Canadian National Report for the Convention on Nuclear Safety

Eighth Report
August 2019

Gouvernement du Canada
Government of Canada

Canada

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

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

Executive Summary

This eighth 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 2016 to March 2019. During this period, Canada effectively maintained and, in many cases, enhanced its measures to meet its obligations under the CNS. Enabled by a modern and robust 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 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 supplements each NPP licence with a licence conditions handbook that clarifies the regulatory requirements and expectations for the facility and licensee.

The CNSC has a comprehensive program to assure compliance with the regulatory framework and monitor the safety performance of the NPPs. The CNSC continued to enhance the compliance program for operating NPPs during the reporting period.

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 interveners 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.

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 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 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 percent of derived release limits. The CNSC's ratings of NPP safety performance confirmed that regulatory requirements and performance expectations in all 14 of its safety and control areas were met or exceeded at all NPPs during the reporting period.

The 2015 *Vienna Declaration on Nuclear Safety* (VDNS) was adopted by Contracting Parties to the CNS. 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).
- Integrated safety reviews for the refurbishment of specific NPPs have been completed. The introduction of periodic safety reviews for 10-year operating licences has enhanced the systematic adoption of safety improvements at existing NPPs.

During the reporting period, the CNSC and Canadian nuclear industry 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. See subsections 12(a) and 16.1(a) for details.

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 largely complete, and the CNSC has a robust process to continue reviewing, revising and developing regulatory documents.

To address 7RM C-3, the CNSC plans to update the regulatory process for transition of an NPP from operation to decommissioning end state, G-219 *Decommissioning Planning for Licensed Activities,* with lessons learned from NPPs that are approaching end of life and decommissioning, with a focus on multi-unit NPPs. Canada's current fleet of multi-unit NPPs are currently undergoing refurbishment or life-extension activities, which has delayed the necessity of this initiative.

Table of Contents

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
AOO	anticipated operating occurrence
BDBA	beyond-design-basis accident
Canadian report	the [n^{th}] Canadian report refers to the [n^{th}] *Canadian National Report for the Convention on Nuclear Safety,* submitted on behalf of Canada for the [n^{th}] Review Meeting of the Convention on Nuclear Safety
CANDU	Canada Deuterium Uranium
CCP	commissioning control point
CEAA	*Canadian Environmental Assessment Act,2012*
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
CNSC Action Plan	*CNSC Integrated Action Plan on the Lessons Learned from the Fukushima Daiichi Nuclear Accident*
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
COP	continued operations plan
CSA	Canadian Standards Association (now called "CSA Group")
CSI	CANDU safety issue
CSS	Commission on Safety Standards
CVC	compliance verification criteria
compliance assessment	all verification activities limited to the review of documents and reports submitted by licensees (including quarterly technical reports, annual compliance reports, special reports and documentation related to design, safety analysis, programs and procedures)
DG-IAEA Report	*The Fukushima Daiichi Accident: Report by the Director General*
DLA	dynamic learning activity
DRL	derived release limit
EA	environmental assessment
EC6	Enhanced CANDU 6
EFPH	equivalent full-power hours

EIR	event initial report
EIS	environmental impact statement
EME	emergency mitigating equipment
EMEG	emergency mitigating equipment guideline
EPREV	Emergency Preparedness Review
EPRI	Electric Power Research Institute
ERA	environmental risk assessment
event review	all verification activities related to reviewing, assessing and trending of licensees' event reports
FAI	Fukushima action item
FERP	Federal Emergency Response Plan
FNEP	Federal Nuclear Emergency Plan
focused inspection	a special Type I or Type II inspection that is performed as a regulatory follow-up in response to an event, inspection findings or a licensee's performance
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
HOP	human and organizational performance
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
IPPAS	International Physical Protection Advisory Service
IRS	Incident Reporting System
IRRS	Integrated Regulatory Review Service
ISO	International Organization for Standardization
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)
NPP	nuclear power plant
NRCan	Natural Resources Canada
NSCA	*Nuclear Safety and Control Act*
NSCMP	Nuclear Safety Culture Monitoring Panel

NSRB	Nuclear Safety Review Board
OAG	Office of the Auditor General of Canada
OECD	Organisation for Economic Co-operation and Development
OP&P	operating policies and principles
OPEX	operating experience
OPG	Ontario Power Generation (Inc.)
OSART	Operational Safety Review Team
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 2013 to March 2016
RN-Med-Prep	Radiological/Nuclear Medical Emergency Preparedness and Response
RPD	Regulatory Program Division
SAM	severe accident management
SAMG	severe accident management guideline
SCA	safety and control area
SOP	sustainable operations plan
SSCs	structures, systems and components
TBq	terabecquerel
TBq-MeV	terabecquerel-million electron volts
TECDOC	Technical Document (IAEA publication)
Type I inspection	all verification activities related to onsite audits and evaluations of licensee programs, processes and practices
Type II inspection	all verification activities related to routine (item-by-item) checks and rounds
UNENE	University Network of Excellence in Nuclear Engineering
UOIT	University of Ontario Institute of Technology
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 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 eighth Canadian report, which is for the Eighth Review Meeting, 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 the emergency response organizations of the provinces of New Brunswick, Ontario and Quebec.

A.1 Scope

As required by article 5 of the Convention, this eighth Canadian report demonstrates how Canada fulfilled its obligations under articles 6 to 19 of the Convention during the reporting period, which extended from April 2016 through March 2019. 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 eighth 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 seventh Canadian report. A particular focus is placed on the challenges identified for Canada at the Seventh Review Meeting.

In Canada, all reactor facilities are designated as Class 1A facilities and regulated under the *Class 1 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 1A 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.

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 sixth *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 2017.

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

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 form the Sixth Review Meeting that remained open from 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 identified for Canada at the Seventh Review Meeting and those that remain 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
- planned future activities to improve safety

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 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. A list of websites of relevant organizations mentioned throughout this report is included in Appendix A. This eighth Canadian report will be available on the IAEA website upon submission in August 2019 and will be posted to the CNSC website in late 2019 or early 2020, 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

At the Seventh Review Meeting of the Convention, held in Vienna in March 2017, Canada was part of Country Group 3, which also included Japan, Pakistan, Romania, Latvia, Belarus, Turkey, Nigeria, Ghana, Bangladesh, The Republic of Moldova and Myanmar. Canada responded to 163 comments and questions from numerous countries. These comments and questions pertained to topics such as the criteria for deciding who receives money under the CNSC Participant Funding Program, budgets allocated for nuclear safety research in Canada, integrated safety reviews, periodic safety reviews, reviews of operating experience, aging of reactors, radiation protection, public disclosure, and others.

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 eighth Canadian report are provided.

Major Review Results for Canada from 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	7.2(ii)(e)

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

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, the Natural Sciences and Engineering Research Council of Canada and the Generation IV International Forum. (See Appendix D for a description of publically and privately funded R&D, including details on the FNST Work Plan in Appendix D.3.)

In addition to yearly funding, the Government of Canada has also agreed to provide over $67M in direct investment to the nuclear industry since 2015 through programs such as the Strategic Innovation Fund and Sustainable Development Technology Canada. This is in addition to R&D funded privately (see Appendix D).

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 percent decarbonized electricity mix, supporting climate change mitigation. The Canadian nuclear energy sector is a very important component of Canada's economy.

- In 2017, nuclear energy supplied about 15% of Canada's electricity.
- In the province of Ontario, approximately 58% 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 of the in-province 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.

The unique design of CANDU reactors allows for the production of medical isotopes, along with electrical energy production. NPP operators in Canada continue to look for innovative means to produce a broad range of isotopes. 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 and cesium-137). The NPP at Darlington is also seeking to produce molybdenum-99 as early as 2020, which would make it the only supplier of molybdenum-99 in North America.

Canada is the world's second-largest producer and exporter of uranium, with about 22% of total world production (13,353 tonnes of uranium metal) in 2017. More than 85% of this production is exported and contains energy equivalent to approximately one billion barrels of oil- comparable to Canada's oil exports in 2017.

Canada recognizes the potential for development and deployment of SMRs and is engaging stakeholders to help assess priorities and challenges and inform policy regarding the possible development and deployment of SMRs in Canada. See section D.4 for details.

Canada's entire nuclear industry, including power generation, contributes more than six billion dollars a year to the gross domestic product, directly employing more than 30,000 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 policies, priorities and programs for energy science and technology
  - administers the *Nuclear Energy Act*, the *Nuclear Liability and Compensation Act* (which came into force on January 1, 2017 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 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, which:
  - contributes to sustainable development through pollution prevention in order to protect people and the environment from the risks associated with toxic substances
  - is responsible for supporting the *Canadian Environmental Protection Act* and the *Canadian Environmental Assessment Act, 2012* (CEAA), which delegates

responsibility for conducting environmental assessments of proposed nuclear projects under the NSCA to the CNSC

- 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

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

Under a restructuring plan for AECL, a government-owned, contractor-operated model was implemented in 2015 for AECL's nuclear laboratories. AECL continues to function as a federal Crown corporation and continues to have the same mandate but delivers it through contractual arrangements with Canadian Nuclear Laboratories (CNL) to provide science and technology to meet core federal needs through the FNST Work Plan (see appendix subsection D.3 for details), and to support the nuclear industry through access to science and technology facilities and expertise on a commercial basis. In addition, AECL also retains ownership of the nuclear laboratories' physical and intellectual property assets and its 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 is investing $1.2 billion over ten years (starting in 2014-2015); in the revitalization of Chalk River Laboratories. These investments are intended to create a "big science" infrastructure for the broad benefit of all those in Canada wishing to leverage its capabilities – infrastructure that is accessible to academics, industry experts, and others, including small companies.

Although there is no national energy policy related specifically to SMRs, NRCan brought together essential enabling partners for a process related to the possible private sector deployment of SMRs; see section D.4 for details. The CNSC has also established a strategy for ensuring regulatory readiness for SMRs that is built upon three basic pillars.

- a robust but flexible regulatory framework that provides a sound legal basis upon which regulatory decisions can be made and enforced
- risk-informed processes by which the regulatory framework is applied

- a capable workforce with sufficient capacity and technical expertise, operating within an agile organization

Developments related to SMRs are described in section D.4.

Internationally, 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 has invited review missions for both IRRS (scheduled for September 2019; see Article 8) and EPREV (scheduled for June 2019; see Section 16.1(g)). 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, including the International Nuclear Regulators Association, the CANDU Senior Regulators Group, the Nuclear Energy Agency (NEA) of the Organisation 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 among regulatory and other organizations. For example, by chairing the CANDU Senior Regulators' Meeting, the CNSC is able to share regulatory information that is specifically relevant to CANDU NPPs. Canada is also a participant in the Multinational Design Evaluation Programme (MDEP; see Article 18) and the Generation IV International Forum (see Appendix subsection D.5).

Canada has signed and ratified six other multilateral, nuclear-related 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*

Canada also continued to enhance its international cooperation and assistance to improve nuclear safety worldwide, through cooperation with international partners in 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 six of Canada's ten provinces are shown). Of the 22 nuclear power reactor units in Canada, 19 are currently producing power. In addition, two units at Pickering and the one unit at Gentilly-2 are in a safe storage state. The Gentilly-2 unit has started the process toward decommissioning (see description below). The operation and activities of these reactors are governed by five licences issued by the CNSC.

The Canadian NPPs are operated by four licensees:

- 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

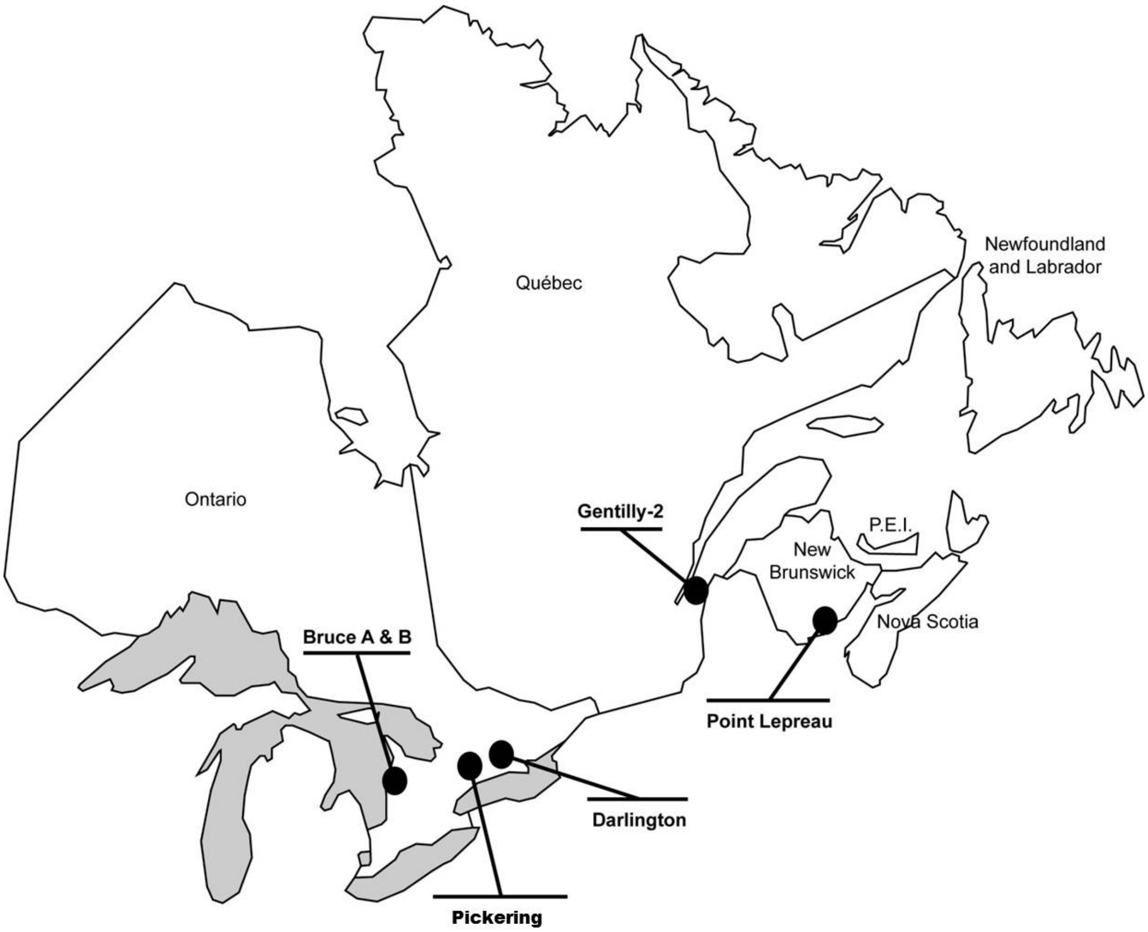

Figure D.1 Partial Map of Canada Showing the Locations of NPPs

The licensees and number of reactors at each licensed site (and their status) are summarized in the following table.

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

The following timeline shows the main historical periods of operation for the NPPs in Canada. Long periods of non-operation correspond to extended outages, such as for refurbishment.

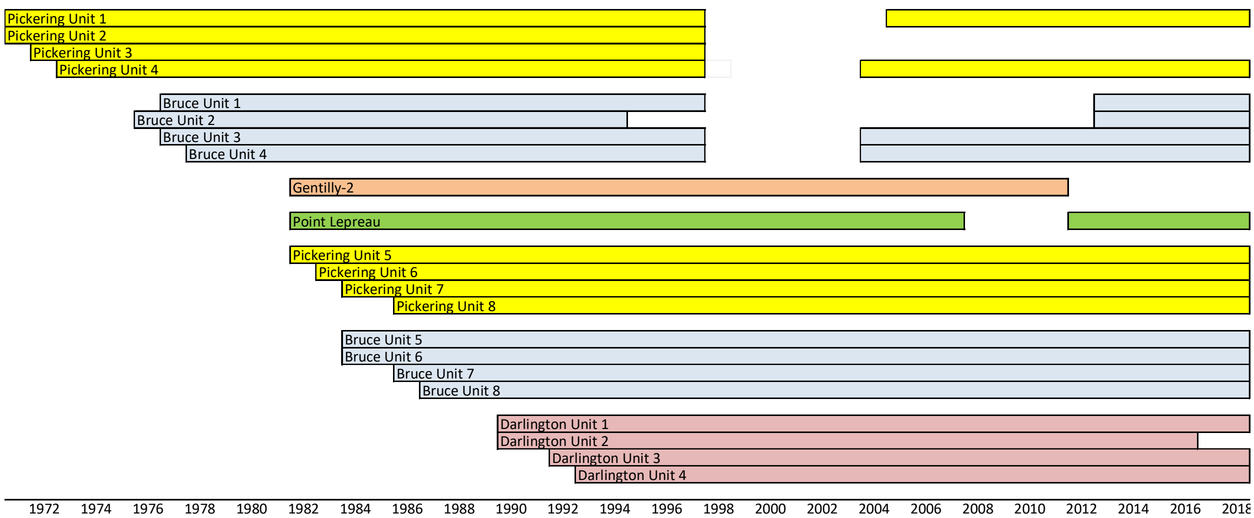

Figure D.2 Timeline of NPPs in Canada

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). Besides Canada, there are six other countries with CANDU reactors in operation. A full description of CANDU reactors was provided in the first and second Canadian reports.

Candu Energy acts as the original designer and vendor of the CANDU technology in Canada. Candu Energy has four reactor designs:

- CANDU 6: Heavy-water moderated reactor utilizing natural uranium fuel and on-power refuelling
- 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, low-enriched

uranium and plutonium-mixed oxide and thorium, in addition to the conventional natural uranium)

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, 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 20 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 subsection 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 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 replacing or upgrading 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. Each of them has a condition in its licence to operate that requires the licensee to complete the IIP. Any significant changes to the IIP would constitute a change in the licensing basis of the NPP – the licence requires that such changes are subject to the approval of the Commission.

[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.

Bruce A and B refurbishment

In December 2015, Bruce Power and the Independent Electricity System Operator of the Province of Ontario entered into an amended, long-term agreement to secure 6,400 megawatts of electricity from the Bruce site, through a multi-year, life-extension program. 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 will begin in Unit 6 in January 2020, and will extend the lives of Units 3 to 8 over a period of 13 years. Bruce A Units 1 and 2 have already been fully refurbished and returned to service in 2012. Asset management and MCR outages will allow Bruce Power's units to operate safely through to 2064.

In February and May of 2018, Bruce Power appeared before the CNSC Commission in public hearings requesting a ten-year licence renewal and approval of the MCR scope. This request was granted in September of 2018 with a renewed licence being issued from October 1, 2018 to September 30, 2028.

Darlington refurbishment

Darlington Unit 2 refurbishment commenced in October 2016, and significant progress was made during the reporting period toward completion of the work items in the IIP, which was based on an ISR. At the end of the reporting period, the installation of the Unit 2 fuel channels was complete and feeder installation was continuing. OPG presented a refurbishment project update to the Commission in February 2019. The Unit 2 refurbishment project remained on schedule and on budget. Just after the reporting period ended, OPG completed the re-fill of the moderator system (May 2019).

There are some CNSC "regulatory hold points" for the project - the first one being prior to loading fuel. An OPG-CNSC protocol for the removal of the regulatory hold points related to Darlington Unit 2 refurbishment was developed and revised in December 2017. OPG is to provide a completion assurance document for each hold point.

OPG expects to complete the planning for Unit 3 refurbishment by the end of 2019 and to commence refurbishment in the first quarter of 2020.

Pickering extended operation

Pickering Units 1 to 4 (formerly known as Pickering A) came into service in 1971. Following refurbishment activities, Units 1 and 4 were returned to service in 2005 and 2003, respectively. In 2005, OPG decided not to return Units 2 and 3 to service, based on an economic evaluation. In 2010, Units 2 and 3 were each placed in a safe storage condition, which involved removing the fuel and heavy water from 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.

Pickering Units 5 to 8 (formerly known as Pickering B) came into service in 1983. An extensive ISR was completed in 2010 to assess the options for its ongoing, long-term service. In 2010, OPG decided that incremental life extension, rather than the options of shutdown or refurbishment, was the best option for Units 5 to 8. The decision to not refurbish was based on economic factors, such as the capacity of the units, rather than on safety concerns.

In 2010, OPG developed a continued operations plan (COP) to document the technical basis actions required to support the incremental life extension of the Pickering Units 5 to 8 to the end of 2020. A COP was not required for Units 1 and 4 given that these units had recently been refurbished. In 2011, OPG developed a sustainable operations plan (SOP) for all operational Pickering Units (1, 4 and 5 to 8) that contains strategic plans recognizing the unique challenges associated with the approach to the end of commercial operation which at the time was planned for 2020. The SOP describes the arrangements and activities required to demonstrate that Pickering's safe and reliable operation will be maintained and sustained for the period of operation until all units are permanently shut down.

For the previous Pickering licence to operate (August 2013 to August 2018), the Commission approved the operation of the Pickering Units 5 to 8 beyond the assumed pressure tube design life (210,000 equivalent full-power hours), based on continued demonstration of fitness for service and up to a maximum of 247,000 equivalent full-power hours. Some of the activities required to demonstrate pressure tube fitness for service were documented and tracked in the COP. A similar limitation was unnecessary for the pressure tubes of Units 1 and 4, which had been subject to less than 15 years of service by that time.

Additional studies, including technical and economic assessments, suggested there was value in pursuing further work to support extending the operation of Pickering units. In 2015, the business case supporting extended operation was approved to continue operating Pickering to 2024 and subsequently in January 2016, the province of Ontario announced its support for OPG's plans to operate Pickering to 2024, subject to completion of the necessary assessments and regulatory approval.

In May 2016, OPG issued a notice of intent to the CNSC to renew Pickering's licence to operate for a ten-year term from September 1, 2018 to August 31, 2028. In August 2017, OPG submitted a comprehensive application for licence renewal to support continued commercial operation of all Pickering units through to December 31, 2024 followed by a transition to safe storage by 2028. OPG also requested the CNSC's authorization to operate the pressure tubes in Pickering Units 5 to 8 up to a maximum of 295,000 equivalent full-power hours. The licence application was supported by an extensive PSR that assessed all Pickering units and used the previously developed COP as a starting basis. The PSR concluded that OPG had effective programs and processes for continued safe operation through 2024. As part of the associated IIP, OPG committed to completing enhancements, which were subsequently accepted by the CNSC. In addition, OPG was required to develop and submit a SOP five years prior to the shutdown of any unit and a stabilization activities plan (SAP) three years prior to the shutdown of any unit. These reports must be updated and submitted for CNSC review on an annual basis following initial submission. The intent of the SOP and SAP is to document OPG's plans for safe operation leading to the NPP's end of commercial operation and transition to safe storage.

In August 2018, the Commission renewed the licence to operate Pickering up to August 31, 2028. The Commission also authorized OPG to operate the pressure tubes in Pickering Units 5 to 8 up to a maximum of 295,000 equivalent full-power hours. The Commission directed OPG to inform the CNSC prior to December 31, 2022 of an intent to operate any unit beyond 2024. As operation beyond 2024 would constitute a licensing basis change, the Commission noted that OPG would require authorization from the Commission in the context of a separate public hearing.

By May 2019, OPG had completed approximately half of the IIP actions to which it has committed as part of relicensing, and all remaining actions are on track for completion per schedule.

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 completing 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 currently in the pool. Other main activities planned for this phase are the establishment of program for preventive maintenance; aging management of structures, systems and components (SSCs); and environmental monitoring. Hydro-Québec foresees having all fuel in dry storage by 2020 and dismantling the NPP between 2059 and 2064, with restoration of the site being completed by 2066.

D.4 New-build developments

Specific measures taken by CNSC and NPP licensees with respect to new-build projects are given in subsection 7.2(i)(c) and sub-article 17(ii).

Darlington New Nuclear Project

In 2006, OPG submitted an application for a licence to prepare site for future construction of NPPs within the existing boundary of the Darlington site. Subsequently, in 2009, as part of the environmental assessment (EA) process, OPG submitted an environmental impact statement with supporting documentation to apply for a licence to prepare site. A joint review panel (JRP) was appointed to consider the EA and the application for a licence to prepare site for the Darlington New Nuclear Project (DNNP). In 2011, the JRP concluded that the project was not likely to cause significant adverse environmental effects, provided mitigation measures are in place, and that OPG was qualified to carry out the site preparation activities requested in the application.

In August 2012, the JRP, as a panel of the Commission, subsequently issued OPG a 10-year licence to prepare site for the DNNP.

In 2013, citing the low electricity demand growth in the province of Ontario, the Government of Ontario directed OPG to defer the construction of new nuclear reactors at Darlington; however, it requested that OPG maintain the licence to prepare site for the DNNP. During the reporting period, OPG pursued several long-lead-time work activities to fulfill OPG's commitments made during the EA and licencing process, including:

- bank swallow monitoring and mitigation
- intake and diffuser structures siting
- support of CNSC activities to engage stakeholders in developing policy for land use around NPPs

OPG completed a mid-term report for the licence to prepare site for the DNNP, as requested by the JRP, and presented it at a public meeting of the Commission on December 13, 2018. OPG has notified the CNSC of its intent to renew its licence to prepare site, which expires in August 2022. OPG is conducting activities to support its application.

Initiatives involving SMRs

During the reporting period, Canadian interests have been involved in various efforts to develop and design SMRs. The concepts vary significantly in size, design features and cooling types and could potentially be sited in places quite different from past NPP projects (e.g., in small and isolated communities). Besides potentially serving different electricity markets and enhancing grid stability, they may have uses beyond electricity generation, such as hydrogen production, desalinization and industrial or district heating.

During the reporting period, a number of technology developers and potential proponents continued to express interest in the possible deployment of SMRs in Canada. In 2018, Natural Resources Canada convened the SMR Roadmap process to engage stakeholders in order to better understand their views on priorities and challenges related to the possible development and deployment of SMRs in Canada. Over ten months, an engagement process was led by interested provinces, territories, and power utilities with industry and potential end users, including Indigenous and northern communities and heavy industry. The stakeholder-led report of the SMR Roadmap was released in November 2018 and can be found at https://SMRroadmap.ca/.

The roadmap investigated three major areas of SMR applications:

- on-grid power generation, especially in provinces phasing out coal in the near future
  - utilities want to replace end-of-life coal plants with non-emitting base-load plants of similar size
  - larger SMRs are likely to align with this application
- on- and off-grid combined heat and power for heavy industry
  - oil sands producers and remote mines would benefit from medium-term options for bulk heat and power that would be more reliable and cleaner than their current energy sources
  - small or medium SMRs are likely to fit this need
- off-grid power, district heating, and desalination in remote communities
  - these communities currently rely almost exclusively on diesel fuel, which has various limitations (e.g. cost, emissions)
  - very small SMRs may address these needs

The report was released on November 7, 2018 with 53 recommendations for all key enablers.

In order to maintain a strong degree of regulatory independence from industry sector discussions, CNSC participation in the SMR Roadmap initiative was limited to observations of the discussions and providing clarifications on regulatory topics and issues.

Although the Government of Canada is not directly involved in SMR technology development, it may provide funding. Notably, the Strategic Innovation Fund was recently increased to provide an additional $800 million over five years to support innovation, which could include SMRs, if criteria are met.

On March 20, 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 CNSC licensing process began with a sufficiency review of the application and project description. If and when the project description is assessed as complete, the next step would be to issue a notice of commencement. The project description would then become available for public comment as part of the EA process.

In line with the SMR Roadmap, the NPP licensees are also exploring the possible deployment of SMRs. Bruce Power and OPG have entered into agreements and memoranda of understanding with several SMR vendors and other partners to investigate the feasibility of deployment of SMRs in Canada.

The Province of New Brunswick established agreements with ARC Nuclear and Moltex Energy to each invest $5M, matched by equal funding from the province, to progress the design, R&D and a CNSC phase 1 vendor design review for their SMR designs (vendor design reviews are described in Article 18). The work also involves an assessment of the feasibility of the establishment of a supply chain in New Brunswick. If successful, this could eventually lead to a commercial demonstration at the Point Lepreau site.

At the end of the reporting period, Bruce Power, NB Power and OPG had not committed to proceed with any project. However, they will continue to investigate the feasibility and business cases over the next reporting period.

COG has initiated two vehicles for industry members to develop common technical positions to support SMR deployment among vendors and partners in SMR development. 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.

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 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.

Details of how Canada fulfilled the VDNS can be 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 at five sites. There are four sites – Bruce, Darlington, Pickering and Point Lepreau - , each having its own CNSC licence to operate. Gentilly-2 is shut down and has a CNSC licence to decommission. Hydro-Québec completed the transition to safe storage during the reporting period and will be proceeding to decommissioning the NPP. OPG began refurbishing the four reactors at Darlington, starting in 2016, and intends to extend operation of the six reactors that remain in operation at Pickering beyond 2020. Bruce Power plans to refurbish six of the eight reactors at the Bruce site, commencing in 2020.

Nuclear-related activities at NPPs in Canada are governed by robust, modern 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. Canada's nuclear regulator, the CNSC, is mature and well established. A system of licensing is in place to control activity related to NPPs and to maintain the associated risks to the health and safety of persons, the environment and national security at reasonable levels. The CNSC uses a comprehensive compliance program to assure the compliance of the licensees with the regulatory framework and monitor the safety performance of their NPPs. The Canadian NPP licensees fulfill their responsibilities to safety, giving it the highest priority at all levels of their organizations. Many provisions are in place that contribute to the safe operation of NPPs in Canada. Both the CNSC and the licensees make a strong commitment to nuclear safety on an ongoing basis, striving for continuous improvement.

Overall safety performance

Canada's nuclear industry has an excellent safety record spanning several decades. Any safety issues that arise are addressed by the licensees, in order to keep risk at their NPPs at reasonable levels. Canadian NPP licensees also collaborate on many projects to address safety issues and share information. For example, Bruce Power and OPG have collaborated to ensure industry vendor capability exists to execute the complexity of work at both utilities.

None of the safety-significant operational 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 at any NPP during the reporting period. Furthermore, the licensees' efforts to address these operational events were effective in correcting any deficiencies and preventing recurrence.

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 very low, 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.

Regulatory framework and improvements

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). These changes have been introduced into the regulatory framework in a risk-informed way by focusing on technology neutral fundamental safety objectives. Renewals of operating licences for NPPs (which occur approximately every ten years) were used to introduce new standards and requirements, with provisions for implementation of the new requirements over predefined time periods.

The CNSC revised the *Class I Nuclear Facilities Regulations* and the *Radiation Protection Regulations*.

With the publication in 2015 of CNSC regulatory document REGDOC-2.3.3, *Periodic Safety Reviews*, and its implementation to the licensing basis of Canadian NPPs, licensees now perform periodic safety reviews (PSRs) for licence renewals.

The CNSC published a number of new regulatory documents that further clarify requirements for new NPP projects, including:

- REGDOC-1.1.1, *Site Evaluation and Site Preparation for New Nuclear Facilities* and REGDOC-1.1.3, *Licence Application Guide: Licence to Operate a Nuclear Power Plant*
- for safety culture and human performance: REGDOC-2.1.2, *Safety Culture*, REGDOC-2.2.1, *Human Factors*, a set of volumes under REGDOC-2.2.4 about fitness for duty, and REGDOC-2.2.5, *Minimum Staff Complement*
- REGDOC-2.5.1, *General Design Considerations: Human Factors*

To the extent practicable, consideration was given, in the development of these documents, to the application of the requirements and guidance to various types and sizes of projects including SMR projects. Provisions exist for a project proponent / applicant to propose how to address CNSC expectations consistent with a graded approach while still meeting the safety objectives articulated in the regulatory documents. This is further articulated in CNSC regulatory document REGDOC 3.5.3, *Regulatory Fundamentals*.

CNSC is also enhancing licence application guidance for the licence to construct and is developing supplementary guidance for the licence application guides that can be applied to SMR projects through CNSC regulatory document REGDOC-1.1.5, *Supplemental Information for Small Modular Reactor Proponents.*

Licensing and compliance

NPP licences are relatively similar and contain general requirements for the most part, although they do contain specific and detailed licence conditions when needed. The CNSC supplements each licence with a more detailed licence conditions handbook (LCH), which describes the requirements and expectations for the NPP and provides a comprehensive list of the codes, standards, and regulatory documents that form part of its licensing basis. The CNSC has a comprehensive program to assure compliance with the licensing basis (as detailed in the LCH) and to monitor the safety performance of the NPPs. The CNSC has continued to enhance the compliance program for operating NPPs. This includes developing and updating inspection guides and establishing the compliance program elements for overseeing the various new-build licensing stages. During the reporting period, 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) when they arose.

Assessments and peer reviews

The results of the compliance program drive the CNSC's follow-up activities and inform regulatory program planning. They are also used to determine safety assessment ratings of the CNSC safety and control areas (SCAs) for each licensee that are documented and presented to the Commission every year in a regulatory oversight report. The CNSC's ratings of NPP safety performance confirmed that CNSC's requirements and expectations in all 14 of its safety and control areas were met or exceeded at the NPPs for the reporting period. The overall ratings were either "fully satisfactory" or "satisfactory" for all NPPs in 2016, 2017 and 2018.

Canada hosted its initial IAEA Integrated Regulatory Review Service (IRRS) mission in 2009 and a follow-up review in 2011. The next IRRS mission is scheduled for September 2019. Health Canada invited the IAEA in February 2017 to conduct an EPREV in Canada, focusing on emergency preparedness Category 1 facilities. This invitation was accepted by the IAEA in March 2018. The EPREV mission in Canada will be conducted in June 2019, and will involve a range of federal, provincial and municipal emergency preparedness and response stakeholders, as well as the nuclear generating station operators.

Addressing the challenges and suggestion for Canada from the 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. Country Group 3 also identified three new challenges and one suggestion for Canada. The following describes the highlights of activities undertaken during the reporting period to address those challenges and suggestion.

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

During this reporting period, Health Canada published the updated *Canadian Guidelines for Protective Actions during a Nuclear Emergency*. The guidelines address protective measures and operational intervention levels for the public, including evacuation, sheltering, iodine thyroid blocking and water and food consumption. 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

During the reporting period the CNSC was involved in a number of recovery phase initiatives, including participation in the IAEA's Modelling and Data for Radiological Impact Assessments Programme. The CNSC requested public review of draft REGDOC-2.10.1, *Nuclear Emergency Preparedness and Response, Volume II*, which discussed and provided examples of best practices on preparedness for recovery. Recovery measures were also tested during an emergency exercise, Synergy Challenge at Point Lepreau, which included a full day in testing the implementation of early recovery actions. See subsection 16.1(a) for further details.

The planned activities to address Challenge 6RM C-3 will continue during the next reporting period. Canada recommends that this challenge remain open.

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, amendments to the *Class I Nuclear Facilities Regulations* and the *Radiation Protection Regulations* to address lessons learned from Fukushima came into force. 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 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. The transition to the improved regulatory framework is largely complete - remaining revisions to the framework are expected by 2020 – and a robust process already exists for ongoing review, revision and development of regulatory documents. See subsection 7.2(i)(b) for further details. 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 CNSC developed a regulatory process for transition of an NPP from operation to decommissioning end state, G-219 *Decommissioning Planning for Licensed Activities,* which will be updated with lessons learned from NPPs that are approaching end of life and decommissioning, with a focus on multi-unit NPPs. Canada's fleet of multi-unit NPPs is currently undergoing refurbishment or life-extension activities, which has delayed the necessity of this initiative. See subsection 7.2(ii)(e) for further details. The planned activities to address Challenge 7RM C-3 will continue during the next reporting period. Canada recommends that this challenge remain open.

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

At the end of 2017, there were four remaining Category 3 CSI issues, three of which are related to a large-break loss-of-coolant accident (LOCA).

AA9 analysis for void reactivity coefficient (Category 3)
PF9 fuel behaviour in high-temperature transients (Category 3)
PF10 fuel behaviour in power pulse transients (Category 3)

The industry continues to develop the CAA methodology described above in order to address the LBLOCA CSIs. Through an industry-wide agreement, Bruce Power is taking the lead in the regulatory application of the CAA methodology.

The fourth Category 3 issue, IH6, is related to systematic assessment of the effects of high energy pipeline breaks inside containment. It is only applicable to PNGS and Point Lepreau. The CNSC re-categorized IH6 from Category 3 to Category 2 for PNGS Units 5 to 8 in June 2018, and for Point Lepreau in January 2019.

See subsection 14(i)(e) for further details.

