waste
- reusing and recycling materials and components

The CNSC expects the licensee to perform characterization to determine, or verify, the properties of the waste to assist with determining or finalizing conditioning, processing and disposition options, and verifying the suitability of the intended disposition path.

Radioactive wastes generated from NPP operations are classified as low-, intermediate-, or high-level radioactive waste. All wastes generated at NPPs are characterized and classified at their point of origin and segregated as likely clean or radioactive. Low- and intermediate-level radioactive wastes are further sorted into distinct categories, such as incinerable, compactable or non-processible. Sorting the wastes helps to facilitate its subsequent handling, processing, storage, transport and future disposal. The low- and intermediate-level wastes are then processed, if applicable, and placed into safe storage until a final disposal option becomes available.

The handling, processing, storage and transport of radioactive waste may be contracted out to other CNSC licensees. For example, this could include the decontamination of parts and tools, laundering of protective clothing and the refurbishment and rehabilitation of equipment.

Spent fuel is classified as high-level radioactive waste and is stored in interim storage at the site where it was generated in either wet or dry storage. When the fuel first exits the reactor, it is transferred to water-filled irradiated fuel bays for cooling and radiation shielding. After the minimum amount of time in the bays – six to ten years (the exact cooling period is site-specific) – the spent fuel can be transferred to an onsite, interim dry storage facility where the fuel is stored in containers or modules. The spent fuel will be stored on site in dry storage until a final disposal option becomes available.

The use of natural uranium in CANDU reactors results in fuel bundles – either fresh or irradiated – that cannot lead to a critical state either in air or light water. Therefore, a criticality accident cannot occur when CANDU fuel is stored in an irradiated fuel bay or dry storage facility. This is an inherent safety design of the CANDU system.

APPENDICES

Appendix A
Relevant websites

Document or organization	Web site
Nuclear Safety and Control Act	laws-lois.justice.gc.ca/eng/acts/N-28.3
Canadian Environmental Assessment Act,2012	laws-lois.justice.gc.ca/eng/acts/C-15.21
General Nuclear Safety and Control Regulations	laws-lois.justice.gc.ca/eng/regulations/SOR-2000-202
Class I Nuclear Facilities Regulations	laws-lois.justice.gc.ca/eng/regulations/SOR-2000-204
Radiation Protection Regulations	laws-lois.justice.gc.ca/eng/regulations/SOR-2000-203
Canadian Nuclear Safety Commission Cost Recovery Fees Regulations	laws-lois.justice.gc.ca/eng/regulations/sor-2003-212
Administrative Monetary Penalties Regulations (Canadian Nuclear Safety Commission)	laws.justice.gc.ca/eng/regulations/SOR-2013-139
Nuclear Liability and Compensation Act	laws.justice.gc.ca/eng/acts/N-28.1
Atomic Energy of Canada Limited	aecl.ca
Bruce Power	brucepower.com
Impact Assessment Agency of Canada	canada.ca/en/impact-assessment-agency.html
Canadian Nuclear Laboratories	cnl.ca
Canadian Nuclear Safety Commission	nuclearsafety.gc.ca
CANDU Owners Group	www.candu.org
CANTEACH (CANDU)	canteach.candu.org
Environment and Climate Change Canada	ec.gc.ca
Global Affairs Canada	international.gc.ca/international
Health Canada	hc-sc.gc.ca
Hydro-Québec	https://www.hydroquebec.com/residential/
Impact Assessment Act	https://laws.justice.gc.ca/eng/acts/I-2.75/index.html
Institute of Nuclear Power Operations	inpo.info
International Atomic Energy Agency	iaea.org
Natural Resources Canada	nrcan.gc.ca
NB Power	nbpower.com
Ontario Power Generation	opg.com

Document or organization	Web site
Public Health Agency of Canada	phac-aspc.gc.ca
Public Safety Canada	publicsafety.gc.ca
SNC-Lavalin Nuclear	snclavalin.com/en/nuclear
Transport Canada	
University Network of Excellence in Nuclear Engineering	unene.ca
Ontario Tech University	https://ontariotechu.ca/
World Association of Nuclear Operators	www.wano.info

Appendix B
List and status of nuclear power plants in Canada

Reactor	Licensee	Gross capacity (MW)	Construction start	First criticality	First Grid Connection	Operating status
Bruce A, Unit 1	Bruce Power	836	Jun. 1, 1971	Dec. 17, 1976	Jan. 14, 1977	Operating
Bruce A, Unit 2		836	Dec. 1, 1970	Jul. 27, 1976	Sep. 4, 1976	Operating
Bruce A, Unit 3		836	Jul. 1, 1972	Nov. 28, 1977	Dec. 12, 1977	Operating
Bruce A, Unit 4		836	Sep. 1, 1972	Dec. 10, 1978	Dec. 21, 1978	Operating
Bruce B, Unit 5	Bruce Power	872	Jul. 1, 1978	Nov. 15, 1984	Dec. 2, 1984	Operating
Bruce B, Unit 6		872	Jan. 1, 1978	May 29, 1984	Jun. 26, 1984	Operating
Bruce B, Unit 7		872	May 1, 1979	Jan. 7, 1986	Feb. 22, 1986	Operating
Bruce B, Unit 8		872	Aug. 1, 1979	Feb. 15, 1987	Mar. 9, 1987	Operating
Darlington, Unit 1	Ontario Power Generation	934	Apr. 1, 1982	Oct. 29, 1990	Dec. 19, 1990	Operating
Darlington, Unit 2		934	Sep. 1, 1981	Nov. 5, 1989	Jan. 15, 1990	Operating
Darlington, Unit 3		934	Sep. 1, 1984	Nov. 9, 1992	Dec. 7, 1992	Operating
Darlington, Unit 4		934	Jul. 1, 1985	Mar. 13, 1993	Apr. 17, 1993	Operating
Gentilly-2	Hydro-Québec	675	Apr. 1, 1974	Sep. 11, 1982	Dec. 4, 1982	Safe storage
Pickering, Unit 1	Ontario Power Generation	542	Jun. 1, 1966	Feb. 25, 1971	Apr 4, 1971	Operating
Pickering, Unit 2		542	Sep. 1, 1966	Sep. 15, 1971	Oct. 6, 1971	Safe storage
Pickering, Unit 3		542	Dec. 1, 1967	Apr. 24, 1972	May 3, 1972	Safe storage
Pickering, Unit 4		542	May 1, 1968	May 16, 1973	May 21, 1973	Operating
Pickering, Unit 5	Ontario Power Generation	540	Nov. 1, 1974	Oct. 23, 1982	Dec. 19, 1982	Operating
Pickering, Unit 6		540	Oct. 1, 1975	Oct. 15, 1983	Nov. 8, 1983	Operating
Pickering, Unit 7		540	Mar. 1, 1976	Oct. 22, 1984	Nov. 17, 1984	Operating
Pickering, Unit 8		540	Sep. 1, 1976	Dec. 17, 1985	Jan. 21, 1986	Operating
Point Lepreau	NB Power	705	May 1, 1975	Jul. 25, 1982	Sep. 11, 1982	Operating

Appendix C
Significant events during reporting period

Location/date[3]	Description	Corrective action by licensee	Regulatory action
Primary heat transport pump motor fire, Point Lepreau February 5, 2021	While returning to full power, with the station at critical low power, flames were observed coming from the top of a PHT pump motor. The cause of the fire was determined to be the unanticipated application of a pump motor brake at high speed. A similar unanticipated application of the brake had occurred a few days earlier, resulting in smoke. NB Power staff determined that the likely cause of the unanticipated brake application was that the neoprene bladder in the brake mechanism had a separation between layers of the neoprene which contained trapped air. As the pump heated up, the trapped air expanded and created a localized bubble in one region of the bladder causing an uneven application of the brakes at high speed.	To evaluate the event, NB Power formed a Complex Troubleshooting (CT) team, which included NB Power staff and experts from industry. NB Power conducted a root cause analysis following the event, finding a direct cause, two root causes and two contributing causes. The pump motor was swapped out with a spare motor and an extent of condition review was conducted on the other PHT pump motors; as a result, bladders and solenoid valves were replaced. Actions following an enhanced brake component inspection included: modifications to the maintenance procedure and increased monitoring during the next run-up.	CNSC site inspectors followed up on the event and were present throughout the troubleshooting process. CNSC staff issued a finding of non-compliance specific to a deficiency in declaring a fire emergency (rather than a fire alert), which led to a delayed notification to the supporting offsite fire departments as well as the regulator and other agencies.
Pickering Unit 5 stator cooling water failure	A stator cooling low-flow alarm and indication of generator hydrogen pressure falling led to a turbine generator runback and a unit setback,	OPG had reinstituted the PM prior to the event after a resin excursion occurred in the Unit 8 SCW system due to a degraded filter. However, OPG was waiting to	CNSC site inspectors performed a field inspection and monitored the status of Unit 5 with enhanced frequency. The field inspection

[18] All the events listed in this appendix were presented to the Commission during public hearings/meetings.

Location/date[3]	Description	Corrective action by licensee	Regulatory action
September 30, 2021	ultimately tripping the turbine on low stator cooling water (SCW) flow. Field reports indicated water was spraying from the SCW head tank. The hydrogen cooling system was leaking into the SCW system increasing the pressure, overwhelming the makeup tank and spilling water and hydrogen into the turbine hall, which needed to be vented to reduce the explosion hazard. The direct cause was determined to be a degraded duty filter in the water box, leading to a buildup of conductive debris, which short circuited the stator. A resulting sudden, brittle failure of the SCW water box cover filled the generator with debris. The filter had been in wet standby for three years when it was installed, despite supplier recommendation of one year in wet standby The root cause was determined to be the deferral and cancelling of preventive maintenance (PM) on the filter.	replace the filter in Unit 5 until an upcoming outage. A full replacement of all SCW filters was completed following the event. OPG performed a root cause analysis and will be issuing a corrective action plan to the CNSC in the next reporting period.	resulted in the issuance of a finding of medium safety significance related to the cancellation of the PM for the filters without suitable justification.
Bruce Units 3 and 6 July 5 to 8, 2021	On July 5, 2021, Bruce Power reported that outage measurements obtained in scrape samples from one Unit 6 pressure tube showed hydrogen	Both units were shut down at the time and there were no immediate safety concerns. Unit 6 pressure tubes were all removed and are being replaced as part of the	CNSC staff requested that Bruce Power: • analyze the impact of this information on the

Location/date[3]	Description	Corrective action by licensee	Regulatory action
	equivalent concentrations (Heq) above the generic predictions and exceeding the licence limit of 120 ppm. The measurement obtained at the burnish mark was 211ppm. On July 8, 2021, Bruce Power reported that scrape samples from a Unit 3 pressure tube also showed elevated Heq (131 ppm). The limit for Heq of 120 ppm applies to the length of the tube between the rolled joint burnish marks and is based upon validity limits of the current pressure tube fracture toughness model. Continued operation of units currently online was determined to be safe as: • the Heq level had no impact on fracture toughness at high temperatures • reactors were designed with consideration of an event of a pressure tube rupture and because adequate defence-in-depth design provisions are incorporated to ensure safe shutdown • there is no concern of elevated Heq in units that have recently been refurbished	Major Component Replacement Outage. Bruce Power completed technical operability evaluations for the remaining operating units. Units 1 and 2 were found to be unconditionally operable as their pressure tubes had been replaced. Units 4,5,7 and 8 were asserted to be operable based on material behaviour at full-power operating temperatures, lack of flaws observed in the region of interest and the concurrence between predictive and measured Heq values outside the region of interest where flaws are known to exist.	demonstration of pressure tube fitness for service • conduct necessary tests and analysis to verify that operation of all reactors remains within the licensing basis • inform the CNSC of any other measures taken in response to this information • assess the impact of this information on the plan for Unit 3 restart • analyze the hydrogen uptake model validity The CNSC issued a designated officer order to Bruce Power (and OPG) requiring them to obtain authorization from the Commission prior to restart of any units following any outage that results in the cooldown of the heat transport system.

Appendix D
Nuclear research and development in Canada related to nuclear power plants

D.1 Introduction and context

Canada holds the view that nuclear safety research is important in supporting the safe design and operation of NPPs. To obtain licensing approval in Canada, applicants (with the aid of the NPP designer) must be able to provide adequate safety justification. Fulfilling this responsibility includes the provision of adequate experimental data to support analytical models and safety analyses. As practice shows, ongoing experimental research is needed to address emerging issues for operating plants and for plant life extension. New reactor design requires substantial investment in research and development (R&D) to adequately demonstrate the safety of new technologies.

R&D supporting NPPs in Canada is conducted by many organizations, including Atomic Energy of Canada Limited (AECL), Canadian Nuclear Laboratories (CNL) and the CANDU Owners Group (COG), as well as utilities, universities and private-sector laboratories and other organizations. The following subsections describe the key elements of R&D supporting NPPs in Canada.

D.2 CANDU Owners Group R&D program (existing NPPs)

To support the safe, reliable and economic operation of CANDU reactors, the COG R&D program addresses current and emerging operating issues in the areas of:

- fuel channels
- safety and licensing
- health, safety and the environment
- chemistry, materials and components
- the Industry Standard Toolset (software for design, safety analysis, and operational support)
- strategic R&D

While this work generally supports operation of existing NPPs, COG also has initiatives related to small modular reactors (SMRs); see section D.3.2 for details.

The COG R&D program is co-funded by domestic CANDU licensees, CNL, the Romanian Societatea Nationala Nuclearelectrica, the Korea Hydro and Nuclear Power Company, Third Qinshan Nuclear Power Company Ltd, and CNNP Nuclear Power Operations Management Co. Ltd. (CNNO), with current funding of about $44 million annually, benefiting from a stable multi-year commitment. In addition, COG’s Joint Projects & Services supports domestic and international CANDU NPPs with co-founded, collaborative joint projects totaling $15 million to $20 million annually. COG holds an EPRI membership on behalf of the domestic CANDU licensees and the Romanian Societatea Nationala Nuclearelectrica.

In 2016, COG embarked on a strategic R&D program that focuses on developing technologies and other solutions to keep CANDU reactors operating safely, reliably and competitively for an extended plant life.

The COG member organizations also provide significant financial support to the Canadian University Network of Excellence in Nuclear Engineering (UNENE), an alliance of universities, nuclear power utilities, and research and regulatory agencies. Established as a not-for-profit corporation in 2002, UNENE supports and develops nuclear education, R&D capability in Canadian universities.

Fuel channels

The strategic objective of the fuel channels R&D program is to develop and support adequate models for the following phenomena and potential degradation mechanisms:

- crack initiation
- fracture toughness through the full operating range over the full operating life
- leak-before-break
- pressure tube rupture frequency
- deuterium ingress
- deformation including pressure tube to calandria tube gap predictions in support of blister avoidance
- fitness for service of Inconel X-750 fuel channel annulus spacers

Safety and licensing

The COG safety and licensing R&D program is focused on the following areas:

- plant aging
- safety design basis and safe operating envelope of existing facilities
- resolution of outstanding generic safety and licensing issues
- post-Fukushima enhancements and regulatory issues

This program comprises working groups and task teams covering containment, fuel and fuel channels, fuel normal operating conditions, reactor physics, thermal hydraulics and probabilistic risk assessment (PSA).

Health, safety and the environment

R&D on health, safety and the environment aim to:

- improve plant performance with respect to radiation protection and emissions reduction (both radiological and conventional)
- develop technologies to address issues associated with future refurbishment and decommissioning of aging facilities
- address regulatory issues associated with radiation dose management and with generating the required databases and models to address new and emerging regulations on the environmental impacts to non-human biota
- maintain R&D capability to address current and future industry issues in the areas of health physics and environmental impacts
- ensure future expertise will be available to deal with industry problems, by encouraging funding of R&D in Canadian universities to train future scientists and technologists for the industry
- leverage COG funding through undertaking collaborative research with other organizations that have common interests

Chemistry, materials and components

The chemistry, materials and components R&D program:

- covers a diverse range of issues that can affect the safe, reliable and efficient operation of major CANDU systems and their auxiliaries
- is focused to support long-term operation and plant life extension
- is integrated with the EPRI R&D program to maximize synergies and minimize duplication

It comprises working groups and task teams covering:

- chemistry
- concrete
- steam generator material integrity
- steam generator non-destructive inspection
- steels
- valves
- cables
- buried piping

Industry Standard Toolset

R&D for the Industry Standard Toolset – computer programs for CANDU reactor design and analysis – addresses:

- qualification, development and maintenance activities on computer codes
- migration to a modern thermalhydraulics code architecture

Strategic R&D

The Strategic R&D program focuses on developing the technologies and solutions needed to keep the current and refurbished fleet of CANDU reactors operating safely, reliably and competitively for an extended plant life (i.e., 60 to 90 years).

Strategic focus areas in progress:

- reduced outages: Develop technology to reduce maintenance effort during outages. This includes built-in inspection and monitoring provisions to minimize work during outages and possibly avoid or shorten outages.
- updated/enhanced computer codes: Provide updated/enhanced computer codes to better characterize safety margins.
- improved understanding of material properties: Develop an improved understanding of material properties of reactor core components (pressure tubes, calandria tubes, end fittings, feeders, spacers, etc.) to provide longer overall reactor life.
- decommissioning and long-term waste management: Develop technology and infrastructure to support decommissioning and long term waste management, including processes and procedures to minimize all forms of radioactive wastes and to reduce dose. This may include alternative fuel cycles to minimize high level waste.
- potential impacts of climate change: Assess potential impacts of climate change on existing and planned CANDU physical facilities, CANDU operations, nuclear activities (e.g. nuclear substance transportation, construction), and nuclear refurbishment work.

- low dose radiation: Advance knowledge and public acceptance.

D.3 Development and deployment of reactor designs

D.3.1 CANDU designs

Candu Energy, which is part of SNC-Lavalin Nuclear, in addition to providing services related to the operation of existing CANDU reactors, has four reactor designs:

- CANDU 6: Heavy-water moderated reactor utilizing natural uranium fuel and on-power refueling
- Enhanced CANDU 6 (EC6): Generation III, 700 MWe heavy-water moderated and cooled reactor based on the successful CANDU 6 model
- Advanced CANDU Reactor (ACR-1000): Generation III+, 1,200 MWe heavy-water reactor
- Advanced Fuel CANDU Reactor: Designed to use alternative fuel sources such as recovered uranium from the reprocessing of used light-water reactor fuel, in addition to the conventional natural uranium)

SNC-Lavalin Nuclear has an active Product Development program with annual funding to advance the CANDU design and technologies including the above-mentioned reactor designs and to support reactor operations. In addition, these developments include advancements in retube tooling designs such as the retube removal tooling to simultaneously remove the pressure tube and calandria tube during a retube project, which resulted in a reduction in worker dose while achieving a significant reduction in critical path time on the retube (refer to Article 18 (ii)). SNC-Lavalin Nuclear continues to maintain and further develop qualified analytical software used in the design and analysis of various reactors, and support reactor operations.

D.3.2 SMRs

Research and development is ongoing in support of the two current SMR projects at the licensing stage: OPG is partnering with GE Hitachi Nuclear Energy for the DNNP and Global First Power is working with Ultra Safe Nuclear Corporation for the project at Chalk River Laboratories. In addition, OPG continues to maintain agreements and memoranda of understanding with other SMR vendors to explore the feasibility of deploying other reactor technologies in Ontario. Other initiatives related to Canada’s SMR Action Plan are being executed in parallel.

The Strategic Innovation Fund is the federal government’s main funding mechanism for SMR research, development and demonstration projects. To date, the Strategic Innovation Fund has provided support to two SMR projects:

- $20 million to Terrestrial Energy on October 15, 2020 toward a $68.9 million project to conduct R&D in order to complete phase two of the Canadian Nuclear Safety Commission’s (CNSC) pre-licensing Vendor Design Review (VDR) by December 2021.
- $47.5 million to Moltex Energy on March 18, 2021 toward a $97.6 million project to develop a “Stable Salt Reactor-Wasteburner” SMR technology to potentially produce emissions-free energy that recycles existing nuclear fuel waste to fuel the production of clean energy.

The Atlantic Canada Opportunities Agency (ACOA) has also provided funding to SMR related projects. In March 2021, ACOA announced funding for the following projects:

- $3 million to Moltex Energy to demonstrate the company's technology to validate the viability of their technology to convert used CANDU fuel into recycled fuel usable in their SMR technology.
- $5 million to New Brunswick Power for site preparation to demonstrate SMR technologies at an approved site in New Brunswick.
- $562 thousand to University of New Brunswick to expand its capacity to support the SMR technology cluster in the province.

Bruce Power has entered into agreements and memoranda of understanding with several SMR vendors and other partners to investigate the feasibility of deployment of SMRs in Canada.

In addition, COG has initiated two vehicles for industry members to develop common technical positions to support SMR deployment among vendors and partners in SMR development (see subsection 9(c)).

D.4 AECL R&D program

AECL, through the Federal Nuclear Science and Technology (FNST) Work Plan, provides CNL with $76 million annually to perform nuclear-related science and technology research that supports core federal roles and responsibilities in the areas of energy, health, safety and security and the environment, while maintaining necessary capabilities and expertise at CNL. CNL also supports the nuclear industry through access to science and technology facilities and expertise on a commercial basis.

AECL is responsible for the management and oversight of the FNST Work Plan. The FNST Work Plan serves the collective interests of 14 federal departments and agencies that inform the program of work and budget in four theme areas:

1. Supporting the development of biological applications and understanding the implications of radiation on living things
    - This theme area supports S&T activities to further our understanding of the biological applications of nuclear research, including the understanding the effects of exposure to ionizing radiation on the health of Canadians. The theme area comprises three sub-themes: 1) understanding the health effects of ionizing radiation; 2) quantifying exposure to ionizing radiation; and 3) developing medical applications.
2. Enhancing national and global security, nuclear preparedness and emergency response
    - This theme area supports S&T activities to support the Government of Canada's national and international security and policy objectives in the areas of nuclear non-proliferation and counter-terrorism and the ability to respond in the event of a nuclear emergency and would include all preparedness and response responsibilities. The theme area comprises three sub-themes: 1) nuclear forensics and detection; 2) cyber security; and 3) emergency response and preparedness.
3. Supporting safe, secure and responsible use and development of nuclear technologies
    - This theme area supports S&T activities to maintain and improve the viability, competitiveness, safety and security of nuclear technologies in Canada and abroad, and to provide scientific-based information for regulations, codes, standards and licensing. The theme area comprises three sub-themes: 1) Advanced Reactors and Hybrid Energy Systems; 2) Reactor Sustainability; and 3) Hydrogen and Tritium.

4. Supporting environmental stewardship and radioactive waste management
    - This theme area supports S&T activities to support environmental stewardship and responsible nuclear waste management. The theme area comprises two sub-themes: 1) understanding of the effects of radiation on the environment; and 2) providing S&T to support radioactive waste management.

More information on AECL's FNST Work Plan and its projects can be found at 'Federal Nuclear Science & Technology Work Plan - AECL'

CNL's Canadian Nuclear Research Initiative (CNRI) is a program to support collaborative Advanced Reactor (AR) research projects with third-party proponents in Canada. The goal of the program is to accelerate the deployment of safe, secure, clean, and cost effective ARs in Canada. Annually, CNRI issues a call for proposals (CFP), and CNL enters into joint R&D projects based on the results of a review of these proposals. The objective of CNRI is to make CNL's technical capabilities and expert knowledge available and accessible to the AR community in order to equip them with the technical support required to progress towards AR deployment in Canada. An example of the list of focus areas for the 2021 CNRI Advanced Reactor CFP include: Advanced Fuels, Advanced Materials and Chemistry, Reactor Safety, and component development and testing.