The planned activities to address Suggestion 7RM S-1 are complete, although work will continue in the next reporting period to address the remaining three Category 3 CSIs. Canada recommends that this suggestion be closed.

Preparations for possible deployment of small modular reactors

During the reporting period, Canada continued developmental work related to the possible deployment of small modular reactors (SMRs) and accelerated efforts on some fronts.

- Canada developed a policy “roadmap”
- Canada continued to refine its regulatory approach to ensure suitability for SMRs, including the establishment of additional guidance information, review of regulatory processes, and adjustment of regulatory capacity
- At the end of the reporting period, the CNSC received an application for a licence to prepare a site for an SMR at Chalk River Laboratories from Global First Power

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 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 has introduced PSRs for 10-year operating licences, 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 during the reporting period

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

- refurbishment of Darlington and integrated implementation plan (IIP)
- 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
- preparations for the decommissioning of Gentilly-2
- installation of a portable HVAC and filtration system for the secondary control area at Point Lepreau

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).

Summary of planned activities to improve safety

The CNSC and NPP licensees plan to continue the initiatives and safety improvements described above and to undertake other activities to further enhance safety. The planned improvements during the next reporting period include:

- 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
- refurbishment of Units 1 and 3: replacement of fuel channels and feeders.
- implementation of multi-unit PSA at Darlington
- installation of auxiliary shutdown cooling system at Darlington

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 all 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 help, 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. Both the CNSC and the licensees 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) and the Operational Safety Review Team (OSART) 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, probabilistic safety assessments (PSAs) and licence renewal assessments. Safety assessments have also been conducted in response to significant events and national and international operating experience. The licensees have reassessed the safety cases of their NPPs through regular safety analysis report updates but also as part of environmental assessment follow-ups or as reviews of lessons learned in the context of special circumstances (e.g., the Fukushima accident).

As explained in subsections 14(i)(c) and 14(i)(d), licensees are also updating analyses and implementing new requirements for both deterministic safety analyses and PSAs.

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 NPP licensees 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, the licences for three 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 7.2(ii)(d), "Licence renewals and updating the licensing basis").

Licensees implemented safety upgrades on a continual basis to maintain safety margins and incrementally enhanced safety at their sites (see annex 18(i) for examples). Further, NPP licensees have conducted periodic safety reviews (PSRs), as part of the planning for potential refurbishment projects and to support licence renewals (These exercises have included comprehensive and systematic plant condition assessments and the identification of safety improvements that are reflected in IIPs. In conjunction with life extension, these activities have helped enhance the level of safety of refurbished NPPs as compared to their pre-refurbished conditions. The NPP licensees began implementing CNSC regulatory document REGDOC-2.3.3, *Periodic Safety Reviews*, for licence renewals (see subsection 7.2(ii)(d), "Periodic safety review within the licensing framework").

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)(f) 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 at any NPP during the reporting period. (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.) 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, including, orders, administrative monetary penalties or prosecution at Canadian NPPs, as described in sub-article 7.2(iv).

Conclusion

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

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 subsections C.1 and C.2 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 consists of 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 regulatory instruments 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)). The NSCA, regulations, regulatory documents, licences and orders are described in more detail in the subsections below.

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, including the use of discussion papers, which play an important role in the selection of regulatory approaches and the development of the regulatory framework and regulatory program.

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.)

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, quasi-judicial administrative tribunal responsible for regulating the development, production and use of nuclear energy, and the production, possession and use of nuclear substances, prescribed equipment and prescribed information. Other responsibilities of the Commission include the dissemination of objective scientific, technical and regulatory information to the public and preventing unreasonable risk to the environment, the public and national security. (The independence of the Commission is described in subsection 8.2(a)). It also makes legally binding regulations subject to the approval of the Governor in Council (Cabinet) and independent licensing decisions. 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 CNSC'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

    - 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 set regulations that govern those facilities and to issue, amend, suspend and revoke licences that set out 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 re-determine decisions in light of new information
- the authority to order remedial actions in hazardous situations and to require responsible parties to bear the costs of decontamination and other remedial measures
- the authority to include licence conditions (including the power to demand 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 groups 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, the most important being Global Affairs Canada, which has overall responsibility for international agreements and conventions, as well as Canada's bilateral and multilateral relationships.

7.1 (b) Other legislation, conventions or legal instruments

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 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*
- *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*

Canada signed the *Convention on Supplementary Compensation for Nuclear Damage* in December 2013. That convention entered into force on April 15, 2015 under the auspices of the IAEA. Canada's domestic nuclear liability legislation, the *Nuclear Liability and Compensation Act*, entered into force on January 1, 2017[3], replacing the *Nuclear Liability Act*. Under the new law, the operator of an NPP is responsible to pay up to $850 million (increasing to $1 billion on January 1, 2020) for civil damages resulting from an accident at that NPP. Among other changes, the new law expands the types of damages for which people and businesses affected by the accident can be compensated, and it provides a longer time period for making claims for bodily injury. Furthermore, the *Nuclear Liability and Compensation Act* provides the Government of Canada with 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

[3] The new legislation was a prerequisite for the ratification of the *Convention on Supplementary Compensation for Nuclear Damage*, which subsequently entered into force for Canada on September 4, 2017.

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, Environment Canada and at the provincial level. That is, provincial environmental legislation applies to nuclear facilities and the CNSC also shares the federal regulation of environmental protection with Environment Canada, in accordance with the *Canadian Environmental Protection Act, 1999*.

7.2 Provisions of the legislative and regulatory framework

7.2 (i) National safety requirements and regulations

The NSCA allows for a range of supporting and complementary regulatory instruments, including regulations, licences, regulatory documents and standards. The CNSC has a long-term regulatory framework plan for designing, implementing and managing the development and use of those 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 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 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 CNSC's affairs.

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

- *General Nuclear Safety and Control Regulations*
- *Administrative Monetary Penalties Regulations (Canadian Nuclear Safety Commission)*
- *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*
- *Canadian Nuclear Safety Commission Rules of Procedure*
- *Canadian Nuclear Safety Commission By-laws*

Generally, these regulations give licensees the details of how to comply with legislative requirements. 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 required an applicant for a licence for a Class I facility to describe its proposed human performance program (see ubsection 12(a)) and its management system, including measures to promote and support safety culture (see subsection 13(a)).

One of the planned amendments to the *Class I Nuclear Facilities Regulations*, requiring licence applicants to submit off-site emergency plans, was considered unnecessary. See subsection 16.1 (d) for details.

The amendments to the *Radiation Protection Regulations* involved an alignment with international guidance on overall preparedness for, and response to, radiological emergencies and establishing 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, are also expected to be made in 2020. See Article 15 for details.

Both CNSC staff and industry have confirmed that, with the exception to the Nuclear Security Regulations which are more prescriptive in nature, the regulations are suitable for regulating activities involving the use of SMR technologies. The CNSC is in the process of developing more performance based amendments to the Nuclear Security Regulations. Some specific developments related to the detailed regulatory framework for SMRs are described in subsection 7.2(i)(b).

During the reporting period, the CNSC also made amendments to other regulations that were outside the scope of the Convention - the *Nuclear Non-proliferation Import and Export Control Regulations* and (for safeguards reporting) the *General Nuclear Safety and Control 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.

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 licensees develop specific provisions to meet the requirements. Specific requirements can be established where necessary.

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 requirements in the areas of planning, constructing and operating NPPs and small reactors, safety culture, human performance and fitness for duty. Many of these were revisions to existing regulatory documents:

- REGDOC-1.1.1, *Site Evaluation and Site Preparation for New Reactor Facilities*
- REGDOC-1.1.3, *Licence Application Guide: License to Operate a Nuclear Power Plant*
- REGDOC-1.5.1, *Application Guide: Certification of Radiation Devices or Class II Prescribed Equipment*
- REGDOC-1.6.1, *Licence Application Guide: Nuclear Substances and Radiation Devices*, Version 2
- REGDOC-2.1.2, *Safety Culture*
- REGDOC-2.2.1, *Human Factors*
- REGDOC-2.2.2, *Personnel Training*, Version 2
- REGDOC-2.2.3, *Personnel Certification: Exposure Device Operators*
- REGDOC-2.2.4, *Fitness for Duty: Managing Worker Fatigue*
- REGDOC-2.2.4, *Fitness for Duty, Volume II: Managing Alcohol and Drug Use*, Version 2
- REGDOC-2.2.4, *Fitness for Duty, Volume III: Nuclear Security Officer Medical, Physical and Psychological Fitness*
- REGDOC-2.2.5, *Minimum Staff Complement* (actually published just after the reporting period, on April 9, 2019)
- REGDOC-2.4.3, *Nuclear Criticality Safety*
- REGDOC-2.5.1, *General Design Considerations: Human Factors*
- REGDOC-2.5.4, *Design of Uranium Mines and Mills: Ventilation Systems*
- REGDOC-2.5.5, *Design of Industrial Radiography Installations*
- REGDOC-2.5.7, *Design, Testing and Performance of Exposure Devices*
- REGDOC-2.6.1, *Reliability Programs for Nuclear Power Plants*
- REGDOC-2.6.2, *Maintenance Programs for Nuclear Power Plants*
- REGDOC-2.7.3, *Radiation Protection Guidelines for the Safe Handling of Decedents*
- REGDOC-2.9.1, *Environmental Protection: Environmental Principles, Assessments and Protection Measures, version 1.1*
- REGDOC-2.10.1, *Nuclear Emergency Preparedness and Response, Version 2*
- REGDOC-2.11, *Framework for Radioactive Waste Management and Decommissioning in Canada*
- REGDOC-2.11.1, *Waste Management, Volume II: Management of Uranium Mine Waste Rock and Mill Tailings*
- REGDOC-2.11.1, *Waste Management, Volume III: Assessing the Long-Term Safety of Radioactive Waste Management*
- REGDOC-2.12.1, *High Security Facilities, Volume I: Nuclear Response Force, Version 2*
- REGDOC-2.12.1, *High Security Facilities, Volume II: Criteria for Nuclear Security Systems and Devices*
- REGDOC-2.13.1, *Safeguards and Nuclear Material Accountancy*
- REGDOC-2.13.2, *Import and Export, Version 2*
- REGDOC-2.14.1, *Volume II: Radiation Protection Program Design for the Transport of Nuclear Substances*
- REGDOC-3.1.1, *Reporting Requirements for Nuclear Power Plants, Version 2*
- REGDOC-3.1.2, *Reporting Requirements, Volume 1: Non-Power Reactor Class I Facilities and Uranium Mines and Mills*

- REGDOC-3.2.1, *Public Information and Disclosure*
- REGDOC-3.4.1, *Guide for Applicants and Intervenors Writing CNSC Commission Member Documents*
- REGDOC-3.5.1, *Information Dissemination: Licensing Process for Class I Nuclear Facilities and Uranium Mines and Mills, Version 2*
- REGDOC-3.5.3, *Regulatory Fundamentals*
- REGDOC-3.5.4, *Pre-licensing Review of a Vendor's Reactor Design*
- REGDOC-3.6, *Glossary of CNSC Terminology*

The transition to the improved regulatory framework, as referenced in Challenge 7RM C-2, is complete to a large extent. The CNSC is working towards a target date of introducing all new REGDOCs and completing the revisions to current REGDOCs by 2020, after which the regulatory framework will be 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).

The CNSC REGDOC development process 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 documents that apply to NPP licensees is provided in annex 7.2(i)(b).

Use of other proven practices in the development of CNSC REGDOCs

The CNSC requires the use of proven practices in the conduct of regulated activities. The CNSC sets requirements and guidance by adopting (or adapting) appropriate industry, national, international or other standards as it deems appropriate. An applicant or licensee may put forward a case to demonstrate that the intent of a requirement is addressed by other means and demonstrated with supportable evidence. Where standards either do not apply or do not exist, the CNSC will consider high quality information from science and technology activities that is demonstrated to be sufficient and relevant to the specific application. Information submitted in support of an application to conduct activities must demonstrate that proposed safety and control measures will meet or exceed CNSC expectations. This is in line with the Government of Canada *Cabinet Directive on Regulation* and is consistent with the CNSC's vision of regulatory excellence.

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. 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 used to develop CNSC documents.

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. Several CNSC staff members 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-16-01, *How the CNSC Considers Information on Costs and Benefits: Opportunities to Improve Guidance and Clarity*
- DIS-16-02, *Radiation Protection and Dosimetry*
- DIS-16-03, *Radioactive Waste Management and Decommissioning*
- DIS-16-04, *Small Modular Reactors: Regulatory Strategy, Approaches and Challenges*
- DIS-16-05, *Human Performance*
- DIS-17-01, *Framework for Recovery in the Event of a Nuclear or Radiological Emergency*

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 by the regulatory documents published by the CNSC.

During the reporting period, the nuclear industry, the CNSC and the 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:

- CSA N290.5-16, *Requirements for electrical power and instrument air systems of CANDU nuclear power plants* (New Edition)
- CSA N290.6-16, *Requirements for monitoring and display of nuclear power plant safety functions in the event of an accident* (New Edition)
- CSA N286.10-16, *Configuration management for high energy reactor facilities* (New Standard)
- CSA N299.1-16, *Quality assurance program requirements for the supply of items and services for nuclear power plants, Category 1* (New Standard)
- CSA N299.2-16, *Quality assurance program requirements for the supply of items and services for nuclear power plants, Category 2* (New Standard)
- CSA N299.3-16, *Quality assurance program requirements for the supply of items and services for nuclear power plants, Category 3* (New Standard)
- CSA N299.4-16, *Quality assurance program requirements for the supply of items and services for nuclear power plants, Category 4* (New Standard)
- CSA N285.0.1-16, Commentary on CSA N285.0-12, *General requirements for pressure-retaining systems and components in CANDU nuclear power plants* (New Commentary, 1st edition)
- CSA N288.8-17, *Establishing and implementing action levels for releases to the environment from nuclear facilities* (New Standard)
- CSA N290.17-17, *Probabilistic safety assessment for nuclear power plants* (New Standard)
- CSA N290.18-17, *Periodic safety review for nuclear power plants* (New Standard)
- CSA N285.0-17/N285.6 Series-17-17, *General requirements for pressure-retaining systems and components in CANDU nuclear power plants / Material Standards for reactor components for CANDU nuclear power plants* (New Edition)
- CSA N290.0-17, *General requirements for safety systems of nuclear power plants* (New Edition)
- CSA N290.2-17, *Requirements for emergency core cooling systems of nuclear power plants* (New Edition)
- CSA N287.2-17, *Material requirements for concrete containment structures for nuclear power plants* (New Edition)
- CSA N287.7-17, *In-service examination and testing requirements for concrete containment structures for nuclear power plants* (New Edition)
- CSA N292.6-18, *Long-term management of radioactive waste and irradiated fuel* (New Standard)
- CSA N289.1-18, *General requirements for seismic design and qualification of nuclear power plants* (New Edition)
- CSA N288.9-18, *Guidance for design of fish impingement and entrainment programs at nuclear facilities* (New Standard)

- CSA N285.0.1-18, Commentary on CSA N285.0-17, *General requirements for pressure-retaining systems and components in CANDU nuclear power plants* (New Edition - Commentary)
- CSA N285.5-18, *Periodic inspection of CANDU nuclear power plant containment components* (New Edition)
- CSA N290.13:18, *Environmental qualification of equipment for nuclear power plants* (New Edition)
- CSA N290.19:18, *Risk-informed decision making for nuclear power plants* (New Standard)
- CSA N291:19, *Requirements for nuclear safety-related structures* (New Edition)
- CSA N292.0:19, *General principles for the management of radioactive waste and irradiated fuel* (New Edition)

All CSA Group standards that are relevant to NPPs are shown in the table in annex 7.2(i)(b). The table provides numerous examples of where IAEA standards have been used to develop the CSA Group standards.

Regulatory framework for new NPPs

During the reporting period, the CNSC continued to update its regulatory framework for new NPPs. The revised framework draws upon international standards and best practices, including the IAEA's safety standards, to the extent practicable. The IAEA standards set out high-level safety goals and requirements that apply to all reactor designs; that is, they are technology-neutral.

The CNSC's requirements and guidance for reactor facilities are generally articulated to be technology-neutral and, where possible, 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

The CNSC regulatory documents that are an important part of the suite of documents required for the licensing of new-build projects can be found in table 1 of annex 7.2 (i)(b). 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).

Small modular reactors (SMR)

The CNSC published discussion paper DIS-16-04, *Small Modular Reactors: Regulatory Strategy, Approaches and Challenges*, during the reporting period to examine key areas where SMRs could post regulatory challenges. Details are provided in annex 7.2 (i) (b).

Small modular reactors are not legally defined in Canada because they fall under the Class I Facilities Regulations. However, they are generally understood to include reactors for the generation of power or heat for industrial purposes. Reactors for non-power generation uses (e.g., isotope production and research and development activities) are understood to be research reactors.

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 table also shows that CNSC regulatory documents and CSA standards incorporate the content of a significant number of IAEA publications as references. The referenced IAEA publications are given in annex 7.2(i)(b) but additional IAEA publications were also considered in the development of the CNSC regulatory documents and CSA standards.

7.2 (ii) System of licensing

Section 26 of the NSCA prohibits any person from preparing a site, 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(5) of the NSCA 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 CNSC's regulatory regime defines NPPs as Class IA nuclear facilities and the regulatory requirements for these facilities are found in the *Class I Nuclear Facilities Regulations*. These regulations 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

If the necessary applications are filed with the required information, the Commission may, at its discretion, 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.

It is important to consider that 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 22 existing reactors covered by this report are spread across five sites, each with a CNSC licence: Bruce, Darlington, Pickering, Point Lepreau, and Gentilly-2. Each of the first three sites has a single facility licence to operate multiple reactors, whereas Point Lepreau has a licence to operate a single reactor. Gentilly-2 has a licence to decommission the power reactor on site. Adjacent to the existing four-unit Darlington site, is a new site (Darlington New Nuclear Plant, DNNP) licenced under a *Licence to Prepare Site* issued in 2012.

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. The Commission may choose to hold a public hearing in one or two parts. For a 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 will focus on the presentations and submissions of intervenors as well as all information submitted by the parties who participated in Part 1 of the hearing. The CNSC Rules of Procedure set out the requirements for one-part and two-part public hearings.

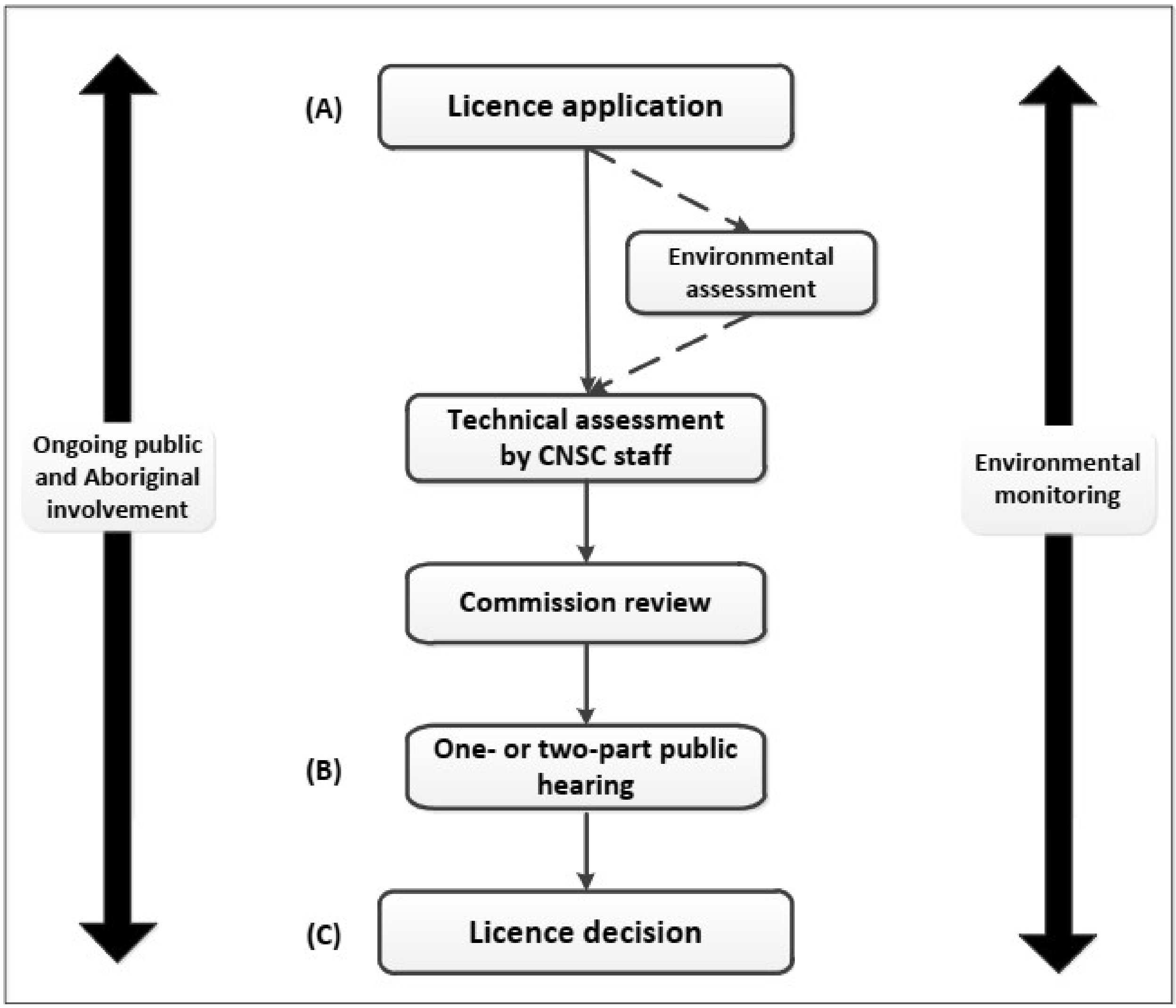

Figure 7.2 Process for obtaining an NPP licence under the NSCA

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*.

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

The Canadian regulatory approach to licensing SMRs is built on the long-established foundation of risk-informed regulation that has been applied to traditional reactor facilities. The Canadian nuclear regulatory framework is comprehensive and in large part technology neutral, which means that that it allows for all types of technologies to be safely regulated. Regulatory tools and decision-making processes are structured to enable a licence applicant for a reactor facility to propose alternative ways to meet regulatory objectives.

Most SMR concepts, although based on technological work and operating experience from older NPPs, employ a number of novel approaches. Novel approaches, or even proven approaches used in different ways, can affect the certainty of plant performance under both normal operation and accident conditions, raising regulatory questions during the licensing process. Proposals must demonstrate, with suitable information, that they are equivalent to or exceed regulatory requirements.

The CNSC established processes for the licensing of SMR projects. Potential areas to consider (e.g., application of the graded approach) are described briefly in annex 7.2(i)(b) in the context of CNSC discussion paper DIS-16-04, *Small Modular Reactors: Regulatory Strategy, Approaches and Challenges*.

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 applicants clearly understand what is necessary to satisfy the requirements of the applicable regulations under the NSCA. The following table lists published and planned CNSC REGDOCs that provide guidance on licence applications for NPPs.

Document #	Title	Published
REGDOC-1.1.1 (supersedes RD-346)	*Site Evaluation and Site Preparation for New Reactor Facilities* *Site Evaluation for New Nuclear Power Plants*	July 2018 November 2008
RD/GD-369 (to be superseded by REGDOC-1.1.2)	*Licence Application Guide: Licence to Construct a Nuclear Power Plant*	August 2011
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*	Being drafted

REGDOC-1.1.1, which was published during the reporting period, covers the specific activities to evaluate the suitability of a site, and prepare it, for new reactor facilities. CNSC staff would use it to assess new applications or applications to renew a licence to prepare the site of a new NPP. The CNSC also published REGDOC-1.1.3 during the reporting period, while Bruce Power and OPG were preparing their applications to renew their licences to operate Bruce A and B and Pickering, respectively. Although CNSC did not use REGDOC-1.1.3 to assess their applications, Bruce Power and OPG did consult the draft and published versions when preparing their licence applications.

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 are 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).

Per the CEAA, before any federal authority issues a permit or licence, grants an approval, or takes any other action for the purpose of enabling a project to be carried out in whole or in part, an environmental assessment (EA) must be carried out for certain designated physical activities to identify whether the project is likely to cause significant adverse environmental effects. For all new NPPs, the EA is performed before the first licence – namely, the licence to prepare a site – is issued. An EA addresses all the phases of the project lifecycle, from site preparation through to abandonment. EAs are described in more detail in subsection 17(ii)(a).

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.

CNSC staff members document the conclusions and recommendations from their reviews in Commission member documents (CMDs), submitting them to the Commission for a public hearing held in one or two parts. In the more conventional two-part hearings, the Commission considers the initial conclusions and recommendations at the Part One public hearing (refer to figure 7.2 shown previously), along with information provided by the licence applicant. At the

Part Two public hearing, the Commission, in accordance with the *Canadian Nuclear Safety Commission Rules of Procedure,* invites interventions by other interested parties (e.g., members of the public, non-government organizations, Indigenous communities, labour unions, municipalities, other government departments, industry) who are then given the opportunity to present information that they feel is relevant to the licensing decision at hand.

For the licensing of NPPs, intervenors are typically allotted significant periods of time at the Part Two 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 Two hearing as follow-up to discussion at Part One. 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.

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 the set of requirements and documents comprising:

(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 all aspects of operation to which the licensee makes reference, documents describing conduct of operations, and documents describing conduct of maintenance.

The licensing basis sets the boundary conditions for acceptable performance at a nuclear facility. As such, it establishes the basis for the CNSC's compliance program (see sub-article 7.2(iii)), which is designed to ensure licensees continue to meet requirements and conduct the licensed activity within the licensing basis.

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. The licensee must obtain the written approval of the Commission if it wants to make a change outside the licensing basis.

These 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, including references to regulatory documents or industry standards that licensees must meet. 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 Act.

NPP licences may include specific control provisions that require approval or consent to proceed for situations or changes where the licensee could be:

- not compliant with regulatory requirements set out in applicable laws, regulations or licence conditions
- outside the licensing basis

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 subsection37(2) of the NSCA, including the power to issue, renew, suspend, amend, revoke or replace a class of licence identified by the Commission. NPP licences may also indicate if the Commission has the option of delegating the authority to grant the approval to CNSC staff (a process known as “CNSC staff consent”).

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.

Examples of Commission approval and CNSC staff consent for a hold point for a licence to operate an NPP are provided in subsection 7(ii)(d) “Licence renewal and updating the licensing basis.”

Licence amendments

The NSCA gives the Commission the authority to issue, renew, suspend, amend, revoke or replace licences (to modify existing licence conditions or to add new licensing requirements, for example). Licence amendments can be initiated by the Commission or at the request of 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.

Licence conditions handbooks

NPP licences contain relatively general requirements that are common to all NPPs in Canada. This greatly reduces the need for the Commission to amend the licence during the licence period. However, each NPP site with a licence has an associated licence condition 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.

Both licences and LCHs are organized by the CNSC safety and control areas (SCAs). These 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.

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. It also provides for the management of records and documents, including.

All revisions to an NPP LCH during the licence period are approved by CNSC staff:

existing, operating NPPs	Director General of the Directorate of Power Reactor Regulation
new build applications	Director General of the Directorate of Regulatory Improvement and Major Projects Management

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, under Natural Resources Canada (NRCan), assumes the role of proponent if it directly sponsors a federal (i.e., government-run) NPP project. 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 the preamble of 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 EA 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 the public can express its views and question the applicant.

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

CNSC regulatory document REGDOC-2.3.1, *Conduct of Licensed Activities: Construction and Commissioning Programs*, provides assurance to the applicant and the regulator that facilities will be constructed per design, the reactor facility will meet its safety requirements and will operate safety. CNSC staff use this REGDOC to assess new applications for licences to construct reactor facilities. The CNSC is reviewing RD/GD-369: *Licence Application Guide, Licence to Construct a Nuclear Power Plant*, which provides guidance to applicants on the information to submit in an application for a licence to construct an NPP. 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, the 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 licensee compliance with the NSCA, associated regulations and its licence. Compliance activities focus on confirming that the NPP construction is consistent with the design and 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 RD/GD-369 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

7.2 (ii) (d) Licence to operate

The licensing process for a licence to operate is described in CNSC Regulatory Document REGDOC-3.5.1, *Licensing Process for Class I Nuclear Facilities and Uranium Mines and Mills*.

When applying for a licence to operate, 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. This includes a demonstration 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.

The following list outlines some of the information required in support of an application for a licence to operate a new NPP in order to satisfy the regulations and CNSC regulatory documents REGDOC-1.1.3, *Licence Application Guide: Licence to Operate a Nuclear Power Plant*:

- a description of the SSCs, including their design and operating conditions
- the final safety analysis report
- proposed measures, programs, policies, methods and procedures for:
  - Phase B, C and D commissioning (i.e., the commissioning of all SSCs with first fuel in the core)
  - 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
- 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
- updated preliminary decommissioning plan
- proposed financial guarantee for the activities to be licensed

The information needed by the applicant to submit a successful application for a licence to operate is articulated in CNSC's regulatory document REGDOC-1.1.3.

For a licence to operate a new NPP, 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 (i.e., Phases B, C and D). These activities complete the overall commissioning program of 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).

Licence period

The CNSC uses flexible licence periods that enable it to regulate NPPs in a more risk-informed manner (in particular, through the adjustment of the licence period according to the licensee's previous performance and the findings resulting from its 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 members need to consider when making recommendations to the Commission regarding 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 safety and control areas
- the requirements of the *Canadian Nuclear Safety Commission Cost Recovery Fees Regulations*
- the facility's planning cycle

The imposition of a relatively short licence period by the Commission is an option where overall licensee performance, or one of the other factors listed above, is unsatisfactory.

Licence renewal and updating the licensing basis

During the reporting period, the licences to operate Pickering, Bruce and Point Lepreau were all renewed. The operating licences for Pickering and Bruce were renewed, in separate hearings in 2018, for ten years. The operating licence for Point Lepreau was renewed in 2017 for five years.

The licence to operate Gentilly-2 expired during the reporting period (see subsection 7.2(ii)(e)). In 2016, the Commission issued Hydro-Québec a license to decommission Gentilly-2 for a period of ten years.

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. This type of information becomes part of the licensing basis of the NPP once a licence to operate is granted, as described in subsection 7.2(ii)(a). The CNSC plans and conducts a balanced assessment of the licensee programs and activities, which provides the Commission with a comprehensive review of the facility and of the licensee's activities and performance. It also supports staff recommendations for any licensing decision and guides ongoing regulatory activities. See subsection 14(i)(b) for a description of this assessment.

Licence renewal is a mechanism to implement 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 to achieve full compliance. 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 contains the anticipated implementation date of the new REGDOC or standard, which may be projected to be 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 requirements. 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 are also transitioning to the practice of conducting PSRs in conjunction with the renewals of their licences to operate. PSRs also account for the possible implementation of new requirements associated with modern codes, standards and practices. The status of PSRs in Canada is described below.

Licence renewal and regulatory hold points

The renewals of licences to operate NPPs during the review period also involved the imposition of regulatory hold points. 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. 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 of to the Executive Vice-President and Chief Regulatory Operations Officer of the Regulatory Operations Branch of the CNSC.

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

Periodic safety review within the licensing framework

CNSC REGDOC-2.3.3, *Periodic Safety Reviews*, is consistent with the IAEA's Specific Safety Guide No. SSG-25, *Periodic Safety Review for Nuclear Power Plants*.

PSRs are complementary to the CNSC's existing assessments within its process to renew a licence to operate an NPP. The safety and control areas that provide the framework for the licence renewal safety assessment (and ISR/PSR) cover the IAEA PSR safety factors. The implementation of PSR at the CNSC is relatively straightforward in that it simply assigns a regular frequency to regulatory activities that have been previously conducted in the "one-off" occasions of life-extension projects. As explained above, the imposition of requirements in new REGDOCs and standards has already been well-established in the CNSC's licence renewal process, prior to the adoption of PSR.

Per REGDOC-2.3.3, 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
- integrated implementation plan (IIP)

The integrated implementation plan identifies corrective actions and safety improvements that address all gaps found in the PSR.

In the transition to a PSR-based regulatory regime, CNSC staff members began recommending 10-year operating licences for NPPs with a PSR performed every 10 years to coincide with licence renewal. The introduction of PSRs for NPPs was the lead activity in a broader CNSC initiative to consider implementing PSRs for all Class I facilities in Canada. This initiative was further supported by an amendment to the *Class I Nuclear Facilities Regulations* in 2017 that requires all NPPs to conduct a PSR at an interval as specified in the licence.

The following describes the developments during the reporting period for PSRs applicable to each of the sites 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, which includes the major component replacement outages.

Bruce Power submitted the safety factor reports to the CNSC in August 2015 and September 2016 for Bruce A and B, respectively. In December of 2016, Bruce Power submitted a combined global assessment report and IIP for Bruce A and Bruce B, given that the designs are similar and they share common programs. The Commission approved the IIP through the licence renewal process in 2018. The operating licence includes a condition that requires Bruce Power to implement the IIP.

Pickering

OPG conducted a PSR in support of the 2017 application for renewal of the licence to operate Pickering. The review considered a ten-year licensing period including commercial operation until the end of 2024 followed by a stabilization and safe storage phase to the end of 2028.

OPG submitted the PSR basis document to the CNSC in July 2016. By July 2017, it completed 15 safety factor reviews and two complementary reviews. Strengths identified and gaps were input into to the global assessment process. In February 2018, OPG submitted the global assessment report to the CNSC. The Commission approved the IIP through the licence renewal process in 2018. The operating licence includes a condition that requires OPG to implement the IIP.

Darlington

During the previous reporting period, OPG had conducted an integrated safety review in support of its application for renewal of the licence to operate Darlington. The Commission approved the resulting IIP through the licence renewal process in 2015 and imposed a licence condition requiring OPG to implement it. The refurbishment work began in October 2016 and will continue into the next reporting period. The licence to operate Darlington contains a separate condition requiring OPG to conduct its first PSR in support of its next licence renewal.

Point Lepreau

NB Power had conducted an integrated safety review 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 is conducting a PSR in support of an application for a 10-year licence. By the end of the reporting period, NB Power had completed the PSR basis document and the bulk of the safety factor reviews, while initiating the global assessment.

7.2 (ii) (e) Licence to decommission

Specific requirements for a licence to decommission a Class I nuclear facility are listed in section 7 of the *Class I Nuclear Facilities Regulations* (CINFR). Information listed in section 3 of the *General Nuclear Safety and Control Regulations* (GNSCR) and the general requirements section of the CINFR are also required. Examples of the requirements for 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 the maintenance of national security, including an emergency response plan

The CNSC requires that planning for decommissioning take place throughout a licensed activity's life-cycle, and that both a preliminary decommissioning plan (PDP) and a detailed decommissioning plan (DDP) be prepared for approval by the CNSC. Regulatory guide G-219, *Decommissioning Planning for Licensed Activities* provides regulatory expectations to licensees regarding the preparation and content of PDPs and DDPs for activities licensed by the CNSC.

As part of its ongoing modernization of the regulatory framework, the CNSC is currently in the process of developing REGDOC-2.11.2, *Decommissioning*. This regulatory document will supersede G-219. Furthermore, CSA N294.0, *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 licence, the CNSC requires licensees to maintain a decommissioning plan and a financial guarantee for decommissioning.

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

Canada's fleet of multi-unit NPPs is currently undergoing refurbishment or life-extension activities, which has delayed the necessity of this initiative.

The 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 operation of the facility. Normally, this occurs several years in advance which allows plans to be developed and implemented to assure continued safe operations over the final years and a smooth transition of the facility into a permanent safe shutdown and eventual implementation of the planned decommissioning strategy.

The CNSC requires the licensee to develop a plan for the facility's end of operation. This is a broad plan that comprises steps for approaching permanent shutdown and the facility's transition from shutdown to a stable state (i.e., stabilization activities).

REGDOC-2.11.2 is intended to codify regulatory expectations for the preparation for decommissioning, including expectations for the facility's transition from operation to decommissioning. As a result, the planned activities to address Challenge 7RM C-3 will continue during the next reporting period. Canada recommends this challenge remain open.