D.5 CNSC research program

The CNSC funds extramural research to obtain knowledge and information needed to support the CNSC's regulatory mission. The program provides access to independent advice, expertise, experience and information through contracts placed with the private sector or through grants or contributions to other organizations in Canada and elsewhere. CNSC has high-level research goals which in turn are aligned to the CNSC's SCAs. These include:

- human performance management
- safety analysis
- physical design (including new technologies)
- fitness for service
- radiation protection
- environmental protection
- waste management

The CNSC research program issues grants and contributions to non-profit organizations, academic institutions and both domestic and foreign governments. Examples include:

- UNENE
- IAEA
    - International Generic Ageing Lessons Learned
    - Review of Safety-Related Aspects of Handling ALPS-Treated Water at the Fukushima Daiichi Nuclear Power Station
    - Small Modular Reactor Regulators Forum
    - External Events Safety Section
- OECD/NEA
    - Component Operational Experience, Degradation and Ageing Programme
    - High Energy Arcing Fault Events Project
    - Support for OECD Fire Incident Records Exchange Project Phase V

- Support for the International Common-Cause Data Exchange Phase VIII
- HALDEN Human, Technology and Organization Program

- USNRC
  - Cooperative Agreement of Thermalhydraulic Code Applications and Maintenance Program
  - Cooperative Severe Accident Research Program
  - Radiation Protection Code Analysis and Maintenance Program
  - International Steam Generator Tube Integrity Program ISG-TIP-6
- CSA Group
- ICRP

The annual budget of the CNSC research program is approximately $3.7 million, which is spread across 11 research goals.

D.6 Generation IV International Forum

In 2001, ten countries, including Canada, initiated the Generation IV International Forum (GIF) to collaboratively develop the next generation of nuclear energy systems that will provide competitively-priced and reliable energy in a safe and sustainable way. Currently, the GIF brings together 13 countries (Argentina, Australia, Brazil, Canada, China, France, Japan, Korea, Russia, South Africa, Switzerland, the United Kingdom and the United States), as well as Euratom – representing the 28 European Union members − to co-ordinate R&D on Generation IV systems.

The *Framework Agreement for International Collaboration on Research and Development of GIF Nuclear Energy Systems* (the GIF Framework Agreement), a treaty-level agreement, was signed in 2005. In 2016, the GIF Framework Agreement was extended by all 11 active GIF members for 10 years.

Under the GIF Framework Agreement, NRCan is the designated implementing agent for the Government of Canada. In Canada, nuclear energy falls constitutionally within the jurisdiction of the federal government. NRCan's role encompasses R&D, as well as the regulation of all nuclear materials and activities in Canada. NRCan promotes the sustainable development and responsible use of Canada's natural resources. It is responsible for ensuring the energy future for Canada through developing policies and programs which enhance the economic and environmental well-being of Canadians.

NRCan formally agreed to two System Arrangements in 2006, namely, for the Super Critical Water Reactor (SCWR) and Very High Temperature Reactor (VHTR) in 2006. NRCan withdrew from the VHTR system arrangement in 2012 because of the changes in the program priorities at the time, but continued in the SCWR system arrangement and signed (DG-ERB) the 10-year extension of the SCWR SA in 2016.

NRCan nominated Terrestrial Energy (TEI) to participate in the provisional System Steering Committee of the molten salt reactor (MSR) system arrangement in 2018. TEI formally agreed to the MSR memorandum of understanding in 2019. NRCan held consultations with various Canadian stakeholders in 2020 to explore other opportunities for participation in the GIF activities that would benefit Canadian efforts towards R&D of Small Modular Reactors. Based on these consultations, as of 2021, Canada has re-signed on to the VHTR system arrangement.

Appendix E
Description of the CNSC's assessment of performance for nuclear power plants

The CNSC's rating system uses information from regulatory activities to assess and summarize the performance of NPP and other licensees across the 14 CNSC SCAs. The CNSC uses three rating categories:

SA Satisfactory
BE Below expectations
UA Unacceptable

The definitions of these categories are as follows.

Satisfactory - Licensee meets all the following criteria.

- Performance meets CNSC staff expectations
- Licensee non-compliances or performance issues, if any, are not risk-significant
- Any non-compliances or performance issues have been, or are being, adequately corrected

Below expectations - One or more of the following criteria apply:

- Performance does not meet CNSC staff expectations
- Licensee has risk-significant non-compliance(s) or performance issue(s)
- Non-compliances or performance issues are not being adequately corrected

Unacceptable **-** One or both of the following criteria apply:

- Risk associated with a non-compliance or performance issue is unreasonable
- At least one significant non-compliance or performance issue exists with no associated corrective action

The CNSC's annual assessment of NPPs

The CNSC prepares an annual staff report for the Commission and the public on all Canadian NPPs. It includes any waste management facilities on the same site as one of the NPPs. The *Regulatory Oversight Report for Canadian Nuclear Power Generating Sites* integrates information gathered through CNSC staff licensing and NPPs' compliance verification activities. The activities include inspections (Type I, Type II, desktop and field), compliance technical assessments of licensee submissions, and surveillance and monitoring.

The report uses the rating system to summarize the SCA performance assessments for each NPP. The document makes comparisons where possible, shows trends and averages, and highlights significant issues in the industry at large. It uses a variety of SNSC safety performance indicators to illustrate safety performance. The annual staff report describes major developments, initiatives, issues and challenges during the year as related to the operating NPPs. It also describes major revisions to licence conditions handbooks during the year.

Table E.1 shows the specific areas that comprise each SCA. Table E.2 compares the IAEA safety factors to the SCAs.

Table E.1: CNSC functional areas, SCAs, and specific areas

Functional area	SCA	Specific area
Management	Management system	Management system
		Organization
		Performance assessment, improvement and management review
		OPEX
		Change management
		Safety culture
		Configuration management
		Records management
		Management of contractors
		Business continuity
	Human performance management	Human performance program
		Personnel training
		Personnel certification
		Work organization and job design
		Fitness for duty
	Operating performance	Conduct of licensed activities
		Procedures
		Reporting and trending
		Outage management performance
		Safe operating envelope
		Severe accident management and recovery
		Accident management and recovery
Facility and equipment	Safety analysis	Deterministic safety analysis
		Hazard analysis
		Probabilistic safety assessment
		Criticality safety
		Severe accident analysis
		Management of safety issues (including R&D programs)
	Physical design	Design governance
		Site characterization
		Facility design
		Structure design
		System design
		Components design
	Fitness for service	Equipment fitness for service/equipment performance
		Maintenance
		Structural integrity
		Aging management

Functional area	SCA	Specific area
		Chemistry control
		Periodic inspections and testing
Core control processes	Radiation protection	Application of ALARA
		Worker dose control
		Radiation protection program performance
		Radiological hazard control
	Conventional health and safety	Performance
		Practices
		Awareness
	Environmental protection	Effluent and emissions control (releases)
		Environmental management system
		Protection of people
		Assessment and monitoring
		Environmental risk assessment
	Emergency management and fire protection	Conventional emergency preparedness and response
		Nuclear emergency preparedness and response
		Fire emergency preparedness and response
	Waste management	Waste characterization
		Waste minimization
		Waste management practices
		Decommissioning plans
	Security	Facilities and equipment
		Response arrangements
		Security practices
		Drills and exercises
		Cyber security
	Safeguards and non-proliferation	Nuclear material accountancy and control
		Access and assistance to the IAEA
		Operational and design information
		Safeguards equipment, containment and surveillance
		Import and export
	Packaging and transport	Package design and maintenance
		Packaging and transport
		Registration for use

Table E.2: Comparison of IAEA safety factors to CNSC SCAs

IAEA safety factor	Related CNSC SCAs
Plant design	Management system, operating performance, safety analysis, physical design, fitness for service, radiation protection, conventional health

IAEA safety factor	Related CNSC SCAs
	and safety, environmental protection
Actual condition of structures, systems and components important to safety	Management system, safety analysis, physical design, fitness for service, radiation protection, conventional health and safety, environmental protection
Equipment qualification	Management system, safety analysis, physical design, fitness for service, radiation protection, conventional health and safety, environmental protection
Ageing	Management system, human performance management, operating performance, safety analysis, physical design, fitness for service, radiation protection, conventional health and safety, environmental performance
Deterministic safety analysis	Management system, safety analysis, physical design, fitness for service, radiation protection, emergency management and fire protection
Probabilistic safety assessment	Safety analysis, physical design, fitness for service
Hazard analysis	Management system, operating performance, safety analysis, physical design, fitness for service, radiation protection, conventional health and safety, environmental protection, emergency management and fire protection, security, safeguards and non-proliferation, transport and packaging
Safety performance	Management system, operating performance, safety analysis, fitness for service, radiation protection, conventional health and safety, environmental protection, waste management
Use of experience from other plants and research findings	Management system, human performance management, operating performance
Organization, the management system and safety culture	Management system, human performance management, operating performance
Procedures	Management system, human performance management, operating performance, radiation protection, conventional health and safety, emergency management and fire protection
Human factors	Management system, human performance management, operating performance, fitness for service, radiation protection, conventional health and safety
Emergency planning	Management system, human performance management, operating performance, conventional health and safety, emergency management and fire protection
Radiological impact on the environment	Management system, operating performance, environmental protection

Note: The 14 IAEA safety factors listed above are from IAEA Specific Safety Guide SSG-25, *Periodic Safety Review for Nuclear Power Plants.*

ANNEXES

Annex 7.2 (i) (a)
CNSC regulation-making process

When making or amending regulations, the CNSC must abide by the Government of Canada's regulatory policy *Cabinet Directive on Regulation*.

The CNSC starts a regulation-making or amendment process with regulatory policy analysis, in which issues are thoroughly considered within the current organizational and regulatory environment, with special consideration of their potential judicial, legislative, regulatory and societal impacts. This process includes pre-consultation with stakeholders to gain early input on potential regulatory proposals and to learn about concerns. Taking into consideration this feedback, the CNSC determines the approach it will take to the new or amended regulations and prepares drafting instructions that explain to legal drafters at Justice Canada what the CNSC wishes the regulations to contain.

At the same time, the CNSC documents the analysis and rationale for the regulations and how the following factors were considered:

- potential impact of the regulation on health and safety, security, and the environment, as well as the social and economic well-being of Canadians, including "gender-based plus" impacts
- cost or savings to government, business or Canadians and the potential impact on the Canadian economy and its international competitiveness
- regulatory alignment, both domestic and international, with other federal departments or agencies, other governments in Canada and Canada's foreign affairs
- degree of interest, contention and support among affected parties
- impacts on Indigenous Nations and communities and modern treaty implications

Draft regulations undergo a series of internal CNSC and Natural Resources Canada (NRCan) approvals before being presented to the Minister of Natural Resources. The Minister submits them to the Treasury Board for approval for pre-publication, which is done using the Government's *Canada Gazette*, Part I. This is a requirement of the *Statutory Instruments Act* and is intended to ensure all Canadians have the opportunity to comment on the proposed regulations, as drafted. The comment period varies from 30 to 75 days. The CNSC posts comments received during the pre-publication period on the CNSC website for interested parties to provide additional feedback.

Following the pre-publication comment period, the draft regulations are amended, if necessary, to take into account comments received from stakeholders. Once the final draft regulations are completed, they must again be circulated for internal approvals before being presented to the Commission. If approved by the Commission, the Minister of Natural Resources must recommend that the Governor in Council approve the draft regulations. Once approved and registered, the new or amended regulations are published in the *Canada Gazette*, Part II.

Annex 7.2 (i) (b)
Regulatory framework documents

Recently published regulatory documents are identified with the label “REGDOC”. Previous naming conventions are described in the footnote to the table below.

REGDOCs may provide specific information, clarifying to licensees and applicants what they must achieve to meet requirements, guidance that advises licensees and applicants on how to meet the requirements, and/or general information on the CNSC’s practices and processes.

REGDOCs are developed using a lifecycle approach, from identification of a regulatory issue or concern through analysis to determine the best regulatory approach, development and publication of the document and finally to regular review and continuous improvement of the document. In developing REGDOCs, CNSC staff apply lessons learned from industry operating experience and from international standards and guides, such as those published by the IAEA. Requirements and guidance for NPPs are technology-neutral and performance-based where practicable, take a risk-informed approach, and apply to SMRs or other (non-CANDU) power reactor technologies.

External stakeholders are provided the opportunity to comment on the proposed contents of each REGDOC through a rigorous public consultation process. Draft documents are published on the CNSC website and stakeholders are informed through various vehicles, including email notifications, the CNSC’s social media accounts and the Government of Canada’s central consultation website. In addition, the CNSC uses newsletters and targeted mail-outs to ensure affected stakeholders are aware of the consultation. Stakeholders are encouraged to provide their comments. In addition, all comments are published on the CNSC website inviting further feedback.

The table includes key documents of the CNSC and the CSA Group that are relevant to reactor facilities (existing NPPs and SMRs). Many of the CSA Group standards were written for CANDU reactors, but their requirements can be adapted to other reactor types. The CNSC documents are available on the CNSC website. All CSA Group nuclear standards may be viewed through the CNSC website or on the CSA Group website directly.

The CNSC licensing process takes a phased approach to implementing CNSC regulatory documents and CSA Group standards into licence conditions handbooks (LCHs). Many of the new CNSC REGDOCs and CSA Group standards listed in the table are in the process of being incorporated into LCHs. Some of the documents in the table are captured in LCHs for existing NPPs as guidance. Their applicability as requirements or guidance for new reactor facilities, including SMRs, will depend on the design and operation being proposed. The table also lists the IAEA standards that are referenced in the CNSC regulatory documents and CSA Group standards.

Regulatory framework developments for small modular reactors

During the reporting period, CNSC continued to ensure that the regulatory framework would be suitable for licence application involving SMR technology. In doing this, CNSC staff have consulted with technology developers and held outreach activities with the public at conferences and academic institutions. Recently developed or revised REGDOCs include REGDOC-1.1.1, *Site Evaluation and Site Preparation for New Reactor Facilities*, REGDOC-1.1.2, *Licence Application Guide: Licence* to Construct a Nuclear Power Plant, and REGDOC-1.1.3, *Licence*

Application Guide: Licence to Operate a Nuclear Power Plant. They communicate CNSC expectations with regards to the licensing of activities related to new reactor facilities. Additionally, the CNSC developed REGDOC-1.1.5, *Licence Application Guide: Supplemental Information for Small Modular Reactor Proponents*. This document is to be used in conjunction with other licence application guides and existing regulatory documents to assist proponents in developing risk-informed proposals that take into account CNSC expectations regarding all safety and control measures to support the safety case for the site.

CNSC regulatory framework documents and CSA Group standards related to NPPs

The following table includes published CNSC regulatory documents and CSA Group standards that are relevant to NPPs in the context of the CNS. Although older versions of these documents may still be in use for some NPPs, for simplicity this table only includes the latest documents and versions. Some of the more recently-published documents or versions are not yet implemented by any NPP licensee because a transition period is typically needed to align programs and other safety and control measures with the new documents. The table is organized according to the CNSC SCAs, although note that some SCAs are outside the scope of the CNS. Thus, not all CNSC regulatory documents and CSA Group standards that could be considered relevant to NPPs or NPP licensees and licence applicants are included. The last column lists the IAEA documents that are cited as references in each regulatory document or standard, although note that many more IAEA documents are indicated as “additional reading material” in the Canadian regulatory documents and standards.

Doc number[19]	**Document title**	**Referenced IAEA documents**
Management systems		
REGDOC-1.1.1	*Site Evaluation and Site Preparation for New Reactor Facilities*, Version 1.1 (2022)	• IAEA NS R 3 (Rev 1) • Safety Standards Series No.NS-G-3.2 • Safety Standards Series No. SSG-9 • Safety Standards Series No.NS-G-1.5 • Safety Standards, Series No.NS-G-3.6 • Specific Safety Guide No. SSG-18 • Safety Standards Series No. SSG-21 • Safety Standards Series No.NS-G-3.1 • Safety Series No.GSR Part2 • Safety Series No. GS-G-3.1 • Safety Series No. GS-G-3.5 • TECDOC-1657 • Safety Guide No.WS-G-2.3 • Safety Guide No.WS-G-2.3 • Safety Standards Series No.GS-R-2 • Safety Standards Series RS-G-1.8

[19] The naming convention for CNSC regulatory documents has evolved over time. All regulatory documents are now called REGDOCs when published. Some of the older CNSC regulatory documents that are still in use have numbers with other nomenclature. In this table, two other abbreviations are used: RD (regulatory document) and GD (guidance document). The document numbers for the CSA Group standards in the table begin with ‘N’ (nuclear series) with one exception – standard Z1000, which is applicable to conventional health and safety.

REGDOC-1.1.2	*Licence Application Guide: Licence to Construct a Nuclear Power Plant* (2019)	• Safety Guide No. GS-G-3.5
REGDOC-1.1.3	*Licence Application Guide: Licence to Operate a Nuclear Power Plant*, Version 1.1 (2022)	
REGDOC-1.1.5	*Supplemental Information for Small Modular Reactors* (2019)	
N290.19	*Risk-informed decision making for nuclear power plants* (2018)	• INSAG-10 • SSG-4
REGDOC-2.1.1	*Management System* (2019)	• GSR Part 2 • TECDOC-1169
REGDOC-2.1.2	*Safety Culture* (2018)	• Safety Report Series No. 83 • Safety Standards Series No. SF-1 • Safety Standards Series No. GSR Part 1 • Safety Standards Series No. GSR Part 2 • Safety Standards Series No. GS-G-3.5 • Safety Standards Series No. NS-G-2.4 • International Nuclear Safety Group report INSAG-24 • International Nuclear Safety Group report INSAG-15 • Safety Series Report No.11 • Information Circular 274 Rev. 1 Mod. 1 • Nuclear Security Series No. 7 • TECDOC -1801 • Nuclear Security Series No. 20 • Nuclear Security Series No. 13 • Nuclear Security Series No. 14 • NEI 09-07 Revision 1 • TECDOC -1329
N286-12	*Management system requirements for nuclear facilities* (2012)	
N286.7	*Quality assurance of analytical, scientific and design computer programs for nuclear power plants* (2016)	• TECDOC 1740
N286.10	*Configuration management for reactor facilities* (2016)	
N299 series	*Series of standards on*	• INSAG-15

N299.1 N299.2 N299.3 N299.4	*quality assurance program requirements for the supply of items and services for nuclear power plants* Category 1 (2019) Category 2 (2019) Category 3 (2019) Category 4 (2019)	• Safety Standard Series No. GS-G-3.5 • TECDOC-1329
Human performance management		
REGDOC-2.2.1	*Human Factors* (2019)	
REGDOC-2.2.2	*Personnel Training*, Version 2 (2016)	
REGDOC-2.2.3	*Personnel Certification: Radiation Safety Officers* (2014)	
REGDOC-2.2.3	*Personnel Certification, Volume III: Certification of Persons Working at Nuclear Power Plants* (2019)	
REGDOC-2.2.4	*Fitness for Duty: Managing Worker Fatigue* (2017)	
REGDOC-2.2.4	*Fitness for Duty, Volume II: Managing Alcohol and Drug Use*, Version 3 (2021)	• GSR Part I (Rev.1) • NS-R-2 • GS-G-1.3 • GS-G-1.2 • NS-G-2.4 • NS-G-2.8
REGDOC-2.2.4	*Fitness for Duty, Volume III: Nuclear Security Officer Medical, Physical and Psychological Fitness* (2018)	
REGDOC-2.2.5	*Minimum Staff Complement* (2019)	
Operating performance		
REGDOC-2.3.1	*Conduct of Licensed Activities: Construction and Commissioning* (2016)	• Specific Safety Guide No. SSG-28 • Safety Guide No. NS-G-2.3
REGDOC-2.3.2	*Accident Management*, Version 2 (2015)	• Safety Fundamentals No. SF-1 • Safety Standards Series No. NS-G-2.15, STI/PUB/1376 • Safety Standards Guide NS-G-2.15, STI/PUB/1376 • Safety Reports Series No. 32, STI/PUB/1167 • Services Series No. 9, IAEA-SVS-09 • Safety Requirements No. SSR-2/2

		• INSAG-10 • INSAG-12, 75-INSAG-3 Rev. 1 • TECDOC-1440
REGDOC-2.3.3	*Periodic Safety Reviews* (2015)	• Specific Safety Guide No. SSG-25 • Safety Fundamentals No. SF-1 • Safety Standards Series No. NS-G-2.10
N290.15	*Requirements for the safe operating envelope of nuclear power plants* (2019)	
Safety analysis		
REGDOC-2.4.1	*Deterministic Safety Analysis* (2014)	• Safety Reports Series No. 55 • Safety Standards Series No. NS-R-4 • Safety Standards Series No. SSG-2 • Safety Standards Series No. GSR Part 4
REGDOC-2.4.2	*Probabilistic Safety Assessment (PSA) for Nuclear Power Plants* (2014)	• Safety Standard SSG-3 • Safety Standard SSG-4 • Safety Fundamentals No. SF-1
REGDOC-2.4.3	*Nuclear Criticality Safety*, Version 1.1 (2020)	• Safety Standards, SSR-4, • Safety Standards, SSG-6, • Safety Standards Series No. GS-R-2 • Safety Standards Series No. SSR-6 Rev. 1
N286.7	*Quality assurance of analytical, scientific and design computer programs* (2016)	• TECDOC-1740
N290.16	*Requirements for beyond design basis accidents* (2016)	• INSAG-10 • Nuclear Energy Series No. NW-T-2.7 • Safety Series No. 98
N290.17	*Probabilistic safety assessment for nuclear power plants* (2017)	• Safety Standard SSG-3 • Safety Standard SSG-4 • TECDOC 1804 Safety Standards Series No. SSG-3 • Safety Standards Series No. SSG-4
N290.18	*Periodic safety review for nuclear reactor facilities* (2017)	• Safety Reports Series No. 57 • Safety Standards Series No. SSG-25 • TECDOC-1740
Physical design		
REGDOC-2.5.1	*General Design Considerations: Human Factors* (2019)	

REGDOC-2.5.2	*Design of Reactor Facilities: Nuclear Power Plants* (2014)	
RD-367	*Design of Small Reactor Facilities* (2011)	As REGDOC-2.5.2 above
N290.13	*Environmental qualification of equipment for nuclear power plants* (2018)	
N285.0/N285.6 series	*General requirements for pressure-retaining systems and components in CANDU nuclear power plants/Material Standards for reactor components for CANDU nuclear power plants* (2012)	
N287.1	*General requirements for concrete containment structures for nuclear power plans* (2014)	
N287.2	*Material requirements for concrete containment structures for nuclear power plants* (2017)	
N287.3	*Design requirements for concrete containment structures for nuclear power plants* (2014)	
N287.4	*Construction, fabrication, and installation requirements for concrete containment structures for nuclear power plants* (2019)	
N287.5	*Examination and testing requirements for concrete containment structures for nuclear power plants* (2020)	
N287.6	*Pre-operational proof and leakage rate testing requirements for concrete containment structures for nuclear power plants* (2022)	
N291	*Requirements for nuclear safety-related structures* (2019)	
N289.1	*General requirements for seismic design and qualification of nuclear power plants* (2018)	• Safety Standards Series No. NS-G-1.6 • Safety Standards Series No. NS-G-2.13 • Safety Report Series (SRS) No. 28 • Specific Safety Guide No. SSG-25 • Safety Report Series No. SR-66 • TECDOC-1333
N289.2	*Ground motion determination for seismic qualification of nuclear power plants* (2021)	• Safety Standards Series No. NS-G-1.5 • Safety Standards Series No. NS-G-3.6 • Safety Standards Series No. SSG-9