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 adequate 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 program that:

- is informed by risk (to health, safety, 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 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
- verification activities to confirm licensees are complying with requirements and expectations
- reactive control measures to enforce compliance (see sub-article 7.2(iv))
- consistency in the method and conduct of compliance activities

The compliance 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 legal requirements. The goal is to maximize compliance, by strengthening those factors that encourage it and by 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

Verification includes all the activities related to determining and documenting whether a licensee's programs and performance comply with legal requirements and conform to acceptance criteria. Although they can be tailored to specific licensees and circumstances, the activities are organized according to the CNSC's safety and control areas. 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
- compliance technical assessments, which are 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
- field inspections, which focus primarily on observations made within the nuclear power plant and can be completed within a short timeframe
- 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)

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

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.

In general, acceptance criteria that can be used to assess compliance during compliance technical assessments or inspections 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; and field component line-up checks.

Some inspections monitor licensee activities as they unfold (e.g., exercises, outages). Other surveillance and monitoring activities collect real-time information about licensee performance and possible emerging issues.

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 (see subsection 8.1(b) for further details). 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 (defined below). The results are recorded in a CNSC report to the licensee and follow-up actions are documented and assigned target completion dates.

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 organized according to the CNSC's safety and control areas.

Type I inspections are used to evaluate licensee programs, and may be conducted after programmatic changes. As Canadian NPP licensees are well-established, Type I inspections are rarely conducted. Type I inspections are planned to a high degree of detail, with acceptance criteria spelled out in advance. The results from Type I inspections are transmitted by letter to licensees.

Type II inspections are used to evaluate the output of licensee programs and are conducted at a regular frequency. A suite of CNSC Type II 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. The results of Type II inspections are transmitted by letter to licensees.

Field inspections are single-day inspections used to determine the current status of the NPP, personnel and its management system. The processes, functions, facilities and equipment that are typically covered are listed in annex 7.2(iii)(b)). 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.

The baseline regulatory activities take place over a schedule of five years. For safety and control areas 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 primary heat transport pump seals at Bruce A or the internal contamination event at the Darlington retube waste processing building, which are described in Appendix C).

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 Plants* (see Appendix E for details).

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 regulatory document 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 members 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 members 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 (EIR), 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 members use these safety performance indicators to:

- benchmark acceptable levels of operational safety
- allow tracking of operational trends important to safety and, in some cases, performance comparisons across NPPs
- assess, summarize and report on the performance of licensees with respect to safety in the licence renewal process, in annual/quarterly reviews of NPP performance and in the *Regulatory Oversight Report for Canadian Nuclear Power Plants*

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

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 safety and control areas. These reports include information about the least significant reportable events discussed above that the CNSC uses for trending and analysis. The quarterly compliance reports, which include safety performance indicators, are designed to highlight areas of potential non-compliance with regulations and licence conditions. Annual reports provide information on program status and performance.

7.2 (iv) Regulatory oversight report

CNSC staff produce an annual regulatory oversight report for NPPs that 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 safety and control areas, 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.

7.2 (v) Enforcement

Enforcement includes all activities to compel a licensee into compliance and to deter non-compliance with legal requirements. The choice of enforcement tool is governed by the CNSC process to select and apply enforcement tools, which is based on a graduated approach. The process 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. 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 lead 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

During the reporting period, graduated enforcement tools available to the CNSC included:

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

The first two types of enforcement in this list – written notices and increased regulatory scrutiny – are less formal and 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 three types of written notices: recommendations, action notices and directives.

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.

An action notice is a written request that the licensee take action to correct a non-compliance that is not a direct contravention of the NSCA, the applicable regulations, or a licence condition, but that can compromise safety, the environment or national security and may lead to a direct non-compliance if not corrected. Such non-compliances include:

- a failure to satisfy acceptance criteria not directly referenced in the applicable regulations or licence conditions
- a significant, but non-systemic failure to comply with the licensee's own policies, procedures or instructions that have been established to meet licensing requirements (including programs and internal processes submitted in support of a licence application)

A directive is a written request that the licensee or a person subject to enforcement action take action to correct:

- a non-compliance with the NSCA, the applicable regulations, or licence conditions
- a general or sustained failure to adhere to the documents, policies, procedures, instructions, programs or processes established by the licensee to meet licensing requirements

Directives to NPP licensees are relatively rare, typically one to two per year.

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 example of such a request is provided in Appendix C.

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 – there were none issued during the reporting period. In fact, no orders related to safety have been issued to NPP licensees in the history of previous Canadian reports.

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 a licence amendment to the Commission. Licence amendments cover a wide range of possibilities and are decided on a case-by-case basis. Examples of licence amendments include the following:
    - limitations to on-power operation
    - a requirement to obtain Commission approval before reactor start-up
    - a requirement to appear before the Commission on a regular basis, to provide status reports on progress in improvements to operation and maintenance programs
- Decertification of persons
- Refusal to certify or renew certification
- Licence suspension or revocation: CNSC staff may recommend to the Commission to 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 what has been given previously regarding licensing actions initiated by CNSC, and per the NSCA, the Commission may, on its own motion, renew, suspend in whole or in part, amend, revoke or replace a licence under the prescribed conditions.

A licensee that is subject to enforcement action that involves an order or amendment, suspension or revocation of its 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

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 or corporation 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 16 AMPs during the reporting period. None of these AMPs were issued to an NPP.

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.

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 to meet the purposes of the NSCA (see subsection 8.1(b) for a detailed description of CNSC staff).

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).

As described in section 7.2(ii)(a), the Commission holds hearings for the purpose of considering applications, CNSC staff recommendations, interventions and related information pertinent to licensing decisions. 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, overall industry performance, and the results of CNSC compliance verification activities.

CNSC staff members 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.

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.

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 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.

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 CNSC makes independent, fair and unbiased decisions to regulate the nuclear industry.

The Commission is accountable to Parliament and also has legal accountability:

- 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*).

The Commission requires the involvement and support of the Minister of Natural Resources to make or amend regulations and on 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*. For example, when its workload increases for activities that have no direct benefit to individual licensees, the CNSC, with the support of its Minister, seeks incremental funding through the Government of Canada’s annual budget process. While the CNSC always seeks to increase the efficiency of its operations, it can also address workload pressures associated with fee-paying licensees through an increase of its regulatory fees.

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 (see subsection 7.1(b)).

In particular, CNSC staff members 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 *Canadian Environmental Assessment Act, 2012* (CEAA; see subsection 7.2(ii)(a)) the CNSC is identified as a responsible authority for the purpose of conducting environmental assessments (EAs). The CNSC has responsibility for both the process and decision-making under the CEAA.

In addition to federal government entities, the CNSC works with several provincial and municipal organizations, as appropriate, in fulfilling its mandate.

The CNSC issues licences for the nuclear operations of provincially-owned electrical utilities OPG, Hydro-Québec and NB Power (as well as to 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. CNSC activities that are not recovered through cost recovery fees are funded through annual appropriations from Parliament. This accounts 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 request additional funding from the Government of Canada (as stated in the previous subsection).

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 President also has supervision over and direction of the work of the other Commission members, includes the assignment of a panel of the Commission, its member or members and the member who will preside over the panel. The CNSC's current organizational structure is described in Figure 8.1 (b):

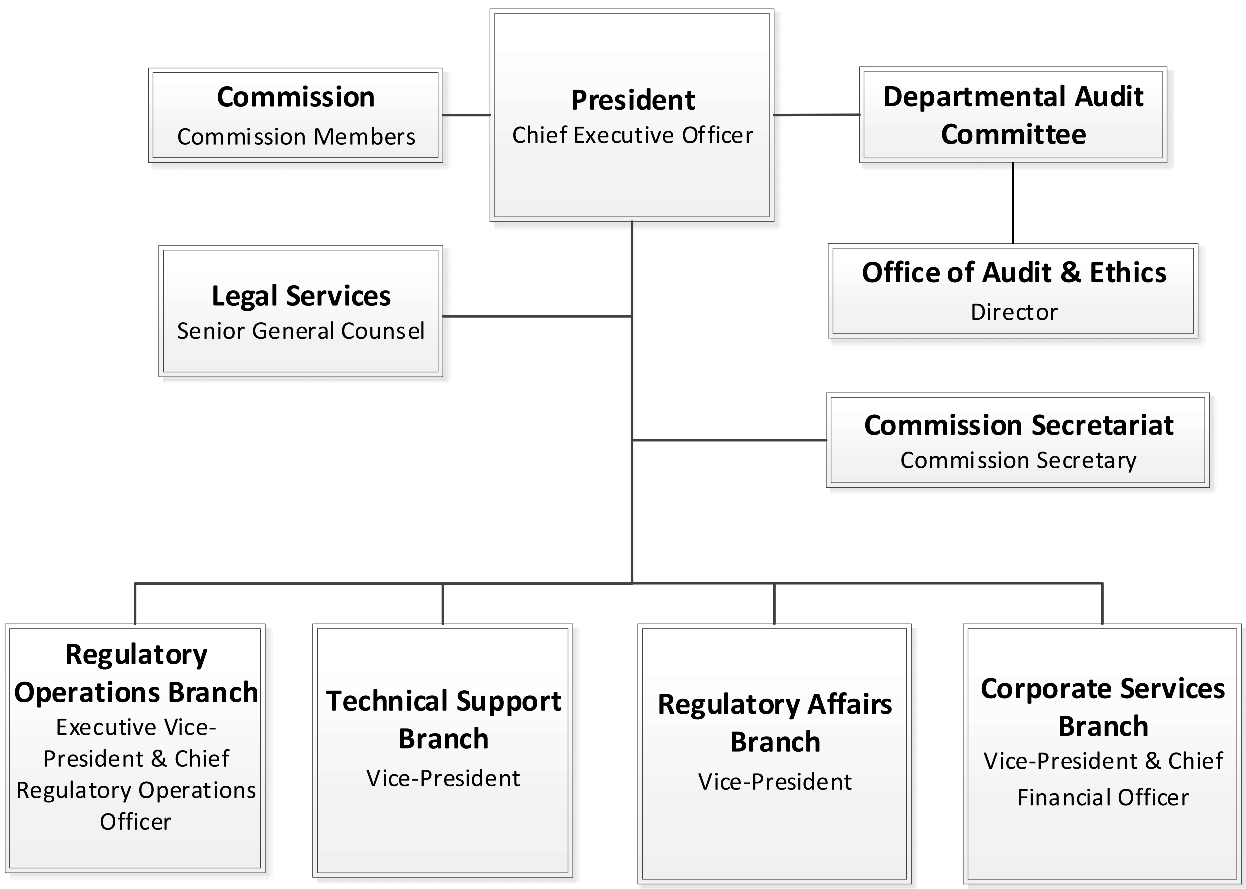

Figure 8.1 (b) Organization of the CNSC

Authority for the Departmental Audit Committee (DAC) is derived from the Federal Government's Financial Administration Act along with the Treasury Board's Policy and Directive on internal auditing in the Government of Canada. 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 Secretary. The DAC reviews all core areas of CNSC management control and accountability, risk management, values and ethics practices and the internal audit function. The DAC also reviews CNSC financial statements, financial reports and the annual Statement of Management Responsibility and associated plans and assessments with respect to internal controls over financial reporting. The Commission Secretariat consists of the Commission Secretary and supporting staff. It plans the Commission Tribunal's hearings and meetings; provides technical and administrative support to the President and other members of the Commission Tribunal; communicates with stakeholders including government departments, interveners, licensees, media and the public; acts as the official registrar for Commission Tribunal documentation; and provides guidance about values and ethics.

The Office of Audit and Ethics, (OAE), reports directly to the CNSC President in her role as Deputy Head of the organization. The OAE provides independent, objective assurance and consulting services that add value to and improve CNSC operations. The objective of the audit function is to provide reasonable assurance that the governance, risk management and internal control processes of the CNSC are adequate and effective for helping to achieve the CNSC's strategic and operational objectives. All aspects of the internal audit program are carried out in accordance with Internal Auditing Standards for the Government of Canada, which includes the Institute of Internal Auditors (IIA) International Standards for the Professional Practice of Internal Auditing and both the Treasury Board policy and Treasury Board Directive on Internal Audit

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 members.

The CNSC as an organization includes four branches: Regulatory Operations, Technical Support, Regulatory Affairs and Corporate Services.

Regulatory Operations Branch

The Regulatory Operations Branch is responsible for managing regulatory activities, including those related to licensing, compliance verification and enforcement. The relevant regulatory decisions may be made by designated officers within the branch, where 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 Regulatory Improvement and Major Projects Management

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 currently 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 regarding 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.

In each RPD, there are permanently situated CNSC staff members who work 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, technical staff at the CNSC's head office are also assigned to each RPD.

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 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.

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, transport).

The Directorate of Regulatory Improvement and Major Projects Management consists of three divisions:

- Internal Quality Management Division
- Regulatory Operations Coordination Division
- New Major Facilities Licensing Division

The responsibilities of the Internal Quality Management Division include strengthening the CNSC's management system, promoting a healthy safety culture, conducting and coordinating the CNSC's Harmonized Plan for improvement initiatives (see subsection 8.1(e)), and implementing self-assessments of key regulatory processes.

The responsibilities of the Regulatory Operations Coordination Division include the coordination of the annual operations planning, monitoring and reporting process, as well as the maintenance and central coordination of support activities and programs across regulatory programs. The New Major Facilities Licensing Division is mandated to provide regulatory oversight through licensing, compliance, and other activities for potential new NPPs to be built in Canada; ensure a state of readiness for licensing any emerging technologies (such as small modular reactors); and manage new major projects and their related regulatory framework improvement projects. This division manages the CNSC's pre-licencing vendor design reviews, which provide vendors with regulatory guidance in regards to their NPP reactor designs. It also participates in international activities that have a bearing on new-build projects, including those of the Multinational Design Evaluation Programme (MDEP). See the preamble to article 18 for more details on pre-licencing vendor design reviews and MDEP.

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. This is accomplished 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 eight divisions:

- Engineering Design Assessment Division
- Operational Engineering Assessment Division
- Probabilistic Safety Assessment and Reliability Division
- Systems Engineering Division
- Physics and Fuel Division

- Reactor Behaviour Division
- Reactor Themalhydraulics Division
- Assessment Integration 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 EA, 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 reviewing the adequacy of regulatory instruments, managing 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.

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).

The CNSC's new graduate recruitment initiative has brought 154 new graduates to the CNSC since 2014, resulting in the permanent integration of 86 new graduates into the organization. To support the professional development of the new graduates within the first two years, these employees are expected to gain diversified work experience in order to progress within the organization. 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.

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.

To enhance 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 by 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 site supervisor at the NPP determines that the inspector-in-training has achieved all the training requirements. From the time a new inspector enters into the program, it takes approximately 18 months to obtain an inspector's certificate.

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

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

8.1 (d) Management system

The management system links the people, processes and resources within the CNSC's 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 to 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 goal to be "an employer of choice" and its vision to remain a world class regulator, are all incorporated into the management system to ensure it meets the needs of the CNSC.

Management System Manual

The CNSC *Management System Manual* is the top-level document in the management system's document hierarchy. It applies to all CNSC staff. While it applies to the relationship and process interfaces with the Commission, the tenets of the manual do not apply to the Commission itself.

The purpose of the *Management System Manual* is to describe for CNSC employees and contractors how the management system integrates people, processes and resources within the CNSC's overarching regulatory framework to manage all work across the organization and ensure consistent, high-quality results. 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 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 *Management System Manual* identifies the CNSC's key processes as follows:

- management processes
- core processes (regulatory framework, licensing and certification and compliance)
- enabling processes

The *Management System Manual* also identifies the CNSC governance structure and describes the role of process owners who are responsible for the development, implementation and maintenance of the key processes. Each key process has a single process owner, appointed by senior CNSC management.

The CNSC staff work instructions are also found in the *Management System Manual* under processes. These important process-related documents provide more detailed guidance to staff.

Planning process for regulatory activities

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, reviews 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

In the fall of 2016, the Office of the Auditor General conducted an audit of the CNSC inspection program for nuclear power plants. The audit found that when CNSC inspectors identified issues during a site inspection, they followed up with the licensee one hundred percent of the time to ensure compliance. However, the report provided recommendations for improving the documentation of the nuclear power plant site inspection program.

The five recommendations were as follows:

- The Canadian Nuclear Safety Commission should develop and implement a well-documented planning process for site inspections of nuclear power plants that can demonstrate that the process is systematic and risk-informed. This should include determining the minimum required frequency and type of inspections needed to verify compliance, updating the five-year baseline inspection plan, and assessing whether it is assigning the appropriate number and levels of staff to carry out the number of inspections required to verify compliance
- The Canadian Nuclear Safety Commission should develop detailed criteria to help it identify when to conduct Type I inspections
- The Canadian Nuclear Safety Commission should ensure that its inspections follow its own procedures. This requires that it develop approved inspection guides with appropriate criteria before conducting inspections to assess that nuclear power plants are complying with applicable regulatory and licence requirements. The CNSC should clearly explain to its staff how to decide which documents should be considered transitory and which documents should be retained after they issue inspection reports

- The Canadian Nuclear Safety Commission should ensure that it documents lessons learned in carrying out its inspections to help it make continuous improvements to its inspection practices
- The Canadian Nuclear Safety Commission should determine why it does not issue timely final inspection reports and decide whether it needs to make any changes to its processes or standards

Upon being informed of the findings from the report, the CNSC undertook corrective actions to address all five recommendations. These improvements were completed by March 31, 2017.

EPREV mission to Canada

The CNSC will participate in the Emergency Preparedness Review (EPREV) mission to Canada in June 2019, along with other federal, provincial and municipal emergency preparedness and response stakeholders, as well as the nuclear generating station operators. See section 16.1(g) for more details. The ninth Canadian report will identify highlights and progress on addressing any findings relevant to the CNS.

IRRS mission to Canada

As part of its commitment to regulatory excellence, the CNSC will host its second IRRS mission in September 2019 to review elements of its framework for safety and its core regulatory processes.

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.

At the conclusion of the 2019 IRRS mission to Canada, a report outlining the mission's findings will be prepared and made available to the public. The ninth Canadian report will identify highlights and progress on addressing any findings relevant to the CNS.

Harmonized Plan for Improvement Initiatives

The Harmonized Plan is a continuous improvement program at the CNSC that was established in 2008 to identify, prioritize and manage all cross-functional CNSC improvement initiatives. The Harmonized Plan strengthens the CNSC's Management System and brings together resources from across the organization that are impacted by the improvement, into one team, to achieve common goals. Deliverables from improvement initiatives could include programs, policies, processes, systems or tools. The executive authority for the Harmonized Plan is the CNSC's Executive Vice-President and Chief Regulatory Operations Officer.

Many Harmonized Plan initiatives have helped improve the effectiveness and efficiency of regulatory oversight programs. Some examples are:

- systematically and consistently training inspectors (ITQP)
- establishing framework of safety and control areas the process to conduct technical assessments to facilitate consistent and comprehensive technical and regulatory assessments to support regulatory decisions
- establishing process to conduct inspections to facilitate consistent inspections across all regulated facilities and activities
- automating the inspection and reporting process with the development and implementation of the Mobile Inspection Kit

CNSC assessments and oversight

CNSC management oversight includes: self-assessments include internal audits and program evaluations. These services follow different standards and guidelines, with evaluations following internal CNSC guidance and audits following standards and guidance from the Institute of Internal Auditors (IIA). They are conducted per the schedules approved by senior management and in accordance with established Government of Canada policies and procedures. Final reports are posted on the internal website for staff review and/or shared with the public on the CNSC website. Each self-assessment results in action plans that are approved and then monitored by senior management.

During the reporting period, the CNSC conducted 12 internal audits, which including the following that were relevant to NPPs.

- follow up on the 2016 performance audit of CNSC's processes for compliance verification for NPPs by the Office of the Auditor General of Canada
- financial guarantees
- nuclear emergency management program
- annual planning process for operations
- contracting and procurement

In addition, the CNSC participated in horizontal audits, with other federal departments led by the Office of the Comptroller General.

In addition, program evaluations were conducted during the reporting period on the CNSC Nuclear Emergency Management Program, the compliance verification program for the Directorate of Nuclear Substance Regulation, the CNSC grants and contributions program, and CNSC contributions to the Organisation for Economic Co-operation and Development (OECD). Also, there was a program evaluation of the Harmonized Plan to ensure that it remains as effective as possible. The recommendations from the evaluation are planned to be implemented in the next reporting period.

Other

CNSC staff members 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 improvements related to their insights. Interactions with IAEA Member States and other

Government of Canada agencies take place on many technical and non-technical topics on a regular basis.

8.1 (f) Openness and transparency

Dissemination of information – General

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

The CNSC has many outreach activities focusing on youth, 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, YouTube, webinars, interactive online modules, email updates to subscribers and attendance at third-party events and conferences. CNSC staff members also host information sessions to explain to stakeholders how the nuclear industry is regulated and how to participate in the regulatory process.

The CNSC is equally committed to helping licensees and the nuclear industry to understand and comply with its regulatory framework. It 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 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 (see subsection 8.1(g)) 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 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 arise. 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, public hearings associated with the licence renewal of the Pickering, Point Lepreau and Bruce NPPs were held in the respective host communities, as well as hearings related to a decommissioning licence for Gentilly-2 and a licence renewal for Chalk River Laboratories. Public participation for these hearings was promoted through advertising in local community newspapers, by notices sent to CNSC email subscribers and through the CNSC's Facebook, Twitter and YouTube channels. CNSC information sessions were also held in the communities well in advance of the hearings. The Commission considered more than 492 public submissions during these hearings.

The CNSC also has significant opportunities for public involvement in its regulation making process (see subsection 7.2(i)(a)) and its regulatory document writing process (see 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 possible.

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 peoples, 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 peoples and the public to participate in aspects of environmental assessments (EAs) and 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 to Indigenous 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 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 $2,597,724. To date, the CNSC has also awarded over $700,000 to fund five Indigenous knowledge studies in relation to the EAs for three Canadian Nuclear Laboratories sites.

8.1 (g) 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 NPP licensees 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 IPPAS, Operational Safety Review Team (OSART), EPREV, etc., 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 (h) Targeted consultation with Indigenous communities

The CNSC's commitment to effective and well-managed Indigenous consultation processes is guided by *Aboriginal Consultation and Accommodation – Updated Guidelines for Federal Officials to Fulfill the Duty to Consult – March 2011.* The CNSC's *Codification of Current Practice: CNSC Commitment to Aboriginal Consultation* outlines the organization's approach to fulfilling its legal obligations for Indigenous consultation on CNSC-regulated projects as an agent of the Government of Canada and as a regulatory body.

In February 2016, the CNSC published regulatory document REGDOC-3.2.2, *Aboriginal Engagement*, which sets out guidance for licensees whose proposed projects may raise the Government of Canada's duty to consult with Indigenous peoples. By making sure that licensees are following the guidance of the REGDOC, the CNSC helps ensure that licensees are meaningfully consulting with Indigenous communities on projects that could potentially affect their rights, traditional territories, and communities. The implementation of REGDOC-3.2.2 has led to more effective Indigenous engagement practices, strengthened relationships with Indigenous communities, assisted the CNSC in meeting its duty to consult obligations, and reduced the risk of delays in regulatory review processes. In addition, the CNSC is also in the process of implementing a long-term engagement strategy with Indigenous communities with an interest in CNSC-regulated facilities and activities. The purpose of the strategy is to work in collaboration with Indigenous communities to formalize relationships and continue engagement activities outside of the CNSC's regulatory processes. The implementation of the long term engagement strategy is expected to help build long-term, meaningful relationships with Indigenous communities that will increase their participation in the CNSC's monitoring activities and lead to more effective consultation on and engagement in future projects.

8.1 (i) Regulatory readiness for small modular reactors

CNSC staff have established a strategy for ensuring regulatory readiness for SMRs that 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

Furthermore, the CNSC has established an SMR Steering Committee (SMRSC) to provide senior management governance, ensure these pillars are appropriately balanced, and direct prioritization of the activities that will enable achievement of the strategic objective. CNSC's SMRSC provides leadership to set the foundation for the regulation of SMRs. In so doing it provides strategic-level direction and senior management oversight and support for the development of the regulatory strategy and position associated with the review and licensing of SMR technologies.

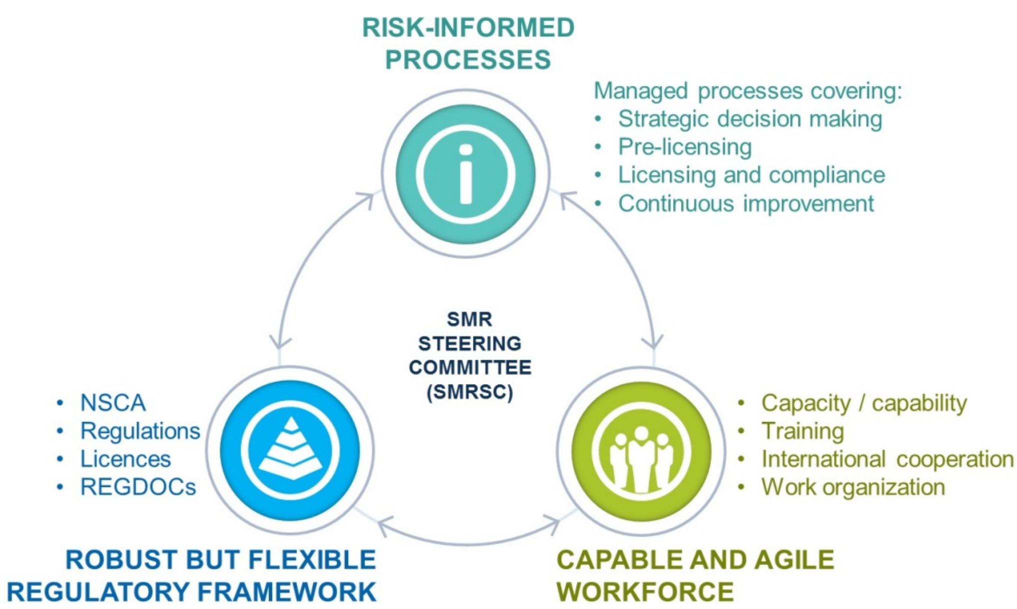

Figure 8.1(i) Regulatory readiness for SMRs

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 Commission (described in subsection 7.1(a)) is defined as a court of record in the NSCA, 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 Secretariat. With the exception of the Secretariat and the President, CNSC staff members 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 fair (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.

Office of Audit and Ethics

The CNSC Office of Audit and Ethics administers four internal ethics-related compliance programs: 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. 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 Office of Audit and Ethics also manages complaints made by external entities, to ensure that a neutral body within the CNSC oversees the investigation and resolution processes. In addition, this Office prepares annual reports to the Management Committee and Departmental Audit Committee that describe briefly the files dealt with in these programs. Internal audit reports are shared with Treasury Board through the Office of the Comptroller General and on the CNSC external website. Finally the OAE provides the administrative and secretarial support to the Departmental Audit Committee.

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, 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 only issue licences 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 related to 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 of 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 on site 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. If 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.

During operation, licensees fulfill their responsibilities through the following 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 (see Article 19)
- defining and following operating policies and principles (OP&Ps); defining safe operating limits and working within them (see sub-article 19(ii))

- developing safety policies and an organizational culture committed to ensuring safe NPP operation (see Article 10)
- monitoring both employee and facility performance to ensure expectations are met (see 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 (see sub-article 11.1)
- ensuring adequate qualified resources are always available to respond to planned activities and contingencies (see subsection 11.2(b))
- implementing managed systems to control risks associated with NPP operations to govern the above activities (see Article 13)

As explained in subsection 13(a), all licensees implement and maintain a management system. 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. Licensees 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)).

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)(d)). 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.

Canada has invited the IAEA to conduct OSART missions at several Canadian facilities over the next few years.

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): a not-for-profit organization dedicated to providing programs for cooperation, mutual assistance and exchange of information for the successful support, development, operation, maintenance and economics of CANDU technology. 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 subsection D.2), COG facilitates the execution of licensee responsibility by:

- sharing operating experience 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 (described in subsection 11.2(b) under external training programs)

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 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.

The Chief Nuclear Officers also engage in high-level communications with CNSC executives (see subsection 8.1(g)).

Proactive disclosure and public communications

CNSC regulatory document 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 NPP licensee outreach activities conducted during the reporting period are, provided in annex 9(c).

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

To assure 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 to renew each licence to operate, 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 and change approvals. 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 regulatory document REGDOC-3.1.1, *Reporting Requirements for Nuclear Power Plants*, which establishes reporting requirements for safety-significant developments and 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 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 orders, licensing action or prosecution (as described in sub-article 7.2(iv)) by the CNSC was not required to resolve 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 executing numerous improvements to safety. Since original construction, the NPP licensees in Canada have made many safety improvements based on CNSC requirements, industry research, national and international operational experience, and heightened public expectations.

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.

The collective priority to safety by organizations engaged in activities related to nuclear facilities is, in part, demonstrated by the 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)(d)). The licensees also demonstrate an ongoing commitment to safety through their sponsorship of, and involvement in, safety-related research and development activities (see Appendix D for details). Canada 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)). In addition, the CNSC has an active research program that focuses on regulatory issues (see sub-article 8.1).

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, guiding 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 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 maintain the priority on safety.

CSA Group standard N286-12, *Management System Requirements for Nuclear Facilities*, has been implemented by the NPP licensees (see subsection 13(a) for details). This standard 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.

10 (b) Safety culture at 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 making decisions and performing work. This is accomplished 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 personal dedication 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 assures 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 assured by means of coaching and mechanisms to encourage problem identification and effective corrective action.

Safety culture regulatory document

In April 2018, the CNSC published REGDOC-2.1.2, *Safety Culture* to:

- formalize 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
- formalize requirements and expectations for licensees regarding safety culture at NPPs

- clarify and implement 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

The NPP licensees began to plan the implementation of REGDOC-2.1.2 during the reporting period.

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. As such, 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 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 licensees have adopted the nuclear safety culture monitoring panel (NSCMP) process monitors process inputs that are indicative of the health of the organization's nuclear safety culture (internal events, trends, and organizational changes), and identify 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 the NSCMP process.

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

Ontario Power Generation

OPG conducts a comprehensive nuclear safety culture self-assessment once every three years at each of its NPPs. The assessment has two phases: a detailed safety 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 process continues to be refined based on the lessons learned from each preceding assessment and industry best practices. OPG enhanced both the staff survey tool and the onsite assessment process to facilitate the collection and consistency of assessment inputs, and to allow OPG to benchmark its results with other utilities that use the INPO safety culture survey.

OPG completed 5 nuclear safety culture assessments in 2018 that involved external team members from various organizations. The five assessments were conducted for:

- Darlington
- Pickering
- Nuclear Projects
- Nuclear Waste
- Nuclear Corporate

Overall, the assessments determined that OPG has a healthy nuclear safety culture, a healthy respect for nuclear safety, and nuclear safety is not compromised by production priorities. There are some slight differences between sites but overall OPG has a very consistent culture. Since 2015, the culture at OPG has shown good improvement in all 10 Traits of a Healthy Nuclear Safety Culture detailed in the INPO/WANO framework. Most personnel feel they can raise concerns and challenge decisions related to nuclear safety without fear of professional or personal implications. Strengths identified in the various assessments include fostering an environment in which employees feel comfortable raising safety concerns, building a high level of trust among employees, developing incentives, and rewards that are aligned with nuclear safety policies and behaviors and employees willingness to challenge the unknown and stop when faced with uncertainty.

A focus area noted at both Pickering and Darlington is in the area of resources where staffing demands required to support the NPPs have placed a strain on supervisors and the available experienced workers needed to support the NPPs.

Concerns about temporary/term worker proficiency are being expressed by supervisors and tenured workers as this places higher demands on this group to ensure work is executed safely. It is important to note that the resource issue is not with regard to the number of staff but the experience and proficiency of the staff in place. This issue is receiving focus at both Pickering and Darlington as part of the company’s OPG 25 People Powering the Future strategic initiative. Additionally, actions to address findings from the Nuclear Safety Culture Assessments are tracked at the respective Nuclear Safety Culture Monitoring Panels held quarterly.

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 10 Traits of a Healthy Nuclear Safety Culture Framework 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 contractor 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 are being considered. The corrective action program is being used to address findings.

Bruce Power plans to conduct another safety culture assessment in 2020, in accordance with CNSC regulatory document REGDOC-2.1.2, *Safety Culture*.

NB Power

NB Power conducted a comprehensive nuclear safety culture self-assessment in the late fall of 2016. The assessment was carried out in two parts: a survey of NB Power employees and an interview process to validate the survey responses and gain additional insights.

The 2016 assessment revealed a healthy nuclear safety culture that values nuclear safety over other competing priorities such as production. NB Power utilizes 10 nuclear safety culture "action statements" derived from the INPO document, Traits of a Healthy Nuclear Safety Culture. The action statements provide information on what the traits should mean to all employees at NB Power.

- The 2016 assessment results showed improvements in almost every area in comparison to the 2014 assessment. The improvements were driven by the fact that:the organization has become more focused and self-aware
- previous improvements had time to become embedded in the culture
- the organization has been self-critical and striving for change

Some of the assessment areas that were identified as focus areas included:

- equipment reliability
- capability and experience
- hiring process

NB Power's actions to address these focus areas include:

- Equipment Reliability Index greater than 88 as a station goal for the fiscal year 2019
- increased focus on succession planning as well as targeted training on advanced operations overview for managers and "Leadership Bootcamp" for all employees
- hiring process changes where inputs are now weighted differently than in the past

NB Power plans to conduct another safety culture assessment in 2020.

Hydro-Québec

The most recent self-assessment at Gentilly-2 was an evaluation by peers in 2012. See the sixth Canadian report for details.

SNC-Lavalin Nuclear

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 (Candu Energy Inc. and SNC-Lavalin Nuclear Inc.) joined INPO as supplier members. Using the INPO framework, SNC has developed and implemented a comprehensive "Building a Culture of Excellence" program that incorporates many of the INPO teachings (e.g., INPO 12-012, Traits of a Healthy Nuclear Safety Culture).

SNC-Lavalin Nuclear has provided significant support to foster similar improvements across the Canadian nuclear industry and supplier community to foster a healthy nuclear safety culture. As part of the healthy dialogue between licensees and the CNSC on human performance, SNC-Lavalin Nuclear engagement included helping industry to broaden the INPO HU principles with definitions of the fundamentals to provide defence in depth as an organisational 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 and 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 supply chain, the need to embrace a managed defences approach to support human performance excellence and safety culture.

10 (c) CNSC framework for assessing safety culture at NPPs

As stated in CNSC regulatory document REGDOC 2.1.2, *Management System: Safety Culture*, the CNSC defines safety culture as:

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

REGDOC-2.1.2 identifies the following:

- 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 members 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 members examine the self-assessment approach 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.

10 (d) Priority to safety at the CNSC

The CNSC prioritizes safety in all of 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 members to maintain their focus on nuclear safety while addressing all organizational priorities.

During the reporting period, the CNSC completed a regulatory safety culture self-assessment. CNSC staff presented the findings, recommendations, and management action plan at a public Commission meeting in October of 2018. The CNSC plans to conduct a follow-up assessment in May 2022 to confirm the effectiveness of the actions taken resulting from this assessment and to deepen the commitment to continuously strengthen the CNSC`s regulatory safety culture.

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

Each NPP licensee in Canada has the prime responsibility for the safety of its facility per Article 9. This responsibility includes providing 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 will be 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 guide G-206, *Financial Guarantees for the Decommissioning of Licensed Activities.* 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 plant. 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 are presented form the basis for the decommissioning financial guarantees.

Further details on financial guarantees and decommissioning can be found in Canada's *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 late 2027. Under these plans, partial shutdown would begin at the end of 2024, followed by full NPP shutdown at the end of 2025. Some preliminary plans for the activities associated with the transition of Pickering into safe storage were provided in the stabilization activity plan which was submitted to the CNSC in December 2016.

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

Canada's nuclear liability regime was revised in 2015. The *Nuclear Liability and Compensation Act* came into force on January 1, 2017, once the key regulations and financial security mechanisms were in place. It replaced the *Nuclear Liability Act*, providing a stronger legislative framework that better addressed liability and compensation after a nuclear incident.

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.

The *Nuclear Liability and Compensation Act* included the following changes from the previous legislation:

- It increased the absolute liability limit of an NPP operator to $1 billion from the $75 million specified in the previous legislation. The $1 billion limit will apply in the fourth year, progressively increasing from $650 million when the new legislation entered into force (January 1, 2017). Operators of nuclear installations other than NPPs will have lower liability limits, commensurate with their risk, as established in regulations.
- It expanded the definition of compensable damage to include, 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.
- It introduced a longer limitation period – 30 years from the current 10 years – for submitting compensation claims for bodily injury and loss of life. Through an indemnity agreement with operators, the Government of Canada will provide coverage for claims occurring between 10 and 30 years. The limitation period for other forms of damage remains at 10 years, as in the previous legislation.
- It required operators to maintain financial security to cover their full liability limit. This financial security must be in the form of insurance obtained from an insurer approved by the Minister of Natural Resources. Subject to the approval of the Minister, operators are permitted to cover up to 50 percent of their liability with alternate forms of financial security such as provincial government guarantees or letters of credit.
- It established a quasi-judicial claims tribunal to replace the courts if necessary, to accelerate claim payments and provide an efficient and equitable forum.

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." 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 held fully 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 regulatory document 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 shall 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 regulatory 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 members 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 objectives and criteria for accreditation of training programs (such as those developed by 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 behaviour 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. The majority of staff members are also trained to a radiation protection level that qualifies them to be responsible for their own protection and able to sponsor supplemental staff and provide radiation protection oversight. In addition, 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.

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 CNL:

- NPP operating licences
- REGDOC-3.1.1, *Reporting Requirements for Nuclear Power Plants*
- the NSCA and its regulations
- introduction to safety analysis
- regulatory issues management
- regulatory communications and technical writing
- International Nuclear Event Scale (INES) training

The use of supplemental staff is important to licensees' performance of critical work on safety systems and safety-related systems during maintenance outages. While supplemental workers are typically recruited to augment outages, they can also be involved in engineering or design work.

Licensee training programs consider the requirements for supplemental personnel (e.g., electrical, hoisting and rigging, pressure boundary) as well as personnel performing a contract management role. The training programs consider previous training and experience through the use of standard task evaluations based on 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.

SNC-Lavalin Nuclear also has a well-developed training program. During the reporting period, SNC-Lavalin Nuclear delivered training to staff to align the company's human performance tools with the human performance tools in use at Bruce Power.

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 regulatory document RD-204, *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, known as the minimum staff complement (MSC). CNSC regulatory document REGDOC-2.2.5, *Minimum Staff Complement* provides guidance to assist Class I nuclear facility licensees and applicants to demonstrate to the CNSC that they will 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.

For NPPs, CNSC staff reviews the licensee's systematic analysis that is used to determine the MSC and 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.

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. The adequacy of the MSC is demonstrated by an integrated validation exercise that is observed by CNSC staff.

11.2 (b) Capability maintenance at NPP sites

The nuclear industry in Canada has robust workforce-development and worker-replacement programs in place to meet future needs. 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 five related areas:

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

Workforce capability analyses

NPP licensees regularly conduct detailed workforce capability analyses to predict gaps between forecasted supply and planned resource levels in 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.

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

Better supply and demand data

- OPG is collaborating with Bruce Power, Electrical Power Systems Construction Association (EPSCA), vendors and unions to share skilled trades information and development of forecasts (total nuclear long-term demand for all skilled trades) and partnership strategies. Currently, trade supply for boilermakers is critical to meeting forecasted demand.

Build up new source of trades

- tri-partite agreement between Durham College, the Boilermakers' Union, and OPG to fast-track 100 new pre-apprentices into the Boilermakers' Union for 2019
- creation of new "helper" and "RP assistant" classifications for boilermakers to assist with supply

Optimize the current supply of trades

- streamlined security clearances between OPG and Bruce Power
- the use of travel cards and permit trades
- working with the Government of Canada to promote the recruitment of skilled trades persons from out of the country
- Darlington's Indigenous Opportunities in Nuclear (ION) program, aimed at improving the recruitment and retention of Indigenous peoples working on the refurbishment project, as well as across the nuclear fleet
- ION partnership with Kagita Mikam (local Indigenous employment centre)
- Government of Canada assistance with establishing 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 conducted. Development plans prepare potential candidates to assume critical positions as employees retire. To address anticipated readiness gaps at senior levels, OPG has a program to accelerate the development of high-potential individuals through 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 volatility of business, balancing customer needs and ensuring a consistent approach, while complying with its collective agreements and using best practices. System elements are grouped on the basis of supply, demand, resource planning, development of resources 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.

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. 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 applying 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 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 now have programs aimed at hiring members of Indigenous communities. For example, Bruce Power has committed to hiring a minimum of 50 Indigenous persons each year either directly or through vendors. To support this, Bruce Power is funding training programs, scholarships and internships to ensure that Indigenous people have the opportunities to develop the required skills and knowledge. 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 from Candu Energy Inc. or the licensee organizations). Further, recruitment by SNC-Lavalin Nuclear utilizes social media and innovative partnerships with Canadian universities.

External training programs

In addition to the partnerships mentioned above, there are a number of specific programs in Canada to develop new workers for the nuclear industry.

The University of Ontario Institute of Technology (UOIT) has a nuclear engineering program designed specifically to meet industry needs. Its Faculty of Energy Systems and Nuclear Science offers undergraduate (bachelor's), post-graduate (master's) and doctorate (PhD) degrees, graduate courses and diploma programs that focus on nuclear engineering, radiation science and related areas to support continuing-education needs.

More than 680 undergraduate students, over 100 graduate diploma students, 110 master's students and nine PhD students have graduated from the programs offered by the Faculty of Energy Systems and Nuclear Science since 2007. A close interface with industry members, the CSA Group and the CNSC is used to formulate advice on the curriculum and make available thesis and research topics at the university. UOIT is strongly committed to promoting educational and career opportunities for women in science and engineering. The nuclear programs focus on reactor kinetics, reactor design, plant design and simulation, radiation detection and measurement, radiation biophysics and dosimetry, radiation protection, environmental radioactivity, nuclear security, production and utilization of radioisotopes, waste management, fuel cycle, radiation chemistry and material analysis with radiation techniques.

The University Network of Excellence in Nuclear Engineering (UNENE) is an alliance of 12 Canadian universities, several nuclear industry organizations in Ontario, including the Ontario NPP operators and CNSC. UNENE was created to provide a sustainable supply of qualified nuclear engineers and scientists to meet the current and future needs of the Canadian nuclear industry through university-based graduate courses and training courses. UNENE Head Office is located at McMaster University, but the main universities that provide graduate level courses include UOIT, Western University, Queens' University, and University of Waterloo. Through UNENE, nuclear professorships in participating universities have been sustained. The above-mentioned five universities currently offer a common graduate-course-based master of engineering (M.Eng.) program aimed at professionals already working in the nuclear industry. In the past 15 years since UNENE creation, 116 students have graduated from the UNENE M.Eng. program. Currently, there are 22 active students in the program. A new, shorter diploma program was introduced by UNENE in April 2015 to enable young industry professionals to acquire focused knowledge in selected areas of expertise. UNENE also supports M.Sc. and Ph.D. research.

CANTEACH is a web-based knowledge repository that provides high-quality technical documentation relating to the CANDU nuclear energy system. The CANTEACH program was established by AECL, OPG, COG, Bruce Power, McMaster University, l'École Polytechnique de Montréal and the Canadian Nuclear Society. Its aim is to develop and maintain a comprehensive set of web-accessible documents for use in various aspects of education, training, design and operation. The CANTEACH program continues to accumulate information contributed by the Canadian nuclear industry, universities and the CNSC.

UNENE has published a peer-reviewed CANDU textbook "The Essential CANDU" for senior undergraduate and graduate students, educators, trainers and working professionals. It consists of two volumes and was updated in April 2017. It enables those new to CANDU technology to learn about the overall system and pursue specialized topics in depth. As such, it prepares undergraduates for a career in the nuclear industry, facilitates the technical training of new employees, and supports knowledge enhancement of experienced employees. It also supports university level nuclear education curricula. It is available on the UNENE website and is intended to be a living document.

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 accelerate 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 its 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 common nuclear products and services to multiple CANDU 6 NPPs

- provision of training programs to the industry as a whole (within Canada and in other CANDU countries), e.g., recent training on seismic Probabilistic Safety Assessment and various CANDU Industry Standard Toolset computer codes

Maintaining research and development 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.

Every three years, 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 2017 assessment 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, are adequate to maintain the R&D capabilities in the CANDU industry. This should provide the CANDU utilities with assurance that, when unexpected problems occur, they will have ready access to the appropriate expertise on short notice. While the older experimental facilities at CNL are facing the possibility of decommissioning due to underutilization, the site is being rejuvenated as summarized in this report, 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. The licensees are required to report to the CNSC significant findings generated by R&D that reveals a hazard different than previously represented to the CNSC according to CNSC REGDOC-3.1.1, *Reporting Requirements for Nuclear Power Plants*.

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.

“Human factors” are those that influence human performance and thereby influence the safety of a nuclear facility or activity during any (or all) phases, including specification, 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 he/she belongs, the work environment and the training received. The application of human-factors knowledge and methods, in areas such as interface design, procedures, training and organization and job design, improves the reliability of humans performing tasks under various conditions.

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 has issued several regulatory documents and guides to assist licensees and licence applicants in the planning and implementation of human factors activities. In addition, a number of CNSC regulatory documents include specific requirements for the consideration of human factors during new-build and life-extension projects. Relevant regulatory documents include:

- REGDOC-2.2.1, *Human Factors*
- REGDOC-2.5.1, *General Design Considerations: Human Factors*
- REGDOC-2.2.5, *Minimum Staff Complement*
- REGDOC-2.6.2, *Maintenance Programs for Nuclear Power Plants*
- REGDOC-2.3.2, *Accident Management*, Version 2
- REGDOC-2.3.3, *Periodic Safety Reviews*
- 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

Additionally, CNSC regulatory documents RD/GD-369, *Licence Application Guide: Licence to Construct a Nuclear Power Plant* and REGDOC-2.3.1, *Conduct of Licensed Activities: Construction and Commissioning Programs* address human and organizational factors throughout its guidance. It stresses the necessity for the applicant to demonstrate the knowledge, skills and abilities of its workers and those of the major contractors and their subcontractors, as well as an overall commitment to fostering a healthy safety culture.

Additionally, the CSA Group has published the following standards relevant to human factors activities:

- N286-12, *Management system requirements for nuclear facilities*
- N290.6, *Requirements for monitoring and display of nuclear power plant safety functions in the event of an accident*

- N290.12, *Human factors in design for nuclear power plants*

In the next reporting period, CNSC staff will continue its work developing and improving the regulatory framework in support of human factors. Such work includes initiatives on human performance, fitness for duty (including fatigue management), safety culture and minimum shift complement.

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

Technical review area	Sub-article/subsection
Reporting and trending	7.2(iii), 19(vii)
Safety culture	10(b)
Minimum shift 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 (Human factors in design)	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 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 defined performance requirements under the conditions in which the system is employed. Human performance programs aim to minimize the potential for human error by addressing the range of factors that affect human performance. 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 in carrying out their work safely. 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 plant 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. CNSC incorporated feedback from the discussion paper in regulatory framework projects, such as for REGDOC-2.2.1.

In 2017, CNSC amended the *Class I Nuclear Facilities Regulations* to include a requirement for all Class I facilities to have a human performance program for the activity to be licensed, including measures in place to ensure workers' fitness for duty (discussed further below).

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 human factors-related issues. Licensees have developed coding schemes to effectively identify and track the causes of adverse conditions (see sub-article 19(vii) for more information).

In this learning environment, licensees strive to operate in a blame-free environment, which 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 benefit of licensees encouraging employees to get more involved in devising methods to improve the quality, reliability and safety of their work, and more fully appreciating their roles in nuclear safety. An example of this is the human performance advocates network implemented by Bruce Power.

CNSC staff's review of human performance programs assesses the organization's ability to create, integrate and implement defences that prevent or mitigate the consequences of human error in work activities, and 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 event reviews 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 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.

CNSC regulatory document RD-204, *Certification of Persons Working at Nuclear Power Plants*, requires licensees to have a documented fitness-for-duty program for certified workers.

Following extensive research, benchmarking and public consultation, the CNSC published regulatory REGDOC-2.2.4, *Fitness for Duty: Managing Worker Fatigue* in 2017. 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.

Also in 2017 the CNSC published regulatory document REGDOC-2.2.4 Vol. II, Fitness for Duty: Managing Alcohol and Drug Use, Version 2. This document is applicable to all workers who could pose a risk to nuclear safety or security at high-security sites and includes the full breadth of requirements to provide reasonable assurance that these workers are free from the influence of alcohol and drugs while at work, including alcohol and drug testing. As part of the process to ensure workers possess the capacity to perform their jobs safely and competently, licensees will be required to implement alcohol and drug testing across a broad range of testing circumstances including random. Testing for alcohol and drug use is limited to safety-sensitive and safety-critical positions.

In 2018 CNSC published regulatory document REGDOC-2.2.4, Volume III, Nuclear Security Officer Medical, Physical and *Psychological Fitness*, to set out the fitness-for-duty requirements for nuclear security officers.

12 (c) Procedures

NPP licensees have processes for producing and maintaining procedures used for testing, maintenance and operations (both normal and abnormal). In addition, most licensees have a guide that addresses relevant human factors.

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 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)(c).) 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 and 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, including 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 (human factors in design)

The consideration of human factors engineering (HFE, but also referred to as human factors in design) applies to the design of new facilities and to the modification and decommissioning of existing facilities. The concept of HFE is concerned with ensuring that the design or modification 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.

CNSC regulatory document 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 regulatory document 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. The NPP licensees have implemented or are in the process of implementing them.

As part of an periodic safety review (PSR) for a life-extension project or licence renewal, licensees must determine the extent to which the current NPP and plant performance conform to modern standards and practices and identify any gaps between those standards and actual performance (see subsection 14(i)(f) for details). The CNSC expects that modern HFE principles and standards using best practices will be consulted when plant modifications are being considered, although it is recognized that the existing technologies, space limitations and control room practices may limit their application to older NPPs. CNSC staff members continue to work with licensees conducting PSR 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 human factors in design considerations.

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

CNSC staff's review of HFE assures that there is a systematic process for effectively incorporating human factors considerations into system requirements, definition, analysis, design and verification and validation activities. CNSC staff members 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 members review the management processes related to organizational performance (e.g., business planning, the establishment of the organization, change management of roles and responsibilities, communications, 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(c).

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 shift 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 licence applicants to propose its management system for the following licensed activities:

- site preparation
- construction
- operation
- decommissioning

The *Class I Nuclear Facilities Regulations* and the *Uranium Mines and Mills Regulations* were amended in 2017 to require licence applicants to propose a management system for the activities listed above, including measures to promote and support safety culture.

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, through its life cycle 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 understand 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.
- 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 by implementing processes, aligned with the generic requirements that apply to all of their licensed activities.

It is of particular importance that licensees conduct self- and independent assessments of their core processes and programs to evaluate the effectiveness of the management system in ensuring requirements are met. Licensees routinely conduct self-assessments, sometimes referred to as functional area self-assessments, on their core processes to provide objective information to senior management for their overall management review activity. This is supplemented with information from independent assessments and other important metrics and indicators.

CNSC staff members routinely review the licensees' assessment information to ensure the processes are properly implemented and that licensees' senior management are receiving objective information on the organization's performance for fact based improvement decisions.

Complementary to N286-12 is CSA Group standard N286.0.1-14, *Commentary on CSA N286-12, Management system requirements for nuclear facilities*, providing background information concerning certain clauses and requirements. This document is currently under revision.

In addition, the following quality assurance/management system standards work in harmony with N286-12; they do not duplicate the generic requirements of N286-12 but provide more specific direction for certain requirements:

- CSA Group standard N286.7-16, *Quality Assurance of Analytical, Scientific and Design Computer Programs for Nuclear Power Plants*
- CSA Group standard N286.10-16, *Configuration management for high energy reactor facilities*
- International Organization for Standardization (ISO) document 14001-2015, *Environmental management systems – Requirements with guidance for use*

In the next reporting period, the CNSC plans to publish REGDOC-2.1.1 *Management System*, to provide guidance information:

- on management systems that are applicable to different types of CNSC licensees

- related to N286-12
- on specific topics - leadership, safety culture, supply chain, configuration management and software quality assurance - 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
- on radiation safety oversight related to nuclear substances, radiation devices and Class II nuclear facilities

The following CNSC regulatory documents contain additional management system requirements that would be applicable to new NPPs:

- REGDOC-1.1.1, *Site Evaluation and Site Preparation for New Reactor Facilities* requires applicants/licensees to:
  - establish a management system when it can be applied to the site evaluation process
  - have provisions for effective management of site characterization and evaluation, site reparation, design, construction, commissioning and technical support functions (including contractor management) being performed under the licence to prepare site so as to promote and assure safety
  - ensure that design activities are managed according to the design organization's management system for the reactor technologies under consideration
- REGDOC-2.5.2, *Design of Reactor Facilities: Nuclear Power Plants* requires applicants/licensees to establish a management system for ensuring the continuing safety of the plant design throughout the lifetime of the NPP with specific requirements and guidance on design authority, design management, design control measures, proven engineering practices, operational experience and research, safety assessment, and design documentation
- REGDOC-2.3.1, *Conduct of Licensed Activities: Construction and Commissioning Programs* requires applicants/licensees to manage construction and commissioning activities in accordance with their management system, as defined in the licensing basis, and further clarifies how the management system's generic requirements apply specifically to construction and commissioning activities

13 (b) Addressing the issue of suspect material

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. 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 CFSI issues.

CSA Group standard N299, *Quality assurance program requirements for the supply of items and services for nuclear power plants*, is an update to the former Z299 series of standards into which requirements for measures to address CFSIs have been introduced. It was published in September 2016 and the NPP licensees are in the process of implementing it.

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. They are described in the following, except PSR, which is described in subsection 7.2(ii)(d) in the context of the renewal process for a licence to operate an NPP.

14 (i) (a) Assessment of licence applications

CNSC staff members 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. Licence application guides have been written to supplement the regulations. They are written in the context of the 14 CNSC safety and control areas as well as the other matters of regulatory interest described in Appendix E. CNSC staff members use assessment plans, along with staff work instructions, to coordinate the assessment of licence applications related to NPPs. During the reporting period, the CNSC continued to develop a comprehensive set of technical assessment criteria to aid these assessments. See sub-article 7.2(ii) for more details on these topics.

The rest of this subsection describes the CNSC's assessment of an application to renew a licence to operate an NPP. The CNSC conducts a balanced assessment of the licensee/applicant's programs and activities, with priority placed on certain areas based on performance history, risk and expert judgment. In their assessments, CNSC staff members focus on:

- the performance of the licensee and the NPP over the previous licence period
- the licensee's plans for operation and safety improvement over the next licence period
- significant activities envisaged by the licensee for an extensive period beyond the next licence period

To help summarize the overall assessment of an application to renew a licence to operate, CNSC staff members assess and rate the applicant's performance under the CNSC safety and control areas.[4]

As explained in subsection 7.2(ii)(d), the PSR process is being integrated into the overall CNSC licence renewal process. This process was described in the seventh Canadian report for the 2015 renewal of the Darlington licence to operate, where the integrated safety review for refurbishment served as the initial PSR. In 2018, PSRs were major inputs to the operating licence renewal process for both Bruce and Pickering.

The following is a description of the process for the licence renewal for Bruce A and B. Bruce Power was issued an operating licence in 2018 for Bruce A and Bruce B for a licence period from October 1, 2018 to September 30, 2028. The assessment of the application to renew this licence to operate produced or confirmed the following major results:

- The assessments for the major component replacement and life extension of Bruce A and Bruce B met the requirements of CNSC regulatory document REGDOC-2.3.3, *Periodic Safety Reviews.*
- The safety and control areas for Bruce A and Bruce B were all rated as "satisfactory" or "fully satisfactory" during the licensing period.
- Bruce Power's PSA results showed that the safety goal limits were met.
- Bruce Power had demonstrated the fitness for service of pressure tubes up to the planned pre-replacement service life of 300,000 equivalent full-power hours (EFPH). (See subsection 14(ii)(b) for details.)
- The distribution and pre-stocking of potassium iodide (KI) pills was completed in accordance with regulatory requirements. (This is discussed further in subsection 16.1(d).)
- All CNSC Fukushima action items were closed.
- Bruce Power was required to complete the integrated implementation plan (IIP).
- Bruce Power was required to submit the next PSR and IIP as part of the subsequent licence renewal application, no later than one year prior to the expiry of the new licence.

14 (i) (b) Deterministic safety analysis

General requirements and approach

General requirements for safety analysis are found in the *Class I Nuclear Facilities Regulations*. In particular, 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))

[4] These ratings are, in fact, produced for all licensees and all safety and control areas on an annual basis, as described in appendix E.

- 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, CNSC regulatory document REGDOC-2.5.2, *Design of Reactor Facilities: Nuclear Power Plants,* 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)(b).

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 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, and 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 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 for safety analysis 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 continued to extend the validation of these codes to align with expanded applications.

In accordance with CNSC regulatory document 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 structures, systems and components (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 ongoing continuously – e.g., to include the effects of aging of the primary heat transport system. See the discussion in the next subsection.

During the reporting period, CNSC staff reviews of the safety analysis reports confirmed that the safety margins for all Canadian 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 are 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)(c).

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.

Further, 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

A set of siting criteria for assessing the acceptability of NPPs can be found in subsection 14(i)(c) of the sixth Canadian report.

The key document related to safety analysis is CNSC regulatory document REGDOC-2.4.1 *Deterministic Safety Analysis*. Aligned with the IAEA standards on safety analysis, it modernizes and improves transparency and consistency of safety analysis activities supporting the safe 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)(b). Assessments of the gaps (now being conducted through PSRs in accordance with CNSC regulatory document REGDOC-2.3.3, *Periodic Safety Reviews* between the requirements of REGDOC-2.4.1 and the existing safety reports are being used to prioritize the safety report updates. The safety margins and degree of conservatism in the analyses will continue to be re-assessed in light of operating experience and new knowledge, for example in the area of aging management. To facilitate this work there is a task team involving the CNSC and industry.

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. During the reporting period, the lessons learned from pilot studies in the previous reporting period were used to update a COG document that provides guidance for deterministic safety analysis 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)(e), which is being led by Bruce Power.

Fire safety assessment

Each facility has a fire safety assessment (which involves a fire hazard assessment and fire safe shutdown analysis) that is drafted in accordance with CSA Group standard N293-12, *Fire protection for nuclear power plants*, which is part of the licensing basis for all NPPs. The licensees are currently working to implement modifications proposed in corrective actions plans provided to the CNSC following recent revisions of the fire safety assessments. The recommendations being addressed but will enhance fire protection at the NPPs.

14 (i) (c) 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 regulatory document 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. One of the key requirements is CNSC acceptance of the methodology and the computer codes used for the PSA.

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.

REGDOC-2.4.2 refers to the IAEA safety series (SSG-3 and SSG-4) to provide general guidance on PSA methodology. 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 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. The safety goals for new NPPs, which are established in

CNSC regulatory document REGDOC-2.5.2, *Design of Reactor Facilities: Nuclear Power Plants*, are summarized in the table below. These safety goals are consistent with those in International Nuclear Safety Group (INSAG) document INSAG-12, *Basic Safety Principles for Nuclear Power Plants*.

CNSC safety goals for new NPPs

Safety goal	Rationale	Numerical objective
Core damage frequency	Related to accident prevention	Sum of frequencies of all event sequences that can lead to core degradation is less than 10^{-5} per reactor-year
Small release frequency	Release that would trigger evacuation	Sum of frequencies of all event sequences that can lead to a release of more than 10^{15} Bq of I-131 is less than 10^{-5} per reactor-year
Large release frequency	Release that would trigger long-term relocation	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 (corresponds to 1% of the Chernobyl accident radioactive release) is less than 10^{-6} per reactor-year

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 (SCDF) of less than 10^{-4} per reactor-year
- large release frequency (LRF) 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

Canadian NPPs have had PSAs for many years - at the time of writing the sixth Canadian report, NPP licensees had developed Level 2 PSAs that included both internal and external events. In 2014, CNSC published REGDOC-2.4.2 which includes the amendments regarding lessons learned from the Fukushima accident.

REGDOC-2.4.2 require Level 1 and Level 2 PSAs to be conducted that include all potential, site-specific initiating events and potential hazards:

- internal initiating events and internal hazards
- external hazards, both natural and human-induced, but non-malevolent

The revised requirements consider all sources of radioactivity – not just the reactor core. It contains requirements related to multi-units, irradiated fuel bays, and low-power operational states. It identifies specific external initiating events, such as seismic events, flooding, and high wind. It also requires licensees to consider potential combinations of external hazards.

Consequential events (e.g., external consequential events, such as a tsunami caused by an earthquake) are also considered in the PSAs. A PSA is required for 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
- Level 1 internal flood
- Level 1 and 2 fire
- Level 1 and 2 seismic
- Level 1 and 2 high wind

NPP licensees have started to transition towards compliance with all REGDOC-2.4.2 requirements and all licensees are expected to be fully compliant by the end of 2020. Full-scope PSAs are either completed or the licensees are making acceptable progress towards completion.

The new requirements for the irradiated fuel bay PSA may be dealt with through alternative methods to PSA (as allowed by REGDOC-2.4.2), for which guidance has been developed by industry.

Recent PSA updates (now submitted every five years) have included estimates of the multi-unit PSA results (severe core damage frequency and large release frequency). Further, industry collaborated through COG in the development of a concept-level, whole-site PSA methodology. Industry developed a safety goal framework and a pilot application (Pickering pilot whole-site PSA) and presented them to the Commission during hearings in 2018 for the renewal of the licence to operate Pickering. The project demonstrated that the Pickering site met the CNSC’s expectations to prevent unreasonable risk to the environment and to the health and safety of persons. It also demonstrated adherence to the IAEA Fundamental Safety Principle: Protect people and the environment from harmful effects of radiation.

Use of probabilistic safety assessment

Licensees are at various stages of utilizing the results from their PSAs. Typical applications 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. The most recent revisions of the PSAs have been used to develop computerized tools (e.g. EOOS – equipment out of service) for routine risk monitoring for both outages and full-power operation, by all licensees The PSAs will continue to be used to enhance operational risk monitoring programs, optimization of testing and maintenance programs and will also provide input to NPP design change and refurbishment and safety improvement decisions. 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 to the end of life for Pickering.

Status of PSAs at each NPP

<u>Bruce A and Bruce B</u>

In 2014, Bruce Power developed/updated a full scope of PSAs (including Level 1 and Level 2, for internal and external events, and for both full power and shutdown states) for Bruce A and Bruce B to meet CNSC Regulatory Standard S-294 requirements. The PSA results showed that the safety goals were met for both Bruce A and Bruce B.

In 2019, Bruce Power has completed the update of the PSAs for Bruce A and Bruce B for REGDOC-2.4.2 compliance purpose. The updates PSAs have addressed new introduced regulatory requirements (multi-unit impact, other radioactive sources such as spent fuel pool, possible combination of external hazards, and other operational states, etc.) as part of the lessons learned from the Fukushima accident.

In addition, Bruce Power has developed a whole-site PSA methodology which is aligned with industry guidance and practice.

Bruce A and Bruce B 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, operational events ranking, etc.

<u>Point Lepreau</u>

NB Power had developed a full scope of PSAs (including Level 1 and Level 2, for internal and external events, and for both full power operation and shutdown states) which has been in compliance with REGDOC-2.4.2 (including the consideration of spent fuel pool and potential combination of external hazards) since 2016. The PSA results show that the safety goals for existing plants are met.

The next PSA update for Point Lepreau is expected by 2021 and NB Power has recently updated its PSA methodologies.

NB Power has used PSA results and insights to support licence renewal, identify systems important to safety for its reliability program, risk configuration management for at-power operation and outage schedule planning, etc.

<u>Darlington</u>

In 2016, OPG developed/updated a full scope of PSAs (including Level 1 and Level 2, for internal and external events, and for both full power and shutdown states) for Darlington NGS to meet CNSC Regulatory Standard S-294 requirements. The PSA results showed that the safety goals were met for Darlington NGS.

In 2018, OPG has revised the PSA methodologies for Darlington, Pickering A and Pickering B for REGDOC-2.4.2 compliance purpose. It is expected the Darlington PSA tasks associated with new REGDOC-2.4.2 requirements will be completed by 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, etc.

Pickering A (Unit 1&4) and Pickering B (Unit 5-8)

OPG developed/updated a full scope 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 CNSC Regulatory Standard S-294 requirements. The PSA results showed that the safety goals were met for both Pickering B and Pickering A.

In 2018, OPG has revised the PSA methodologies for Darlington, Pickering A and Pickering B for REGDOC-2.4.2 compliance purpose. It is expected the Pickering PSA tasks associated with new REGDOC-2.4.2 requirements will be completed by 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 (EOOS) for power operation and outage schedule planning, identification of safety improvement items for continuation of operation of Pickering NGS, etc.

In addition, OPG has completed the pilot project of whole-site PSA for Pickering Site (for all 6 units) in 2017. The preliminary results illustrate the site level risk in terms of core damage frequency and large release frequency, and demonstrate that Pickering site met the CNSC's expectations to prevent unreasonable risk to the environment and to the health and safety of persons.

14 (i) (d) Reviews by the World Association of Nuclear Operators and IAEA

The NPP licensees are members of WANO, an organization dedicated to helping 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)	2017
Bruce A	September 2016, October 2018
Bruce B	May 2017
Darlington	May 2016/October-November 2018
Pickering	December 2017
Point Lepreau	November 2017
Gentilly-2	None

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)	August 2019
Bruce A	2020
Bruce B	June 2019
Darlington	March 2020
Pickering	October-November 2019
Point Lepreau	October 2019
Gentilly-2	No peer reviews scheduled

An IAEA OSART mission was conducted at the Bruce B facility during 2015 with the follow up mission conducted in June of 2017.

There was also an OSART mission conducted at the Pickering facility during 2016 with the follow up mission conducted in September of 2018.(see subsection 14(i)(e)). The OSART team identified 8 good practices, 10 recommendations and 11 suggestions. Good practices were identified in the areas of: severe accident management simulator application for supporting multi-unit guideline development, obsolescence management that considers long term aging management assessments, transition to decommissioning requirements and established and long standing relationships with community partners.

14 (i) (e) 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 (see sub-articles 7.2(iii) and (iv)).

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. 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.

To address the Category 3 CSIs effectively, they have been logically separated into two groups – those relevant to LBLOCAs and those that are not (referred to as non-LBLOCA issues).

The remaining Category 3 CSIs divided by category, are as follows:

- Category 3 LBLOCA CSIs:
  - Analysis for void reactivity coefficient
  - Fuel behaviour in high temperature transients
  - Fuel behaviour in power pulse transients
- Category 3 non-LBLOCA CSI:
  - Systematic assessment of high energy line break effects

- For the LBLOCA CSIs, the CNSC has developed an interim regulatory position, which involves a set of interim action level limits for safety margin parameters and acceptance criteria for design-basis accidents for all NPPs. This position is consistent with the risk control measures for CSIs and will remain in effect until the recommendations of the industry LBLOCA working group are accepted by the CNSC and are fully implemented by the licensees.

Descriptions of the Category 3 issues and the required risk control measures are provided in the CNSC annual *Regulatory Oversight Report for Nuclear Power Generating Sites* and its predecessor, the *Regulatory Oversight Report for Nuclear Power Plants*.

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

During the reporting period, the licensees developed the composite analytical approach to address the LBLOCA Category-3 CSIs. Although OPG and NB Power cooperated in this work, Bruce Power took the lead in its application. In December 2018, Bruce Power submitted a comprehensive study to the CNSC to demonstrate that the occurrence of a large break in a large pipe in a CANDU reactor is of very low frequency. CNSC staff are reviewing the submission.

The non-LBLOCA CSI has been re-categorized for Bruce A and B, Darlington, Pickering B and Point Lepreau. OPG submitted its re-categorization analysis for the only NPP for which it remains open - Pickering A - and the CNSC is reviewing it.

By submitting this report, the planned activities to address Suggestion 7RM S-1 are complete, although work will continue in the next reporting period toward re-categorization of the remaining three Category 3 CSIs. Canada recommend this suggestion be closed, noting that Canada continually monitors known and emerging safety issues.

14 (i) (f) Fulfilling principle (2) of the 2015 *Vienna Declaration on Nuclear Safety*

Principle (2) of the 2015 *Vienna Declaration of Nuclear Safety* (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 off site 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 fulfils principle (2) through both global and specific assessments that are described in detail in this article. NPP licensees have completed PSRs (and/or integrated safety reviews for the refurbishment) 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 7.2(ii)(d) for a description of the most recent PSRs and integrated safety reviews completed by each of the licensees.

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 that 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 from specialists from CNSC headquarters in Ottawa.

CNSC staff members also review details in reports submitted by NPP licensees per CNSC regulatory document 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 special 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 members also review and approve certain operational changes or other changes to items in the licensing basis (see subsection 7.2(ii)(a)). CNSC staff members verify that proposed changes are within the licensing basis (e.g., by confirming that they do 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 (see subsection 14(ii)(a)) and various aging management programs to address specific critical systems and aging mechanisms (see subsection 14(ii)(b)).

14 (ii) (a) Testing - General

CNSC regulatory document 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 EPRI and the American Society of Mechanical Engineers publications.

Thousands of safety-related tests are conducted annually at each NPP. These tests typically have a pass rate on the order of 99.9 percent.

14 (ii) (b) Aging management

All NPPs experience materials 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 an NPP's 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 regulatory document 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 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.

The original assumed pressure tube design life was based on 30 years of operation at 80 percent capacity factor (which correspond to 210,000 equivalent full power hours (EFPH) per reactor from the date of first criticality).

Through a joint Fuel Channel Lifecycle Management program that entails multiple research and development activities in several key areas of fuel channel material degredation, industry developed refined engineering methodologies and models for predicting material properties over the full operational life of the fuel channel components (specifically, pressure tube and Inconel X-750 annulus spacers). Canadian utilities routinely apply these methodologies and models to demonstrate the continued fitness for service of components operated beyond 210,000 EFPD 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 and imposing them through requirements in the licence to operate. 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.

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 to 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.

To support long-term operation, the CNSC has also used licence renewal to update requirements related to monitoring, inspection and reporting related to the fitness for service of pressure tubes.

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.

Canada sponsors significant R&D in the field of nuclear safety, as described in Appendix D. A significant portion of the activity 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[5] 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, 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 patterned after the International Commission on Radiological Protection (ICRP) Publication 60 (1990) and the IAEA's *Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards* GSR Part 3 (1996).

The CNSC has been engaging stakeholders and initiating changes to the RPR. The CNSC solicited feedback from stakeholders and members of the public regarding proposals to amend the RPR in 2013 through a discussion paper (DIS-13-01, *Proposals to Amend the Radiation Protection Regulations*, which was described in the seventh Canadian report). Following the analysis of stakeholder input (*What We Heard Report* for DIS-13-01), the CNSC moved forward with amendments to the RPR in October 2017 to

- incorporate international guidance, aligning with GSR Part 7, *Preparedness and Response for a Nuclear or Radiological Emergency* (2015)
- fully describe requirements for addressing radiological hazards during various phases of an emergency for the protection of persons involved in the control of an emergency, based on the lessons learned from Fukushima

Additional amendments to the RPR were also ongoing to modernize the regulations and to align with ICRP Publication 103 (2007) and the IAEA's GSR Part 3 (2014). The proposed amendments include:

- revising the equivalent dose limit for the lens of an eye for a nuclear energy worker from the current limit of 150 mSv to 50 mSv in a one-year dosimetry period
- adding a new equivalent dose limit for the lens of an eye for a nuclear energy worker of 100 mSv in a five-year dosimetry period

[5] Nuclear energy worker 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.

- adding new requirements for the protection of breastfed infants

Stakeholders will have a further opportunity to comment on the proposed amendments when they are published in the *Canada Gazette*, Part I, which is anticipated in 2019.

To support the implementation of the regulatory requirements for radiation protection, regulatory guides and standards have been developed by the CNSC for use by licensees. The CNSC is currently developing three new regulatory documents:

- REGDOC-2.7.1, *Radiation Protection*
- REGDOC-2.7.2, *Dosimetry, Volume 1: Ascertaining Occupational Dose*
- REGDOC-2.7.2, *Dosimetry, Volume 2: Technical and Management System Requirements for Dosimetry Services*

These new regulatory documents will not only supersede existing regulatory guides and standards, but will also provide new information on and guidance for radiation protection.