		• Safety Standards Series No. SSG-21 • TECDOC-1796 • TECDOC-CD-1833
N289.3	*Design procedures for seismic qualification of nuclear power plants* (2020)	• Safety Standards Series No. NS-G-1.6 • Safety Standards Series No. SSG-9 • Safety Standards Series No. NS-G-3.6
N289.4	*Testing procedures for seismic qualification of nuclear power plant structures, systems and components* (2022)	
N289.5	*Seismic instrumentation requirements for nuclear power plants and nuclear facilities* (2012)	
N290.0/N290.2 Package	*General requirements for safety systems of nuclear power plants (2017)* *Requirements for emergency core cooling systems of nuclear power plants* (2017)	• NS-G-1.11
N290.0/N290.1 Package	*General requirements for safety systems of nuclear power plants (2011)* *Requirements for the shutdown systems of nuclear power plants* (2013)	
N290.0/N290.3 Package	*General requirements for safety systems of nuclear power plants (2011)* *Requirements for the containment system of nuclear power plants* (2016)	
N290.4	*Requirements for reactor control systems of nuclear power plants* (2011)	
N290.5	*Requirements for electrical power and instrument air systems of CANDU nuclear power plants* (2016)	
N290.6	*Requirements for monitoring and display of nuclear power plant safety functions in the event of an accident* (2016)	• NP-T-3.16
N290.11	*Requirements for reactor heat removal capability during outage of nuclear power plants* (2021)	
N290.14	*Qualification of digital hardware and software for use in instrumentation and control applications for nuclear power plants* (2015)	

N290.12	*Human factors in design for nuclear power plants* (2014)	
Fitness for service		
REGDOC-2.6.1	*Reliability Programs for Nuclear Power Plants* (2017)	• TECDOC-524
REGDOC-2.6.2	*Maintenance Programs for Nuclear Power Plants* (2017)	
REGDOC-2.6.3	*Aging Management (2014)*	• Safety Standards Series, Safety Guide, No. NS-G-2.12 • Safety Report Series No. 57 • Safety Standards Series, Specific Safety Guide, SSG-25 • Safety Report Series No. 82
N285.4	*Periodic inspection of CANDU nuclear power plant components* (2019)	
N285.5	*Periodic inspection of CANDU nuclear power plant containment components* (2018)	
N285.7	*Periodic inspection of CANDU nuclear power plant balance of plant systems and components* (2015)	• TECDOC-1511
N285.8	*Technical requirements for in-service evaluation of zirconium alloy pressure tubes in CANDU reactors* (2021)	
N287.7	*In-service examination and testing requirements for concrete containment structures for nuclear power plants* (2017)	
N287.8	*Aging management for concrete containment structures for nuclear power plants* (2015)	• Safety Report Series No. 57 • NS-G-2.12 • TECDOC-1025
N290.8	*Technical specification requirements for nuclear power plant components* (2015)	
N290.9	*Reliability and maintenance programs for nuclear power plants* (2019)	
N290.20	*Aging management requirements for nuclear power plants*	• TECDOC-1740 • Safety Report Series No. 57 • Safety Report Series No. 82 • Safety Standards Series No. SSG-25 • Safety Standards Series No. SSG-48

		• Safety Standards Series No. SSR-2/2 (Rev.1)
Radiation protection		
REGDOC-2.7.1	*Radiation Protection* (2021)	
REGDOC-2.7.2	*Dosimetry, Volume I: Ascertaining Occupational Dose* (2021)	• TECDOC-1162 • Safety Series No. 114 • Safety Report Series No. 37
REGDOC-2.7.2	*Dosimetry, Volume II: Technical and Management System Requirements for Dosimetry Services* (2020)	
Conventional health and safety		
REGDOC-2.8.1	*Conventional Health and Safety* (2019)	
Z1000	*Occupational health and safety management* (2014)	
Environmental protection		
REGDOC-2.9.1	*Environmental Protection: Environmental Principles, Assessments and Protection Measures*, Version 1.2 (2020)	
N288.1	*Guidelines for modelling radionuclide environmental transport, fate, and exposure associated with the normal operation of nuclear facilities* (2020)	• Safety Report Series No. 19 • Safety Series No. 50-5G-59 • TECDOC-857 • TECDOC-964 • Technical Reports Series No. 364 • Technical Reports Series No. 422 • Technical Report Series No. 472
N288.2	*Guidelines for calculating the radiological consequences to the public of a release of airborne radioactive material for nuclear reactor accidents* (2019)	• Safety Guide No. NS-G-3.2 • Safety Guide No. 50-P-12 • Safety Guide No. GS-G-2.1 • Safety Guide No. GS-R-2 • GSR Part 7 • TECDOC-955 • TECDOC-1200
N288.3.4	*Performance testing of nuclear air-cleaning systems at nuclear facilities* (2013)	
N288.4	*Environmental monitoring programs at nuclear facilities and uranium mines and mills* (2019)	• AQ 48 • Safety Series No. RS-G-1.2

N288.5	*Effluent and emissions monitoring programs at nuclear facilities* (2022)	
N288.6	*Environmental risk assessments at nuclear facilities and uranium mines and mills* (2022)	• Safety Reports Series No. 21 • Technical Reports Series No. 332 • Technical Reports Series No. 472 • Technical Report Series No. 479
N288.7	*Groundwater protection programs at Class I nuclear facilities and uranium mines and mills* (2015)	• Safety Guide No. WS-G-1.2
N288.8	*Establishing and implementing action levels for releases to the environment from nuclear facilities* (2017)	
N288.9	*Guideline for design of fish impingement and entrainment programs at nuclear facilities* (2018)	
Emergency management and fire protection		
REGDOC-2.10.1	*Nuclear Emergency Preparedness and Response*, Version 2 (2016)	• Safety Standards Series GS-R-2 • Safety Standards Series GS-G-2.1
N293-12	*Fire protection for nuclear power plants* (2012)	• INSAG Series No. 10 • INSAG Series No. 12 • Safety Reports Series No. 10 • Safety Reports Series No. 46 • Safety Standards Series No. NS-G-1.7 • Safety Standards Series No. NS-G-2.1
N1600	*General requirements for nuclear emergency management programs* (2021)	• EPR-Exercise (2005) • EPR Public Communication (2012) • EPR Public Communication Plan (2015) • EPR Method (2003) • EPR-NPP Public Protective Actions (2013) • IAEA-SVS-12 (Rev 1) (2016) • Safety Glossary (2018) • Safety Guide GS-G-2.1 (2007) • Safety Standards No. GSG-11 (2018) • General Safety Guide GSG-13 (2018) • Safety Standards Series No. GSR Part 7 (2015)
REGDOC-3.1.1	*Reporting Requirements for Nuclear Power Plants*, Version 2 (2016)	

REGDOC-3.2.1	*Public Information and Disclosure* (2018)	
REGDOC-3.2.2	*Indigenous Engagement*, Version 1.2 (2022)	
REGDOC-3.5.1	*Information Dissemination: Licensing Process for Class I Nuclear Facilities and Uranium Mines and Mills*, Version 2.1 (2022)	
REGDOC-3.5.2	*Compliance and Enforcement: Administrative Monetary Penalties, Version 2* (2015)	
REGDOC-3.5.2	*Compliance and Enforcement, Volume II: Orders under the Nuclear Safety and Control Act* (2019)	
REGDOC-3.5.3	*Regulatory Fundamentals*, Version 2.1 (2022)	
REGDOC-3.5.4	*Pre-licensing Review of a Vendor's Reactor Design* (2018)	

Annex 7.2 (iii) (b)
Details related to verification of compliance

The following table indicates some of the systems and areas of verification activities that are covered by Type II and field inspections at operating NPPs.

Processes and functions	**Facilities and equipment**
Fuel handling Startup Shutdown safety Heat sinks Outage management Fuel and physics Pressure boundary Effluent control and monitoring Environmental monitoring	Control room Reactor building Turbine hall Battery room Control equipment room Containment Emergency coolant injection Shutdown system 1 Shutdown system 2 Stand-by safety systems Safety-related systems Electrical systems Emergency mitigation equipment

Annex 8.1 (b)
CNSC organizational details

The CNSC includes five branches that report to the President: Legal and Commission Affairs, Regulatory Operations, Technical Support, Regulatory Affairs and Corporate Services. Regulatory Operations Branch and Technical Support Branch are described in subsection 8.1(b), whereas the Technical Support, Regulatory Affairs and Corporate Services Branches are described below. Besides the five branches, the Internal Audit, Evaluation and Ethics Division (IAEED) also reports to the CNSC President. Its evaluation function is described in subsection 8.1(e), whereas its values and ethics services are described here.

Internal Audit, Evaluation and Ethics Division (IAEED) – Values and Ethics

The Values and Ethics function within the IAEED administers five internal ethics-related programs that directly or indirectly support regulatory independence:

- The Values and Ethics Program provides counselling and training to CNSC employees to support ethical decision making in the work environment.
- The Internal Disclosure Program is designed to help employees safely and constructively disclose wrongdoing and protects them from reprisal when making allegations in good faith or testifying in disclosure cases under the *Public Servants Disclosure Protection Act*.
- The Conflict of Interest and Post-employment Program offers employees tools to prevent and avoid situations that could create the appearance of a conflict of interest or result in a potential or actual conflict of interest.
- The Political Activities Guidelines set the principles that allow employees to engage in election campaigns while upholding their duty to conduct their CNSC responsibilities in a politically impartial manner.
- The fraud risk management oversight program ensures that the CNSC has effective controls in place to prevent, detect and respond to fraud risks.

The IAEED also manages complaints made by external entities to ensure that a neutral body within the CNSC oversees the investigation and resolution processes.

Technical Support Branch

The Technical Support Branch consists of a large number of employees with particular knowledge and skills who provide technical support to the activities of the Regulatory Operations Branch (including the Directorate of Power Reactor Regulation) and the Regulatory Affairs Branch. The branch accomplishes this by providing specialist advice for regulatory programs, reviewing NPP licensee submissions, participating in inspections and helping to develop regulatory framework documents. Collaborations frequently include contributions involving several disciplines from across the Technical Support Branch and the Regulatory Operations Branch, requiring an integrated approach to resolving issues. The staff of the Technical Support Branch also share scientific and technical information and experience with stakeholders in Canada and other countries and undertake special projects within their expertise and mandate.

The Technical Support Branch comprises four directorates:

- Directorate of Assessment and Analysis
- Directorate of Safety Management
- Directorate of Environmental and Radiation Protection and Assessment
- Directorate of Security and Safeguards

The Directorate of Assessment and Analysis has expertise in the areas of chemistry, nuclear fuel, reactor physics, engineering (electrical, materials, mechanical, metallurgical, nuclear, civil/structural, and systems), design, aging management, maintenance, and equipment qualification, as well as fire protection, robustness, vulnerability design engineering and safety analysis, including deterministic safety analysis, probabilistic safety assessment and hazards analysis. The Directorate of Assessment and Analysis consists of six divisions:

- Engineering Design Assessment Division
- Operational Engineering Assessment Division
- Probabilistic Safety Assessment and Reliability Division
- Systems Engineering Division
- Reactor Behaviour Division
- Reactor Physics and Thermalhydraulics Division

The Directorate of Safety Management has expertise in the areas of human and organizational safety management, human factors, safety culture, management systems, examination, certification and training. It consists of four divisions:

- Management Systems Division
- Personnel Certification Division
- Human and Organizational Performance Division
- Training Program Evaluation Division

The Directorate of Environmental and Radiation Protection and Assessment has expertise in the areas of environmental assessment/impact assessment, environmental risk assessment, environmental monitoring and environmental management systems, as well as radiation protection, dosimetry and health sciences. It consists of five divisions:

- Environmental Risk Assessment Division
- Environmental Assessment Division
- Laboratory Services Division
- Radiation Protection Division
- Health Sciences and Environmental Compliance Division

The Directorate of Security and Safeguards has expertise in the area of emergency management and response. It is responsible for the CNSC’s Nuclear Emergency Management Program, including its implementation and the planning of activities with other federal/provincial agencies and international organizations (see article 16). It also has expertise in nuclear security; import and export of nuclear substances, equipment and devices; safeguards; and non-proliferation. It consists of four divisions:

- Nuclear Security Division
- Emergency Management Programs Division
- Non-proliferation and Export Control Division
- International Safeguards Division

Regulatory Affairs Branch

The Regulatory Affairs Branch plays a central role in managing the regulatory framework in addition to communications and stakeholder relations. It encompasses the Regulatory Policy Directorate, the Strategic Planning Directorate and the Strategic Communications Directorate. The Regulatory Policy Directorate is charged with managing the regulatory framework, which includes reviews of the adequacy of regulatory instruments, management of their revision, and producing new instruments (including new REGDOCs). The Strategic Planning Directorate is responsible for planning and reporting at the organizational level (e.g., reporting to Parliament), and for evaluating the CNSC's effectiveness and efficiency in relation to its regulatory mandate. It also manages international affairs and Indigenous relations. The Strategic Communications Directorate is responsible for both internal and external communications and hence contributes to measures related to openness and transparency.

Corporate Services Branch

The Corporate Services Branch manages organizational-wide services, activities and resources that are administered to support the needs of programs and other corporate obligations of the organization. These include management and oversight, human resources management, financial management, information and technology management, acquisition services, and other administrative services. It provides services and resources that apply across the organization.

Annex 9 (c)
Public information programs of NPP licensees and applicants

The availability and clarity of information pertaining to nuclear activities is essential to establishing an atmosphere of openness, transparency and trust between the applicant/licensee and the public.

The primary goal of a public information and disclosure program is to ensure that information related to the health, safety and security of persons and the environment, and other issues associated with the lifecycle of the NPP are effectively communicated in plain language to the public, stakeholders, target audiences and Indigenous Nations and communities.

Public information and disclosure programs are supported by disclosure protocols that outline the type of information on the facility and its activities that will be shared with the public (e.g., major changes to operations, periodic environmental performance reports) and timelines for sharing that information.

Each licensee works to keep all its target audiences informed of current and future operations, emergency preparedness measures, and its commitment to safety, security and the environment. The licensee does this through the production and distribution of community newsletters, open house meetings, website updates, event reporting, news releases, community partnership and sponsorship, public and Indigenous engagement, social and traditional media, government relations, external stakeholder engagement, and employee and retiree communication tools.

During the reporting period, NB Power, Bruce Power and OPG (Darlington) requested licence renewals or amendments for their power reactor operating licence. Because of the importance of these requests, specific licence renewal or amendment information packages, including operational and scientific information were communicated with the public and target audiences.

Prior to licence renewals, each licensee consults the public, its stakeholders, its target audiences and Indigenous Nations and communities through various methods previously determined as meaningful to its audiences. Topics of discussion include licence requirements (such as those related to the environment, safety and security), periodic safety reviews, waste management, *Fisheries Act* authorization information, Indigenous engagement and environmental risk assessments. In parallel, CNSC staff complete a full review of each public information program and hosted independent engagement sessions to provide audience-specific public information to communities associated with each licence renewal. In turn, members of the public and target audiences have the opportunity to meet directly with the CNSC.

The public information and disclosure programs of NPP licensees are required to have the following elements:

- objectives
- target audience identification
- public and media opinion-tracking
- public information strategy and products
- public disclosure protocol
- public disclosure notification to the CNSC
- program evaluation and improvement process

- documentation and records
- contact information

The public information strategies and products within the licensees’ programs typically consist of:

- community newsletters mailed directly to households and businesses
- advertising in local newspapers
- regular updates provided to local municipal, provincial and federal governments
- an interactive visitors’ centre
- annual open houses on operational performance
- an Indigenous affairs program
- communication with employees
- an informative website and social media channels
- regular information sessions on topics identified as areas of public interest
- public polling and focus groups to gather information on public opinion
- media releases

For illustration, some examples of the public outreach undertaken by Bruce Power, NB Power and OPG during the reporting period are described below.

During the reporting period, Bruce Power:

- consulted with Indigenous Nations and communities whose treaty or Indigenous rights may be directly affected by the NPP’s operation
- continued an Indigenous scholarship program to assist students as they further their studies at post-secondary institutes
- offered to the public (prior to the onset of the pandemic) free summer bus tours to the public (in 2019, more than 6,200 people took advantage of the initiative, visiting the Bruce Power Visitors’ Centre and learning more about nuclear power followed by a bus tour of the site; in its fifth year, the program attracts visitors from summer tourists from across Canada and internationally)
- posted its monthly newsletter on its website
- continued to invest in support programs in the local community (e.g., health and wellness, youth development)
- conducted regular provincial and regional public opinion polling to scientifically measure support in a number of key areas
- conducted a series of television advertising campaigns in the Province of Ontario to promote the production of cobalt-60 and lutetium-177 by Bruce Power for the use in sterilizing medical equipment and in cancer treatment
- provided updates on a number of site initiatives including the major component replacement outage for Unit 6, Bruce Power Net Zero and power increases due to turbine side efficiency improvements
- provided public updates on the pressure tube inspections that had discovered elevated hydrogen content
- hosted a number of virtual community open houses with local health officials to provide COVID-19 information to the local communities
- supported a number of communities with the setup of “Hockey Hub” COVID-19 vaccination clinics and recovery centres in hard-hit communities

During the reporting period at Darlington, OPG:

- distributed a community newsletter, 'Neighbours', three times per year to more than 100,000 households and businesses in Clarington and Oshawa (the newsletter is also available online)
- provided regular updates to local municipal levels of government, community organizations and local businesses
- provided regular updates to existing community committees (Durham Nuclear Health Committee, Darlington Community Advisory Council) and other stakeholders
- held regular meetings with local Indigenous Nations and communities regarding Darlington operations, environmental reporting and projects (refurbishment updates, DNNP mid-term report) as well as OPG's "Indigenous opportunities in nuclear" employment and training program
- shared information on what to do in the event of a nuclear emergency
- provided support to community initiatives through its corporate citizenship program
- provided information to the public through its website and social media program (tens of thousands of visitors annually to its website, more than 3,000 Instagram followers and more than 1,200 Facebook followers)

During the reporting period, NB Power:

- hosted virtual and in-person public information sessions to keep the public apprised of activities, including the licence renewal process and the full-scale integrated emergency exercise (Synergy Challenge)
- hosted stakeholder meetings throughout the province to provide updates on activities at Point Lepreau
- held community meetings with Indigenous Nations and communities, municipalities, local fisher and community representatives, environmentalists and the general public to discuss NB Power activities including its *Fisheries Act* authorization, licence renewal and NPP operations
- supported the local naturalist clubs by allowing access and services to the Point at Point Lepreau to support observation of migrating birds and monarch butterfly tagging programs and activities
- hosted Indigenous Nations and communities and members of the public at Point Lepreau to participate in and learn about environmental protection initiatives
- participated in monthly meetings with New Brunswick Indigenous representatives to discuss and share NB Power activities as well as learn from their community members interests and activities
- provided information to the public through its website and social media
- distributed its quarterly newsletter within a 20 km radius of the NPP and posted the newsletter to the NB Power website
- conducted regular provincial public opinion polling to measure support and understand key interests
- produced, distributed to the local communities and posted on the NB Power website a calendar featuring pictures taken within the local community and containing information on general and nuclear emergency preparedness and background information on radiation
- supported community initiatives through the NB Power corporate citizenship program

- participated in educational programs with local school children, youth and college/university students
- participated in trade and technical education initiatives to promote science and technology
- provided speakers to various service clubs and organizations

In addition to the typical public information programs for existing NPPs, Bruce Power, NB Power and OPG also conduct on-going and comprehensive outreach programs focused on the pre-distribution of potassium iodide pills in the vicinity of their NPPs. More details can be found in subsection 16.1(d).

Indigenous Nations and communities and external stakeholders were informed that the CNSC received the licence application from Global First Power (during the previous reporting period for its project at Chalk River). Outreach and consultation are ongoing following the processes established for environmental assessment and CNSC licensing. Throughout the reporting period GFP held several town halls and open houses as well as engaged directly with various Indigenous organizations and external stakeholders, including community members and elected officials.

Annex 10 (a)
Safety policies at the nuclear power plants

Nuclear power poses unique hazards due to the enormous energy in the reactor core, radioactive material and decay heat produced by the fuel. Nuclear safety involves the protection of workers, the public and the environment from these hazards. Therefore, as stated in article 10, each NPP licensee in Canada has given due priority to safety as part of its management system.

Each existing licensee has adopted a different style of demonstrating its priority to safety, with some choosing to state high-level safety principles as part of a distinct nuclear safety policy for their organization.

Ontario Power Generation

The OPG nuclear safety policy states that:

> Nuclear Safety and Security shall be the overriding priority in all activities performed in support of OPG nuclear facilities. Nuclear Safety shall have clear priority over schedule, cost and production. This policy identifies the Chief Nuclear Officer as being accountable to the Chief Executive Officer and the Board of Directors to establish a management system that fosters nuclear safety as the highest priority.

Bruce Power

Ensuring a healthy nuclear safety culture is an objective for the Bruce Power management system and a means to high standards of excellence. Bruce Power states its commitment to safety within its nuclear safety policy as follows:

> Bruce Power is committed to fostering a healthy nuclear safety and security culture whereby all employees strive to embrace our safety-first value - guarding our four safety pillars (reactor, industrial, radiological, and environmental) - to ensure we protect each other, our plant, our community and the environment. Reactor safety is the overriding priority. We promote cooperation and sharing of good practices related to nuclear security culture. Having a healthy nuclear safety and security culture contributes to achieving excellence and business results of safe, reliable, securing tomorrow.

NB Power

The *Nuclear Management Manual*, the highest-level document governing the operations of Point Lepreau, has the following as the first point of the management commitment:

> NB Power is committed to the safe, reliable and efficient operation of Point Lepreau Generating Station.

The first of the core values of the organization is stated as follows:

> Safety First - Nuclear Safety shall be the overriding priority in all activities performed in support of the Point Lepreau Nuclear Generating Station. Nuclear Safety shall have clear priority over schedule, cost, and production. We are committed to employee and public safety.

In addition, the *Nuclear Management Manual* is introduced by the following statement:

> Our Management System is a combination of the culture and interrelated activities that are used to direct and carry out work. It includes the management and support of

personnel to enable them to implement the documented processes established within the Management System so that the performance objectives are achieved safely, consistently and efficiently.

Employee responsibilities are stated in the NB Power management system and are also stated in the *Station Instruction on Operations Expectations and Practices* for Point Lepreau.

Annex 11.2 (a)
Details related to training and numbers of workers

Improvements to licensees training programs

The following summarizes some ways that NPP licensees have improved their training programs during the reporting period.

Leadership skills: Bruce Power

In 2019, Bruce Power developed the “accountable leadership” program to improve the leadership effectiveness of front-line managers and section managers. This mandatory, two-week program is anchored on the Bruce Power models for excellence and accountability and participants work through examples to use and reinforce the models with their teams. Throughout the program, senior leaders are highly engaged as class sponsors, speakers and mentors to share their leadership experiences and knowledge of the business. This training has enabled participants to model behaviours consistent with healthy accountability, articulate how work connects to the business and the achievement of excellence, set clear expectations and achieve greater alignment when working cross-functionally.