To verify compliance with licence conditions and regulations, CNSC staff review documentation and operational reports submitted by applicants and licensees and evaluate the implementation of licensees' radiation protection and environmental protection programs through technical assessments and compliance activities. 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), which is operated by Health Canada.

Events related to potential and actual exposure to radiation or hazardous substances, 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 regulatory document 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. An example is provided in Appendix C. 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 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 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 nuclear energy worker
- 4 mSv for the balance of the pregnancy for a pregnant nuclear energy worker
- 1 mSv per calendar year for a person who is not a nuclear energy worker

Section 14 of the RPR prescribes the following equivalent dose limits:

- 150 mSv to the lens of an eye in a one-year dosimetry period for a nuclear energy worker
- 15 mSv to the lens of an eye in a one calendar year period for a person who is not a nuclear energy worker
- 500 mSv to the skin in a one-year dosimetry period for a nuclear energy worker
- 50 mSv to the skin in a one calendar year period for a person who is not a nuclear energy worker
- 500 mSv to the hands and feet in a one-year dosimetry period for a nuclear energy worker
- 50 mSv to the hands and feet in a one calendar year period for a person who is not a nuclear energy worker

As mentioned at the beginning of this article, some changes to equivalent dose limits were being proposed at the end of the reporting period.

Additional information on the RPR, dosimetry requirements, and guidance related to the ALARA principle and the setting of radiation protection action levels is provided in annex 15(a).

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 dose to workers. Remote monitoring for radiological hazards has reduced dose 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. Robotics have been used by some licensees to inspect and remove hot spots of elevated contamination, thereby minimizing worker dose. Moving into 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 operational experience, all licensees have enhanced their contamination control programs to better manage and control risks from alpha hazards.

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 is best 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). Further, mock-ups have also been used to give Nuclear energy workers 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.

Doses to workers

Health Canada maintains the National Dose Registry (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 who are currently monitored, and contains monitoring records back to the 1940's.

Doses to workers were below regulatory limits during the reporting period (see annex 15(a), which charts and discusses doses to workers at Canadian NPPs). During the reporting period, the total collective dose at Canadian NPPs varied due to a number of 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* provides additional details regarding requirements for environmental protection. Paragraph 12(1)(c) of the *General Nuclear Safety and Control Regulations* requires 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 life cycle 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 (f), (g), and (k) require 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 NPP operators 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 life cycle stage, the specific requirements of the *Class I Nuclear Facilities Regulations* for NPP operators are as follows:

- Paragraph 6 (h): predict the effects on the environmental and health of persons and the mitigation measures that will be taken to prevent of mitigate those effects
- Paragraph 6 (i): indicate the point of release, 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): propose measures to control releases of nuclear and hazardous substances into the environment
- Paragraph 6 (k): propose 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

The CNSC published regulatory document REGDOC-2.9.1, version 1.1 *Environmental Protection: Policies, Programs and Procedures* in April 2017. It supersedes the previous version of REGDOC-2.9.1 (2013) as well as CNSC Regulatory Policy P-223 (2001).

Licensees have implemented, or are in the process of implementing REGDOC-2.9.1v1.1 for operational NPPs. The requirements and guidance in this document are consistent with modern national and international practices addressing issues and elements that control and enhance nuclear safety and establish a modern, risk-informed approach to environmental protection. The general EP regulatory framework is described by figure 15(b).

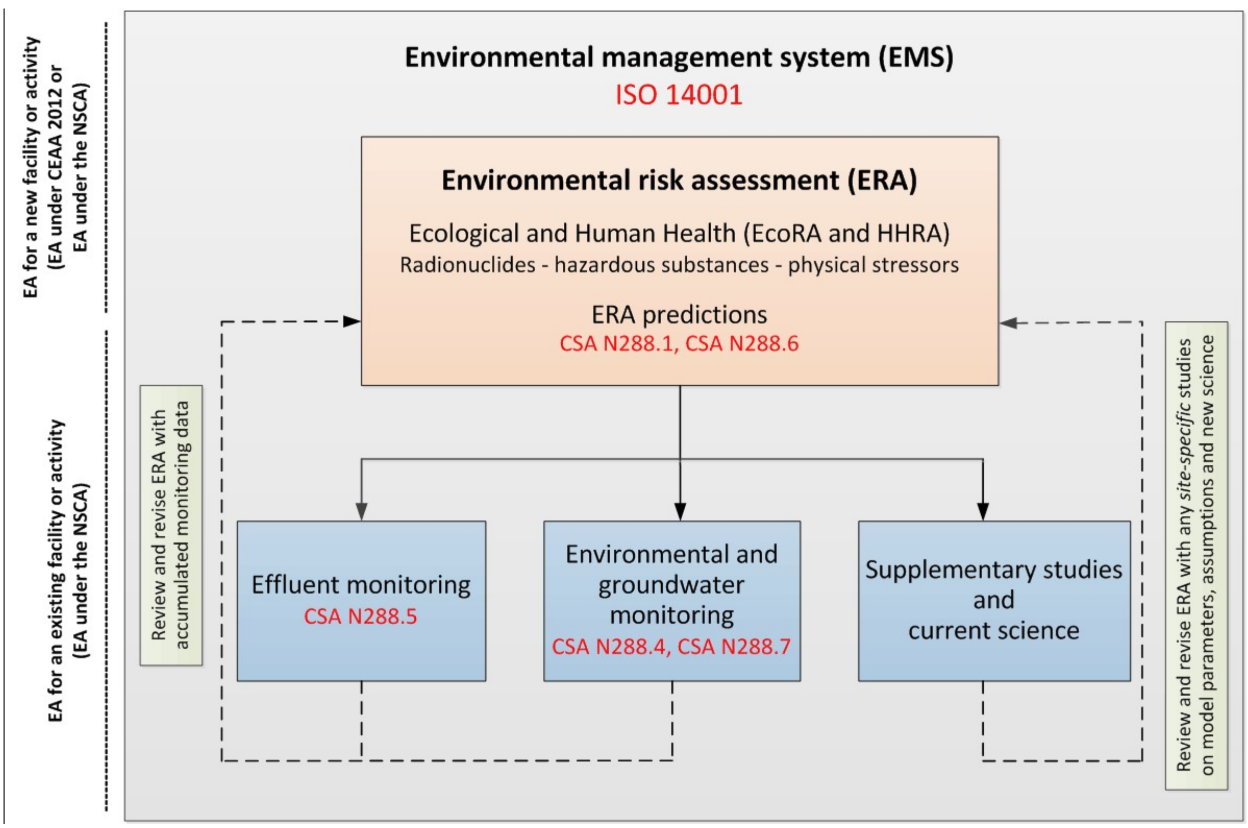

Figure 15(b) Ensuring adequate provision for the protection of the environment

For each NPP, the CNSC must determine that NPP operators have made adequate provision for the protection of the environment by keeping releases to the environment as low as reasonably achievable (ALARA), social and economic factors being taken into account for radiological substances, and through the application of best available technology and techniques economically achievable (BATEA) for hazardous substances where appropriate. For this purpose, NPP operators use environmental risk assessments (ERAs) to make predictions of 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. The authorization to operate an NPP is based on these ERA predictions. NPP licensees are required to establish an environmental management system that includes, for example, the ERA as well as the monitoring programs (e.g., effluent, environmental, 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. CNSC staff review the information collected by these programs on an annual basis to verify that ERA predictions have been met. After five years of annual reporting, the ERA is updated with the data collected with the effluent and environmental monitoring programs, special studies, and new science The sections below discuss in more details the environmental management system, the ERA, and the effluent and environmental monitoring programs.

Environmental risk assessment

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 operators are required to follow CSA Group 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, hazardous substances or thermal releases) to predict the source terms of releases; the transport of radiological and hazardous substances through environmental pathways (e.g. atmospheric, surface water); and the 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 or new science. In the event that ERA predictions are not met, adaptive management measures (e.g., mitigation measures) can be implemented if necessary based on the updated ERA.

Environmental management systems

As part of environmental management systems, Canadian NPPs have established programs to control and monitor the effect of operations (both nuclear and hazardous) on human health and the environment (Figure 15(b)). These programs include an objective to maintain a low level of public risk compared to other normal public risks that arise from industrial activity. Typical elements include management of releases and waste, worker training and informing the public.

Effluent and emission monitoring

Other important measures include the monitoring of releases, 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 or waterborne effluent, expressed as percentages of their respective DRLs, exceeds 100 percent, 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 Calculating Derived Release Limits for Radioactive Material in Airborne and Liquid Effluents for 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, vary in values, and depend on several factors (assumptions, representative person characteristics, site-specific data, etc.). 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.

For environmental protection, licensees set environmental action levels well below the DRLs. These action levels provide a warning, when exceeded, of a possible loss of control in the emissions management systems and allows for prompt corrective action. This enables licensees to keep liquid effluent and gaseous emission releases well below their respective DRLs.

NPP licensees monitor airborne emissions for tritium, iodine, noble gases, carbon-14 and particulates, as well as waterborne emissions for tritium, carbon-14 and gross beta-gamma radioactivity. Releases of gaseous emissions and liquid effluents from Canadian NPPs from 2016 to 2019 are tabulated in annex 15(b), along with the corresponding DRLs. During the reporting period, all releases from Canadian NPPs were very low: less than 1 percent of the DRLs. From 2016 to 2018, there were no reported cases of environmental action levels being exceeded.

The licensee effluent monitoring program is based on the requirements of CSA standards N288.5, *Effluent monitoring programs at Class I nuclear facilities and uranium mines and mills* and

Environmental Monitoring

In addition to tracking radiological emissions from the NPP, licensees have radiological environmental monitoring programs to monitor radioactivity and other interactions with the environment around the facilities in the air, water and food chain products. The environmental monitoring programs aim to:

- 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, on the effectiveness of containment and effluent control, 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 ensure that the public legal limit in Canada for effective dose from the operation of NPPs is not exceeded and the environment is protected based on the ERA predictions used to authorize the activity.

15 (c) Independent Environmental Monitoring Programs

CNSC IEMP

In 2013 the CNSC launched the Independent Environmental Monitoring Program (IEMP) to align with other Canadian and international regulatory bodies. The IEMP complements CNSC staff reviews and approvals of licensees' environmental monitoring programs 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 there are no expected health impacts as a result of facility operations. Conclusions and data are then published to a user-friendly map on the CNSC website. A full technical report is also available upon request.

IEMP results for Canadian NPPs are available on the CNSC website for the following years:

- Bruce A and B 2013, 2015, 2016
- Darlington 2014, 2015, 2017
- Pickering 2014, 2015, 2017
- Point Lepreau 2014, 2015, 2016, 2017
- Gentilly-2 2015, 2016

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 comprised of 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. Data from the FPS network is made available in real-time to authorities through the IAEA's International Radiation Monitoring Information System, and 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 ORSP monitors the air, water and food around nuclear power plants for radioactivity.

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 nuclear facilities. The most recent ORSP report, produced by the Ontario Ministry of Labour in 2014, concluded that the public in the vicinity of major nuclear facilities in Ontario can be assured that their health, safety, welfare and property are not adversely affected by emissions from the nuclear facilities.

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 among the three levels of government (municipal, provincial and federal), operators, and non-government organizations in a bottom-up approach. 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, 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 in 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 off-site 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. It is responsible for coordinating the overall federal government response to emergencies in support of the provinces and territories, including nuclear emergencies.

Public Safety Canada is the lead authority for the *Federal Emergency Response Plan* (FERP), Canada's all hazards plan. The FERP outlines the processes and mechanisms to facilitate an integrated Government of Canada response to an. Governance for the FERP is provided through the Assistant Deputy Ministers Emergency Management Committee structure.

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 organizations and capabilities and serve as pre-agreements for federal support in a nuclear emergency. 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, 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 Defense/Canadian 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 to the IAEA as part of its emergency response functions ranging from local to global atmospheric 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 (NRCan), which is responsible for providing emergency radiation mapping and surveying services, 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*

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 describes some of the developments during the reporting period in these areas.

The CNSC amended the *Radiation Protection Regulations* in 2017 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"

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. They 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 off-site 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.

Canada has specific measures in place for the post-accident recovery phase. During the reporting period, the Ontario Provincial Nuclear Emergency Response Plan, the Ontario implementing plans for the Bruce, Darlington and Pickering NPPs and the New Brunswick Point Lepreau Nuclear Off-Site Emergency Plan were updated. These emergency plans include provisions to manage the recovery phase following an accident.

During the reporting period, provincial stakeholders in Ontario continued to develop an Environmental Radiation and Assurance Monitoring Plan and associated procedures and training, which would be implemented in an emergency to inform decision-making regarding ingestion control and recovery planning.

During the reporting period, recovery measures were also tested in New Brunswick during an emergency exercise. Exercise Synergy Challenge, a two-day exercise at Point Lepreau, included a full day to test the implementation of early recovery actions, exercise and evaluate off-site surveying, including post-accident environmental surveillance, evacuation reception centres, characterization of contaminated areas, assurance monitoring, public communications and the management of the psycho-social community response. Details on this exercise can be found in annex 16.1(f).

The FNEP also includes measures to manage the recovery phase as needed at the federal level - see annex 16.1(e).

During the reporting period, Canada continued work related to guidance for the post-accident recovery phase.

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.

In 2018, the CNSC requested public review of draft regulatory document 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), which 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. At the end of the reporting period, CNSC were reviewing the comments received.

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"

Specific measures for the transition to recovery and for recovery, such as authorizing the return of evacuees, would be based on an adaptive approach as the recovery phase proceeds, in line with IAEA GSR Part 3, GSR Part 7 and GSG-11. Health Canada's *Generic Criteria and Operational Intervention Levels for Nuclear Emergency Planning and Response* recommends that criteria for the return of evacuees should include confirmation that there is no further threat of a release of radioactive material, that the situation that gave rise to the emergency is stable and that the residual dose to returning individuals will not exceed the upper limit of the ICRP's reference band for existing exposure situations (i.e., 20 mSv/y). This guidance can serve as the basis for decisions on the return of evacuees, taking into consideration the radiological conditions and social and other circumstances following the accident

To establish the public acceptability of any measures, 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.

The planned activities to address Challenge 6RM C-3 will continue during the next reporting period. Canada recommends this challenge remain open.

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 the information related to emergency preparedness that must accompany an application for a licence to operate a Class I nuclear facility. Specifically, the application 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, operating experience 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.

CNSC published the updated regulatory document REGDOC-2.10.1, *Nuclear Emergency Preparedness and Response, Version 2*, in February 2016. Additionally, the CSA Group revised standard N1600, *General requirements for emergency management for nuclear facilities* in March 2016; it addresses lessons learned from Fukushima. The licensees will pursue implementation of these two newer documents in the next reporting period.

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 regulatory document 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 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 kept up to date 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 (for example, schools, prisons, 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 and are established by the province or territory and are under control of the region or municipality.

In Canada, the term “exclusion zone” refers to a parcel of land, within or surrounding a nuclear facility, on which there is no permanent dwelling and over which a licensee has the legal authority to exercise control. The size of the exclusion zone is proposed by the applicant who is expected to demonstrate consideration of effective dose under normal operation and accident conditions, the design-basis threat (security) and emergency preparedness.

Before submitting the application for a licence to prepare site, the applicant shall 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 federal, provincial and municipal government agencies playing a role in emergency preparedness and response
- 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, and so on)

The applicant shall document the strategy and process for effective two-way ongoing consultation with emergency management agencies affected by site operations throughout the projects lifecycle. Emergency management agencies include security agencies involved in the development of the site selection threat risk assessment 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 Specific additional criteria found in these regulatory documents that need to be considered at the design and construction phase include the following:

- The containment design allows sufficient time for the implementation of offsite emergency procedures.
- The design and functionality of 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 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 with a wide range of potential or actual emergencies in accordance with defined plans and procedures. 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.

The seventh Canadian report noted a plan to amend the *Class I Nuclear Facilities Regulations*, requiring a licence applicant to submit its applicable provincial and municipal off-site emergency plans. However, the post-Fukushima review, subsequent improvements to the off-site emergency plans, and the completeness of existing guidance for licence applicants rendered such an amendment to the *Class I Nuclear Facilities Regulations* unnecessary.

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 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, amongst others:

- 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 directly at the municipal level)
- establishing emergency worker centres to ensure radiation protection for emergency workers (typically managed directly 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.

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 a sufficient quantity of iodine thyroid-blocking agents (such as potassium iodide (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, with the last distribution of new KI pills being conducted in 2015. 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 the reporting period, all NPP licensees with operating reactors 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. Pre-distribution of KI pills to residents within the specified area for Point Lepreau has been in place since 1982.

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 also 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 in the public forum.

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; analysing 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; and, 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, led by Public Safety Canada.

While leadership for emergency management falls to the Federal Minister of Public Safety, section 6 of the *Emergency Management Act* sets out responsibilities of other federal ministers. Coordination of federal nuclear emergency planning and response was 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, trans-boundary or international nuclear emergency. The FNEP complements the relevant nuclear emergency plans of other jurisdictions inside and outside Canada.

The FERP and FNEP were updated in 2011 and 2014, respectively; the updates addressed the lessons learned from Fukushima. These federal plans undergo periodic review to determine if updates are required to ensure that they remain fit for purpose.

The FNEP describes the roles and responsibilities of federal departments and agencies as well as the 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, NRCan and Transport Canada. AECL and 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 its federal Interdepartmental Radiological-Nuclear Emergency Management Coordinating Committee and the Federal/Provincial-Territorial Radiological-Nuclear Emergency Management Coordinating Committee. The Interdepartmental Committee is integrated into the broader federal all-hazards planning through the Assistant Deputy Ministers Emergency Management Committee structure. 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, the revision of FNEP provincial annexes, and the Canadian EPREV mission planned for June 2019. The governance provided by the FERP and FNEP allows the various jurisdictions and organizations that have responsibilities for aspects of nuclear emergency preparedness (municipal and provincial governments, the licensee, and federal departments and agencies) to discharge their responsibilities in a cooperative, complementary and coordinated manner. Provincial annexes to the FNEP describe interfaces between the Government of Canada and the provincial emergency management organizations in those provinces that have operating NPPs or ports hosting foreign nuclear-powered vessels.

The provincial annexes to the FNEP for Ontario and New Brunswick were finalized and approved in 2015 and 2017, respectively. Both annexes were tested in a series of exercises throughout the reporting period and 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 modelling capabilities for nuclear emergency management. For nuclear emergencies having trans-border impact there are arrangements 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 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.

Emergency plans of federal departments and agencies

As per the *Emergency Management Act*, individual federal organisations, 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 as part of the overall emergency management system.

Other federal organizations have specific primary functions for nuclear emergency preparedness and response under the FNEP: the Public Health Agency of Canada, the Canadian Nuclear Safety Commission (CNSC), Transport Canada, Environment and Climate Change Canada (ECCC), Natural Resources Canada (NRCan), the Department of National Defence and Canadian Forces (DND/CF), and the Canadian Food Inspection Agency (CFIA). 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. More details on the CNSC's role in emergency preparedness are provided in annex 16.1(e).

During the reporting period, the NPP licensees established links with the CNSC's emergency operations centre to enable on-line, automated transfer of plant data during an emergency, which will enhance the CNSC's ability to execute its oversight and advisory responsibilities during a nuclear emergency. Details are provided in annex 16.1(e).

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 after action 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 licensed 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 regulatory document 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 practise the required skills on a regular basis. All emergency exercise objectives are addressed over a five-year period, with a full-scale emergency exercise conducted every three years.

CNSC staff members 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, three such exercises were evaluated; the CNSC's conclusions are briefly summarized as follows:

- Bruce A and B (Huron Resolve, October 2016): Bruce Power rigorously demonstrated its emergency preparedness and response over a 5 day, full-scale exercise.
- Pickering (Unified Control, December 2017): OPG successfully demonstrated their preparedness, and the interoperability with government agencies and local communities to respond to a severe event.
- Point Lepreau (Synergy Challenge, October 2018): NB Power and the offsite agencies successfully demonstrated their emergency preparedness, interoperability, and response to a simulated serious accident. This exercise successfully demonstrated that New Brunswick Power, the Province of New Brunswick and key organizations at the regional and federal levels are prepared to respond effectively together. It also demonstrated early offsite recovery operations in response to a simulated release.

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 practise 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 off-site components to provide support to the province in accordance with the FNEP provincial annexes. Other federal departments may also participate.

Health Canada's evergreen, five-year exercise program for the FNEP includes different types of exercises The program includes anticipated key FNEP events and exercises for a rolling, five-year schedule as well as an annual nuclear training and event calendar, which is shared with Public Safety Canada's Federal Exercise Working Group for inclusion in a national all-hazards emergency exercise calendar. The FNEP recommends a large-scale, multi-jurisdictional exercise occurring, in general, once every seven, plus or minus one, years.

During the reporting period, the FNEP emergency management coordinating committees developed a new exercise strategy, with the objective of providing a framework for a sustainable and effective multi-jurisdictional nuclear exercise program. The strategy was approved in February 2017, and will integrate 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 organisations from all jurisdictions and the participation of senior management in order to exercise decision making at all levels. Smaller-scale exercises would occur routinely between the national priority exercises. Training and emergency exercises conducted during the reporting period are described in more detail in annex 16.1(f).

16.1 (g) EPREV

In February 2017, Health Canada invited the IAEA to undertake an Emergency Preparedness Review (EPREV) for Category 1 facilities (NPPs) in Canada. Per the EPREV guidelines, Canada undertook a self-assessment of its emergency preparedness arrangements against IAEA Safety Standard GSR Part 7 and submitted it to the IAEA in January 2018, with an update submitted in January 2019. Following the submission of the self-assessment, the IAEA accepted Canada's invitation to host an EPREV, and a preparatory meeting was conducted in May 2018. The composition of the EPREV Review Team was established in late 2018. An updated self-assessment and Advanced Reference Material were provided to the IAEA and Review Team members in March 2019. The mission is scheduled for June 2019, and will involve a range of federal, provincial and municipal emergency preparedness and response stakeholders, as well as the NPP licensees. It will focus on arrangements for emergencies at Class I nuclear facilities, including the NPPs in the provinces of Ontario and New Brunswick.

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 regulatory document 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 the affected. The provinces inform all relevant stakeholders prior to issuing the emergency bulletins to the public which is public 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 (PHAC) 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 to Communications 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 listed.

Statement of Intent between Health Canada and United States Department of Energy

Health Canada and the U.S. Department of Energy National Nuclear Security Administration 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 also registered its NPP accident-analysis capability under RANET in 2016. Health Canada participates in RANET technical meetings to review and update the RANET guidelines as necessary and to exchange experience in 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 of 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 trans-boundary 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 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(f), as well as 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.

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).

Prior to the CNSC's issuance of a site preparation licence, a positive decision regarding an environmental assessment (EA), which will be described in this article, is required. The EA process evaluates the effects of the project lifecycle of a proposed NPP on the environment. The CNSC separately evaluates the licence applicant's proposed measures to protect individuals, society and the environment during site preparation activities.

Fulfilling principle (1) of the 2015 *Vienna Declaration on Nuclear Safety* as it relates to siting

Principle (1) of the 2015 *Vienna Declaration on Nuclear Safety* (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.

Following the Fukushima accident, the IAEA revised five Safety Requirements, which were approved by the Board of Governors in March 2015. Subsequently, the Director General of the IAEA requested the Commission on Safety Standards (CSS) to review the need for further revisions to the Safety Requirements. In August 2015, the Chair of the CSS determined that there was no need for further revisions because the technical objectives of the VDNS were already well reflected in the 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. The design information provided by the applicant must be credible and sufficient to adequately bound the evaluations of environmental effects and site suitability from a range of reactor designs that might later be deployed at the site.

The bounding design parameters must contain sufficient information 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 in the approved environmental assessment 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. When applying for a licence to construct, the applicant will be expected to submit detailed design information to verify that the evaluations presented previously remain valid. If the level of information provided at the outset is limited, however, there is a greater likelihood that fundamental barriers to licensing will appear during the review process for a licence to construct. Thus, it is in the best interest of the applicant to make its submissions as complete as possible at the outset.

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 (BDBA, which include severe accidents)

For EA purposes, the limiting source terms must consider accident sequences that could occur with a frequency greater than 10^{-6} per reactor-year of operation. For those less than 10^{-6} per reactor-year, but sufficiently close to this frequency, the rationale for not including them for further analysis should be provided.

For site evaluation carried out in support of licensing (including emergency planning purposes), the CNSC expects severe accident sequences to be addressed. 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.

If the applicant chooses to pursue a licence to prepare a site without choosing a final NPP technology, 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 a "smart buyer". This means that the applicant will be expected to demonstrate a clear understanding of the technologies it is proposing to use and the basis from which the site selection case is developed.

Site evaluation criteria – general

The information provided in an application for a licence to prepare a site is assessed against the criteria described in the CNSC regulatory document REGDOC-1.1.1, *Site Evaluation and Site Preparation for Nuclear Reactor Facilities*. REGDOC-1.1.1 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 7.2(i)) and the impact of the NPP on the surrounding population and the environment (see subsection 7.2(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 (see subsection 16.1(c)) 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.

The site evaluation includes:

- evaluation against safety goals
- consideration of evolving natural and human-induced factors
- evaluation of the hazards associated with external events
- determination of the potential effects of the NPP on the environment

- consideration of projected population growth in the vicinity of the site along with emergency planning that takes those projections into account

An example of an evaluation against safety goals, set in the context of OPG's EIS and application for a licence to prepare a site for the Darlington new-build project, was provided in annex 17 of the sixth Canadian report.

If the site evaluation indicates safety concerns that design features, site protection measures, or administrative procedures cannot remedy, the site is deemed unacceptable. Additional details related to site evaluation criteria are provided under sub-articles 17(i) and 17(ii) below.

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 (specifically, IAEA safety guides NS-G-1.5, NS-G-3.2, NS-G-3.4 and NS-G-3.5).

Licensees also have to perform a site-specific external hazards screening to identify other hazards that may require a Probabilistic Safety Assessment (PSA) or a bounding analysis. Further, the licensees 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.

It should be pointed out that consequential events are also considered in the PSAs (see subsection 14(i)(c)) required in the licensing process following the application for a licence to prepare site.

REGDOC-1.1.1 requires the applicant to consider climate change when evaluating the potential impact of these phenomena. An example of this consideration for Bruce A and B was provided in annex 17(iii)(a) of the sixth Canadian report.

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, access to the site, emergency preparedness and security.

The licence applicant addresses these criteria during the application process for a licence under the NSCA (and in its EIS as part of the EA process), the results of which are integrated into the safety case. Applications identify and assess the site characteristics that may be important to the safety of the proposed NPP, including:

- land use
- present population and predicted population expansion
- principal sources and movement of water
- water usage
- meteorological conditions
- seismology
- local geology

17 (ii) Impact of the installation on individuals, society and environment

17 (ii) (a) Environmental assessment

Under the current regulatory regime, an EA pursuant to the *Canadian Environmental Assessment Act, 2012* (CEAA) is initiated following an application for a licence to prepare a site. EAs identify whether a specific project is likely to cause significant adverse environmental effects taking mitigating measures into account. The potential impact on the environment is evaluated in the EA process by examining the effects on parameters such as water supply, air quality, wildlife, lakes and rivers. EAs ensure that, early in a project, potentially adverse environmental effects are identified and mitigated to the extent possible. In accordance with REGDOC-1.1.1, prior to the triggering of the EA and licensing processes, the applicant is expected 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. This case forms the backbone for submissions in support of the EA and the application for a licence to prepare the site, which is reviewed by the CNSC and other applicable federal authorities.

An environmental risk assessment (ERA), see subsection 17(iii)(a), forms the basis of an EA. In accordance with paragraph 15(a) of the CEAA, an EA is required when the CNSC is the responsible authority with respect to a designated project per the *Regulations Designating Physical Activities*. In addition, an EA under the CEAA is carried out early in the licensing process (at the beginning of the lifecycle of the project) and serves as a planning tool.

For applicants proposing facilities or activities in areas of Canada subject to land claim agreements (such as the territories and parts of Quebec and Newfoundland and Labrador), CNSC staff members support the EA process of that land-claim regime and the Commission uses the information gathered in the EA process in its licensing decision under the NSCA.

There were no EAs conducted under the CEAA for Canadian NPPs or new-build projects during the reporting period. Details on the site evaluation studies for the Darlington New Nuclear Project (DNNP) during the previous reporting period (2010–13) can be found in annex 17 of the sixth Canadian report. See subsection D.4 of chapter I for additional details on the EA and licensing decisions related to Darlington new-build.

As mentioned in the Introduction, CNSC received an application for a licence to prepare site for a small modular reactor on Atomic Energy of Canada Limited's property at Chalk River Laboratories. If CNSC staff determines that application is sufficient for detailed consideration, the project description will be made available for public comment as part of the EA process.

The CNSC published a new version of REGDOC-2.9.1 in 2017. The updated document, which is titled *Environmental Protection: Environmental Principles, Assessments and Protection Measures*, outlines the CNSC's EA and environmental protection practices. Further, at the end of the reporting period, the Canadian Parliament was debating proposed legislation (titled the Impact Assessment Act) to potentially replace the CEAA.

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 shall 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.

17 (ii) (c) New-build outreach

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 are provided in annex 9(c).

Current licensing activities for new reactor facilities include one new application and one renewal of a Licence to Prepare a Site (LTPS).

OPG's current licence to prepare site (PRSL 18.00/2022) for the DNNP project issued from August 17, 2012 and expires on August 17, 2022. As requested by the Commission in its Record of Decision, CNSC staff and OPG publically presented a mid-term update on this licence in December 2018. This update to the Commission included information on CNSC staff oversight of OPG activities under this licence and OPGs notification to CNSC of its intent to renew the licence. OPG has not performed any site preparation activities to date. Identified Indigenous groups with interest in the DNNP project and the public will continue to be informed of the status of the project.

CNSC received Global First Power's application March 20, 2019 for a licence to prepare site for a small modular reactor on Atomic Energy of Canada Limited's property at the Chalk River Laboratories location. Indigenous groups and external stakeholders were informed that the CNSC received the licence application from Global First Power. The CNSC is following established processes for the conduct of the outreach for the Environmental Assessment and licensing.

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
- changes to neighbouring man-made facilities (such as a newly constructed oil refinery, rail corridor, airport flight path or chemical plant)
- climate change

CNSC regulatory document 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
- PSA
- 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, prescribes transboundary notification requirements to all member countries, of which Canada is a signatory. The Convention requires transboundary notification in the situation where all three conditions below are applicable:

- project in Canada is likely to have a significant transboundary impact on another Party to the convention,
- the project is subject to a federal EA; and

- the project is listed under the Espoo Convention.

Canada shares borders with the United States of America (U.S.A), Denmark (Greenland), and France (Saint Pierre and Miquelon). All four countries are signatories of the Convention, however, the U.S.A. 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 U.S.A. The Espoo Convention has thus never been applied with the U.S.A.

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 U.S. 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 U.S, 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.

The CEAA requires that effects to the environment that may occur outside of Canada (transboundary effects) be included in the EA review for designated projects listed in the *Regulations Designating Physical Activities*, including new NPPs.
Furthermore, public participation opportunities (such as public hearings) are an important component of the CNSC's licensing and EA process. The CNSC emphasizes public engagement and participation, and members of the public, including people from outside Canada, are provided the opportunity to review licensing and EA 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.

All operating NPPs in Canada are CANDU designs. CANDU reactors feature heavy-water coolant and moderator, as well as fuel channel and fuel bundle designs that enable online fuelling. 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. Canada sponsors significant R&D that address the area of design and construction (see Appendix D for details).

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, new-build licence applications, the CNSC continues to update its design requirements for NPPs, participate in the Multinational Design Evaluation Programme (MDEP) and conduct pre-licensing vendor design reviews. These activities are described in the following subsections. The CNSC has also developed work instructions for the review of applications for a licence to construct an NPP. Work instructions are described in more detail in subsections 7.2(ii)(a) and 8.1(d).

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 regulatory document 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 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's regulatory review of an application for a licence to construct will include a clause-by-clause assessment of the proposed design against the requirements in REGDOC-2.5.2.

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. Integrated safety reviews (ISRs) conducted for life-extension projects and the recently introduced periodic safety reviews (PSRs) 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 2015 *Vienna Declaration of Nuclear Safety* (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 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 2015 Vienna Declaration of Nuclear Safety (VDNS) states that 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 emergency response.

As explained above, design changes have been made to address new standards, on an ongoing basis when licenses are renewed or amended and through the application of ISR and PSR. Specific examples of design changes are given in annex 18(i).

Multinational Design Evaluation Programme

The CNSC plays 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

The involvement of the CNSC in MDEP covers multiple areas of interest to Canada, including:

- design-specific safety issues and activities surrounding the AREVA European Pressurized Reactor and Westinghouse AP1000 designs
- issue-specific activities, such as:
    - methods by which multinational vendor inspections can be utilized
    - convergence of pressure boundary component codes and standards
    - resolution of regulatory issues around digital instrumentation and control standards

Pre-licensing vendor design reviews

The CNSC has established a 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 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 of the review 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 necessary detailed evidence to support the adequacy of the proposed design.

In November 2018, CNSC published regulatory document REGDOC-3.5.4, *Pre-licensing Review of a Vendor's Reactor Design*.to describe the process to interested parties and stakeholders (it replaced CNSC regulatory guide GD-385, of the same name). The CNSC has also developed work instructions to guide its assessment of information submitted by the vendor. The 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.

The CNSC was engaged in many pre-licensing vendor design reviews for SMRs during the reporting period. Their status is described in annex 18.

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, in parallel with MDEP activities, 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

To ensure a low probability of failures or combinations of failures that would result in significant radiological consequences, 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, 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 Canadian NPPs to safely operate and, when necessary, safely shutdown their reactors, even for low-probability or rare internal and external events.

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)(b)). 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.
During the reporting period, CNSC staff deemed the level of defence in depth at all Canadian NPPs to be acceptable. It was concluded that the design basis for Canadian NPPs is comprehensive and that the NPPs met the design requirements. It was also concluded that the risk to the Canadian public from beyond-design-basis accidents (BDBAs) at 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.

18 (ii) Incorporation of proven technologies

Measures are embedded in the Canadian licensing process to ensure the application of state-of-the-art, proven technologies. 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 for design and safety analysis.

The CANDU design criteria and requirements include the design and construction of all SSCs to follow the best applicable code, standard or practice and to 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 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 CSA Group standard N286.7, *Quality Assurance of Analytical, Scientific and Design Computer Programs for Nuclear Power Plants*.

CNSC regulatory document REGDOC-3.1.1, *Reporting Requirements for Nuclear Power Plants*, requires NPP licensees to update their safety analysis report at least once every five years or when requested to do so by the CNSC. 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 safety analysis report incorporates new methodologies, computer codes, 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.

Further, CNSC regulatory document 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).

Environmental qualification programs at Canadian NPPs also help to prove that safety 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 ongoing inspections of these systems.

For new-build projects, in addition to the criteria for existing NPPs (such as those found in CSA Group standards N285.0, N286.7 and N290.13), there are requirements in CNSC regulatory document REGDOC-2.5.2, *Design of Reactor Facilities: Nuclear Power Plants*, for proving engineering practices and qualifying designs (see annex 18). The safety analyses submitted in support of the application will also be assessed against the requirements in REGDOC-2.4.1 related to the use of methods and inputs that have been proven by validation.

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 CNSC regulatory document REGDOC-2.5.2, *Design of Reactor Facilities: Nuclear Power Plants*, that are related to reliability, operability, human factors and the human–machine interface are provided in annex 18.

Additionally, CNSC regulatory document 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.

To illustrate how human factors and human–machine interface are considered in the design of Canadian NPPs, one can examine the requirements for safety parameter display. REGDOC-2.5.2 calls for 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. Post-accident monitoring parameters, parameters that monitor when process or safety limits are being approached and the status of safety systems are all available on the panel displays for existing CANDU NPPs. Candu Energy has designed a dedicated safety parameter display system to provide a concise display of critical safety parameters and safety system status to the operations and emergency response staff, to aid them in rapidly and reliably determining the safety state of the NPP. This safety parameter display system has been integrated into the EC6 design in the main control room, secondary control area, technical support area and emergency support centre.

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 analyse 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.

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). (See subsection 7.2(ii)(d) for additional details regarding information that an applicant is required to submit with an application for a licence to operate.) 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 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 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 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. 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 upon between the licensee and the CNSC and incorporated into the licence to operate.

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 assures 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, 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

The requirement for NPP licensees to describe, in an application for a licence to operate a Class I nuclear facility, the systems and equipment, including their design and operating conditions, is stated in paragraph 6(b) of the *Class I Nuclear Facilities Regulations*.

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, availability requirements)
- requirements on process systems (e.g., limiting parameters, testing and surveillance principles and specifications, 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 function, 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 limits. 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 safe 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 safe operating envelope (SOE) documentation (see subsection 19(ii)(b)). 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 safe operating envelope (SOE) project was to more clearly define the safe operating limits for Canadian NPPs, so that they are readily measurable by 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 represent only a subset of the relevant limits, the licensees undertook a project to more fully define the SOE as a complete and comprehensive set of limits derived from the safety analysis through controlled processes, based on the requirements of CSA standard N290.15-10, *Requirements for the safe operating envelope of nuclear power plants*. With SOEs implemented, all licensees commenced the maintenance phase, and will 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 systems, equipment and components at the NPPs are conducted in accordance with approved governance and procedures. The governance and procedures are incorporated into various licensee programs within the structure of 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.

The CNSC regulatory document 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 regulatory document 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 (see subsection 14(i)(d)), deterministic analyses (see subsection 14(i)(c)) and expert panels. NPP's have requirements for the maintenance and testing procedures for special safety systems to ensure no safety function is ever compromised by maintenance activities. Safety system testing is required at a frequency that demonstrates that each safety function is operating correctly and meets availability limits (typically, greater than 99.9 percent). Each component of a special safety system is subject to a regular functional test. 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, detailed station condition records or event reports are written by the licensees. 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. Bruce Power has reorganized all maintenance activities under one centralized division, known as the Equipment Performance Division, by bringing maintenance, engineering, work management and assessing together into performance teams responsible for key equipment, and giving these teams the authority and ability to drive equipment health improvement. Bruce Power expects that this reorganization will result in improved safety and operational performance through improved ownership of equipment by the performance teams.

At Darlington, the shutdown system monitoring computers for each unit are undergoing an upgrade project to manage hardware obsolescence, as well as to ensure SDS reliability and plant safety are sustained for extended Darlington operations. The shutdown system computers (display/test and trip) have been replaced on Unit 2 in 2018. OPG has committed to upgrade the

SDS computers for each unit during its scheduled refurbishment window, between 2020 and 2026.

Although all OPG NPPs have always had digital control and monitoring for reactor control and fuel handling, the transition of other control room instrumentation from analog to digital continued at all OPG NPP sites to improve monitoring and control capabilities.

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 regulatory document 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.

It is recognized that 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 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 at any NPP during the reporting period. There were also no events that required rating using the International Nuclear Event Scale (INES), as all events based on pre-rating review were assessed as Level 1 or below-scale (i.e., Level 0).

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 can be found in the CNSC regulatory document REGDOC-2.3.2, *Accident Management*, *Version 1*, but is also addressed in the CNSC regulatory document REGDOC-2.3.2, *Accident Management*, *Version 2*

The severe accident management provisions may differ between NPPs, depending on the location and nature of the NPP, as some NPPs are single-unit facilities in relatively remote rural locations and others are multi-unit facilities close to major urban centres.

Severe accident management guidelines

Conversion of the generic SAMGs into plant-specific ones and implementation of the plant-specific SAMGs have been completed for each of the Canadian NPPs except at Gentilly-2. Since the reactor at Gentilly-2 has been shut down and placed in a safe storage state, the licensee completed the development and implementation of its SAMGs for the irradiated fuel bay only.

The development and implementation of plant-specific 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.

The emergency mitigating equipment guidelines (EMEGs) have been developed and implemented to guide the deployment of emergency mitigating equipment as an additional onsite capability to provide water and electricity to cope with accidents. Integration of plant procedures (e.g., abnormal incident manuals, emergency operating procedures) with SAMGs and EMEGs is complete. Bruce Power has deployed SAMG kits at strategic locations in the plant to allow for

rapid implementation of SAMG measures. The kits include all of the required tools, materials and equipment to allow SAMG actions to be carried out in a timely fashion.
Verification of the SAMG/EMEG documentation and training, along with the validation of the SAM program are being done mainly through table-top exercises, plant drills or large-scale emergency exercises that simulate severe accident scenarios.

During the reporting period, CNSC staff undertook a number of activities to review the licensees' SAM programs. These activities included:

- compliance technical assessments of technical basis and documentation for NPP-specific SAMGs
- reviews of the EMEGs and their integration with SAMGs and other plant procedures and manuals
- interviews with plant staff involving SAM and emergency response
- evaluations of plant drills simulating severe accidents where SAMGs and EMEGs are 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 2015 *Vienna Declaration on Nuclear Safety*

Principle (2) of the 2015 *Vienna Declaration of Nuclear Safety* (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 off site 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.

Example of a Licensee SAMG Program

OPG adopted the COG generic SAM guidelines and used them as a building block to station specific SAM guidelines for Pickering NGS and Darlington NGS as per the design features, specifications and capabilities of each station. Various modifications and additions to existing systems were made to incorporate defence in depth by adding additional lines of defence using portable emergency mitigating equipment (See annex 18 for details). OPG SAMGs include guidance to potential Severe Accidents associated with non-reactor sources such as irradiated fuel bays.

Emergency Mitigating Equipment Guidelines (EMEGs) were developed to cater to the deployment of EME at all the stations. The EME equipment include all the tools to assist in connecting to the existing systems, structures, and components (SSC) and operation of the equipment. The effectiveness of these SAM guidelines is tested and verified periodically through drills and exercises performed by OPG for all their stations under CNSC observation. Lessons learned from these drills and exercises are used to enhance the SAM guidelines, EMEGs and associated procedures.

OPG has off-site facilities, such as the Site Management Centre, Corporate Emergency Operating Facility, etc. to organize a safe and coordinated response to severe accidents. Various means of communications are made available at these facilities to ensure constant communication with the site.

All SAMGs, EMEGs, facilities, procedures and training and qualification requirements in conjunction with the beyond-design-basis modifications and BDBA program provide a robust framework for OPG's SAM program.

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 under decommissioning.

Article 11 addresses licensee financial and human resources, which are planned throughout the NPP's life as well as decommissioning. Budgets are also made 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 process to assure that the services rendered to them serve the purpose and meet the relevant requirements.

For example, OPG's supply chain process establishes 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

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 NPPs have generally the same reactor design and licensees therefore work closely with their partners, for example, 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 the World Association of Nuclear Operators (WANO) and COG also provides access to assistance between member organizations.

Hydro-Québec is continuing to maintain the necessary engineering and technical support at Gentilly-2 during the safe storage state. The engineering and technical group at Gentilly-2 has access to additional support from Hydro-Québec staff working at other non-nuclear locations or specialized contractor organizations.

At Pickering, significant staff reductions are anticipated to be required as a result of the end of commercial operations at the NPP. In 2014, OPG established a team to focus on the end of commercial operations. The team is accountable for the overall planning for the end of commercial operations at the NPP. This includes the plans for resourcing as well as plans for the physical plant, such as the safe storage project and decommissioning plans. Resourcing plans will ensure appropriate staff members are redeployed internally for decommissioning work.

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 the CNSC regulatory document 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 INES thresholds to the IAEA Nuclear Event Web-based System (NEWS).

Canada is also committed to reporting to the International Reporting System (IRS), a database of international events that is operated by both the IAEA and the NEA, on significant events occurring at Canadian NPPs. Canada appoints a member of the 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 Working Group on Operating Experience.

Issues arising from operating experience (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 (EIRs), which are submitted to the Commission. Guidance for screening EIRs is available to assist CNSC staff with preparing these reports for 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) Operational experience feedback

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 operating experience (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 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 information 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, NB Power has developed a problem identification and corrective action system, while OPG has an OPEX website that incorporates station condition records. NPP licensees utilize OPEX from the WANO, COG and the Institute of Nuclear Power Operations (INPO) websites.

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, ensuring that relevant events are followed up in a timely manner. The OPEX Clearinghouse draws information from several sources including:

- Central Event Reporting and Tracking System, which is a database used to collect and categorize reported events at Canadian NPPs and track follow-up
- IRS

- NEA Working Group on Operating Experience

Problems or issues that arise from event reviews that may be applicable to other NPPs are identified and brought to the attention of CNSC site inspectors and different specialist groups in the CNSC.

CNSC staff members 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 audits 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 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.

The CNSC has published the following regulatory document specific to waste management:

- REGDOC-2.11, *Framework for Radioactive Waste Management and Decommissioning in Canada*

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.

Pursuant to paragraph 3(1)(j) of the GNSCR all licence applicants who perform waste management activities must provide the CNSC with the name, quantity, form, origin and volume of any radioactive waste or hazardous waste that may result from the activities to be licensed, including 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* specifies that an application for a licence to operate any Class I nuclear facility, including a predisposal waste management facility, shall 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.

As part of continuous improvement, the CNSC is in the process of developing the following regulatory documents:

- REGDOC-2.11.1, *Waste Management, Volume I: Management of Radioactive Waste*
- REGDOC-2.11.1, *Waste Management, Volume III: Assessing the Long-term Safety of Radioactive Waste Management*, version 2

Additionally, the CSA Group has published the following standards relevant to waste management activities:

- CSA N292.0, *General principles for the management of radioactive waste and irradiated fuel*
- CSA N292.1, *Wet storage of irradiated fuel and other radioactive materials*
- CSA N292.2, *Interim dry storage of irradiated fuel*
- CSA N292.3, *Management of low- and intermediate-level radioactive waste*
- CSA N292.5, *Guideline for the exemption or clearance from regulatory control of materials that contain, or potentially contain, nuclear substances*
- CSA N292.6, *Long-term management of radioactive waste and irradiated fuel*

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 and CSA N292.3. 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, which are reviewed by CNSC staff, 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, conditioning); storage; transport; and, disposal.

As radioactive waste disposal facilities are not yet available, primary emphasis is placed on: safe 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:
  - 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 reactor 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
Canadian Environmental Assessment Agency	ceaa-acee.gc.ca
Canadian Nuclear Laboratories	cnl.ca
Canadian Nuclear Safety Commission	nuclearsafety.gc.ca
Candu Energy Inc.	candu.com
CANDU Owners Group	www.candu.org
CANTEACH	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	hydroquebec.com
Institute of Nuclear Power Operations	inpo.info
International Atomic Energy Agency	iaea.org
Natural Resources Canada	nrcan.gc.ca
	SMRroadmap.ca/.
NB Power	nbpower.com
Ontario Power Generation	opg.com
Public Health Agency of Canada	phac-aspc.gc.ca

Document or organization	Web site
Public Safety Canada	publicsafety.gc.ca
SNC-Lavalin Nuclear	snclavalin.com/en/nuclear
University Network of Excellence in Nuclear Engineering	unene.ca
University of Ontario Institute of Technology	uoit.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
Failure of primary heat transport (PHT) pump seals Bruce A, Unit 3 and 4 August 2, 2017 and March 4, 2018	During a planned maintenance outage for Bruce A Unit 3, a leak developed on the gland seal system of the PHT system. This caused approximately 6,000 litres of heavy water to leak out of containment into a dyked area of the powerhouse, causing a tritium and loose contamination hazard in the area. The leak was caused by a rapid and unexpected failure of the primary and secondary seals and disaster bushing (tertiary seal). The direct cause of the seal failures was the hard contact between the pump shaft and the stationary seal components (a result of a design issue dating back to original construction).	Bruce Power conducted a root cause analysis and a gap analysis to identify gaps between Bruce Power practices and industry standards for inspection and risk assessment of large, rotating equipment. As a result of the root-cause analysis, Bruce Power implemented a design change has been implemented to eliminate the equipment root cause on all of the susceptible PHT pump seals at Bruce Power. The licensee addressed deficiencies in their vibration monitoring equipment and brought their vibration technology up to industry standards. A quarterly peer group meeting with rotating equipment owners, including predictive maintenance program owners has been established. Bruce Power also revised its maintenance procedures for PHT pump seal rebuilds, PHT seal installation and PHT pump motor installation.	CNSC staff performed a focused inspection on this incident, and increased the frequency of surveillance and monitoring in relation to this system and determined that the actions taken by Bruce Power to address the issue were appropriate and adequate
Darlington refurbishment	Two workers performing lidding operations of dry storage overpacks in	OPG is hiring staff to support oversight in radiation protection programs and for field	CNSC staff conducted a reactive inspection, leading to enforcement

[6] 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
Retube Waste Processing Building – internal contamination event February 5, 2018	the Retube Waste Processing Building (RWPB) had uptakes of contamination that resulted in recordable alpha doses which were below action levels defined by OPG in accordance with the RPR.	execution in response to a causal factor that indicated OPG's radiation protection coordinators (RPCs) were under-resourced, under pressure, and/or lacked adequate knowledge of RP fundamentals. It is also issuing a guidance document to clarify stop-work authority and escalation when workplace conditions warrant intervention. Finally, OPG is designing and implementing a "fundamental alignment" program to enhance knowledge and skills training of RPCs.	actions to address deficiencies of its alpha monitoring and control in the RWPB. CNSC site staff increased the frequency of walk-downs and field inspections to verify that controls and measures are in place and remain effective. On June 29, 2018 the CNSC issued a request (per subsection 12(2) of the *General Nuclear Safety and Control Regulations*) to OPG for further information to provide adequate assurance that current and future work in the RWPB and in the Darlington Unit 2 vault would proceed safely and take into account the lessons learned from the event. On November 29, 2018 the CNSC was informed of two contractors working on Unit 2 feeder replacement who had low levels of alpha particulate on their Personal Air Samplers (PAS). Following this identification, OPG identified seven more instances of PAS containing alpha emitters. The CNSC issued another 12(2) request to OPG to initiate a follow up dose assessment for all individuals whose PAS's showed positive results for alpha, as well as to conduct a self-assessment

Location/date[3]	Description	Corrective action by licensee	Regulatory action
			of its alpha dosimetry program. OPG confirmed that seven individuals submitted samples for analysis with one individual having a recordable alpha dose. OPG submitted a response to the December 13, 2018 12(2) request, including a dose assessment for this individual on March 29, 2019. CNSC staff reviewed OPG's submission and concurred with the alpha dose assigned to this individual. Both 12(2) requests have been satisfactorily addressed and are considered closed. CNSC staff are monitoring the implementation of OPG's changes to its alpha dosimetry program, including confirmatory in-vitro monitoring of workers. The CNSC revised the compliance plan for the refurbishment of Darlington Unit 3 to include additional compliance oversight activities of OPG's radiation protection program.
Transformer fire and mineral oil leak at Bruce B Unit 8 December 6,	During the Bruce B Unit 8 outage the Station Service Transformer caught fire. The automatic deluge fire suppression system was activated, the onsite fire brigade was deployed to the	Bruce Power promptly set-up a containment boundary to mitigate the impact to the environment from possible run-off of mineral oil. Bruce Power promptly began removing	The CNSC monitored Bruce Power's recovery activities and will assess Bruce Power's root cause investigation and corrective action plans in the next reporting period.

Location/date[3]	Description	Corrective action by licensee	Regulatory action
2018	scene and the fire was brought under control after several hours The transformer casing cracked and mineral oil, mixed with firefighting water and foam escaped from the retention basin around the transformer and onto the Bruce site.	mineral oil, water and foam from the site and monitoring the lake for impact. Bruce Power initiated a root cause investigation.	
Unplanned outages due to algae run Pickering July 22, 2018	From July 21 to July 22, 2018, Pickering was impacted by a large accumulation of algae on the screens (a mesh used to catch and remove debris in the cooling water intake). The algae was anticipated during this time of year; however, the volume of algae exceeded expectations and led to a rare shutdown of Units 5, 6, 7 and 8. Throughout this event the control of reactor power was maintained, fuel cooling in each core was maintained and containment was not challenged.	OPG harvested algae by a boat in the forebay to reduce loads on the screen house equipment. Units 5, 6, 7 and 8 were returned to service once the algae accumulation was over. To prevent the algae from overwhelming plant equipment in the future, the licensee is planning to install a bubbler wall (spring 2019) to help to keep algae out of the forebay. In addition, the licensee has worked with Massachusetts Institute of Technology to develop an app to better predict algae bloom development and movement based on criteria such as lake temperature and wind direction. The licensee can reduce the number of pumps operating based on the prediction of algae, which reduces the intake flow into the screen house so algae can be more easily collected.	CNSC staff monitored the progress of algae removal and verified that Pickering B units (Units 5, 6, 7 and 8) were restarted in a safe manner. CNSC staff continue to monitor the implementation of the bubbler wall and the effectiveness of the prediction app developed following the events in 2018.
Unplanned outage due to	On August 4, 2018, Pickering Unit 4 started to experience high condenser	This event was related to the earlier algae bloom event in late July, which led to	CNSC staff assessed the event. CNSC staff met with OPG and

Location/date[3]	Description	Corrective action by licensee	Regulatory action
condenser cooling backpressure Pickering August 4, 2018	backpressure due to a clogged condenser debris filter. The clogged filter coupled with a four degree Celsius increase in lake temperature reduced the effectiveness of the Unit 4 condenser. The high condenser back pressure alarm caused an automatic reactor set back to 87% of full power. Concurrently, operators manually tripped the turbine to account for the reduction of power. During the manual turbine trip, Unit 4 incurred a partial loss of Class IV power, due to a circuit breaker that failed to close during the transfer of class IV power to the system service transformer, which provides electrical power from the grid to the unit.	accumulation of debris on the condenser filter. OPG repaired the failed circuit breaker prior to Unit 4 returning to service.	reviewed OPG's description and sequence of events, its apparent cause, and the path forward. CNSC staff verified that Pickering Unit 4 was restarted in a safe manner.

Appendix D
Nuclear Research 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. The following subsections describe the key elements of R&D supporting NPPs in Canada, where the primary focus is on CANDU reactor design.

D.2 CANDU Owners Group research and development program

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

The COG R&D program is co-funded by domestic CANDU licensees, CNL, the Romanian Societatea Nationala Nuclearelectrica and the Korea Hydro and Nuclear Power Company, with current funding of about $40 million annually, benefitting from a stable multi-year commitment. COG also arranges other projects that are executed by the Electric Power Research Institute (EPRI) and other R&D contractors, which leverage another $15–20 million annually for R&D that supports NPPs in Canada.

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, research and development 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 is comprised of working groups and task teams covering containment, fuel and fuel channels, fuel normal operating conditions, reactor physics, thermalhydraulics and probabilistic risk assessment (PSA).

Health, safety and the environment

R&D on health, safety and the environment aims 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 the undertaking of 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., 60-90 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 & 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 CANDU existing and planned 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 AECL/CNL research and development program

AECL, through the Federal Nuclear Science and Technology (FNST) Work Plan, provides CNL with $76 million annually to perform nuclear-related Science & Technology research that supports core federal roles and responsibilities in the areas of energy, health protection, public safety, security and environmental protection, 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 oversees the FNST Work Plan through an Assistant Deputy Minister level steering committee. An integration committee, consisting of co-chairs from Health Canada, the CNSC, Defence Research & Development Canada, Natural Resources Canada and AECL, provides recommendations to the Steering Committee. The integration committee also oversees the five technical sub-committees, which serve to prioritize federal research needs within the following five theme areas:

1. supporting the development of biological applications and understanding the implications of radiation on living things
2. enhancing national and global security by supporting non-proliferation and counter-terrorism
3. supporting nuclear preparedness and emergency response
4. supporting safe, secure and responsible use and development of nuclear technologies
5. supporting environmental stewardship and radioactive management

D.4 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 CNSC's safety and control areas. These include:

- human performance management
- safety analysis
- physical design
- 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 & foreign governments. Examples include:

- UNENE
- IAEA
    - International Generic Ageing Lessons Learned
    - 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

- 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, most of which is allocated to NPP safety research.

D.5 Generation IV International Forum

Canada is a founding member of the Generation IV International Forum, which was initiated in 2001 with the signing of the Forum's Charter for the collaborative development of next generation nuclear energy systems that will provide safe and reliable energy in a competitively priced and sustainable way.

In 2005, Canada, along with four other countries, signed the Framework Agreement for International Collaboration on Research and Development of six Generation IV nuclear energy systems. This is a binding international treaty-level agreement that unites all participating countries in large-scale, multilateral research. As of 2019 ten countries plus Euratom are signatory to the Framework Agreement.

In 2006, NRCan established the Generation IV National Program to support Generation IV R&D specifically relevant to Canada and to meet Canada's commitments. It brought together government, industry and universities from across the country to participate in the multilateral development of advanced nuclear-based energy systems, with a focus on improving safety, reducing waste, lowering costs and increasing resistance to proliferation.

Of the six reactor systems endorsed by the Generation IV International Forum, Canada is focusing on the development of the supercritical water-cooled reactor system. The system is viewed as the most natural evolution of existing CANDU technology and best enables Canada to contribute to the R&D initiative by mobilizing existing Canadian CANDU expertise and research facilities.

Appendix E
Description and Results of the CNSC's Assessment and Rating System for Nuclear Power Plants

The CNSC's rating system, which assesses the performance of NPP licensees across the 14 CNSC safety and control areas (SCAs), consists of four categories:

FS	Fully satisfactory
SA	Satisfactory
BE	Below expectations
UA	Unacceptable

The definitions of these categories are as follows.

Fully Satisfactory	Compliance with regulatory requirements is fully satisfactory. Compliance within the area exceeds requirements and CNSC expectations. Compliance is stable or improving and any problems or issues that arise are promptly addressed.
Satisfactory	Compliance with regulatory requirements is satisfactory. Compliance within the area meets requirements and CNSC expectations. Any deviation is only minor and any issues are considered to pose a low risk to the achievement of regulatory objectives and CNSC expectations. Appropriate improvements are planned.
Below expectations	Compliance with regulatory requirements falls below expectations. Compliance within the area deviates from requirements or CNSC expectations, to the extent that there is a moderate risk of ultimate failure to comply. Improvements are required to address identified weaknesses. The licensee or applicant is taking appropriate corrective action.
Unacceptable	Compliance with regulatory requirements is unacceptable and is seriously compromised. Compliance within the overall area is significantly below requirements or CNSC expectations, or there is evidence of overall non-compliance. Without corrective action, there is a high probability that the deficiencies will lead to an unreasonable risk. Issues are not being addressed effectively, no appropriate corrective measures have been taken and no alternative plan of action has been provided. Immediate action is required.

The CNSC's annual assessment of NPPs

The CNSC prepares an annual staff report for the Commission and the public on all Canadian NPPs. The *Regulatory Oversight Report for Canadian Nuclear Power Plants* integrates information gathered through CNSC staff licensing and NPPs' compliance activities. The activities include:

- technical assessments (compliance technical assessments of licensees' management system documented information, such as policies, methods, procedures and records)

- Type I inspections (onsite assessments of the programmatic aspects of the management system's policies, methods, procedures and records)
- Type II inspections (onsite assessments of the outcomes of licensed activities)
- Desktop inspections

The report uses the rating system described on the previous page to summarize the SCA performance assessments and determine the integrated plant rating for each NPP. The integrated plant rating combines the ratings for the 14 SCAs to provide an overall safety assessment 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 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 CNSC SCA. Table E.2 compares the IAEA safety factors to the SCAs. Table E.3 shows the licensees' performance ratings during the reporting period. CNSC requirements and performance expectations in the 14 SCAs were met or exceeded at the NPPs for the three years of the reporting period.

Table E.1: CNSC functional areas, safety and control areas, and specific areas used to rate Canadian NPP performance

Functional area	Safety and control area	Specific area
Management	Management system	Management system
		Organization
		Performance assessment, improvement and management review
		Operating Experience (OPEX)
		Change management
		Safety culture
		Configuration management
		Records management
		Management of contractors
		Business continuity
	Human performance management	Human performance program
		Personnel training
		Personnel certification
		Initial certification examinations and requalification tests
		Work organization and job design
		Fitness for duty
	Operating performance	Conduct of licensed activities
		Procedures
		Reporting and trending
		Outage management performance
		Safe operating envelope

Functional area	Safety and control area	Specific area
		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
		Chemistry control
		Periodic inspections and testing
Core control processes	Radiation protection	Application of ALARA
		Worker dose control
		Radiation protection program performance
		Radiological hazard control
		Estimated dose to public
	Conventional health and safety	Performance
		Practices
		Awareness
	Environmental protection	Effluent and emissions control (releases)
		Environmental management system (EMS)
		Assessment and monitoring
		Protection of the public
		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

Functional area	Safety and control area	Specific area
		Decommissioning plans
	Security	Facilities and equipment
		Response arrangements
		Security practices
		Drills and exercises
	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 safety and control areas

IAEA safety factor	Related CNSC safety and control areas
Plant design	Management system, operating performance, safety analysis, physical design, fitness for service, radiation protection, conventional health 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

IAEA safety factor	Related CNSC safety and control areas
	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.*

Table E.3: Performance ratings of safety and control areas for NPPs, 2016–2018

Safety and control area	Bruce A			Bruce B			Darlington			Pickering			Gentilly-2			Point Lepreau		
	'16	'17	'18	'16	'17	'18	'16	'17	'18	'16	'17	'18	'16	'17	'18	'16	'17	'18
Management system	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA
Human performance management	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA
Operating performance	FS	FS	FS	FS	FS	FS	FS	FS	FS	FS	FS	FS	SA	SA	SA	SA	SA	FS
Safety analysis	FS	FS	FS	FS	FS	FS	FS	FS	FS	FS	FS	FS	SA	SA	SA	FS	FS	FS
Physical design	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA
Fitness for service	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA
Radiation protection	FS	FS	FS	FS	FS	FS	FS	SA	SA	SA	SA	FS	SA	SA	SA	SA	SA	SA
Conventional health and safety	FS	FS	FS	SA	SA	FS	SA	FS	FS	SA	FS	FS	SA	SA	SA	FS	FS	FS
Environmental protection	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA
Emergency management and fire protection	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA
Waste management	FS	FS	SA	FS	FS	SA	FS	FS	SA	FS	FS	SA	SA	SA	SA	SA	SA	SA
Packaging and transport	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA
Integrated plant rating	FS	FS	*	SA	SA	*	FS	FS	*	FS	FS	*	SA	SA	*	SA	SA	*

Legend: FS = Fully satisfactory
SA = Satisfactory

Note: Ratings for the **Security** and **Safeguards and non-proliferation** SCAs have been omitted from this table as they are outside the scope of the *Convention on Nuclear Safety*.

* - The Integrated Plant Rating was discontinued in 2018

ANNEXES

Annex 7.2 (i) (a)
CNSC Regulation-making Process

Under section 44 of the NSCA, the Commission may make regulations with the approval of the Governor in Council.

When making or amending regulations, the CNSC must abide by the Government of Canada's regulatory policy *Cabinet Directive on Regulation* (CDR), which came into effect in 2018. This directive updated and replaced the *Cabinet Directive on Regulatory Management* (2012).

The CNSC starts a regulation making or amendment process with regulatory policy analysis where 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 which explain to legal drafters what the CNSC wishes the regulations to contain. These are provided to the Department of Justice.

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 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 or on Canada's foreign affairs
- degree of interest, contention and support among affected parties
- impacts on Indigenous groups and modern treaty implications

Draft regulations undergo a series of internal CNSC and Natural Resources Canada approvals before being presented to the Minister of Natural Resources who 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* that 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 its 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 recommends 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 referred to as “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, the CNSC staff apply lessons learned from industry operating experience and from international standards and guides, such as those published by the IAEA (see table for details). Requirements and guidance for NPPs are technology-neutral and performance-based where practicable, take a risk-informed approach, and apply to small modular reactors 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 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 (formerly the Canadian Standards Association) that are relevant to reactor facilities (NPPs and small reactors). 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 nuclear standards may be viewed through the CNSC website or on the CSA 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 regulatory documents (REGDOCs) and CSA standards listed in table 1 are in the process of being incorporated into LCHs upon licence renewal. The table shows which CNSC regulatory documents and CSA standards are part of the licensing basis for currently licensed NPPs as of the end of the reporting period. Other documents in the table are typically 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. Table 1 also lists the IAEA standards that were used in the development of the CNSC regulatory documents and CSA Group standards.

Regulatory framework developments for small modular reactors

Over the past several years, a number of technology developers have expressed interest in the possible deployment of small modular reactors (SMRs) in Canada. During the reporting period, CNSC continued efforts to ensure that the regulatory framework would be suitable for any potential 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.

The CNSC published discussion paper DIS-16-04, *Small Modular Reactors: Regulatory Strategy, Approaches and Challenges*, in May 2016. The document examines key areas with potential licensing challenges. In some cases, the CNSC confirmed that its requirements are valid and useful. In other areas, it concluded that the implications of the proposed innovative approaches need to be examined further to confirm the level of applicability of existing requirements and guidance – and the extent to which different requirements or guidance are needed.

The following list of topics were covered in DIS-16-04 (although the paper also prompted discussion on other issues):

- technical information, including research and development activities used to support a safety case
- licensing process for multiple module facilities on a single site
- licensing approach for a new demonstration reactor
- licensing process and environmental assessments for fleets of SMRs
- management system considerations
    - e.g., SMR applicants may operate or be managed quite differently than current NPP licensees
- safeguards verification
- deterministic/probabilistic safety analyses
- defence in depth and mitigation of accidents
- emergency planning zones
- transportable reactor concepts
- increased use of automation for plant operation and maintenance
- human/machine interfaces in facility operation
- impact of new technologies on human performance
- financial guarantees for operational continuity
- site security provisions
- waste management and decommissioning
- subsurface civil structures important to safety

The CNSC followed up on DIS-16-04 through the accompanying What We Heard Report published in September 2017. Some central themes identified in this report, which CNSC is considering through regulatory framework improvements, include:

- Greater clarity on application of the graded approach
    - The CNSC hosted a workshop on the Application of the Graded Approach in Regulating Small Modular Reactors in November 2017. The Stakeholder Workshop report summarized the activities of the workshop; overall, the concepts and approach were well understood by stakeholders, and proponents are aware of the type of info they need to provide to support their safety cases, in particular, when proposing novel approaches in reactor designs.
    - Vendor design review activities (including vendor comments) are indicating that the design and safety analysis requirements and guidance can be applied as-is to new

  technologies; case studies from completed vendor pre-project design reviews are used to identify specific areas where potential clarifications to existing requirements and guidance may be needed to inform the adequacy of CNSC's regulatory framework to accommodate novel technologies.
  - There is ongoing work on the application of the graded approach and development of more agile, technology-neutral and flexible nuclear security regulation in Canada, while ensuring the scope of regulation remains unchanged and international obligations continue to be fulfilled.
- Greater clarity on licensing of SMRs
  - The CNSC is committed to engaging with stakeholders who plan to submit applications for SMRs.
  - Pre-licensing engagement can be used to understand the specific objectives of a "first–of-a-kind" or demonstration reactor and how the application process could proceed in light of these objectives.

CNSC regulatory documents 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 communicate CNSC expectations with regards to the licensing of activities related to new reactor facilities.

Additionally, the CNSC is developing REGDOC-1.1.5. Licence Application Guide: Supplemental Information for Small Modular Reactor Proponents. This document is intended 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 standards related to NPPs

Doc Number[7]	Document title	Status[8]	Associated IAEA document used to develop
Regulated facilities and activities			
Reactor facilities			
REGDOC-1.1.1	*Licence to Prepare Site and Site Evaluation for New Reactor Facilities* (2018)		• Safety Series No. GS-R-3 • Safety Guide No. WS-G-2.3 • Nuclear Security Series 17 • Safety Standards Series No. NS-R-3 • 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. NS-G-3.1 • Safety Series No. GS-G-3.5 • Safety Guide No. RS-G-1.8 • Safety Standards Series No. GS-R-2 • TECDOC-1657
RD/GD-369	*Licence Application Guide: Licence to Construct a Nuclear Power Plant* (2014)		• GS-G-4.1, Format and Content of Safety Analysis Reports
			•
			•
REGDOC-1.1.3	*Licence Application Guide: Licence to Operate a Nuclear Power Plant* (2017)		GS-G-4.1, Format and Content of Safety Analysis Reports
Nuclear substances and radiation devices			

[7] 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 had numbers with abbreviations such as RD (regulatory document), GD (guidance document), G (guidance), P (policy), EG (examination guide), S (standard), C (consultative), and R (requirement). 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.

[8] Status refers to the inclusion of the document in the licensing basis for one or more operating licences as a regulatory requirement for existing NPPs.