Maintenance skills: Bruce Power

Bruce Power maintenance leaders, in collaboration with the training division, have incorporated concepts of technical skills into daily practice, both within the plant and the training environment. This has resulted in maintenance technicians demonstrating an improved understanding of technical skills during work execution, evidenced by the reduced need for rework and the absence of consequential events. Maintenance fundamentals and human performance tools are embedded into initial and continuing training, and technical skills training is delivered each quarter. As-found and as-left proof-of-practice has been implemented in continuing training for maintenance for each of the equipment performance teams. This training will drive further curriculum improvements.

Onboarding training: Bruce Power

Bruce Power has created a large single location for onboarding and enhanced its capacity for skills development and verification of skills for supplemental workers. A centralized location was required to deliver training efficiently and effectively to the hundreds of supplemental workers needed each month to support Bruce Power’s long-term life extension projects. The instruction provided ranges from skills related to nuclear safety culture, nuclear professionalism, radiation protection and human performance to more in-depth, hands-on skills training.

COVID response: Bruce Power

Bruce Power’s training programs were transformed as a result of the COVID-19 pandemic. Classroom capacity was severely restricted under social distancing requirements and was not sufficient for continuing traditional classroom delivery strategies. A significant amount of knowledge-based training was moved to e-learning or a virtual platform. The modernized learning methods have been well-received by staff. To maintain worker proficiency, skills-based training in simulator, shop or laboratory settings has been prioritized for in-person learning and is supported by micro-learning videos.

Training change management: Bruce Power

Due to the complexity and duration of long-term life extension projects, Bruce Power established a dedicated training change management team to identify the training requirements for all scopes of work. Every plant modification is executed as a project in accordance with engineering change control. These modifications encompass physical changes to plant components and systems, major design or analysis changes that impact on the approved operating envelope for components and systems, and major procedural changes that impact the conduct of operations or maintenance activities. The training change management team coordinates all functions, including the analysis of all training needs, between the projects and the various training division sections to ensure that qualification and training requirements are accurately documented in contract language, provide quality oversight of any vendor-conducted training and monitor and report on training change control processes.

Tritium removal facility simulator: Ontario Power Generation

During the reporting period a new simulator for the Tritium Removal Facility was developed to enhance its operator training program. The simulator provides a realistic training environment where operators can be trained to standards similar to those of the fuel handling staff and certified operations staff. The simulator is also being used to enhance operator proficiency through “just-in-time” training prior to infrequently performed evolutions.

Professional development: Ontario Power Generation

A new learning management system was implemented in 2019 with an initial suite of 6000 professional development courses available to staff. The system is integrated with the suite of human resource systems such as development planning and succession planning tools, which employees can use to link their learning to development objectives.

Adaptive learning: Ontario Power Generation

OPG integrated adaptive learning principles into a small number of e-learning courses. Course content is catered to the individual development needs; trainees bring a different level of education, skills, experience and knowledge into training and adaptive learning ensures each trainee receives the right level of focus on each learning objective. The pilot program will be assessed for further training adoption.

Dynamic learning activities: NB Power

NB Power has developed an integrated dynamic learning activity to address the application and use of human performance tools and techniques by all NPP staff. The activity incorporates three tasks: cleaning strainers in a field environment, performing manipulations in a radiation area requiring a radiation exposure permit, and doing calculations in an office. These tasks are done simultaneously and then integrated to solve a common goal when successful. Successful completion of tasks requires “engaged, thinking workers” who effectively use the organization’s human performance tools.

All NPP staff, starting with the site vice-president and station directors, are required to complete the dynamic learning activity, including contract staff joining the organization to support outages (a total of up to 1,400 staff members). Staff learning is observed by their peers, supervisors and managers when they return to work activities, and alignment is achieved with expectations, critical steps and observation and coaching methodologies. Personnel use tools in the field in the same manner as the training they completed before an outage.

Requirements and guidance for qualification and numbers of workers

A hierarchy of laws, regulations, licence conditions and regulatory documents specify the requirements for the number of workers to be present at an NPP as well as the qualifications and training of personnel who perform critical, safety-related activities.

The NSCA and its regulations provide the legislative basis for the number of workers and the qualification, training, examination and certification of personnel. Specifically, the *General Nuclear Safety and Control Regulations* state that the licensee shall:

(a) ensure the presence of a sufficient number of qualified workers to carry on the licensed activity safely and in accordance with the Act, the regulations made under the Act and the licence
(b) train the workers to carry on the licensed activity in accordance with the Act, the regulations made under the Act and the licence

The *Class I Nuclear Facilities Regulations* require each applicant for a licence to construct, operate or decommission a Class I nuclear facility (e.g., an NPP) to provide details about the qualifications, training and experience of any worker involved in the facility's operation or maintenance.

The licensing basis for NPPs include the following requirements related to numbers of workers, qualifications and training:

- A minimum staff complement (sufficient qualified personnel) must be in attendance at all times to ensure safe operation of the NPP. This includes a sufficient number of qualified personnel to ensure adequate emergency response capability. The minimum staff complement is specified in licensee documents that are submitted as part of the application for a licence.
- A sufficient number of the following certified positions must be in attendance at all times at an NPP. These will vary depending upon the design of the NPP:
    - authorized nuclear operator/control room operator (all NPPs are required to have an authorized nuclear operator in direct attendance at each unit's main control room panels at all times)
    - Unit 0 control room operator (Bruce A, Bruce B, Darlington)
    - control room shift supervisor and shift manager for multi-unit NPPs
    - shift supervisor for single-unit NPPs (Point Lepreau)
- A certified responsible/senior health physicist must be appointed.
- Certified personnel must meet the relevant certification requirements applicable to their positions, as specified in CNSC regulatory document REGDOC-2.2.3, *Certification of Persons Working at Nuclear Power Plants*.

Annex 11.2 (b)
Workforce planning processes

All licensees have processes to ensure adequate resources and facilities are always available for responding to planned activities and contingencies. The following is an example of Bruce Power's processes to plan and optimize its workforce.

The workforce planning process is reviewed annually as part of Bruce Power's business planning cycle. The process includes a talent segmentation exercise that analyzes the requirements for various positions and the available staff. It identifies the specific criticality levels of all jobs across the company, as well as the normal complement (e.g., requirements) for those positions. This information is then applied as business assumptions for future staffing-level planning activities.

Several business assumptions are also applied against actual headcount and job-level targets to mitigate risks to critical positions. An attrition model forecasts future retirements and staff movements across the site, based on historical retirement and staff movement trends, retirement surveys, available skills within and outside the organization, and a risk assessment/environmental scan of internal and external factors. In addition, the lead time (e.g., recruitment and training) is identified for all critical positions (including certified staff) and serves as a basis for "pre-hiring" before an incumbent actually leaves his or her position. This ensures mission-critical knowledge can be captured and transferred to a new hire.

Bruce Power's workforce planning process allows for continuous adjustments to the workforce plan, as it is considered a living document that must meet business requirements. Senior managers also review the status of Bruce Power's planned staffing efforts and other critical reports semi-monthly.

This experience, knowledge and continual review are applied to execute a gap analysis between current staffing levels and the optimal future state. During annual business planning sessions, executives and senior managers reconcile work program requirements and Bruce Power's long-term workforce model to develop appropriate staffing levels across the site for each year of the planning horizon. Consequently, Bruce Power has a system in place to ensure that current programs are managed, while implementing improvement strategies to reach its future workforce model and staffing levels.

Annex 12 (a)
Responsibilities and accountabilities for human performance at NPPs

Each licensee incorporates, in its management system, an organizational and management philosophy that uses a hierarchical method to account for human performance:

- The primary responsibility for human performance rests with each individual.
- First-line managers are accountable for monitoring and correcting human performance issues.
- Management provides the necessary expectations, facilities and tools to aid human performance.
- Non-line organizations provide independent oversight of human performance.

The priority given to safety by each licensee and the focus on safety culture (as discussed in article 10) are critical to this hierarchical approach. Clear lines of authority and communication are established, so that individuals throughout the organization are aware of their responsibilities toward nuclear safety. At the individual level, the emphasis is on personal dedication and accountability for each individual engaged in an activity that affects the safety of the NPP. An individual's recognition and understanding of this responsibility, as well as a questioning and self-checking attitude, are essential for minimizing human errors.

Human performance tools for workers are used to anticipate, prevent and detect errors before they cause harm to people, the plant, property or the environment. Although these tools can be used by any employee in a wide range of situations, they are particularly useful to front-line workers and their managers, who touch plant equipment and are capable of altering its status. Human performance tools help workers maintain positive control of a work situation, ensuring the job is done correctly the first time.

Errors by knowledge workers, especially engineers, potentially have the greatest adverse impact on NPP safety. "In-process" errors are often more subtle than front-line active errors committed by operators and maintainers on plant equipment, in that they tend to create latent errors that, if undetected, become embedded in the physical configuration of the plant equipment or documentation. Additionally, latent errors may go unnoticed for very long periods. Human performance tools for knowledge workers assist them in anticipating, preventing and catching most errors related to their work. Knowledge worker tools provide a defensive barrier against latent errors that can affect plant safety or production later.

Management's roles and responsibilities to aid in human performance include:

- clearly communicating performance expectations through policies and procedures
- establishing an effective organization with well-defined and understood responsibilities, accountabilities and authorities
- ensuring an operational safety focus
- hiring sufficient numbers of properly-qualified workers
- developing sound procedures to clearly define safety-related tasks
- creating a workplace environment where people are encouraged to provide honest feedback and report errors without fear of reprisal
- continuously enhancing the procedures by incorporating lessons learned

- providing the necessary training and education to emphasize the reasons behind established safety practices and procedures, together with the consequences of safety shortfalls in personal performance
- providing sufficient and proper facilities, tools and equipment, and support staff
- conducting self-assessments to promote continuous improvement
- ensuring that human factors issues are systematically considered in any new design or modification to an existing facility
- providing additional levels of oversight, independent of the line organization, to evaluate human performance
- ensuring the use of OPEX feedback

Each level of management is also vested with a specific level of authority as defined in management system documents. Managers should have a clear understanding of what they can approve versus what they must refer to a higher authority. Errors are minimized by requiring anyone who approves a document or activity to verify consistency and compliance with:

- the individual's limits of authority
- the applicable external requirements (e.g., laws, regulations and the licence) and internal boundaries (e.g., operating policies and principles (OP&Ps), safety reports and quality assurance manuals)
- operating and maintenance practices
- design assumptions and intent

First-line managers are accountable for monitoring and correcting human performance issues. The primary method is direct observation of pre-job planning and preparation, work execution and post-job wrap-up activities. The flow of information and the communication of problems both up and down the line, including identification of human errors, are key to human error detection and correction.

A formal observation and coaching program assists managers and supervisors in directing their observation activities to those areas where the most significant impact will be achieved. The program also provides guidance on effective non-confrontational approaches to interacting with employees when managers and supervisors deliver coaching feedback on performance that met or did not meet the requirements.

Annex 12 (e)
Human factors engineering in NPP design and modification

In the Canadian nuclear power industry, human factors engineering (HFE) is applied in new designs from the conceptual design phase to the final detailed design, installation and commissioning phases. In operating NPPs, HFE considers operational, maintenance and aging management factors – and is integrated in the development of procedures as well as change control processes when any modifications are made.

In CANDU NPPs, a rigorous HFE approach is used to design main control rooms, secondary control areas, emergency support facilities, instrumentation and controls, safety systems and local field interfaces (e.g., in the areas of human system interface components, equipment layouts, control room habitability, control room display design, panel design and annunciation design, as well as for the design of structures, systems and components (SSCs) for testing, inspection, maintenance, fuel handling, transport and storage, waste management, chemistry, radiation, security, emergency response and management). HFE is applied in a graded manner, using human-factor-related criteria based on risk and complexity.

A systematic process is defined, documented and implemented to integrate human factors into the design process. HFE activities are identified and documented for each design and incorporated into the design plan and/or human factors plan. The plans are based on the regulatory requirements, international standards and best practices, as well as experience derived from the application of HFE to previous CANDU design projects throughout the evolution of CANDU technology. The plans are then implemented to ensure that the resulting design is compatible with human capabilities and limitations and that the systems and equipment can be safely and effectively operated and maintained for all postulated system states and operating conditions. HFE summary reports are produced to document the results of the process. All licensees and SNC-Lavalin Nuclear perform periodic self-assessments of their HFE programs to confirm they are fully implemented and effective.

HFE is incorporated into nuclear design projects, including new-build and refurbishment projects and nuclear engineering services, in accordance with regulatory requirements and industry standards. HFE in design applies to the entire system design and extends beyond nuclear systems (e.g., balance of plant and fuel handling).

HFE effort addresses the 11 elements included in CSA Group standard N290.12, *Human factors in design for nuclear power plants*:

- HFE program management
- OPEX review
- functional requirements analysis and function allocation
- task analysis
- staffing and qualification
- treatment of important human actions
- human-system interface design
- procedure development
- training program development
- human factors verification and validation
- design implementation (integration)

All NPP licensees fully implemented CSA Group standard N290.12-14, *Human factors in design for nuclear power plants,* during the reporting period.

In addition to providing input about the design itself, human factors are also addressed as part of the constructability, operability, maintainability and safety review as well as in the development of procedures, instructions and training. Also, human factors considerations and human performance tools are used throughout a nuclear facility to address installation and commissioning of the design as well as the operability, maintainability and safety of NPPs during operation and shutdown.

Annex 14 (i) (c)
Details on deterministic safety analysis

Content of the safety analysis reports for existing NPPs

NPP licensees maintain deterministic safety analyses as documented in their safety analysis reports. Deterministic safety analysis demonstrates that the radiological consequences of certain events do not exceed the accident-dependent reference public dose limits specified in the design requirements. The events include postulated initiating events – which involve a single process failure – and events involving a single process failure in conjunction with a failure in one of the special safety systems.

The typical safety analysis report covers the following main areas as given below.

Introduction and site description

This section addresses the following characteristics:
- general description
- geography and land use for recreation and commerce, as well as information such as population distribution
- meteorology
- hydrology
- geology and seismology

Systems and components

This section provides sufficient detail for understanding the interaction of the systems and for use in following the accident analysis details. The elements typically covered include:
- safety design philosophy
- design criteria
- structures
- reactor
- reactor process systems
- special safety systems and safety-related systems
- instrumentation and control
- electrical power systems
- turbine/generator and auxiliaries
- fuel and fuel handling
- auxiliary systems
- radiation protection
- waste management

Deterministic safety analysis summaries

This section provides the detailed description of the accident analysis for the NPP. This presents the analysis of all the design-basis accidents to demonstrate that the safety design objectives of all postulated accidents are met. The elements typically covered include:
- identification of initiating events

- fuel handling system failures
- electrical system failures
- control failures
- small loss-of-coolant accidents (LOCA)
- large LOCAs
- LOCAs outside containment
- feedwater system failures
- steam supply system failures
- shutdown cooling system, shield cooling system and moderator system failures
- support system failures
- common-mode incidents:
  - design-basis earthquake
  - turbine breakup
  - design-basis tornado
  - design-basis rail-line blast
  - spurious closure of the heat transport loop interconnect valves
  - toxic corrosive chemical rail-line accident
  - internal fires
- event classification
- description of major computer models

Examples of improvements to deterministic safety analyses

As provided in CNSC REGDOC-2.6.3, *Aging Management*, an important aspect of life management is the impact of aging on facility safety, including safety margins, as determined through an updated deterministic safety analysis. This analysis requires a systematic and integrated approach to aging management. Safety analyses have been performed to demonstrate the adequacy of safety margins in the scenarios most affected by aging. For example, the NPP licensees continually update safety analyses that include the effects of aging of the primary heat transport system (a primary aging mechanism is the diametric creep of the pressure tubes).

Revised safety analyses are being conducted in the context of the licensees' implementation of CNSC REGDOC-2.4.1, *Deterministic Safety Analysis*.

<u>Ontario Power Generation</u>

OPG continues to implement the requirements of REGDOC-2.4.1 in accordance with the implementation plan revision issued in November 2021. The new analyses are also planned and executed in conjunction with the heat transport system aging management strategy. Under the aging management strategy for the heat transport system, updated analyses for loss of flow, small break LOCA, and neutron overpower protection accident scenarios were completed for future aged system conditions to support continued safe operation of OPG reactors.

The previously completed analysis of the loss of moderator heat sink was incorporated into the 2017 update of the Darlington safety report. Other analysis was completed for the Darlington large break LOCA with a more realistic implementation of the limit of operating envelope methodology in March 2018. As part of updating analyses to REGDOC-2.4.1 requirements, new LBLOCA analysis is being performed using the composite analysis approach. Regarding analyses of other accident scenarios, during the reporting period, OPG completed the planning for Darlington loss of flow analysis, loss of reactor power regulation, and in-core LOCA.

OPG also completed the analyses for Pickering common-cause events and included them in the 2018 version of the updated safety report for Pickering units 1 to 4.

As part of ongoing support for Darlington refurbishment and Pickering safe storage activities, additional assessments are being planned. OPG is also conducting reviews to support the ongoing Darlington PSR for the renewal of the operating license for the 2025 to 2035 period.

Bruce Power

In December 2017, Bruce Power completed a three-year project to upgrade the safety analysis summary sections of the safety reports for Bruce A and Bruce B to meet the new requirements of REGDOC-2.4.1. Bruce Power also added new appendices on common-mode failures, which brought detailed analysis of internal and external hazards related to such failures into the safety report for the first time. The common-mode analysis addressed loss of instrument air, service water failure, fire, seismic events, internal flooding and high winds. Over the reporting period, Bruce Power worked to address CNSC comments on the new analysis.

Going forward, Bruce Power plans to comply with REGDOC-2.4.1 for any new or revised safety analysis. The next revisions to the final safety reports for Bruce A and Bruce B will be issued in 2022.

NB Power

During the reporting period, NB Power continued to progress its safety analysis program to meet the requirements of REGDOC-2.4.1 and to close gaps in accordance with its graded (risk informed) approach. Completed analysis includes events such as fast loss of reactivity control, high-energy line breaks and small-break LOCA in the context of aging effects; loss of flow (forced circulation); steam supply failures (main steam line break); and boiler feedwater failures. NB Power identified additional analyses to further address (a) plant aging; and, (b) legacy gaps with requirements in REGDOC-2.4.1 and incorporated them in multi-year planning. NB Power also addressed regulatory comments on its graded approach for the identification of anticipated operational occurrence events for further analysis, and incorporated lessons learned from the analysis of the fast loss of reactivity control. No additional anticipated operational occurrences were identified that require analysis to demonstrate defence in depth. All new analyses will be reflected in future updates to the safety report.

Annex 14 (ii) (b)
Aging management programs at each nuclear power plant

CNSC REGDOC-2.6.3, *Aging Management*, establishes the regulatory requirements and provides guidance for integrated and component-specific aging management programs at NPPs.

Along with the aging management programs required by REGDOC-2.6.3, Canadian licensees have developed a series of periodic inspection programs and plans that expand the minimum inspection and testing program requirements to address operational and safety issues. The most significant of these programs and plans are described below.

Feeder pipe lifecycle management plan

This plan establishes an inspection and maintenance strategy to mitigate risks related to feeder aging and degradation mechanisms. Specific program inspection and maintenance activities are described to mitigate degradation caused by bend thinning, bend cracking, localized flaws adjacent to welds and weld cracking. A visual inspection program is included to detect any localized feeder fretting due to contact with components and structures in close proximity. This plan also documents the strategy for determining whether feeder replacement is needed.

Fuel channel lifecycle management plan

This plan includes strategies for ensuring that the effects of fuel channel aging are monitored (with inspections conducted per CSA Group standard N285.4, *Periodic inspection of CANDU nuclear power plant components*) and managed effectively. It also discusses degradation mechanisms – including pressure tube dimensional changes due to service conditions (axial and diametral expansion, wall thinning and tube sag), deuterium uptake, fracture toughness changes, pressure tube to calandria tube contact and the potential for blister growth, as well as re-fueling-related, service-induced damage to inside surfaces. Degradation mechanisms for fuel channel annulus spacers are also discussed along with plans to ensure their fitness for service. Research results are used to guide the inspection plans.

Flow-accelerated corrosion program

This program identifies susceptible systems and monitors and manages degradation related to flow-accelerated corrosion and other degradation mechanisms (such as erosion), mainly in secondary-side (non-nuclear) and certain primary-side (nuclear) piping systems. The program is based on the Electric Power Research Institute (EPRI) program. It uses the Chexal-Horowitz engineering corrosion (CHECWORKS) software as a guide in identifying and selecting inspection locations and processing measured data to determine thinning rates and acceptability for continued service. For piping that cannot be modelled using CHECWORKS due to geometrical constraints or thinning mechanisms (such as small-bore piping or thinning due to an erosive mechanism), manual calculations are used to evaluate the thinning rate and acceptability for continued service.

Steam generator lifecycle management plan

This plan establishes the inspection and maintenance strategy used to control risks related to steam generator aging and degradation mechanisms, and includes measures to detect, record, trend and mitigate those mechanisms. Program elements include tube wall inspections and inspections of other internal components (e.g., moisture separators, tie rods, feedwater boxes, and nozzles), water chemistry management, and primary- and secondary-side deposit management and removal (via water lancing, internal tube blasting, blow-down practices during operation and occasional chemical cleaning).

Containment

Requirements for the design, construction, commissioning and in-service inspection of concrete containment structures are contained in CSA Group standard N287.7, *In-service examination and testing requirements for concrete containment structures for CANDU nuclear power plants*. Licensees perform periodic in-service inspection and testing of the containment at specified intervals, to ensure that structural integrity and leak-tightness are maintained. Licensees are required to submit the periodic inspection and testing results, as well as their evaluations, to the CNSC for review. If inspection results indicate an adverse trend, the CNSC may require the licensee to increase the frequency of the inspection and/or provide compensatory measures.

Additional inspection requirements for containment components are specified in CSA Group standard N285.5, *Periodic inspection of CANDU nuclear power plant containment components*.

Component replacement

The Canadian nuclear industry continues to take initiatives to prevent and manage problems with acquiring replacements for equipment that is no longer available from the original manufacturer. Often this results in the design, installation and commissioning of replacement components or systems within a rigorous engineering change control process that dispositions the potential impacts of any form, fit or function changes. Another strategy is to purchase a lifetime quantity of spare parts where feasible and economically justified. COG has an emergency spares assistance process that obtains spare parts from other utilities to meet the needs of CANDU NPPs. As well, a number of replacement components (including gaseous fission product detectors, 48-volt indicating fuses, heavy-water leak-detection systems, potentiometers, shut-off rod motors and digital control computers) were acquired through COG on behalf of several CANDU NPPs. The Canadian industry has also developed some capability, within an appropriate quality assurance program, to reverse-engineer and manufacture replacement parts that are no longer available.

Example of integrated plant life management plan

Bruce Power and OPG have evolved their approach to managing the aging and health of key structures, systems or components in alignment with evolving regulatory requirements, best practice, and OPEX. Their asset management approach is an example of the implementation of an integrated NPP aging management program to support key assets in reaching their target lifetimes for reliable operations. The asset management approach utilizes existing processes by integrating engineering practices for monitoring system and component health, periodic inspection, equipment reliability and aging management, thus continuously gathering data in a “plan-do-check-act” cycle. A number of initiatives and strategies are underway to achieve or exceed target lifetimes. The program’s scope and process have been developed with consideration for nuclear industry regulatory requirement documents, along with best practice and guidance documents. These documents include:

- CNSC REGDOC-2.3.3, *Periodic Safety Reviews*
- CNSC REGDOC-2.6.3, *Aging Management*
- CNSC REGDOC-2.6.1, *Reliability Programs for Nuclear Power Plants*
- IAEA safety guide NS-G-2.12, *Ageing Management for Nuclear Power Plants*

NB Power has enhanced its approach to aging management through its long-term assessment management program and aging management program to ensure long-term safe reliable operation of SSCs. The programs assess the long-term needs of key equipment against CNSC regulatory documents, CSA Group standards, and international guidance.

Annex 15 (a)
Detailed requirements and guidance for control of radiation exposure of workers and the public

The *Radiation Protection Regulations* (RPR) forms the primary regulatory basis for radiation protection, including the requirement for licensees to implement radiation protection programs. The regulations incorporate many of the International Commission on Radiological Protection (ICRP) recommendations (ICRP 103, 2007) and the IAEA's *Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards* (BSS) No. GSR Part 3 (2014).

The RPR address the following:

- implementation and requirements of licensee radiation protection programs
- requirements for ascertaining and recording doses
- definition of action level and the actions to be taken when an action level has been reached
- requirement for informing workers of the risks associated with radiation to which the worker may be exposed and of effective and equivalent dose limits
- requirement for when to use licensed dosimetry services to ascertain dose
- effective and equivalent dose limits for nuclear energy workers (NEWs), pregnant NEWs and persons who are not NEWs
- dose limits that apply during the control of emergencies
- actions to be taken when a dose limit is exceeded and the process for authorizing return to work
- requirements for licensed dosimetry services
- requirements for labelling containers and devices
- requirements for posting radiation warning signs

The CNSC has developed a number of regulatory documents to assist licensees in matters related to radiation protection and environmental protection.

During the reporting period, the CNSC published the following new radiation protection regulatory documents that supersede existing regulatory guides and standards:

- REGDOC-2.7.1, *Radiation Protection*
- REGDOC-2.7.2, *Dosimetry, Volume I: Ascertaining Occupational Dose*
- REGDOC-2.7.2, *Dosimetry, Volume II: Technical and Management System Requirements for Dosimetry Services*

REGDOC-2.7.1, *Radiation Protection*, describes measures licensees can take to keep all doses to persons ALARA, social and economic factors being taken into account. Elements that the CNSC considers to be essential in the approach to ALARA are:

- demonstrated management commitment to the ALARA principle
- implementation of the ALARA principle through a licensee's management of work practices(including provision of dedicated resources, training, documentation and other measures)
- programs that control exposures to workers and the public
- planning for unusual situations
- development of performance goals and regular operational reviews

Section 8 of the RPR requires licensees to use a CNSC-licensed dosimetry service to measure and monitor radiation doses of NEWs who have a reasonable probability of receiving either an effective dose greater than 5 mSv or an equivalent dose to the skin, or the hands and feet, greater than 50 mSv in a one-year dosimetry period. REGDOC-2.7.2, *Dosimetry, Volume II: Technical and Management System Requirements for Dosimetry Services* specifies the requirements for licensed dosimetry service providers. Along with the technical requirements and the requirements for annual independent testing by accredited national calibration laboratories, the dosimetry service licensees must implement quality assurance programs. Section 19 of the RPR requires every licensee who operates a dosimetry service to file with the National Dose Registry (NDR) the dose results of each NEW for whom it has measured and monitored a dose of radiation.

Summary of doses to NPP workers during the reporting period

The RPR require licensees to ensure that the effective dose received by workers at NPPs does not exceed 50 mSv in a one-year dosimetry period or 100 mSv in a five-year dosimetry period. The data in the table below shows the collective dose from routine operations and outages, as well as the total collective dose and maximum individual effective dose received by a worker at Canadian NPPs for the years 2019 to 2021. As indicated, no worker exceeded the annual dose limit of 50 mSv.

Occupational dose summary for Canadian NPPs, 2019 to 2021

NPP	Year	Number of reactors	Collective dose from routine operations (person-mSv)	Collective dose from outages, (including forced outages) (person-mSv)	Total collective dose (person-mSv)	Maximum individual effective dose (mSv)
Bruce A and B*	2019	8	911	8,825	9,735	16.69
	2020	8	988	16,310	17,298	18.44
	2021	8	831	17,535	18,366	19.16
Darlington*	2019	4	394	7,263	7,657	12.37
	2020	4	311	2,375	2,686	9.59
	2021	4	273	13,135	13,408	19.95
Gentilly-2	2019	1	0	8.41	8.41	1.13
	2020	1	0	5.71	5.71	0.91
	2021	1	0	7.32	7.32	1.83
Pickering*	2019	6	869	2,216	3,085	10.32
	2020	6	810	5,407	6,217	16.58
	2021	6	987	2,915	3,902	14.15
Point Lepreau*	2019	1	224	372	596	14.8
	2020	1	211	1,056	1,267	9.61
	2021	1	170	117	287	8.69

* Refurbishment activities conducted during this reporting period.

** The Gentilly-2 reactor was shut down during the previous reporting period.

The RPR require licensees to ensure that the effective dose for the five-year dosimetry period (defined as the period of five calendar years beginning on January 1, 2001 and every period of five calendar years after that period) does not exceed 100mSv. The table below shows the maximum individual effective dose accumulated for the five-year dosimetry period of 2016 to 2020. As shown in the table, no worker exceeded the five-year dose limit of 100mSv.

Maximum five-year individual effective dose to workers at each Canadian NPP, for five-year dosimetry period of 2016 to 2020

Station	Maximum individual effective dose (mSv)
Bruce A and B	65.74
Darlington	52.19
Gentilly-2	2.73
Pickering	69.55
Point Lepreau	39.26

The table below summarizes the collective dose data for NPPs.

Total collective dose at all Canadian nuclear power plants, 2019 to 2021

Year	Number of operating reactors	Collective dose (person-Sv)
2019	19	20.4
2020	19	27.2*
2021	19	35.5**

*Increase due to new refurbishment activities at Bruce B and increased outage activities at Pickering NGS and Point Lepreau NGS

** Increase due to increased outage activities at Bruce A and Darlington NGS

Annex 16.1 (b)
Onsite emergency plans at Canadian nuclear power plants

Bruce Power Nuclear Emergency Plan

In the context of the Bruce Power Nuclear Emergency Response Plan, a nuclear emergency is any emergency that poses a radiation hazard to people or property offsite. The Bruce Power Nuclear Emergency Plan is a corporate-level plan that serves as the common basis of site-specific nuclear emergency preparedness and response arrangements. It describes concepts, structures, roles and processes needed to implement and maintain Bruce Power's radiological emergency response capability. It also represents a basis for controlling changes and modifications to the Bruce Power emergency preparedness capability.

As well as its response to design-basis events, the plan takes into account requirements for supporting a sustained response to a beyond-design-basis, multi-unit event resulting in an extended loss of offsite power for up to 72 hours without assistance. Bruce Power's emergency response capability is consistent with the onsite planning basis and process of determining minimum staff complement. This process involved a review and justification of the staffing requirements required for dealing with the spectrum of events that could require both operational and emergency response.

The province of Ontario's Provincial Nuclear Emergency Response Plan (PNERP) is described in annex 16.1(d) Bruce Power revised its plan to take into account the changes to the PNERP in 2018.

The Bruce Power plan defines a station emergency as a sudden, unexpected occurrence of unusual radiological conditions with the potential for accidental exposure to staff or the public exceeding regulatory limits. A station emergency can also be declared for a non-radiological event requiring protection of onsite personnel and activation of Bruce Power's emergency response organization.

The emergency plan is consistent with the corresponding Bruce Power safety analysis and reports provided to the CNSC to meet the requirements set out in CNSC regulatory document REGDOC-2.10.1 *Nuclear Emergency Preparedness and Response*.

Security (or hostile action) response is addressed through separate provisions. However, the provisions regarding potential releases of radioactive materials also apply to security incidents (e.g., the need for offsite notification, situation updates or confirmation of any radioactive releases). Emergency response related to transportation of nuclear substances is addressed by a separate plan.

To implement its emergency plan, Bruce Power has developed specific nuclear emergency preparedness and response arrangements. In the event of an onsite nuclear emergency at the Bruce Power site, staff would immediately classify the nuclear emergency in accordance with criteria specified in the station emergency procedure. Should this emergency have offsite implications, staff would further categorize it according to criteria contained in the PNERP. To simplify this step, many events have been categorized according to the province of Ontario's notification designations.

Emergency drills and exercises are an integral part of Bruce Power's overall program assessment process. These exercises are conducted periodically at Bruce A and B in cooperation with other organizations and jurisdictions that have a role in nuclear emergency preparedness and response. Every three years, Bruce Power participates in a provincial nuclear emergency exercise, which includes internal and external stakeholder participation, to test Bruce Power's response to the Provincial Nuclear Emergency Response Plan.

Bruce Power maintains emergency public response capabilities within various communications departments, including employee communications, investor and media relations, government relations and community relations. The primary targets of Bruce Power's nuclear emergency public information program are people who live or work near Bruce A and B as well as certain Bruce Power employees and contacts who would need to be informed of an emergency. In the event of a nuclear emergency involving Bruce A and B, Bruce Power's emergency response procedures and agreements require the corporation to coordinate its public information efforts and activities with those of other participating jurisdictions or organizations, such as provincial agencies operating within the framework of the PNERP.

Bruce Power's communications response in a given emergency will depend upon the related circumstances. For events that are not severe enough to warrant activation of the PNERP but may be of interest to neighbours and other stakeholders, Bruce Power would issue news releases or verbal briefings to the local media, with copies provided to provincial and municipal officials. If the situation warrants, Bruce Power may activate its local media centre for briefing or interview purposes.

More severe events may require activation of the PNERP and the Province of Ontario's Joint Emergency Information Centre operated by the Office of the Fire Marshall and Emergency Management. Pending activation and operation of the centre, Bruce Power's emergency response organization would, on an interim basis, communicate relevant information to the public and the media. With the Joint Emergency Information Centre in operation, the provincial government would assume control of information regarding the offsite response. The Municipality of Kincardine (where Bruce is located) would establish a local emergency information centre at its offices. Bruce Power would assist the municipality with preparing information for the local public by ensuring its accuracy. Emergency-related information prepared at local and provincial emergency information centres would be jointly scrutinized for accuracy by all three parties prior to its release.

Ontario Power Generation Consolidated Nuclear Emergency Plan

The OPG Consolidated Nuclear Emergency Plan is a corporate-level plan that serves as the common basis of site-specific nuclear emergency preparedness and response arrangements at Darlington and Pickering. It describes concepts, structures, roles and processes to implement and maintain an effective OPG response to radiological emergencies that could endanger onsite staff, the public or the environment. It provides a framework for interaction with external authorities and defines OPG commitments under the PNERP.

Similar to Bruce Power, the OPG Consolidated Nuclear Emergency Plan defines a station emergency as a sudden unexpected occurrence of unusual radiological conditions with the potential for accidental exposure to staff or the public exceeding regulatory limits. The OPG plan focuses on the release of radioactive materials from fixed facilities and on OPG interfaces with the PNERP. The formal scope of the plan excludes security incidents (hostile action) at OPG NPPs, as these incidents are dealt with in detail in other OPG documents. However, the plan's provisions regarding potential releases of radioactive materials also apply to security incidents. These include the requirements for offsite notifications, situation updates and confirmation of any radioactive releases.

The emergency plan is consistent with the corresponding OPG nuclear safety analyses and reports provided to the CNSC.

To implement its nuclear emergency plan, OPG has developed site-specific nuclear emergency preparedness and response arrangements for its NPPs. In the event of an onsite nuclear emergency at an OPG NPP, OPG staff would immediately classify the nuclear emergency in accordance with criteria specified in emergency procedures. Should this emergency have offsite implications, OPG staff would further categorize it according to criteria contained in the PNERP. PNERP categorization criteria are referenced in procedures to ensure alignment. Offsite notifications would be made following categorization within required time limits.

Emergency drills and exercises are an integral part of OPG's overall process of program assessment. Exercises are conducted regularly at all OPG NPPs, in cooperation with other organizations and jurisdictions that have a role in nuclear emergency preparedness and response. Five drills or exercises are conducted at each OPG NPP annually to test the effectiveness of the emergency plans and procedures, facilities, equipment and training effectiveness, as well as members of OPG's emergency response organizations. Included in these drills are multi-unit severe accidents to validate OPG's severe accident management guidelines and the deployment of emergency mitigating equipment.

OPG maintains emergency public information capabilities within its nuclear public affairs department. The primary audiences for OPG's nuclear emergency public information program are those who live or work near OPG NPPs. In the event of a nuclear emergency involving an OPG NPP, OPG emergency response procedures and agreements require it to coordinate its public information efforts and activities with those of other participating jurisdictions or organizations, such as provincial agencies operating within the framework of the PNERP.

The OPG public affairs response in a given emergency would depend upon the related circumstances. For events that are not severe enough to warrant activation of the PNERP but that may be of interest to neighbours and other stakeholders, OPG would issue news releases or verbal briefings to the local media, with copies provided to provincial and municipal officials. Should the situation warrant, OPG may activate its onsite or near-site Emergency Information Centre for briefing or interview purposes.

More severe events may require activation of the PNERP and provincial and municipal emergency information centres. OPG may also communicate relevant information within its jurisdiction to the public and media.

Point Lepreau Nuclear Emergency Response Plan

The NB Power Nuclear Emergency Response Plan is an all-hazards, onsite emergency plan for Point Lepreau. This plan serves as the basis for emergency preparedness, prevention and mitigation, response and recovery at the NPP. The plan outlines hazards, command structure, roles and responsibilities, and processes required to implement and maintain NB Power's emergency response capability.

The Nuclear Emergency Response Plan is built on the basis of protecting the NPP, public, personnel and environment during any event which may occur within this framework, including radiological, fire, medical, hazmat, severe weather, natural and security events, and severe accidents.

Although security events are captured within the plan, security response to hostile actions is dealt with through separate provisions. However, the provisions regarding potential release of radioactive materials also apply to security incidents.

To support the Nuclear Emergency Response Plan, Point Lepreau has a full suite of response procedures that are integrated into the management system. These procedures and response guidelines allow the emergency response organization to effectively respond to and manage any event that may occur. The plan is consistent with the corresponding NB Power safety analysis and reports provided to the CNSC.

Emergency drills and exercises are an integral part of Point Lepreau's emergency management program. Exercises are conducted regularly with the NPP's emergency response organization, in cooperation with other organizations and jurisdictions that have a role in nuclear emergency preparedness and response.

The New Brunswick Emergency Measures Organization (NBEMO), an agency of the provincial government, is responsible for actions to protect the public. As such, NBEMO manages the Point Lepreau Offsite Emergency Plan (see annex 16.1(d)), including the development and testing of its capabilities. NB Power has a direct partnership with NBEMO and supports the offsite plan in all aspects. This includes the mass decontamination plan, which details requisite monitoring and decontamination in the event that a nuclear emergency requires evacuation of local residents.

Annex 16.1 (d)
Provincial offsite emergency plans

Province of Ontario

The provincial *Emergency Management and Civil Protection Act* governs emergency preparedness and response in Ontario. This legislation requires the provincial government to formulate a plan for emergencies arising in connection with nuclear facilities. It also permits the province to designate municipalities that must plan for nuclear emergencies. Emergency Management Ontario administers the Province of Ontario’s Provincial Nuclear Emergency Response Plan (PNERP) on behalf of the province and coordinates nuclear emergency preparedness and response in Ontario. The PNERP is approved by the Ontario Cabinet and has been in place since 1986. As the lead provincial document for offsite nuclear emergency preparedness and response, the PNERP details the support and coordination of the activities of provincial ministries, nuclear facilities, the Government of Canada (including the CNSC) and designated municipalities in order to meet the plan’s objectives.

The PNERP provides the offsite basis for nuclear emergency planning, preparedness and response, with the primary aim of ensuring public safety in the event of a nuclear emergency. These include those at the three NPPs in Ontario, other types of nuclear facilities (including research reactors), and NPPs in neighbouring jurisdictions, as well as for other types of radiological events.

The plan covers various components, including:

- aim and guiding principles
- hierarchy of emergency plans and procedures
- description of the hazard
- planning basis
- preparedness
- protective action response strategy
- concept of operations
- emergency organization
- operational policies
- emergency information
- public education
- detailed responsibilities of the various participants
- provincial and municipal committee oversight

The plan also includes considerations for the recovery phase and notes that recovery phase actions may be described in a separate plan.

Full-scale exercises focusing on nuclear or radiological emergencies are conducted regularly with the participation of the licensees and different levels of government.

The planning basis for the PNERP was most recently reviewed following the 2011 Fukushima accident. Following a consultation process that included both stakeholders as well as the public, the PNERP master plan was updated and approved by the Ontario Cabinet in late 2017, and is currently under review as part of the 5-year review cycle. The site-specific and detailed implementing plans for Pickering, Darlington and Bruce NPPs were subsequently updated and approved in 2018/19 and the implementing plan for FERMI-2[20] was updated in December 2021. Work continues on the review and update of the remaining implementing plans (Chalk River, trans-border and other radiological emergencies).

Province of New Brunswick

The provincial nuclear emergency program is governed by a partnership between NB Power and the New Brunswick Department of Justice and Public Safety. The primary agencies for emergency management and public security in New Brunswick are the:

- New Brunswick Emergency Measures Organization (NBEMO), which is the provincial lead agency for emergency management and business continuity, including radiological-nuclear contingencies
- New Brunswick Office of the Provincial Security Advisor, which is the provincial lead agency for security and critical infrastructure protection

NBEMO has the lead responsibility to develop provincial emergency action plans and to direct, control and coordinate emergency responses under New Brunswick's *Emergency Measures Act*. NBEMO prepares the New Brunswick Emergency Measures Plan, which designates responsibility for actions to mitigate the effects of any emergency, other than war, in the province. The plan defines the lead responsibilities of the New Brunswick Department of Justice and Public Safety and the supporting roles of 23 departments, agencies or organizations, which make up the Provincial Emergency Action Committee. The committee directs, controls and coordinates provincial emergency operations and supports municipalities as required in both standby mode (i.e., on call) and in an emergency state from the Provincial Emergency Operations Centre. NBEMO's Regional Emergency Management Coordinators coordinate the use of provincial resources to deal with emergency situations in rural areas and urban municipalities.

Enhancements to emergency preparedness and response in New Brunswick, during the reporting period and the previous reporting period, included the following:

- developed an annual NBEMO training and exercise strategy for major scenarios, including nuclear response
- replaced the inventory of potassium iodide pills and updated demographic information for the emergency planning zone
- established the Everbridge Notification System (automated telephone and email notification system)
- improved communications systems linking the Offsite Emergency Operations Centre (owned and maintained by NB Power) and the Provincial Emergency Operations Centre

NBEMO maintains a multi-year emergency exercise program that allows regular exercises and training to take place, fully supported by NB Power through their partnerships. This includes exercises at the Offsite Emergency Operations Centre (which would be operated and supported during an event by representatives from both organizations) in accordance with the Point Lepreau Offsite Emergency Plan. The plan includes the specific responses that would be carried out by various agencies to deal with the emergency. It contains information on actions to enable recovery, including identifying areas that are potentially contaminated, activating the New

[20] Fermi-2 is located in the USA on Lake Erie, less than 20 km from the Province of Ontario border.

Brunswick Radiological Ingestion Pathway Monitoring Plan, disseminating information to the public, and providing health and human services. NBEMO reviews the plan annually.

Annex 16.1 (e)
Details of federal emergency provisions

Detailed provisions of the Federal Nuclear Emergency Plan

Health Canada administers the Federal Nuclear Emergency Plan (FNEP).

Within the FNEP, a nuclear emergency is defined as an event that has led or could lead to the uncontrolled release of radioactive material or exposures to uncontrolled sources of radiation, which pose or could pose a threat to public health and safety, property and the environment.

The FNEP contains:

- an outline of the Government of Canada’s aim, authority, emergency organization and concept of operations for dealing with the response phase of a nuclear emergency
- a description of the framework of federal emergency preparedness policies, the planning principles on which the FNEP is based and the links with other specific documents of relevance to the FNEP
- a description of the specific roles and responsibilities of participating organizations that are involved in the planning, preparedness or response phases of a nuclear emergency
- provincial annexes that describe interfaces among federal and provincial emergency management organizations, as well as the arrangements for a coordinated response and the provision of federal support to provinces affected by a nuclear emergency

Five nuclear emergency event categories are defined in the FNEP, according to the potential scope of impacts on Canada and Canadians:

- Category A**:** an emergency at an NPP in Canada
- Category B**:** an emergency at an NPP in the United States or Mexico
- Category C**:** an emergency involving a nuclear-powered vessel in Canada
- Category D**:** other serious radiological emergencies or potential threats in Canada that require a multi-departmental or multi-jurisdictional response
- Category E**:** a nuclear emergency outside of North America

The scope of the FNEP excludes the following situations:

- emergencies that pose only a limited radiological threat over a localized area and are not anticipated to exceed the capabilities of regulatory, local or provincial/territorial authorities to respond:
- management and coordination of the Government of Canada’s actions during the recovery phase

As an emergency evolves, the coordinated response will be scaled according to the scope of the emergency and associated triggers. During routine operations, FNEP notification and alerting capabilities are provided by a 24/7 FNEP duty officer, who monitors situations of interest, conducts internal reporting, and responds to drills, exercises and requests for information. These activities are managed by Health Canada’s Radiation Protection Bureau with input from specific partners when required and include normal preparedness activities.

The occurrence of a radiological or nuclear emergency would lead to a sequence of response actions and technical support functions focused on managing the event, mitigating its effects and protecting the public and environment from actual or potential radiological impacts. The extent of coordinating arrangements described in the FNEP and occurring between individual departments and agencies would depend on the nature, magnitude and location of the event, the responsibilities within federal jurisdiction and the level of assistance requested. The Government of Canada would conduct emergency operations within the federal mandate and would provide, in accordance with prior arrangements or at the request of a provincial government, national support services and resources.

Under the FNEP, a multi-departmental technical assessment group (TAG) would be convened to provide federal-level technical assessment of the threat and risk associated with the offsite radiological hazard, as well as associated protective action recommendations, as required, for mitigating the radiological consequences to health, safety, property and the environment. The TAG supports the broader federal response and coordinates the scientific and technical response to a nuclear emergency at the federal level and in collaboration with similar groups at the provincial level. Because of the inherent technical nature and complexity of nuclear emergencies, the FNEP introduces event-specific nuclear emergency functions, which are technical response functions that group actions specifically related to nuclear emergency preparedness and response and that complement the emergency support functions in the FERP.

Responsibilities for each nuclear emergency function are assigned to primary and supporting departments or agencies. As roles and responsibilities depend upon the specific mandates and capabilities of Government of Canada institutions, and the nature of the emergency, functions and assigned departmental responsibilities include, but are not necessarily limited to those identified in the FNEP. All organizations involved in the FNEP are expected to develop their own plans, procedures and capabilities to fulfil their nuclear emergency function responsibilities. The FNEP TAG manual defines the roles and responsibilities of the individuals responding to a radiation emergency under the FNEP. These individuals may be from any of the 18 departments/agencies identified in the FNEP.