Doc Number[7]	Document title	Status[8]	Associated IAEA document used to develop
REGDOC-1.6.1	*Licence Application Guide: Nuclear Substances and Radiation Devices (2015)*		• Safety Guide No. RS-G-1.9
Safety and control areas			
Management system			
REGDOC-2.1.1	*Management System* (2019)		
REGDOC-2.1.2	*Safety Culture* (2018)		
N286-12	*Management system requirements for nuclear facilities* (2012)	x	• Safety Reports Series No. 42 • Safety Standard Series No. GS-R-3 • Safety Standard Series No. GS-G-3.1 • Safety Standard Series No. NS-G-2.9 • Safety Standard Series No. NS-R-2 • Safety Standard Series No. NS-R-3 • Safety Series No. 75-INSAG-3 Rev.1 • Safety Series No. 75-INSAG-4 • TECDOC-1101 • TECDOC-1491
N286-05	*Management system requirements for nuclear power plants* (2005)		
N286.0.1	*Commentary on N286-12, Management system requirements for nuclear facilities* (2014)		
N286.7	*Quality assurance of analytical, scientific and design computer programs for nuclear power plants* (2016)	x	
N286.7.1	*Guideline for the application of N286.7-99* (2009)		• Safety Series No. 50-C/SG-Q
N286.10	*Configuration management for reactor facilities*		• INSAG-19 • TECDOC-1335 • Safety Series No. 65
N299 series	*Series of standards on quality assurance program requirements for the supply of items and services for nuclear power plants* (drafts)		• INSAG-15 • Safety Standard Series No. GS-G-3.5 • TECDOC-1329
Human performance management			
REGDOC-2.2.1	*Human Factors*		
REGDOC-2.2.2	*Personnel Training*, Version 2 (2016)	x	• TECDOC-1057
REGDOC-2.2.3	*Personnel Certification: Initial Certification*		

Doc Number[7]	Document title	Status[8]	Associated IAEA document used to develop
	Examinations (draft)		
REGDOC-2.2.3	*Personnel Certification: Radiation Safety Officers* (2014)		
	Requirements for the Requalification Testing of Certified Shift Personnel at Canadian Nuclear Power Plants, Revision 2 (2009)	x	
REGDOC-2.2.4	*Fitness for Duty: Managing Worker Fatigue* (2017)	x	
REGDOC-2.2.4	*Fitness for Duty, Volume II: Managing Alcohol and Drug Use* (2017)	x	
REGDOC-2.2.4	*Fitness for Duty, Volume III: Nuclear Security Officer Medical, Physical and Psychological Fitness* (2018)		
RD-204	*Certification of Persons Working at Nuclear Power Plants* (2008)	x	• Safety Guide No. NS-G-2.4 • Safety Guide No. NS-G-2.8
RD-363	*Nuclear Security Officer Medical, Physical, and Psychological Fitness* (2007)	x	• Safety Standards Series NS-G-2.8
REGDOC-2.2.5	*Minimum Staff Complement*		
G-323	*Ensuring Presence of Sufficient Qualified Staff at Class I Nuclear Facilities: Minimum Staff Complement* (2007)		
P-119	*Policy on Human Factors* (2000)		
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)	x	
REGDOC-2.3.2	*Severe Accident Management Programs for Nuclear Reactors* (2013)	x	• 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

Doc Number[7]	Document title	Status[8]	Associated IAEA document used to develop
			• Safety Requirements No. SSR-2/2 • Safety Fundamentals No. SF-1 • INSAG-10 • INSAG-12, 75-INSAG-3 Rev. 1 • TECDOC-1440 • INSAG-10
REGDOC-2.3.3	*Periodic Safety Reviews* (2015)	x	• Specific Safety Guide No. SSG-25 • Safety Fundamentals No. SF-1 • Safety Reports series No. 57 • Safety Guide NS-G-2.12 • Safety Guide NS-G-2.6 • INSAG-12, 75-INSAG-3 Rev.1
EG-1	*Requirements and Guidelines for Written and Oral Certification Examinations for Shift Personnel at Nuclear Power Plants* (2005)	x	
EG-2	*Requirements and Guidelines for Simulator-Based Certification Examinations for Shift Personnel at Nuclear Power Plants* (2004)	x	
RD-360	*Life Extension of Nuclear Power Plants*(2008)	x	• Safety Standards Series No. NS-G-2.10
N290.15	*Requirements for the safe operating envelope of nuclear power plants* (2010)	x	
Safety analysis			
REGDOC-2.4.1	*Deterministic Safety Analysis* (2014)	x	• 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)	x	• Safety Standard SSG-3 • Safety Standard SSG-4 • INSAG-10
REGDOC-2.4.3	*Nuclear Criticality Safety* (2018)		

Doc Number[7]	Document title	Status[8]	Associated IAEA document used to develop
RD-310	*Safety Analysis for Nuclear Power Plants* (2008)	x	
RD-327	*Nuclear Criticality Safety* (2010)	x	• Safety Standards No. SSG-5 • Safety Standards No. NS-R-5 • Safety Standards No. SSG-6 • Safety Standards No. GS-R-2
GD-327	*Guidance for Nuclear Criticality Safety* (2010)		
S-294	*Probabilistic Safety Assessment (PSA) for Nuclear Power Plants* (2005)	x	• Safety Series No. 50-P-4 • Safety Series No. 50-P-8
G-144	*Trip Parameter Acceptance Criteria for the Safety Analysis of CANDU Nuclear Power Plants* (2006)		
G-149	*Computer Programs Used in Design and Safety Analyses of Nuclear Power Plants and Research Reactors* (2000)		
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 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*		•
REGDOC-2.5.2	*Design of Reactor Facilities: Nuclear Power Plants* (2014)		• Specific Safety Requirements SSR-2/1 • Safety Guide NS-G-2.15 • INSAG-10 • Safety Guide NS-G-2.2 • Safety Series No. 50-P-1 • Safety Reports Series No. 46 • Safety Guide NS-G-2.9 • Nuclear Security Series No. 17 • Safety Guide NS-G-2.5 • Safety Guide WS-G-2.1 • Safety Guide NS-G-1.8

Doc Number[7]	Document title	Status[8]	Associated IAEA document used to develop
			• Safety Guide NS-G-1.4 • TECDOC-1657 • Safety Guide NS-G-1.10 • Safety Guide NS-G-1.9 • Safety Guide NS-G-1.12 • Safety Standards No. SSG-2 • Safety Standards No. SSG-3 • Safety Standards No. SSG-4 • Safety Reports Series No. 3 • Safety Guide NS-G-1.5 • Safety Guide NS-G-3.1 • Safety Standards No. SSG-9 • Safety Guide NS-G-2.1 • Safety Guide NS-G-3.5 • TECDOC-967, Rev.1 • TECDOC-1276 • Safety Series No. 50-P-10 • Safety Guide NS-G-1.3 • INSAG-19 • Safety Guide NS-G-2.6 • Safety Requirements No. GS-R-3 • Safety Requirements No. GS-G-3.5 • Safety Requirements No. GS-G-3.3 • Safety Guide NS-G-3.4 • Safety Standards No. SSG-18 • INFCIRC-225, Rev.5 (draft) • Safety Guide No. RS-G-1.1 • Safety Report Series No. 8 • Safety Requirements No.GS-R-2 • Safety Guide NS-G-1.7 • Safety Guide NS-G-1.11 • Safety Guide NS-G-1.13 • Safety Reports Series No. 25 • Safety Guide NS-G-1.2 • General Safety Requirements Part 4

Doc Number[7]	Document title	Status[8]	Associated IAEA document used to develop
			• Safety Series No. 110 • Specific Safety Requirements SSR-2/2 • Safety Guide NS-G-1.6 • Specific Safety Guide SSG-9 • Safety Guide NS-G-1.1 • Safety Guide NS-G-2.11 • Safety Series No. 50-P-7
REGDOC-2.5.7	*Design, Testing and Performance of Exposure Devices* (2017)		
RD-367	*Design of Small Reactor Facilities* (2011)		As REGDOC-2.5.2 above
G-276	*Human Factors Engineering Program Plans* (2003)		
G-278	*Human Factors Verification and Validation Plans* (2003)		
Pressure-retaining systems and components			
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)	x	
Concrete containment structures			
N287.1	*General requirements for concrete containment structures for nuclear power plans* (2014)		
N287.2	*Material requirements for concrete containment structures for CANDU nuclear power plants* (2008)		
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 CANDU nuclear power plants* (2009)		
N287.5	*Examination and testing requirements for concrete containment structures for nuclear*		

Doc Number[7]	**Document title**	**Status**[8]	**Associated IAEA document used to develop**
	power plants (2011)		
N287.6	*Pre-operational proof and leakage rate testing requirements for concrete containment structures for nuclear power plants* (2011)		
N291-15	*Requirements for safety-related structures for nuclear power plants* (2015)	x	
N291-08	*Requirements for safety-related structures for CANDU nuclear power plants* (2008)	x	
Seismic design and qualifications			
N289.1	*General requirements for seismic design and qualification of CANDU nuclear power plants* (2008)	x	• Safety Standards Series No. NS-G-1.6 • Safety Standards Series No. NS-G-2.10
N289.2	*Ground motion determination for seismic qualification of nuclear power plants* (2010)	x	• Draft Specific Safety Guide DS405 • Safety Standards Series No. NS-G-1.5 • Safety Standards Series No. NS-G-3.3 • Safety Standards Series No. NS-G-3.6
N289.3	*Design procedures for seismic qualification of nuclear power plants* (2010)	x	• Safety Standards Series No. NS-G-1.6 • Safety Standards Series No. NS-G-3.3 • Safety Standards Series No. NS-G-3.6
N289.4	*Testing procedures for seismic qualification of nuclear power plant structures, systems and components* (2012)	x	• Safety Guide No. NS-G-2.13
N289.5	*Seismic instrumentation requirements for nuclear power plants and nuclear facilities* (2012)	x	• Safety Report Draft, Rev.12
Special safety systems			
N290.0	*General requirements for safety systems of nuclear power plants (2011)*	x	
N290.1	*Requirements for the shutdown systems of nuclear power plants* (2013)		
N290.2	*Requirements for emergency core cooling systems of nuclear power plants* (2011)		
N290.3	*Requirements for the containment system of nuclear power plants* (2011)		
N290.4	*Requirements for reactor control systems of*		

Doc Number[7]	Document title	Status[8]	Associated IAEA document used to develop
	nuclear power plants (2011)		
N290.5	*Requirements for electrical power and instrument air systems of CANDU nuclear power plants* (2011)		
N290.6	*Requirements for monitoring and display of nuclear power plant safety functions in the event of an accident* (2009)		
N290.11	*Requirements for reactor heat removal capability during outage of nuclear power plants* (2013)		
N290.14-15	*Qualification of digital hardware and software for use in instrumentation and control applications for nuclear power plants* (2015)	x	
N290.14-07	*Qualification of pre-developed software for use in safety-related instrumentation and control applications in nuclear power plants* (2007)		
N290.16	*Requirements for beyond design basis accidents* (2016)		• INSAG-10 • Nuclear Energy Series No. NW-T-2.7 • Safety Series No. 98
Design governance			
N290.12	*Human factors in design for nuclear power plants* (2014)	**x**	
Fitness for service			
REGDOC-2.6.1	*Reliability Programs for Nuclear Power Plants* (2017)	x	•
REGDOC-2.6.2	*Maintenance Programs for Nuclear Power Plants* (2017)	x	•
REGDOC-2.6.3	*Aging Management (2014)*	x	• Safety Guide No. NS-G-2.12 • Safety Report Series No. 82 • Safety Report Series No. 57 • Specific Safety Guide SSG-25 • Safety Guide NS-G-2.6 • Safety Guide NS-G-2.4 • Safety Requirements NS-R-2 • Safety Report Series No. 3 • Safety Report Series No. 62

Doc Number[7]	Document title	Status[8]	Associated IAEA document used to develop
			• TECDOC-1197 • TECDOC-1188 • TECDOC-1025 • TECDOC-981 • Safety Report Series No. 15
RD/GD-98	*Reliability Programs for Nuclear Power Plants* (2012)	x	• TECDOC-524
RD/GD-210	*Maintenance Programs for Nuclear Power Plants* (2012)	x	• TECDOC-658 • Safety Standards Series No. NS-G-2.6
S-98, Rev.1	*Reliability Programs for Nuclear Power Plants* (2005)	x	
S-210	*Maintenance Programs for Nuclear Power Plants* (2007)	x	• Safety Reports Series No. 42 • Safety Series No. 110 • Safety Standards Series No. NS-R-2 • Standards Series NS-G-2.6 • Safety Standards Series No. 50-SG-07
N285.4-05	*Periodic inspection of CANDU nuclear power plant components* (2005)	x	
N285.4-14	*Periodic inspection of CANDU nuclear power plant components* (2014)		
N285.5	*Periodic inspection of CANDU nuclear power plant containment components* (2008)	x	
N285.7	*Periodic inspection of CANDU nuclear power plant balance of plant systems and components* (2015)	x	• TECDOC-1511
N285.8	*Technical requirements for in-service evaluation of zirconium alloy pressure tubes in CANDU reactors* (2010)	x	
N287.2	*Material requirements for concrete containment structures for CANDU nuclear power plants* (2008)		
N287.7	*In-service examination and testing requirements for concrete containment structures for CANDU nuclear power plants* (2008)	x	

Doc Number[7]	Document title	Status[8]	Associated IAEA document used to develop
N287.8	*Aging management for concrete containment structures for nuclear power plants* (2015)		• Safety Report Series No. 57 • Safety Standards Series No. NS-G-2.12 • TECDOC-1025 • Safety Standards Series No. NS-G-2.6 • TECDOC-1503 • TECDOC-1736 • Technical Reports Series No. 338 • Safety Report Series No. 15 • Safety Series No. 50-P-3 • Safety Report Series No. 82
N290.8	*Technical specification requirements for nuclear power plant components* (2015)		
N290.13	*Environmental qualification of equipment for CANDU nuclear power plants* (2005)	x	
Radiation protection			
REGDOC-2.7.3	*Radiation Protection: Guidelines for the Safe Handling of Decedents* (2018)		
RD-58	*Thyroid Screening for Radioiodine* (2008)		
G-91	*Ascertaining and Recording Radiation Doses to Individuals* (2003)		
G-147	*Radiobioassay Protocols for Responding to Abnormal Intakes of Radionuclides* (2003)		
GD-150	*Designing and Implementing a Bioassay Program* (2010)		
G-129, Rev.1	*Keeping Radiation Exposures and Doses "As Low as Reasonably Achievable (ALARA)"* (2004)		• Safety Series No. 21 • Safety Series No. 102 • Safety Series No. 103
G-228	*Developing and Using Action Levels* (2001)		
Conventional health and safety			
	No applicable CNSC regulatory documents		
Z1000	Occupational health and safety management		
N286	Management system requirements for nuclear facilities		
Environmental protection			

Doc Number[7]	Document title	Status[8]	Associated IAEA document used to develop
REGDOC-2.9.1	*Environmental Protection Policies, Programs and Procedures* (2013)	x	
REGDOC-2.9.1	*Environmental Protection: Environmental Principles, Assessments and Protection Measures*, version 1.1 (2017)	x	
S-296	*Environmental Protection Policies, Programs and Procedures at Class I Nuclear Facilities and Uranium Mines and Mills* (2006)	x	
G-296	*Developing Environmental Protection Policies, Programs and Procedures at Class I Nuclear Facilities and Uranium Mines and Mills* (2006)	x	
N288.1	*Guidelines for calculating derived release limits for radioactive material in airborne and liquid effluents for normal operation of nuclear facilities* (2008)	x	• 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
N288.2-14	*Guidelines for calculating the radiological consequences to the public of a release of airborne radioactive material for nuclear reactor accidents* (2014)		• Safety Guide No. NS-G-3.2 • Safety Guide No. 50-P-12 • Safety Guide No. GS-G-2.1 • Safety Guide No. GSG-2 • Safety Guide No. GS-R-2 • TECDOC-955 • TECDOC-1200
N288.2-M91 (R2008)	*Guidelines for calculating radiation doses to the public from a release of airborne radioactive material under hypothetical accident conditions in nuclear reactors* (2008)		• Safety Guide Series No. 50-SG-S3
N288.3.4	*Performance testing of nuclear air-cleaning systems at nuclear facilities* (2013)		
N288.4	*Environmental monitoring programs at Class I nuclear facilities and uranium mines and mills* (2010)	x	
N288.4-10	*Environmental monitoring programs at Class I*	x	

Doc Number[7]	Document title	Status[8]	Associated IAEA document used to develop
(R2015)	*nuclear facilities and uranium mines and mills* (2015)		
N288.5	*Effluent monitoring programs at Class I nuclear facilities and uranium mines and mills facilities* (2011)	x	
N288.6	*Environmental risk assessments at class I nuclear facilities and uranium mines and mills* (2012)	x	• Safety Reports Series No. 21 • Technical Reports Series No. 332 • Technical Reports Series No. 472
N288.7	*Groundwater protection programs at Class I nuclear facilities and uranium mines and mills* (2015)	x	• Safety Guide No. WS-G-1.2
N288.8	*Establishing and implementing action levels to control releases to the environment from nuclear facilities* (2017)		
Emergency management and fire protection			
REGDOC-2.10.1	*Nuclear Emergency Preparedness and Response* (2014)	x	
REGDOC-2.10.1	*Nuclear Emergency Preparedness and Response, Version 2* (2017)		• Safety Standards Series GS-R-2 • Safety Standards Series GS-G-2.1
RD-353	*Testing the Implementation of Emergency Measures* (2008)	x	• Safety Series No. 73 • Safety Standards Series No. GS-R-2
N293-07	*Fire protection for CANDU nuclear power plants* (2007)	x	• INSAG Series No. 10 • INSAG Series No. 12 • Safety Reports Series No. 10 • Safety Reports Series No. 46 • Safety Series No. 50-P-9 • Safety Standards Series No. NS-G-1.7 • Safety Standards Series No. NS-G-2.1
N293-12	*Fire protection for nuclear power plants* (2012)	x	• Same as for N293-07 (above), but not including Safety Series No. 50-P-9
N393	*Fire protection for facilities that process, handle, or store nuclear substances* (2013)		
N1600	*General requirements for nuclear emergency management programs* (2014)		• Safety Guide GS-G-2 • Safety Guide GS-G-2.1

Doc Number[7]	Document title	Status[8]	Associated IAEA document used to develop
			• Safety Standards Series No. GS-R-2 • General Safety Requirements GSR Part 7
Waste management			
REGDOC-2.11	*Framework for Radioactive Waste Management and Decommissioning in Canada* (2018)		
REGDOC-2.11.1	*Waste Management, Volume III: Assessing the Long-Term Safety of Radioactive Waste Management* (2018)		
G-219	*Decommissioning Planning for Licensed Activities* (2000)		
N292.0	*General principles for the management of radioactive waste and irradiated fuel* (2014)		• INFCIRC/164 • INFCIRC/225/Rev.5 • Safety Requirements No. TS-R-1 • Safety Guide No. SSG-15 • Safety Standards Series No. GS-R-2 • TECDOC-1325 • General Safety Guide No. GSG-1 • Safety Fundamentals No. SF-1 • Safety Guide No. GS-G-3.3 • Safety Guide No. GS-G-3.4 • Safety Guide No. WS-G-2.5 • Safety Reports Series No. 34 • Safety Reports Series No. 35 • Safety Series No. 111-F • Safety Series No. 115 • Safety Standards Series No. NS-G-2.7 • Safety Standards Series No. RS-G-1.7 • Safety Standards Series No. RS-G-1.9 • Safety Standards Series No. WS-G-2.7 • Safety Standards Series No. WS-G-6.1 • Safety Standards Series No. WS-R-2 • TECDOC-1222 • TECDOC-1256 • TECDOC-1282

Doc Number[7]	Document title	Status[8]	Associated IAEA document used to develop
			• TECDOC-1372 • TECDOC-1398 • TECDOC-1504 • Technical Reports Series No. 402 • Technical Reports Series No. 421 • Technical Reports Series No. 427 • Technical Reports Series No. 434 • Technical Reports Series No. 441
N292.1	*Wet storage of irradiated fuel and other radioactive materials* (2016)		• General Safety Guide No. GSG-3 • INFCIRC/225/Rev.5 • Safety Fundamentals No. SF-1 • Safety Guide No. GS-G-4.1 • Safety Reports Series No. 55 • Safety Standards Series No. GSR Part 5 • Safety Standards Series No. GS-R-2 • Specific Safety Guide No. SSG-3 • Specific Safety Guide No. SSG-8 • Specific Safety Guide No. SSG-9 • Specific Safety Guide No. SSG-15 • Specific Safety Guide No. SSG-25 • Specific Safety Guide No. SSG-31 • TECDOC-1267
N292.2	*Interim dry storage of irradiated fuel* (2013)		• INFCIRC/164 • INFCIRC/164/Add.1 • Safety Standards Series No. GS-R-2
N292.3	*Management of low- and intermediate-level radioactive waste* (2008)	x	• INFCIRC/164 • Safety Guide No. DS 390 (draft) • Safety Series No. 111-G-1.1 • Safety Standards Series No. GS-R-2 • Safety Fundamentals No. SF-1 • Safety Reports Series No. 34 • Safety Reports Series No. 35 • Safety Series No. 111-F • Safety Series No. 115

Doc Number[7]	Document title	Status[8]	Associated IAEA document used to develop
			• Safety Standards Series No. NS-G-2.7 • Safety Standards Series No. RS-G-1.7 • Safety Standards Series No. RS-G-1.9 • Safety Standards Series No. WS-G-2.5 • Safety Standards Series No. WS-G-2.7 • Safety Standards Series No. WS-G-6.1 • Safety Standards Series No. WS-R-2 • TECDOC-1222 • TECDOC-1256 • TECDOC-1282 • TECDOC-1325 • TECDOC-1372 • TECDOC-1397 • TECDOC-1398 • TECDOC-1504 • Technical Reports Series No. 402 • Technical Reports Series No. 412 • Technical Reports Series No. 421 • Technical Reports Series No. 427 • Technical Reports Series No. 434 • Technical Reports Series No. 441
N292.5	*Guideline for the exemption or clearance from regulatory control of materials that contain, or potentially contain, nuclear substances* (2011)		• Safety Guide No. RS-G-1.7 • Safety Reports Series No. 44 • Safety Series No. 115
N294	*Decommissioning of facilities containing nuclear substances* (2009)	x	• TECDOC-1476 • Safety Guide WS-G-5.1 • Technical Report Series No. 420
Security			
REGDOC-2.12.1	*High Security Facilities, Volume I: Nuclear Response Force, Version 2* (2018)		
REGDOC-2.12.1	*High Security Facilities, Volume II: Criteria for Nuclear Security Systems and Device* (2018)		
REGDOC-2.12.1	*High-Security Facilities, Volume I: Nuclear Response Force* (2013)	x	

Doc Number[7]	Document title	Status[8]	Associated IAEA document used to develop
REGDOC-2.12.2	*Site Access Security Clearance* (2013)	x	• Nuclear Security Series No. 8
REGDOC-2.12.3	*Security of Nuclear Substances: Sealed Sources* (2013)	x	• Safety Guide RS-G-1.9 • TECDOC-1344 • Safety Standards No. TS-R-1 • TECDOC-1355 • Nuclear Security Series No. 7 • INFCIRC/225/Rev.5 (draft) • INFCIRC/663 • TECDOC-953 • Nuclear Security Series No. 9 • Nuclear Security Series No. 11 • Nuclear Security Series No. 14 • TECDOC-1276 • Safety Standards No. SSG-5
RD-321	*Criteria for Physical Protection Systems and Devices at High Security Sites* (2010)	x	
RD-361	*Criteria for Explosive Substance Detection, X-Ray Imaging, and Metal Detection at High Security Sites* (2010)	x	
S-298	*Nuclear Response Force* (2003)	x	
G-208	*Transportation Security Plans for Category I, II or III Nuclear Material* (2003)		
G-274	*Security Programs for Category I or II Nuclear Material or Certain Nuclear Facilities* (2003)		
N290.7	*Cyber security for nuclear power plants and small reactor facilities* (2014)	x	
Safeguards and non-proliferation			
REGDOC-2.13.1	*Safeguards and Nuclear Material Accountancy* (2018)	x	
REGDOC-2.13.2	*Import and Export* (2018)		
RD-336	*Accounting and Reporting of Nuclear Material* (2010)	x	• INFCIRC/164
GD-336	*Guidance for Accounting and Reporting of Nuclear Material* (2010)		

Doc Number[7]	Document title	Status[8]	Associated IAEA document used to develop
Packaging and transport			
REGDOC-2.14.1	*Information Incorporated by Reference in Canada's Packaging and Transport of Nuclear Substances Regulations, 2015* (2016)		
REGDOC-2.14.1	*Volume II: Radiation Protection Program Design for the Transport of Nuclear Substances*		
Other regulatory areas			
Reporting requirements			
REGDOC-3.1.1	*Reporting Requirements for Nuclear Power Plants*, Version 2 (2016)	x	• Safety Standards Series SF-1
Public and Aboriginal engagement			
REGDOC-3.2.1	*Public Information and Disclosure* (2018)		
RD/GD-99.3	*Public Information and Disclosure* (2012)	x	
REGDOC-3.2.2	*Aboriginal Engagement* (2016)		
Financial guarantees			
G-206	*Financial Guarantees for the Decommissioning of Licensed Activities* (2000)		
CNSC processes and practices			
REGDOC-3.5.1	*Licensing Process for Class I Nuclear Facilities and Uranium Mines and Mills*, Version 2 (2017)		
REGDOC-3.5.2	*Administrative Monetary Penalties, Version 2* (2015)		
REGDOC-3.5.3	*Regulatory Fundamentals* (2018)		
REGDOC-3.5.4	*Pre-licensing Review of a Vendor's Reactor Design* (2018)		
REGDOC-3.5.3	*Regulatory Fundamentals* (2018)		
P-211	*Compliance* (2001)		
P-242	*Considering Cost-Benefits Information* (2000)		

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 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 9 (c)
Public Information Programs of NPP Licensees

The availability and clarity of information pertaining to nuclear activities is essential to establishing an atmosphere of openness, transparency and trust between the licensee and the public.

The primary goal of a licensee's public information and disclosure program, as it relates to the licensed activities, 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 groups.

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., incidents, major changes to operations, periodic environmental performance reports) and timelines for sharing that information.

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, each licensee works to keep all of their target audiences informed of current and future operations, emergency preparedness measures and their commitment to safety, security and the environment.

During the reporting period, New Brunswick Power, Bruce Power and OPG (Pickering) requested power reactor operating licence renewals. As such, specific licence renewal information packages, including operational and scientific information were communicated with the public and target audiences.

In advance of each Commission hearing for the licence renewal, each licensee consulted the public, their stakeholders, their target audiences and Indigenous groups through various methods previously determined as meaningful to their audiences. Topics of discussion included licence requirements (such as those related to environment, safety and security), periodic safety reviews, waste management, *Fisheries Act* authorization information, Indigenous engagement and environmental risk assessments. In parallel, CNSC staff completed a full review of each public information program and hosted independent engagement sessions to provide audience-specific public information to impacted communities associated with each licence renewal. In turn, members of the public and target audiences had the opportunity to meet directly with the CNSC.

The public information and disclosure programs of Canadian 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 in the region
- advertising in local newspapers
- regular updates provided to local politicians at the municipal, provincial and federal levels
- 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 by OPG during the reporting period are described below.

During the reporting period, Bruce Power:

- conducted a series of 5 open houses and 6 webinars to inform the public on licence renewal activities and how the public could participate in the process
- consulted with Indigenous groups 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 the Bruce Power site summer bus tour program for visitors
- 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 Colbalt-60 at Bruce Power for the use in sterilizing medical equipment and cancer treatment

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 which 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 communities regarding Darlington operations, environmental reporting and projects (refurbishment updates, Darlington new nuclear mid-term report,) as well as OPG's Indigenous Opportunities in Nuclear (ION) 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, with tens of thousands of visitors annually to its website and more than 11,000 Twitter followers, more than 3,000 Instagram followers, and more than 1,200 Facebook followers
- hosted "open doors" sessions to more than 3,000 members of the public, which included a tour of the Darlington refurbishment training mock-up facility

During the reporting period, NB Power:

- hosted public information sessions to keep the public apprised of activities, including licence renewal participation process and the full-scale integrated provincial emergency exercise (Synergy Challenge)
- hosted key stakeholder meetings throughout the province to provide updates on station activities
- held community meetings with Indigenous communities, municipalities, local fisher and community representatives, environmentalists and the general public to discuss NB Power activities including fish authorization, licence renewal and NPP operations
- supported the local naturalist clubs by allowing access and services to the point to support their migrating bird watching and monarch butterfly tagging programs and activities
- hosted Indigenous groups and members of the community and public at the Point Lepreau site to participate in the monarch tagging initiative and learn about the environmental protection of the monarch sanctuary
- participated in monthly meetings with New Brunswick Indigenous representatives to discuss and share NB Power activities as well as learning from their community members interests and activities.
- provided information to the public through its website and social media
- distributed quarterly newsletter within a 20 km zone radius of the NPP and posted 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 iodine thyroid blockers (i.e., potassium iodide pills) in the vicinity of their stations. More details can be found in subsection 16.1(d).

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 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 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:

> Individuals at all levels of the organization consider nuclear plant safety as the overriding priority. Their decisions and actions are based on this priority, and they follow up to verify that nuclear safety concerns receive appropriate attention. The work environment, the attitudes and behaviours of all individuals reflect and foster such a safety culture.
> Bruce Power shall ensure that reactor safety is the overriding priority in its business decisions and activities, and as the operator of a nuclear power plant accepts that its fundamental reactor safety objective is to protect the public, site personnel and the environment from harm, by establishing and maintaining effective defences against radiological hazards.

This policy provides additional elaboration related to the protection of safety margins, maintenance of defence in depth, and safety analysis.

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.

Hydro-Québec

For Gentilly-2, the Hydro-Québec policy on nuclear safety has a similar statement of high-level values and goals, with a set of supporting principles:

> Management, Nuclear Production, has assigned its highest priority to nuclear safety at Gentilly-2. This commitment is supported by the following statements:
>
> Each employee is personally responsible for safety.
> Managers must demonstrate their commitment to safety.
> Confidence and transparency prevail in the organization.
> Decisions made reflect the priority assigned to safety.
> Nuclear technology is recognized as special and unique.
> A questioning attitude is valued.
> Continuous improvement is sought by the organization.
> Safety is continuously under review.
> Employees, partners and suppliers respect all safety related requirements.

Annex 11.2 (a)
Details Related to Training and Numbers of Workers

Improvements to licensees training programs

The following provides examples of how NPP licensees have improved their training programs during the reporting period.

Professional Development: Bruce Power

Bruce Power has consolidated listings of professional development activities into an interactive on-line catalogue for the purpose of improving staff's professional development and engagement.

Bruce B Unit 7 and Unit 0 Simulator: Bruce Power

Bruce Power has built a second Bruce B full scope simulator which will include Units 7 and 0. This will allow training to occur on modifications associated with life extension activities, as well as training on the unmodified units. This will ensure that control room workers will maintain proficiency in all unit configurations during major component replacement outages.

Systematic Approach to Training (SAT) software implementation: Bruce Power

Bruce Power updated its learning management system software. This included new standards and tools for test item and test development; re-performing job analyses associated with all key qualifications (and many others) to a higher standard; and building more reliable processes to revise the SAT basis documents upon changes to underlying control documents.

Supplemental Worker Task Performance Evaluations (TPE): Bruce Power

Bruce Power has adopted the Electrical Power Research Institute (EPRI) TPE program for supplemental workers. This program augments other methods to ensure journeypersons arriving as supplemental workers have the specific knowledge and skills required for their assignments. The TPE program uses knowledge and skills testing, designed to an exacting EPRI standard, to ensure competence.

Major Component Replacement Training Facility: Bruce Power

The 129,000 square-foot building was constructed to hold offices and the unique training tools that will be vital to the success of the major component replacement projects, which will begin in 2020 in Unit 6 and occur on six of Bruce Power's eight reactors through 2033. The building features a two-story office area including office space, classrooms and amenities for the occupants; a one-story, high-bay shop area to host training, shop, and storage space; 330 office workers and 150 workers in the shop space; and parking, amenities, and facilities for about 500 employees.

Tritium Removal Facility (TRF) Simulator – Ontario Power Generation

A new TRF simulator is being developed to enhance the TRF operator training program. The simulator will provide a realistic training environment where operators can be trained to standards similar to the fuel handling and certified operations staff. The simulator can also be used to enhance operator proficiency through "just-in-time" training prior to infrequently performed evolutions. The project is expected to be completed by the end of 2019.

Professional Development – Ontario Power Generation

There are plans for a new learning management system to be implemented by June 2019 with an initial suite of 6000 professional development courses. The system is integrated with the suite of human resource systems such as development planning and succession planning tools employees can use to link their learning to development objectives.

Project Management Training – Ontario Power Generation

PMPRO is a new, fully-established, comprehensive, enterprise-wide training and qualification program designed for OPG project managers. ProPEL is a program designed for those not yet in project management who wish to pursue project management as a career path. These programs provide the training, tools, and developmental framework necessary for OPG project managers to deliver projects safely, with the required quality, on time, and on budget.

Dynamic learning activities: NB Power

NB Power has developed an integrated dynamic learning activity (DLA) to address the application and use of human performance tools and techniques by all NPP staff. The activity incorporates three tasks: strainer cleaning 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” effectively using the organization’s human performance tools.

All NPP staff, starting with the site vice-president and station directors, are required to complete the DLA, 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 the tools 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 NSCA, its regulations and the licence
(b) train the workers to carry on the licensed activity in accordance with the NSCA, its regulations 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 to provide details about the qualifications, training and experience of any worker involved in the NPP’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 RD-204, *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, and that Bruce Power maintains an adequate level of employees in positions required to safely manage the NPP.

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 now applied to execute a gap analysis between current staffing levels and the optimal future state. During yearly business planning sessions, executives and senior managers reconcile current 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 to safety of 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, 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
- 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 operating experience feedback

Each level of management is also vested with a specific level of authority as defined in their 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 in 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 delivering 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.

A rigorous HFE approach is used in the areas of human system interface components, equipment layouts, control room habitability, control room display design, panel design and annunciation design. 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 Candu Energy Inc. 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
- operating experience 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) (b)
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 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 do not exceed the accident-dependent reference public dose limits specified in the design requirements.

The typical safety analysis report covers the following main areas as given below.

<u>Introduction and site description</u>

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

<u>Systems and components</u>

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

<u>Deterministic safety analysis summaries</u>

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 LOCA
- LOCAoutside 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 regulatory document 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. The NPP licensees continually update safety analyses that included the effects of aging of the primary heat transport system. A primary aging mechanism is the diametric creep of the pressure tubes. Safety analyses have been performed to demonstrate the adequacy of safety margins in the scenarios most affected by aging.

Revised safety analyses are being conducted in the context of the licensees' implementation of CNSC regulatory document REGDOC-2.4.1, *Deterministic Safety Analysis*. The following describes the work being carried out by each licensee to implement REGDOC-2.4.1.

<u>Ontario Power Generation</u>

OPG continues to implement the requirements of REGDOC-2.4.1 in accordance with the November 2017 revision of its implementation plan. The new analyses are also planned and executed in conjunction with the heat transport system (HTS) aging management strategy. The previously completed loss of moderator heat sink analysis was incorporated into the safety report appendix as part of the 2017 update of the Darlington safety report. Analysis was completed for the Darlington large break LOCA with a more realistic implementation of the limit of operating envelope methodology in March 2018. Regarding other accident scenarios, the analysis planning stage has been completed for Darlington loss of flow analysis, loss of reactor power regulation, and in-core LOCA during the reporting period.

Additionally, OPG completed the analyses for Pickering common cause events in December 2017, and included these new analyses in the updated safety report for Pickering Units 1,4. The new appendix is planned to be incorporated into the Pickering 5-8 safety report as part of the safety report update process in 2019. Under the HTS aging management strategy, updated analyses for loss of flow, small break LOCA, and neutron overpower protection accident scenarios are being performed for future aged HTS conditions to support continued safe operation of OPG reactors.

Bruce Power

In December 2017, Bruce Power completed a three-year project to upgrade the safety analysis summaries 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.

Bruce Power has developed an approach for deterministic analyses in support of seismic events, fire and floods, drawing from post-Fukushima assessments and probabilistic safety assessments.

Going forward, any new or revised safety analysis will comply with REGDOC-2.4.1.

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. 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 10-year planning. NB Power also addressed regulatory comments on its graded approach for the identification of anticipated operational occurrences (AOO) events for further analysis, and incorporated lessons learned from the analysis of the fast loss of reactivity control. No additional AOOs were identified that require analysis to demonstrate Level 2 defence-in-depth. All new analysis will be reflected in future updates to the safety report.

Annex 14 (ii) (b)
Aging Management Programs at Each Nuclear Power Plant

CNSC regulatory document 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-fuelling-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 operating experience. Their asset management approach is an example of the implementation of an integrated NPP licensee 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 has been developed with consideration for nuclear industry regulatory requirement documents, along with best practice and guidance documents such as:

- CNSC regulatory document REGDOC-2.3.3, *Periodic Safety Reviews*
- CNSC regulatory document REGDOC-2.6.3, *Aging Management*
- CNSC regulatory document REGDOC-2.6.1, *Reliability Programs for Nuclear Power Plants*
- IAEA safety guide NS-G-2.12, *Ageing Management for Nuclear Power Plants*

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 60, 1991) and the IAEA's *Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards* (BSS) GSR Part 3 (1996).

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, pregnant nuclear energy workers and persons who are not nuclear energy workers
- 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. CNSC regulatory guide G-129, *Keeping Radiation Exposures and Doses "As Low As Reasonably Achievable" (ALARA)*, 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

The CNSC is currently developing the following new radiation protection regulatory documents which will supersede existing regulatory guides and standards:

- REGDOC-2.7.1, *Radiation Protection*
- REGDOC-2.7.2, *Dosimetry, Volume 1: Ascertaining Occupational Dose*
- REGDOC-2.7.2, *Dosimetry, Volume 2: Technical and Management System Requirements for Dosimetry Services*

Section 8 of the RPR requires licensees to use a CNSC-licensed dosimetry service to measure and monitor radiation doses of nuclear energy workers who have a reasonable probability of receiving an effective dose greater than 5 mSv in a one-year dosimetry period. CNSC regulatory document S-106 revision 1, *Technical and Quality Assurance 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. The requirements of the quality assurance programs from S-106 revision 1 are nearly identical to the requirements set out in ISO/IEC 17025, *Testing and calibration laboratories*, although they include additional requirements that apply specifically to dosimetry laboratories. 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 nuclear energy worker.

Summary of doses to NPP workers during the reporting period

The *Radiation Protection Regulations* require that licensees ensure that workers at NPPs are restricted to dose limits of 50 mSv in a one-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 2016-2018. As indicated, no worker exceeded the annual dose limit of 50 mSv.

Occupational dose summary for Canadian NPPs, 2016–2018

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	2016	8	799	8,981	9,780	23.05
	2017	8	893	5,393	6286.0	13.05
	2018	8	956.8	8928.8	9885.5	22.19
Darlington*	2016	4	495	2,600	3095.0	9.13
	2017	4	429	12,068	12497.0	18.94
	2018	4	449.19	9505.77	9954.96	18.47
Gentilly-2**	2016	1	0	2.1	2.1	0.85
	2017	1	0	9.6	9.6	1.16
	2018	1	0	7.59	7.59	2.16
Pickering	2016	6	762	4296	5058.0	18.04
	2017	6	719	3309	4028.0	14.58
	2018	6	749.92	4108.99	4903.91	15.7
Point Lepreau	2016	1	199	806	1005.0	14.01
	2017	1	204	361	565.0	11.35
	2018	1	217	963	1180	13.3

* Unit 2 at the Darlington NGS was undergoing refurbishment activities in 2017 and 2018.
** The Gentilly-2 reactor was shut down during this period.

The *Radiation Protection Regulations* require that licensees 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.) The table below shows the maximum individual effective dose accumulated to date (only three years of the five year dosimetry period from January 1, 2016 to December 31, 2020). If a rolling five-year period was used from 2014 to 2018, no worker would have exceeded the five-year dose limit of 100 mSv.