The FNEP TAG would establish task teams or experts within its operations to undertake specific technical assessment functions, such as risk assessment and prognosis, environmental-pathways modelling, radiological assessment, field-based monitoring and surveillance, and human monitoring. The information generated by the FNEP TAG would be shared with provincial technical teams through liaison officers and information exchange platforms to inform overall situational awareness and decision making. FNEP TAG information and analysis also supports the Chief Public Health Officer of Canada who is the federal spokesperson on public health issues during a nuclear emergency. The information would also help inform notifications sent to the IAEA under the *Convention on Early Notification of a Nuclear Accident*, as well as any notifications made under the auspices of the *International Health Regulations*.

As the Fukushima and Chernobyl accidents demonstrated, a severe nuclear emergency at an NPP that is distant from Canada would have a limited effect within Canada. Although small quantities of radioactive material might reach Canada, they would be unlikely to pose a direct threat (e.g., from exposure to fallout) to Canadian residents, property or the environment. Consequently, Canada’s response under the FNEP to a nuclear emergency occurring outside North America would likely focus on:

- controlling food imported from areas near the accident
- assessing the impact on Canadians living or travelling near the accident site
- assessing the impact on Canada and informing the public
- coordinating responses or assistance to foreign jurisdictions and organizations (national or international)

The potential severity of other serious radiological emergencies or potential threats, as defined in the FNEP, would depend on case-specific factors. For fixed facilities and materials in transit, appropriate responses to possible emergencies can be planned in some detail. In other situations, emergency planning can be complicated by such factors as the potential magnitude and diversity of the radiation threat, the location of the source of the radiation, any impacts on essential infrastructures and the speed at which related circumstances may evolve.

Transition to recovery

Once a nuclear emergency situation is stabilized and immediate actions to protect public health and safety are completed, emergency management of the radiological hazard shifts from the response phase to the recovery phase. FNEP senior officials (from Health Canada and the CNSC), in consultation with the TAG Chair, the Federal Assistant Deputy Minister of the Emergency Management and Regional Operations Branch (Public Safety Canada) and the Federal Coordinating Officer would recommend the return of the FNEP to a routine reporting level as well as the termination of some or all components of the FNEP not required for the transition to recovery. The Federal Assistant Deputy Minister Emergency Management Committee, in consultation with the Privy Council Office, would approve the transition to recovery and termination of the emergency.

Responsibility for recovery falls primarily within provincial/territorial jurisdiction. If federally assisted recovery actions were required, the responsibility for coordinating recovery operations would be assigned to a specific Minister of the Government of Canada by the Privy Council Office and the Prime Minister.

The FNEP identifies the following activities that are recognized as part of the recovery phase, and for which federal organizations could be requested to provide support to the provinces:

- development of a long-term recovery management plan, including reference levels on residual dose from long-term contamination and a strategy for restoration of normal socio-economic activities, including international aspects
- monitoring of contaminated areas, assessment of potential doses to public and workers and assessment of medium- and long-term health hazards
- environmental decontamination and radioactive waste disposal operations
- maintenance of dose registries for emergency workers
- non-radiological recovery operations
- proactive and transparent public information and international communication related to all of the above activities

Guidance for recovery is available in Health Canada’s *Guidance on Planning for Recovery Following a Nuclear or Radiological Emergency.* The document aligns with the most recent guidance from the IAEA on the termination of a nuclear emergency and addresses recommendations that were identified following an international review of Canada’s preparedness to respond to a nuclear emergency. The document also focusses on the non-radiological impacts of nuclear emergencies to the public, and provides best practices for minimizing the psychosocial impacts that are applicable to most emergency recovery scenarios. The inclusion of psychosocial consequences is new to the field of emergency management in general, and to nuclear emergency management in particular.

Provisions of the CNSC in emergency preparedness and response

The CNSC maintains an Emergency Operations Centre (EOC) at its headquarters in Ottawa to enhance its ability to respond to nuclear emergencies. This facility is used during nuclear emergency exercises to confirm nuclear emergency preparedness. The CNSC EOC uses public electricity but it can also rely on an emergency generator in the event of loss of the electricity grid. The CNSC has an alternate site for emergency staff to assemble should its main headquarters be inaccessible. The CNSC's response to a nuclear emergency during the COVID-19 pandemic will continue to operate under the same principles and objectives allowing for adjustments and special considerations to be implemented for working safety from its EOC at headquarters and for working remotely.

The CNSC nuclear emergency response (NER) plan describes the CNSC's tactical response to nuclear and radiological emergencies that fall within the CNSC's mandate.

The NER plan supports the requirements established in the CNSC's Strategic Emergency Management Plan, demonstrates how the CNSC fulfills its legislative requirements regarding the tactical response to nuclear emergencies and generally describes how a CNSC emergency response would transition to recovery.

The NER plan also describes the strategies and guidelines the CNSC would follow to cope with a nuclear emergency. It describes:

- the role and responsibilities of the CNSC in nuclear emergencies
- the organizational structure of the CNSC during and emergency
- the response activities at a tactical level and discusses the demobilization and transition to recovery role
- the EOC technical infrastructure

It also describes the actions performed by EOC staff to provide CNSC executives with accurate and up-to-date information on the status of the emergency and to inform the Commission, the Minister of Natural Resources Canada (NR Can), the Parliament of Canada, the Prime Minister, other government officials and the public what actions are being taken, both onsite and offsite.

The NEO is composed of two groups: the Emergency Executive Team (EET) and the Emergency Response Organization (ERO).

The plan is issued under the authority of the President of the CNSC, in accordance with the objectives of the NSCA and its regulations and the *Emergency Management Act*. The plan is designed to provide a compatible interface with the emergency plans and procedures of CNSC licensees, provincial governments, the Government of Canada and international organizations

Ultimately, a declared emergency could involve the following parties:

- the CNSC's nuclear emergency organization (CNSC employees)
- the Commission
- CNSC licensees
- transporters, shippers and others involved in or affected by the transport of nuclear substances
- other departments and agencies of the Government of Canada
- provincial government departments and agencies
- news media organizations

- the USNRC
- the IAEA and other international organizations

The NER plan is in effect at all times in one of four response levels:

1. routine monitoring – for an event that does not require prompt action beyond normal CNSC procedures
2. enhanced monitoring – for a situation requiring careful monitoring in case of escalation or media/public attention
3. partial activation – for an emergency that may have a direct or indirect impact on the CNSC's regulatory role and requires response coordination
4. full activation – for an emergency that requires a fully staffed EOC to respond to the event effectively and efficiently

Within the context of the NER plan, a nuclear emergency is an abnormal situation that may increase the risk of harm to the health and safety of persons, the environment or national security, and that requires the immediate attention of the CNSC. Some examples are:

- an emergency at a nuclear facility
- an emergency involving a nuclear-powered vessel in a Canadian port
- an emergency involving the loss, theft or discovery of radioactive material
- a terrorist attack using radioactive material

The nature of the CNSC's involvement could range from exchanging ideas and information to coordinating plans, making emergency orders, attending training programs, participating in exercises and responding to actual emergencies. The NER plan provides corporate guidelines for employee involvement. Specifically, it defines the CNSC staff members who would participate in the NEO (depending upon the nature of the emergency). Responsibilities of CNSC staff members in the event of a nuclear emergency parallel their responsibilities during routine CNSC operations.

As part of the NER Plan, the CNSC has established various technical and administrative arrangements including bilateral cooperation agreements with other national and international jurisdictions, as well as a CNSC duty officer program. Normally, the CNSC is notified of an emergency through the 24/7 emergency telephone line of the duty officer. Additionally, anyone can seek emergency information, advice or assistance 24 hours a day for actual or potential incidents involving nuclear materials or radiation through the duty officer.

The CNSC has arrangements with the NPP licensees related to the automated transfer of plant data from the facilities to the CNSC's EOC. This "real-time" link would enhance the CNSC's ability to conduct regulatory oversight of the licensee's emergency measures and to advise other responsible authorities when detailed knowledge and information is required. The following arrangements have been made at the operating NPPs.

- Bruce Power phased out DLAN at the end of 2019 and implemented an application that provides web-based access for automatic plant data transfer. Work is under way to move to a cloud-based service, which would be available should onsite servers lose class IV power. An update on the progress of that work will be provided by the end of the reporting period.
- OPG completed the implementation of real-time automatic data transfer at Darlington and Pickering in 2017.

- Point Lepreau completed its direct plant data transfer system and successfully tested the automatic transfer of data to the CNSC EOC in 2018.

Annex 16.1 (f)
Description of major emergency exercises, training and other initiatives

Exercise Unified Command

On February 23, 24 and 25, 2022 OPG conducted Exercise Unified Command (ExUComm) at Darlington. This full-scale emergency exercise involved the full participation of the OPG emergency response organization as well as more than 30 organizations and government agencies at the municipal, regional, provincial, federal and international levels. ExUComm was one in a series of drills and exercises conducted to meet the requirements of the OPG Consolidated Nuclear Emergency Plan and CNSC regulatory document REGDOC-2.10.1, *Nuclear Emergency Preparedness and Response*. The scope of the exercise included: accident assessment and response in both design basis and beyond design basis accident (BDBA) conditions, initial event categorization and notifications, event information communication, field radiation monitoring and communication, dose predictions, public protective action decision-making and communications, consultation around radioactive release decisions, public communications and media interactions. A security sub-scenario (on-site protesters) and contaminated casualty scenario were included. Day 3 of the exercise included a recovery planning virtual tabletop discussion without formal evaluation.

OPG exercise design included activation of the Site Emergency Operations Centre, Site Management Centre, Corporate Emergency Facility, Emergency Information Centre, the Crisis Management and Communications Centre and OPG provincial/regional liaison officers.

The high-level (Tier 1) objectives of the exercise that were successfully tested included the following:

- test the preparedness of OPG, government and non-government agencies to respond to a nuclear emergency at Darlington
- assess the interoperability of the participating organizations to respond to a nuclear emergency
- examine the consultation process between OPG and stakeholders regarding decision-making to ensure the safety of the public, emergency workers and the environment
- demonstrate the ability to coordinate a common and effective message when sharing information with the public and media
- assess the interoperability of participating organizations in the transition to recovery following a release of radioactive material to the environment
- produce a joint evaluation report

In April 2022, OPG submitted a report to the CNSC documenting the assessment of OPG's response to the lower level (Tier 2 and Tier 3) performance objectives. In summary, all objectives were met and ExUComm successfully demonstrated and confirmed that OPG, the Province of Ontario, Durham Region and key organizations at the municipal, regional, and federal levels were prepared and ready to respond effectively together to a BDBA at Darlington. Overall exercise performance to Tier 1 objectives and any associated interoperability findings will be described in a multi-agency report in 2022. Other participating agencies may also issue their own internal reports assessing the performance of their respective organizations.

Exercise Synergy Challenge

NB Power, supported by the Province of New Brunswick, neighbouring jurisdictions, federal and international agencies, conducted a two-day, full-scale integrated exercise called Synergy Challenge 2021. The exercise simulated a nuclear incident initiated by a cyber event affecting Point Lepreau. Synergy Challenge 2021 involved more than 40 organizations. The overall objective of Synergy Challenge 2021 was to validate the preparedness of NB Power, Point Lepreau, government and non-government organizations and agencies to respond to a cyber security event in addition to a radiological emergency, in order to mitigate the effects of onsite and offsite consequences.

Synergy Challenge 2021 showcased the significant efforts that have been invested to optimize a coordinated and collaborative response effort to a nuclear emergency in New Brunswick. Organizations have continuously improved their plans and strengthened their inter-agency relationships based on recommendations obtained from past exercises; this progress was evident in the low number of opportunities for improvement identified during this exercise.

The exercise confirmed that NB Power, the Province of New Brunswick and key organizations at the regional, provincial and federal levels are prepared and ready to respond effectively together to an incident at Point Lepreau. The lessons learned from this exercise will be used to further improve both the onsite and offsite emergency response plans.

Synergy Challenge 2021 also demonstrated how COVID-19 has changed the landscape of emergency management. During the exercise, an effective hybrid environment successfully incorporated a virtual component within an in-person model.

IAEA Convention Exercise series

Between April 2019 and March 2022, Health Canada participated in 14 exercises of the IAEA Convention Exercise (ConvEx) series. The most comprehensive exercise was the October 2021 edition of ConvEx-3, which occurs once every three to five years and tests the full operation of the information exchange mechanisms and procedures for requesting and providing assistance for an international nuclear incident. This exercise involved a simulated international transboundary incident to test the capabilities and roles for both international and domestic response using the IAEA's Unified System for Information Exchange in Incidents and Emergencies site. The exercise involved a general emergency at an NPP in the United Arab Emirates. For this exercise, Health Canada played as the "competent authority abroad" and worked directly with the CNSC, which was the "competent authority domestic" to evaluate and respond as necessary to information received from the IAEA Incident Command Centre. Both teams worked together in a virtual emergency operations centre for the successful completion of the exercise.

METER training

The medical emergency treatment for exposures to radiation (METER) course is delivered to train medical professionals who respond to the medical aspects of a radiological or nuclear emergency. This course is periodically offered by Health Canada at various locations across Canada. During the reporting period, only one METER session was delivered (November 2019) to 50 trainees.

Other planned training deliveries were postponed due to the pandemic. A project is underway to provide a condensed version of the METER training virtually. This will include virtual presentations to participants who will also receive a case containing a radiation detector, check sources and personal protective equipment. First delivery of this virtual training was expected by March 2022.

Radiological assurance monitoring training

On request from the provinces and territories, Health Canada and FNEP partners can provide support for field operations during a nuclear emergency. The FNEP Field Response Team can perform field radiation monitoring and surveillance and provide assurance monitoring in the zones where the population is being maintained. Health Canada organizes regular offsite training for the FNEP Field Response Team to maintain readiness and expand operational capacity, comply with health and safety practices, and "train the trainer." During the reporting period, two training sessions were organized But, because of the pandemic, three field training sessions were cancelled. The FNEP Field Response Team participated in the 2019 IAEA RANET Joint Assistance Team (JAT) exercise/training held in Nevada, USA.

Annex 18
Supporting details related to CNSC design requirements and design assessments

Design requirements in CNSC REGDOC-2.5.2

CNSC REGDOC-2.5.2, *Design of Reactor Facilities: Nuclear Power Plants*, sets out technology-neutral expectations (to the extent possible) for the design of new, water-cooled NPPs. REGDOC-2.5.2 includes direction on:

- establishing safety goals and objectives for the design
- utilizing safety principles in the design
- applying safety management principles
- designing structures, systems and components (SSCs)
- interfacing engineering aspects, NPP features and facility layout
- integrating safety assessments into the design process

In general terms, the dose acceptance criteria in REGDOC-2.5.2 follow from the postulate that the risks due to a new technology should not be significant contributors to existing societal risks. The dose acceptance criteria must also be sufficient to ensure that very few accidents will require protective measures. The safety goal for large-release frequency is expressed in terms of the release of cesium-137 that would require long-term relocation of the local population to mitigate potential health effects. The safety goal for small-release frequency is expressed in terms of the release of iodine-131 that would require temporary evacuation to mitigate health effects. To achieve a balance between prevention and mitigation, a third goal is defined to limit the frequency of severe core damage. This ensures the designer does not place too much reliance on reactor containment. The actual safety goals are shown in subsection 14(i)(d).

REGDOC-2.5.2 stipulates that SSCs important to safety are of proven design and are designed according to appropriate modern standards. Where a new SSC design, feature or engineering practice is introduced, adequate safety is proven using a combination of supporting R&D programs and an examination of relevant experience from similar applications. A qualification program is established to verify that the new design meets all applicable safety expectations. New designs are tested before entering service and are then monitored in service to verify that their expected behaviour is achieved. REGDOC-2.5.2 stipulates that the NPP design draws on OPEX in the nuclear industry as well as on relevant research programs.

REGDOC-2.5.2 also contains requirements related to reliability, operability and human factors (as they relate to design).

The requirement in REGDOC-2.5.2 to design for reliability includes consideration of common-cause failures and allowances for equipment outages. There are design requirements related to single-failure criteria for safety groups and fail-safe designs for SSCs important to safety. There are also special considerations for shared instrumentation among safety systems and shared SSCs between reactors.

REGDOC-2.5.2 sets a requirement for various safety actions to be automated so that operator action is not necessary within a justified period of time from the onset of anticipated operational occurrences or design-basis accidents. Appropriate and clear distinctions between the functions assigned to operating personnel and to automatic systems is facilitated by the systematic consideration of human factors and the human–machine interface. The need for operator intervention on a short timescale is minimized.

REGDOC-2.5.2 requires a human factors engineering (HFE) program that facilitates the interface between operating personnel and the NPP by utilizing proven, systematic analysis techniques to address human factors. The program must promote attention to plant layout and procedures, maintenance, inspection and training, as well as the application of ergonomic principles to the design of working areas and environments. The NPP's design must facilitate diagnosis, operator intervention and management of the NPP's condition during and after anticipated operational occurrences, design-basis accidents and beyond-design-basis accidents (BDBAs). This facilitation is achieved by adequate monitoring instrumentation and plant layout and suitable controls for the manual operation of equipment.

The HFE program should:

- reduce the likelihood of human error as much as is reasonably achievable
- provide means for identifying the occurrence of human error and methods by which to recover from such error
- mitigate the consequences of error

Human factors verification and validation plans are established for all appropriate stages of the design process to confirm that the design adequately accommodates all necessary operator actions.

REGDOC-2.5.2 also stipulates that the human–machine interfaces in the main control room, the secondary control room, the emergency support centre and the plant provide operators with necessary and appropriate information in a usable format that is compatible with the necessary decision and action times. Design requirements are established for both the main control room and emergency support centre to provide a suitable environment for workers under all possible conditions, taking ergonomic factors into account.

Pre-project vendor design review

The CNSC process for pre-project vendor design review is divided into three distinct phases.

<u>Phase 1</u>

The CNSC confirms that submissions for the specific design demonstrate that the vendor understands Canadian regulatory requirements and expectations. The scope of submissions is fixed by the CNSC.

<u>Phase 2</u>

The CNSC confirms that submissions for the specific design demonstrate that the proposed design complies with REGDOC-2.5.2 and related documents. The scope of the review is fixed by the CNSC and usually involves assessment in 19 focus areas:

- general plant description, defence in depth, safety goals and objectives, and dose acceptance criteria
- classification of SSC
- reactor core nuclear design
- means of reactor shutdown
- fuel design and qualification

- control system and facilities
    - main control systems
    - instrumentation and control
    - control facilities
    - emergency power systems
- emergency core coolant and emergency heat removal systems
- containment/confinement and safety-important civil structures
- prevention and mitigation of BDBAs and severe accidents
- safety analysis (deterministic safety analysis, probabilistic safety assessment (PSA) and analysis of internal and external hazards
- pressure boundary design
- fire protection
- radiation protection
- vendor research and development program
- human factors
- out-of-core criticality
- robustness, safeguards and security
- management system (design process and quality assurance in design and safety analysis)
- incorporation of decommissioning in design considerations

Phase 3

Based on feedback received from the CNSC, the vendor may discuss, in more depth, resolution paths for any design issues identified in phase 2. The scope of submissions is fixed by the vendor.

The review does not include non-technical considerations such as:

- design costs
- completion of design
- scheduling factors relative to the review of a licence application
- capacity factors
- design changes that could be required as a result of future findings

The following table lists the pre-project vendor design reviews that were in progress at the CNSC during the reporting period. The status column indicates the status of the review at the end of the reporting period.

Vendor	**Design**	**MW electrical (approx)**	**Review phase**	**Status**
Terrestrial Energy Inc.	Integral Molten Salt Reactor	200	1	complete
			2	in progress
Ultra Safe Nuclear Corporation	MMR-5 and MMR-10 (high-temperature gas)	5–10	1	complete
			2	in progress

LeadCold Nuclear Inc.	SEALER (molten lead)	3	1	on hold (vendor request)
Advanced Reactor Concepts Ltd.	ARC-100 (liquid sodium)	100	1	in progress
			2	in progress
Moltex Energy	Stable Salt Reactor (molten salt)	300	1, 2 (in series)	phase 1/2 in progress
SMR, LLC	SMR-160 (pressurized water)	160	1	complete
NuScale Power, LLC	NuScale Integral (pressurized water)	60	2*	in progress
U-Battery Canada Ltd.	U-Battery (high-temperature gas)	4	1	project start pending
GE-Hitachi Nuclear Energy	BWRX-300 (boiling water) reactor	300	2*	in progress
X Energy, LLC	Xe-100 (high-temperature gas)	80	2*	in progress

*Phase 1 objectives will be addressed within the Phase 2 scope of work

Several other pre-project vendor design reviews were being negotiated and/or planned during the reporting period, involving phase 1 or phase 2 reviews of designs from the above vendors and other vendors not listed.

Annex 18 (i) Details related to assessing and improving defence in depth

This annex describes the NPP licensees' work to continuously assess and improve safety of their facilities. In terms of design aspects relevant to lessons learned from the Fukushima accident, the designs of Canada's operating NPPs (all of which are CANDU reactors) include several features that prevent accidents and can help mitigate impacts should an accident occur. These were described in annex 18(i) of the sixth Canadian report. This edition of the annex summarizes recent (post-Fukushima) assessments and improvements with respect to defence in depth and provides an update on the improvements made during the reporting period.

Although the risk of an accident is very low, NPP licensees have implemented modifications to improve their NPPs' ability to withstand severe external events and other hazards (e.g., flood protection). Besides the consideration of specific hazards, the licensees have also systematically verified the effectiveness of, and supplemented where appropriate, the existing NPP capabilities in beyond-design-basis accidents (BDBAs) and severe accidents, which could involve a prolonged loss of power or the loss of all heat sinks. Numerous assessments and modifications that have already been completed were described in annex 18(i) of the seventh Canadian report. The following summarizes additional activities during the reporting period; tables at the end of this annex provide more details for various improvements to defence-in-depth that have been completed at the NPPs since the accident at Fukushima.

The licensees have evaluated means to provide additional coolant makeup from alternate sources. To support the coolant makeup strategies, Canadian NPP licensees have completed modifications to their plants, procured additional emergency mitigating equipment (EME) and developed procedures for its deployment.

As an example, OPG is deploying its EME in two phases. The scope of the implementation of EME Phase 1 was for accident mitigation with the objective to cool and contain the reactor core using passive water inventories in situ as well as portable pumps, generators, and uninterruptible power supplies. Phase 2 addresses containment pressure, water recovery and hydrogen mitigation strategies. In addition, Phase 2 will result in the re-powering of plant equipment required to mitigate containment pressure rise and recover the water from the sump. Phase 2 will also introduce strategies to mitigate hydrogen buildup and ensuring that irradiated fuel bay cooling is maintained. Work is still under development for the implementation of EME Phase 2.

In addition, OPG plans to install permanent fire-water pumps at Darlington to augment the existing emergency service water system for supply to the firewater system. OPG will also install permanent piping from the emergency service water system to allow the new firewater pumps to supply emergency makeup water to the heat transport system.

To address the topic of overpressure protection of the main systems and components, the licensees demonstrated that the installed relief valves on the bleed condenser provide sufficient relief capacity to mitigate pressure boundary failure due to overpressure. OPG investigated potential design changes for shield tank and calandria vault pressure relief. As a result of this investigation, Darlington installed additional overpressure protection in all four units to prevent potential shield tank failure in the event of total and sustained loss of heat sink to any unit. This allows for optimal design and effective operation of the containment filtered venting system (described below) by protecting the shield tank from potential failure, thus precluding a challenge to the containment system.

All Canadian NPPs have installed passive autocatalytic recombiners (PARs) for protecting against hydrogen buildup in containment and detonation that might cause structural damage and consequently the uncontrolled release of radioactivity to the environment. NPP licensees have performed confirmatory assessments demonstrating the efficacy of PARs for severe accidents and have determined that PARs are not needed in the irradiated fuel bay areas.

During its refurbishment, Point Lepreau installed an emergency containment filtered venting system. Licensees other than Point Lepreau are evaluating the means to prevent containment system failures and, to the extent practicable, unfiltered releases of radioactive products in BDBAs, including severe accidents. The options being considered include emergency filtered containment vents. For example, OPG has installed a containment filtered venting system at Darlington to prevent containment system failure from over-pressurization following the unlikely event of a multi-unit severe accident. The system will limit radioactive releases of fission products to the environment through the use of high-efficiency dry metal fiber filter modules using the Westinghouse technology. The modifications completed or planned for Bruce A and B and Pickering are listed in the tables below.

NPP licensees have established special measures for obtaining information by restoring power to the critical safety parameter monitoring equipment to support NPP recovery actions. The initial power supply is obtained from portable, uninterruptable power supply batteries that provide a buffer time to deploy Phase I EME generators that can restore power in the long term to the critical safety parameter monitoring equipment. OPG has finished modifications to install connection points for these generators and procured the portable generators to support this strategy.

The licensees have demonstrated that the equipment and instrumentation necessary for severe accident management will perform their function for the duration they are needed. In addition, licensees have evaluated the habitability of control facilities under conditions arising from BDBAs and severe accidents. Through COG, the industry developed a generic methodology with which to evaluate the habitability of control facilities during a severe accident, including non-radiological hazards.

The licensees have also assessed options for water and temperature monitoring from a safe location in the case of a loss of cooling inventory. They are procuring emergency equipment (e.g., power supplies, pumps) that could be stored onsite or offsite and used to provide backup services during a BDBA.

The following tables list design modifications completed at Darlington (DNGS), Pickering (PNGS A, PNGS B), Bruce A and B, and Point Lepreau to improve safety margins. The DNGS and PNGS improvements are combined in one table for OPG. A number of these modifications are the result of the integrated implementation plans from the PSRs for these NPPs.

OPG modifications

Modification	Station/unit	In-service
Strengthening defence in depth		
Conversion of EPG3 from Temporary to Permanent Modification (“TMOD to PMOD”)	Pickering Units 5 -8	2020
Unit 1 Class III Service Water – Bearing design change for Class III Low and High Pressure Service Water pumps	Pickering Units 1 & 4	2019
Replacement of EPG1 and EPG2 Rectifiers and Batteries (058-55400-RF1/RF2, BY1/BY2).	Pickering Units 5-8	2020
Conversion of EPG3 from Temporary to Permanent Modification (“TMOD to PMOD”)	Pickering Units 5 -8	2020
Unit 1 Class III Service Water – Bearing design change for Class III Low and High Pressure Service Water pumps	Pickering Units 1 & 4	2019
Replacement of EPG1 and EPG2 Rectifiers and Batteries (058-55400-RF1/RF2, BY1/BY2).	Pickering Units 5-8	2020
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Replacement of EPG1 and EPG2 Rectifiers and Batteries (058-55400-RF1/RF2, BY1/BY2).	Pickering Units 5-8	2020
Conversion of EPG3 from Temporary to Permanent Modification (“TMOD to PMOD”)	Pickering Units 5 -8	2020
Unit 1 Class III Service Water – Bearing design change for Class III Low and High Pressure Service Water pumps	Pickering Units 1 & 4	2019
Replacement of EPG1 and EPG2 Rectifiers and Batteries (058-55400-RF1/RF2, BY1/BY2).	Pickering Units 5-8	2020

Bruce Power modifications

Modification	Station/unit	In-service
Aging management		
Emergency Power Generators 1 and 2 Upgrades	B	2019
Steam Generator Replacement	6	2021
Irradiated Fuel Bay Heat Exchanger Replacements	AB	2021, 2022
PHT Pump Bellows Seal Replacement	6	2021
Strengthening defence in depth		
Additional provisions for make-up water		
EME connection to Moderator System	6	2021
Wide-range ECI sump level indication	A	2019
Fire Protection Upgrades		
U0 Fuel Storage Area Sprinkler Upgrades	B	2019
Fireworks Terminal Replacement	B	2019
Unit 1 and 2 Fire Protection Upgrades	1,2	2020
Firewater Pipe Replacement	B	2020
Unit 8 Fire Upgrades	8	2020
Air Foam System Replacement	AB	2021
Fire Barriers Upgrades (Cable Wraps)	B	2021
Fire Detection Upgrades	B	2021
Passive filtration for containment		
Installation of filtered containment venting system	AB	2022
Enhancing emergency response		
Installation of New Digital Site Radio System	AB	2021

Note 1 – Installation was partially completed and will be finished as part of the Major Component Replacement Outage.

NB Power modifications

(Significant safety upgrades were completed during the refurbishment and were described in the eighth Canadian report)

Modification	In-Service
Strengthening defence-in-depth	
Diesel fire pump replacements	2021
Enhancing emergency response	
Enhancements to on-site emergency facilities to support full IT integration	2019

Annex 19 (i)
Conduct and regulatory oversight of commissioning programs

Before an NPP is commissioned, several CNSC staff members are located at the NPP site to observe and report on the commissioning and start-up processes and activities.

CNSC staff do not attempt to follow all aspects of a licensee's commissioning program. Rather, reliance is placed on the licensee's internal review process, which is mandated by the commissioning quality assurance program. Detailed commissioning specifications define the acceptance criteria to be used in inspections and tests performed as part of the commissioning program. Typically, the licensee's procedures require the designers to verify that:

- the program is checking the right items
- the acceptance criteria being used are appropriate to prove that the equipment can perform the safety functions intended in the design

In some cases, partial tests are done if complete tests are not practical (as in the case of commissioning tests of emergency core cooling systems). For example, in the past, commissioning tests were done that involved injection of emergency coolant into the reactor core. However, tests in which cold water is injected into a hot core were not attempted, because such tests could lead to high stresses in the primary coolant system components. The components are designed to withstand these stresses during a limited number of emergencies, but exposing them to such high stresses simply for testing purposes could not be justified.

The commissioning quality assurance program also requires the process of approving the specifications and results to be documented. Any failure to meet the acceptance criteria must be referred back to the design organization, which will decide which, if any, design changes are required. CNSC staff can perform inspections, at any time, to confirm that procedures are followed and appropriate decisions are made.

Direct involvement of CNSC staff in commissioning concentrates on a few major tests, such as those that check the overall NPP response to specific events (e.g., a loss of normal electrical power supplies). CNSC staff also witness major commissioning tests of special safety systems, such as functional tests of the shutdown systems where the reactor is actually tripped and the rate of power reduction is measured (and compared to the rate assumed in safety analyses).

When reviewing commissioning, CNSC staff concentrate on these major tests because they are considered particularly important to safety. These tests check the overall performance of an NPP's safety features and can reveal problems that tests of individual components would not detect. CNSC staff also review test proposals, including detailed commissioning specifications, which are examined to confirm that the tests' acceptance criteria are consistent with the system's safety design requirements (as defined in the licence application). When tests are completed, CNSC staff review the test results and commissioning reports.

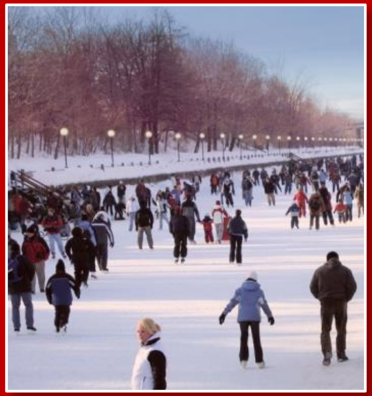
The CNSC requires the licensee to submit commissioning completion assurances prior to first loading of fuel, prior to leaving the reactor guaranteed shutdown state, and upon completion of the approach to criticality, low-power tests and high-power tests.

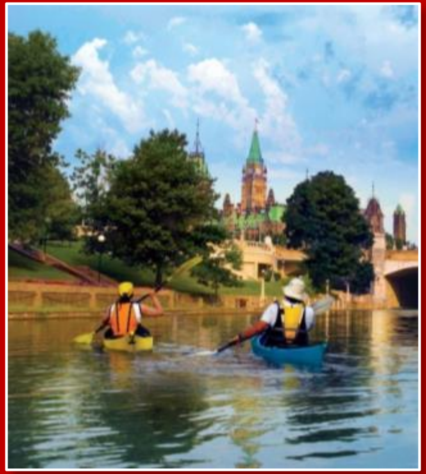
Commissioning completion assurances are written certifications with the following statements:

- Commissioning has been completed according to the process described in the licence application.
- Commissioning results were acceptable.

The completion assurance statements may contain lists of tasks not yet completed, such as the completion of commissioning reports that are not prerequisites for the approvals being sought. This helps to ensure that these tasks are not subsequently overlooked. Typically, the licensee holds a series of commissioning completion assurance meetings to review the work done on particular systems. CNSC staff members at the site attend some of these meetings.

Canada





Government of Canada Gouvernement du Canada

Canada

The Joint 8th & 9th Review Meeting of the Convention on Nuclear Safety

Canada's Presentation

Country Group 4

March 22, 2023

Vienna

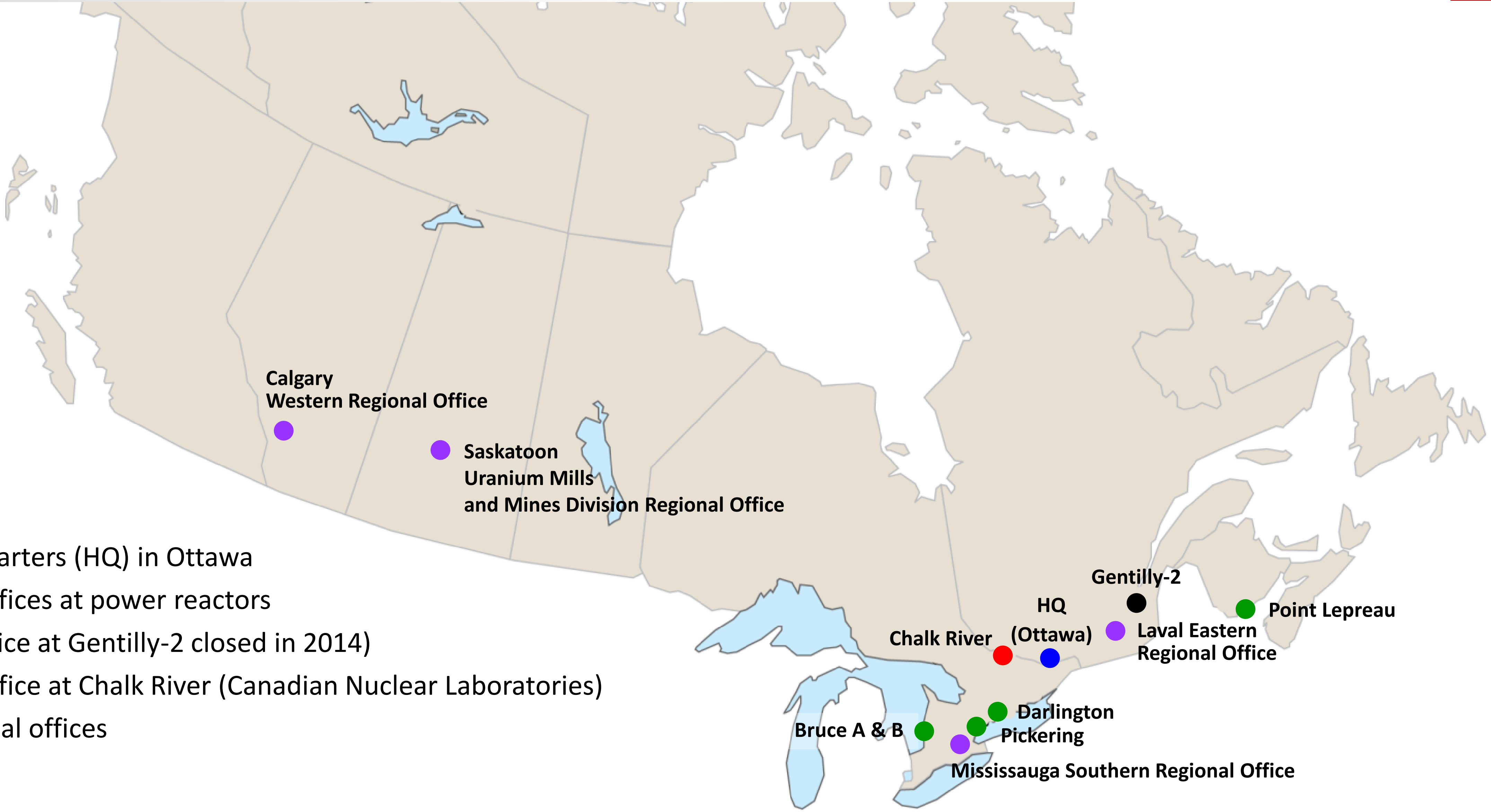
Presentation Outline

- Introduction
- Highlights of Canada's Report
- Responses to CNS Challenges to Canada
- Peer Review Missions
- Vienna Declaration on Nuclear Safety
- Fukushima Follow-up
- Responses to Questions and Comments
- Themes of Topical Sessions
- Proposed Challenges, Good Practices and Areas of Good Performance
- Updates to Canada's Report
- Response to COVID-19 Pandemic
- Response to Invasion of Ukraine
- Conclusions

Canada

INTRODUCTION

Locations of CNSC Offices and NPPs in Canada



- Headquarters (HQ) in Ottawa
- 4 site offices at power reactors
- (Site office at Gentilly-2 closed in 2014)
- 1 site office at Chalk River (Canadian Nuclear Laboratories)
- 4 regional offices

Status of NPPs in Canada

Bruce

A1	A2	A3	A4
In service 1977/2012 Mwe 750	In service 1977/2012 Mwe 750	In refurbishment 1978 Mwe 750	In service 1979/2003 Mwe 750

B5	B6	B7	B8
In service 1985 Mwe 882	In refurbishment 1984 Mwe 882	In service 1986 Mwe 882	In service 1987 Mwe 882

Darlington

1	2
In refurbishment 1992 Mwe 881	In service 2016 Mwe 881

3	4
In refurbishment 1993 Mwe 881	In service 1993 Mwe 881

Pickering

A1	A2	A3	A4
In service 1971/2005 Mwe 515	In service 1971/ Now in safe storage state	In service 1972/ Now in safe storage state	In service 1971/2003 Mwe 515

B5	B6	B7	B8
In service 1983 Mwe 516	In service 1984 Mwe 516	In service 1985 Mwe 516	In service 1986 Mwe 516

Gentilly QC

In Safe Shutdown since Dec. 28, 2012

Point Lepreau NB

In Service 1983/2012 Mwe 705

Typical share of nuclear energy in total electricity generation

- Canada - **17%**
- Ontario - **66%**
- New Brunswick - **31%**

In service / not refurbished

Being refurbished

In service / refurbished

Safe storage

The Canadian Nuclear Safety Commission

Established in May 2000, under the ***Nuclear Safety and Control Act***

- Replaced the Atomic Energy Control Board, founded in 1946 under the ***Atomic Energy Control Act***
- Assigns power and authority necessary to independently regulate nuclear activities

Over 75 years of nuclear safety

Canada

The Commission

- Independent, quasi-judicial tribunal and court of record
  - Consists of up to seven members
  - One member is designated as President of the Commission and Chief Executive Officer of the CNSC
- Commission makes all licensing decisions and regulations
- Supported by scientific, technical and professional staff

The Commission's decisions are reviewable only by the Federal Court of Canada

Canada

The Canadian Nuclear Safety Commission

- **Mission:**

  The CNSC regulates the use of nuclear energy and materials to protect health, safety, security and the environment; implements Canada's international commitments on the peaceful use of nuclear energy; and disseminates objective scientific, technical and regulatory information to the public

- **Technical Support Branch** forms an integral part of the CNSC

- In-house **Legal Services**

Transparent, science-based decision making

CNSC Four Priorities

- To have a **modern** approach to nuclear regulation
- To be a **trusted** regulator
- To maintain **global** nuclear influence
- To be an **agile** organization

Licensees of Operating Canadian NPPs (1/2)

Ontario Power Generation (OPG)

- Public company owned by the Government of Ontario
- Licensed by the CNSC to operate the Darlington and Pickering sites (ten operating CANDU reactors and two reactors in safe storage)
- Capacity: 6,600 megawatts of nuclear electricity


Darlington Nuclear Generating Station (DNGS)


Pickering Nuclear Generating Station (PNGS)

Canada

Licensees of Operating Canadian NPPs (2/2)

Bruce Power

- Private corporation
- Licensed by the CNSC to operate the Bruce A & B sites (eight CANDU reactors)
- Capacity: 6,400 megawatts of nuclear electricity
- Largest operating NPP in the world in terms of electricity capacity

Bruce A and Bruce B Nuclear Generating Stations

New Brunswick Power

- Crown corporation owned by the Government of New Brunswick
- Licensed by the CNSC to operate the Point Lepreau site (one CANDU reactor)
- Capacity: 660 megawatts of nuclear electricity

Point Lepreau Nuclear Generating Station

Canada

Associated Organizations

CANDU Owners Group (COG)

- Not-for-profit organization of licensees and international operators (Argentina, Canada, China, India, Republic of Korea, Pakistan and Romania)
- Coordinates research and development activities and promotes sharing of operating experience
- Provides various programs for its members

CSA Group (formerly the Canadian Standards Association)

- Canada’s largest, member-based standards development organization
- Sets voluntary consensus standards (CSA Group standards) developed by national stakeholders and public interests related to NPPs and other nuclear facilities and activities

Other Government Organizations Involved in NPP Safety

- **Health Canada**
  - Establishes radiological protection guidelines and assessments
  - Responsible for the Federal Nuclear Emergency Plan
- **Global Affairs Canada**
  - Responsible for Canada's nuclear non-proliferation policy
- **Provincial emergency authorities**
  - Responsible for planning and executing nuclear emergency response
- **Natural Resources Canada**
  - Administers *Nuclear Energy Act*, *Nuclear Liability and Compensation Act* and *Nuclear Fuel Waste Act*
  - Establishes policies, priorities and programs for energy science and technology
    - Led development of Action Plan for Small Modular Reactors (SMRs) to coordinate work by diverse set of stakeholders

HIGHLIGHTS OF CANADA'S REPORT

Safety Record

Excellent safety record during reporting period

- Licensees fulfilled their responsibilities for safety and their regulatory obligations
- Radiation exposures well below regulatory limits to workers, the public and the environment
- Radiological releases to the environment extremely low and well below regulatory limits
- No serious process failures

All events addressed in an orderly fashion with no resulting harm to the health, safety or security of persons or the environment

Regulatory Framework (1/2)

- The *Nuclear Safety and Control Act* is the CNSC's enabling legislation
- The Commission makes regulations through a transparent process, which includes public participation and public meetings
- The Commission issues licences with general requirements
- Regulatory documents and CSA Group standards provide detailed requirements and guidance
- Extensive consultation with stakeholders in developing regulatory documents and CSA Group standards

Regulatory Framework (2/2)

CNSC regulatory documents

- Aligned with IAEA safety standards
- Cover all CNSC safety and control areas
- Reviewed and updated, as needed, in five-year plan

CSA Group standards

- Developed through collaboration between industry, the CNSC and other international stakeholders
- Continuously updated

Regulatory documents and CSA Group standards

- Integrated in regulatory framework
- Reviewed and updated following the Fukushima Daiichi accident

Licensing

Operating reactors

- **Licence for operating power reactors**
  - Standardized licence conditions
  - Supported by licence conditions handbook (LCH) which provides detailed compliance criteria and guidance
  - In accordance with the licensing basis of the facility as approved by the Commission
- **Licence renewal**
  - In accordance with the requirements in the *Nuclear Safety and Control Act*, regulations, regulatory documents and CSA Group standards
  - Conducted multiple times over the life of the reactor
  - Systematic review of licensee's past performance
  - Improvement plans over the proposed operating period, which involves implementation of new regulatory documents and CSA Group standards
  - Licence renewals incorporate periodic safety reviews (PSRs), which are conducted on 10-year cycle

Regulatory Oversight Compliance and Enforcement

Inspections and verifications of NPPs

- CNSC inspectors on site at each operating NPP
- Five-year baseline compliance program
- Additional inspections are risk-informed and performance-based

Enforcement

- Set of graduated enforcement actions to compel compliance
  - Select and Apply Enforcement Tools process assists inspectors in choosing the most appropriate tool

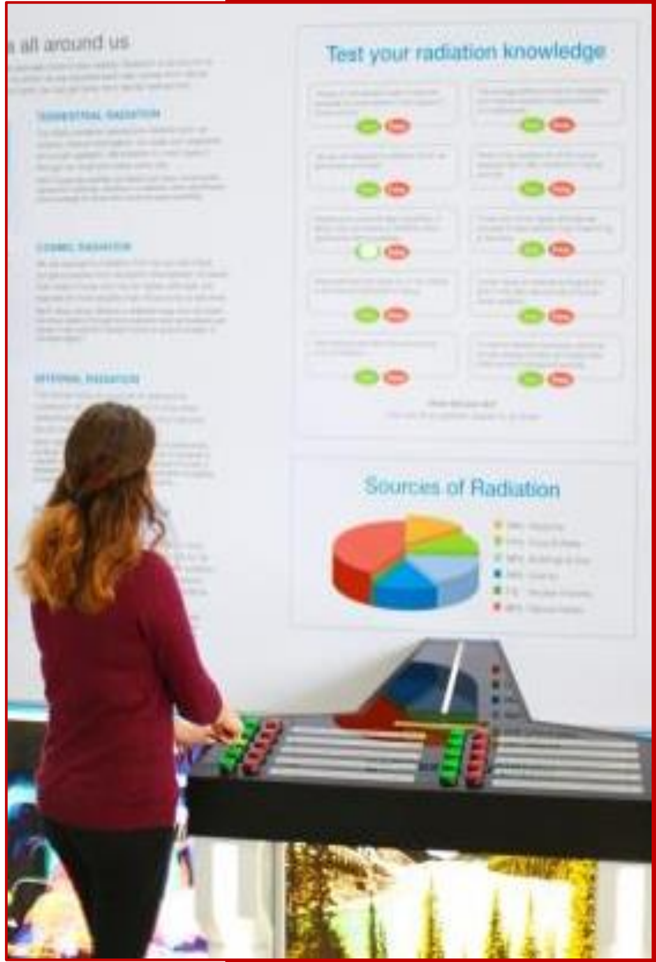
Openness and Transparency (1/2)

- CNSC has mandate to disseminate scientific, technical and regulatory information to all stakeholders
- CNSC outreach programs
- Participant Funding Program
- Public participation during CNSC hearings or meetings held in Ottawa or local communities
  - Use of webcasts for public hearings/meetings
  - "Hybrid" hearings/meetings also conducted to allow in-person and virtual participation

Canada

Openness and Transparency (2/2)

- Extensive licensee programs for proactive disclosure and public information program
  - Public disclosure protocols
- Licensee outreach programs
  - Consultation with Indigenous nations and communities
  - Consultation with municipal governments and local stakeholders
- Licensees make their regulatory information, including environmental monitoring results, available through
  - Corporate websites
  - Social media
- Social media used to disseminate information, e.g.,
  - Facebook, Instagram, LinkedIn, Twitter, YouTube



Canada

Independent Environmental Monitoring Program

The Independent Environmental Monitoring Program (IEMP)

- Complements CNSC regulatory oversight
- Complements monitoring programs of other government agencies, such as Health Canada’s Canadian Radiation Monitoring Network, as well as provincial and licensee monitoring programs
- Complements and confirms licensees’ environmental programs

- CNSC staff collects samples in public areas from air, water, soil, sediment, vegetation and foodstuffs

- IEMP results for all Canadian NPPs available to public through technical reports and interactive map on the CNSC website

Safety Improvements at Existing NPPs During Review Period

- Refurbishment of Darlington Units 2 and 3
- Major component replacement of Bruce Unit 6
- Completion of PSR for Bruce A and B
- Completion of full-scope PSAs at all operating NPPs and development of a methodology for whole-site PSA
- Installation of passive containment filtered venting system at Bruce A and B

Activities Related to SMRs

- **Provinces, utilities, vendors pursuing initiatives on several fronts**
- **Darlington New Build**
  - CNSC renewed OPG's licence to prepare site
  - OPG selected design (GE Hitachi's BWRX-300) and submitted application to CNSC for licence to construct
- **Chalk River**
  - Global First Power submitted application for licence to prepare site (Ultra Safe Nuclear Corporation's Micro Modular Reactor)
  - Environmental assessment ongoing
- **CNSC Vendor Design Reviews (VDRs)**
  - Multiple reviews completed and ongoing for variety of SMR designs
  - VDRs are optional "licensability" assessments – not design certification or binding

Major Common Issues

Issue Common to Contracting Parties	Section of National Report
Safety Culture	Summary, 10(b)
Peer Reviews	Summary, 8.1(e), 14(i)(e)
Legal Framework/Independence	Summary, 7.1, 7.2
Financial/Human Resources	Summary, 8.1(a)(b)(c)
Knowledge Management	Summary, 11.2(b)
Supply Chain	Summary, 13(b), 19(v)
Aging Management	Summary, 14(i)(b),(ii)(b)
Emergency Preparedness	Summary, 16
Stakeholder Consultation	Summary, 7.2(i)(a)(b), 8.1(f), 17(iv)

RESPONSES TO CNS CHALLENGES TO CANADA

Response to remaining 6th Review Meeting Challenges (1/2)

Challenge 3:

Establish guidelines for the return of evacuees post-accident and to confirm public acceptability of it.