Maximum five-year individual effective dose to workers at each Canadian NPP, for five-year dosimetry period of 2016–2020

Station	Maximum individual effective dose (mSv)
Bruce A and B	43.78
Darlington	36.67
Gentilly-2	2.7
Pickering	33.89
Point Lepreau	46.1

The table below summarized the collective dose data for NPPs.

Total collective dose at all Canadian nuclear power plants, 2016–2018

Year	Number of operating reactors	Collective dose (person-Sv)
2016	19	18.94
2017	19	23.34*
2018	19	25.9*

*Increase due to DNGS Unit 2 refurbishment dose (for 2017 and 2018)

Annex 15 (b)
Radiological Emissions from Canadian NPPs

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). This annex reports the magnitude of these releases for each NPP in Canada for the years 2016 to 2018. This annex also indicates how these releases compare with the derived release limits (DRLs) imposed by the CNSC. In the majority of cases, the levels of gaseous and liquid effluents from all NPPs were below 1 percent of the DRLs.

Gaseous emissions released from Canadian NPPs, 2016–2018

Year	Tritium oxide (TBq)	Carbon-14 (TBq)	Noble gases (TBq-MeV)	Iodine-131 (TBq)	Particulates (TBq)
Bruce A					
DRL	1.98E+05	6.34E+02	1.12E+05	1.14E+00	1.73E+00
2016	5.66E+02	1.69E+00	5.63E+01	4.40E-06	3.14E-07
2017	7.32E+02	1.89E+00	9.40E+01	2.06E-05	4.39E-07
2018	6.08E+02	1.14E+00	8.46E+01	6.57E-06	1.28E-06
Bruce B					
DRL	3.16E+05	7.56E+02	2.17E+05	1.35E+00	3.61E+00
2016	5.70E+02	1.13E+00	5.25E+01	<LD[a]	1.13E-06
2017	7.14E+02	1.23E+00	4.82E+01	1.41E-06	2.34E-06
2018	3.86E+02	1.13E+00	4.24E+01	3.43E-06	2.21E-06
Darlington					
DRL	5.9E+04	3.5E+02	4.5E+04	1.4E+00	6.7E-01
2016	1.8E+02	1.6E+00	1.6E+01	1.4E-04	3.2E-05
2017	2.4E+02	1.4E+00	1.5E+01	1.5E-04	2.6E-05
2018	2.1E+02	8.4E-01	4.7E+01	1.4E-04	2.5E-05
Gentilly-2					
DRL	1.7E+05	1.2E+03	NA[1]	NA[1]	8.0E-01
2016	7.31E+01	3.79E-01	NA[1]	NA[1]	5.17E-07
2017	7.31E+01	4.47E-01	NA[1]	NA[1]	8.32E-06
2018	9.17E+01	4.63E-02	NA[1]	NA[1]	2.15E-06
Pickering Units 1–4					
DRL	1.2E+05	2.2E+03	3.2E+04	9.8E+00	4.9E-01
2016	2.2E+02	1.2E+00	1.1E+02	9.9E-06	5.5E-06
2017	3.1E+02	1.3E+00	1.5E+02	9.6E-06	6.9E-06
2018	3.0E+02	2.3E+00	1.2E+02	7.0E-06	4.2E-06
Pickering Units 5–8					
DRL	1.9E+05	2.0E+03	4.7E+04	8.9E+00	7.2E-01
2016	4.6E+02	1.2E+00	5.8E+00	4.1E-06	2.4E-05
2017	3.8E+02	1.3E+00	3.5E+00	4.3E-06	2.0E-04
2018	3.2E+02	1.4E+00	5.0E+00	4.7E-06	3.5E-06
Point Lepreau					
DRL	2.8E+05	6.8E+03	a	6.0E+01	a
2016	1.5E+02	1.1E-01	9.5E+01	5.2E-07	<2.2E-06
2017	1.5E+02	3.1E-01	4.6E+01	<5.2E-07	<2.2E-06
2018	1.4E+02	3.3E-01	2.5E+01	1.3E-06	<2.2E-06

<LD[a] = less than analytical detection limit
NA[1] = not applicable as facility is in safe shutdown

Liquid effluent released from Canadian NPPs, 2016–2018

Year	Tritium oxide (TBq)	Gross beta-gamma (TBq)	Carbon-14 (TBq)
Bruce A			
DRL	2.30E+06	4.58E+01	1.03E+03
2016	2.36E+02	9.96E-04	1.66E-03
2017	2.26E+02	1.08E-03	9.13E-04
2018	1.96E+02	1.20E-03	9.73E-04
Bruce B			
DRL	1.84E+06	5.17E+01	1.16E+03
2016	5.07E+02	1.42E-03	1.76E-03
2017	7.15E+02	2.04E-03	2.39E-04
2018	5.60E+02	2.55E-03	1.38E-03
Darlington			
DRL	5.3E+06	7.1E+01	9.7E+02
2016	3.5E+02	4.9E-02	2.2E-03
2017	5.6E+02	2.6E-02	1.7E-03
2018	2.2E+02	2.6E-02	1.2E-03
Gentilly-2			
DRL, 2013-2014 Since 2015	1.1E+07	5.3E+01	7.3E+02
2016	3.83E+01	1.33E-04	5.64E-02
2017	2.17E+02	3.28E-04	2.79E-01
2018	5.45E+01	2.51E-05	1.71E-04
Pickering Units 1–4			
DRL	3.7E+05	1.7E+00	3.2E+01
2016	1.1E+02	6.8E-03	Note 3
2017	1.1E+02	6.6E-03	Note 3
2018	1.4E+02	9.3E-03	Note 3
Pickering Units 5–8			
DRL	7.0E+05	3.2E+00	6.0E+01
2016	2.1E+02	5.1E-02	4.7E-03
2017	2.7E+02	2.0E-02	1.9E-03
2018	2.8E+02	3.4E-02	1.1E-03
Point Lepreau			
DRL	4.6E+07	a	3.3E+02
2016	1.8E+02	7.8E-05	2.9E-03
2017	1.2E+02	7.8E-05	1.8E-03
2018	2.4E+02	9.7E-05	4.9E-03

Note 1: The carbon-14 releases in liquid effluent from Pickering Units 1–4 are reported in the carbon-14 releases in liquid effluent from Pickering Units 5–8

a = Specific DRLs are calculated for a range of noble gas and particulate categories

Annex 16.1 (b)
Onsite Emergency Plans at Canadian Nuclear Power Plants

Bruce Power Nuclear Emergency Plan

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 shift 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 Nuclear Emergency Response Plan (PNERP; see annex 16.1(d)) 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. 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. Bruce Power is revising 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 meet the requirements set out in CNSC 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.

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 that 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 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 hostile (security) action incidents 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 OPGs 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 response 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 local media 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.

Gentilly-2 Nuclear Emergency Plan

The Hydro-Québec *Plan des mesures d'urgence* describes its arrangements to cope with actual or potential nuclear emergencies at Gentilly-2. That publication and various supporting documents define the Gentilly-2 nuclear emergency preparedness and response plan in detail, including application criteria, roles and responsibilities, requirements for coordination, classification of emergency alerts, notification of offsite authorities, communications with the media and the public, emergency procedures, response logistics, technical and equipment support and emergency training and drills.

The plan stipulates that abnormal onsite events that increase the risk (radiological or conventional) to employees, the public or the environment shall be announced by the declaration of an appropriate level of alert, indicating the severity or potential severity of the incident. Gentilly-2 has four alert levels:

- An area alert indicates a dangerous or potentially dangerous situation within a limited area of the NPP.
- A station alert indicates a dangerous or potentially dangerous situation within an important area of the NPP.
- A local alert indicates:
  - significant radioactive materials were released or potentially released to the environment
  - low risk to the population and environment
  - no protective measures are required for the population
  - the event has been declared by Gentilly-2 authorities
- A general alert indicates:
  - significant radioactive materials were released or potentially released to the environment
  - significant risk to the population and the environment
  - protective measures are recommended for the population near Gentilly-2
  - the event has been declared by public authorities of the Province of Quebec

Emergency drills are conducted at Gentilly-2 at least once per year. The NPP also participates in externally organized drills in cooperation with offsite authorities. Gentilly-2 managers, staff and workers receive both basic and specialized instruction in nuclear emergency preparedness and response, on an as-required basis.

Gentilly-2 provides emergency preparedness services according to a well-defined process that includes:

- treatment of information and requests related to the process
- determination of risks (conventional or radiological), activation criteria and alert-level criteria
- documentation of emergency response (framework and response procedures)
- determination of emergency response organization (mission and responsibilities)
- determination of emergency resources (staff, installations and equipment)
- development of interfaces with offsite authorities
- maintenance and development of communication and public relations framework
- training
- drills and exercises
- emergency preparedness implementation (risk assessment, alert declaration, emergency response organization activation, notification of offsite authorities, management intervention, accident assessment, staff protection, recommendation of protection measures to the population, end of alert and return to normal)
- evaluation of the emergency preparedness process

The emergency preparedness process comprises these major outputs:

- policy and framework documents
- emergency procedures
- collaboration and agreements with offsite authorities
- emergency response organization
- emergency installations and equipment
- tested emergency plans

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 event preparedness, prevention, 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. The events covered within this framework include 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 station's management system. These procedures and response guidelines allow the emergency response organization to affectively respond to and manage any event that may occur.

The onsite emergency 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 overall emergency management program. Exercises are conducted regularly with the station's emergency response organization, and are done 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 area 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. The Office of the Fire Marshal and Emergency Management administers the Province of Ontario Nuclear Emergency Response Plan (PNERP) on behalf of the province and coordinates nuclear emergency preparedness and response in Ontario. As a legislated plan, the PNERP is approved by the Ontario Cabinet.

The PNERP has been in place since 1986 to govern the Province's response to nuclear and radiological emergencies. These include those at the 3 NPPs in Ontario other types of nuclear facilities (including research reactors), nuclear power plants in neighbouring jurisdictions, as well as other types of radiological events. This plan has never been fully activated, although events have occurred that resulted in formal notifications to the province. These events were monitored until it was determined that they posed no risk to the public or environment.

The PNERP defines a nuclear emergency as an emergency that has led or could lead to the release of radioactive material, or exposures to uncontrolled sources of radiation, which pose, or could pose, a threat to health and safety, property, and the environment. The plan defines a radiological emergency as an emergency caused by an actual or environmental hazard from ionizing radiation emitted by a source other than a reactor facility.

The aim of the plan is to safeguard the health, safety, welfare and property of the province's inhabitants and to protect the environment. The PNERP, as the lead provincial document for offsite nuclear emergency preparedness and response, 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 details the arrangements in place for nuclear emergency planning, preparedness and response in Ontario. 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 Fukushima accident. Following a consultation process that included both stakeholders as well as the public, the PNERP Master Plan was updated and approved by provincial cabinet in late 2017. The site specific and detailed Implementing Plans for Pickering, Darlington and Bruce NPPs were subsequently updated and approved in 2018/2019. Work continues on the review and update of the remaining Implementing Plans (Chalk River, Fermi 2, Trans-border and Other Radiological Emergencies).

Province of Quebec

Within the Province of Quebec, under the *Civil Protection Act*, municipalities are responsible for emergency measures on their territory. In the event their capacity to respond is or is likely to be exceeded, the Ministère de la sécurité publique would coordinate responses and additional support from the Government of Quebec partners, according to the missions described in the Plan national de sécurité civile du Québec (PNSC), which provides the terms of reference for major emergencies in the Province of Quebec. The Organisation de la sécurité civile du Québec which is composed of senior officials of stakeholder ministries, is responsible for emergency planning and response to major hazards, including offsite nuclear emergencies.

The Plan *des mesures d'urgence nucléaire externe à la centrale nucléaire Gentilly-2 (PMUNE-G2)* was abandoned in 2016 due to the reduced offsite risk related to closing of Gentilly-2 NPP. Should there be the need to respond to a nuclear or radiological emergency affecting the province, the province will use the Plan national de sécurité civile du Québec.

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 (OPSA), which is the provincial lead agency for security and critical infrastructure protection

The Government of New Brunswick has consolidated justice and public safety and security responsibilities (including the provincial nuclear emergency program) under the mandate of the New Brunswick Department of Justice and Public Safety, in conjunction with the following enhancements to emergency preparedness in New Brunswick:

- strengthening the prevention of and preparedness and response for all hazards, including the integration of crisis and consequence management apparatus under a single emergency management system
- investing significantly in provincial government Internet infrastructure to make it more reliable and fault-tolerant and to improve its capacity

- updating and strengthening operational capability at the NBEMO Provincial Emergency Operations Centre, which includes enhancing the business process and investments in infrastructure to improve connectivity and collaboration among federal and provincial intervening organizations, with more focus on operational readiness
- developing a training and exercise strategy for major scenarios, including nuclear response, so that NBEMO is exercised annually rather than every three years (as in the past)
- replacing the inventory of potassium iodide pills, updating demographic information for the emergency planning zone and improving communications systems linking the Offsite Emergency Operations Centre (owned and maintained by NB Power) and the Provincial Emergency Operations Centre

New Brunswick Emergency Measures Plan

Under New Brunswick's *Emergency Measures Act*, NBEMO has the lead responsibility to develop provincial emergency action plans and to direct, control and coordinate emergency responses.

The New Brunswick Emergency Measures Plan, prepared by NBEMO, defines an emergency as any abnormal situation requiring prompt action beyond normal procedures to limit damage to persons, property or the environment. The aim of the plan is to designate 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. Representatives of these stakeholders make up the Provincial Emergency Action Committee, which directs controls and coordinates provincial emergency operations and assists and supports municipalities as required. NBEMO has recently updated the committee's handbook, which includes all the tasks the different departments are responsible for when there is an event.

The Provincial Emergency Action Committee maintains two states of readiness. The standby state requires representatives of departments to be available (on call). An emergency state requires action from NBEMO or other departments. During an emergency state, departmental representatives are called to the Provincial Emergency Operations Centre and briefed on the corresponding emergency.

The province is divided into twelve regions that are overseen by the Regional Emergency Management Coordinators from NBEMO. In each region, emergency management coordinators support the development and refinement of emergency planning by municipalities and provide advice and assistance on the development of emergency plans. They coordinate the use of provincial resources to deal with emergency situations in rural areas and urban municipalities. To accomplish this, regional emergency committees are formed to provide assistance to municipalities and the population of unincorporated areas. These committees consist of representatives from the provincial Departments of Environment, Health, Justice, Natural Resources, Social Development, Transportation and Infrastructure, as well as local governments.

Local authorities are responsible for emergency planning and response within their physical boundaries and, in some cases, for certain areas outside their boundaries. Communities may assist each other in accordance with mutual aid agreements. However, when an emergency arises in which the resources of a community (or group of communities) are insufficient, the province will provide assistance through the regional emergency coordinators. Regional emergency operations centers are located in government facilities.

Point Lepreau Offsite Emergency Plan

NBEMO developed the Point Lepreau Offsite Emergency Plan in accordance with the framework described above. The Plan contains the basic information, detailed responsibilities, and immediate actions required to safeguard the public and the environment. It contains the specific responses which will be carried out by various agencies to deal with the emergency. The plan goes through an annual review under the authority of NBEMO to ensure the information contained within it is accurate. The plan was last updated and issued during the reporting period in August 2018. The plan uses the CSA Standard Z1600-14 Emergency and Continuity Management Program for simplicity and to enable responders to familiarize themselves quickly with the requirements of their department's role, function, and those of other member agencies.

An automated telephone and email notification system, Evergridge Notification System, has been established to send messages to all residents. Radio, television, RCMP and the warden service would also be used to advise the public of the need for any protective actions. Should it be necessary to alert the public to an offsite emergency, wardens would oversee designated areas to ensure residents were appropriately informed of any actions required. The RCMP are the lead agency responsible for conducting an evacuation, however, arrangements are in place to help individuals who might require physical assistance should evacuation prove necessary.

The Government of New Brunswick utilizes the Incident Command System (ICS), an organizational structure based principally on the United States' National Incident Management System and a suite of information management and decision support tools. The emergency organization and tools are designed around the requirement for interoperability with provincial and local emergency management partners, as well as with federal agencies such as Public Safety Canada, Health Canada, the Public Health Agency of Canada and the Department of National Defence.

The plan contains information on actions to enable recovery, including identifying areas possibly contaminated, activating the New Brunswick Radiological Ingestion Pathway Monitoring Plan, disseminating information to the public, and providing Health and human services.

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).

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). The FNEP is an event-specific annex to the *Federal Emergency Response Plan* (FERP), which is the federal all-hazards planned administered by Public Safety Canada. The FNEP is reviewed regularly and updated as needed (the last update was in 2012). During the reporting period, the plan was reviewed to ensure that the roles and responsibilities of implicated federal organizations were still accurate.

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 amongst 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 through the overarching framework of the FERP, National Emergency Response System and provisions of the FNEP or a provincial annex in the FNEP.

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 off-site 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 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 (NEFs). NEFs 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 NEF 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 NEF 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. 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 were completed, emergency management of the radiological hazard would shift 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) These should be considered in the development of recovery plans as part of the transition to recovery:

- 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

Provisions of the CNSC in emergency preparedness and response

As the federal nuclear regulatory body, the CNSC participates in nuclear emergency prevention, preparedness, response and recovery activities as part of its responsibilities under Canadian legislation.

Because the CNSC's regulatory obligations extend to a wide range of circumstances, facilities, activities and materials, it must plan for its possible involvement in a similarly diverse range of emergency scenarios. 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 ongoing FNEP and CNSC drills and training 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.

To fulfill CNSC's requirements established in the CNSC Strategic Emergency Management Plan (SEMP), and the CNSC Nuclear Emergency Response Plan (NERP), emergency management relies on staff to assess and confirm the significance of an emergency and to communicate these findings to senior management, other staff, the public, media, the licensee and all levels of government.

The NERP describes the strategies and guidelines the CNSC would follow to cope with a nuclear emergency. In particular, it describes:

- the role and responsibilities of the CNSC in nuclear emergencies
- the organizational structure of the CNSC during and emergency
- the CNSC's Nuclear Emergency Organization (NEO)
- the response and recovery activities at a tactical level
- the EOC technical infrastructure
- the training requirements of staff

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, the implementation of the NERP in the event of a declared emergency could involve the following parties:

- the CNSC's NEO
- CNSC employees to staff the various parts of the NEO
- 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

The NERP is in effect at all times in one of four response levels:

1. Routine monitoring, an event does not require prompt action beyond normal CNSC procedures.

2. Enhanced Monitoring, a situation requires careful monitoring in case of escalation or media/public attention.
3. Partial Activation, an emergency may have a direct or indirect impact on the CNSC's regulatory role and requires response coordination.
4. Full Activation, an emergency requires a fully staffed EOC to effectively and efficiently respond to the event.

Within the context of the NERP, 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, attending training programs, participating in exercises and responding to actual emergencies. The NERP 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 NERP, 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.

During the reporting period, the CNSC made 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 were made at the operating NPPs.

- In 2018, Bruce A and B implemented the Disaster LAN electronic data management system system, which would provide the necessary connection to the CNSC. Bruce Power then began investigating options for automatic connectivity between plant data systems and the Disaster LAN system. Automated transfer will be available for a planned exercise in the fall of 2019
- 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 Control

In December 2017, OPG, supported by the Province of Ontario, neighbouring jurisdictions, and federal and international agencies, conducted a two-day full-scale integrated inter-operability exercise called Exercise Unified Control (ExUC). The exercise simulated a beyond-design-basis accident at Pickering NPP resulting in a controlled offsite release. This exercise was supported by regional, provincial and federal institutions. Over 800 people representing more than 30 agencies and organizations participated in the exercise. The primary objectives of ExUC were to validate the onsite and offsite nuclear emergency plans and to test the interoperability of organizations to effectively coordinate the response to a simulated nuclear emergency in the Province of Ontario.

The high-level objectives of the exercise that were successfully tested included the following:

- test the preparedness of OPG, government, non-government agencies, and communities to respond to a nuclear emergency at the Pickering Nuclear Generating Station;
- assess the interoperability of the participating organizations
- examine the consultation process between the utility and stakeholders regarding decision making to ensure the safety of the public and the environment
- demonstrate the ability to coordinate a common and effective message when sharing information with the public and media
- produce a joint evaluation report detailing the preparedness and response of participating organizations to a nuclear emergency in Canada

The scope of the exercise included: accident assessment and response in both design-basis and beyond-design-basis 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. At OPG, the exercise involved real-time activation of emergency response facilities, Site Emergency Operations Centre (EOC), Site Management Centre, Corporate Emergency Operations Facility, Local Media Centre and Crisis Management and Communications Centre, and exercise player turnover briefings, as well as participation of the OPG provincial and regional emergency response organization liaison officers.

Overall, there were many benefits identified throughout each stage of ExUC. Agencies were able to highlight and further strengthen the already excellent inter-agency relationships, test and improve interoperability in six key areas of response, and find training opportunities that encourage collective learning. ExUC also provided a platform to test new equipment and procedures in a full-scale exercise, such as Unified Rascal Interface (the new dose assessment software used by OPG, the Province of Ontario, and CNSC). The exercise also generated a high level of interest from participating and non-participating organizations to observe the exercise, resulting in an informative one-day guided VIP tour, comprised of representatives from various domestic and international organizations with an interest in the nuclear industry.

ExUC successfully demonstrated and confirmed that OPG, the Province of Ontario, the Region of Durham, and key organizations at the municipal, regional, and federal levels are prepared and ready to respond effectively together to an incident at Pickering. ExUC was another example of OPG and government organizations working together to enhance interoperability and optimize a coordinated and collaborative response capability to a nuclear event.

Exercise Huron Resolve

The provincial-level exercise, Huron Resolve, was held over a five-day period in October 2016. This event challenged more than 30 agencies and more than 1,000 people to respond to a large-scale radiological event, in addition to a variety of other related and unrelated incidents.

The exercise tested Bruce Power's integrated emergency response to an external initiating event, triggering a design-basis accident transitioning to a beyond-design-basis accident. This permitted testing the implementation of the severe accident management guides. During the exercise, emergency mitigating equipment was successfully deployed to provide back-up power and cooling water to the station. The automated on-site and off-site remote radiation monitoring network was fully utilized to provide scenario simulation injects, which prompted actual deployment of the off-site survey team and deployable remote radiation monitoring equipment.

Additionally, the scenario tested the transportation emergency response procedure and the contaminated casualty procedures, with active participation of the local hospital.

The scenario involved coordination of provincial and federal agencies in developing and implementing on-site and off-site protective measures, both pre-release and post-release. Bruce Power's Emergency Management Centre (EMC) relocated to one of the back-up facilities as part of the on-site pre-release protective measures.

In addition, the crisis management team was activated which included full participation of the President and Chief Executive Officer and members of the executive team throughout the five-day exercise. Following the exercise, a continuation of the scenario was used to conduct a table-top exercise of various elements of the business continuity plan.

Exercise Synergy Challenge

NB Power, supported by the Province of New Brunswick, neighbouring jurisdictions, and federal and international agencies, conducted a two-day full-scale integrated exercise called Synergy Challenge 2018 (SC2018). The exercise simulated a beyond-design-basis accident occurring at Point Lepreau and represented the first time that a Canadian NPP had tested the early recovery phase as part of the emergency management cycle. The exercise was supported by regional, provincial and federal institutions. Approximately 1,000 people representing more than 35 agencies and organizations participated in the exercise. The primary objectives of SC2018 were to validate the on-site and off-site nuclear emergency plans and to test the interoperability of organizations to effectively coordinate the response to, and early recovery from, a simulated nuclear emergency(subsequently validating the collective preparedness of the utility and the province).

SC2018 incorporated knowledge gained from Exercise Intrepid, New Brunswick’s last full-scale nuclear emergency exercise in 2015, and operating experience from other NPP exercises as well as lessons learned from recent weather-related emergency recovery efforts in New Brunswick. Organizations were able to test internal objectives, validate aspects of their plans, and identify areas of response and recovery where interoperability with other agencies could be improved. Through this process, existing inter-agency relationships were strengthened, and the overall effectiveness of their response plans was enhanced. Organizations were also able to test the recovery aspect of their plans using a realistic and challenging scenario that served as an excellent learning opportunity. The unique aspects of the recovery phase highlighted the importance of large-scale exercises as part of the continued effort to build on the strategic preparedness for a highly unlikely incident at Point Lepreau.

Early on day two of the exercise, the criteria to transition from the response phase to the recovery phase was confirmed: the release from Point Lepreau had ended; there was no further chance of another release; and the NPP was in a stable state. With the transition to recovery, the emergency still exists but the urgency now is focused on deliberate planning. The planning was defined as: establish staging areas; define the contaminated area; deploy aerial and ground surveys; conduct sampling; conduct re-entry; plan for adjusting restricted areas; and plan for the return of evacuees. Assurance monitoring teams were deployed in multiple locations in order to redirect the worried well from the local hospitals.

Natural Resources Canada (NRCan) completed the aerial survey in order to establish the contaminated areas, and the Point Lepreau off-site survey teams continued to conduct ground surveys around the plant as well as defining the boundary of the contamination. The Federal Nuclear Emergency Plan Technical Assessment Group Environmental Monitoring and Surveillance Group field teams from Health Canada and Canadian Nuclear Laboratories conducted ground surveys around the plant defined the boundary of the contamination. Survey teams focused on mapping and characterizing the contaminated area around Point Lepreau.

In the afternoon, a Town Hall session supported the psycho-social and public health response for the community. Food, air, fish, animal and water samples were collected by several New Brunswick provincial departments, delivered to the NB Power Health Physics lab in Fredericton, NB, and analyzed for radioactive contamination with results provided to the province to support decision making, food bans and ingestion pathway monitoring. Throughout the day, public communications specialists handled numerous requests and questions from the local population regarding the safety of the area around the plant, when they could return to their homes, status of livestock and properties, and traffic and highway conditions.

This exercise successfully demonstrated and confirmed that NB Power, the Province of New Brunswick and key organizations at the regional 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 strengthen and improve both the onsite and offsite emergency response plans.

IAEA participation in Canadian exercises

Exercise Unified Response included an international component, specifically, the notification to the IAEA by the national competent authorities (i.e., the CNSC and Health Canada) and notification through the International Nuclear Event Scale (INES) by the CNSC. Several action items were identified and resolved as a result of this exercise.

IAEA Convention Exercise series

Between January 2016 and December 2018 Health Canada participated in 13 exercises of the IAEA Convention Exercise (ConvEx) series. The most comprehensive was the participation in the June 2017 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, testing the capabilities and roles for both international and domestic response using the IAEA's Unified System for Information Exchange in Incidents and Emergencies (USIE) site. The exercise involved a General Emergency at an NPP in Hungary and Health Canada played as the Competent Authority Abroad (CA-A), receiving contaminated water samples to analyse in real time. This was an opportunity to complete an inter-comparison between two laboratories at Health Canada's Radiation Protection Bureau and the CNSC's laboratories.

METER training and RN-Med-Prep

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 of 2016 - 2018, five METER sessions were delivered to over 200 trainees. In July 2016, the METER course was delivered in Kincardine, Ontario in advance of Exercise Huron Resolve in October 2016. During the exercise, Health Canada staff travelled to the local health centre to observe the implementation of the METER course in the treatment of a contaminated casualty.

In 2016, the METER eLearning module was launched and made available through the web. Since then over 350 individuals have completed the course, including those from federal departments and agencies, provincial ministries and municipalities, local health authorities, local response authorities, hospitals and universities, among others.

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 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 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 and many federal, provincial/territorial and municipal organizations participated.

Annex 18
Supporting Details Related to CNSC Design Requirements and Design Assessments

Design requirements in CNSC regulatory document REGDOC-2.5.2

CNSC regulatory document 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

REGDOC-2.5.2 describes five levels of defence in depth:

- 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

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 could 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, which 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)(c).

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 operating experience 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 considering 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 the sharing of 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 time scale is to be 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. 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.

Phase 1

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.

Phase 2

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, 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
- beyond-design-basis accidents (BDBAs) and severe accidents (SA) prevention and mitigation
- safety analysis (deterministic safety analysis, probabilistic safety analysis) and 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 of 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 in phase 2, 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 (IMSR)	200	1	complete
			2	in progress
Ultra Safe Nuclear Corporation	MMR-5 and MMR-10 (high-temperature gas)	5–10	1	complete
LeadCold Nuclear Inc.	SEALER (molten lead)	3	1	on hold (vendor request)
Advanced Reactor Concepts Ltd.	ARC-100 (liquid sodium)	100	1	in progress
Moltex Energy	Stable Salt Reactor (molten salt)	300	1, 2 (in series)	Phase 1 in progress
SMR, LLC	SMR-160 (pressurized light water)	160	1	in progress
NuScale Power, LLC	NuScale Integral (pressurized water)	60	2*	Project start pending

*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 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 BDBA and severe accident conditions, 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 following the accident at Fukushima.

The licensees have evaluated means to provide additional coolant makeup from alternate sources. To support the coolant make-up strategies, Canadian NPP licensees have completed modifications to their plants, procured additional EME and developed procedures for its deployment.

The deployment of EME is being implemented by NPP licensees. 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 portable 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 while introducing 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 and 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 extremely unlikely 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 the 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 had 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 recovery actions. The initial power supply is obtained from portable, uninterruptable power supply batteries which 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 – and essential to the execution of the SAMGs – will perform their function for the duration for which 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 in 2014 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, Pickering and Bruce A and B to respond to and mitigate BDBAs and severe accidents.

OPG Modifications

Modification	Station/unit	In-service
Providing make-up water	—	—
Installation of Stand-pipes for EME suction	PNGS A&B and DNGS	2013
Redundant EME connections to steam generators	PNGS A&B and DNGS	2013 (PNGSs) 2015 (DNGS)
Redundant EME connections to irradiated fuel bays	PNGS A&B and DNGS	2013
Procurement of Emergency Mitigating Equipment (Phase I Pumps and Generators and Phase II generators (1.4 MWe))	n/a	2013 (Phase 1) 2017 (Phase II)
Strengthening defence in depth	—	—
Additional provisions for make-up water	—	—
EME SAMG/BDBA connection to Primary Heat Transport System	PNGS A&B and DNGS	2015
EME SAMG/BDBA connection to Moderator System	PNGS A&B and DNGS	2015
EME SAMG/BDBA connection to Shield Tank	PNGS B and DNGS	2015
Installation of Shield Tank overpressure protection	DNGS	2017
External power supply enhancements	—	—
Procurement of portable generators (Phase I and Phase II, cables, trailers	PNGS A&B and DNGS	2017
Installation of receptacle panel for quick connections for CSPM	PNGS A&B and DNGS	2013 (PNGS) 2018 (DNGS)
Connecting quick-connect panel to EPS buses	PNGS A&B and DNGS	2017
Power supply to Hydrogen Igniters via Phase II EME generators	PNGS A&B and DNGS	2017
Passive filtration for containment	—	—
Installation of containment Filtered Venting System	DNGS	2016
Powered Filtered Air Discharge System (FADS) Operation	—	—
Supply power to Main Vacuum Volume Pump for FADS operation (350 kWe Generator)	PNGS A and B	2018
Passive Autocatalytic Recombiners	PNGS A, B and DNGS	2014

Bruce Power Modifications

Modification	Station/unit	In-service
Providing make-up water	—	—
Installation of dry hydrants	AB	2012
Redundant EME connections to steam generators	AB	2013
Redundant EME connections to irradiated fuel bays	AB	2013
Procurement of Emergency Mitigating Equipment	n/a	2012
Strengthening defence in depth	—	—
Additional provisions for make-up water	—	—
EME connection to Primary Heat Transport System	12345678	2019
EME connection to Moderator System	123456[1]78	2019
SAMG connection to Primary Heat Transport System	12345678	2016
SAMG connection to Moderator System	12345678	2016
SAMG connection to Shield Tank	12345678	2016
Installation of Shield Tank overpressure protection	12345678	2019
Wide-range ECI sump level indication	A	2019
External power supply enhancements	—	—
Procurement of portable generators, cables, trailers	AB	2011
Installation of receptacle panel for quick connections	AB	2012
Connecting quick-connect panel to QPS/EPS buses	AB	2012
Passive filtration for containment	—	—
Installation of containment venting connection point	AB	2016
Installation of filtered containment venting system	AB	2022
Passive Autocatalytic Recombiners	AB	2015
Enhancing emergency response	—	—
New Emergency Management Centre (EMC)	—	—
Commissioning of new state-of-the-art facility	n/a	2014
Procurement of mobile emergency centre	n/a	2013
Backup power for emergency facilities, equipment	—	—
Portable generator for EMC	n/a	2014
Fuel truck, portable generator for fuel transfer pumps	n/a	2012
Communications upgrades	—	—
Radio, satellite phone upgrades at EMC, EOCs and Fire Dispatch	n/a	2014
Installation of VSAT at EMC	n/a	2014
Offsite monitoring capability	—	—
Installation of remote gamma monitors	n/a	2014
Installation of remote aerosol monitors	n/a	2015

Note 1 – Installation was partially completed and will finish the installation within the Major Component Replacement Outage.

NB Power Modifications

Modification	In-Service
Provision of Make-up Water	
EME connection points at freshwater pumphouse and Secondary Control Area tunnel for supplying external water to steam generators, primary heat transport system and dousing tank.	2015
EME connection point at Moderator Purification system for moderator make-up for in-vessel retention	2017
EME connection point outside containment for make-up to calandria vault/end shield for in-vessel retention	2012
Procurement of portable diesel-driven water pump	2014
Installation of dry hydrant at Emergency Water Supply Pumphouse to draw water from on-site fresh water pond using portable diesel-drive water pump	2014
Procurement of towable hose distribution trailer	2014
Procurement of Manitou debris clearing equipment for deployment	2014
Procurement of towable fuel transfer trailer for in-situ EME refueling	2014
Procurement of Kalmar terminal tractors for EME delivery (water pump or generators)	2014
Installation of on-site diesel fuel storage tank and dispensing system	2015
Procedures established for usage of blitz fire monitor for make-up to spent fuel bay through exterior doors	2015
Strengthening Defence-in-depth	
Additional provisions for make-up water	
Installation of over-pressure protection for calandria vault/end shield	2010
Installation of calandria vault water level measurement that can operate during a severe accident	2016
Installation of reactor building basement water level measurement that can operate during a severe accident	2016
External Power Supply Enhancements	
Procurement of 2x 275 kw portable diesel generators for power supply to the on-site emergency management centre and switchyard auxiliaries	2015
Procurement of 2x 545 kW portable diesel generators for power supply to Emergency Power Supply (and, hence, Emergency Water Supply); and, to critical Class III loads	2015/ 2016
Procurement of a generator testing load bank	2016

Modification	In-Service
Installation of connection points for all diesel generators	2015/ 2016
Containment Provisions	
Installation of emergency filtered containment venting system	2012
Installation of 3rd personnel airlock door (submarine style door over inner penetration) to protect the personnel airlock due to external water addition to the reactor building from EME	2016
Installation of severe accident sampling and monitoring system	2012
Passive autocatalytic recombiners (installed for design basis accidents but later confirmed also effective for beyond design basis accidents)	2012
Installation of wide-range containment pressure gauges	2010
Enhancing Emergency Response	
Establishment of mutual aid agreement between nuclear utilities	2012
Installation of fixed real-time boundary gamma radiation monitoring system	2016
New off-site emergency operations centre (OEOC) outside 20 km emergency planning zone	2019
Procurement of satellite phones and high powered bag cell phones for communications	2013
Construction of storage facility for EME capable of withstanding seismic and wind events with a 10,000 year return period	2016
Severe Accident Management Guidelines (SAMG) implemented	2011
SAMG implemented for spent fuel bay events	2015
SAMG implemented for events involving dry fuel storage canisters or SRWMF	2012
Standpipe in Secondary Control Area (SCA) tunnel with through-wall connections to allow dewatering of the SCA tunnel using fire trucks in the event of an extreme precipitation event	2016
Procurement of, and installation of connection points for, a portable filtered air supply unit for the Secondary Control Area (SCA) to ensure habitability during a severe accident	2019
Development of emergency procedure for shift supervisor actions to prepare for a potential tsunami	2012
Improvement of source term and dose modeling tools	2015

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 members 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, while commissioning tests were done that involved injection of emergency coolant into the reactor core, 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 procedural requirements are being complied with and that 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 members 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 members 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 members 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 members 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 reactor guaranteed shutdown state, and upon completion of approach to critical, 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.