Response:

- CNSC requested public review of draft **REGDOC-2.10.1**, *Nuclear Emergency Preparedness and Response, Volume II*
- In 2020, following amendments based on comments from CNSC's public consultation, Health Canada published content of draft REGDOC as *Guidance on Planning for Recovery Following a Nuclear or Radiological Emergency*
  - Seed document, **REGDOC-2.10.1** Volume II, not published and no longer needed
- Additional recovery phase measures at federal level in the Federal Nuclear Emergency Plan

Canada recommends this challenge be closed

Response to remaining 6th Review Meeting Challenges (2/2)

Challenge 5:

Update emergency operational interventional guidelines and protective measures for the public during and following major radiological events.

Response:

- During reporting period, Health Canada published the updated *Canadian Guidelines for Protective Actions during a Nuclear Emergency*
- Guidelines address protective measures and operational intervention levels for the public, including evacuation, sheltering, iodine thyroid blocking and water and food consumption
- Aligns with the latest recommendations from the IAEA and International Commission on Radiological Protection

Canada recommends this challenge be closed

Response to the 7th Review Meeting Challenges (1/3)

Challenge 1:

Publish the drafted amendments to the *Class I Nuclear Facilities Regulations* and the *Radiation Protection Regulations* that address lessons learned from Fukushima.

Response:

- In 2017, amendments to the Class I Nuclear Facility Regulations and the Radiation Protection Regulations to address lessons learned from Fukushima came into force

Canada recommends this challenge be closed

Response to the 7th Review Meeting Challenges (2/3)

Challenge 2:

Complete the transition to the improved regulatory framework (CNSC regulatory documents).

Response:

- The transition to the improved regulatory framework was completed during the reporting period
  - Full alignment with CNSC safety and control areas
  - During the 9th reporting period 31 REGDOCs were either published or revised

Canada recommends this challenge be closed

Response to the 7th Review Meeting Challenges (3/3)

Challenge 3:

Formalize the planned approach to end-of-operation of multi-unit NPPs.

Response:

- **REGDOC-3.5.1**, Information Dissemination: Licensing Process for Class I Nuclear Facilities and Uranium Mines and Mills contains the regulatory process for end of commercial operations
- The CNSC is applying this approach for Pickering
- **REGDOC-2.11.2**, *Decommissioning* contains additional requirements and guidance for the preparation for decommissioning

Canada recommends this challenge be closed

Response to the 7th Review Meeting Suggestion (1/2)

Suggestion 1:

Canada should address any CANDU safety issues that are Category 3 referenced in the 7th national report and provide a report to the 8th RM.

Background:

- In Canadian context, “addressing a CSI” effectively means re-categorizing it from Category 3 to Category 2
  - Category 3 - experiments and/or analysis are required to improve knowledge/understanding and to confirm adequacy of safety margins
  - Category 2 - appropriate control measures are in place to address the issue and maintain safety margins
- A group of CSIs are related to large-break loss-of-coolant accidents – “LBLOCA CSIs”
- Others are referred to as “non-LBLOCA CSIs”

Response to the 7th Review Meeting Suggestion (2/2)

Suggestion 1:

Canada should address any CANDU safety issues that are Category 3 referenced in the 7th national report and provide a report to the 8th RM.

Response:

Progress on LBLOCA CSIs

- Three remaining Category 3 CSIs were re-categorized for Bruce during the reporting period and re-categorized for Darlington after the reporting period
- They remain Category 3 for Pickering and Point Lepreau; assessment of re-categorization is ongoing

Progress on Non-LBLOCA CSIs

- Re-categorization of the two remaining Category 3 CSIs was completed in 2020

Canada will continue to report on CSI progress in CNS reports

Canada recommends this suggestion be closed

PEER AND OTHER REVIEW MISSIONS

Reviews Including International Peer Reviews

- **Integrated Regulatory Review Service (IRRS) mission**
  - Full-scope IRRS mission in September 2019 highlighted 6 good practices and provided 16 suggestions and 4 recommendations
- **Emergency Preparedness Review (EPREV)**
  - Mission in June 2019 reported 5 Good Practices, and provided 6 recommendations and 6 suggestions
- **Office of Auditor General (OAG) of Canada**
  - Audits in 2022
- **World Association of Nuclear Operators (WANO)**
  - Evaluations done every two years at each NPP
- **Operational Safety Review Team (OSART)**
  - Pickering in 2016 (with follow-up in 2018)

Canada

IRRS Review

2019 IRRS Mission – Good Practices (NPP related):

- Comprehensive system for collecting, analyzing and sharing regulatory experience feedback
- The CNSC is very committed to ensuring a high level of transparency and openness
- Proactively developed extensive guidance and processes to assist potential applicants determine the content of SMR application

All findings can be found on IAEA Website - 2019 Review Missions. Follow up mission in 2024 to confirm closure of recommendations and suggestions

Canada

EPREV

2019 EPREV mission – Good Practices:

- Streamlined process for timely submission and processing of claims after a nuclear or radiological emergency, including a fully accessible web platform
- The implementation of the arrangements for pre-distribution of KI pills maximizes the public awareness and the effectiveness of the protective action
- The Warden Service in New Brunswick is an innovative approach to help ensure that relevant information is provided to the public during the preparedness stage
- The use of social media simulators in exercises has enhanced the ability of response organizations to respond to misinformation
- Completion of a self-assessment prior to EPREV mission

All findings can be found on IAEA Website - 2019 Review Missions. Follow up mission in June 2023 to confirm closure of recommendations and suggestions

Office of the Auditor General (Canada)

- **2022 update on past OAG audit on inspection of NPPs found:**
  - The CNSC successfully implemented actions addressing all recommendations from the 2016 report
  - Significant progress has been made in performance metrics related to these recommendations
- **2022 OAG audit on the management of low and intermediate level radioactive waste also had findings relevant to regulation of NPPs, including**
  - The CNSC is effective in its role as Canada’s nuclear regulator
  - CNSC uses risk-based planning

OSART Reviews

- **Pickering 2016 – Good Practices:**
  - Obsolescence management that considers long-term aging management assessments
  - Severe Accident Software Simulator application for supporting multi-unit severe accident management guideline development
  - Longstanding positive relationship with community partners to develop young leaders and improve environmental stewardship
- **Follow-up Missions also conducted**
  - Bruce B in 2017
  - Pickering in 2018

VIENNA DECLARATION ON NUCLEAR SAFETY

Vienna Declaration on Nuclear Safety – Fulfilling Principle 1

Principle 1 addressed through technical criteria and standards that align with objective of preventing accidents

- Regulatory documents clarifying requirements for new NPP projects
  - **REGDOC-1.1.1**, *Site Evaluation and Site Preparation for New Nuclear Facilities*
  - **REGDOC-1.1.3**, *Licence Application Guide: Licence to Operate a Nuclear Power Plant*
- Technical criteria and standards to address the objective of mitigating and avoiding releases
  - **REGDOC-2.5.2**, *Design of Reactor Facilities: Nuclear Power Plants*
    - Based on IAEA SSR-2/1, *Safety of Nuclear Power Plants: Design*
    - Engineered systems to protect containment and to cool the core debris
    - Containment to maintain leak-tight barrier for sufficient time to allow implementation of offsite emergency procedures
  - **REGDOC-2.3.2**, *Accident Management*
    - Severe accident management guidelines

Vienna Declaration on Nuclear Safety – Fulfilling Principle 2 and 3

Principle 2 addressed by National requirements on periodic comprehensive and systematic safety assessments of existing NPPs:

- **REGDOC-2.4.1**, *Deterministic Safety Analysis*
- **REGDOC-2.4.2**, *Probabilistic Safety Assessment (PSA) for Nuclear Power Plants*
- **REGDOC-2.3.3**, *Periodic Safety Reviews*

- Periodic safety reviews (PSRs), including integrated implementation plans
  - Required by licence conditions
  - Details found in **REGDOC-2.3.3**, including 10-year periodicity
  - Specific risk/engineering objectives and limits provided in list of modern codes, standards, and practices

Principle 3 is addressed by aligning and/or informing the regulatory framework with IAEA safety standards

FUKUSHIMA FOLLOW-UP

Fukushima Follow-up

- ***Class I Nuclear Facilities Regulations*** and the ***Radiation Protection Regulations*** were updated in 2017 to address lessons learned from Fukushima
- **Full-scope PSAs completed** incorporating new regulatory requirements as part of lessons learned from Fukushima
- **REGDOC-2.10.1**, *Nuclear Emergency Preparedness and Response, Version 2* and **N1600**, *General requirements for emergency management for nuclear facilities* updated as part of lessons learned from Fukushima
- **Standardized emergency mitigating equipment across NPPs**
- **Implementation of post-Fukushima updates in SAMGs**, and the demonstration of SAMG effectiveness through exercises and plant drills
- **Remaining seven items from DG-IAEA report on Fukushima were addressed** by Health Canada's proposed publication of *Guidance on Planning for Recovery Following a Nuclear or Radiological Emergency*

Canada's Fukushima enhancements and follow-up completed

RESPONSES TO QUESTIONS AND COMMENTS

Canada

Questions to Canada on the National Report (1/3)

Knowledge Management (Article 11)

Knowledge transfer course and a retirement transition program (33777)

Formal succession plans in place (32624)

Student co-op programs (32575)

Certified staff refresher training (32038)

Counterfeit, Fraudulent and Suspect Items (Article 13)

Licensee management system required to have a process to prevent, detect, control CFSI (32934)

Supplier requirements (32040)

CNSC inspection of supply chain (31795)

(#s are CNS question IDs)

Questions to Canada on the National Report (2/3)

KI pill distribution (Article 16)

Consumption criteria (3296)

Provincial guidelines (31802)

Stockpiles and distribution (31801)

Replacement of expired pills (31803)

Radiation dose limits (Article 15)

Requirements on monitoring of workers (32474)

Lens of the eye limits (32476, 32044, 32047)

Dose from various radiation sources (32477)

Pregnant worker dose limits (32046, 31799)

Nuclear Energy Worker limits vs. general public (31800)

Questions to Canada on the National Report (3/3)

Small modular reactors (Article 18)

Regulatory training on SMRs (32321)

Design requirements for power levels (31796)

Design requirements (31804)

Licensing process (31246)

Graded approach (30534)

Regulatory readiness strategy (30170)

Recruitment of expertise (30172)

Safety Culture (Article 10)

Honest disclosure vs disciplinary action (31932)

Self-assessments for regulator and licensees (31790, 31244, 30171)

Objectivity (31792)

Corrective actions (30845)

THEMES OF TOPICAL SESSIONS

Canada

Aging Management

- **REGDOC-2.6.3**, *Aging Management* discusses the impact on safety margins, as determined by an updated deterministic safety analysis. Licensees are revising analyses in the context of **REGDOC-2.4.1** *Deterministic Safety Analysis*
  - OPG completed the planning for Darlington loss of flow analysis, loss of reactor power regulation and in-core LOCA
  - NB Power identified additional analyses to further address plant aging and legacy gaps with REGDOC-2.4.1 and incorporated them in multi-year planning
- **REGDOC-2.5.2**, Design of Reactor Facilities: Nuclear Power Plants states that the final safety analysis report shall account for postulated aging effects of SSCs
- **COG programs** address aging of heat transport system
  - Fuel channel lifecycle management program
  - Safety analysis improvement program

Safety Culture (1/3)

Operator Safety Culture:

- CSA Standard N286-12, *Management System Requirements for Nuclear Facilities* includes a requirement on safety culture
- NPP licensees have implemented CNSC **REGDOC-2.1.2**, *Safety Culture*, which was published in 2018
- NPP licensees adopted nuclear safety culture monitoring panel process and conduct regular safety culture self-assessments

Safety Culture (2/3)

CNSC Oversight of Operator Safety Culture:

- For safety culture self-assessments at NPPs, CNSC assesses licensees' approaches and provides feedback on self-assessments
- CNSC examines evaluation of security culture in the context of safety culture at NPPs

CNSC co-hosted, with OECD Nuclear Energy Agency and World Association of Nuclear Operators, a Country-Specific Safety Culture Forum in Sept 2022

Safety Culture (3/3)

Regulatory safety culture:

- CNSC has an executive champion for safety culture
- “Open Door Policy”, “town hall meetings” and emphasis on diversity and inclusion promote dialog and improve/broaden culture
- Conflict management options include process for difference of professional opinion
- CNSC assessed its own safety culture and is executing plan to address findings, e.g.,
  - Created an opportunity for improvement tool and a regulatory safety culture policy

CHALLENGES, GOOD PRACTICES AND AREAS OF GOOD PERFORMANCE

Proposed Challenges (1/2)

- Update guidance document Generic Criteria and Operational Intervention Levels for Nuclear Emergency Planning and Response and include guidance on protection strategies and reflect guidance in provincial plans
- Approve and implement revision of Ontario's Provincial Nuclear Emergency Plan

Proposed Challenges (2/2)

- Optimize regulatory capacity and capability to effectively and efficiently assess licence applications for SMRs and potentially other nuclear technologies
- Ensure an effective approach between federal departments to provide proponents with certainty related to process and timelines for environmental/impact assessments

Good Practices/Performance (1/4)

In the 8th and 9th review cycles, other Contracting Parties identified the following as noteworthy achievements:

- Systematic approach for NPP related knowledge and on-the-job training for NPP site inspectors in both technology and regulatory processes
- Use of Licence Condition Handbooks and specifically the compliance verification criteria to promote consistency and objectivity of regulatory oversight
- Development of methodology and submission to CNSC of whole-site PSAs for multi-unit NPPs

Good Practices/Performance (2/4)

Continuation of list of achievements identified as noteworthy by <u>other Contracting Parties</u> during 8th and 9th review cycles:

- Publication of discussion papers to solicit early public feedback on regulatory initiatives
- CNSC readiness to regulate SMRs
- Development of policy roadmap for SMRs and adjustment of regulatory framework to enable new technologies

Good Practices/Performance (3/4)

Other notable achievements for Canada

- Development of, and executing, Canadian SMR Action Plan
- Readiness for CNSC oversight of SMRs
  - Regulatory strategy
  - Enhancement to regulatory framework for deployment of new technology
  - Capacity building
  - International collaboration
- Measures to enhance regulatory safety culture
- Increased participant funding to further facilitate stakeholder engagement in Commission proceedings
- Annual, comprehensive regulatory oversight reports, presented in public forum, that summarize safety performance at nuclear facilities
- Canada’s Indigenous engagement, including interweaving of Indigenous knowledge with western science

Good Practices/Performance (4/4)

Continuation of list of other notable achievements for Canada

- Updates to analyses in safety reports for existing NPPs based on modern requirements, including CNSC **REGDOC-2.4.1**, *Deterministic Safety Analysis*
- Effective aging management programs for existing NPPs based on clear requirements using guidelines informed by research and diverse and innovative technologies
- Rigorous planning for safe execution of extensive refurbishments, including replacement of major components, of multiple units in parallel

UPDATES TO CANADA'S REPORT

Updates to National Report to Joint 8th and 9th RM (1/2)

- OPG nearing completion of refurbishment of Darlington Unit 3 and studying feasibility of life extension of Pickering Units 5 to 8
- Bruce Power started outage for major component replacement for Bruce Unit 3 in March 2023
- A major emergency exercise, Huron Endeavour, was conducted at Bruce in October 2022
- OPG submitted application for licence to construct an SMR at Darlington in Oct 2022
- NB Power and SaskPower selected SMR technologies
  - NB Power has selected the site in New Brunswick
  - SaskPower is exploring two site options in Saskatchewan

Updates to National Report to Joint 8th and 9th RM (2/2)

Government of Canada granted $121M to support regulatory readiness and research related to SMRs

- Includes $30M to help develop SMR supply chain and fund research on SMR waste management

Potential for large new-build

- Exploratory discussion ongoing for possible large new-build in Ontario

CNSC published/revised three CNSC REGDOCs

- Including Version 2 of **REGDOC-1.1.2**, *Licence Application Guide: Guide to Construct a Reactor Facility* in Oct 2022

RESPONSE TO COVID-19 PANDEMIC

Canada

Response to COVID-19 pandemic (1/2)

CNSC undertook various activities to adjust to pandemic

- Activated business continuity plan
- Adopted hybrid methods to verify compliance and revised procedures to allow for remote inspection
- Included pandemic-related information to pre-job briefs for on-site activities and provided PPE
- Benchmarked with regulators worldwide regarding inspection practices
- Increased focus on licensees' adherence to pandemic response plans and health protocols
- Exercised regulatory flexibility

Response to COVID-19 pandemic (2/2)

NPP licensees also adjusted to the pandemic

- Activated business continuity plans
- Ensured minimum staff complement was not compromised:
  - Restricting access to control room
  - Cleaning crews more frequent
  - Staggering shift changes, using larger rooms for shift turn-over
  - Using thermal-imaging cameras for active screening
- Delayed major activities (emergency/security exercises)
- Provided on-site testing and vaccines to employees / families, as well as PPE to hospitals and medical institutions

During pandemic, Darlington Unit 2 returned to service safely and on schedule following refurbishment

PLANNED ACTIVITIES FOR CONTINUOUS IMPROVEMENT DURING NEXT REPORTING PERIOD

Planned Activities During Next CNS Reporting Period (1/2)

Bruce Power's ongoing replacement of major components in Units 6, 3

Bruce Power to begin replacement of major components in Unit 4

OPG's ongoing refurbishment of Darlington Units 1 and 3

OPG to begin refurbishment of Darlington Unit 4

OPG to decide on life extension for Pickering Units 5-8 with request for approval of CNSC

CNSC review of OPG's application and Commission decision for licence to construct an SMR at Darlington

Completion of environmental assessment for SMR at Chalk River and CNSC decision on licence to prepare site

Planned Activities During Next CNS Reporting Period (2/2)

- Industry, regulatory, and government readiness for expected deployment of SMRs and, potentially, large reactors
- Continued advocacy for enhanced international collaboration and harmonization of requirements and approaches with focus on SMRs
- Follow-up missions for EPREV in June 2023 and IRRS in 2024

RESPONSE TO INVASION OF UKRAINE

Canada

Canada's Response to Invasion of Ukraine (1/2)

Escalation of emergency operations

- Escalated the response level of Canada's Federal Nuclear Emergency Plan, activated emergency operations centres and the Federal Technical Assessment Groups to address a range of humanitarian and nuclear safety issues
- Ongoing risk assessments for potential releases from Zaporizhzhia (ZNPP) and other NPPs in Ukraine
- Developed health impact and protective action messaging for Canadian missions in eastern Europe and situation reports

Tangible support

- Canada providing funding and equipment through IAEA to enhance nuclear safety in Ukraine

Dissemination of timely information to public

- Public statements, interviews with media outlets, website updates

Canada's Response to Invasion of Ukraine (2/2)

- **Revising emergency plans**
  - Updating Health Portfolio Emergency Response Plan
  - Reviewing Federal Nuclear Emergency Plan and associated arrangements
- **Enhancing radiation monitoring and protection**
  - Enhance environmental radiation monitoring capabilities to improve emergency preparedness and response at Health Canada's Radiation Protection Bureau

CONCLUSIONS

Conclusions

Canada has demonstrated

- Commitment to the Convention's objectives
- Compliance with the Articles of the Convention
- Fulfillment of the *Vienna Declaration on Nuclear Safety*
- Commitment to continuous improvement based on operating experience, best practices, research
- Openness and transparency

Canada's plans for continuous safety improvements

- Ongoing refurbishment at Bruce, Darlington and other aging management activities
- Robust licensing and PSR processes
- Readiness for expected SMR deployment to assure their safe construction and operation
- Continuing engagement with all stakeholders and international involvement and leadership

Canada encourages Contracting Parties to commit to peer reviews, openness and transparency

Recommendations to IAEA and Contracting Parties (1/2)

Contracting Parties should:

- **Continue to meet their CNS obligations** and make their national reports publicly available
- **Actively commit** to strengthening CNS processes to adapt to changing circumstances while continuing to effectively achieve its objectives

To enhance the accountability of the CNS:

- **The Summary Report** should continue to identify Contracting Parties that do not meet the obligations of the CNS
- **The President's Report** should identify Contracting Parties that do not meet the obligations of the CNS
- **The President of the Review Meeting** should communicate this information to the national governments of the Contracting Parties in question

Recommendations to IAEA and Contracting Parties (2/2)

- The IAEA and Contracting Parties should continue to **encourage countries to sign and ratify the CNS**, especially those with existing or emerging nuclear power programs
- **The IAEA should work with WANO** to engage non-responsive operators and to report them to their respective regulator and national government
- The IAEA and Contracting Parties should **continue to aid and support Ukraine** to enable it to fulfill its CNS obligations

Canada